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SST: The Unanswered Questions

WHEN FLIGHT TESTING of the first supersonic transports begins about a year from now, a start will be made on providing answers to some of the questions which surround the future of the SST.

Technically, there is no doubt about the feasibility of the aircraft projected in Britain, France, Russia and America—although the time-scale for the Boeing SST will probably need to be stretched. Wide-spread doubts remain, however, about the acceptability of sonic booms on the ground, about the economics of the SST and, fundamentally, about the need for the SST at all. Despite the enthusiasm with which the SST programmes described in this issue are now going ahead, these doubts do cloud the future of supersonic operation.

The sonic boom problem, the manufacturers now admit, could mean that the SST is banned from overland supersonic operation. This would leave many international routes, including the transatlantic, available to the SST, but would bar the all-important US transcontinental routes. It can be shown that more than 70 per cent of seat-miles on long-haul routes are produced over water, where SST operation would be possible, and BAC claims that a market for 200 Concordes will exist by 1975 even with an overland restriction. Proponents of the US SST programme appear equally sanguine in the face of sonic boom restrictions.

Nevertheless, the purchase of an aircraft so compromised in its operational flexibility would be contrary to the dictates of normal airline experience, and in many cases would call either for a time-consuming change of aircraft where overland and overwater routes meet, or for uneconomic subsonic operation of the SST on segments of many flights. Whatever the airlines profess in public, we believe their present plans to buy the SST are based on the assumption that by the time these transports are in service, unrestricted use will be possible.

Even so, the SSTs planned at present apparently do not follow accepted air transport criteria which require any new type to have larger capacity, better performance, improved passenger comfort *and lower costs* than the aircraft it replaces. The most optimistic forecast of SST seat-mile costs show them to be comparable with those for the large subsonic jet in use to-day; by the time the SSTs are operating at these costs, however, the subsonic rates will be still lower, thanks to normal evolution and introduction of aircraft like the Boeing 747. It is by no means clear at present what steps the airlines propose to take to ensure that the lowest-cost travel continues to be offered alongside supersonic flights, after the first few years of SST operation.

In the face of these uncertainties, the large-scale expenditure necessary to develop the SST will continue to draw much criticism. We do not believe the SST programmes should therefore be abandoned; but the case for extensive prototype testing and more detailed economic analysis prior to a commitment to full scale production, is very strong.

FORUM

NO 28 SQUADRON

AS A RESULT of the decision to disband No 28 Squadron certain ceremonies are being planned and it is hoped to lay up the Squadron Standard in St Clement Danes Church in April 1967 with a get-together to follow.

All previous members of the Squadron will be most welcome and those interested should write to the Adjutant, No 28 Squadron, RAF Kai Tak, Hong Kong, BFPO 1.

HELICOPTERS FOR COMBAT

I FEEL that I cannot let your otherwise excellent article on "Helicopters for Combat" (Volume 22 No 3) pass without pointing out that it is the Royal Navy and not the RAF that has been responsible for the development of helo armament in this country.

Trials in Malta by 728C Flight (the forerunner of 848 Squadron) in 1958 included the use of 2-in RP, fixed forward firing guns and twin trainable machine guns in the main cabin. The principle of arming helos was firmly established during 848 Squadron's period of front line service from 1959-1962 and when 845 Squadron embarked in HMS *Albion* in 1962 with Wessex HU. Mk.1 aircraft, they were, in addition, fully capable of firing SS11 missiles. The Wessex HU. Mk.5 has, from its inception, been fully modified to take 2-in RP, SS11, .303 machine guns (now replaced by 7.62 mm) as well as a cabin gun fired by the aircrewman.

It is as well to remember that 848 Squadron was operating in Malaya as long ago as 1952 and it is the Navy that has been in the van of all helicopter development in this country for a long time. Incidentally, the long range tanks have also been standard since 1961 on Naval Wessex.

Thus, to say that, after trials by the RAF, the Navy has now turned to arming its helos is completely false: in fact, exactly the opposite is true.

LT CDR P J CRAIG
Commanding Officer
848 *Naval Air Commando Squadron*
RNAS Culdrose, Helston, Cornwall.

MOHAWK EJECTION

WE WERE astonished to read your statement regarding the performance of Martin-Baker ejection seats in Mohawk aircraft operating in Vietnam that "some difficulties have been experienced with low-altitude ejection as, after the first crew member ejects, the aircraft tends to tilt to one side, resulting in a reduction of the apogee attained by the last crew member to leave the aircraft, and on several occasions this has had fatal results."

A study of our records and our investigations, involving well over 100 emergency ejections from eleven different side-by-side seat aircraft, including the Mohawk, show that there is no evidence whatsoever to support this statement.

Correspondence on this subject has been published in Aviation Week and Space Technology, in which I contributed by writing that all of the evidence shows that fatalities which occur in such circumstances are due not to offset loads imparted by the ejection seat but to the time lapse between the first and second man ejecting. My published view was also taken by Lieutenant Colonel George Handley of the US Army's Research Board for Accidents (Aviation Week July 11, 1966).

Denham, Bucks. J JEWELL, O.B.E.
Service Liaison Manager,
Martin-Baker Aircraft Co Ltd.

We are glad of this opportunity to make clear that the fatalities referred to in the article on the Mohawk (Vol 22 No 6) were not attributable to the ejection seats. Martin-Baker ejection seats have to date saved 1,436 lives including those of 525 officers of the US Forces—Ed.

HISTORICAL APPEAL

A HISTORY of the ATC is being compiled by Sqn Ldr J L Boulter, ex-Staff Officer of the Berkshire Wing Air Training Corps and Bryan Philpott, 28 Charter Road, Newbury, Berks, and they appeal to readers for information which may assist them in their task. They are particularly interested in the early days of the Corps and the ADCC; also notable "firsts" or achievements by cadets and squadrons, both during and since World War II.

All information should be sent to Mr Philpott and will be acknowledged, and returned if required, after copies have been made.

ON THE COVER

Over 300 ft (91,44 m) long, the full-scale mock-up of the Boeing swingwing SST gives a preview of the shape of things to come. An article on the Boeing SST proposal appears on pages 415-424 of this issue.

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American air power in the Vietnam conflict

FIRE from the SKIES

FLYING REVIEW INTERNATIONAL analyses the reports from its correspondents in Vietnam

THE NAME "Vietnam" means "The Far-South", and derives from a time in the country's early history when for almost a thousand years it was ruled by China. This period, which was marked by severe oppression and extremely bitter resistance, might be regarded as an unhappily apt background to a nation which even today is dogged by foreign domination and seemingly endless internal strife. The French, who had conquered Indo-China in 1883, and been thrown out by the Japanese in World War II, attempted to regain their former position in 1945, but the end of that year found them under attack by Ho Chi Minh's revolutionary forces (the Vietminh). The war that followed was to cost a million lives and ended in 1954 with a pitched battle at Dien Bien Phu, where the Vietminh man-handled their 75-mm and 105-mm artillery to heights overlooking the French positions, and pounded them into submission and out of Indo-China.

Trouble flared again only three years after the Geneva peace agreement, with a resurgence of activity by guerillas (termed Vietcong) in South Vietnam. Initially they received only covert encouragement from the North, but in 1961 Ho Chi Minh openly declared his country's support for the struggle to "liberate the South". Faced with the prospect of this critical area falling under Communist control, the US first sent in a small number of advisers for the South Vietnamese army (ARVN), and as the situation worsened in 1961 began the build-up that at the end of last year had amassed some 376,000 US servicemen. Together with 685,000 ARVN troops and small South Korean and ANZAC contingents, these hold in check a 280,000-strong insurgent force. Ground fighting in the South has until this year been mainly between ARVN and Vietcong, while the Central Highlands and extreme north are largely the responsibility of US troops, opposed by both Vietcong and regular units from the North (PAVN).

History shows that a well organised and strongly supported guerilla force is almost impossible to destroy (the British action in Malaya is virtually the only successful major counter-insurgency operation on record), and therefore many observers could foresee nothing but a succession of humiliating defeats for the US in attempting what a massive French army had failed to achieve. However, although the French had used both armour and artillery against the Vietminh, the air power available in the theatre had been severely restricted and their only ground attack successes had been a handful of daytime napalm strikes. In contrast, the USAF could deploy vastly superior tactical fighters and transport aircraft, while the US Navy could supply additional cover from an endless succession of carriers off the coast, and the US Army was equipped

with hundreds of turbine-engined helicopters, giving both a worthwhile troop-lift capability and their own close support fire.

Air power might not provide the US with a complete solution to the insurgency problem, but it did offer the prospect that the enemy would be unable to engage in the type of large-scale actions which had finally defeated the French, that infiltration and supply from the North could be restricted, and that the fight could be brought to even the most remote guerilla base camp and training area.

It was originally feared that these aims might be thwarted by tactical aircraft being grounded for extensive periods during the rainy seasons, but this has not proved to be the case. The north-east monsoon which affects the northern half of the country from November to March, and the south-east monsoon which affects the south from May to September, both result in sporadic bad weather rather than downpours continuing for many days. However, South Vietnam's climate is far from ideal for military operations: temperatures of 90-100° F (32-38° C) are not conducive to short field performance and high warloads. The combination of intense heat and relative humidities of 80-90 per cent has necessitated development work on a water-cooled vest to relieve the extreme aircrew discomfort. In addition, monthly rainfall figures of up to 49.5 in (125 cm) can have a serious effect on the dirt strips used by light transports and utility aircraft.

The main stumbling block to the large-scale application of air power was the initial shortage of airfields suitable for conventional fighters, requiring runways of 8,000-10,000 ft (2 500-3 000 m). Although there are several hundred airstrips in the country, the vast majority of the surfaces are dirt, laterite, PSP, or asphalt, and indeed many have lengths of less than 2,000 ft (600 m). Tactical fighters are thus at present only able to operate from seven bases in South Vietnam. Bien Hoa and Tan Son Nhut are both close to Saigon (the second is incidentally now the busiest airport in the world), while Danang in the extreme north is mainly concerned with strikes across the 17th Parallel. Stretching between these main centres, the US has constructed jet bases on the coast at Phan Rang, Cam Ranh Bay, Tuy Hoa, and Chu Lai. The speed with which these airfields have been activated has been due largely to the use of temporary aluminium plank strips, pending the completion of permanent concrete runways. Problems have arisen due to the wearing away of the anti-skid plank facing, and to the movement of the surface under the repeated loads induced by heavy fighters, but on the whole this operational experiment has been highly successful. Early trouble with rain washing sand up through the joints in the planking has been solved by mixing cement with the top layer of soil.

Strikes against North Vietnam and surveillance of the Ho Chi Minh Trail through Laos are mounted not only from Danang, but also from three carriers of Task Force 77 operating in the Gulf of Tonkin, and from Thai airfields at Korat, Ta Khli, Ubon, and Udorn. Thailand, which Radio Moscow currently reviles as an "unsinkable aircraft carrier", also provides a base at Nakhon Phanom on the Laotian border for an air-sea rescue squadron of HU-16 Albatross amphibians.

U CALL—WE HAUL

When US forces moved into Vietnam, rail communications were virtually unusable and movement by road was subject to continual ambush and harassment. Although the situation is now somewhat improved, over 75 per cent of inland freight still has to be delivered by air. Aside from a small number of RAAF Caribous based on Vung Tau, intra-theatre airlift is carried out by the USAF's 315th Air Division (Combat Cargo), which operates a scheduled network linking 135 strips and provides regular supply drops at 45 additional sites.

The C-130 "Herky Bird" carries most of the load, but it is restricted to 31 airfields, and almost all of the remaining route structure is flown by four C-123 Provider squadrons, based on Tan Son Nhut, Nha Trang, and Danang. The smallest fields have until recently been dependent on the CV-2 Caribou, but a number of Providers are being brought up to C-123K standard, with two J85 turbojets in underwing pods, a revised landing gear and a new stall-warning system, in order to facilitate operations from short dirt strips. Aircraft from twelve C-130 squadrons operate as part of the internal airlift for periods of around ten days, in between providing a shuttle service from their bases in the Philippines, Taiwan, Okinawa, and Japan. Both C-123s and C-130s are used for aeromedical evacuation, which is the sole function of four Douglas C-118As.

Aside from their normal airlift, supply drop, and paratroop duties, C-123s are being used (alongside the perennial C-47) for flare dropping in support of night actions, and some have been equipped with batteries of lights to provide continuous illumination. In "Operation Ranch Hand" seven C-123s are employed

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Bell UH-1 helicopters are widely used in Vietnam in a number of different roles. Illustrated here are US Army UH-1D "Slicks", the standard troop-carrying version of the Iroquois.

to spray defoliant around roads and railways, killing the vegetation by overstimulation and denying the Vietcong suitable cover for ambush. Flying at 150 ft (45 m) and 150 mph (240 km/h), these aircraft make ideal targets for Vietcong gunners, and support is therefore provided by A-1E Skyraiders and Martin B-57Bs.

Strategic airlift missions are flown by MAC's C-124 Globemasters, C-133 Cargomasters, and C-141 Starlifters. The introduction of the C-141 and the 463L automated cargo handling system has been nicely timed for the Vietnam war, since together they enable freight loaded at Travis AB, Calif, to be placed on the ramp 8,500 miles (13 600 km) away at Saigon only 22 hours later, allowing for refuelling stops at Guam and the Philippines. At least one C-141 is employed each day in carrying "Red Ball" priority items for the US Army, either across the Pacific or from the East Coast via Alaska and Japan.

The Vietnam conflict has brought fresh ideas to many aspects of military aviation, but the greatest change of all has come in the large-scale employment of helicopters, with over 1,800 now based in the country. The most widely used type is the Bell Iroquois "Huey", which is operated both for fire support (UH-1Bs are known locally as "Hogs or "Cobras") and as a troop carrier (UH-1Ds, referred to as "Slicks"). A typical armament for the UH-1B comprises four 0.30-in (7,62-mm) machine guns mounted on outriggers, two more operated by side gunners, and two pods of seven 2.75-in (6,98 cm) rockets on the sides of the fuselage. The "Slicks" have only an M-60 machine-gun on a flexible mounting in either cabin door. Thanks to the combination of fire power and protective armour, which totals 500 lb (228 kg) in the case of the UH-1D, losses have been kept down to one in 18,000 sorties. A variety of fire suppression systems have been tested in the field, including a General Electric M-5 chin turret enabling the UH-1B to fire 40-mm grenades at 220 rpm, and a similar installation in the CH-47A Chinook combined with two forward-firing 20-mm cannon and five machine guns on flexible mountings.

The CH-47A has revolutionised mobility in Army fire power, since it can carry two 105-mm howitzers internally. The CH-54 Skycrane has been evaluated in Vietnam, and offers the advantage that it can lift a 155-mm gun on a sling. At the opposite end of the scale, the Hughes OH-6A observation helicopter is now replacing the OH-23 Raven and OH-13 Sioux. The latter has been criticised as being short on speed and having such little reserve power that the addition of two machine guns necessitated its operation as a single-seater. The performance of all helicopters has suffered from high ambient temperatures and from the need to add armour and armament, and operational problems have been introduced by the poor surfaces from which much of the flying is carried out. Marine Corps CH-34 Choctaws using sand strips have experienced high blade erosion and engine wear, while in other areas red dust has built up on the compressor blades of CH-47 Chinooks and caused compressor stalling. The high disc loading of the CH-54 Skycrane requires some care in its use, as tents, thatched roofs and frail structures may easily be blown away by its unusually powerful downdraught.

Perhaps the greatest achievement of the helicopter lies in the fact that the proportion of combat wounds proving fatal has been reduced in this theatre even below the Korean level, and also that 60 per cent of aircrew shot down over Vietnam are picked up and return to action. Rescue missions include penetration into the North from secret advance bases, with cover from other helicopters and A-1 Skyraiders. The HH-43 Huskie was for a long time the workhorse of these units, but is now mainly used for fire fighting on air bases, having been replaced by the Sikorsky HH-3, which has 25 per cent more range and has been developed for flight refuelling. The USAF has also ordered the Sikorsky HH-53B, which will be refuelled from the HC-130H. The downed pilot can attract attention by means of a radio "beeper", flares, or a strobe light, and can direct the final stage of his rescue by means of a miniature transceiver radio. If north of the area covered by the HH-3, his only chance is to get out to sea and call in an HU-16 Albatross from Danang or Thailand. This service is now being augmented by the HC-130H, which can lift men from the sea by snatching the cable of a balloon flown from their dinghy.

GENERAL AVIATION

In addition to operating the majority of helicopters, the US Army has roughly 400 fixed-wing aircraft in Vietnam. Observation duties are carried out by O-1 Bird Dogs, while the U-6A Beaver and U-1A Otter are used as light utility aircraft, and the U-8 Seminole as a command transport. The OV-1 Mohawks employed for armed reconnaissance now represent the heaviest aircraft operated by the Army, which at the beginning of the year handed over its CV-2B Caribous and CV-7A Buffalos to the USAF.

In the general aviation category, the USAF employs T-39 Sabreliners to move high priority cargo, while the C-140A Jetstar is used by the Communications Service and the VC-140B by the Special Air Mission Wing of MAC. Courier missions are flown by the U-3 Blue Canoe, the military version of the Cessna 310. Aircraft are also operated in a psychological warfare campaign to encourage the Vietcong to surrender, and the same means are used to warn civilians to avoid areas scheduled for air strikes. Much of this work is carried out by the Helio U-10 Courier ("Super Spad"), but the C-47 can carry 1½ million leaflets, and the battery of loudspeakers that fill the freight entrance obviously carry further than the 1,800-watt output of the U-10. The C-47 has also achieved great success in its AC-47 "Puff-Ship" form, armed with three 0.30-in (7,62-mm) Miniguns firing out of windows in the port side at a combined rate of 18,000 rpm. Carrying their own illumination in the form of 48 flares, these aircraft have

Special colours and insignia were carried during 1965/66 by the Douglas A-1s of the 522nd Fighter Squadron (now disbanded) of VNAF's 83rd Special Operations Group. Based at Ton Son Nhut, they were under the direct control of Premier Ky. The Chinese character on the nose is based on the ace in a pack of playing cards; on the fuselage, the dragon is the symbol of the 83rd Group and the stars represent the five manly virtues of Confucianism.

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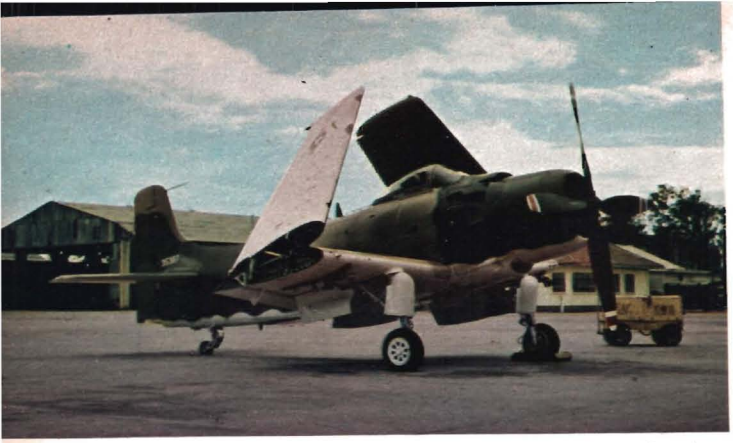


Above, *a newly painted A-1 of the VNAF's 518 Tactical Fighter Squadron. Below, AC-47As, the highly successful "Puff-Ships" or "Magic Dragons" which can let loose 18,000 rounds per minute from three General Electric Miniguns.*

given most effective protection against night-time Vietcong attacks on isolated villages, circling above the reach of ground fire and pouring down a continuous hail of fire.

High speed fighters would have little chance of detecting Vietcong camps or movements, and therefore O-1 Bird Dogs are used by the USAF for Forward Air Controller (FAC) duties, both to find the enemy and to direct any strike that may be required. Sightings frequently occur as a result of information received from agents on the ground, but anyone firing on the O-1 is assumed to be unfriendly, and the rear windows are left open so that the pilot can hear a near miss! The target is then marked by smoke rockets, and the strike monitored by radio. The main criticism of the O-1 is that it is too easily shot down: there is no armour for the engine, and the pilot only has a flak vest to sit on. Two engines are felt to be desirable, plus the ability to climb quickly from the patrol height of 1,500 ft (450 m) to the immunity of 3,500 ft (1 100 m). There is also a demand for some improvement in defensive armament over the hand-held M-16 carbine, and tests have therefore been carried out with a fixed M-60 0.30-in (7,62-mm) machine gun firing out of the port side and slightly downwards.

The effectiveness of daytime visual reconnaissance has undoubtedly placed severe restrictions on Vietcong movements, but it has also underlined the difficulty of performing the same mission at night. USAF RF-4Cs and Army Mohawks equipped with side-looking radar (OV-1Bs) and infra-red surveillance equipment (OV-1Cs) are achieving some success, but real-time all-weather reconnaissance is generally admitted to be still in its infancy. The best results to date have naturally been against relatively large targets, and in particular against sampans. In the USAF's "Snipe Hunt" programme these boats are found by OV-1Bs, illuminated by flares from a C-123, and attacked by A-1s, F-100s, or AC-47s. The US Army's corresponding technique ("Lightning Bug") follows up the OV-1B with an UH-1B mounting a cluster of landing lights, and three more UH-1Bs for the kill.

The ordnance used for the "in-country" war is primarily anti-personnel: napalm, white phosphorus ("Willie Peter"), and cluster bomb units (CBU). Seen in relation to average loads in the region of one ton, the Phantom is an uneconomically heavy machine, but it is nonetheless playing an increasing part in the fighting, both as the USAF's F-4C and the Navy and Marine Corps' F-4B. These last two services also make great use of the A-4C and A-4E "Tinker Toy Bomber" for close support and as a helicopter escort. Marine A-4s and F-4s are frequently used in straight-and-level night bombing missions under the control of TPQ-10 portable ground radar. The other principal ground attack aircraft are the F-100D and Skyraider, the latter soldiering on as the USAF's A-1E and the VNAF's A-1H and A-1G. This piston-engined aircraft has proved capable of operating under cloud ceilings as low as 500 ft (150 m), and its endurance is invaluable in covering a downed pilot, but it lacks fast response and its use would of course be ruled out by flak. Recent changes in equipment include the supply of 75 Northrop F-5s to the VNAF, an increase in the number of B-57s used, the arrival of RAAF Canberras, and the relegation of the F-102 to air defence duties.

The B-52s from Guam operate primarily against strongly-held Vietcong areas such as the "Iron Triangle" and "War Zone D" near Saigon, although they have also been used with fighter escort against the North. In their first raid two aircraft collided and there appeared to be no positive results other than matchstick-making, but eight weeks later some 400 bodies were found in the target area. The heavy bomber may be proving its worth in collapsing caves as deep as 60 ft (18,5 m) and for the psychological effect of approaching unheard and unseen, but the idea of a B-52 crew receiving an air medal after 15 missions in this theatre will still come as a surprise to many.

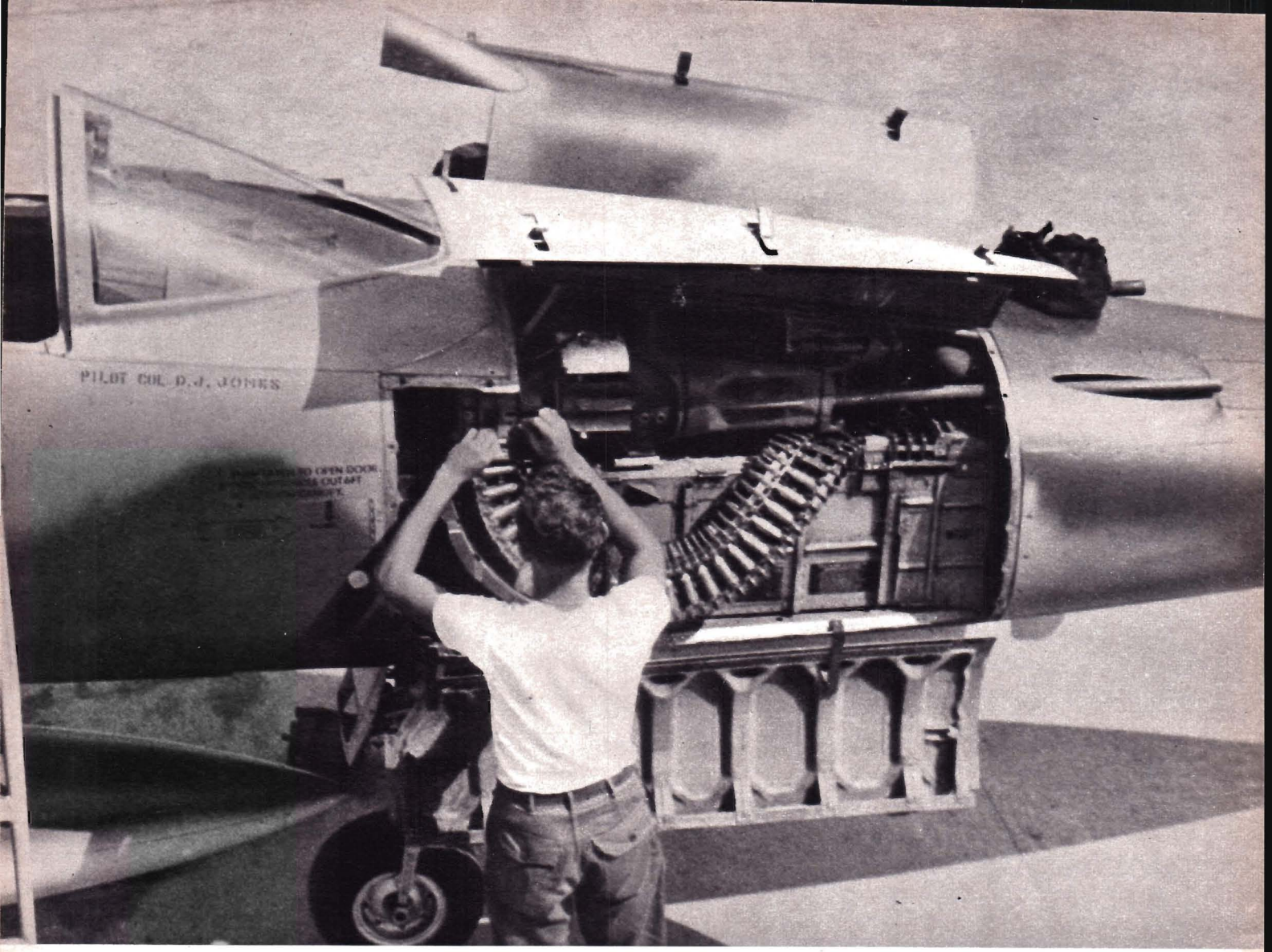
OUT-COUNTRY WAR

Attacks on North Vietnam, Cambodia, and Laos, where the Ho Chi Minh Trail has in parts become a highway protected by flak, are classed together as the "out-country war". Strikes are carried out by the F-105, A-4, and F-4, and reconnaissance by RF-101, RF-8A, RA-5C, and RF-4C. Flight refuelling over the Gulf of Tonkin is by courtesy of the KC-135, and airborne early warning and fighter control by the "Big Eye" EC-121 Warning Star, WF-2 "Willie Fudd" and E-2A "Super Fudd". In bad weather, level bombing can be carried out by formations led by an RB-66, but the only strike aircraft with built-in all-weather capability is the Grumman A-6A. Opposition by fighters has not yet become a major factor, although the use of SA-2 missiles has forced US aircraft to operate at low altitudes, where radar-predicted flak is intense. Electronic counter-measures for this and the SA-2 system are provided by various types, ranging from specially equipped A-4s and EF-10Bs to RB-66s.

Most strike sorties over the North have been flown by the F-105, and the consequent attrition has led to the corruption of its name to "Thunderthud". The best features of the F-105 are its long range, comprehensive attack system, built-in Vulcan gun, and dry wing, but it lacks armour, self-sealing tanks, and twin-engine safety. The F-4, which flies top cover for the F-105, is at present less well equipped for bombing and lacks an internal cannon. Being designed originally as a long-range all-weather interceptor, it is hardly surprising that the F-4 is less manoeuvrable than the MiG-21, but this could lead to a difficult situation if the Communist side can acquire aircraft and well-trained pilots in reasonable numbers.

Although the F-4 may eventually be seen as the most useful

Above, *a Cessna O-1F of the type widely used for Forward Air Controller duties by the USAF; this one has an M.60 machine gun under each wing. Below, a loudspeaker is mounted on the port side of this Helio U-10, used primarily in the psychological warfare campaign.*



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A Martin B-57B begins its run-in over a target in Vietnam, carrying 750-lb (340-kg) bombs under the wing and in the bomb-bay.

aircraft of the war, there is little doubt that the USAF is thoroughly disillusioned over the concept of an all-purpose type. Future planning is concentrated on evolving a series of twin-engined aircraft: an air-superiority fighter, an all-weather strike (or interdiction) aircraft, and a simply equipped close-support machine. The OV-10A COIN aircraft is being rushed into service, eliminating the shortcomings of the O-1, but possibly introducing maintenance problems in dispersed operation. The A-7A will represent a great improvement in load capacity over the F-100D, but it has been criticised as a large single-engined target. The UH-1B will eventually be replaced by the Lockheed AH-56A AAFSS, with the AH-1G Hueycobra as an intermediate step and Cessna O-2 Skymasters have recently been ordered to replace the O-1 Bird Dogs.

New types of equipment may enable the war to be waged more effectively and more economically, but there seems little prospect of an outright win in the South. Attacks on the North have in the main been limited to "choke points" in the transportation system, with the dual purpose of restricting the flow of men and supplies to the South and of forcing Ho Chi Minh to negotiate a peace settlement. This bombing is claimed to pin down 200,000 men in incessant repair operations, although the main routes are seldom closed for more than 24-36 hours. Combined with strikes on fuel depots near Hanoi and Haiphong, which have resulted in all POL (petrol, oil, and lubricants) now being dispersed in small drums, the offensive has brought about a general dislocation rather than a complete stoppage. The 60-mile (100 km) road journey between the two cities can now take up to four days, and reports speak of food shortages due to distribution difficulties. One can only hope that these token attacks are convincing North Vietnam of the futility of taking on the most powerful nation on earth, since with an annual war bill of over £7,000 million ($20 billion) and with a presidential election coming up next year, the patience of the US is obviously not going to last for ever.

Douglas A-1H and A-1G Skyraiders form the backbone of the VNAF, which also has B-57s, a few C-47s and other miscellaneous types. Northrop F-5As are in process of being issued to the VNAF.

SST

Four nations—UK, France, the USA and USSR—are forging ahead with supersonic transports, the first of which are likely to fly within a year. In this series of special articles we report on the aircraft, their engines and some airline thinking on the SST.

Progress with the BAC/SUD Concorde

IN THE FACTORIES of the British Aircraft Corporation and Sud Aviation, and a growing number of component and equipment suppliers, the tempo of work on the Concorde supersonic transport is steadily increasing. With the first flight now only one year away, the programme is forging ahead with precision and enthusiasm: every major milestone in prototype assembly has been achieved on target and in the Sud factory at Toulouse the first aircraft, 001, is now virtually complete so far as major structure is concerned. On the second assembly line in the BAC factory at Bristol, prototype 002 is about six months behind 001 and at present is rather ahead of the schedule for the first flight on September 30, 1968.

Under the terms of the Anglo-French agreement of November 29, 1962, work on the Concorde is shared equally between the two countries. This arrangement is working satisfactorily and during the past few months the exchange of major components between the two countries has got under way, setting the pattern for a regular operation in future. By the middle of this year, when the final large components for 002 at Bristol are received from France, experience will have been obtained in shipping all the items which make up a complete airframe.

There are some 30 major structural pieces which go together in the final assembly jigs, and these come from three BAC factories (Bristol, Preston and Weybridge), four Sud factories (Marignane, Bouguenais, Toulouse and St Nazaire), from Dassault and SNECMA in France and from Rohr in the US. In addition, engines are supplied by Bristol Siddeley and the main and nose undercarriage by Hispano Suiza and Messier respectively. Bringing together all these parts calls for a major transport operation which is not without its own peculiar problems, including the French traffic regulations which prohibit outsize loads from being moved by road at the week-end.

In addition to the factories mentioned above, each drawing upon their individual sources of primary materials, about 100 companies have so far received contracts to supply equipment for the Concorde prototypes. The procedure whereby these companies are chosen is discussed separately on page 414.

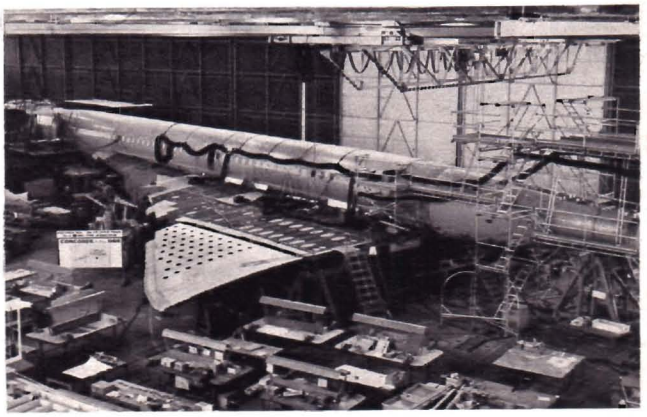
Associated with the work on prototype construction is a vast range of activities concerned with testing and development. Among the recent achievements in testing was completion of a proof pressure test (16.1 psi—1,132 kg/cm²) on the fuselage nose section at Bristol, in preparation for a similar test of the entire fuselage of 001 during January at Toulouse. Soon to come into use at Filton is the fuel flow rig; one of the largest rigs of this kind ever tested, it comprises a full scale representative layout of the Concorde's fuel tanks mounted on gimbals to permit movement in three axes to study fuel flow behaviour at various aircraft attitudes.

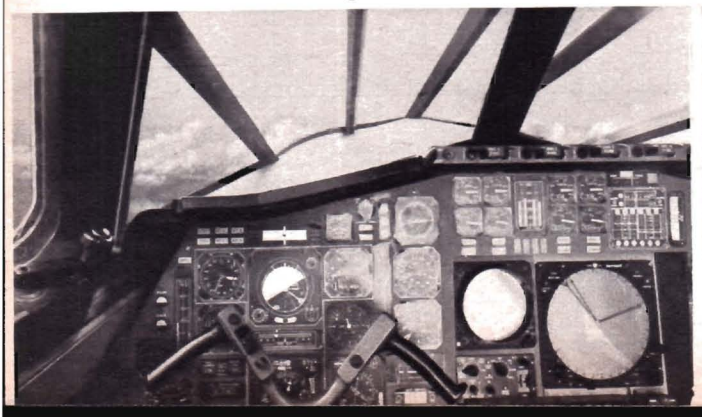
Another important programme at Bristol is concerned with the flight simulator which has been in use for Concorde development since 1963 but has recently been improved and extended to complement the main programme of simulator research at Toulouse. The simulated flight deck is now mounted on a Redifon electro-hydraulic motion system which provides motion in three axes and simulates the effects of turbulence, reverse thrust and taxi rumble. Representative loads can be applied to the control columns for all flight conditions.

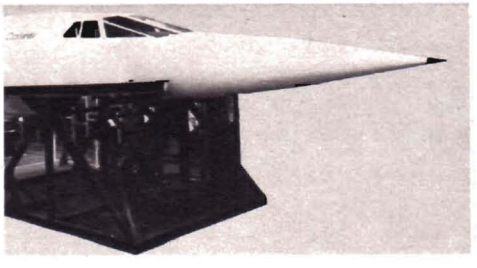
A PACE 231R computer has been added to the original LACE computer to handle the more complex investigations now to be undertaken by the simulator. Prior to these modifications, more than 700 hours had been "flown" and 5,000 take-offs made in the investigation of Concorde flight characteristics. This total was made up of 326 hours take-off, 233 hours low-speed flight, 93 hours transonic, 29 hours end of cruise and 23 hours emergency descent. The Phase II flight deck programme has now started with an investigation of low speed handling.

Mock-ups continue to play an important part in Concorde development and a major new sales demonstration and engineering mock-up is now nearing completion at Bristol. This comprises a complete fuselage to pre-production aircraft standards, mounted at representative height above ground and complete with one half-wing. The flight deck and vision mock-up has now been fitted with the new visor and nose fairing which has been adopted for the pre-production aircraft. In place of the prototype's completely faired-in nose with only two small forward vision windows for supersonic operation, a "stepped" nose has now been accepted with a visor providing almost uninterrupted forward vision. The nose has also been lengthened by 1 ft 11in (0,584 m) to give a new overall length of 193 ft (58,83 m).

Changes such as this are not to be introduced on the two prototypes, since they do not affect airworthiness and would unnecessarily delay completion. The prototypes are in any case slightly smaller than the definitive production Concorde and have a lower gross weight. The max take-off weight of the production (and pre-production) Concorde has recently increased to 350,000 lb (159 000 kg), primarily to accommodate structure weight growth without degrading the design payload-range characteristics. An important improvement in take-off performance has recently been announced, amounting to a 7 per cent reduction in field length for a given take-off weight in ISA at sea level and 8.5 per cent in ISA+20°C. This improvement, which will permit an increase of about 15,000 lb (6 800 kg) in the permitted weight for







Above, the first Concorde prototype under construction at the Sud-Aviation works at Toulouse. Left, the redesigned Concorde nose in high subsonic and supersonic cruise configuration. The "stepped" screen is covered by a visor providing almost uninterrupted forward vision.

CONCORDE SPECIFICATION
(Pre-production aircraft)

DIMENSIONS: Span, 83 ft 10 in (25,6 m); length, 193 ft 0 in (58,83 m); overall height, 38 ft 0 in (11,58 m); wing area, 3,860 sq ft (358,25 m²).

WEIGHTS: Max take-off, 350,000 lb (159 000 kg); max landing, 218,000 lb (98 900 kg); max zero fuel, 183,000 lb (83 000 kg); max payload, 28,000 lb (12 700 kg).

PERFORMANCE: Cruising speed, Mach 2.2 at up to 65,000 ft (19 812 m); approach speed 172 mph (277 km/h); take-off field length required, 9,650 ft (2,941 m) ISA at sea level; range, 4,080 st miles (6 566 km) with max payload of 28,000 lb (12 700 kg) and standard reserves; landing field length required, 7,650 ft (2,332 m).

POWER PLANTS: Four Bristol Siddeley Olympus 593B turbojets each rated (Stage 0) at 32,000 lb st (14 515 kgp) plus 9 per cent afterburning and (Stage 1), 35,080 lb st (15 912 kgp) without afterburning.

take-off from a given field length, has been achieved by unspecified aerodynamic means.

There are six airframes in the programme so far authorised by the British and French governments—the 001 and 002 prototypes, a static and a fatigue test specimen and the 01 and 02 pre-production aircraft. Both prototypes, as already noted, should fly in 1968, with Sud scheduled to complete the static test airframe in the middle of the year. First flights of the pre-production aircraft are scheduled for September (Bristol) and November (Toulouse) 1969, with BAC completing the fatigue test specimen earlier the same year. The first four production Concordes are to fly in 1970 with certification scheduled for April 1971 in time for initial deliveries to customer airlines in May.

It is intended that BOAC, Air France and Pan Am should each receive their first aircraft on the same day, and that deliveries should subsequently keep in step until each of these airlines has six Concordes. Thereafter, deliveries would begin to other airlines, with TWA, American Airlines and Continental among the first to receive Concordes after the first 18. About 40 should be delivered by the end of 1972 with production then reaching a rate of three a month.

At the time of writing, 15 airlines have taken options on 69 Concordes, as follows: Air Canada, 4; Air France, 8; Air India, 2; American Airlines, 6; BOAC, 8; Braniff International, 3; Continental, 3; Eastern, 4; Japan Air Lines, 3; MEA, 2; Pan American, 8; Qantas, 4; Sabena, 2; TWA, 6; United, 6. The option agreement, which includes a cash deposit, provides for completion of a definitive contract six months after the Concorde's first flight. Provided that BAC/Sud then offer a contract including guaranteed performance within the framework indicated in the option agreement (ie, ability to fly Paris-New York with full commercial payload), the airlines must conclude the contract or pay a penalty "substantially in excess" of the deposit. In the case of BOAC and Air France, deposits have not been paid, but the investment by the British and French governments in the Concorde project appears to make such a deposit a mere formality.

The Concorde is tagged at $16 m (£5.7 m), or about $21 m (£7.5 m) including initial investment in spares. Tooling costs are being amortized over 130 aircraft, but arrangements for recovery of development costs by means of a levy on production aircraft have not yet been announced. Current BAC/Sud market studies indicate sale of at least 200 Concordes by 1975, even allowing for certain pessimistic assumptions—ie, that supersonic operation over land will be prohibited by sonic boom considerations; that there will be a 25 per cent fare surcharge for SST passengers compared with basic subsonic rates and that the Concorde will be followed three years later by a US SST with better economics. If any of these premises is over-pessimistic, the Concorde market could be considerably increased.

Concorde seat-mile costs are, BAC admit, higher than those of contemporary subsonic jets—the direct cost per hour is predicted at $1,900 (£680). This, it is believed, is off-set by the superior passenger attraction of the SST and studies show that a Concorde operating with an average passenger load factor of 60 per cent and with a 12-year depreciation, would give a net return on investment of 23 per cent.

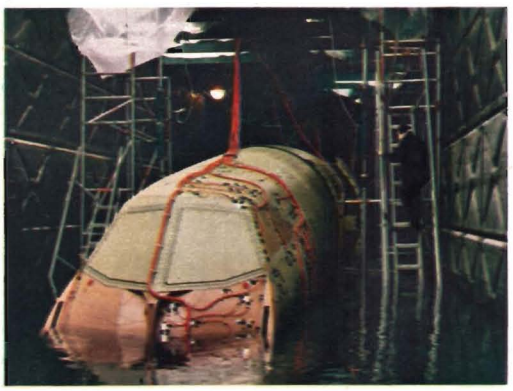
Initial production aircraft will have a 34-month manufacturing cycle, from ordering long lead-time material to delivery of the finished aircraft. To meet the May 1971 delivery target, therefore, the production decision must be made no later than July 1968. This comes a few months after the first flight, by which time all remaining political doubts about the feasibility of the Concorde should have been finally dispelled to permit Europe's most challenging aviation programme to go ahead as planned.

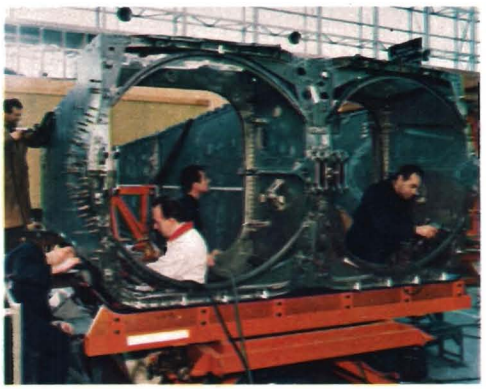
COMPONENT AND SYSTEMS ORDERING

With hundreds of potential accessory suppliers in each of two proud, major countries the selection of equipment to fit out the Concorde is the least enviable of tasks undertaken by BAC and Sud. Yet it has now largely been accomplished to the entire satisfaction of both sides, and without losing time, becoming involved in fruitless argument and without duplication of manufacturing effort.

The underlying urge to maintain a strict basis of 50:50 cost sharing and spending might, without clear top level instruction, have biased decisions in favour of less worthy equipment just to keep the proportions of spending right. But this has not happened and all decisions on accessories and systems have been made entirely on technical and commercial grounds. This is itself a tribute to the standards of equipment available on both sides of the Channel.

In an aircraft which will cost nearly £6 million, bought-in equipment is important. It will account for something like 30 per cent of the delivered price. Each prime contractor is responsible for purchasing minor items for those parts of the Concorde for which it is responsible. This accounts for the British ordering of individual cockpit instruments, for example, and for Sud purchasing fuel gauges and batteries. Although





Top of page, view of main assembly jig at Filton showing aft section of prototype 002 on join-up (right) and front fuselage test specimen in position. Far left, front fuselage test specimen in water tank. Left, port engine nacelle removed from jig.

these types of items are the personal responsibility of individual contractors, each side keeps the other informed of purchases.

Decisions on major items are made at government level. A major item is defined as one which requires a major financial outlay or one which is a technically important task. With the political implications involved in capital expenditure on some of the more expensive systems it is important that the final word should come from engineers directly responsible to the two governments. A bi-national Concorde Directing Committee was formed and this is presented by the manufacturer with a short list, usually three suppliers, drawn up in order of priority, together with their submissions on the specification and the submitted price. This list comes from the engineering design team responsible for that part of the aircraft which will be affected by the system. But decision on manufacturer priority and general technical merit of the equipment also carries the approval of the other prime contractor. In order not to lose time when final lists are submitted the joint Directing Committee sees all submissions as they arrive and is therefore well briefed in advance.

COMMON EQUIPMENT

Another detail which requires joint agreement covers common items of equipment, such as connectors or micro-switches required throughout the aircraft. There is a good deal of give and take in this region of selection and British commitment to the metric system has helped. Design teams in both factories have been asked to raise common standards which allow competitive quotations to be submitted by makers in both countries and these standards have been vetted by a joint technical committee.

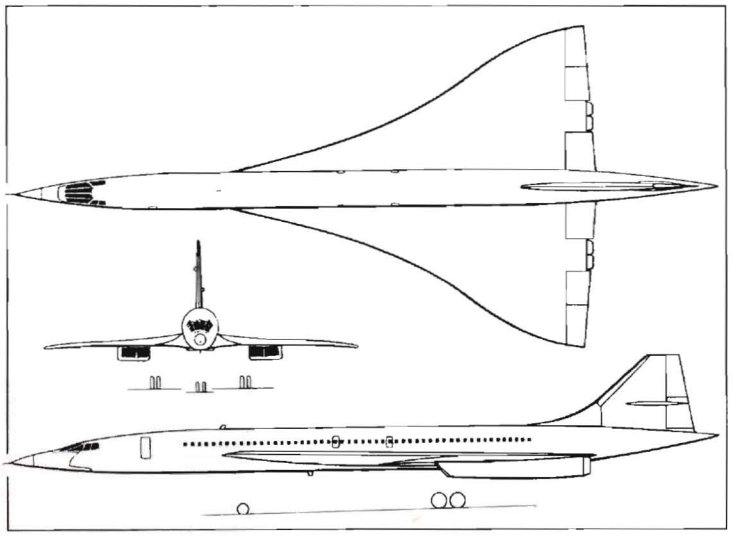
Finally there is a clear protective arrangement under which suppliers of major items who receive government finance for development work on their equipment are required to grant equivalent industrial rights to both countries. The reason for this is that an R & D cost is covered equally by both countries and governments feel that there should be equal opportunity for recovering these costs from production items.

"All these arrangements work well," BAC commented, "largely because all assessments of equipment are made by engineers—right up to government level. There are specific items which have created difficulties but they have not proved to be serious and have not prejudiced the technical or commercial efficiency of the Concorde."

There is complete trust and respect between the prime contractors for each other. In the early days there had been a tendency for each side of the partnership to press for suppliers it had been using in the past but this had died out as each half became aware of the ability of the other.

But whatever method of selection is used there are bound to be disgruntled, unsuccessful competitors who refuse to take the final choice philosophically. Attempts have been made to set up lobbying organisations but they have not affected decisions. Those responsible have astutely maintained the 50:50 balance of spending without compromising their basic rule that equipment must be chosen on quality and price grounds.

The purchase of accessories and systems for the power plants follows an almost identical pattern to the airframe. But here the agreed proportion of spending is 60:40 in favour of Britain. This difference is made good by France being given responsibility for more of the airframe than Britain. Engine accessories and control systems will account for about ten per cent of a delivered price of each engine—which is somewhere in the region of £350,000 without spares.



At the beginning of this year all engine suppliers had been selected. The majority of accessory work for Bristol Siddeley is being co-ordinated by a team led by Earling Payne, power plant systems manager. It organises regular meetings with suppliers to ensure that difficulties are ironed out quickly, specifications are being met and deliveries will be on time.

This is just one facet of a huge and constant endeavour to make sure that with skilful organisation and combined will to succeed an aircraft conceived and made with parts bought in two countries can still meet all its target dates.

The list of companies which follows has been compiled from information supplied by the manufacturers and shows the main suppliers of equipment and accessories for the prototype Concordes and their engines.

Air-Equipement (France) HP fuel system in co-operation with Rotax: flight instr, servo auto selectors, artificial feel system.
Alcan Industries Ltd (UK) Engine gas seal materials.
Associated Electrical Industries Ltd (UK) HE ignition units.
Auxilec (France) Alternators, transformer rectifiers.
Avica Ltd (UK) Flexible pipes and ducting.

BAC Guided Weapons Div (with Radiation Inc) (UK) Magnetic flight-test recorders.
Bendix Corp (USA) ADF marker receivers, vert speed indicators.
Birmingham Aluminium Casting Co Ltd (UK) Aluminium alloy castings.
Boulton Paul Aircraft Ltd (UK) Flight servo controls.
Bristol Aerojet Ltd (UK) Oxygen pressure vessels.
Bronzavia (France) Air conditioning, HP fuel pumps, water separators, humidifiers.

Cegedur (France) Structural materials.
Centrax Misco Ltd (UK) Precision cast stator, segments and turbine blades.
Champion Sparking Plug Co Ltd (UK) Igniters.
Collins Radio Co (USA) HF communications.
Compagnie des Compteurs (France) Test equipment for structure testing including a Pallas computer.
Consolidated Electrical Dynamics Ltd (UK) Vibration transducers.
Cross Manufacturing Co (UK) Engine gas seal rings.
Crouzet (France) Air data computer.
Cramic Engineering Co Ltd (UK) Tape controlled automatic tracing, lofting and measuring machines.
CSF—Compagnie Generale de Telegraphie sans Fil (France) VOR/ILS receiver.

Daniel Doncaster & Sons Ltd (UK) Engine labyrinths and ring forgings.
Darchem Aero Ltd (UK) Engine insulating blankets.
Davall S & Sons (UK) Airborne radiation monitor.
Delaney Gallay Ltd (UK) Engine insulating blankets; fuel heaters.
Dowty Rotol Ltd (UK) Electro-hydraulic selector valves for u/c and nose wheel steering.
Dunlop & Co Ltd (UK) Main u/c tyres, wheels and brakes; nose wheel steer; pneumatic engine fuel controls.

ECE—L'Equipement et la Constructions Electrique (France) Engine fuel equipment in co-operation with Lucas; control boxes, breakers, relays, control panels.
Ekco Electronics Ltd (UK) Weather radar.
Elliott-Automation Ltd (UK) Autopilot; take-off directors; accident recording equipment; fuel measuring equipment; primary engine instruments.
Engel & Gibbs Ltd (UK) Temperature switches.
English Electric Co Ltd (UK) Constant speed units; Spraymat ice protection; constant speed drives, visor heat resist windows; fuselage thermal cycling test equipment.
English Steel Forge & Engineering Corpn Ltd (UK) Engine compressor casing and exit guide casing forgings.
Etudes et Fabrications Aeronautiques (France) Test pilot high altitude survival equipment.

Ferranti Ltd (UK) Inertial platform and pilot displays for SAGEM/Ferranti navigation system; automatic map display.
Firth Derihon Stampings Ltd (UK) Engine Nimonic steel forgings.
Flight Refuelling Ltd (UK) Refuelling equipment.

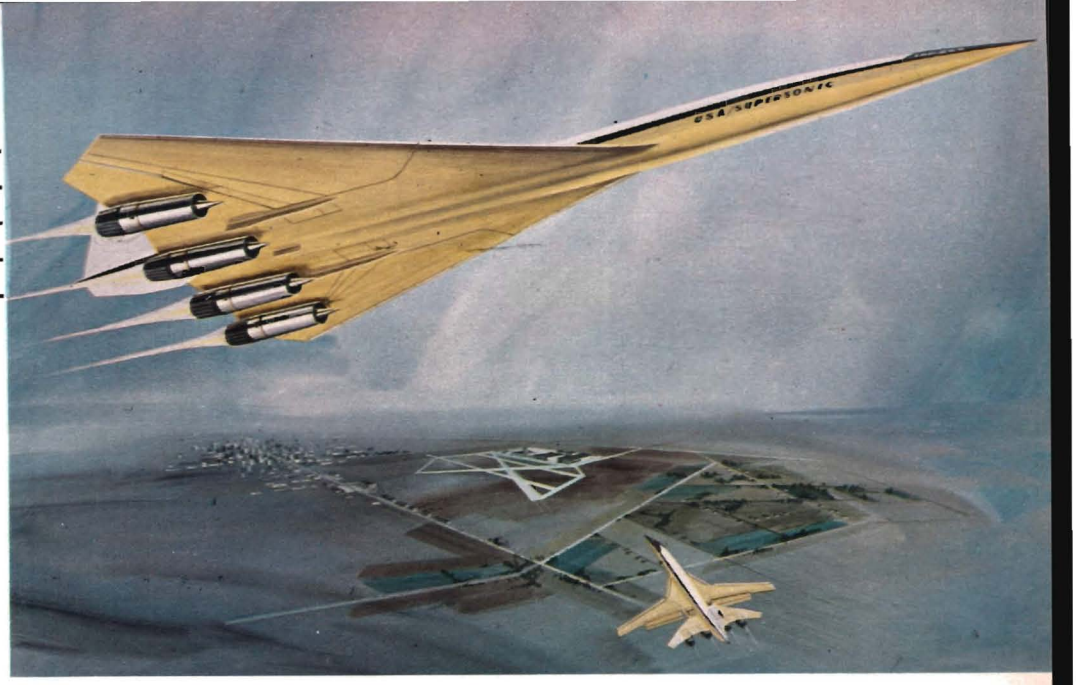
GEC Computers & Automation Ltd (UK) Two digital computers for flight test analysis.
General Precision Systems Ltd (UK) Colour visual, simulator attachment.
Graviner (Colnbrook) Ltd (UK) Engine overheat and fire extinguishing systems.

Hamilton-Standard Division of United Aircraft Corpn (USA) and:—
Hawker Siddeley Aviation Ltd (UK) Design and construction of air conditioning heat exchangers.
Hepworth & Grandage Ltd (UK) Turbine blade machining.
High Duty Alloys Ltd (UK) Engine compressor blades, compressor disc and ring forgings.

continued on page 445

SST

The Boeing Proposal



THE FEDERAL AVIATION AGENCY'S announcement on the last day of 1966 that the Boeing Company had been selected over Lockheed to continue development of a US supersonic transport culminated more than 14 years' work by the company. The first Boeing SST design studies were made in 1952, as part of the project work which is a normal function of any forward-looking design group. At about the same time, the company was actively engaged in making design submissions for various military requirements, including WS102A (won by Convair with the B-58); WS110A (won by North American with the B-70A) and WS125A (a nuclear-engined proposal which was not pursued).

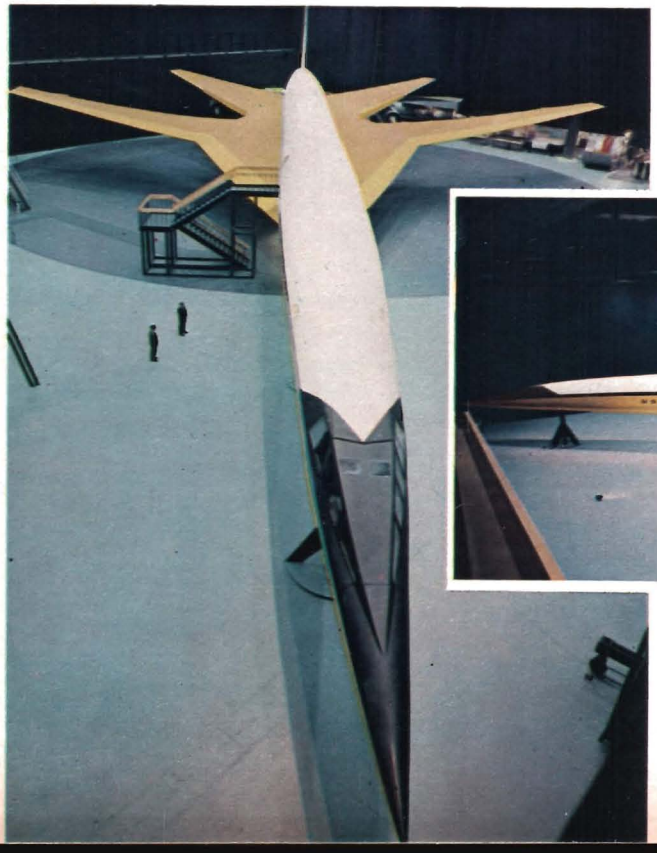
Despite the lack of success with these early military supersonic proposals, Boeing continued to study the SST, and in 1958 set up a small engineering group concerned exclusively with the problem. By 1960, the company was spending about $1m a year on SST studies and, using the Boeing Model number 733, the design group had prepared a number of alternative proposals. Delta wing forms predominated the earlier proposals but the work of another Boeing team on a design for the TFX tactical fighter (eventually eliminated by Department of Defense when the General Dynamics F-111 was selected) focused attention on the advantages of variable geometry. During 1960, a "competition" was held within the Boeing SST group between the two major configurations—delta wing and swing wing—and variable geometry came out with a clear lead. It has remained the Boeing favourite ever since, although from time to time comparative studies of alternative designs have been made to confirm what Boeing believes to be the superiority of this configuration.

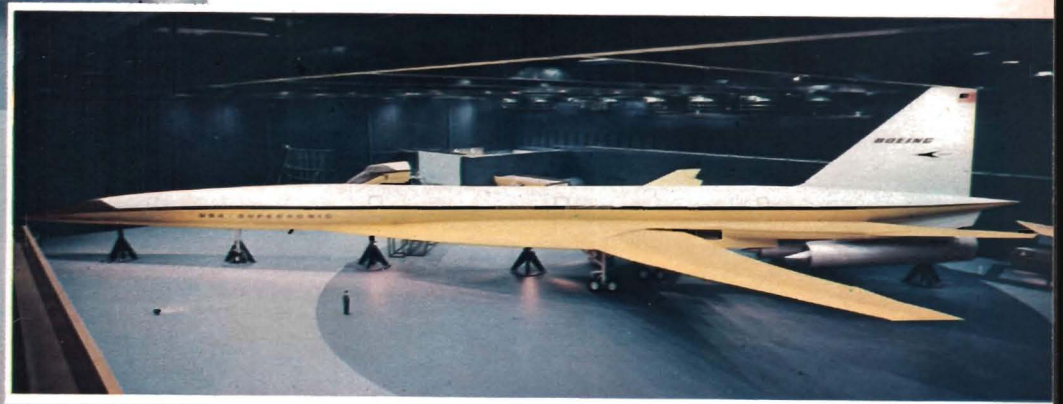
The design which formed the basis of Boeing's final submission to the FAA for competitive evaluation against Lockheed's L-2000 delta was far removed from the swing-wing studies of six years ago, and further refinement has occurred even since the submission was made last September, particularly in fuselage profile shape and cabin arrangement. The following description refers in general to the "1966 model" of the Boeing SST (neither the original design number, 733, nor the tentative Model 2707 are now being used) as represented by the magnificent full-scale mock-up in the company's Developmental Center adjacent to Boeing Field, Seattle. Some of the intermediate stages in reaching the present design are described later.

The mock-up shows an aeroplane which is 306 ft (91,8 m) long, designed for a gross weight of 675,000 lb (302 750 kg) and capable of carrying 313 passengers a distance of just over 4,000 miles (6 436 km). The wing, when fully swept back, has a leading edge angle of 72 deg and integrates with the delta tailplane, beneath which four engines are suspended in individual pods. The mock-up shows both Pratt & Whitney JTF17A and General Electric GE4/J5 pods; the latter were selected by the FAA for further development along with the Boeing SST (see pp 428-431).

The wings of the mock-up can be moved (manually) from fully aft to a forward position with 30 deg sweep on the leading edge, but one modification in the design since the submission in September provides for the wing to come forward to a 20 deg

continued on page 421





The mock-up of the Boeing SST is full-scale and complete, although not wholly representative of the configuration now planned. The view, left, shows the wings spread; compare with front cover illustration showing wings folded.

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As well as many commercial airline aircraft!

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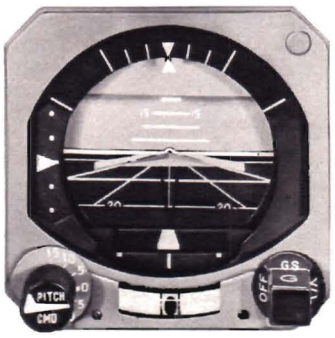

Collins FD-108 features a three-dimensional indicator which gives the pilot positive orientation throughout the entire length of the flight. The natural V-bar command indicator gives pitch and roll commands at all times—takeoff to touchdown. Because the commands for pitch and roll are presented on one indicator, the pilot can make simultaneous corrections of pitch and bank rather than making them separately. This alone is an important consideration when time is running short in the final phase of an approach.

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NEWS in brief

CIVIL AFFAIRS

BRAZIL Three more **Uirapuru** three-seat low-wing monoplanes have been ordered from the Sociedade Aerotec Ltda of Sao José dos Campos, Sao Paulo by the Ministry of Aeronautics. The contract is an "incentive order" to encourage further production of the type, the prototype of which flew in June 1965. The first of the new series is already flying.

FRANCE Government approval has been given for production of a further batch of 20 **Caravelles,** ahead of firm contracts, making a total of 260 authorized to date.

★

Under a rationalisation plan for the **aircraft industry** confirmed by the cabinet in January, Sud-Aviation assumes responsibility for Nord aircraft projects including the Nord 262 and Transall. Nord will concentrate on missiles and space work, including projects previously handled by Sud. M Maurice Papon has been appointed president of Sud-Aviation in succession to General André Puget.

★

During 1966, **export orders** for French aircraft, aero-engines, missiles and equipment had a total value of Fr 2,530 m (£183 m). This figure excludes the French share of orders for the Concorde, Atlantic, Transall and Hawk. Military business accounted for about 70 per cent of the total, and included 86 Mirage IIIs.

★

The **Fan Jet Falcon** has been certificated by the FAA for Cat II operation at suitably equipped airports. The aircraft used to obtain certification was equipped with dual Collins FD–108 flight directors, Collins AP–103F autopilot, AL–101 radio altimeter and other Collins avionics.

★

A new version of the **Wassmer Super IV** has been developed, with a 235 hp Lycoming O–540B engine, higher operating weights and other new features. Known as the Super 4/21, it will be offered in Britain by Altair Aviation at a price of about £11,500 equipped.

UNITED KINGDOM British aerospace **exports** had a record value of more than £200 m in 1966. Nearly 150 civil aircraft were among the exports, including 43 BAC One Elevens, 42 HS 125s, 8 HS 748s, 8 HS Tridents, 6 HP Heralds, 6 Beagle 206s, 5 Beagle Huskys, 2 Short Skyvans, 2 Super VC10s and 17 Westland helicopters.

★

Cunard Steam-Ship Company's 40 per cent shareholding in **British Eagle International Airlines** has been re-acquired by Mr Harold Bamberg, chairman of Eagle International Ltd, the holding company.

★

The **London School of Flying,** Elstree, has been appointed by CSE Aviation Ltd as main dealers for Piper aircraft for North London and surrounding home counties. In addition to adding to its own fleet of Piper aircraft, LSF has sold a Twin Comanche and two Cherokees within the last few months.

★

Hawker Siddeley Aviation has completed its flight development programme for Cat III **automatic landing** of the Trident, using Smiths triplex systems. Since May 1965, more than 2,000 automatic landings have been made at duplex and triplex level, with a final series of 200 landings using the standard of equipment proposed for certification. Modification of the Trident Is for Cat III operation began in February.

★

BOAC will start using the Elliott **automatic landing** equipment in its Super VC10s during the summer to build up operational experience. To date, more than 560 fully automatic landings have been made by Super VC10 G-ASGG, the development aircraft.

USA The Douglas Aircraft Company and the McDonnell Company announced on January 13th that they had agreed to proceed immediately with negotiations looking toward a merger of the two companies. The new company will be called the **McDonnell Douglas Corporation,** with headquarters in St Louis; James S McDonnell will be chairman and chief executive, Donald W Douglas Sr will be honorary chairman and David S Lewis will be president. The plan requires approval by stockholders of both companies and appropriate government agencies.

★

FAA has certificated the **Douglas DC-8 Super 61** for Cat II operation with Sperry SP–30AL autopilot, Collins radio altimeter, Douglas-Sperry flight director and supporting instrumentation. The FAA recently listed 23 airports in the US and Alaska where equipment for Cat II operations will be installed; four are already equipped and 16 of the others will be certificated during 1967.

★

Filper Research has announced plans for a turbine-powered version of its tandem-rotor helicopter. The new model, called **Beta 300,** has a 317 shp Allison 250–C19 turboshaft engine and a longer and wider fuselage to provide a full six-seat capacity. First flight is expected this year. Meanwhile, Filper is completing four more pre-production models of the Beta 200, the first prototype of which has a 210 hp Continental IO–360 engine. Three of the new Beta 200s will have 285 hp Continental IO–520 engines and the last will have a 260 hp Lycoming IO–540. Certification of the Beta 200 is expected this summer with up to 50 aircraft to be delivered by the year's end.

★

Now in flight test in California is the **Carstedt Jet Liner 600,** a stretched de Havilland Dove with two AiResearch TPE–331 turboprops and accommodation for 18 passengers. The fuselage is longer by 7 ft 3 in (2,21 m) and the aircraft has a top speed of 300 mph (482 km/h).

★

Hawaiian Airlines took delivery of its three **NAMC YS-11** transports at Honolulu on December 22, 1966. They join two DC–9s and eight Convair 640s in Hawaiian service.

★

FAA has proposed a new **Basic Pilot** licence which would require less training and

First flown on December 29, 1966, the Beechcraft Duke is a six-seat twin-engined addition to the Beech range. Powered by 380 hp turbo-supercharged Lycoming engines, the Duke has a gross weight of 6,400 lb (2 900 kg) and deliveries will begin next October.

First flown last October, the Yak-40 is Aeroflot's newest and smallest airliner. Powered by three 3,300 lb (1500 kpg) Ivchenko AI-25 turbofans, the Yak-40 seats 24 and has a cruising speed of 340-373 mph (550-600 km/h). The maximum range is 1,240 miles (2000 km). A three-view drawing and preliminary details of the Yak-40 were first published in the special Report from Moscow in FLYING REVIEW INTERNATIONAL VOL 21 No 9.

NEWS in brief..

experience than required for the Private Pilot rating. If adopted, the proposals would increase from 40 to 75 hours the time required to obtain a Private Pilot Licence but with eligibility for instrument rating at the same time. Fifty hours would be added to the 200 needed at present for a Commercial Pilot certificate, and an instrument rating would be essential. Pilots with a Basic rating could carry passengers, but could fly only in daylight with 5 miles and 1,000 ft visibility and only in certain types of aircraft with fixed undercarriage, fixed pitch propellers, no flaps and stalling speeds below 60 mph (97 km/h). More sophisticated types could be flown solo, subject to a type rating being first obtained.

★

Fairchild-Hiller and Fokker are to collaborate in production of a short-haul transport, the FH2-288, which uses parts of the F.28 Fellowship, but has a shorter fuselage. Available in 1970, the FH-288 has a gross weight of 54,500 lb (24 700 kg) and is powered by two 9,830 lb st (4 413 kgp) R-R Trent three-shaft engines. Both Fokker and Fairchild will market the 50-seat FH-228 and the 60/65-seat F.28.

★

North American has announced the **Sabreliner 40** with 6,000 lb st (2 720 kgp) Pratt & Whitney JT12A-8 engines, improved field performance, a new brake system and a third window in each side of the fuselage.

MILITARY AFFAIRS

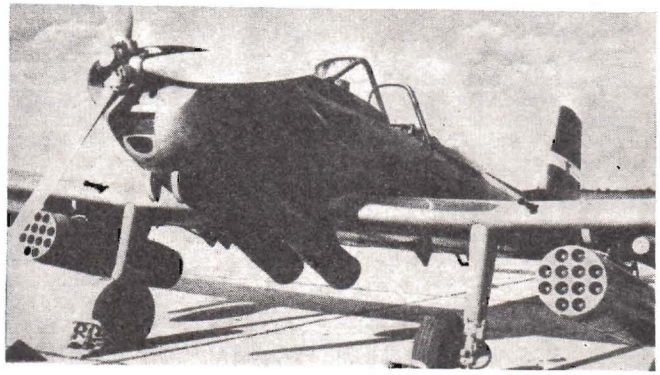
VIETNAM Although the most recent US Defense Department estimate of North Vietnamese air strength lists only 20–25 **MiG-21s** as operational, together with 40–45 **MiG-15s** and **MiG-17s** and six **Il-28s**, reliable reports have indicated substantial additional deliveries by sea to North Vietnam of new Soviet aircraft. Intelligence sources suggest that first-line operational air strength of the North Vietnamese air arm is on the verge of doubling, and with the availability of additional fighter pilots trained during 1966 in the Soviet Union and China, at least 50 MiG-21F (Fishbed-C) and all-weather MiG-21PF (Fishbed-D) interceptors are now operational. Reports indicate that a small number of **MiG-19s** is also now included in North Vietnamese air strength. Several **An-24** (Coke) transports have been delivered to North Veitnam, according to *Ogonyok*, although it is not stated if these are being used for military purposes, and a number of Mil **Mi-6** (Hook) heavy helicopters have been supplied by sea and erected in North Vietnam by a team of Soviet specialists. A North Vietnamese **An-2** (Colt) pilot is claimed to have sunk a US vessel at night by using similar tactics to those developed during World War II by Soviet pilots with light Po-2 biplanes, throttling back the engine and gliding at low altitude towards the vessel silhouetted against the moon. Several An-2s have apparently been converted from the light transport role for the more militant task.

★

The first South Vietnamese squadron of **Northrop F-5s** is scheduled to become operational this month, and it is anticipated that the VNAF will deploy a full 75-aircraft wing of F-5s by the spring of next year. Thirty-three Vietnamese pilots have been undergoing conversion training on the F-5 at Williams AFB, Arizona.

CZECHOSLOVAKIA The Czechoslovak aircraft industry is reportedly actively developing a tandem two-seat supersonic advanced trainer, the **L 39**. Expected to start its flight test programme this year, the L 39 bears a surprisingly close resemblance to the Northrop T-38A Talon in both configuration and appearance, but the wing root intakes of the US trainer are replaced by intakes in the fuselage sides aft of the instructor's cockpit.

FRANCE Avions Marcel Dassault is making intensive efforts to sell the **Mirage 5** single-seat strike and reconnaissance fighter which is reportedly already in production in its Mirage 5J form for Israel. Presentations have been made to the Danish Air Force, *Flyvevåben*, of the Mirage 5DK as a potential successor to that air arm's F-100D Super Sabres, and the Pakistan Air Force is allegedly negotiating with Avions Marcel Dassault for the supply of a quantity of Mirage 5s. The Mirage 5 is essentially a simplified derivative of the *Armée de l'Air's* Mirage IIIE.



Described in our previous issue (page 353), the SOKO Kraguj is a prototype ground attack aircraft for the Yugoslav air force. Powered by a 350 hp Lycoming IGO-540-B1A engine the Kraguj is intended to operate from very small grass fields.

★

The **Super Mirage F1** (formerly known as the Mirage IIIE2 and subsequently as the Mirage F1) is now being proposed by Avions Marcel Dassault primarily as an interceptor which could be delivered to the *Armée de l'Air* by the beginning of 1970 as a successor to the Mirage IIIC. Estimated unit cost of the Super Mirage F1 is estimated at F Fr 7.5m–8m (£543,000–£580,000), armament is envisaged as two 30-mm DEFA cannon, two Sidewinder and two MATRA R 530 (or the later R 540 or R 550) AAMs, Cyrano 30 intercept radar (evolved from the current Cyrano III) will be installed, and by comparison with the Mirage IIIC the Super Mirage F1 will carry one metric ton (2,204 lb) more fuel, resulting in almost twice the range of the earlier fighter. The prototype Super Mirage F1 exceeded Mach 2.0 during its fourth test flight from Melun-Villaroche.

★

On January 16th it was announced that agreement had been reached between the French and British governments that development of the **AFVG** (Anglo-French variable-geometry) aircraft should proceed. The AFVG is to be powered by two SNECMA/Bristol Siddeley M45G-10 turbofans rated at 7,000 lb st (3 175 kgp) and 12,000 lb st (5 445 kgp) with infinitely variable reheat, and the British version will be introduced into RAF service 1974–75, complementing the F-111K initially and eventually supplanting the F-4M Phantom in the intercept role, some 170–180 being acquired to equip ten squadrons. Appreciably smaller than the F-111K, weighing less than 50,000 lb (22 680 kg), the British version of the AFVG will nevertheless be capable of undertaking some 80 per cent of the F-111K's missions, and maximum speed will be of the order of Mach 2.4. The role of the AFVG in *Armée de l'Air* service will be that of interceptor, and deliveries will be later than those to the RAF, probably commencing 1976–77. A navalised version will also be adopted by France's *Aéronavale*, a gross weight of about 40,000 lb (18 145 kg) having been mentioned for this variant. The current development time scale for the AFVG calls for the completion of preliminary design study work and the finalising of the division of work between the French and British companies by September and the initiation of prototype construction in December with initial flight 1971–72. Estimates of development cost for the AFVG are currently of the order of £200m to be shared equally between France and Britain, unit cost excluding spares and support equipment being £1.5m–£1.7m.

★

The French Minister for the Armed Forces, M Messmer, and the UK Secretary of State for Defence, Mr Denis Healey, have approved a collaborative agreement between the two countries concerning three helicopters, the **SA 330** tactical helicopter, the **SA 340** light helicopter, and the **WG.13** utility helicopter. The finalised agreement will ensure that the two countries each receive a fair share of the development and production work in relation to their total orders for these helicopters. Sud-Aviation's SA 330 tactical helicopter is already in production for France's services, and the SA 340, the prototype of which is expected to commence flight trials at Marignane shortly, will be operational in 1970. The WG.13 is a Westland design and will have a British engine.

SWEDEN *Flygvapnet*, Sweden's air arm, is to drastically reduce its operational units, and six interceptor and two attack *Divisions* or squadrons operating 100–120 aircraft will be disbanded from May 1st, and a further four *Divisions* will be disbanded by 1970 to reduce the current strength of 46 combat *Divisions* to 34. Conversion training of pilots to fly the **J 35 Draken** interceptor has been stopped, and some 400 flying trainees will not now complete their training. The reductions in

strength follow a re-alignment of defences in which emphasis has been transferred from interceptors to ground forces and their aviation support.

AUSTRALIA The first of ten **HS 748** transports ordered by the RAAF was delivered in January with the second following in February. These were the two VIP transport models, the remaining eight HS 748s for the RAAF being navigational trainers.

★

The RAAF's No 2 Squadron equipped with eight **Canberra B 20s** has been transferred from Butterworth, Malaya, to South Vietnam to strengthen the RAAF task force in that country. In addition to No 2 Squadron, the RAAF has seven **Caribou** transports of No 35 Squadron, eight Iroquois helicopters of No 9 Squadron, and six Sioux helicopters and three **Cessna 180** observation aircraft of No 161 Independent Reconnaissance Flight (Australian Aviation Regiment) in Vietnam. No 2 Squadron's replacement at Butterworth is to be a **Mirage IIIO** squadron.

BELGIUM Indecision on the part of the Belgian government concerning the purchase of the **Northrop F-5** has prevented the go-ahead of plans for the licence manufacture of the strike fighter and its trainer variant in Belgium and the Netherlands with final assembly by Fokker, and the Netherlands government, which has already announced its intention to acquire the Northrop aircraft, has concluded with Canadair an agreement to buy Northrop F–5s from the Canadian production line at Montreal. A mission from the US headed by Henry J Cuss visited Belgium and the Netherlands in January with the primary purpose of finalising the problem of where the European F–5s would be built. Another issue discussed was the rising cost of the proposed Belgian-Dutch aircraft, the price of the 221 aircraft involved reportedly having risen by $13.8m (£5m) over the $200m (£71.9m) estimate of a year ago. (See *Military Contracts* column below).

USA Lockheed is continuing the flight testing of the prototype **F-104S Starfighter** first flown on December 1st.

★

Sikorsky has proposed to the USAF a flying crane helicopter with a gross weight of 300,000 lb (136 080 kg) and possessing a

CONTRACTS

MILITARY

The Royal Norwegian Air Force, *Luftforsvaret*, has placed an order with de Havilland Aircraft of Canada for four Twin Otters, two being scheduled for delivery in July and the remaining two in September.

On January 9th the Brazilian government announced the placing of an order with the Cessna Aircraft Company for 40 T-37C basic trainers, the contract, including spares and ground handling equipment, being valued at approximately $10m (£3.6m).

The Malaysian government has placed a contract with Sikorsky for 10 Sikorsky S–61A–4 (essentially the CH–3B without rear loading door) for troop transportation and the logistics support of Malaysian forces.

On January 23rd the Cessna Aircraft Company received a $3.6m (£1.3m) letter contract for the manufacture of an undisclosed number of A-37B light attack aircraft (formerly known as AT-37D). The contract, awarded by the USAF Aeronautical Systems Division, is expected to have a total value exceeding $7m (£2.518m), and is the first for the manufacture of the attack version of the T-37, a previous contract placed on August 22nd calling for the modification to A-37B standards of 39 T-37Bs already in production. A $3.5m (£1.26m) contract was placed with Cessna in January for 39 T-37Bs to replace those converted to A-37Bs.

The Japanese Defence Agency has placed an order with Kawasaki for two KV–107–II-5 helicopters for rescue tasks with the JASDF. The contract, valued at Yen 1,332m, calls for delivery of the two helicopters between September and January of next year.

The Royal Netherlands Air Force has contracted to buy from Canadair Ltd, 70 Northrop F-5As and 35 F-5Bs. The former will include a quantity of RF-5As, which will replace RF-104Gs in service with reconnaissance units.

The LTV Aerospace Corporation received a $36.5m (£13.129m) contract from the US Navy for production of the A–7B version of the Corsair II, following a $32m (£11.6m) contract for the A–7B placed in November and bringing the total of contracted funds for the US Navy Corsair II programme since March 1964 to approximately $340.75m (£122.53m). A further US Navy contract for the two-seat A–7C trainer variant of the Corsair II is reportedly imminent.

LTV Aerospace Corporation has received an initial $4m (£1.44m) contract from the US Navy for the modernization and remanufacture of 150 F-8A, -8B and -8C Crusaders. The contract is an extension of a similar one for work on 225 F-8D and -8E Crusaders which, in remanufactured form, are designated F-8H and -8J. The contract provides for the provision of new wings and the installation of hard-harness wiring.

In January the McDonnell Aircraft Corporation was awarded a $134.6m (£48.41m) contract by the US Navy for the continued development and production of the F–4E Phantom II.

CIVIL

Irish International (Aer Lingus) has ordered two Boeing 747s, making a total of 90 on order.

One additional Boeing 707-320C has been ordered by Air India.

Avianca has placed orders with Boeing for two 737–100s, two 727–100s and a 707–320B.

Canadian operator Nordair has ordered a Boeing 737-200C and two plain 737-200s.

Japan Air Lines recently ordered two additional Boeing 727s.

France's Aeropostale de Nuit night mail service is expected shortly to confirm an order for 12 Fokker F.27s which will replace 15 DC-3s in use at present. The Aeropostale services, now operated by Air France with outstanding regularity, are probably to become an independent operation. The deal to buy F.27s is linked with recent additional orders from the Netherlands Government for Alouette IIIs.

Faroe Airways became the 99th customer for F.27s at the end of 1966 when it ordered one Mk 200 with cargo door.

East-West Airlines of New South Wales has ordered its fifth Fokker F.27 for delivery next November.

Airlift International has ordered two Douglas DC–8 Super 63s and has taken an option on a US SST delivery position.

Falcks Flyvetjeneste has purchased an HS 748 (the Series 2 demonstrator) for use on local routes operated on behalf of SAS.

Two DHC Twin Otters have been ordered by NASA Commuter Airlines, established in Houston, Texas, to serve communities around the NASA facilities in the area. Orders for the Twin Otter now total 60.

Island Airlines of Port Clinton recently added a third Ford Trimotor to its fleet, which also includes a Boeing 247D, five Cessnas and a Mooney. The airline flies scheduled services from Port Clinton to four islands in Lake Erie.

Beechcraft Queen Airliners have been ordered by two new third-level carriers in the US—Hub Airlines at Baer Field in Fort Wayne and Altair Airlines based at Philadelphia International Airport. More than 30 Queen Airliners have been ordered for feeder-line operation.

Japan Air Lines has ordered seven Beech Super H18s to serve at a new Pilot Training Institute opening in April at Sendai in Northern Honshu.

Two Beech C55 Barons have been ordered for the Republic of South Korea's National Police Force.

Orders for the Dassault Fan Jet Falcon totalled 151 at the end of 1966, of which 70 had been delivered.

Pacific Southwest Airlines has ordered two Brantly 305s and a B2B to provide a helicopter charter service in the San Diego area.

Italian operator ATI has ordered two more Fokker F.27s.

An order for two DC–8 Super 63s has been placed by VIASA.

Delta Air Lines has ordered six more DC–9s of unspecified "stretched" type.

NEWS in brief.. NEWS in brief..

150,000 lb (68 040 kg) payload capacity to serve as an unloader for the Lockheed C-5A transport. The 180 ft (54,86 m) rotor would be driven by four 20,000 shp turboshaft versions of the Pratt & Whitney J52. If proceeded with, the Sikorsky flying crane helicopter will be more than twice as heavy as the new giant Mil helicopter which is currently being readied for testing in the Soviet Union, and will be more than four times as powerful, the new Mil having some 17,500–18,500 shp available from its three Soloviev turboshafts.

★

The USAF has diverted $200m (£71.94m) from **F-111A** production funds for Vietnam war procurement, production during 1967 being reduced from 48 to 24, although this is not expected to affect the eventual total quantity of F-111As to be acquired by the USAF. Ground testing of a 20-mm General Electric Vulcan cannon in the fifth F-111A began in January. The cannon installation in the lower starboard side of the weapons bay is designed as a kit which may be readily removed and re-installed.

★

US combat losses in North and South Vietnam during 1966 totalled 854 aircraft, 459 fixed-wing aircraft and four helicopters being lost over North Vietnam and 140 fixed-wing aircraft and 251 helicopters being lost over South Vietnam. Approximately 55 per cent of the losses were sustained by the USAF and the remainder by the USN and US Marine Corps. Losses over North Vietnam included ten known to have been destroyed by MiG fighters and 20 by SAMs. One effect of the USAF losses has been a delay in the re-equipment of Air National Guard **F-86H Sabre** and **F-89J Scorpion** squadrons.

BRAZIL Approximately 30 **Neiva U-42 Regente** liaison monoplanes have now been delivered to the *Fôrça Aérea Brasileira* by the Sociedade Construtôra Aeronáutica Neiva, and production is continuing at a rate of four aircraft per month to meet FAB orders for 60 aircraft. An AOP version of the Regente is currently being built as a private venture by Neiva.

★

Despite the intensive demonstration of the Magister jet trainer in Brazil during 1966, and unofficial reports that the FAB was to purchase substantial quantities of surplus *Luftwaffe* trainers of this type, the FAB has selected the **Cessna T-37C** to replace its ageing Gloster Meteor T.7s (see *Military Contracts*).

INDIA The Indian Minister of Defence Production recently stated that work on the turbojet factory at Koraput had not progressed according to expectations, but that the first locally-assembled engines for licence-built **MiG-21PF** fighters would be tested and delivered by May of next year. Hindustan Aeronautics announced in January that the first MiG-21PF airframes assembled in India (and powered by turbojets imported from the Soviet Union) are now being delivered to the IAF from the Nasik plant. The IAF reportedly has four MiG-21F and -21PF squadrons obtained directly from the Soviet Union.

CANADA As a further step towards the total integration of the RCAF, the RCN and the Army into a single Service, preparations have now been made for the flying training of personnel from all three services on a fully integrated basis. Initial training is being standardised on the Canadair Tutor, and trainees showing a particular aptitude for jet flying will be selected for CF-104 Starfighters irrespective of their parent service. As the first integrated service unit and the largest among the Canadian forces, Mobile Command will include four squadrons of Canadair-built CF-5s plus Buffalo transports and Boeing-Vertol 107 helicopters in its tactical Air Regiment.

CORRECTION

In the table of airline pilot data on page 358 of our previous issue, part of two lines of type, referring to BOAC and British Eagle, were transposed in the course of going to press. The information in all columns from "Pilots, total summer 1966" onwards was reversed for these two airlines as a result.

On page 367 of the same issue, Airwork Services Training is said to have started Ministry approved courses in 1965; the latter date should have read 1955, as was clear from the context of the reference.

PROPULSION AND POWER PLANTS

UNITED KINGDOM Rolls-Royce recently delivered its 5,000th **Dart** turboprop, just over 20 years since the Dart R.Da.1 ran in 1946. Total sales of Darts have amounted to some £100m ($279m), of which more than 70 per cent have been to overseas operators. Total foreign revenue earned by the end of 1966, including spare parts, exceeded £117m ($326m). More than 1,300 Dart-powered civil aircraft are in service or on order with 115 airlines and more than 190 other operators in 57 countries. Total Dart flying time exceeds 38 million hours, a figure considerably in excess of that of any other civil turbine.

★

Bristol Siddeley is offering a new 800 shp (811 cv) free-turbine turboshaft, the **BS360**, for the Westland WG.13 utility helicopter project. The BS360 is also proposed by BSE for British purchases of the Sud Aviation SA.340 LOH which at present is powered by the 530 shp (537 cv) Turboméca Astazou 11 single-shaft turboshaft.

FRANCE **SNECMA** will have prime design and development responsibility for the **SNECMA/Bristol Siddeley M45G** turbofan following the recent Franco-British governmental go-ahead on the VG project. The engine has undergone a series of design revisions by the two companies in the course of the past two years. The current version is understood to be the M45G-10 of 7,000 lb thrust (3 175 kgp), rising with afterburning to 12,000 lb (5 443 kgp). By-pass ratio is around 3:1 and pressure ratio about 24:1. SNECMA reports that the M45A civil turbojet, which first ran at the end of last year, has now attained a maximum rated thrust of 2 000 kgp (4,409 lb).

★

USA The FAA has authorized a 9,500-hr TBO for **Pratt & Whitney JT3D** turbofans operated by American Airlines. Although described by P&W as the highest TBO of any aero engine, the JT3D's figure is exceeded by that of the Rolls-Royce Conway R.Co.12 turbofans of Canadian Pacific Airlines. These are authorized by the Canadian Department of Transport for a TBO of 10,000 hours.

★

Lycoming has been awarded an $80,194 (£28,800) feasibility study contract by the Ballistic Research Laboratories, Maryland, on the design and production of a new family of 350 to 400 shp (355–405 cv) turboshafts that would be invulnerable to small arms fire. The contract, which is in three phases, covers the collecting of background data on the penetration characteristics of engine and lightweight armour materials, the integration of low vulnerability forms of component into one engine design, and a final design presentation combining the results of the first two phases. The resulting concept will then be compared with designs of engines at present envisaged for the period 1968–72.

★

Lockheed and Douglas airbus-cum-cargo transport **engine requirements** are emerging as turbofans of three widely differing thrust categories, namely 30,000 lb (13 608 kgp), 44,000 lb (19 958 kgp) and 50,000 lb (22 680 kgp). Rolls-Royce is making proposals covering the first and third sizes, the latter being the tri-spool RB.207, Pratt & Whitney has effectively annexed the 42,000 lb to 47,000 lb (19 051–21 319 kgp) sector with its JT9D which has just made its first run, and General Electric is still withholding its CTF39 proposals for this requirement. If either the 30,000 lb (13 608 kgp) or 50,000 lb (22 680 kgp) categories can be linked with the engine needs of the latest UK/French/German airbus studies, Rolls-Royce may well get its tri-spool concept launched in the advanced technology transport market.

★

The 14,500 lb (6 577 kgp) **Pratt & Whitney JT8D-9** has been chosen to power the NAMC C-X STOL tactical transport project in its two, rather than four, engine configuration. The P&W unit thus wins out over the R-R Trent and General Electric TF79, an aft fan version of the J79 turbojet.

★

Allison has been awarded a $1.44m (£0.52m) USN contract for the initial design phase of the company's new **TF32** high BPR turbofan for the Navy's VSX carrier-based anti-submarine aircraft project (see this column last month). Allison describes the engine as combining a high thrust/weight ratio with minimum size and low fuel consumption to enable the VSX to reach its search area quickly and remain on station for long periods. A very high pressure ratio is used and an emergency rating will be available which will ensure take-off performance under emergency conditions. Allison states that the TF32 will embody advanced components based on an intensive company development effort on lightweight engine structures and high performance compressors and turbines. British sources indicate that the engine has a single stage fan and a 24:1 pressure ratio.

continued from page 415

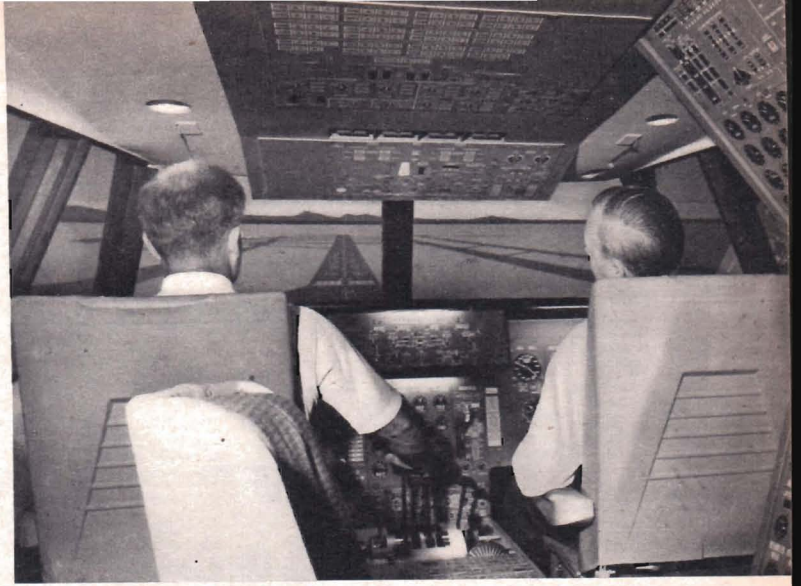
angle for better take-off and landing performance. This makes the maximum span 180 ft 4 in (54,97 m) compared with the earlier figure of 174 ft 3 in (53,11 m). Another improvement not reflected in the mock-up is to increase the width of the cabin by 12 in (0,305 m) at its widest point just ahead of the wing root, and to taper it more finely to the tail. The effect of this is to increase the pronounced area-ruled appearance of the fuselage, which now has no length of constant cross section. In the wider cabin (16 ft 8 in—5,08 m at its maximum) Boeing propose a two-aisle arrangement with pairs of seats adjacent to the cabin walls each side, and a triple unit between the aisles, making seven abreast in all. Further aft, in the narrower cabin section, the seats would be five abreast, three and two separated by a single aisle, while a forward cabin would seat passengers four abreast in paired first-class seats with a central aisle.

The twin-aisle, seven-abreast cabin was proposed as a last-minute alternative in the September submission but is now regarded as the basic aircraft, partly because the aerodynamics of the wider fuselage are favourable and partly because the airlines responded enthusiastically to the layout proposals. There is, however, virtually no change in normal capacity: for example, the mock-up is furnished with 277 seats (30 first class, 247 tourist) in the original narrow fuselage while the twin aisle version has 280 seats (28 first class, 252 tourist).

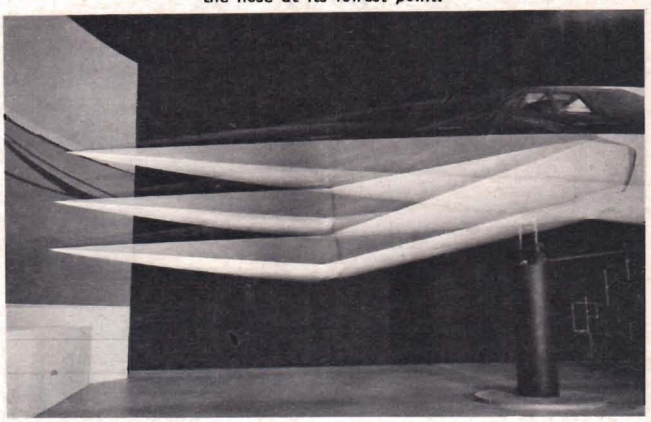
The term "narrow fuselage" in the previous sentence is used in a strictly comparative sense, for even the 15 ft 8 in (4,78 m) of the first proposal is some 4 ft (1,22 m) greater than any subsonic jet transport in service to-day—a fact which quickly impresses visitors upon entering the mock-up. The layout and decor are, of course, no more than Boeing proposals at this stage, but many of the airline customers are likely to be influenced by some of the ideas which have been incorporated. To break up the inevitable tube-effect of the long fuselage, the cabin ceiling has large lighting alcoves, and two galley/toilet areas also help to interrupt the cabin length. Wardrobe racks, galley tray containers and bar units are all mounted on dolleys so that they can be removed from their stowed positions and wheeled up and down the aisles. Overhead luggage racks include restrainers which would allow them to be used for small packages, typewriters, vanity cases, etc, of the kind which passengers must keep under their feet in most current transports.

In-flight entertainment has come to stay, whatever the views of some airlines on the subject at the present time, and Boeing have mocked-up two possible schemes—retractable TV screens in the luggage racks at every sixth seat row, or small permanent screens in consoles between the paired first class seats. The windows

A view in the mock-up showing the overhead luggage racks with restrainers, and fold-down TV sets. Lighted panels around the windows help to break up the fuselage lines.



A mock-up of the nose of the Boeing SST, separate from the full aircraft mock-up, shows the double hinge arrangement which improves the forward view during the approach, as indicated above. In the triple-exposure picture below, the lower screen, extreme left, indicates the height above ground of the nose at its lowest point.



have an outside diameter of only 6 in (15,2 m)—there won't be a great deal to see during most of a supersonic flight—but the inside panes have a diameter of 12 in (30,5 mm), creating an illusion of greater size. In place of sun blinds, Boeing propose an inner pane of polarized glass, which can be rotated to act as a light filter. The seats themselves in the mock-up include the intriguing "concept" seats by Boeing, adjustable, it is claimed, to fit comfortably "a 4 ft 10 in (1,5 m) woman or a 6 ft 7 in (2,0 m) man." In addition to underfloor holds, there is a large baggage compartment to the rear of the passenger cabin.

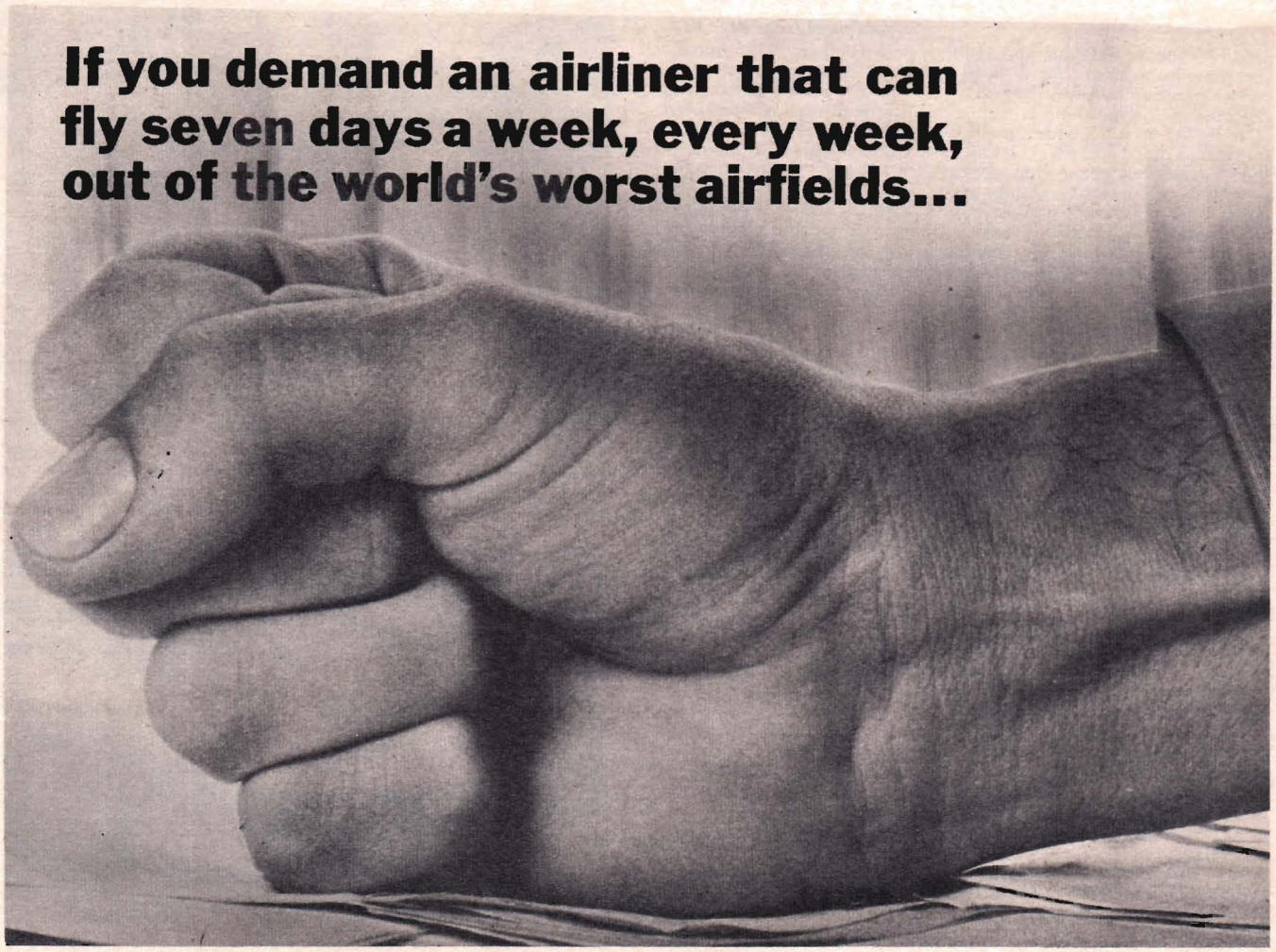
DESIGN EVOLUTION

When Boeing conducted its own "in-house" competition for alternative SST configurations in 1960, it was looking in general terms at a 150-seater capable of flying non-stop between the capitals of Western Europe and cities on the Eastern US seaboard. The projects then were in the 400,000 lb (181 437 kg) weight bracket with operating costs about 115 per cent those of the Boeing 707 then in service. Since that time, there has been a constant evolution and refinement of the designs, coupled with increases in weight and size to obtain better payload-range performance and seat-mile costs. In the process, more than 500 alternative lay-outs have been studied.

The SST programme was officially inaugurated on June 5, 1963, when President Kennedy indicated in a public speech that such a programme had been authorized. In August the same year, the Federal Aviation Agency issued a Request for Proposals (RFP) for a Mach 2.7 SST to three airframe and three engine manufacturers (Boeing, Lockheed, North American, Curtiss Wright, General Electric, Pratt & Whitney). Representing Phase I of the programme, these designs were submitted for FAA evaluation on January 15, 1964, the Boeing proposal at this time being the Model 733-197—alone among the trio of designs in its use of variable geometry.

The 733-197 has a span varying from 173 ft (52,6 m) open to 86 ft (26,2 m) fully swept and a gross weight of 430,000 lb (194 790 kg) for a range of 4,030 miles (6 448 km). Engines were located in four individual pods under the wing centre section

If you demand an airliner that can fly seven days a week, every week, out of the world's worst airfields...



you have to come to Hawker Siddeley.

One of the hardest economic facts of an airline operation is that no airliner earns money while it is being maintained. By designing for progressive maintenance Hawker Siddeley help to cut out this dead time with the HS 748. Briefly this means the aircraft need never be taken out of daily service: maintenance can take place overnight and overhaul costs are reduced. Add to this the ability to use unsurfaced airstrips, complete passenger/freight flexibility, fail-safe construction, a rugged design and you have the ideal DC3 replacement. Sales successes throughout the world, especially in Latin America, demonstrate that the 748 is the No. 1 choice for feeder services.

The HS 748 is only one example of Hawker Siddeley's forward thinking. Other aircraft with the prefix HS include the Trident jetliner (world leader in automatic landing development); the R.A.F.'s HS 801 jet maritime reconnaissance aircraft, the low-level Buccaneer which flies underneath radar defence systems; the very successful HS 125 business jet and the Dominie navigation trainer; the Andover, military sister to the HS 748. Hawker Siddeley have developed Blue Streak launcher for European use; are building E.S.R.O. 2, the first co-operative European satellite, and are supplying the air conditioning for the Concorde. International agreements play a vital part in Hawker Siddeley plans. More than thirty such world-wide links have been established by Hawker Siddeley Dynamics alone, going back over a period of thirty years—about half of them within Europe.

But although Hawker Siddeley has the largest aerospace interests in Western Europe, half the group's sales come from industrial products. Hawker Siddeley's diesel engines and electrical equipment for power generation and distribution are exported to one hundred countries in five continents. Navigational systems, agricultural and road building equipment, road vehicles, and general engineering are also among Hawker Siddeley's industrial interests.

As any engineer knows, there's nothing like a broad base for stability.

HAWKER SIDDELEY 32 Duke Street, St. James's, London, S.W.1, England

Hawker Siddeley Group supplies mechanical, electrical and aerospace capital equipment with world-wide sales and service.

and the primary structural material was titanium. Accommodation could be provided for a maximum of 227 passengers.

FAA evaluation of this and the competing designs established feasibility of the SST, and Phase IIA was initiated on June 1, 1964, for further studies of the proposals by Boeing, Lockheed, GE and P&W. These studies were submitted to FAA on November 1, 1964, the Boeing proposal now being 733-290. In configuration, it was similar to 733-197; but it had grown in size, to a gross weight of 500,000 lb (227 000 kg) and a span of 169 ft 3 in (51,6 m) spread and 95 ft 5 in (30 m) swept. This model would seat 250 and a lighter, transcontinental version was also proposed for domestic US operations.

Phase IIB of the programme, involving more complete studies and testing began January 1, 1965 and continued to July 1st. On the latter date, Phase IIC was announced, allowing the four companies 15 months (until September 6, 1966) to make final submissions of the design they would propose for construction in Phase III, which was to begin on January 1, 1967. In the course of Phase IIB, Boeing undertook a major re-design of the Model 733 to overcome aerodynamic problems and further enlarged the size of the project. Model 733-390 emerged as an aircraft with an integrated wing/tailplane; the outer panels of the wing, hinged as before to swing through 42 deg of arc, now combined with the tailplane, when fully swept, to produce a delta planform for supersonic cruising. At the same time, the engines were relocated beneath the tailplane. The gross weight increased to 600,000 lb (272 160 kg) and the span was now 177 ft 6 in (54,1 m) spread and 107 ft 0 in (32,61 m) swept. Another new feature was the quadruped main landing gear, comprising four separate four-wheel bogies to spread the aircraft weight. Up to 300 passengers could be carried.

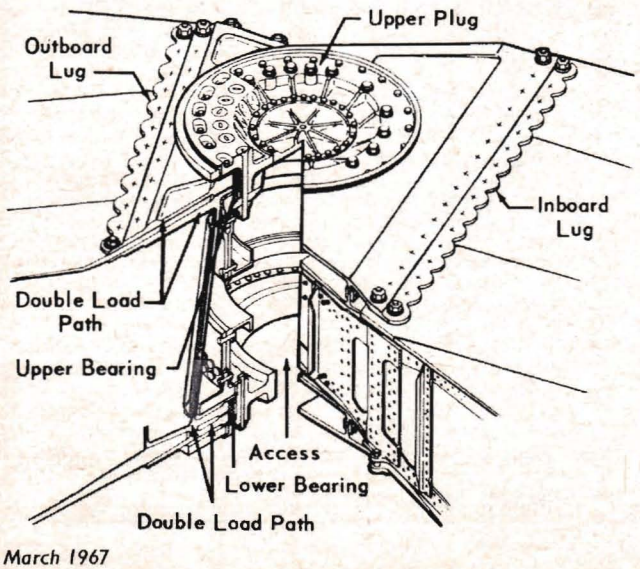
In the final Phase IIC submission to the FAA in September 1966, the Boeing SST was still larger, with the weight up to 675,000 lb (302,750 kg), overall length up from 298 ft (90,83 m) to 306 ft (93,27 m) and maximum accommodation up to 350 passengers. The mock-up had been built in the course of Phase IIC development and was publicly revealed during September, when news of the alternative wide-fuselage version was also first given.

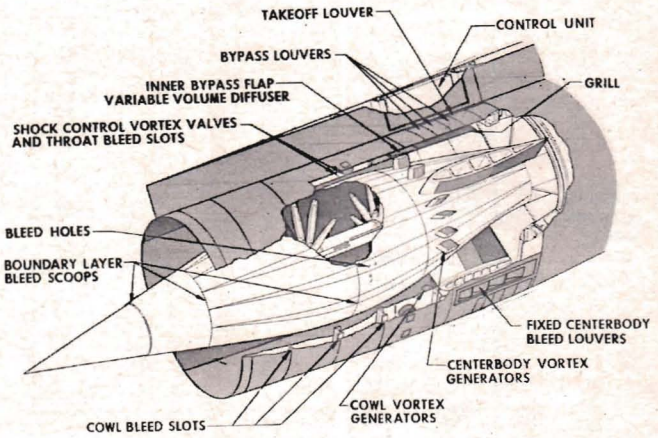
THE AIRFRAME DESCRIBED

The integrated wing/tailplane layout was adopted by Boeing for a combination of reasons. It positions the engines further away from the hazard of ground ingestion of foreign objects, and eliminates the possible sound and heat effects of jet wake upon the tailplane. A large structural advantage is claimed by Boeing, and landing gear loads can be carried without adding to the structure weight. More fuel can be carried in the wing centre section, which no longer has to accommodate engine support structure, and pivot hinge loads are reduced by placing the bearing surfaces further apart.

The wing pivots, which play such a vital part in the Boeing SST concept, were evolved from earlier work at NASA, and are remarkably simple in design. Located between the upper and lower skin surfaces, each pivot comprises an upper and lower bearing carried in double load-bearing members. Trial pivots

The wing pivot design provides structural and operational redundancy. Simple, double load-carrying features are used at both upper and lower surfaces.





The Boeing-designed engine air inlet, with variable diameter shock body.

have already completed many thousands of operations under representative conditions of heat and load. Basic material for the SST structure is a titanium alloy incorporating 6 per cent aluminium and 4 per cent vanadium.

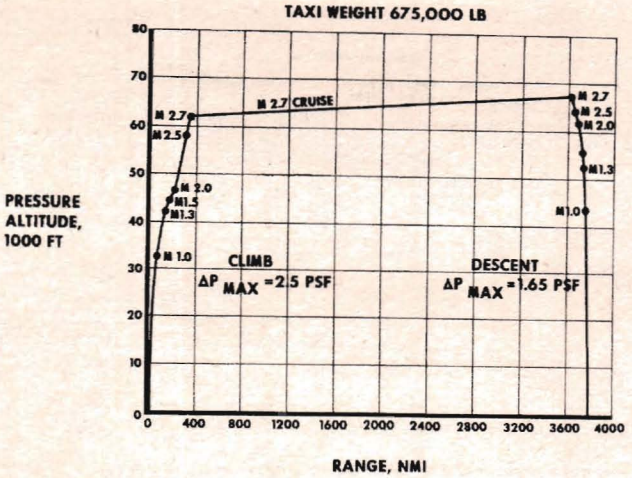
Boeing development of high-lift devices for the Model 707/727/737 family has been taken a stage further for the SST, which has three basic operating configurations—low speed, subsonic cruise and supersonic cruise. In low-speed configuration (ie, take-off, approach and landing) the wings are fully forward; leading edge slats cover the entire span (including the fixed inner portions) and double-slotted trailing edge flaps are provided on the moving portion inboard of conventional low-speed ailerons. There are, in addition, triple slotted flaps in the fixed wing portion just aft of the trailing edge of the moving wing panel and these serve to direct air into the engine intakes at low speed, as well as making a contribution to high lift. Spoilers ahead of the trailing edge flaps contribute to the roll control, and are also used for positive lift control during the approach, when they are set at a 3-deg datum and then operate in conjunction with normal elevator movement to increase or decrease lift.

For subsonic cruise, the wings are set at 42 deg (measured on the leading edge). Trailing edge flaps are partially extended in this configuration for optimum L/D characteristics. When the wings are fully swept, roll control is by means of elevons on the tailplane, which also incorporates primary and auxiliary elevators for use at slower speeds. A conventional rudder is provided.

Actuation of the wing leading edge and trailing edge flaps is mechanically sequenced with wing sweep actuation to prevent the wings passing 42 deg with the flaps extended. The wing sweep actuation system consists of a hydraulically powered central gear box driving dual torque tubes to identical ball-screw actuators attached to each movable wing, thus providing dual load and drive paths, and positive synchronization of the two moving sections. Power to swing the wings is provided by three hydraulic motors, supplied by three independent hydraulic systems and so interconnected that any one motor will provide full torque output at one-third the normal speed. With all three motors operating the wings are swept back in one minute, and forwards in two minutes. An asymmetric detection and shut-off system stops the wing-sweep actuation system if the two wing positions differ beyond a prescribed amount, and there is an automatic shut-off system to ensure that asymmetric wing motion does not result from any failure in the sweep mechanism.

Although the variable sweep configuration allows the Boeing SST to approach and land at comparatively small angles of attack (compared with a delta wing layout), a hinged nose is incorporated to improve the forward view, and to provide for the highly improbable case of a landing with wings fully aft. After considerable investigation, a double jointed nose has been adopted, the forward section remaining at a constant angle as the inner section hinges down. This keeps aerials and weather radar properly aligned and also keeps the extreme nose from rubbing the ground: minimum clearance is 4 ft (1,22 m). The inner section incorporates windows which permit a wide field of vision when the nose is raised for supersonic flight.

Basic layout on the flight deck is for two pilots and a systems engineer, plus two supernumerary seats. The pilots sit 175 ft (53,34 m) ahead of the main landing gear and 14 ft (4,27 m) above the ground: to help achieve a smooth landing, Boeing proposes a closed circuit TV system with the camera in the front of the ventral fin focused to give the pilots a view of the main gear.



A typical Boeing SST mission profile, showing overpressures of 2.5 lb/sq ft and 1.65 lb/sq ft respectively in the climb and descent.

Tests on such a system have been conducted with a Boeing 707.

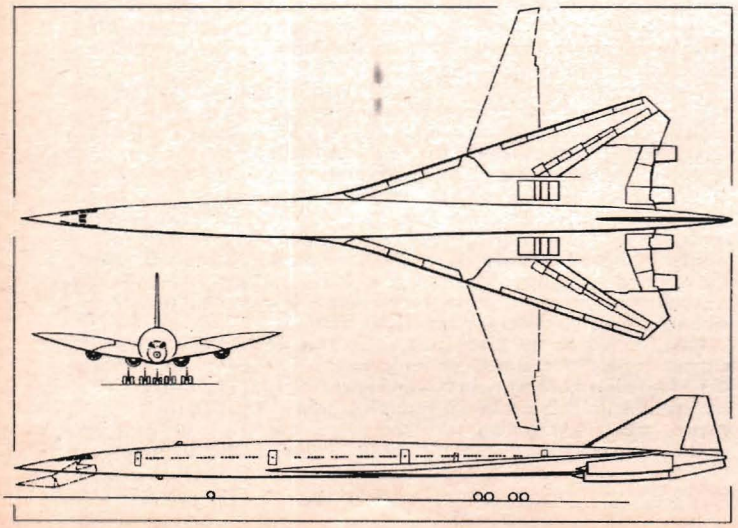
Design of the variable-geometry inlet for the Boeing SST is a highly ingenious one and incorporates a central shock body which can expand and contract to vary the area of the throat around it. This is achieved by constructing the shock-body from a number of overlapping titanium segments, divided into three portions from front to rear; sliding actuators inside the body increase or decrease the diameter at the centre, without altering the overall length of the component.

AIRCRAFT SYSTEMS

Power to drive the electrical, hydraulic, cabin air pressure and engine starting systems is provided by four accessory drive systems (ADS) each normally driven by a shaft from one of the aircraft's engines. Each ADS comprises a gear box and its drive shaft and controllable disconnect coupling, and a continuous-duty air-turbine starter. The air-turbine starter provides power to drive the engine through the ADS gear box for starting; drive the inboard ADS gear boxes for ground check-out of the electric and hydraulic systems; and drive the ADS gear box in flight to power the electric and hydraulic systems in the event of a decouple of the ADS from an operating engine.

There are three independent 3,000 psi (210,9 kg/cm²) primary hydraulic systems, plus a standby for aft main gear steering, brake operation and landing gear extension. A small electrically driven hydraulic pump system provides a third and final power source for landing gear extension and to steer the aft gear during towing. All three primary systems power the flight controls in all axes, the wing sweep and wing outboard trailing edge flaps; any one system provides sufficient power to control the aircraft. Two systems provide power for the high lift devices including inboard trailing edge flaps, and one primary system plus the standby operate landing gear extension and retraction, braking and nose-wheel steering.

This general arrangement drawing shows the latest Boeing SST configuration, with wings at 20 deg sweep for take-off, wide fuselage for twin-aisle seven abreast seating, GE4/J5 engines and other new features.



Ram air from the supersonic inlet of each propulsion pod provides the primary source of air for cabin conditioning and pressurization. It is compressed by air compressors driven by the ADS and passes to the cabin through air/air regenerative and air/fuel heat exchangers and air cycle machines. To cool the cabin walls the cabin air is exhausted through an intrawall system, by way of a collector duct beneath the floor. Cabin pressurization is at a maximum differential of 11.12 psi (0,782 kg/cm²) giving a 6,000 ft (1 830 m) cabin equivalent at 70,000 ft (21 330 m).

The electric power system consists of four channels of 60 kva, 115/200-volt, 400-cycle 3-phase power; a 28-volt DC system powered by six 70-amp transformer/rectifiers and a battery system for standby power. All electronic components required to adapt electronic systems to the aircraft are installed in racks just aft of the flight deck and aft of the passenger cabin in the pressurized section.

Fuel is carried in four main and four auxiliary tanks with a total capacity of 45,620 Imp gal (207 384 l). Tanks are located in the moving wing portions, the tailplane, the wing centre section and the fuselage aft of the pressure bulkhead. Typical average fuel consumption during supersonic cruise is 25,000 lb (11 340 kg) per engine per hour.

PRODUCTION PROGRAMME

Production of the Boeing SST, assuming it goes ahead into the hardware stage, will be shared by many companies, with final assembly probably taking place at one of the existing Boeing facilities in the Seattle area. To date, six major companies have been named as major subcontractors for portions of the wing, fuselage and tail structure. They are Avco Corporation (Aerostructures Division), Republic Aviation Division of Fairchild Hiller, LTV Aerospace Corporation, The Martin Company, North American Aviation and Norair Division of Northrop. Eventually, Boeing expect to subcontract 69 per cent of the aircraft, by weight.

At the time of the submission to the FAA, Boeing indicated that if design and fabrication of prototypes began early in 1967, the first flight could be made in the first half of 1970. With design and fabrication of production aircraft starting early in 1969, flight testing could begin before the end of 1972 allowing about 18 months for certification and introduction into airline service in mid 1974. The effect on this schedule of the delay in placing a hardware contract is uncertain, but for a few months at least, Boeing can proceed with design and test work on the continuing FAA contracts without seriously diverging from this time-table.

Current Boeing market estimates indicates a five-fold increase in air travel in the next 15 years and a ten-fold increase by 1990. By 1980, it is estimated that there will be a market for 390-475 large SSTs. By 1990, and assuming that SSTs generate only 20 per cent of the predicted revenue passenger-miles, about 700 will be required. More optimistic assumptions put the market as high as 1,000 aircraft.

On a 2,000-mile (3.220 km) international flight, the Boeing SST has an estimated direct operating cost of one cent per

continued on page 434

BOEING SST SPECIFICATION

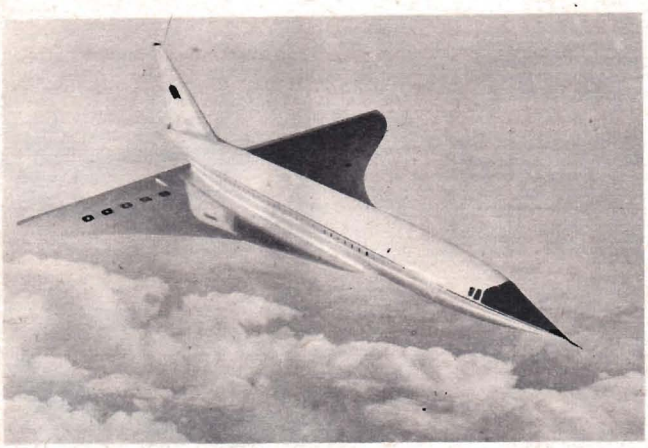
DIMENSIONS: Span (spread), 180 ft 4 in (54,97 m); swept, 105 ft 9 in (32,23 m); overall length, 306 ft 0 in (93,27 m); overall height, 46 ft 3 in (14,10 m); undercarriage track, inner oleo centres, 10 ft 6 in (3,20 m), outer oleo centres, 24 ft 8 in (7,52 m); wheelbase, 117 ft 11 in (35,94 m) (nosewheel to front oleo); minimum ground clearance, nose lowered, 4 ft 0 in (1,22 m), nose raised, 8 ft 9 in (2,67 m); door sill height, forward door 13 ft 4 in (4,06 m); centre door 14 ft 5 in (4,40 m); fuselage max width (external) 16 ft 8 in (5,08 m), max depth (external) 15 ft 7 in (4,75 m); gross wing area, 9,000 sq ft (836,13 m²).

WEIGHTS (International model): Max ramp weight, 675,000 lb (306 175 kg); operating weight empty, 287,500 lb (130 308 kg); max landing weight, 430,000 lb (195 045 kg); fuel capacity, 367,100 lb (166 513 kg); max payload, 75,000 lb (34 020 kg).

PERFORMANCE: Take-off field length required, 5,700 ft (1 870 m); normal cruising speed, Mach 2.7 = 1,800 mph (2 900 km/h) at 64,000 ft (21,000 m); range, 4,250 miles (6 840 km) with 277 passengers; landing field length required, 6,500 ft (2,133 m).

POWER PLANT: Four General Electric GE4/J5P turbojets. Rated take-off power with augmentation, 63,200 lb st (28 667 kgp) each.

SST Tupolev Tu-144



WHEN RUSSIA'S SST, the Tupolev Tu-144, was first publicly revealed —at the Paris Aero Show in June 1965—the first flight date was given officially as 1968. All subsequent references to the Tu-144 have indicated that the project is on schedule; indeed, it has recently been suggested that the first flight will be made very early in 1968 or even, perhaps, in time for the 50th anniversary celebrations of the Revolution in October this year.

Produced by the design bureau headed by Andrei N Tupolev, doyen of Soviet designers, the Tu-144 reflects similar solutions to the problems of supersonic flight to those adopted in the Concorde. Designed to operate at similar speeds (Mach 2.2-2.3), the Tu-144 shares with the Concorde an ogival delta wing shape, a drooping nose for forward visibility in the approach configuration and four turbojet engines located well aft under the wing. Grouping of the engines four abreast in a single large nacelle differs somewhat from the Concorde's pairing arrangement, but this is only a detail; like the Concorde's Olympus engines, the Kuznetsov NK-144s in the Soviet aircraft have a re-heat system.

No dimensions for the Tu-144 have yet been made public, but the reported gross weight of 286,000 lb (130,000 kg), and the all-tourist class accommodation for 121 passengers indicate an aeroplane rather smaller than the Concorde. Its reported range of 4,040 miles (6 500 km) appears to be related to trans-USSR operations, which would be conducted at a cruising altitude of 66,000 ft (20 000 m). The take-off run (without afterburner) is given as 6,233 ft (1 900 m) permitting the Tu-144 to operate from any airfield used by the Tu-104.

Now in his 78th year, Andrei Tupolev continues to exert personal control over the activities of the design bureau which carries his name, although it is unlikely that he is closely involved in actual aircraft design. He has recently described some of the factors which led to the Tu-144 design decisions and it is clear that in this respect he still exercises considerable influence over the aircraft types which emanate from his bureau. It would be natural to assume that the SST has been his major preoccupation for the past few years, representing as it does the culmination of more than 60 years of active design work.

According to Tupolev, one of the targets in the design of the Tu-144 was that its operating costs should match those of contemporary subsonic transports. This in turn made drag reduction a primary design goal, and apart from influencing the overall design, this called for a special effort to achieve a good surface finish and to eliminate external protuberances.

A low-aspect delta wing was selected for the Tu-144 as the most suitable planform for the required performance, but with the addition of highly swept-back, low aspect ratio sections at the wing roots to produce the typical ogival form. The effect of these highly-swept inner sections is to increase the lift at supersonic speeds and thus to minimize the rearward shift of the aerodynamic centre which would occur on a plain delta wing. The aerofoil section of the wing also changes (in Tupolev's own words, "deforms and rotates") from root to tip to counter the change in trim with increasing speed; the alternative of making trim corrections by using the control surfaces would incur a drag penalty.

Control surfaces comprise four sections of elevons on each wing, powered through hydraulic jacks operating off independent circuits; the rudder is similarly powered. A triplicated hydraulic system is also provided for the fuselage drooping nose, which is unpressurized and contains the weather radar and communications aerials. Maximum angle of droop is 12 deg down, matching the 11-12 deg nose-up angle of the Tu-144 on the approach. The aircraft has three-axle, six wheel bogies on each main undercarriage, this arrangement apparently having been adopted to facilitate stowage of the units within the wing. The latter also contains the fuel in integral tanks between the main spars.

The Kuznetsov NK-144 engines are derived from the NK-12 turbofans used in the Ilyushin Il-62 and are rated at 28,660 lb st (13 000 kgp) for take-off, or 38,580 lb st (17 500 kgp) with partial re-heat. The air intake for the four engines is located under the fuselage just behind the wing root leading edge and is divided into two by a vertical splitter. To match the airflow requirements at various speeds, the intake is variable: it has, says Tupolev, "a special controllable panel which with the aid of a monitoring device can be set to give the necessary optimum longitudinal section of the intake." These panels are hinged flaps which can be raised or lowered to alter the size of the opening.

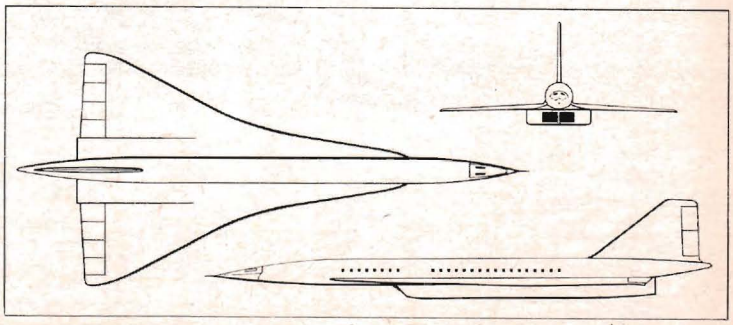
The four individual jet pipes are separated inside the rear of the nacelle by flow separators to prevent transverse flow across the exhaust nozzles. These nozzles are also variable and have provision for reverse thrust. In plan form, the engine nacelle is wedge-shaped, increasing in width from front to rear; this causes a pressure rise (and therefore increased lift) along the underside of the wing in supersonic cruise.

The structural material of the Tu-144 is basically aluminium alloy, with titanium used only where very high temperatures are encountered, such as the wing leading edge. Considerable use is made of integral machining—described as "monolithic construction" by Tupolev—to meet the stringent fatigue life requirements, especially in the pressure cabin.

Normal operating crew for the Tu-144 will be three—two pilots and a flight engineer. During the supersonic cruise, the flight deck will be protected by a visor which has two small windows for forward vision. (An almost identical design is incorporated in the prototype Concordes but a modification recently adopted for the production model will permit virtually unrestricted forward vision even when the visor is up.)

In cross-section the fuselage of the Tu-144 is slightly elliptical being wider than it is deep. The width was set as the minimum possible for five-abreast seating. The basic layout in the Tu-144 provides two cabins seating 40 and 80 respectively, separated by a galley area. There are entrance doors forward and amidships and toilets fore and aft of the cabins.

The flattened cross-section of the Tu-144's fuselage provides no space for baggage under the floor. Instead, there is a large hold in the rear fuselage behind the passenger cabin. It is proposed to carry baggage, freight and mail in nine special containers which will, according to the designer, be winched aboard through a hatch in the floor.

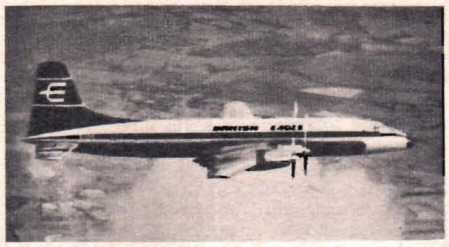


Heir to 44 years' Anglo-French engine experience . . .

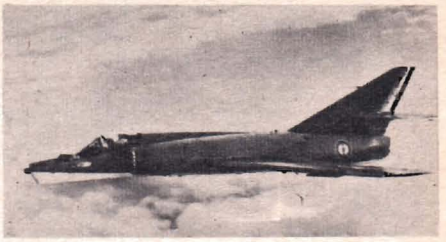
For nearly half a century Bristol Siddeley and SNECMA have supplied engines for the world's aircraft. The two companies' lineage includes such world-renowned engine names as Bristol, Armstrong Siddeley, de Havilland and Blackburn from the United Kingdom, and Gnome et Rhône, Renault and Société Lorraine from France. The combined experience of Bristol Siddeley and SNECMA forms the unique background to Concorde's Olympus 593 turbojets.

◀ Collaboration between Bristol Siddeley and SNECMA dates back to 1922 when Gnome et Rhône manufactured the Bristol Jupiter engine under licence. Gnome-built Jupiters powered many early aircraft, including the Spad 563 six-passenger transport.

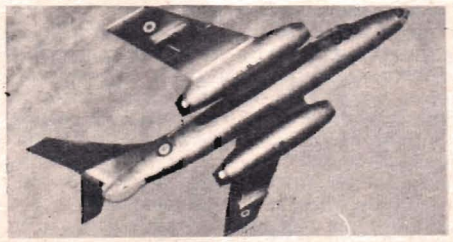
Nearly 100,000 Bristol Hercules engines have been built for service throughout the world. Hercules-powered aircraft include the Short Solent Flying Boat (illustrated); the Vickers Viking, Valetta and Varsity; the Handley Page Hermes and Hastings; and the Bristol Freighter. The Hercules was also made under licence by SNECMA for the Nord 2501. ▶



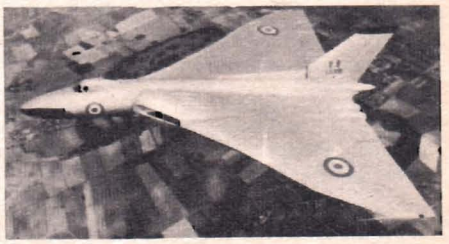
◀ The Bristol Britannia, first of the large turboprop transports, is powered by four Bristol Siddeley Proteus engines. Quiet and virtually free from vibration, the Proteus earned for Britannia the name of "Whispering Giant" and set new standards in passenger comfort.



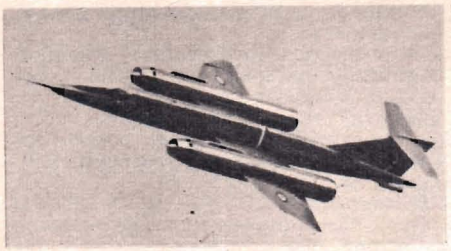
The Dassault Etendard IVM supersonic interception and close support fighter is powered by the SNECMA Atar 08 turbojet. The Etendard is in service with the French Naval Air Arm on board the carriers "Foch" and "Clemenceau". ▶



◀ Two SNECMA Atar 101 E3 turbojets power the French Air Force's SO 4050 "Vautour" light fighter-bomber (illustrated). Atar 101 engines with reheat also power the Dassault Super-Mystère B-2, in service with the French and Israeli Air Forces.

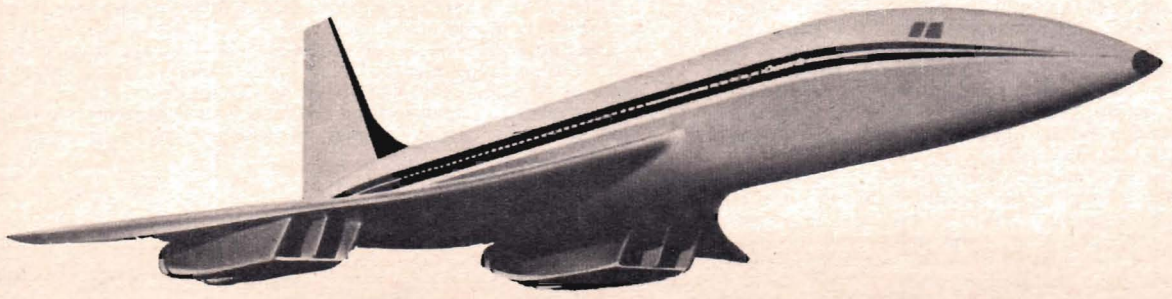


Bristol Siddeley Olympus engines power all Hawker Siddeley Vulcan aircraft in Britain's Bomber Command. A Vulcan is being used as a flying test bed for Concorde's Olympus 593 turbojets with the engine carried under the fuselage. ▶



◀ Powered by two Bristol Siddeley Gyron Junior turbojets, the Bristol T 188 research aircraft was built for investigation of prolonged flight at speeds up to Mach 3. Experience gained from the T 188 has contributed to the design of Concorde.

The Mach 2 Mirage IV A-bombers of France's Nuclear Deterrent Force are powered by two SNECMA Atar 09K turbojets. The 09K is the latest development in SNECMA's Atar family of engines—a family with more than eight years' supersonic experience with air forces throughout the world. ▶



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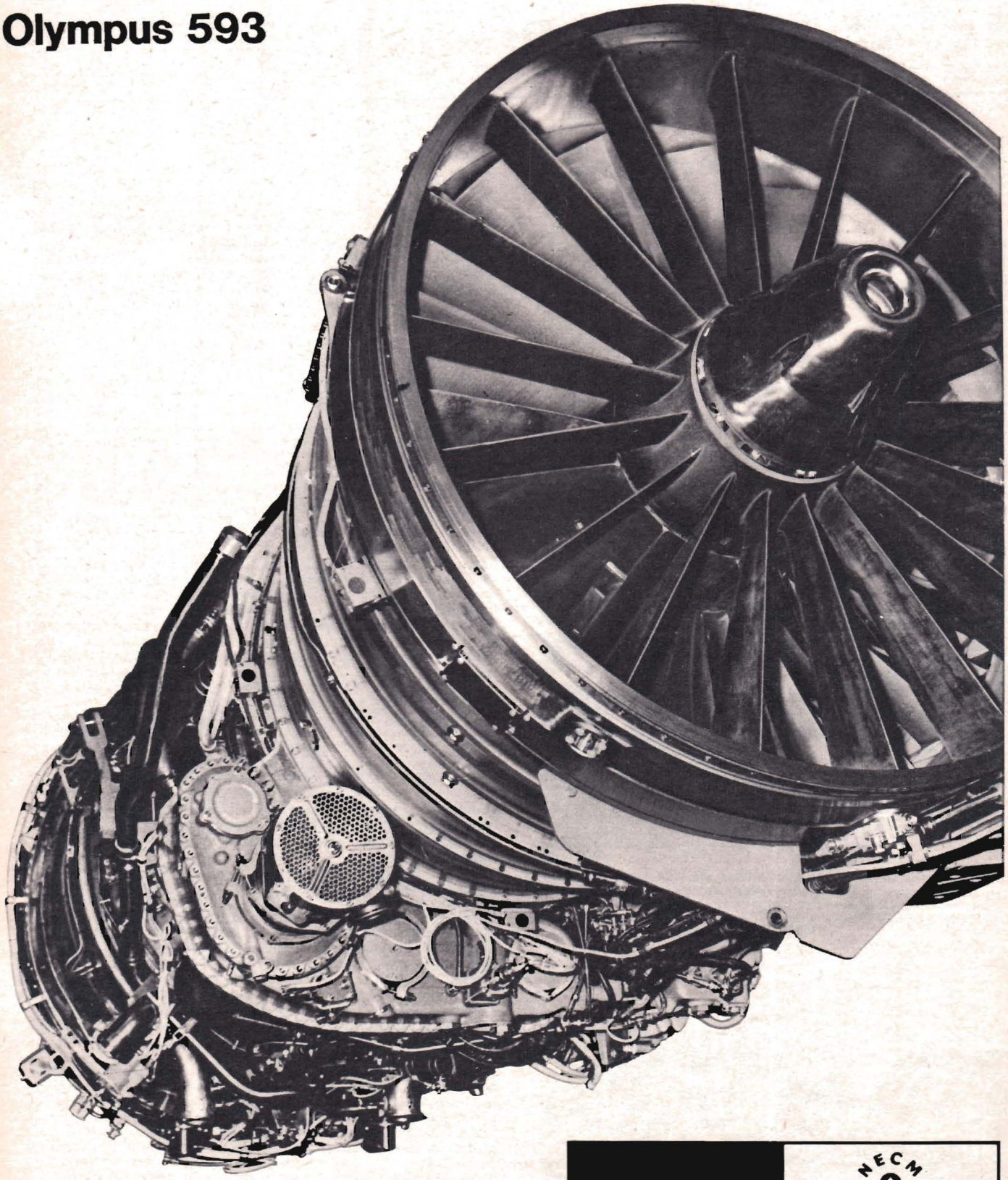


— POWER FOR CONCORDE

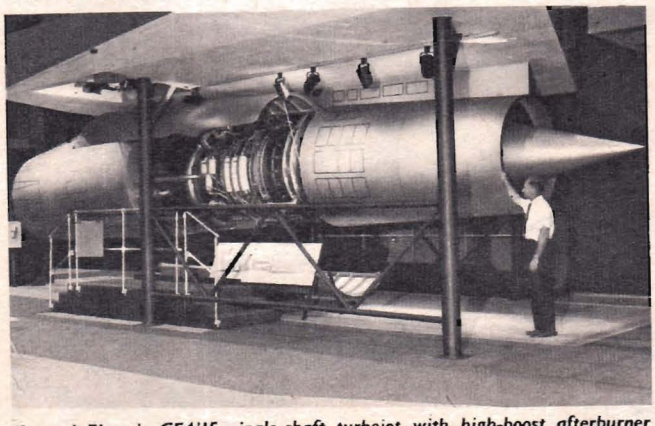
SST Propulsion

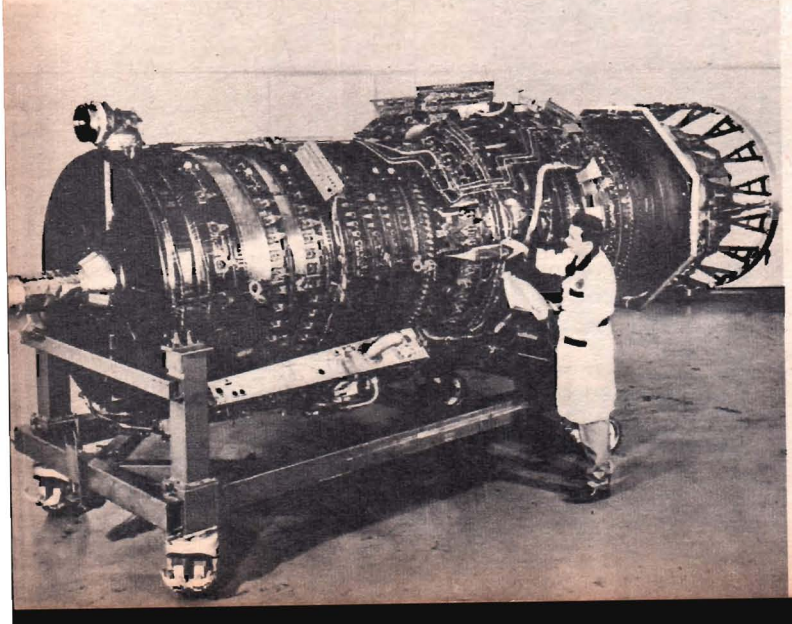
Turbojets versus Turbofans

by Kenneth Fulton

A DECADE after the start of Britain's Supersonic Transport Aircraft Committee's deliberations in 1956, and nearly four years after the initiation of the American SST competition in 1963, controversy still reigns as to what is the optimum form of propulsion for the supersonic transport. The fact that of the four SST engines which have so far run, two are turbojets and two are turbofans, and none are of the same basic configuration, is clear evidence of this dilemma.

A number of factors have contributed to this discrepancy of choice. In addition to individually differing technical opinions, these factors have included companies' desire for continuity of experience, government financial and technical expediency, and the relative work loads of the competing concerns. Also the complex make-up of the typical SST flight plan undoubtedly means that only a fully variable-cycle engine (which would absorb excessive time and money to develop) could provide a truly optimum solution to the propulsion requirements. Thus all the engines at present being tested are, in varying degrees, a compromise answer. Ironically, the one design which appears to come closest to offering the flexibility of operation needed is the Pratt & Whitney JTF17A, recent loser of the American SST competition.





General Electric GE4/J5 single-shaft turbojet with high-boost afterburner has been selected as the winning engine design for the American SST. Demonstrator engines (below) have been tested at 52,600 lb st (23 859 kgp), and the Phase 3 GE4/J5P for the Boeing SST (mock-up pod, above) is rated at 63,200 lb st (28 667 kgp).

The four engines which have reached the test stage are the R-R/BSE/SNECMA Olympus 593 twin-spool afterburning turbojet, the Kuznetsov NK 144 twin-spool afterburning turbofan, the General Electric GE4/J5 afterburning single-shaft turbojet, and the Pratt & Whitney JTF17A twin-spool ductburning turbofan. With the introduction of afterburning and ductburning to airline engines for the first time, the American industry has proposed modified terminology which avoids the word "burning". Thus use of the terms "augmentor" and "duct-heater" is being promoted.

THE CONCORDE ENGINE

Most advanced in its development in the West is the Olympus 593 afterburning turbojet power unit for the Concorde. This is a joint Anglo-French project, and comprises the flange-to-flange engine designed and being developed by the Bristol Siddeley Aero Division of Rolls-Royce, and the exhaust system designed and being developed by SNECMA. Work on the propulsion system (with the exception of the intake which is the responsibility of BAC) is split on a 60/40 basis between the UK and France.

The 593 is a sixth generation derivative of the 9,140 lb st (4 146 kgp) Bristol Olympus B. Ol. 1 which first ran in May 1950. Via the Olympus 100, 200 and 300 Series variants powering the subsonic Hawker Siddeley Vulcan bomber, the 30,000 lb st (13 608 kgp) 320 Series supersonic afterburning engine was developed for the BAC TSR-2 bomber. From the Olympus 320 in turn was evolved the 35,080 lb thrust (15 912 kgp) Olympus 593D civil counterpart for the original smaller Concorde. This version first ran in August 1964. For the definitive Concorde, a 100 per cent new design of engine was produced, the larger Olympus 593B of similar rating but greater thrust growth potential. This latest variant, which first ran in November 1965, is based closely on the aerodynamic and mechanical concepts of its supersonic predecessors but also embodies the development advances provided by early testing of two 593D engines.

In configuration the 593B, now officially designated simply the Olympus 593, comprises a twin-spool turbojet with a seven-stage LP compressor, seven-stage HP compressor, cannular combustion system with eight flame tubes, a single-stage HP turbine, and a single-stage LP turbine. The SNECMA exhaust system, based closely on the afterburner of the company's Atar turbojet, comprises a simple form of afterburner, cascade-type thrust reverser, retractable multi-lobe noise suppressor, and variable geometry convergent-divergent nozzle of high throat/exit area ratio capability.

The basic take-off rating of the engine is 32,800 lb (14 878 kgp) which afterburning raises to 35,080 lb (15 912 kgp), equivalent to seven per cent static boost. A thrust boost of 14 per cent will however be type-tested. After two years of airline operation the non-augmented rating will be raised to 35,080 lb (15 912 kgp) by means of slight increases in rpm and turbine temperature, and the afterburner will then only be on standby for emergencies. Air mass flow at present is 450 lb/sec (204 kg/sec) and pressure ratio is in the region of 15:1. Flange-to-flange length is 138.22 in (350 cm); overall length to the final nozzle is almost twice this; inlet diameter is 47.85 in (121,5 cm); and engine weight approximately 5,600 lb (2 540 kg). Growth ratings up to around 40,000 lb (18 144 kgp) are projected.

Six pre-flight bench engines and one flight standard engine have been built from a total programme of 17 engines. These are being used for development testing at R-R/BSE's Filton Aero Division plant, the NGTE at Pyestock, SNECMA at Melun-Villaroche, and CEP at Saclay. Total running time now exceeds 900 hours, split approximately two-thirds in the UK and one-third in France. This total is increasing at a monthly rate of approximately 100 hours. Maximum time on one engine so far is 192 hours.

Bench tests have already demonstrated a non-augmented thrust of 33,000 lb (14 969 kgp), rising to 37,000 lb (16 783 kgp) with afterburning. Simulated altitude testing has also explored the Concorde's flight envelope up to 60,000 ft (18 288 m) and Mach 2.2.

Flight testing of the 593 under a Hawker Siddeley Vulcan was

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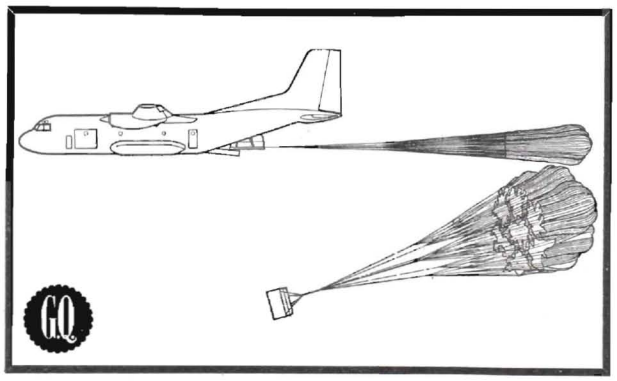

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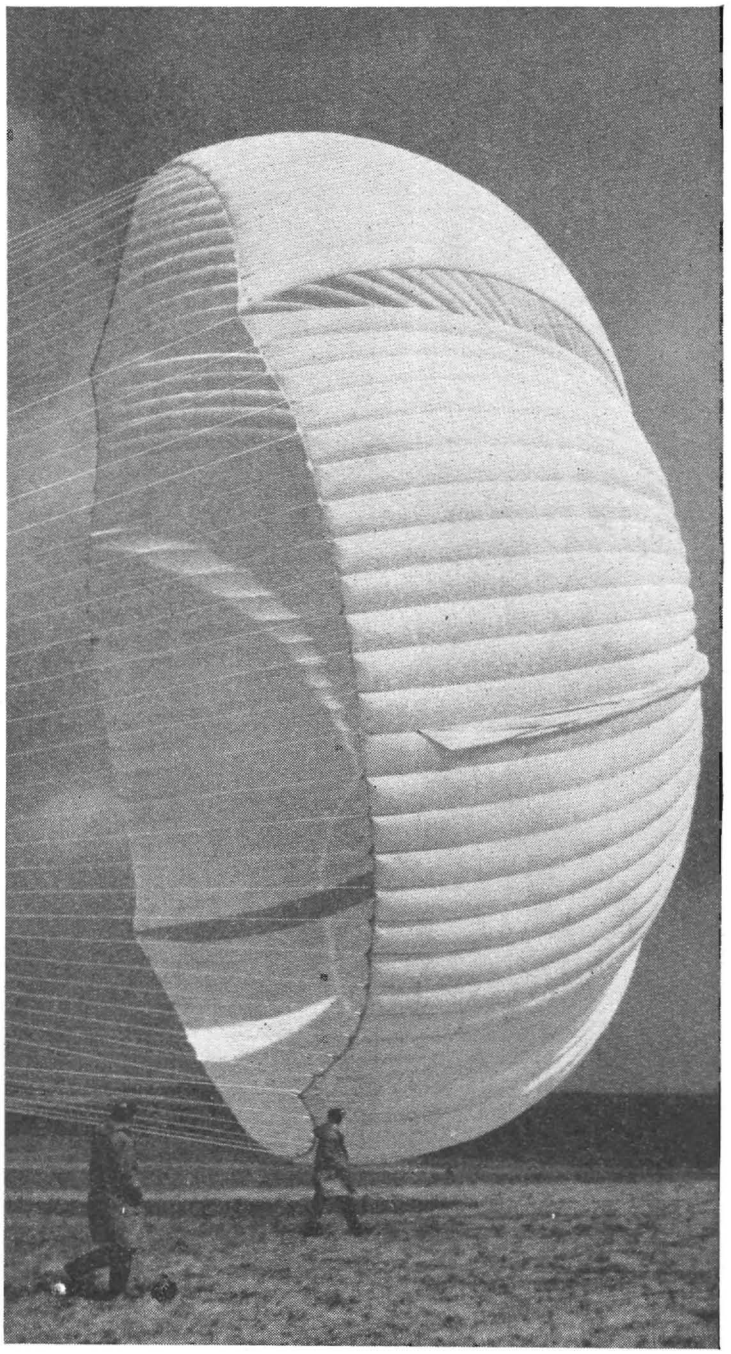

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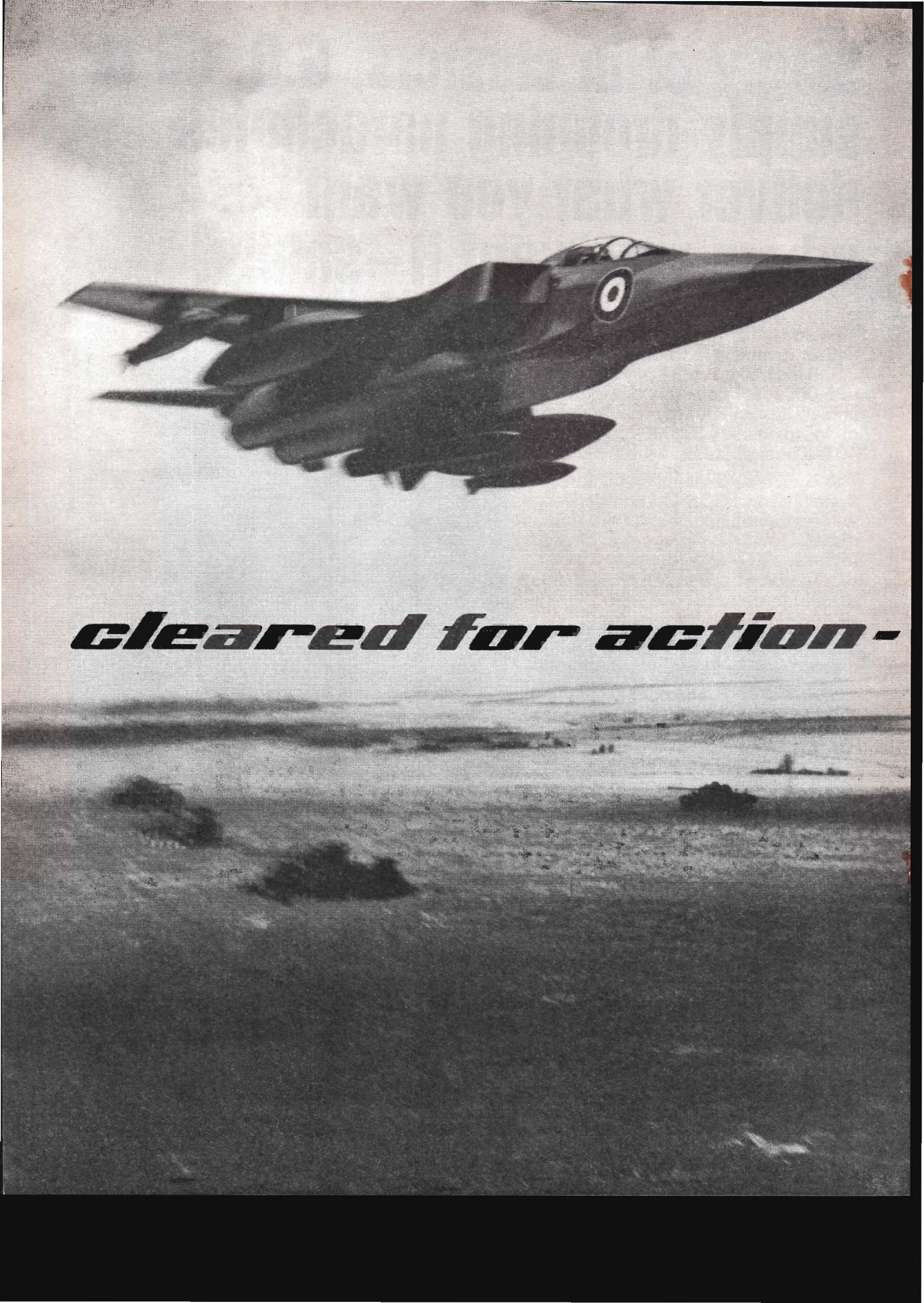
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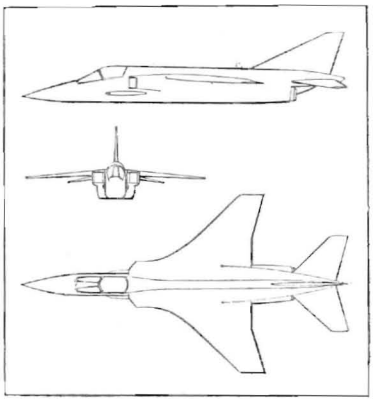

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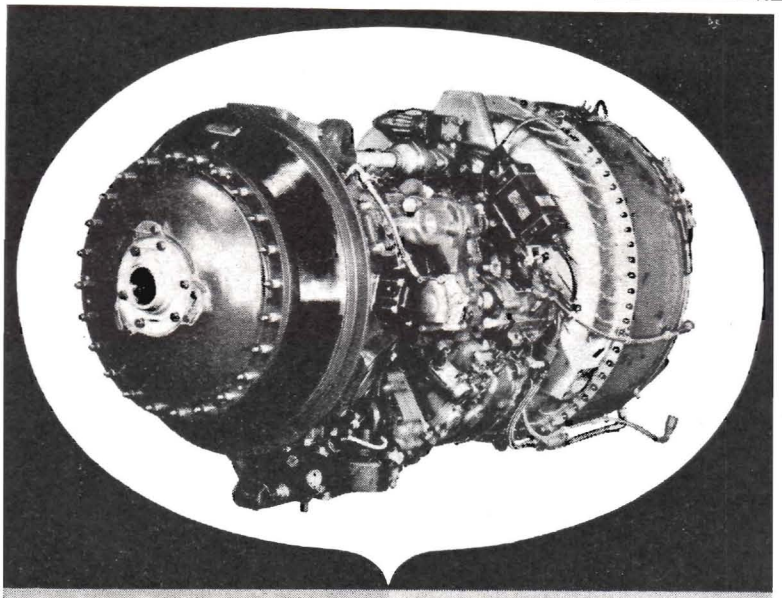

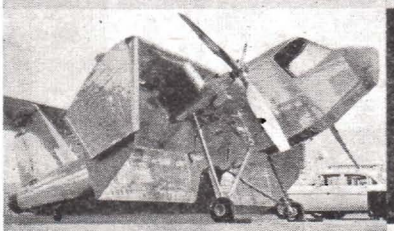

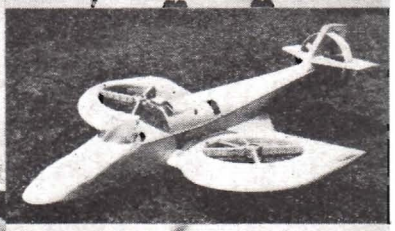

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initiated in September last year using a fully representative Concorde powerplant comprising nacelle, intake, engine, exhaust assembly, and load simulators to provide representative aircraft system demands. Phase one of the flight programme to explore the Concorde's subsonic regime was completed during December. Flying time amounted to some 20 hours with 7½ hours of this being with the 593 operating. The second phase was started during January, and more than two-thirds of an anticipated 250 hours of flight testing are scheduled to have been flown prior to the first flight of the Concorde at the end of February next year.

SNECMA'S exhaust system testing at Villaroche using the 593, started in June last year and has included afterburner, afterburner control system, noise suppressor and thrust reverser tests. In July the first run with a modified design of 593 HP spool was made by the CEP at Saclay. This "half-engine" unit comprises an HP compressor and turbine and associated combustion system, and provides a quicker, less costly method of obtaining performance data with revised designs of HP components.

By 1971 when the Concorde is to enter service, total bench and flight testing of the 593 should reach close on 30,000 hr. This background of experience should enable an introductory TBO of 500 hours to be achieved. Thereafter the period should rise by 1,000 hours each year.

RUSSIA'S SST ENGINE

A number of SST engines are reported to have been tested in the USSR, but of these the NK-144 has been under development for the Tupolev Tu-144 supersonic transport since around 1964. As the second Kuznetsov turbofan, the NK-144 is derived from the bureau's first engine of this configuration, the 10 500 kgp (23,150 lb) NK-8 powering the Ilyushin Il-62 subsonic transport. Basic rating of the NK-144 is 13 000 kgp (28,660 lb), this higher thrust being achieved mainly by the increased mass flow provided by the addition of further fan and compressor stages. These now total five fan and eleven compressor stages, giving the 144 a 15:1 pressure ratio, directly comparable to that of the Olympus 593. Bypass ratio is 1:1, close to the 1.3:1 of the P&W JTF17A, the only other SST turbofan.

The combustion system is fully annular and the turbine comprises a single HP stage and two LP stages and is air-cooled, presumably in its first stage. Turbine entry temperature is 1,300°K (2,370°F). This is cooler than the TET of the Olympus 593 and GE4/J5 turbojets, but directly comparable with that of the JTF17A. As with the two American SST engines, the NK-144 makes use of a high-boost afterburner for use during take-off, transonic acceleration and supersonic cruise. Augmented take-off thrust is 17 500 kgp (37,710 lb), equivalent to a 35 per cent static boost, five times that used on the Olympus. The exhaust system comprises the afterburner, a thrust reverser, and a variable geometry nozzle. A noise suppressor is apparently not included.

Engine weight with afterburner but without variable geometry nozzle is 2 850 kg (6,283 lb), diameter is 150 cm (59 in), and length, presumably without afterburner, is 5.2 m (17 ft 1 in).

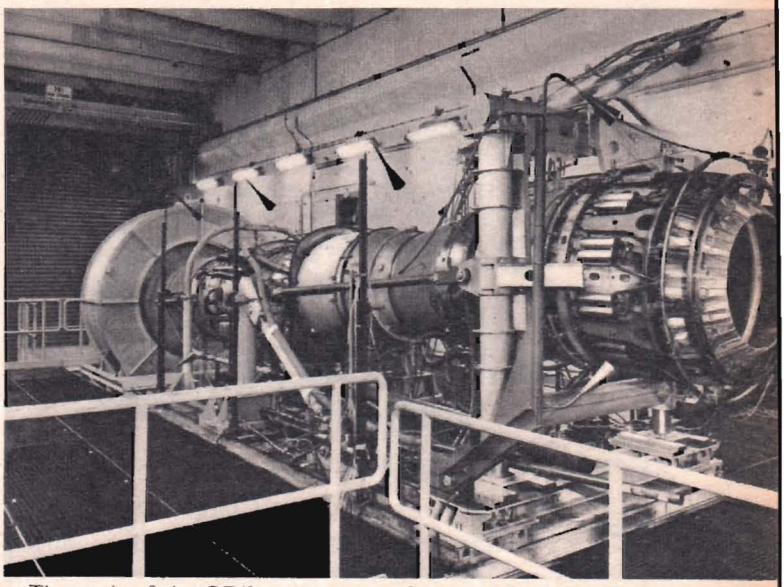
As early as October 1965, five NK-144s had completed 1,500 hours development testing, a considerably higher figure than the combined time on all three of the West's SST engines today. The development programme of the NK-144 would seem to suggest a first run date sometime during 1964, corresponding with that of the early Olympus 593D. As the first flight and into-service dates for the Tu-144 are now comparable with those of the Concorde, these would support the occurrence of closely parallel engine time scales.

No announcement has been made concerning flight testing of the NK-144, but in view of the Tu-144's development schedule, this undoubtedly must now be underway. Any anticipated benefits planned to have been gained for the NK-144 through prior flight experience with the subsonic NK-8 engine would now seem limited as a consequence of the Il-62's known aerodynamic problems. Interest shown by Russian visitors to Rolls-Royce in the Conway's early fan surge difficulties through intake flow distortion, is more than likely to relate to the NK-8. With the NK-144's use of additional fan stages, its consequently higher inlet hub/tip ratio would aggravate any such problem in this component. The flight envelope of the Tu-144 extends to 21 000 m (69,000 ft) and Mach 2.35.

GENERAL ELECTRIC'S WINNER

Winning design of the American SST engine competition, the GE4/J5 single-shaft turbojet represents the second resounding success by General Electric in its American competitor's prime market—transport engines. (GE also won out over Pratt & Whitney in the 1965 C-5A engine competition). If the Boeing SST is eventually committed to production, GE's considerable desire to attain major international status in the big commercial engine field is more than likely to be fulfilled.

Bristol Siddeley Olympus 593 twin-spool turbojet with low-boost afterburner is under joint development by Bristol Siddeley and SNECMA for powering the Concorde. Augmented thrust on entry into service in 1971 will be 35,080 lb st (15 912 kgp). Bench and flight testing are currently underway including (above) *the Vulcan test bed and* (below) *at the Villaroche facility of SNECMA.*



The seeds of the GE4's success were first sown in 1953 when design of the 17,000 lb (7 711 kgp) J79 turbojet was started. From this supersonic single-shaft afterburning engine, with its multi-stage variable stator compressor, was derived the larger 30,000 lb (13 608 kgp) J93 Mach 3 turbojet of similar configuration but with fewer compressor and turbine stages and an annular as opposed to cannular combustion system. Despite its somewhat chequered career the J93, through its sole application in the North American B-70 Valkyrie bomber, provided GE with vital development experience of high Mach number turbojets.

Although only relatively few hours of flight at Mach 3 have been completed by the J93, the J79 has accumulated a high proportion of the West's flying time above Mach 2. In its choice also of an augmented turbojet for its SST entry, GE pointedly emphasized that 99.9 per cent of *all* US supersonic flight experience had been gained using turbojets: above Mach 2.5 this claim rises to 100 per cent. To round off its argument GE also indicated that close on 17,000 GE afterburning turbojets have been built, 9,000 of these being for Mach 2+ aircraft.

The GE4/J5 was first exhibited in mock-up form in May 1965, towards the end of Phase 2B of the FAA's design competition. The first of three demonstrators did not run however until the summer of 1966, nearly four months after its P&W competitor and two-thirds of the way through Phase 2C. In configuration the GE4 closely follows the J93. In its 50,600 lb (22 952 kgp) demonstrator form it comprises an eight-stage compressor incorporating variable incidence stators for each stage, a bulky annular combustion system, two-stage air-cooled turbine, close-coupled afterburner, thrust reverser, and convergent-divergent ejector nozzle. A noise suppressor integral with the nozzle assembly has been developed but not yet installed. Following directly on J93 experience, all the GE4's controls and accessories are housed in a cooled and insulated pod under the compressor.

Other data on the Phase 2C engine includes an air mass flow of

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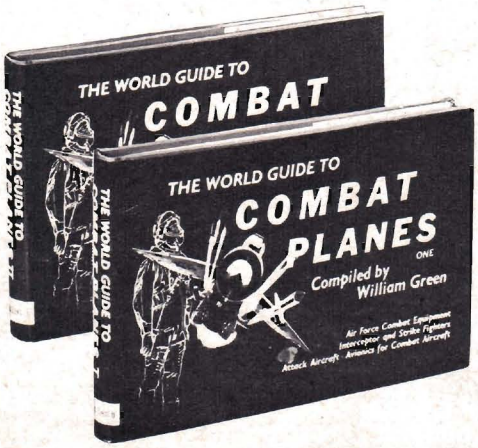

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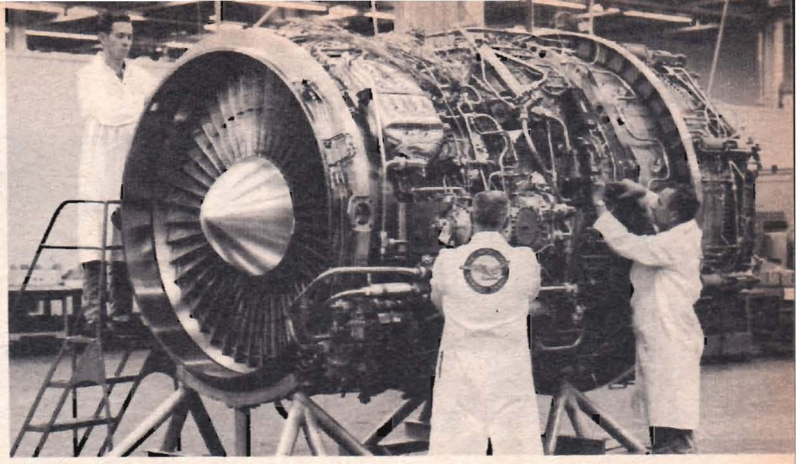
475 lb/sec (215 kg/sec), a weight of around 9,500 lb (4 309 kg), a maximum diameter at the nozzle exit of 71 in (180 cm) and an overall length of 300 in (7,62 m). The engine was designed for propulsion at Mach 2.7 at 70,000 ft (21 336 m) but with a capability to Mach 3.

Testing of GE4 components, extending over many months, was initiated during 1965, and by April the following year, confirmation of compressor aerodynamic performance was well advanced. A J93 was also modified to embody GE4 designs of combustor and turbine which were then tested at representative GE4 temperatures. The afterburner and nozzle were similarly tested in scale form on a J93. This background of component testing enabled the GE4/J5 demonstrator to attain full specification performance in most of its respects within a short time following its first run on July 13th last year. By July 20th the engine had operated at 100 per cent rpm with excellent results, and on August 23rd, a non-augmented thrust of 40,000 lb (18 144 kgp) had been attained, this figure being in excess of the official requirement. In September, turbine entry temperatures exceeding those for full rated thrust were satisfactorily achieved.

Testing of the full-scale afterburner was initially performed using two J79 turbojets to provide the necessary exhaust mass flow. Then on October 28th the GE4/J5 with afterburner was successfully tested at 52,600 lb (23 859 kgp), this figure then being the highest thrust attained by an air breathing engine. The figure exceeded by four per cent the thrust guarantee for the demonstrator. (In December the P&W JTF17A demonstrator bettered this performance by producing more than 57,000 lb (25 855 kg) of thrust). Total running time by the GE4 demonstrator in October exceeded 80 hours, leaving only 20 to be run to complete the 100 hour test total required by the FAA for Phase 2C.

Early in May 1966 General Electric had announced that to provide the 20 per cent increase in thrust demanded by the heavier, definitive Boeing and Lockheed L-2000 designs, a higher performance version of the GE4/J5 would be provided for Phase 3 in 1967. It was this version which formed the subject of GE's submission to the FAA on September 6th. Augmented thrust is raised to 63,200 lb (28 667 kgp) by changes to the compressor which increase the mass flow by 30 per cent to 620 lb/sec (281 kg/sec). The first three compressor stages are re-designed and a zero-stage added to the front to make a total of nine stages. The turbine



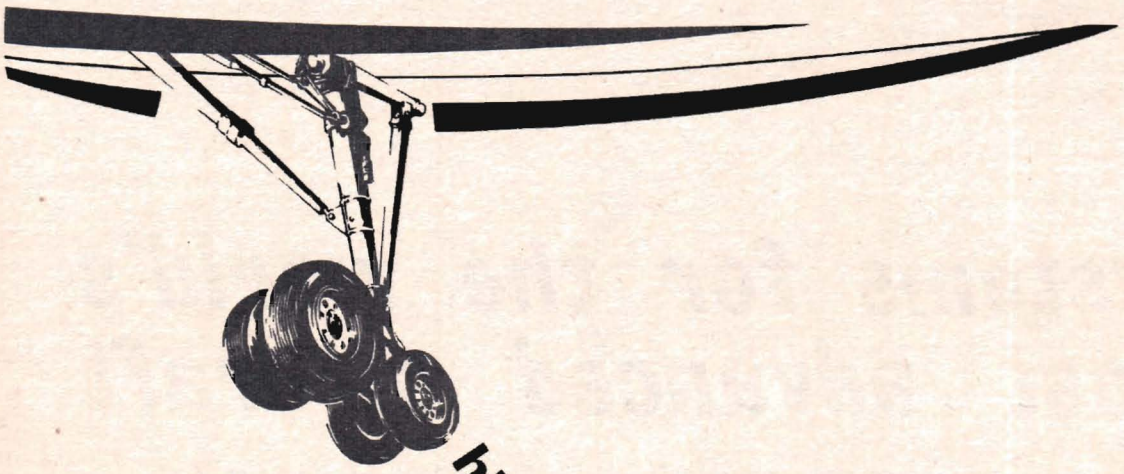
Pratt & Whitney's JTF17A-20 turbofan, now eliminated from the US SST programme, was rated at 57,000 lb st (25 855 kgp) with afterburning.

second stage is increased in diameter by 0.5 in (1,27 cm), and the turbine entry temperature will be substantially the same as for the demonstrator. Afterburner temperature, however, will be 200°F (111°C) higher.

Related changes include an increase in engine diameter to 74.2 in (188 cm), a length increase to 308 in (7,82 m), and weight increase to around 10,500 lb (4 763 kg). In this form the GE4 has growth potential to more than 75,000 lb (34 019 kgp) augmented take-off thrust. The variant for the Boeing SST is designated GE4/J5P.

With the present hiatus in the American SST programme, General Electric, like Boeing, is funded for continuing design and development work on a month-to-month basis. For the GE4 this no doubt involves further bench testing to accumulate additional performance and mechanical experience. A major test facility is already being built by GE to accommodate engines significantly more powerful than 60,000 lb (27 216 kgp) to allow for anticipated thrust growth. For flight testing of the engine, the company has acquired a USAF Boeing B-52 bomber, in which the GE4 will replace the present twin P&W TF33 nacelle on No 3 pylon.

If the SST project does proceed as proposed, the GE4 is planned to enter service with a TBO of 1,000 hours, which should reach 5,000 to 6,000 hours in under six years of airline operation.



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SST — Airline Planning

TWA Prepares for SST Operation

by The Editor

TRANS WORLD AIRLINES was the first airline in the World (albeit by a margin of only a few hours) to place a preliminary contract for the US SST, as well as being an early customer for the Concorde. Its views on SST introduction and the preparations being made within the airline for supersonic operations are therefore of particular interest at the present time; and to hear them at first hand, FLYING REVIEW INTERNATIONAL flew to New York shortly after the FAA announced selection of the Boeing SST and General Electric GE4/J5 for eventual development.

For the record, it was on October 14, 1963, that TWA entered into a commitment to purchase six American-built SSTs and deposited $600,000 with the Federal Aviation Agency to reserve the first and thereafter every second aircraft up to a total of six. The arrangement to reserve delivery positions on an aircraft, which not only had not been designed but for which a manufacturer had not been chosen, was unique, and was the outcome of a proposal made to the FAA by TWA president Charles C Tillinghast Jr a few weeks before. Inauguration of the US SST programme had been announced by President Kennedy the previous June, with the formal Phase I initiated by the FAA on August 1, 1963.

TWA's lead in reserving delivery positions was quickly followed—by Pan American on the same day and by a number of other airlines in subsequent weeks. All reservations were accompanied by a deposit of $100,000 per aeroplane but inasmuch as these were refundable at any time, with interest, they represented no real commitment to the SST programme and could be viewed as no more than a means of preserving competitive positions. Two days after the TWA and PAA deposits were made, the then Administrator of the FAA, Najeeb Halaby, called them "votes of confidence in the program" for which, at that time, the US House and Senate had authorized expenditure of $31 m (£11.1 m). TWA's action, at no risk to the airline, was a deliberate effort "wholeheartedly and enthusiastically" to endorse the joint government-industry efforts to produce, in the words of Mr Tillinghast, "a superior supersonic transport."

The BAC/Sud Concorde had become firmly committed to construction in November 1962 and just less than one year later, on October 30, 1963, TWA placed an order for four Concordes, at the same time reserving four more positions on the US SST production line. In the case of the Concorde, the decision to order was backed by a rather more positive commitment than for the US aircraft. Deposits of approximately $160,000 were paid on each aircraft, with an agreement to pay a second similar amount upon completing a formal contract either six months after the first flight or six months after final purchase contracts for the Concorde had been signed by BOAC or Air France; there was an option to cancel if this final contract could not be completed by BAC/Sud before the end of 1968 or if the purchase price exceeded $10 m plus agreed escalation. TWA also took an option on five Concordes at this time and converted two of these options into a firm contract on April 1, 1964. Delivery positions 22, 32, 34, 38, 44 and 48 have been obtained by TWA; ahead of the first aircraft were six Concordes each for BOAC, Air France and Pan American, one each for American Airlines and Continental Airlines, and one "open" position for a European customer.

Robert W Rummel (left) TWA vice president, planning and research, with Boeing SST models; and Alvin S White (right), manager of flight research and development, with Concorde.

TWA interest in supersonic transports began as early as 1954, according to Robert W Rummel who as vice president, planning and research, plays a leading part in the preparations the airline is making for SST introduction. Exploratory exercises were conducted, and preliminary lay-out designs were discussed with several manufacturers. For several years, NASA and military developments were also studied, giving the airline a good "feel" for what was likely to be achieved. Sud Aviation, which was actively promoting its early "Super Caravelle" SST project before joining with BAC to develop the Concorde, also held discussions with TWA in 1960/61.

When TWA took its options on the proposed US SST, it was assumed that the aircraft would be capable of good "Atlantic gateway" operation (ie, West European capitals to Eastern US seaboard cities) with an economic payload, compatible with air traffic control requirements and with no compromise of safety. "I do not think," said Mr Rummel, "that conditionally certificated aeroplanes should be put into operation." Since 1963, the airline has consistently been encouraging US manufacturers to develop the smallest size SST for economic and sound operation; by matching airframe and engine for the optimum size, an aircraft much larger and more productive than the Concorde has emerged.

In a recent speech, Mr Rummel said, "It is obviously to the best interests of the United States to remain as competitive as possible in commercial aviation and to meet foreign competition head-on with a superior product." Pursuing this point, we enquired whether TWA regarded the Concorde and US SST as being complementary on their routes. The answer was an emphatic negative: the US SST is "too late" even three years after the Concorde (this assumes the provisional in-service date of 1974 is achieved) and TWA regards the two types as "highly competitive" for the same dollars.

Sonic boom is still "one of the greatest unknowns and greatest risks", said Mr Rummel, but not one that *should* be allowed to deter the programme. However, it is recognised that overland supersonic operations may be banned, temporarily or permanently, and TWA recently conducted a comparative scheduling study on a round-the-world flight from New York to San Francisco; the final transcontinental link was not included since, assuming an overland supersonic ban, no case could be made for using an SST at subsonic speed on this sector. For the rest of the flight however, the difference in time between full supersonic operation, and supersonic operation only over water, was 2 hr 52 min and the difference in cost only 5 per cent. Penalties of this magnitude do not appear to be intolerable.

Present TWA orders for ten US SSTs and six Concordes represent no more than the capacity needed for international and overwater routes by 1980. If there is no sonic boom restriction over continental US, the total requirement is expected to be about 50 in the same period.

PROJECT EVALUATION

TWA was one of the ten US trunk airlines invited by the FAA to evaluate the two airframe and two engine proposals in Phase IIC of the US programme. These ten airlines also set up an SST technical steering committee comprising senior technical management representatives, plus several specialist subcommittees which for the past year have monitored the progress of the four manufacturers and have made hundreds of suggestions for design improvements to the FAA and the companies; most of these requests were adopted in the final prototype proposals.

Nearly 50 technical and economic experts within TWA contributed to the evaluation of the proposals, which relied on extensive computer programmes to study the economic and other effects of parametric variations on the specific proposals. The result was one of the most thorough studies ever conducted on an aircraft at the preliminary design stage. Individual recommendations are not publishable but Mr Rummel told FLYING

REVIEW INTERNATIONAL that TWA "believe Boeing can build a very fine aeroplane indeed and that General Electric can build a good engine. We are heartened that a decision has been made. Continuing the programme as at present need not cause any eventual delay, though we feel there must soon be a go-ahead. I accept," he added "that 1974 is a real possibility for the start of airline service. That date includes challenges that call for expeditious action along the way."

Some years ago, TWA set as the goal for SST operation, a seat-mile cost no more than 80 per cent of that for subsonic jets on international routes. It now appears that this may have been too optimistic and a differential may be needed between subsonic and supersonic fares—perhaps as much as 20 per cent. SST costs about the same as those for to-day's subsonic jets seem likely (though the Concorde seat-mile costs, said Mr Rummel, are "far higher" than those of the US SST): but subsonic fares are expected to come down with the introduction of the jumbo jets. Even at a fare differential, SST load factors will be high for several years, as the aircraft will be in relatively short supply; if the same fares are operated, the transition to SST will be as rapid as it was from piston to turbojet types.

Results of the passenger survey which TWA has been conducting are still being analysed; they are expected to give a valid indication of public views on both the Boeing 747 and the SST. It is already clear, says the airline, that "even with some fare differential, supersonic transportation will be in high demand." Many replies indicated a willingness to pay up to $50 more than the basic subsonic fare for a journey of 2,000 miles or more.

PREPARING FOR OPERATIONS

TWA recently announced the appointment of Alvin S White as manager of flight research and development, with particular responsibilities in the SST and Boeing 747 programmes. This appointment is a further step in the preparations which TWA is making for the introduction of supersonic transports. Details of these preparations were given to FLYING REVIEW INTERNATIONAL by Mr White, previously chief test pilot on the XB-70A, together with Robert Mueller, staff vice president—flight operations; Capt Frier, director—flight training and David Spain, director—flight crew control administration.

TWA flight personnel have been participating in SST preparation programmes at Langley Field, Va, for the past two years. At Langley, NASA has a simulator set up to study the interaction of SST operation and air traffic control procedures, in conjunction with an ATC simulator at the FAA Experimental Centre at Atlantic City. Selected crews "fly" the simulator on typical penetration and departure profiles around Kennedy Airport for this purpose. TWA has also taken part in the Human Factors study at Randolph Field and selected flight personnel have participated in Lockheed's industry acquaintance programme in which F-104s are flown on typical SST profiles.

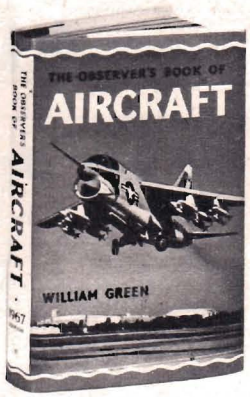
Experience to date, we were told, indicates that some additional training will be needed for SST flight crews, compared with that which is necessary to convert to a new type of subsonic transport. This will be required in such areas as transitioning from subsonic to supersonic flight and back to subsonic, and in some of the specific problems of supersonic flying. Greater emphasis is likely to be placed upon the use of simulators of various kinds in the training programme, and more "on-line" experience will be required for SST qualification than has been necessary in the past.

In view of Mr White's unique experience of flying large aircraft at speeds above Mach 2, we asked what differences pilots of SSTs such as the Concorde and Boeing would notice. The sensations of SST flight, according to Mr White, will not be noticeably different from those experienced by the average pilot in subsonic jet aircraft, and new pilot techniques and procedures will be "minimal" because of the steps already being taken in the expansion of TWA's jet fleets.

However, pilots will have to be trained to appreciate many of the basic obvious differences between the SST and subsonic aircraft, such as greatly increased weights and fuselage lengths. The weight difference alone requires that more consideration be given to the "delay factors involved in changing the direction or attitude of the SST mass", Mr White added.

TWA has "every expectation" that contract seniority principles will govern selection of SST crews to a large extent, although specific age and/or other minimum qualifications have not been established, and government regulations may be developed as a control on age, physical fitness and so on. It is anticipated that the flight crew union will oppose regulation and will attempt to establish, by contract, unencumbered seniority rights. TWA, while requiring that any such contractual provisions must not jeopardize safety or flight crew proficiency, is anxious that its more experienced pilots should operate the SST.

Other programmes within TWA to integrate the SST into total system operation are described as being "in the primary stages" but several groups and committees already exist in the airline to plan accordingly. These include performance analysis studies which are being made under the direction of N R Parmet, vice president, equipment planning and development, and more general investigation being made by a committee headed by John Harrington, staff vice president, advance programme integration.



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BOEING SST

continued from page 424

available seat-mile—less than current subsonic jets and the Concorde, and only slightly more than for the Boeing 747. The first cost is currently estimated at $35.5 m (£12.7 m) but it is not clear how much of this is represented by the levy required to repay Government investment in the programme.

There are still many imponderables in the Boeing SST programme, and the company is necessarily marking time until the Administration clarifies its intentions. Enough work has been done, however, as this article perhaps indicates, for the company to have confidence in its ability to produce a safe, viable transport. Provisional "orders" have been placed for 114 of these aircraft of which 58 are for non-US airlines; as soon as Boeing is able to enter contractual negotiations with these prospective customers, many of these orders will become firm commitments backed by unrefundable dollars.

Meanwhile, a good deal of the work initiated under Phase IIC of the programme is continuing. During January, for example, test specimens of the flight deck "cab" and wing pivot were in final assembly, these being two of the most difficult items of titanium fabrication. A whole new titanium facility, with a floor area of 86,000 sq ft (7 990 m²) is going up alongside the Developmental Center, as part of Boeing's investment, to date, of more than $40m (£14.3 m) of its own money in SST development. The SST undoubtedly represents the most challenging project yet undertaken by Boeing—a company which is unequalled in its experience of jet transport production but which has never built a manned supersonic aircraft. Before the first supersonic transport emerges at Seattle, Boeing will have produced well over 1,500 jet airliners, including the new "little" 737 and the enormous 747. The US SST in undoubtedly is good hands.

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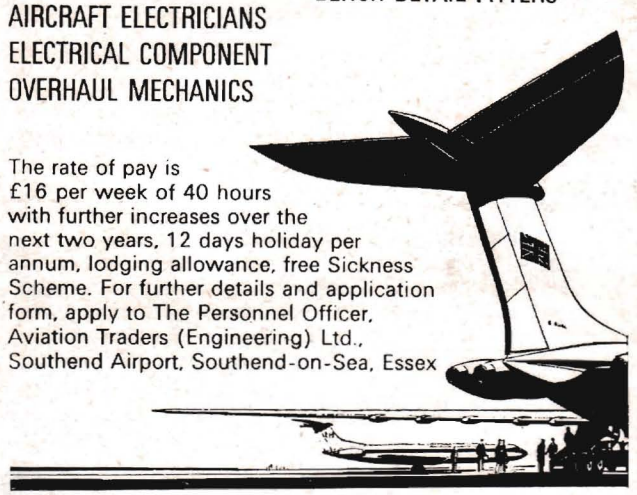

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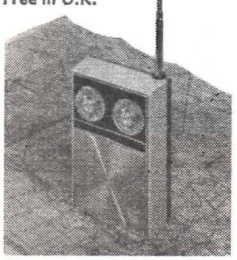

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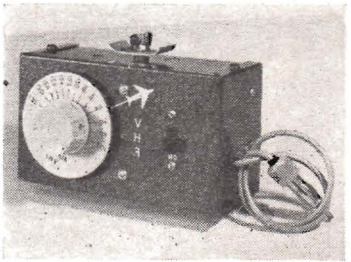

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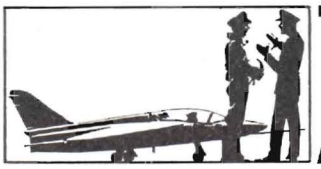

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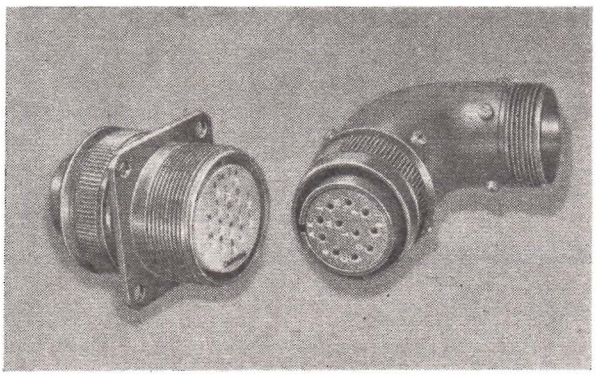

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MISSILES AND ROCKETRY

By KENNETH W. GATLAND

JAPANESE SPACE AIMS

AFTER FAILING in two attempts last September and December to place test-satellites into orbit with Lambda 4S rockets from the Kagoshima Space Centre, Japan will try again within the coming weeks. The four-stage all-solid launcher has a spherical rocket as its final stage which carries the payload within a non-separating nose cap. The combined satellite package, called LS-1, weighs 57.3 lb (26 kg) with a useful payload of 26.4 lb (12 kg). It includes an ionosphere temperature probe of Japanese design and a small battery-operated radio transmitter.

It should be emphasised that this represents only the engineering test-vehicle for Japan's larger Mu satellite launcher. The M-10 booster was test-launched at Kagoshima with dummy upper stages on October 31st; it is planned to have the complete vehicle ready for satellite launching by the end of the year.

Despite the disappointments surrounding the initial launchings of Lambda 4S useful information was obtained. On each occasion the first, second and third stages fired as planned. The fourth stage was due to start firing about seven minutes after lift-off, at a distance of about 869 miles (1 400 km) east of Kagoshima over the Pacific Ocean when the fourth stage and its attached attitude control system had coasted to a height of some 248 miles (400 km). Failure occurred at the time of separation from stage three when the eight H_2O_2 jet-nozzles of the stabilizer were to change the attitude of the fourth stage from inclined to horizontal flight. The attitude control device should then have detached from the rocket and the spin-stabilized fourth stage fired by command signals from the ground to achieve orbital velocity. A similar technique is to be used for the larger Mu launch vehicle.

Leading particulars of the Japanese satellite launchers are as follows:

	Lambda 4S	Mu 4S
Overall Length	55.4 ft (16,9 m)	72.2 ft (22 m)
1st stage diameter	28.9 in (73,5 cm)	55.9 in (142 cm)
2nd stage diameter	16.5 in (42 cm)	55.9 in (142 cm)
3rd stage diameter	16.5 in (42 cm)	33.5 in (85 cm)
4th stage diameter	18.9 in (48 cm) spherical	30.3 in (77 cm) spherical
Launch weight	8.5 tons	39 tons
Launch thrust	40 tons	200 tons
Satellite weight	57.3 lb (26 kg)	154.3 lb (70 kg)
Satellite orbit	248 miles (400 km)	310 miles (500 km)

US short tons—2,000 lb (907 kg).

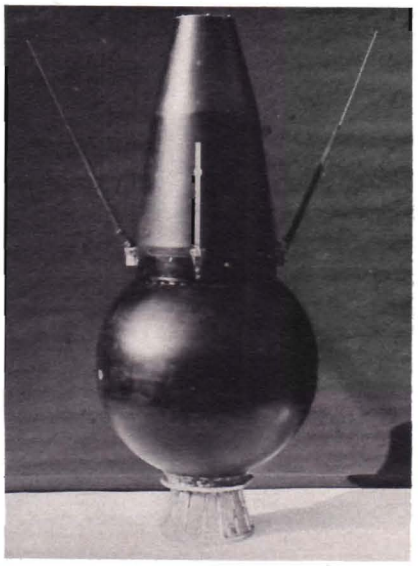
The Mu booster will rise from its launcher under 100 tons of thrust from the M-10 first stage plus a similar amount from eight auxiliary Kappa-class rockets clustered around the base. After the first three stages have fired fourth stage ignition will be commanded by a ground station, and having achieved orbital velocity, the satellite will separate from the final stage.

A series of scientific satellites is under development, the first being MS-1 intended to study electron density, electron temperature, ion density, solar noise and cosmic rays. The 154 lb (70 kg) satellite will have an approximately spherical structure formed by 26 facets. Maximum diameter is 29.5 in (75 cm). Apart from scientific instruments, equipment will include a geomagnetic aspect meter, solar sensor, command receiver, telemetry transmitter, tape recorder, nickel-cadmium storage battery, power converter and solar cells developing 20 W. Satellites two and three will have, in addition to the above, instruments for measuring airglow and atmospheric composition.

Recently I discussed the space programme with leading Japanese officials, Professors Noburu Takagi and Hideo Itokawa. They told me that last summer steps were taken by the Japanese Government to co-ordinate space research and development. On August 3rd the Space Activities Council, which is directly responsible to the Prime Minister, announced that the scientific satellite programme would be under the direction of the Institute of Space and Aeronautical Science of the University of Tokyo. This includes development of the Kappa, Lambda and Mu series of rockets which has given Japan the opportunity to launch her first satellites. By 1970 it is anticipated that Mu will be sufficiently up-rated to orbit satellites of 880 lb (400 kg).

The next stage beyond the present Mu-series of scientific satellites is currently under study. This will be the responsibility of the Space and Technology Agency. It involves both larger scientific satellites and applications satellites but none of this will be accepted for development before the end of the year.

Japan is attempting to launch this test-satellite with Lambda 4S rockets. It comprises the spherical rocket motor of the fourth stage, nose cap containing a transmitter and research instrument, and extensible aerials. The eight-nozzle attitude control unit (not shown) is attached at the base.



What Japan has in mind are satellites having immediate practical value in communications, navigation and meteorology. A communications satellite holds special interest for the Ministry of Posts and Telecommunications whilst the Meteorological Agency is paying close attention to weather satellites which can give advance warning of typhoons which are particularly destructive to life and property along the Japanese coast.

Incredibly, the Japanese space programme began with Pencil rockets only 10 in (28 cm) long in 1955 under the direction of Professor Itokawa of Tokyo University. After ten years of consistent effort and a modest budget by Western standards, significant results are now being achieved over a wide range of altitudes. Last July a Lambda 3H rocket reached a record height of 1,118 miles (1 800 km). There will be much disappointment if 1967-68 does not see Japan a member of the exclusive club of nations—at present comprising Russia, America and France—able to launch their own satellites.

SPACE TERMINAL DOWN UNDER

Australia's Earth Station for communications satellites is being built near Moree, some 300 miles (483 km) north of Sydney. The multi-million dollar contract has gone to Collins Radio Company (Australia) Pty, Ltd.

The ultra-modern terminal will include a 90 ft (27,4 m) steerable dish aerial mounted on top of a slab-sided five-storey support tower with adjoining one-storey flat-roofed station buildings. The terminal will relay television, telephone and telegraph via Intelsat communications satellites in synchronous orbit 22,300 miles (35 880 km) above the Pacific. Initially it will handle 600 telephone calls and one TV channel simultaneously but later the capacity will be considerably increased.

Communications will be possible with any similar station from the US mainland to Thailand, and from Alaska to New Zealand. The contractor, the first to design and build a *complete* station of this kind, is a subsidiary of Collins Radio Company of Dallas, Texas.

SEABORNE COMSAT TERMINAL

Tests of a shipborne satellite terminal for military communications are soon to be made by the Royal Navy from the frigate HMS *Wakeful*. The equipment, called NEST, short for Naval Experimental Satellite Terminal, was developed jointly last year by the Admiralty Surface Weapons Establishment and Plessey Radar of Cowes, Isle of Wight. Its stabilized platform employs Ferranti gyros. Use is made of a 6 ft (1,83 m) diameter dish aerial. The transmitter-receiver has a Mullard amplifier for low-strength signal reception. High-power transmissions require water cooling of the transmitter valve and waveguide systems.

The transmitter, receiver and modulator equipment, aerial control and signal processing equipment, are housed in two transportable cabins specially designed to drop into position on the ship's deck. An auxiliary power supply is provided to augment shipboard supplies.

The trials programme will include extensive experiments in conjunction with three Marconi land-based terminals which have 40 ft (12,19 m) directional antennae, at the Signals Research and Development Establishment, Christchurch, England,

and two others in Cyprus and Singapore. There will also be communication with US ground stations and ships of the US Navy operating in the Pacific.

Satellites used in early tests are those of the Interim Defence Communications Satellite Project being established in multiple launchings by Titan 3C, in near-synchronous orbit at 21,000 miles (33 796 km) altitude. In 1968 Britain expects to have its own US-built military communications satellite in orbit.

MULTI-PURPOSE TARGET

A multi-purpose target vehicle powered by a hybrid rocket motor (part liquid, part solid) is being developed under contracts from the US Air Force Rocket Propulsion Laboratory at Edwards Air Force Base.

An 18-month programme calls for United Technology Centre to design, build and test-fire both static test motors and flight-weight prototype motors. The hybrid system is expected to be less complicated, less expensive, and less sensitive to its environment. The last is especially important as the target missile will be air-launched.

According to UTC, the propulsion system offers for the first time in any rocket engine the ability to select a wide range of flight patterns by the simple expedient of twisting a mechanical dial. Under remote radio control, the liquid oxidizer can be sprayed in varying amounts on to the solid fuel to achieve thrust variations from 500 to 60 lb (226,8 to 27,2 kg). Use is made of a common plastic fuel; the oxidant is a combination of nitric oxides.

The UTC hybrid engine will be a major part of the airframe of the flying target, occupying over 65 per cent of its total length of 15 ft (4,57 m). Various aerodynamic surfaces can be attached to the exterior of the rocket's casing for different missions.

SPACE LASER

A new type of high power laser suitable for communications on Earth and in space has been announced by the Soviet Union. The highly directional infra-red ray is obtained by transparent crystals of fluorite with an admixture of a rare metal, dysprosium, and other unspecified ingredients. According to an official statement, "The invisible ray carries a huge amount of information; communication can be maintained in any weather over great distances from the Earth. Neither fog nor cloud is a serious obstacle." Development has been under Alexander Prokhorov, Lenin and Nobel Prizewinner.

Brazilian Army 114-mm missiles on modified anti-aircraft gun-mounting.

BALLISTICS IN BRAZIL

Artillery rockets designed primarily for coastal defence are now in service with the Brazilian Army. Developed by the Department of Studies and Technological Research, the Type 108-R is a simple, low-cost, bombardment rocket using solid-propellants. It is fired from a battery of 16 tubes from the back of a carrier vehicle of Brazilian manufacture.

The spin-stabilized rockets have a range of 7.45 miles (12 km), rotation being imparted by canted nozzles. They can be fired separately or in different salvo combinations. Each 108-R costs the American equivalent of $34, the launcher $700, less vehicle.

The two-stage 114-mm missile is more elaborate. With a launch weight of 88.2 lb (40 kg) and length of 6.56 ft (2 m), both stages have solid-propellant motors and are fitted with cruciform fins. Maximum speed is about Mach 1.8 and range 15.5 miles (25 km).

Five missiles are carried per launcher which has been adapted from a 90-mm anti-aircraft gun mounting; it can be towed by any Army vehicle.

SOVIET SPACE TEST

Engineer Bogdan, who performed space-simulation tests prior to the first manned flight in a Voskhod spacecraft, was recently reported to be making experiments in long-duration spaceflight with Dr Boris Yegorov, the medical expert who orbited the Earth with two companions in Voskhod 1 in October 1964. The "unusually versatile programme" involved a complete cycle of spacecraft orientation, including manipulation by hand controls and the correction of an emergency situation. The pair worked the equipment inside the cabin, determined the orbital parameters, maintained radio contact with the "command centre" and kept records in a log.

Primary aim of the ground experiment was to test bio-medical effects under conditions "of a particularly long flight." Work inside the spacecraft was preceded by a programme which "instilled the re-subjects." While in the spacecraft cabin quired habits in the organisms of the test-the men endeavoured to retain this conditioning by special exercises. The training was stated to be particularly helpful "in preventing a motionless state of the organism when the heart rhythms grow weak, the muscles become flabby and co-ordination of movement is impaired."

Reporting the experiments the newspaper *Red Star* did not relate them to any particular vehicle or mission. However, they seem more appropriate to space missions of weeks or months than a two-way moon-flight. Could this hint at forthcoming Soviet space-station activity?

CUBAN SATELLITE TERMINAL

The Soviet Union is to help Cuba build a ground station for communications satellites. This will enable the two countries to communicate via Molniya satellites and it should be possible for Cuba to receive television from the Soviet capital. Agreement was reached last October at a Moscow meeting attended by several Eastern bloc countries. Other joint space projects of this kind are expected to emerge elsewhere in the Communist world.

IN BRIEF

The Ministry of Aviation has approved the name "Rapier" for the ET.316 battlefield anti-aircraft weapon developed by British Aircraft Corporation. The highly mobile lightweight system, towed by a Land Rover, should be in service with the British Army next year. Trials have been highly successful and a good export market is expected to develop.

★ ★ ★

ESRO 2, the first European satellite jointly developed by Hawker Siddeley Dynamics, Engins Matra and others, left Britain for the United States on January 6th. It is due to be launched by NASA from the Western Test Range, California, by a Ling-Temco-Vought Scout on or about March 1st. Primary object is to measure solar and cosmic radiation. UK-3, first all-British satellite built by British Aircraft Corporation, is scheduled for launching by a Scout, also from the PMR, at about the same period. Experiments include measurement of molecular oxygen in Earth's atmosphere, radio noise from the galaxy, very low frequency radiation and radio signals from natural terrestrial sources. Measurements will also be made of electron density and temperature in the radio-reflecting layers of the ionosphere.

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It will also be useful to C.P.L. students, and qualified private pilots as a reference book. Price 10/9d.

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WORLD PRODUCT REVIEW

HIGH STRENGTH BEARINGS

SMALL PLAIN and spherical ptfe bushes with high mechanical strength and low co-efficient of friction have been developed by Ampep Industrial Products Ltd. The bearing layer is made up of a fabric woven from multifilament ptfe yarn and secondary yarns such as cotton or glass fibre. It will accept dynamic bearing pressures of 30,000 lb/sq in. Good performance under high frequency, small amplitude and heavy oscillating loads is claimed.

Circle No 40 on Reader Service Coupon

AERIAL UNDERGROUND EXPLORATION

MAPPING the subterranean geology of the earth can now be undertaken from the air with a new geomagnetic prospecting device. Known as a gradiometer it consists of two rubidium magnetometers housed in separate aerodynamic pods one 100 ft vertically above the other. Used together they will outline the shape, size and depth of underground oil-bearing formations. Sensitivity of the gradiometer is 0.01 gamma or one part in five million of the earth's total magnetic field.

Advantages claimed by the manufacturer Varian Associates, California, include a high sensitivity to vertical components of the earth's field enabling geologists to determine the depth and characteristics of underlying structures. A further advantage lies in the independence of the equipment to the changes of the earth's field intensity. A survey giving a map of the total magnetic force and a map of the gradient of the field are both keyed to aerial photographs for analysis.

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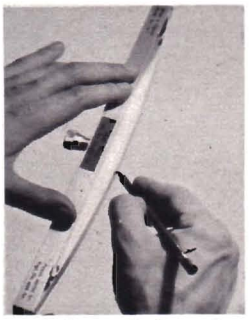
CURVES OF ALMOST ANY RADIUS



A SIMPLE drawing instrument that can be adjusted to give an arc of any radius from 27.25 in (69.2 cm) to infinity has been designed by Alan Fry Controls Ltd for draughtsmen and designers. A small thimble control on the back face of the rule makes setting the curve extremely easy. The Arc Rule is available in lengths of 12 in (30 cm), 38 in (95 cm) and 60 in (150 cm).

Circle No 42 on Reader Service Coupon

FRENCH VASI UNIT

FROM PARIS comes news of a new visual approach slope indicator (VASI) with three optical units, each one being sufficient by itself to meet the ICAO requirement covering these indicators. Each lamp unit is permanently adjusted in the manufacturer's factory—Barbier, Benard & Turenne. They are mounted in rigid frames designed not to lose their shape or the required approach slope. A simple levelling device is fitted to make setting-up easy.

Circle No 43 on Reader Service Coupon

CONVEYOR FOR SMALL PARTS

TRANSFER of Lufthansa documents and small spare parts has been greatly simplified at the airline's Hamburg Airport site by a new pneumatic tube transport system. The builders, the Siemens Organisation, claim that the tube network covering a 100 acre site has revolutionised the handling of servicing spare parts. About 85 per cent of these units are now sent through the four-inch pneumatic tube. The system has 61 despatching and receiving stations with a total of 151 destinations arranged in nine groups.

Circle No 44 on Reader Service Coupon

HIGH SPEED STICK

A NEW cyanoacrylate adhesive which can bond non-porous materials in seconds at normal room temperatures has been developed by Loctite. It is ideal for applications where quick setting is essential or where design requirements involve small

READER INFORMATION SERVICE

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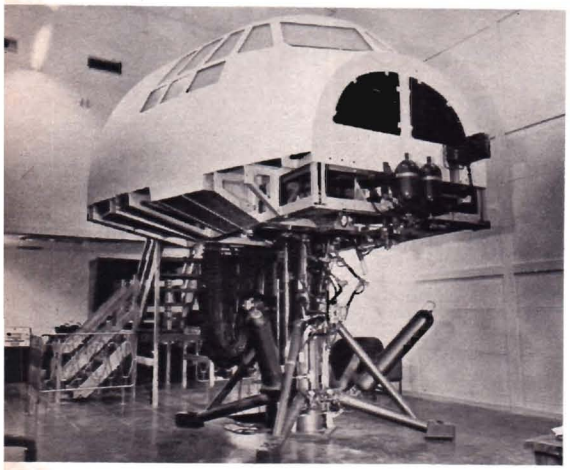
jointing surfaces. The new adhesive is suitable for metals, plastics, rubber, wood, glass and ceramics and will bond dissimilar materials.

Circle No 45 on Reader Service Coupon

BELFAST SIMULATOR

FIRST to be installed in the new simulator building at RAF Brize Norton—and operational since November 1966—is the Short SC.5 Belfast simulator, manufactured by Miles Electronics Limited. It is equipped for pilot, co-pilot and engineer, with an instructor's console in the navigator's station. The simulator is free to move in three axes, pitch, roll and heave,



(above) and in addition to full simulation of all the aircraft systems, the noise system faithfully reproduces the appropriate sounds. First to be fitted with Smiths Triplex Autoland to enable pilots to practice automatic landings, it is also the only military transport simulator with Elliott-Automation head-up display. The computer is 70 per cent analogue and 30 per cent digital, the latter being designed specially by Miles for the radio aids system which is capable of producing synthetic signals representing 60 ground radio stations simultaneously transmitting to 12 different airborne receivers in the simulator and a facility is provided for changing the programming of radio stations by the simple insertion of a punched programming tape. Radio aids include ILS, VOR, ADF and TACAN and the instructors' Radio Instrument Console and Track Recorder unit contains, in addition to the radio aids and faults selectors, all the controls and instruments necessary to conduct the exercises efficiently (below).

The Belfast simulator is shortly to be equipped with a colour vision system of Brize Norton and surrounding district which is being supplied by Redifon Ltd who are also supplying a VC10 simulator. Both simulators will use the same visual system.

Circle No 46 on Reader Service Coupon

ONE-ELEVEN SIMULATOR

A SERIES of fortunate co-incidences gave General Precisions Systems Ltd an opportunity to demonstrate a complete simulator and colour visual attachment recently under training conditions. Two factors contributed to this first ever demonstration of its kind at the company's Aylesbury factory. For the first time GPS provided the colour equipment at the same time as the simulator —a One-Eleven cockpit with a model of Dulles Airport, Washington and the surrounding countryside for American Airlines. Up to that time it has always supplied the colour system separately. Second factor was that although GPS had the complete unit ready AA had not finished its building at Fort Worth. When ready, the training complex there will include a Boeing 727 simulator using the same Link computer and airport model as the One-Eleven.

When the complete GPS unit is installed in the US it is expected to be the first to get a full FAA certificate of approval—the unit has already been cleared in Britain by the Authority and the airline. But General Precision felt satisfied with the equipment approval by AA since an airline acceptance is far more stringent than any government agency. TWA has a GPS colour attachment being fitted to one of its simulators which will run a close second for certification.

As can be seen from the above illustration, colour visual projection is impressively lifelike, especially when coupled with tricks of the simulator trade like inducing take-off acceleration. Colour visual attachments have been ordered for 18 simulators and seven are at the moment being installed.

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HANDWRITING SAVES MONEY

BEA IS SAID to be saving up to £100 a day by using a chain of telegraphic writing and receiving machines, their manufacturer Modern Telephones (GB) Ltd claims. The equipment, known as Electrowriters, links together the Corporation's ground control units at Heathrow Airport, London. Feature of the system is that a hand-written message is received as it is written and as a permanent copy. This saves time by making the message transmitting system available to everyone.

A total of 112 Electrowriters have been installed at Heathrow for BEA, PAA, TWA, BOAC, Air Canada, and British Eagle International.

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NEW ACTUATORS

TWO NEW, high performance, ultra light-weight actuators designed to operate aircraft fuel cocks and valves have been produced by the Electrical Equipment Division of the Plessey Dynamics Group. Both units, Mole and Cub-Mole, are tropicalised and will operate in the temperature range —45°C to +120°C.

Mole has a maximum working load of 100 lb-in and travels 30° to 330° in 3 seconds to 30 seconds. An electromagnetic brake minimises overrun. Mole weighs 1.01 lb (0,46 kg). Cub-Mole has a maximum working load of 50 lb-in and weighs 13.5 oz (383 grm).

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CONTRACTS OF THE MONTH

AIRBORNE EQUIPMENT An order estimated to be worth £3.5m will be placed by BEA for automatic blind landing equipment made by *Smiths Industries Aviation Division*, Cheltenham, to be fitted to the Corporation's existing fleet of Trident 1s and 15 Trident 2s on order ★ South African Airways ordered AD 560 Doppler equipment from the *Marconi Co Ltd*, Chelmsford, for its seven new Boeing 707s ★ Five sets of Slimline aircraft seats worth £50,000 with spares were ordered for Air Algerie Caravelles from *L A Rumbold Co*, London ★ National Airlines ordered sets of Zephyr 2 passenger seats for its fleet of 25 Boeing 727-200 aircraft from *UOP Transportation Equipment Division*, Illinois ★ An order for CL.11 compass systems was placed with *Sperry Gyroscope Co*, Brentford, by the Ministry of Aviation for the new anti-submarine Westland-Sikorsky SH-3D helicopter ★ Another order for helicopter equipment was placed with *Collins Radio Co* for FD-105D flight director systems to be fitted to 13 HH-3F aircraft for the US Coast Guard ★ Handley Page Jetstream wings will be built by *Scottish Aviation Ltd*, Prestwick, under a contract worth £500,000 ★ MoA ordered high altitude pressurised clothing, life jackets, and immersion suits for RAF and RN Phantom crews from the *Frankenstein Group*. Delivery starts in the second half of this year ★ A range of electric fuel booster pumps were ordered by BAC for the Concorde from the *Plessey Dynamics Group*. Each aircraft will have 36 of these pumps. Four new types of actuators designed and built by Plessey were also ordered for the engine areas of this aircraft ★ Experimental take-off directors, which will give a Concorde pilot immediate and comprehensible instructions for achieving the best take-off path at any weight, airport elevation and ambient temperature and which automatically take into account an engine failure, were ordered by Sud from *Elliott-Automation Ltd*, London ★ Loran radio navigation systems worth £132,000 were ordered by Sud from the *Sperry Rand Corp*, New York ★ Electronic overspeed trip units for the Bristol Siddeley Gnome engine and worth £400,000 were ordered from *Smiths Industries Aviation Division*, Cheltenham ★ Royalite rubberised plastics were specified for two aircraft, Boeing 707s of BOAC which are being refurbished and for the Britten-Norman Islander. Royalite is made by *Uniroyal Ltd*, Edinburgh ★ High temperature solenoid valves were ordered from *Hymatic Engineering Co Ltd*, Redditch, for the Short Skyvan.

RESEARCH HMSO ordered an ICT 1900 series computer from *International Computers and Tabulators Ltd*, Putney, for use by MoD at the Defence Codification Data Centre, RAF Hullavington, Wilts ★ A data analysis centre is to be set up at Southampton University under a Science Research Council grant of £55,000 to compute information on sound and vibration.

continued from page 414

Hispano-Suiza (France) Main landing gear anti-skid brakes.
Hughes Johnson Stampings Ltd (UK) Small-medium steel forgings.

Industrial Acoustics Co Ltd (UK) Ground noise suppressors.
International Wilcox Electric Inc (USA) ATC transponders, VHF communications.
Imperial Metal Industries (Kynoch) Ltd (UK) Titanium bar for blade forgings.
Integral Ltd (UK) Hydraulic pumps.
Intertechnique (France) Fuel gauging systems.

Jaeger (France) Engine monitoring systems and miscellaneous instruments.
Jessop-Saville Ltd (UK) Titanium alloys, forgings.

Kollsman Instruments Ltd (UK) Servo altimeters, ASIs, Machmeters, temperature, diff. pressure and other flight instruments.
Kidde, Walter Ltd (UK) Oxygen system components.

LMT-Le Materiel Telephonique (France) Simulator.
Lucas Gas Turbine Equipment Ltd (UK) Design and construction main engine fuel system.

Marconi Instruments Ltd (UK) Microwave equipment.
Marconi Co Ltd (UK) Doppler, DME, Selcal.
Messier (France) Nose landing gear, tail bumper.
ML Aviation Co Ltd (UK) Cartridge ejection for accident recorders.
Monk Bridge Iron & Steel Co Ltd (UK) Compressor blades and forgings.

Napier D & Sons Ltd (UK) Environmental testing.
Normalair Ltd (UK) Cabin pressure regulator; environmental testing, anti-icing control.

Page Engineering Co (Sunbury-on-Thames) Ltd (UK) Electrical instruments, fire alarm systems.
Palmer Aero Products Ltd (UK) Fuel filters.
Pechiney (France) Non-ferrous metals.
Plannair Ltd (UK) Cooling fans for flight data recorders.
Plessey Co Ltd (UK) Actuators; fuel electro pumps; engine starters.

Radiation Inc (with BAC) (USA) Magnetic flight test recorders.
Ransome & Marles Bearing Co Ltd (UK) Ball and roller bearings.
Redifon Ltd (UK) Simulator sub-contractors.
RFD Co Ltd (UK) Emergency equipment.

Rotax Ltd (UK) Contactors, de-icing, electronic timer etc.
Rosemount Engineering Co Ltd (UK) Temperature and air data sensing equipment, deicing heaters.

SAFT—Societe des Accumulateurs Fixes et de Traction (France) Batteries.
SAGEM—Societe d'Application Generale d'Electricite et de Mecanique (France) Gyros, accelerometers and AE 51 general purpose digital computer for SAGEM/Ferranti nav system.
Saunders Valve Co Ltd (UK) Fuel electro valves.
SECAN—Societe d'Etudes et de Constructions Aero-Navales (France) Hydraulics/fuel heat exchangers.
SEMCA (France) Air starter, electro valves.
Serck Radiators Ltd (UK) Oil coolers; heat exchangers.
SFENA—Societe Francaise d'Equipements pour la Navigation aerienne (France) Flight directors, gyro horizon VOR indicators.
SFIM—Societe de Fabrication d'Instruments de Mesure (France) Altitude indicator; oxygen regulator.
Smiths Industries Ltd (UK) Ice detectors; navigation and engine instruments; high temperature engine equipment.
Sperry Rand Corp (USA) Loran C nav equipment.
Sofrance (France) Hydraulic filters.
STAREC (France) Antennae ATC, DME, marker.
Sterling Metals Ltd (UK) Magnesium and aluminium castings.

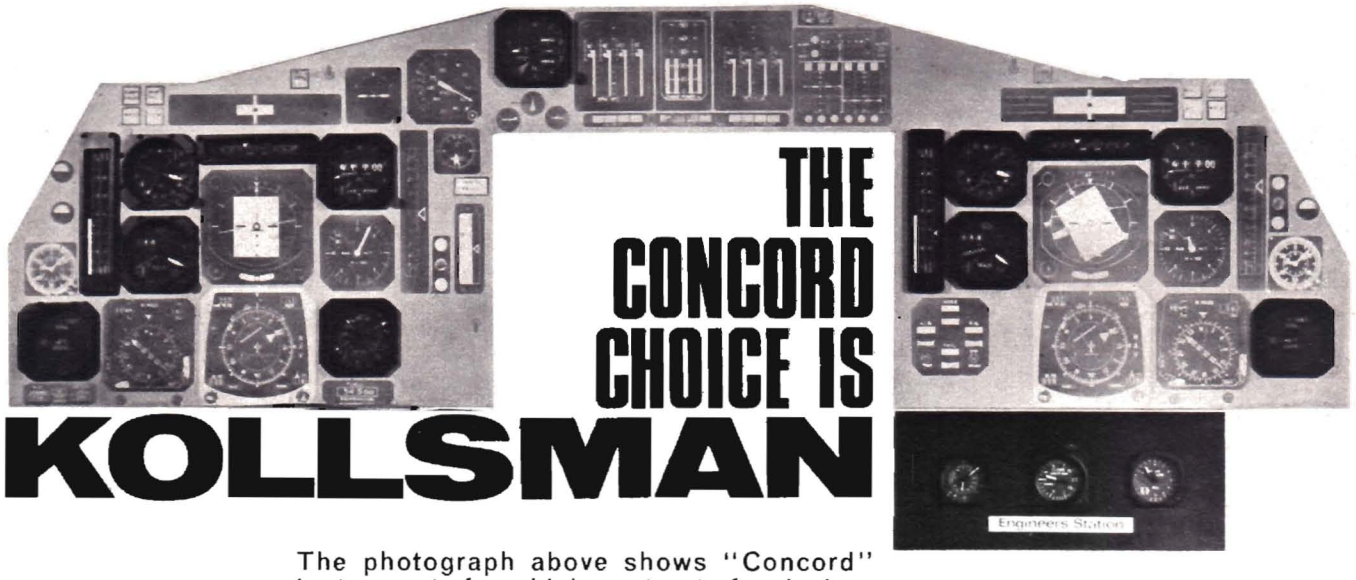
TEAM—Telecommunications Electronique Aeronautique et Maritime (France) Public address systems.
Teddington Aircraft Controls Ltd (UK) Hot air valve and sensing units.
Teleflex Products Ltd (UK) Landing lamps and pilot seats.
Triplex (France) Windscreens and cabin windows.
Triplex Safety Glass Co Ltd (UK) Windscreens.
Titanium Metal Alloys Ltd (UK) Titanium blade fixing rings.
TRT—Telecommunications Radio-electriques et Telephoniques (France) Autoland radio altimeter.
Thompson Ramo Wooldridge Inc (USA) Fuel electric pumps.

Ultra Electronics Ltd (UK) Control amplifiers, engine transducers, throttle transmitters; engine air intake controls.
Union Carbide Ltd (UK) Alloy materials for precision casting.

Vactric Control Equipment Ltd (UK) AC motor generators and pick-offs.

White & Nunn Ltd (UK) VOR/DME/ATC remote control.
Wiggin, Henry & Co Ltd (UK) Nimonic bar, sheet, tubes, precision castings.

Zenith (France) Refuelling collectors.



THE CONCORD CHOICE IS KOLLSMAN

The photograph above shows "Concord" instruments for which contracts for design, development and manufacture have been awarded to Kollsman Instrument Limited by Sud Aviation and British Aircraft Corporation (Operating) Limited.

Kollsman Instrument Limited
THE AIRPORT SOUTHAMPTON HAMPSHIRE Tel Eastleigh 2731

AIRLINES THROUGHOUT THE WORLD RELY ON KOLLSMAN RESEARCH AND DEVELOPMENT

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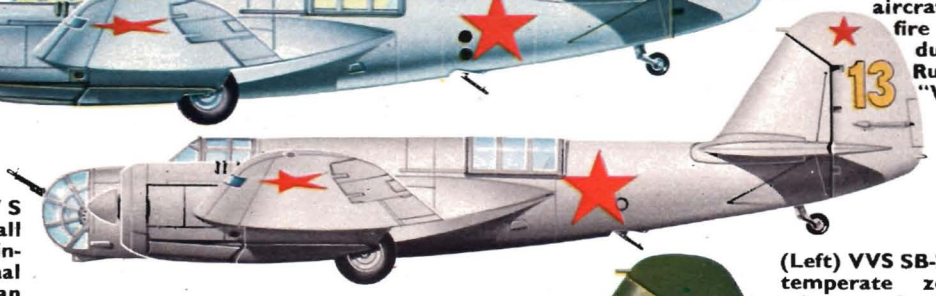
SB-2 and SB-2bis

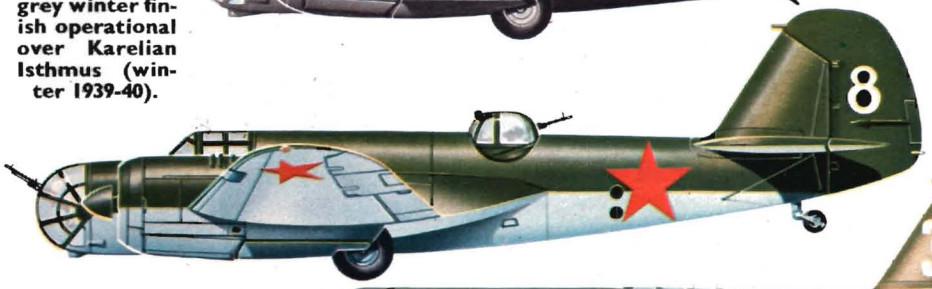
(Immediately below) An SB-2 of the VVS in natural metal finish captured in the western Ukraine (August 1941).

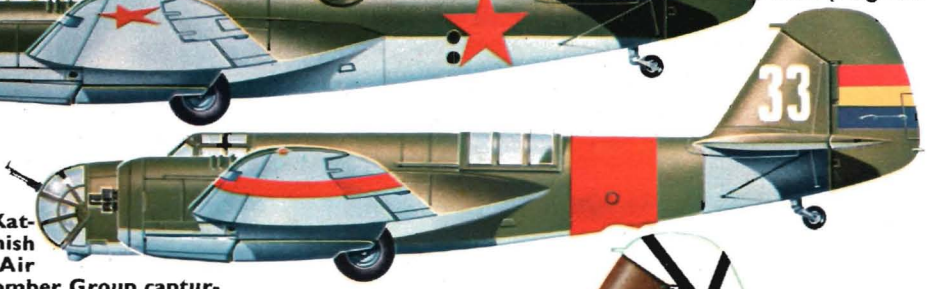
(Right and below) Tail markings of four VVS SB-2s in overall grey winter finish destroyed by Finnish fighters and anti-aircraft fire during Russo-Finnish "Winter War" (1939-40).



(Right) V V S SB-2 in overall grey winter finish operational over Karelian Isthmus (winter 1939-40).

(Left) VVS SB-2 in temperate zone scheme of olive drab and pale blue which force-landed behind German lines (August 1941)

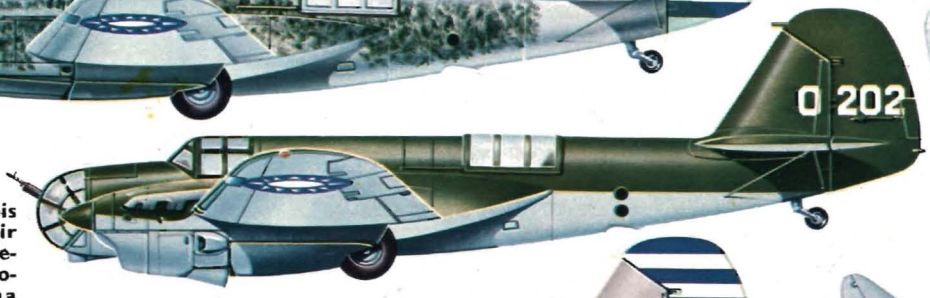




(Right) SB-2 'Katiuska' of Spanish Republican Air Force's 24th Bomber Group captured by Nationalist Forces, and (below) SB-2 'Sofia' of Spanish Nationalist Group 20W (1939).

(Right) The first of 30 Russian-built SB-2s delivered to Czechoslovak Air Force (B 71.1) in light grey overall finish (1937).

(Below) SB-2 of Chinese Air Force operational in vicinity of Hankow (1937).



(Right) SB-2bis of Chinese Air Force which defected to Cochin China (November 1941).

(Below) SB-2bis of Chinese Air Force (1944-45).

(Above) Upper and lower surfaces of SB-2 of Spanish Nationalist Group 20W (1939).

W R MATTHEWS

MODELLING

Can 'Gimmickry' add to Realism?

AS FAR AS WE ARE AWARE the precise meaning of that widely-used Americanism "gimmick" has yet to be defined by the standard works of reference. With tongue in cheek, we humbly suggest some such definition as "A mechanical contrivance frequently of needless complexity and rarely serving a useful purpose." Such a definition certainly *would* be appropriate insofar as the modeller is concerned, for gimmickry is exactly what those manufacturers employ who, carried away with enthusiasm, introduce immense pods ejecting small rockets by means of rubber bands, and undercarriages and control surfaces operated by pulling on myriads of tiny threads. A basic feature of the model assembled from a plastic kit is that its sections are hollow, offering the manufacturer the possibility of incorporating operating parts, such as weapons-bay doors and even small electric motors to spin airscrews. There can be no doubt that such features as, for example, a retractable undercarriage which faithfully reproduces in miniature the full-scale original greatly enhances the realism of any model, and working features of this type are merely an extension of the process of detail development which has made the modern plastic model so immeasurably superior to its wooden counterpart of many years ago.

Such working components are *not*, to our mind, gimmickry, yet many modellers who would violently criticise a kit that did not embody profuse and fine detail on the grounds that it did not make up into a realistic representation of the full-size aircraft, often dismiss a retractable undercarriage out of hand, cementing the moving parts rigidly into place. We have difficulty in understanding this attitude for, after all, an aircraft with a retractable undercarriage, be it Starfighter or Spitfire, is that much less accurate in miniature if its undercarriage is fixed. May we suggest to readers contemptuous of working components that they inspect the kit carefully before assembly, and if the moving components are, in themselves, accurate, and do not distort the finished model, they try assembling them in the form intended by the manufacturer. We are sure that they will not be so contemptuous of such in the future. After all, although "gimmick" may not yet have been defined, the definition of a model is "An accurate representation of an original in miniature", and the emphasis is on "*accurate*" which, in an aircraft model, applies as much to the flaps or undercarriage as to the finish.

THIS MONTH'S COLOUR

There can be no doubt that the ANT-40, alias SB-2, was of very advanced concept at the time of its debut. Already in production when the Blenheim—considered by many to have been epoch-marking in the history of high-speed bomber development—was still on the Filton drawing boards, this remarkable Soviet warplane was destined to have a long service career during which it was to bear the markings of a variety of air arms and fulfil almost as many roles. The number of kits of Soviet warplanes readily available in the West may be counted on the fingers of one hand, and it is therefore with particular pleasure that we can reveal that a kit of the SB-2 is to be marketed by a well-known British manufacturer during the course of this summer. Depicting a late-production version of the basic SB-2 (with the shuttered frontal-type engine radiators) insofar as it features a dorsal gun turret, the kit will lend itself readily to conversion to the earlier turretless version such as was used in China, achieved such notoriety over Spain, and was manufactured under licence in Czechoslovakia. The conversion addict will find that the SB-2 will afford him a field day without demanding more than a modicum of ingenuity, as the drawings on the opposite page and illustrating the accompanying feature on this distinguished aircraft will reveal.

CONCORDE BY AIRFIX

It seems probable that as many models of the Concorde SST will eventually appear on the stockist's shelves as have models of the Boeing 707, and Airfix's 1/144th scale kit is the second to appear on the market, yet another year has to elapse before the first Concorde is scheduled to fly. This kit makes up into a model of the first prototype in the form in which it is to fly on February 28, 1968, and Airfix informs us that they plan to change the kit to conform with the progressive changes expected to be embodied by later Concorde SSTs. The kit is neatly pressed and simple to assemble, although the wings have suffered some shrinkage. On the whole, the component parts fit together well, but the wing halves do not join up quite so accurately as might be desired. An undercarriage is included, but as the nose and cabin visor of the kit are fixed in the flying attitude, it is best to omit this and mount the finished model on the stand provided. The transfer sheet, providing Air France markings, is well printed, and at its UK price of eight shillings and sixpence the kit is good value.

WIDOW MAKER AND THUNDERBOLT

Some very well-known aircraft have been poorly represented in plastic kit form hitherto, and although in general we are against duplication of types already represented in manufacturers' lists and readily available on the market, we welcome a new kit of such a machine if those already available do not do the subject justice. Martin's B-26 Marauder is one such, and at last a really *good* kit is available of the "Widow Maker", a 1/72nd scale offering of the B-26B from Revell. Acceptably accurate, cleanly pressed, and assembling well, Revell's B-26B features highly-detailed engines which may be exposed by detachable cowlings, and a considerable amount of cockpit detail may be seen through the exceptionally clear transparencies. The transfer sheet, which provides the markings of the well-known "Flak Bait" now preserved in the Smithsonian Institute, is beautifully printed; the instructions are clear and easily followed, and the box-lid painting, as is so often the case with Revell kits, is truly a work of art. The ultra particular modeller may feel that the rivet detail is a trifle on the heavy side, and the code letters on the transfer sheet should be light grey and *not* white, but these are minor faults indeed in a kit which, at eight shillings and sixpence in the UK, is first class value for money.

Airfix's P-47D Thunderbolt is, by contrast, rather disappointing. Again to 1/72nd scale, accurate and finely detailed, its peculiar method of wing assembly results in wing sections that do not fit the fuselage correctly, and a great deal of work with files and filling material is necessary to obtain an acceptable result. This spoils the entire model which, otherwise, has some virtues, and we cannot recommend this kit even at the low price of two shillings and threepence in the UK in preference to some of the other Thunderbolt models already available.

CONVERSION KITS

An ingenious idea comes from a new US company, Koster Aeronautical Enterprises of 856 Mason Lane, Des Plaines, Illinois 60016. This is a kit of parts, vacuum-formed in a sheet of thin polystyrene, which enables the Monogram 1/48th scale Bf 109E and Spitfire IX to be converted to Bf 109F or G and Spitfire VII, L.F.VIII. The parts are finely detailed, and although they have to be cut from the sheet, this operation should present no serious difficulty. An excellent instruction sheet is included with each kit. However, owing to the thin plastic used it is advisable to fill some of the deeper sections, such as the nose and spinner of the Bf 109, with body putty or some similar material before cutting out. The price of each kit in the USA is $1.50, and we can foresee very large sales for these and similar products.

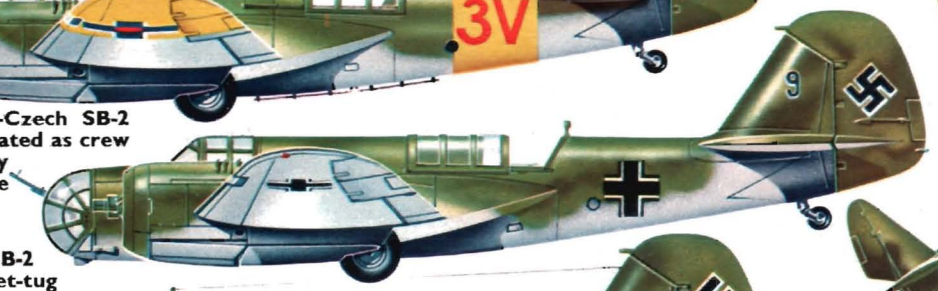
NEW KITS (latest review copies received)

MAKE	AIRCRAFT	SCALE	PRICE
RUCH (Poland)	PZL P-11c	1/72nd	—
RUCH	PZL P-23A Karas	1-72nd	—
AIRFIX	Boeing 314A Clipper	1-144th	7s
FROG	Hawker Tempest V	1-72nd	2s 6d
MONOGRAM	North American P-51B Mustang	1-48th	—
MONOGRAM	Vought OS2U-3 Kingfisher	1-48th	—
V.E.B. (E. Germany)	MiG-21	Believed 1-50th	—
V.E.B.	Ilyushin Il-62	Believed 1-100th	—
Lindberg	Dornier Do 335A	1-72nd	Believed 50 cents (U.S.)
Lindberg	Henschel Hs129	1-72nd	

(Below) SB-2 (B 71) operated by the Slovak Air Force (Trencin, 1944).

(Below) Upper surfaces of Luftwaffe SB-2 (B 71) illustrated lower left. Note non-standard camouflage and absence of national insignia on upper surfaces.

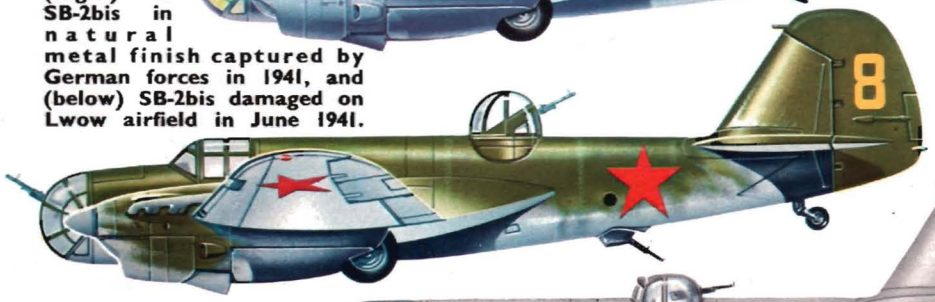
(Right) Ex-Czech SB-2 (B 71) operated as crew trainer by Luftwaffe (1939-40).



(Below) SB-2 (B 71) target-tug (1940-41) probably operated by Luftwaffe's Fliegerzeilgeshwader 1.

Undersurfaces of this aircraft illustrated far right.

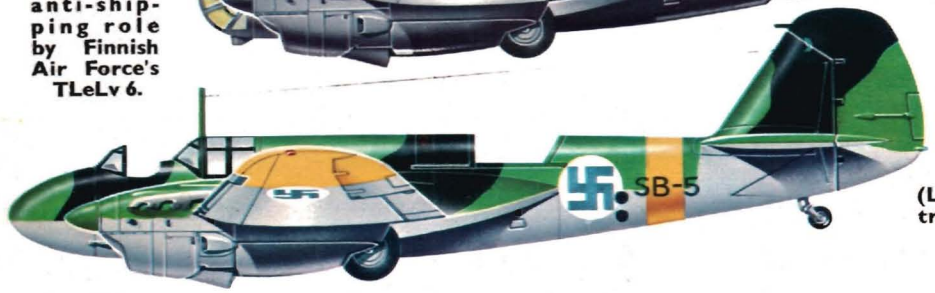
(Right) VVS SB-2bis in natural metal finish captured by German forces in 1941, and (below) SB-2bis damaged on Lwow airfield in June 1941.



(Right) VVS SB-2bis in overall grey winter finish captured by German forces late 1941.

(Below, left) An SB-2bis (SB-14) captured in Ukraine and operated by Finnish Air Force (1943-44).

(Right) An SB-2bis operated in anti-shipping role by Finnish Air Force's TLeLv 6.



(Left and above) An SB-2bis pilot trainer conversion operated by Finnish Air Force (1942-44).

TUPOLEV'S 'FRONTAL BOMBER' . . . THE SB-2

THE HISTORY OF AVIATION has been punctuated with epoch-marking strides that could not be attributed to the genius of a single designer or technician; developments that, collectively, advanced the state-of-the-art in their particular spheres and which were the outcome of research and experiment started spontaneously and independently in several countries almost simultaneously. One such development was the high-performance twin-engined all-metal cantilever bombing monoplane, the début of which rendered most contemporary interceptors obsolescent overnight and set fighter armament specialists by their heels the world over.

Until the early thirties high speed had not been a prerequisite in the specification of any but the smallest bombers. Indeed, in essence bomber design had progressed remarkably little since the end of the First World War. Thirty-four years ago, however, in 1933, a new era in bomber design dawned; the era of the all-metal twin-engined bombing monoplane embodying such refinements as enclosed cockpits and retractable undercarriages. In January of that year Martin's experimental Model 123 was ordered into production for the US Army Air Corps to emerge in the following year as the Model 139, while during the early summer months of 1933, on the other side of the globe in the Soviet Union, one of the most talented of Andrei N Tupolev's design bureau leaders, A A Arkhangel'sky working at the TsAGI (the Central Aero and Hydrodynamic Institute in Moscow) began the design of a closely comparable bomber which was to emerge in prototype form in 1934 as the ANT-40. Destiny was to dictate that the Soviet bomber was to see an appreciably longer operational life and be manufactured in incomparably larger numbers than its American counterpart, and was to link these two bombers from opposite sides of the world in an unexpected fashion early in their service careers.

ADVANCED IN CONCEPT

The Martin 139 and the ANT-40 set the pattern in twin-engined bomber design for the next decade, a pattern which other nations were not slow to follow. Both bombers were advanced in concept and the best aircraft in their class at the time of their service débuts, but whereas the American bomber was essentially a private venture, unhindered by specific US Army requirements, the ANT-40 was designed to meet the requirements of a rigid official specification calling for a "frontal bomber"—a three-seat high-speed aircraft of relatively short range and suited for co-operation with land and naval forces. Indeed, had Arkhangel'sky confined himself to the demands of the specification it is improbable that the ANT-40 would have seen large-scale production.

The sole SB-2 operated by the Slovak Air Force. Nicknamed "Antka", this aircraft was flown by its defecting crew from Trencin airfield in Slovakia to Turkey in August 1944, its crew making its way to the UK to join the Free Czech Air Force.

The specification demanded a maximum speed of 205 mph (330 km/h), or 50 per cent more than that attained by the current TB-3, and a ceiling of not less than 26,250 ft (8 000 m). Range and bomb load requirements were not particularly ambitious at 435 miles (700 km) and 1,100 lb (500 kg), and landing speed was not to exceed 68 mph (110 km/h). From the outset it was obvious that the specification demanded a complete departure from previous Soviet bomber design practice, and Arkhangel'sky, who was at that time engaged in the design of the ANT-29 twin-engined two-seat recoilless cannon-armed fighter, shelved work on the earlier project to meet the needs of the new requirement. Utilising experience gained in the design of the fighter, Arkhangel'sky evolved a clean cantilever monoplane of essentially similar configuration to the ANT-29, with internal bomb stowage and an enclosed position for the nose gunner who previously had been left unprotected from the slipstream. It differed from all previous TsAGI aircraft in having smooth dural skinning for both wings and fuselage, the latter being a light monocoque structure, a method of construction entirely new to the Soviet Union, and, indeed, to most of the rest of the world.

Arkhangel'sky felt strongly, however, that the official specification did not go far enough, and he discussed his ideas for increased fuel tankage and other changes with his chief, Andrei Tupolev, who, on his own initiative, agreed to the incorporation of these modifications in the second of the two prototypes that had been authorised. The project had been allocated the design bureau designation ANT-40, and it had been decided to install a pair of M-25 nine-cylinder radial air-cooled engines in the first prototype and two M-100 twelve-cylinder Vee liquid-cooled engines in the second, both types of engine being fitted with single-speed superchargers. It was proposed that a final choice of engine would be made after comparative flight trials, but so highly promising was the estimated performance data that, in April 1934, while the prototypes were still under construction, Tupolev was informed that the decision had been taken to initiate preparations for large-

Above, a number of SB-2bis bombers were converted for the pilot training role, and this captured example (SB-5) is seen in service with the Finnish Air Force. Left, this late production example of the SB-2bis serving with the VVS early in 1942 was fitted with one of the several types of dorsal turret eventually fitted to this type, and had a more elaborate ventral gun position.

scale production immediately, and lay down assembly lines at several plants, the ANT-40 being allocated the service designation SB-2 ("SB" indicating *Skorostnoi Bombardirovshchik*, or Fast Bomber).

The first prototype, intended to meet the requirements of the official specification in every respect and powered by two M-25 radials rated at 730 hp for take-off and 700 hp at rated altitude, had a fuel capacity of 207 Imp gal (940 l) to meet the original range requirement, and flew for the first time on October 7, 1934. During the subsequent test programme, this prototype attained a maximum speed of 202 mph (325 km/h) at 13,125 ft (4 000 m) at a loaded weight of 10,398 lb (4 717 kg), and a ceiling of 22,310 ft (6 800 m). On December 30, 1934 the second prototype joined the test programme, its M-100 liquid-cooled engines providing 830 hp for take-off and 750 hp at 14,110 ft (4 300 m). These engines, which were more powerful and offered a better altitude performance than the M-25, had shuttered frontal-type radiators and contributed appreciably less to overall drag than the radial cowlings. Internal fuel tankage was almost doubled at 376 Imp gal (1 670 l), transforming what was originally an essentially short-range bomber into an aircraft capable of operating over what at that time were considered to be medium ranges. However, most marked was the improvement in performance over the first prototype, a maximum speed of 251 mph (404 km/h) being attained at 16,405 ft (5 000 m) at a loaded weight of 11,022 lb (5 000 kg), and ceiling being 30,840 ft (9 400 m). It was immediately apparent that the M-100-powered aircraft could outpace any Soviet fighter or, for that matter, any fighter extant.

After completing factory trials, the second prototype was delivered to the official flight test centre for State Acceptance Trials, and although these were not to be completed until July 1935, the decision had already been taken to base the production model on the M-100-powered second machine, and the first series production SB-2s joined VVS bomber formations during the first months of 1936.

BLOODED IN COMBAT

The production SB-2 was a rugged and basically simple three-seater with pleasant flying characteristics if somewhat heavy controls, and the crew, who could not exchange their positions in flight, comprised a pilot, a navigator-bombardier in the extreme nose with twin 7,62-mm ShKAS machine guns with 700 rounds of ammunition, and a radio operator-gunner who was provided with a single 7,62-mm ShKAS with 1,000 rounds beneath a glazed sliding dorsal hatch, and a similar weapon with 500 rounds which could be fired through a hatch in the floor of the rear fuselage. The only armour protection provided was the 9-mm armoured pilot's seat back, and all fuel was housed between the two wing spars, two tanks being mounted in the centre section and two being mounted immediately outboard of the outer panel attachment points. The engines drove two-bladed V-100 metal airscrews, the pitch of which was adjustable on the ground, and the weapons bay immediately aft of the pilot's cockpit could accommodate a variety of loads, such as a pair of 550-lb (250-kg) bombs, four 220-lb (100-kg) and two 55-lb (25-kg) bombs, or six 154-lb (70-kg) and four 22-lb (10-kg) bombs. Normally six vertical racks intended for 154-lb (70-kg) and four horizontal racks for 22-lb (10-kg) bombs were installed. The main undercarriage members retracted aft into the engine nacelles, part of each wheel remaining exposed when the unit was fully retracted, and the retraction mechanism being actuated electrically. The legs had oleo-pneumatic shock absorber struts and oleo brakes.

Owing to the high priority allocated to the manufacture of production tooling for the SB-2 before even the prototypes had flown, delivery tempo built up rapidly, attaining a peak of 13 aircraft per day in 1937. The Russians were in little doubt that in the SB-2 the VVS possessed the best bomber in its category in the world, but they were anxious to evaluate the new warplane under true operational conditions, and when, on July 18, 1936, elements of the Spanish forces rebelled against the Communist-dominated Republican government, the Soviet government was presented with an ideal testing ground over which to wring out the SB-2's remaining teething troubles and simultaneously evolve suitable operational tactics. As soon as it was obvious that the Republican government was not going to quell the revolution quickly, and despite being a signatory to the Non-Intervention Agreement of August 23, 1936 and Josef Stalin's subsequent decree ostensibly forbidding the export of Russian war materials to Spain, the Soviet government began shipping arms to the Republican government late in September. During the first three weeks of October a dozen Russian cargo vessels carrying arms passed the Bosphorus en route for Spain, although ostensibly bound for Mexico, London and Hamburg, and along with the first shipments of tanks, guns and ammunition to leave Odessa were SB-2 bombers together with their VVS crews.

In payment for the bombers and other war materials Spanish gold to the value of £63,265,684 was shipped by the Republicans from Cartagena for Odessa on October 25, 1936, so Soviet motives were in no way altruistic, payment being made for the bombers and the services of their VVS crews and, simultaneously, the desired operational experience being obtained. The first appearance of the SB-2 in Spanish skies took the opposing Nationalist forces completely by surprise. It was faster than the Fiat CR.32 and, above 21,330 ft (6 500 m) had a better rate of climb, and at altitudes above 16,400 ft (5 000 m) it was even faster than the Messerschmitt Bf 109B which had still to make its appearance over Spain. Used for both bombing and visual reconnaissance sorties, the SB-2 initially appeared immune from fighter interception, but Nationalist pilots quickly evolved tactics that gave them a chance of intercepting the SB-2s with their slower fighters, and on October 28, 1936, the first SB-2 was shot down by a CR.32 flown by a Spanish pilot named Salas, a performance repeated five days later by the Italian pilot Mantelli.

In the autumn months of 1936, the new Soviet bomber was virtually unknown outside the Russian borders, and as the Martin 139, which it had at one time been intended to manufacture under licence in Spain, was the only known bomber of this configuration to have attained service, "reliable neutral observers" immediately assumed that the American bomber was being supplied to the Republican Government, and it was widely suggested that the US Government was interpreting the Monroe Doctrine in a very strange fashion indeed. The Republicans fostered the belief that they were receiving Martin 139s by issuing photographs of the American bomber from which the USAAC markings had been carefully erased and Spanish markings superimposed. Thus, some time elapsed before it was realised that the bomber, which had been dubbed *Katiuska* by the Spanish Republicans, was, in fact, of Russian origin.

PROGRESSIVE DEVELOPMENT

Within eight months of the arrival of the first SB-2 in Spain approximately 150 bombers of this type were operating against the Nationalists, and the first Russian SB-2 pilots operating over Spain had been designated Heroes of the Soviet Union in Moscow for their success in undertaking "difficult government tasks". In all, some 210 SB-2s were to reach Spain during the conflict but, in

the meantime, the lessons learned in Spanish skies were being applied on the SB-2 production line, and even before the bomber had been blooded in action, an improved version with more powerful M-100A engines had been flown in 1936.

The M-100A engine offered 860 hp at 10,826 ft (3 300 m), and resulted in a marginal performance improvement, maximum speed being 263 mph (424 km/h) at 13,125 ft (4 000 m) at a loaded weight of 12,636 lb (5 732 kg). Range with a 2,200-lb (1 000-kg) bomb load was 621 miles (1 000 km), and service ceiling was 30,366 ft (9 560 m) with fixed-pitch airscrews and 34,450 ft (10 500 m) with VISh-22 three-blade variable-pitch airscrews. With a wing area of 559.19 sq ft (51,95 m²) the wing loading was 22.65 lb/sq ft (110,5 kg/m²), and power loading was 7.32 lb/hp (3,32 kg/hp).

Late in 1936, the Czechoslovak Government, anxious to modernize its bombing force, entered into an agreement by which Czechoslovakia received a batch of 30 SB-2s together with a manufacturing licence from the Soviet Union in exchange for specimen examples and the manufacturing rights to the Skoda C 5 7,62-cm mountain gun. The Czech SB-2s were to be powered by Avia-built Hispano-Suiza 12Ydrs engines of 860 hp, these being essentially similar to the standard M-100As which, too, were licence-built derivatives of the French Hispano-Suiza engine. The Czechoslovak designation B 71 was applied to the SB-2, and the first Russian-built airframe arrived in Prague where it was fitted with its Avia-built engines and flown on April 17, 1937. Subsequently, Avia sent the HS 12Ydrs engines to the Soviet Union where the remaining 29 aircraft (B 71.2 to B 71.30 inclusive) were completed and ferried to Czechoslovakia.

Production of the SB-2 was initiated in Czechoslovakia in 1937, the original plans calling for 40 (B 71.62 to B 71.101) to be built by Letov, 50 (B 71.102 to B 71.151) to be built by Aero, and 70 (B 71.152 to B 71.221) to be built by Avia. In the event, a cut-back in orders in the autumn of 1938 resulted in the Letov plant being eliminated from the programme, but Aero went on to complete 45 of the 50 machines that it was scheduled to produce, Avia completing a further 66 machines to bring Czech SB-2 production to 111 machines; a proportion of these were completed *after* the German occupation of Bohemia and Moravia and the dissolution of the Czechoslovak Republic in March 1939. Forty-two of these were delivered to the Bulgarian Air Force in 1939-40, being known by this service as the "Avia-Katusa M-8", and the bulk of the remainder were sequestered by the *Luftwaffe* which took over both Czech- and Russian-built SB-2s which had served with the Czech 5th Air Regiment at Brno and the 6th Air Regiment at Nemecky Brod (now Havlickuv Brod). A number of these were employed by the *Luftwaffe* as crew trainers, but the majority served in the target-tug role with the *Fliegerzielgeschwader* 1 and several of the nine autonomous *Fliegerzielstaffeln*. One Avia-built SB-2 served with the Slovak Air Force until August 1944 when its crew flew the aircraft from the Trencin airfield to Turkey, subsequently reaching England and joining the Free Czech Air Force.

In 1936, shortly after the M-100A-powered model of the SB-2 had entered production, yet another variant appeared, the SB-2bis with M-103 engines driving VISh-22 variable-pitch airscrews and rated at 960 hp at 13,125 ft (4 000 m). Fuel capacity was again increased, maximum range with overload fuel and a 1,100-lb (500-kg) bomb load being 1,430 miles (2 300 km), loaded weight being 17,195 lb (7 800 kg). On September 2, 1937, an SB-2bis flown by M Yu Alekseyev established a new international load-to-altitude record by lifting a 2,200-lb (1 000-kg) load to 40,181 ft (12 246,5 m). The SB-2bis possessed a maximum speed of 280 mph (450 km/h) at 13,452 ft (4 070 m) at a loaded weight of 14,330 lb (6 500 kg), normal range at this weight being 995 miles (1 600 km) at 186 mph (300 km/h).

Numerous modifications were introduced during production of the SB-2 and SB-2bis, including provision of a variety of single- and twin-ShKAS dorsal turrets in place of the sliding glazed hatch, and a more elaborate ventral gun position, and several variants of the basic design were produced during 1938 and 1939, including the PS-40 commercial transport version which served with *Aeroflot*, a pilot training model with an open cockpit for the pupil ahead of the normal cockpit, and a dive-bomber derivative initially designated SB-RK and subsequently redesignated Ar-2. The SB-RK alias Ar-2 was powered by two M-105R engines rated at 1,100 hp for take off and fitted with two-speed superchargers. By comparison with that of the SB-2bis, the wing area of the SB-RK was reduced by 86.112 sq ft (8 m²), and air brakes were hinged beneath the wings. The air intakes were repositioned as part of a drag reduction programme, and maximum speed rose to 298 mph (480 km/h) at 15,420 ft (4 700 m), range being 621 miles (1 000 km) with a 2,200-lb (1 000-kg) bomb load. A total of 200 SB-RK aircraft was built.

With the signing of the Non-Aggression Pact between the Soviet Union and the Chinese Central Government, a number of SB-2s were supplied to China for use against the invading Japanese, these making their appearance in 1937, harrying Japanese forces advancing on Hankow. Substantial numbers of SB-2bis bombers were also delivered to China, some of these remaining in service until 1946, although the record for service longevity was to go to those in Spanish service, for several of the 18 SB-2s that formed a part of the spoils of war after the Nationalist victory and were used to equip the newly-formed 20W Group in 1939 remained in Spanish service until the beginning of the fifties.

When German forces invaded the Soviet Union in June 1941, the SB-2 and SB-2bis, and their dive-bomber derivative, the Ar-2, equipped the bulk of VVS bomber squadrons, but the margin of performance superiority enjoyed by the SB-2 when it first appeared over Spain in 1936 no longer existed five years later, and Arkhangel'sky's now ageing bomber presented the *Luftwaffe's* fighters with few problems. Whereas over Spain the SB-2 relied on a combination of speed and altitude to evade interception, attacking its objective from high altitude and then turning and diving for home, similar tactics being employed over China, such methods proved less efficacious over the Ukraine where the *Luftwaffe* enjoyed almost undisputed aerial superiority, for the German fighter arm had also taken the lessons of the Spanish Civil War to heart. The lack of armour and light defensive armament of the SB-2 and SB-2bis rendered the Soviet bombers easy meat for the Bf 109F and Fw 190A, and the VVS was forced to adopt low-level tactics, becoming targets for the very efficient German light flak. The attrition suffered by SB-2-equipped units was such that, apart from isolated incidents, the Arkhangel'sky-designed bomber had virtually disappeared from Russian skies in which *Luftwaffe* fighters were likely to be encountered in strength by the summer of 1942.

Like so many other VVS formations, a large proportion of the SB-2-equipped units had been deployed too far to the West, and hundreds were destroyed on their airfields during the initial German onslaught. Others were abandoned undamaged in the face of the *Wehrmacht's* rapid advance, and it is odd to relate that on the one front where the SB-2 lingered in VVS service well into 1943, Russian Karelia, the elderly bomber was operated by *both* sides! A number of SB-2bis bombers captured intact by the *Wehrmacht* in the Ukraine were overhauled and *sold* to Finland. In Finnish service they were employed primarily for maritime reconnaissance and anti-submarine duties by TLeLv 6 alongside such antiquities as the Blackburn Ripon II and Norwegian-built M.F.11 float biplanes and Dornier Do 22 float monoplanes. One SB-2bis of TLeLv 6 (VP-10) was officially credited with the destruction of no fewer than four Russian submarines.

In China this old-stager was to soldier on into the mid forties and in Spain examples still existed at the beginning of the fifties, but the SB-2 and SB-2bis had been largely phased out of first-line VVS service by the end of 1943, and apart from a few units in Eastern Russia in which these aircraft still fulfilled their original tasks, the survivors of the many thousands of examples of Arkhangel'sky's bomber were serving out their time in the glider tug, target-tug, crew training and communications roles.

The service record of the SB during World War II had not been particularly remarkable, but the SB-2 had made its mark on military aviation history, and no fewer than 6,666 SB-2s in all its versions had been built in the Soviet Union when production finally terminated. It had brought home to the world the fact that the Soviet Union was capable of designing and manufacturing warplanes fully up to the standards of the technologically more advanced western countries, and it had revealed the fact that Andrei Tupolev and his assistant A A Arkhangel'sky were just as advanced-thinking as their contemporaries in the West, and were not, as was so widely believed, dedicated to the archaic, lumbering, slab-sided monstrosities that droned over Moscow in a seemingly endless stream on every Aviation Day, their corrugated metal fuselages, open crew positions and ungainly fixed undercarriages providing built-in headwinds of a strength to make any self-respecting western designer shudder.—WG

One of several SB-2bis bombers (SB-14) captured by the Wehrmacht in the Ukraine and subsequently sold to the Finnish Air Force for use by TLeLv 6 in the anti-shipping and intruder roles.

FACTS BY REQUEST

AN INFORMATION SERVICE FOR READERS

All requests for information should be limited to one aircraft type or subject and should be accompanied by the reader's full name and address. It is regretted that readers' requests cannot be answered by post.

BELGIUM'S LAST FIGHTERS

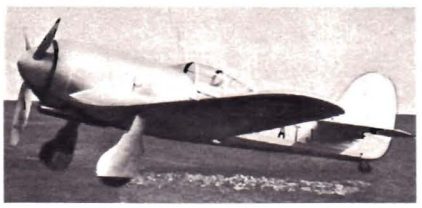
Please publish photographs, details and three-view drawings of the Belgian Renard R-40 and its predecessors which I believe escaped to France at the time of the German invasion. I would be particularly interested to learn their eventual fate.

Lee E Bishop, Los Angeles 45, Calif.

Although it has been stated that the Renard R-40 prototype, powered by a Rolls-Royce Merlin engine and featuring a special cockpit capsule which the pilot could detach from the airframe for escape purposes, was transported to France for trials in 1940, we have been unable to discover any evidence to support such statements, and believe the R-40 to have been no more than a projected development of the Renard series of experimental fighter monoplanes, the last of which to be actually flown being the R-38.

In 1936, M Alfred Renard initiated design of a modern single-seat fighter monoplane to meet the requirements of a specification intended to provide Belgium's *Aéronautique Militaire* with a successor to the Fairey Firefly. This aircraft, the R-36 (OO-ARW) powered by a 910 hp Hispano-Suiza 12Ycrs liquid-cooled engine, was flown for the first time on November 5, 1937 at Haren-Bruxelles. The R-36 was of all-metal construction, the fuselage being of rectangular section faired to an oval and covered forward by detachable light metal panels and aft by fabric, and the wing being a three-spar structure (two parallel and the third forming a zig-zag between the other two) with light metal skinning. An unusual feature of the design was the immense wing root leading-edge fairing which resulted in the R-36 appearing in planform to possess an exceptionally short nose. Weighing 3,896 lb (1 767 kg) empty and 5,633 lb (2 555 kg) loaded, the R-36

Renard R-36 (OO-ARW)



Renard R-37 (OO-ATJ)

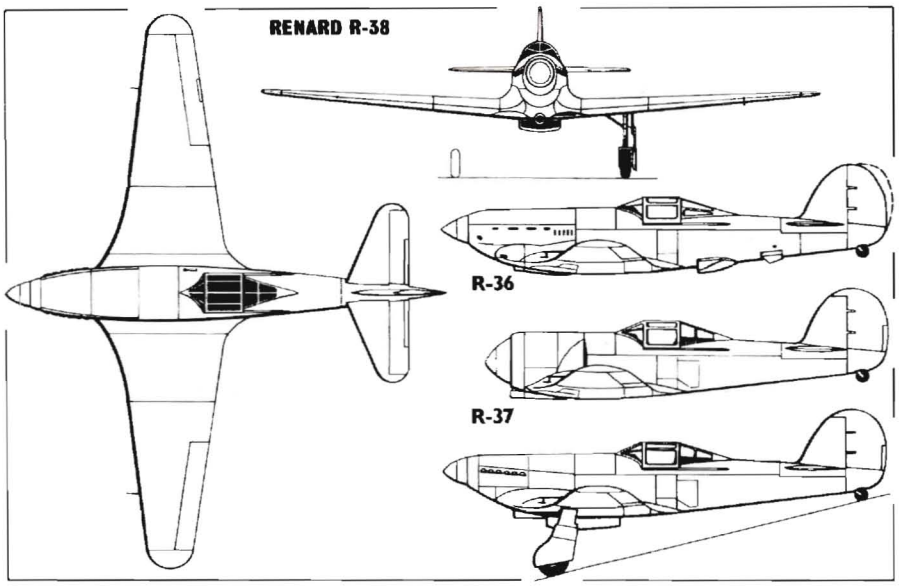
carried an armament of one 20-mm Hotchkiss cannon mounted between the engine cylinder banks and four 7,7-mm FN-Browning machine guns mounted in the wings. Overall dimensions included a span of 37 ft 10¾ in (11,54 m), a length of 28 ft 0¾ in (8,54 m), a height of 9 ft 6 in (2,9 m), and a wing area of 204.5 sq ft (19 m²), and performance attained during trials included a maximum speed of 259 mph (417 km/h) at sea level and 313 mph (505 km/h) at 13,120 ft (4 000 m), this altitude being reached in 4 min 56 sec. Cruising speed was 248 mph (400 km/h) at 13,120 ft (4 000 m), range being 620 miles (1 000 km), and service ceiling was 40,680 ft (12 400 m), 45 min 26 sec being required to reach this altitude.

The initial trials with the R-36 aroused considerable interest, and several foreign delegations, including French and Chinese, witnessed tests. Renard initiated work on a pre-series of six aircraft in 1938 when the Belgian government took an option on 40 fighters of this type, but shortly after the completion of military trials the R-36 crashed at Nivelles on January 7, 1939 in inexplicable circumstances. Soon afterwards, the Belgian government elected to purchase the Hurricane as a successor to the Firefly, ordering 20 from the UK with a further 80 to be manufactured by Fairey-Gosselies. Although considerable recrimination followed the choice of the Hurricane in favour of the R-36, the urgency of the need to re-equip favoured the British fighter.

In the meantime, work had been proceeding on the first two of the pre-series aircraft, the R-37 (OO-ATJ) with a close-cowled Gnôme-Rhône 14N-21 14-cylinder air-cooled radial of 1,100 hp, and the R-38 (OO-ATK) with the liquid-cooled 12-cylinder Rolls-Royce Merlin II of 1,030 hp. The R-37, which, it was anticipated, would attain a maximum speed of 317 mph (510 km/h) at 16,400 ft (5 000 m), was destined never to be flown, but the R-38 flew in the early summer of 1939, being demonstrated to representatives of Belgium's *Aéronautique Militaire* on July 18th of that year.

Renard R-38 (OO-ATK)

The R-38, which possessed similar overall dimensions to those of the R-36, and was intended to carry an armament of four wing-mounted 7,7-mm FN-Browning machine guns, weighed 4,319 lb (1 959 kg) empty and 5,719 lb (2 594 kg) loaded. Performance included maximum speeds of 267 mph (430 km/h) at sea level, 292 mph (470 km/h) at 6,560 ft (2 000 m), and 339 mph (545 km/h) at 19,685 ft (6 000 m). An altitude of 16,400 ft (4 000 m) was reached in 5 min 3 sec, service ceiling was 37,720 ft (11 500 m), and range was 620 miles (1 000 km). Trials with the R-38 were continuing at Haren-Bruxelles at the time

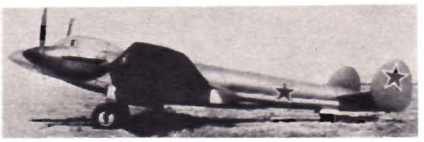


of the German invasion of Belgium, and the aircraft was evacuated to Bordeaux-Mérignac. However, the aircraft was abandoned when the decision was taken to transfer remaining *Aéronautique Militaire* equipment to Morocco, and was allegedly destroyed after capture by German forces.

PETLYAKOV FIGHTER

I have read that a fighter version of Petlyakov's Pe-2 bomber existed for, I believe, the high-altitude interception role. I have been unable to discover any facts relating to this aircraft, and I shall be grateful if you will include in "Facts by Request" a general arrangement drawing, photos and some details of this fighter if it existed.

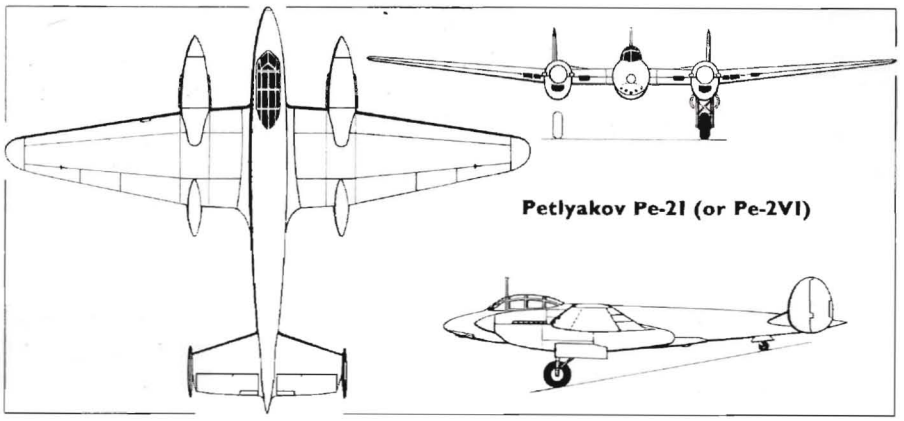
R Sampson, Walton-on-Thames, Surrey. The aircraft to which you refer, Mr Sampson was known officially both as the Pe-2I (the "I" suffix indicating *Istrebityel*, or Fighter) and as the Pe-2VI (indicating *Viisotni Istrebityel*, or High-Altitude Fighter), development of the basic Pe-2 design having turned the complete circle with the appearance of this model, the immediate predecessor of the Pe-2, the VI-100, having been designed as a pressurized high-altitude fighter with turbo-supercharged engines before modification for the bombing role. The Pe-2I alias Pe-2VI represented a major redesign of the basic Pe-2, particular attention being given to aerodynamic cleanliness. The fineness ratio of the fuselage was improved by lengthening the nose from which the transparent panels were removed. A pressurized cockpit accommodating two crew members was provided, the height of



the canopy being reduced and its lines being improved to reduce drag. The wing was raised on the fuselage from low to full mid position, and the VK-105PF (M-105PF) engines rated at 1,210 hp for take-off were supplanted by VK-107A engines rated at 1,650 hp.

The prototype Pe-2VI was flown in

1944, and during trials attained a maximum speed of 408 mph (657 km/h) at 18,700 ft (5 700 m). Armament comprised four 20-mm ShVAK cannon mounted in a tray in the lower part of the fuselage nose. It was proposed that, for the fighter-bomber role, the Pe-2VI would carry a 2,200-lb (1 000 kg) bomb load externally although provision was made for an internal weapons bay, and a parallel development, the VB-109 intended for the high-altitude bombing role, was to have carried 4,410 lb (2 000 kg) of bombs internally, and to have been powered by two VK-108 engines of 1,850 hp which, it was anticipated, would have boosted maximum speed to 435 mph (700 km/h). In the event, the sole prototype of the Pe-2VI crashed in 1945 as a result of an engine fire, and no production was undertaken.



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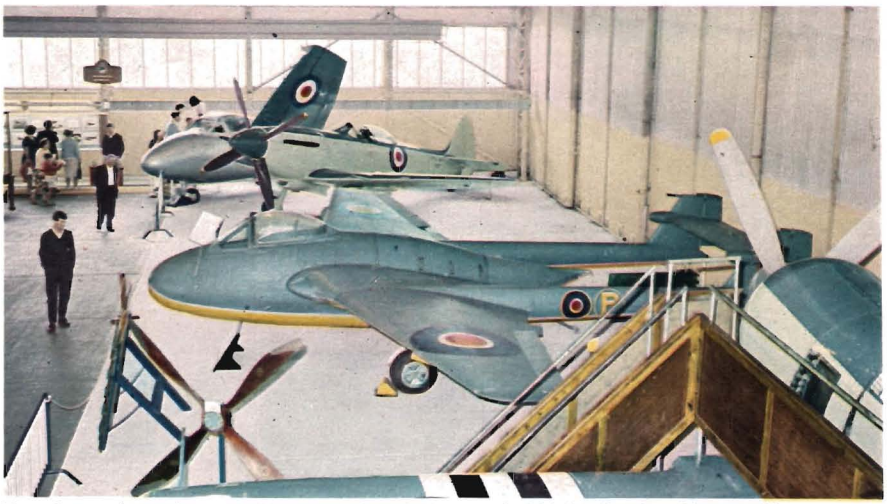


THE FAA MUSEUM

TWO IMPORTANT ADDITIONS have been made to the Fleet Air Arm Museum at RNAS Yeovilton for the 1967 season—the last surviving Supermarine Walrus in Britain and a Westland Dragonfly. The Museum, containing one of the most important collections of historic aircraft in Britain, will re-open to the public on March 17th and will be open daily (including Sundays) until October 1st.

Ten complete aircraft will be exhibited this year, as follows: de Havilland Vampire LZ551; Fairey Swordfish HS 618 (painted as V6105); Grumman Martlet AL246; Hawker Sea Fury FB.Mk.11 WJ231 (painted as WE726); Supermarine Walrus L2301; Supermarine Seafire F.Mk.XVII SX137; Supermarine Attacker WA473; Vought Corsair KD431; Westland Wyvern TF.Mk.1 VR137 and Westland Dragonfly WN493. The Walrus and Dragonfly are on loan from the Historic Aircraft Preservation Society.

Also housed at RNAS Yeovilton is the Fairey Swordfish LS326, which is maintained in flying condition. In addition to the aircraft the museum contains a number of other exhibits which help to tell the story of Naval aviation in Britain, including photographs and documents, engines, armament and models.

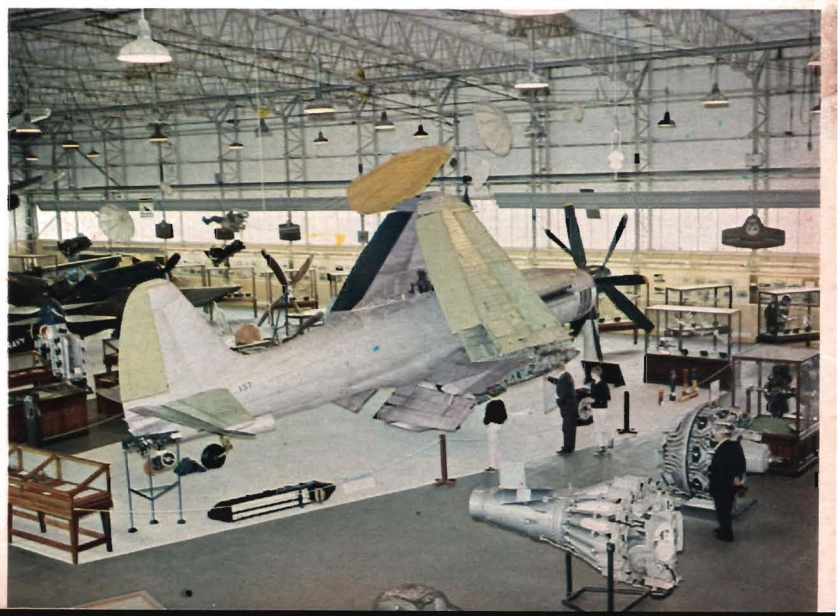
Addition of a Walrus to the FAA Museum is especially welcome and follows the discovery of a badly damaged airframe at Thame airfield, near Oxford, in 1963. This aircraft was minus wings, floats and much else when found by members of the HAPS, and its restoration by the RN Engineering School at Arbroath occupied nearly three years. During this time, every effort has been made to trace spare parts but most of the missing components have had to be fabricated and L2301, which is not flyable, is now part-replica and part-veteran.

This actual Walrus is one of the three purchased from a Fleet Air Arm contract by the Irish Army Air Corps in 1939, with which it served until 1945 as N18. It was then sold to Aer Lingus as EI-ACC, and in 1947 was purchased (for £150) by No 615 Squadron, R Aux AF, as a means of giving ground staff some air experience. Registered G-AIZG and based at Biggin Hill, it was used in this way for two years before being sold as scrap to a company at Thame. Its survival for the next 14 years appears to have been fortuitous.

Apart from the aircraft at Yeovilton, the Naval Air Command currently holds 11 other historic types. At RNAS Lossiemouth there are the Fulmar N1854, Hellcat KE209, Sea Fury VX653 and Sea Hawk WF259; RNAS Brawdy holds Sea Hawk XE340; RNAS Culdrose has Avenger XB446, Firefly TT.Mk.4 VH127, Seafire VP441 and Skyraiders WT121 and WV106; while HMS Daedalus at Lee-on-Solent looks after the Swordfish NF389.

Top of page, the newly restored Walrus L2301, the history of which is related on this page. Above, a scene inside the FAA Museum showing the Vampire LZ551, the second prototype which was later used for deck-landing trials.

General views inside the hangar at Yeovilton showing, left, the Swordfish HS618 and right, the Wyvern VR137, one of the pre-production Eagle-engined Mk.1s.



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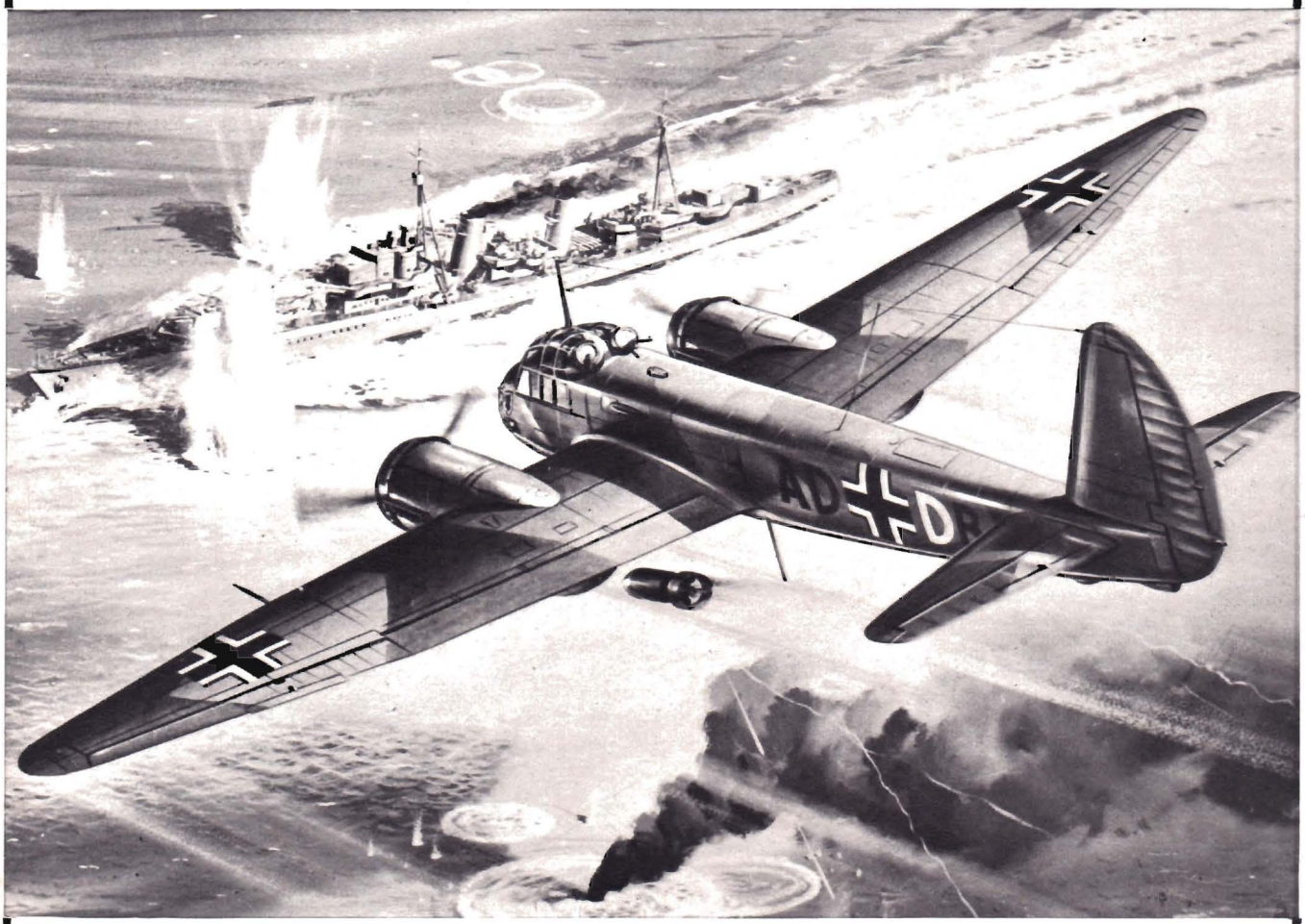

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