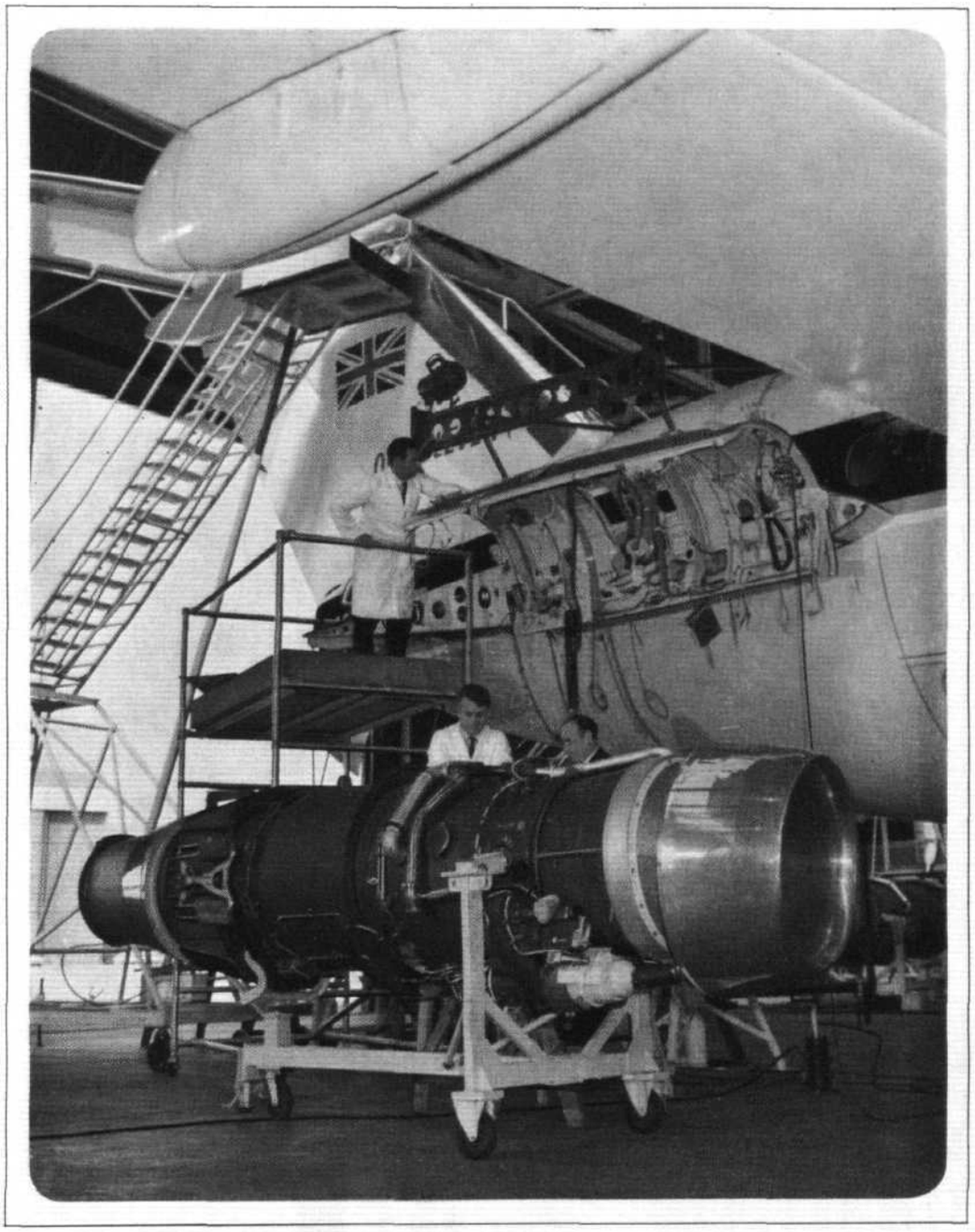
Aero Engines

7 January 1965
e Shilling and Sixpence

FLIGHT International



A Rolls-Royce Spey by-pass jet being fitted into a BAC One-Eleven airliner... Spey engines also power the Hawker Siddeley Trident in service with BEA and have been chosen for the Fokker F.28 Fellowship.

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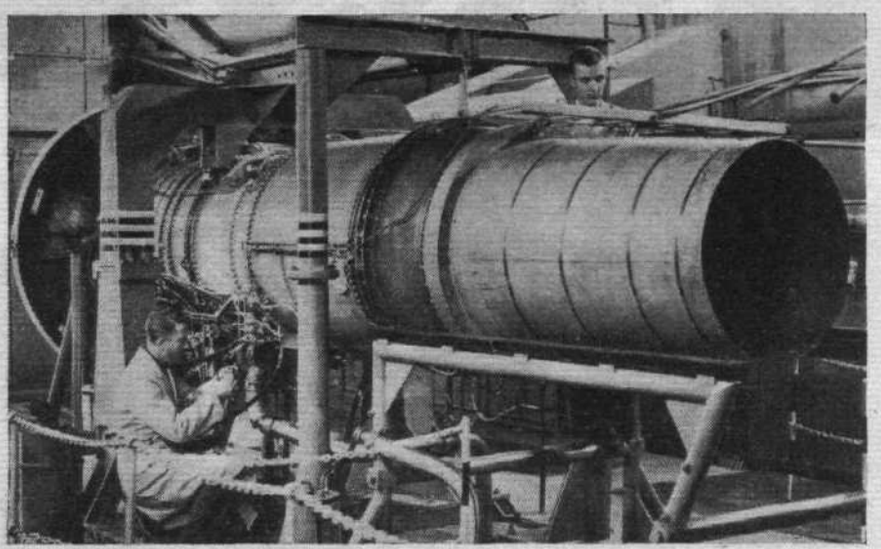
RESEARCH

Flygmotor is pursuing extensive research activities in various fields of aeronautics. The firm has excellent laboratory facilities for testing jet-engines under simulated flight conditions at supersonic speeds, and for testing ramjets and various types of rocket motors.

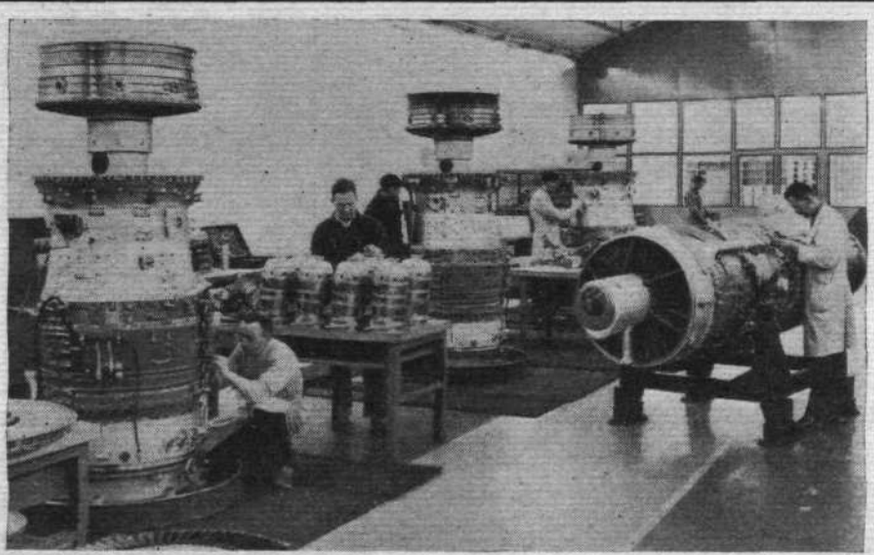
A model of the RR1 ramjet engine about to be tested at Mach 5.



DEVELOPMENT

At the present time the company is engaged in developing the Pratt & Whitney JT8D1 bypass engine to give a military version (designated RM8) with considerably increased thrust. A reheat system is also being developed for this engine, which will power the new SAAB Viggen 37 aircraft.

A modified Pratt & Whitney JT8D1 engine being tested.



PRODUCTION

Flygmotor is producing a special version of the Rolls-Royce Avon 300 series engine under licence, for use in the SAAB Draken 35 aircraft. They are also manufacturing the above engine's reheat system, which is of Flygmotor design.

Production of the initial parts for RM8 has begun, and the up-to-date production layout is being prepared to turn out a series of about 1000 engines.

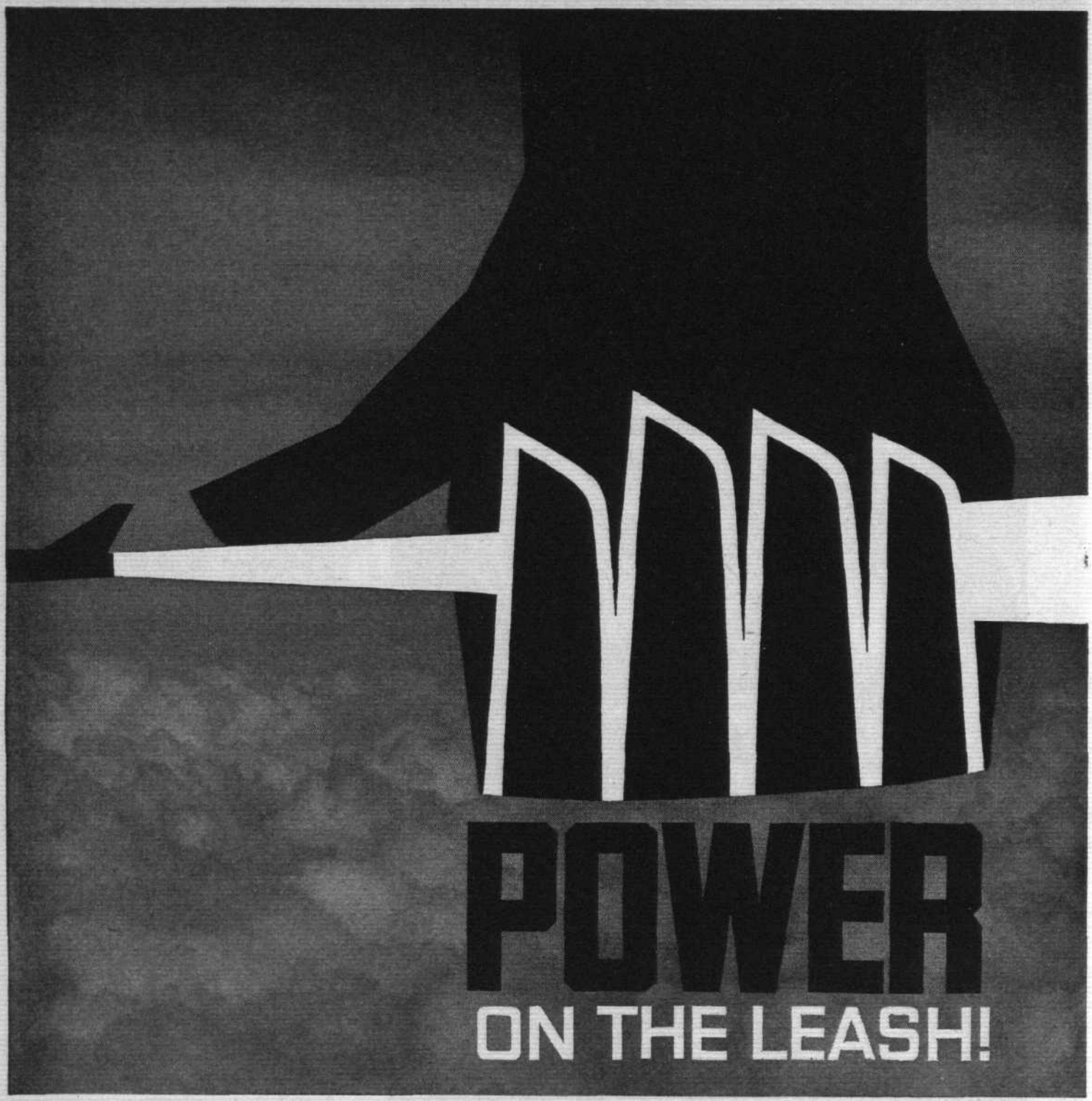
View in the underground factory where RM6 engines are being assembled.

Background to the Swedish Aero-Engine Company is provided by the Volvo and Bofors concerns, with a combined turnover of 500 million dollars and 30,000 employees.

Flygmotor

SVENSKA FLYGMOTOR AKTIEBOLAGET

TROLLHÄTTAN SWEDEN



FOR THE TSR2

The first comprehensive electrical control system for Supersonic engines. Single-lever operation.

This electrical control system for the new Bristol Siddeley *Olympus* incorporates many 'firsts' and new techniques, notably that of variable area nozzle control. Through the pilot's throttle lever, the system controls the primary engine functions of main fuel flow, reheat fuel flow and nozzle area, plus the subsidiary functions of acceleration, turbine interstage temperature and compressor delivery. It calls up the required value of thrust to a safe maximum for any given instantaneous speed and ambient conditions. Control is fully automatic and requires no special action or consideration by the pilot—thrust changes are linear with movement of the pilot's lever. Engine mounted components operate in environmental temperatures up to 250°C., and the aircraft mounted control unit up to 120°C.

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FLIGHT international

Official Organ of the Royal Aero Club First Aeronautical Weekly in the World Founded in 1909

THURSDAY 7 JANUARY 1965

Number 2913 Volume 87

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Cost Control

IT would be "premature," says the Minister of Aviation, to reveal the cost of the TSR.2's electronics. When, we wonder, *will* the time be ripe? When the costs have grown so much that they can no longer be concealed, a public scandal is precipitated, and the project comes to a halt?

At the same time comes news that the Ministry has completed its inquiry into the culpability of officials in the Ferranti cost affair. The report is being studied by the Minister's permanent secretary, Sir Richard Way, who will decide whether anyone should be reprimanded or dismissed.

Past failures in British aviation will not be avenged in this way, nor future failures avoided.

Government and industry in partnership should regularly publish estimates of defence and civil expenditure, project by project. The plea of security cannot be entered. The Americans do it, they have always done it, and the free world is still free. The Canadians do it, and so do the Australians. Even the French, who some may think are more tolerant of autocracy than the British, will say how many francs they have budgeted for, say, the Mirage in 1970.

It would be more positive and progressive of the SBAC to form a cost control council than to set up—as it has done—a committee to put a flea in the ear of Mr Richard Worcester, the protagonist of US aviation, whose reports have been studied by the Labour Government. Britain has been responsible for some of the greatest innovations in world aviation, and her aircraft industry possesses some of the best people in the country. It is up to them, in partnership with the Government, to open the books. It will be far less painful than the ultimate reckoning.

BEA and BOAC

BIG efforts are being made by BEA's management to improve efficiency. The challenge now is to convince staff, who only six months ago were being told that BEA's £3m profit was proof of efficiency, that wage demands can only be met out of dramatic improvements in productivity and cost level.

All the signs point to a reversal of the image of BEA as the profit-maker and BOAC as the loss-maker. There is perhaps no need to wish BOAC a prosperous New Year; their enviable difficulty now will be to keep net annual profits below £10m in the years ahead. But we sincerely wish prosperity to BEA, who have a fine record to live up to.

The 1965 "Flight"

WITH this first issue of 1965 we introduce two new regular columns and make four alterations to existing regular features.

On the second World News page Sensor will anticipate the changes that are in the air. On the third World News page another new regular column will be about the Press. The aviation business is as sensitive to the Press as it is to anything, and what is written and broadcast is of concern to everyone.

There are four changes to the familiar regular features. Service Aviation is expanded and renamed Defence. Missiles go to Defence, and Spaceflight now has a place in its own right. Air Commerce becomes Air Transport, this being the professional term which more sensibly embraces all the subjects—including operations and engineering—we normally cover. Lastly, Straight and Level goes to the last page of each issue. Our worthy columnist Roger Bacon is not quite sure whether this is promotion or otherwise, but he consoles his ego with the thought that Straight and Level will be more readily found in this position.

WORLD NEWS

PLOWDEN AND PUBLICATION

Lord Shackleton, asked last month in the Lords to say whether the Plowden report will be published, replied that the Minister of Aviation, Mr Roy Jenkins, will "undoubtedly do his best to provide, one way or another, as full an account as possible of the committee's conclusions. But . . . this inquiry will cover matters of national security and also commercial confidence, and this will inevitably restrict the amount of information that can be disclosed. But it is equally clear, I think, that it is very important that as much as possible should be published; I fully accept that."

MORE TSR.2 FLIGHTS

The prototype BAC TSR.2 strike and reconnaissance aircraft made its second and third flights from Boscombe Down last week. The second flight was on December 31 and lasted for 15min; this was followed by an eight-minute third flight on January 2. The aircraft first flew on September 27, 1964.

C-5A CONTRACTS

The US Defense Department announced on December 31 research contracts worth over $41m in connection with the C-5A heavy military cargo aircraft. Boeing, Lockheed and Douglas are each awarded a $6m contract for detailed studies; and General Electric and Pratt & Whitney have received contracts worth $1.9m and $1.4m respectively for project studies on engines. The two engine companies have also been awarded contracts of $10.4m and $9.6m respectively for the construction of prototype powerplants.

IN THE HONOURS LIST

Among members of the aircraft industry named in the New Year Honours are Dr G. H. Hough, technical director of Hawker Siddeley Dynamics, who is appointed CBE, and Mr A. V. Cleaver, Rolls-Royce chief engineer (rocket propulsion), who is made OBE, as is Mr R. H. Sandifer, Handley Page assistant chief designer (structures). Also among the OBEs is Capt J. R. Jeffrey, chairman of the British Air Line Pilots' Association; and several airline and test pilots receive the Queen's Commendation for Valuable Service in the Air. A more detailed list will appear in these pages next week.

OTTERS FOR ICAO

Eight Otter utility aircraft have been ordered by the International Civil Aviation Organization from de Havilland Aircraft of Canada for use with the United Nations FUNDWI (Fund for the Development of West Irian) programme. Two are amphibians. The contract is worth approximately $1,060,000 (£360,000) and deliveries are to begin next month.

VOR BEACONS FOR RUSSIA

The Soviet Union, for the first time, has ordered Western-built ground-based units of the VOR navigation system. Aviaexport of Moscow has signed a contract with Standard Telephones and Cables of London for two high-power long-range beacons to be installed on the airway between the Soviet capital and the Baltic coast. The Soviet national carrier Aeroflot had previously bought STC airborne VOR receivers for use on its international routes, but had relied principally on NDBs for navigation along internal routes. Now western airliners flying to Moscow will be able to use their standard medium-range navigation aid along the whole route.

USSR TEAM AT SMITHS

On Tuesday of last week a group of engineers from Ilyushin spent a day with Smiths Aviation Division. The party included Mr Smirnov, deputy head of Ilyushin, and other representatives were Mr Pakholkov and Mr Sinisyn. The party inspected the Smiths autopilot and instrument systems in a BEA Comet at London Airport and then visited Smiths' technical services centre there. Among the equipment which they examined was Smiths' range of civil flight systems and autopilots as well as SADIE, the check-out system.

A PIONEER PASSES

That happy company of early air pioneers is now the sadder by the loss of undoubtedly its oldest member—Gustavus Green, who died on December 29, just 73 days short of his hundredth birthday.

Gustavus Green—a "Flight" photograph taken 55 years ago

The successful range of engines which he designed and built so perfectly (writes a friend) provided the power by which so many early aviators gained the mastery of flight. A 60 h.p. Green engine helped the late Lord Brabazon in 1909 to win a £1,000 prize for the first all-British aeroplane to complete the first circular flight of one mile. Many successes followed; Sopwith, A. V. Roe, Cody, Grahame-White, Harry Hawker and Bert Hinkler are but a few who used his engines. Many of the fast Naval craft and MTBs of the First World War were powered by Green marine engines.

At 55, on doctor's orders, Mr Green

British Beacons for USSR *Signing the Soviet order for VOR beacons from Standard Telephones & Cables (news item above). Seated, l to r: Mr Max Settelen, STC; Mr I. Mantashev, Aviaexport; Mr E. Beliaev, USSR Trade Delegation to London. Standing: Mr. V Sinisyn, USSR; Mr S. J. W. Gilbert, STC; Mr S. H. Matthiae, STC (partly concealed); Mr V. Smirnov, USSR; Mr N. A. Smith, STC; Mr G. Pakholkov, USSR. Several of the Russian team also visited Smiths Aviation Division, as recorded above*

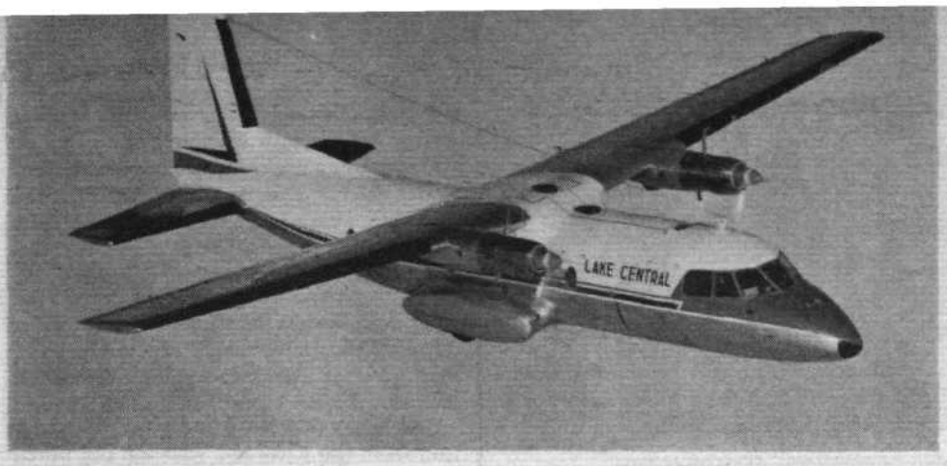
AIRLINE ACCIDENT RATE DOWN
Air Transport, page 5

BUA OBTAINS BRAZIL TRAFFIC RIGHTS:
Air Transport, page 6

F-111A MAKES FIRST FLIGHT
page 13

OVER 100 SPACECRAFT LAUNCHED IN 1964: Spaceflight, page 35

TWO RAAF AIRFIELD BUILD-UPS
Defence, pages 37, 38



Lake Central's First Nord 262 *will be delivered this summer. This American local service carrier, the first to order a new turbine replacement of a size comparable with that of the DC-3, contracted with the French manufacturer last June for eight of the airliners*

retired to his spacious old house at Twickenham, Middx. Here, surrounded by treasures of a past age, he found new pleasures and delights in collecting, making and repairing intricate and beautiful clocks and watches; only a week before Christmas he was busy adjusting a clock he intended to present to his doctor.

Seven years ago the world discovered that this great air pioneer was still living, and at the suggestion of Mr H. F. Cowley the Royal Aeronautical Society bestowed upon him its Honorary Companionship.

Mr Green's good health and happiness during the last decade were due in no small measure to the unstinting devotion of his daughter-in-law Rina and his son Charles; as an Avro test pilot, Charles helped to prepare the Avro Baby, which, fitted with that faithful ten-year-old 35 h.p. Green engine, brought victory to Bert Hinkler in the Aerial Derby of 1919.

HS-DH CHANGES

Divisional director and general manager of the DH Division of Hawker Siddeley Aviation, Mr A. S. Wheate is leaving the company in order to take up another appointment in the industry. He is succeeded by Mr J. L. Thorne, divisional sales manager of the Hawker Blackburn Division. Mr Thorne held senior positions with the Ministry of Aircraft Production and Ministry of Supply between 1941 and 1955, including a period as Private Secretary to

Mr J. L. Thorne

Sir Edwin (now Lord) Plowden and Sir Archibald Rowlands. From 1955 to 1960 Mr Thorne was sales manager of Fairey Aviation and subsequently held various appointments with Westland Aircraft until he joined Hawker Siddeley in February 1964.

HSI DIRECTORSHIP

Mr W. H. B. Rees, well known as the general sales manager of Bristol Siddeley Engines Ltd, has been appointed a director of Hawker Siddeley International Ltd, from February 1, next. On March 29 he will take over as director in charge of industrial export sales, succeeding Sir George Briggs, director and deputy chairman, who reaches the normal retirement age early this year and has expressed the wish to retire from full-time executive duties. Sir George will remain on the HSI board. Mr Rees joined Bristol Siddeley Engines in 1956 and has been general sales manager since 1959.

DEATH OF RADIO PIONEER

Often referred to as "the father of modern radio telecommunications," Charles Samuel Franklin, CBE, MIEE, died last month at the age of 76. Joining the Marconi Company in 1899, he worked for many years in close association with the famous founder of that business. In 1916 the two inventors started their first short-wave wireless experiments.

For the remainder of his career with the company—he retired in 1939 but was retained as a research consultant—Mr Franklin concentrated on the development of his short-wave beam system. Sixty-five patents that stand to his credit include the variable capacitor, the ganged capacitor, the reaction circuit and the concentric feeder.

BS REORGANIZES

The major part of Bristol Siddeley's reorganization, begun last October with the formation of the Small Engine Division, has been completed with the formation last week of two new divisions, Aero and Industrial. Each of the three divisions will now be responsible for classes of engines. Large aircraft engines will come from the Aero Division, which includes the BS factories at Bristol, Whitchurch, Bentham and Parkside.

The Industrial Division, previously known as the Power Division, holds responsibility for applying the company's gas turbines to purposes other than aviation, i.e., to power generation, ships and ACVs. This division will also be responsible for the company's rocket engines.

As already announced, the Small Engine

(Continued overleaf)

SENSOR

The Minister of Aviation has been looking at the relations between the British independent airlines and the corporations, and has decided to make another important change in addition to his recent granting of trooping rights to BOAC and BEA. The new change, which will not involve legislation or any alterations to the licensing machinery, may be expected before the end of this month.

Recent departure of Mr C. J. Stephens from his post as Director (Space) at the Ministry of Aviation on completing his tour of duty leaves an unfortunate gap, with decisions on ELDO's present overspending and future programmes balanced on the knife-edge of this month's intergovernmental meeting in Paris. The Ministry can ill afford to throw away valuable experience and continuity at this time.

The 7s 6d "passenger service charge" which the Ministry ended on November 1 is still being collected by the airlines at British airports. Most passengers believe that this charge is a Government tax, but it is a straightforward mark-up of the price of the ticket. There is no point in arguing at the airport; just write to the airline later, saying that you want your 7s 6d back. It cannot legally refuse. In April, however, the airlines intend officially to add its equivalent to the fare charged for the journey.

It is hardly surprising that the recent Aerodrome Owners' Association increase in landing charges has aroused a bitter outcry from the underprivileged private and club pilots. Why, they wonder, should one pay the same amount for the use of a rough, backwoods field with no facilities as for the full treatment at a well-equipped municipal airport such as Elmdon?

Behind-the-scenes advance organization of the World Gliding Championships at South Cerney next May is now going well, a tobacco firm having weighed in with the financial assistance made necessary by the Treasury's charging the British Gliding Association for the use of the airfield. Getting the contest in shape on time is now a team effort, blending the persistence of Ann Welch, the thoroughness and facilities of the RAF, and sheer hard work by a multitude of spare-time helpers.

BEA are giving renewed thought to the idea of forming a charter subsidiary to compete with the independents. The main economic obstacle would be BALPA's demand for BEA pay-scales which would price the subsidiary out of the charter market.

Hunting for a Way Out? *Apparently hemmed-in by mountains, skyscraper flats and a hangar, Hunting Survey's Cessna 310G is pushed on to the Kai Tak tarmac preparatory to beginning a major mapping operation—the survey of Hong Knog and the New Territories, referred to on page 1105 last week*

WORLD NEWS...

Division comprises the ex-DH Engines factories at Edgware, Leavesden and Hatfield.

Mr Hugh Conway, who became BS managing director last October, will also act as divisional managing director of the Aero Division, and will be a member of each divisional board. Mr W. F. Saxton, previously production director of the company, becomes managing director of the Industrial Division. Mr G. L. Hack succeeds Mr Saxton as overall production director of the company and will be directly responsible for Aero Division production. Mr B. D. Blackwell is managing director of the Small Engine Division.

"JANE'S": A SECOND LOOK

Closer perusal of the 1964-65 edition of *Jane's All the World's Aircraft** (briefly referred to in our issue of December 17, page 1032) confirms the first impression of a more comprehensive compilation than ever before. Mr John Taylor, the editor, can claim to have produced once again the standard up-to-date reference to the world's aircraft, aero engines, missiles, space vehicles and ACVs. There are 18 more pages, and more words to the page—deeper and wider columns—and a completely new section on systems.

The leading article attracted much attention in the UK newspapers, in particular the passages about the effectiveness of the RAF's V-vomber deterrent. Most pointed, perhaps, is the passage on the need for greater international co-operation ("to have four V/STOL strike aircraft under development in Britain, France, Germany and Italy at the present time is clearly ridiculous").

Jane's has obviously had good co-operation from the Russians, who are not noted for their response to western requests for aviation information. This is significant, because it gives a measure of the international standing of the work, the circulation of which is 70 per cent foreign. International response to the engine section appears to have been very good, and the compilers of this special issue of *Flight* gratefully acknowledge the co-operation of Mr Taylor in this field.

New are the detailed Victor, Vulcan and Hunter performance figures, and the pictures of the ingenious Steward-Davis Fairchild Skypallet (page 302) and of the highly original Transavia (Australia) Airtruk (page 526).

This year's *Jane's*—the 55th—appears to perhaps twice as much information as the editions of ten years ago.

**Sampson Low, Marston & Company Ltd, London, 8 gns.*

press

ROBERT BLACKBURN

What journalists call a powerful piece appeared in the *Daily Telegraph* on December 30 under the by-line of the air correspondent, Air Cdre E. M. Donaldson: "Air crews no longer feel they are being properly supported by the Government or the air marshals at the Ministries. . . . Many officers I have spoken to are seeking other employment, discouraged at the outcome of years of futile arguments for up-to-date fighting equipment . . ." The story pointed out that "Britain is now the only major nation with subsonic strike aircraft." A *Telegraph* leader entitled "Biggles v. the MiG" continued the theme: "It is not only Indonesian aircraft that can fly twice as fast as our strike fighters. Egypt, Cuba, Finland, Hungary, Iraq and Jugoslavia can do the same." Evidently the leader writer had not seen the *New York Times* News Service report, quoted the same day by *The Times* in London, that "a small but increasing number" of MiG-21s have been flown recently by the Chinese Air Force.

It is surprising that until now Fleet Street has not made more of Britain's lack of supersonic strike aircraft. The ammunition has been lying around for some time. On August 6 last year, for example, *Flight* staff writer Bob Rodwell reported—after flying with the RAF at West Raynham—on the deficiencies of the Hunter FGA.9 and its equipment. "Even more remarkable than the missing generation of aircraft," he wrote, "are the *two* generations of close-support weapons development which have been missed in Britain." The result was that the Hunter's armament consisted of 30mm guns of anglicized Mauser wartime design, 1,000lb bombs or rocket projectiles designed 22 years ago, and a gunsight of not much more recent vintage. And trials had then only recently begun with a French armour-piercing rocket which had been available since 1956.

On December 28 Mr John Stonehouse, Parliamentary Secretary to the Ministry of Aviation, left London for Rio de Janeiro. Several London dailies reported the next day that he was leading a new effort to sell British airliners to South America. In fact, the Ministry had not disclosed any specific reason for Mr Stonehouse's journey, though it denied that he was leading a sales drive. Apparently the story was speculation. By January 1 the real purpose of the visit was clear. It was announced in Rio that the Brazilian Government had granted traffic rights for a weekly British United VC10 service to Rio de Janeiro. Up till then most of us had been unaware that BUA had not been permitted to pick up or set down any passengers at Rio. The *Financial Times* reported Mr F. A. Laker as saying "there is no doubt that Mr Stonehouse's intervention has helped a lot. The Government has given 100 per cent support."

The case for retaining a strong and independent industry and the four major projects now under review has seldom been more succinctly put than by Mr Maurice Edelman, MP (Lab, Coventry N), in a letter to *The Times* of December 30. The correspondence columns of *The Times* provide a platform almost on a par with the Commons itself.

Another MP, Mr George Currie (U.U., Down N), made news on December 29 in the *Daily Mail* with the reported claim that "130 passengers had to leave a long-delayed BEA Vanguard airliner at London Airport because a pilot collapsed from fatigue minutes before take-off." This was a Page 1 lead story. An inside page of the next day's *Daily Mail* carried a strong BEA denial of fatigue: a Vanguard captain had felt unwell and passengers were delayed while a replacement was found. The whole unfortunate matter was sparked off by a question which Mr Currie is to ask the Minister of Aviation about permitted duty hours of BEA pilots. The information he seeks is unlikely to cause any public concern and is, of course, freely accessible without any public action whatever. BEA duty hours are well within legal limits and pilot utilization rates are by world standards low.

Finally, from the same day's *Daily Mail*, a thought for the week from Bernard Levin's column. He called the Concorde "a heap of aluminium-coated rubbish," but added ". . . if you think the Q4 is any better a proposition you are mistaken."

AIR TRANSPORT

1964's Best-ever Safety Record

PROVISIONAL accident figures for 1964 show that this was, by accepted statistical yardsticks, the "safest" year yet for passengers on scheduled services. According to *Flight*'s figures —based largely on the records published in *Lloyd's List*— there were 583 fatalities in 20 accidents on scheduled services. ICAO's year-end statistics show that a total of 107,000 million passenger-miles were flown by the world's scheduled airlines (ex USSR and China) in 1964. That being so, the accident rate was equivalent to 0.545 fatalities per 100 million passenger-miles.

This is the lowest world figure so far recorded. The 1963 figure, according to ICAO statistics, was 0.76 and the 1962 figure was 0.95. All the previous years' fatality rates were higher than one per 100 million passenger-miles, with a lowest figure, between 1950 and 1961, of 1.02 in 1959 and a highest of 3.15 in 1950.

Last year was also the most satisfactory when using other accepted yardsticks. The number of accidents on scheduled services (20) was the fewest since 1951, when there were also 20 accidents. Total number of passengers killed (583) was the lowest since 1957, when 507 were killed. The number of fatal accidents per 100 million miles flown in 1964 (using the ICAO mileage figure of 2,280 million) was 0.9—which was the lowest figure recorded—and the number per 100,000 aircraft hours, at 0.24, was also the lowest.

The non-scheduled record for 1964 was slightly worse than for 1963, with 175 fatalities in 12 accidents, but much better than for 1962 when about 400 passengers were killed. Non-scheduled figures are obviously less reliable on a world-wide basis than those for scheduled services. Our list does not include air-taxi and similar accidents, and there is no absolute certainty that every non-scheduled accident in other categories has been recorded—or recorded in sufficient detail for inclusion in the tabulation.

Passenger fatality rate for US scheduled operations in 1964 was less good than in 1963—though much lower than the world figure. In the first 11 months the rate per 100 million passenger-miles on domestic and international operations was, according to *Aviation Daily*, nearly 0.3, whereas the 12-month figure for 1963 was 0.23.

FATAL AIR CARRIER ACCIDENTS, 1964

ıte	Carrier	Aircraft	Location	Fatalities Pass.	Crew	Circumstances
9	Aerotransportes del Litoral Argentino *	DC-3	Nr Zarate, Argentina	28	3	Engine failure and fire. Pilot believed overcome by fumes while attempting forced landing
15	Lloyd Aereo Boliviano *	DC-3	Potosi Airport, Bogota	1	—	Crashed on take-off
3	South Central Airlines *	Beech 18	Gainesville Mun Airport	9	1	Crashed and burned on take-off
3	Turk Hava Yollari	DC-3	Nr Ankara	—	3	Hit hillside
4	Lloyd Aereo Boliviano *	DC-3	Nr Yacuiba, Bolivia	1	1	Crashed soon after take-off
18	Nitto Airlines	Grumman Mallard	Nr Osaka	1	1	Engine trouble, lost altitude, crashed
21	Philippine Air Lines *	DC-3	Lanao del Sur province	28	3	Crashed in bad weather
25	Eastern Air Lines *	DC-8	Lake Pontchartrain, N of New Orleans	49	7	Dived into lake approx 9min after take-off from New Orleans
27	Fuji Airlines *	Convair 240	Oita Airport, Kyushu	20	—	Crashed into embankment on landing, caught fire
29	British Eagle *	Britannia 312	12m SE of Innsbruck	75	7	Hit mountain, possibly during preliminary descent
1	Paradise Airlines	L-1049	Sierra Mts, Nevada	81	4	Hit high ground in snowstorm while on initial approach to Lake Tahoe
8	Lineas Aereas Taxader *	DC-3	West of Bogota	25	3	Not known. Reports of explosion
9	Snow Valley Ski Airline	DC-3	Chicago	—	1	Crashed on approach to O'Hare
10	Slick Airways	DC-4 (cargo)	Boston Harbour	—	3	On approach to Logan Intl.
12	Frontier Airlines *	DC-3	Nr Miles City, Montana	2	3	Crashed during approach in snowstorm
28	Alitalia *	Viscount	Mt Vesuvius, Italy	40	5	Hit mountain during approach to Naples
20	Middle East Airlines *	Caravelle	10m S of Dhahran	42	7	Crashed in sea on approach in sandstorm
May 7	Pacific Air Lines *	F-27	12m E of Concord, Cal	41	3	Pilots shot by passenger
May 20	Philippine Air Lines *	Otter	Nr Zamboanga	10	1	Crashed in bad weather
June 21	TASSA	DC-3	Off coast of Majorca	1	—	Ditched after engine failure on take-off
June 21	Civil Air Transport *	C-46	Taichung, Formosa	52	5	Engine failure after take-off
July 9	United Air Lines *	Viscount	Nr Newport, Tenn	35	4	Fire in flight
Aug 16	VASP	C-46 (cargo)	Nr River Capim, Brazil	—	4	Crashed after losing No 1 propeller
Aug 22	Servicios Aereos Cochabamba	DC-3	Nr Tipuani, Bolivia	2	2	—
Sep 3	VASP *	Viscount	NE of Rio de Janeiro	34	5	Hit mountain
Oct 2	Union de Transportes Aériens	DC-6	Sierra Nevada Mts, Spain	73	7	Hit Mt Alcazaba
Nov 15	Bonanza Air Lines *	F-27	Nr Las Vegas, Nevada	25	3	Hit mountain in snowstorm during approach to Las Vegas
Nov 20	Linjeflyg *	Convair 440	Angelholm, SW Sweden	29	2	Hit power cables on approach
Nov 23	TWA *	Boeing 707	Fiumicino Airport, Rome	37	11	Explosion and fire after aborted take-off
Nov 29	Belgian International Air Services	DC-4	Stanleyville Airport, Congo	5(?)	2(?)	Crashed on take-off; probably damaged by rebel gunfire
Dec 8	Aerolineas Abaroa	DC-3	Between Tipuani and La Paz, Bolivia	11	4	Dynamite sabotage by passenger suspected
Dec 21	Fleming Air Service	DC-3	Aklan Province, Philippines	—	1	Crashlanded in lake
Dec 24	Flying Tiger	L-1049 (cargo)	3m W of San Francisco	—	3	Hit San Bruno Mountain
Dec 30	Linea Aerea Sud Americana	?	Turrialba Volcano, Costa Rica	—	5	Struck volcano
			Totals	757	114	
*Scheduled			Total	871		

AIR TRANSPORT...

Ansett-ANA's Sikorsky S-61N made its first flight in Australia last month and is seen here on a test flight over Melbourne. It is being used for flights between the Queensland coast and Hayman Island, a tourist resort on the Great Barrier Reef

BRAZIL TRAFFIC RIGHTS FOR BUA

UNTIL last week British United Airways had been without traffic rights in Brazil for its South American services. Approval of passenger rights for one flight a week through Rio de Janeiro was announced on December 31. BUA operates two flights a week through Brazil and will obviously press for similar rights on the second weekly service.

Although pick-up and set-down rights had been obtained for Montevideo (Uruguay), Buenos Aires (Argentina) and Santiago (Chile) the Brazilian authorities had, after earlier hopes, remained intransigent; because of its inability to serve Rio BUA has had very low load factors on its South American services. Last week Mr John Stonehouse, Parliamentary Secretary to the Ministry of Aviation, arrived in Rio de Janeiro on the first stage of a tour of the cities on BUA's route. He evidently pressed the Brazilian authorities successfully for a decision.

Swissair Has Ordered a DC-9 Simulator from Canadian Aviation Electronics. Delivery of the airline's ten DC-9s is due to start in June 1966.

First Boeing 727 for BWIA was handed over on December 22 and has been flown out to Trinidad before returning to Miami for crew training this month. British West Indian Airways has three 727s on order.

A DC-8-50 has been ordered by VIASA, the Venezuelan carrier, for delivery in the autumn of this year. VIASA's long-haul services are at present operated by KLM DC-8s on wet lease. DC-8 sales now total 244.

The accident in Bolivia to Abaroa Airlines' DC-3 (*Flight*, December 24, page 1068) is now believed to have been caused by a dynamite charge planted by a heavily insured passenger. The aircraft was flying between Tipuana and La Paz.

British United Airways' 1964 Traffic Provisional figures for scheduled operations by BUA and its home-based associates include totals of 1,109,981 passengers (5.2 per cent up on 1963) and 38,849 short tons of freight (19 per cent up on 1963).

A Second Handley Page Herald (a Series 200) has been ordered by Bavaria Fluggesellschaft of Munich, which has also taken an option on a third Herald. The aircraft will be used for inclusive tours, freighting and for scheduled services flown on behalf of Lufthansa.

No Moscow Rights Yet for KLM Reports from the Netherlands that KLM had obtained traffic rights through Moscow on its services to and from the East (*Flight*, December 24, page 1066) were premature. Discussions have, as reported, been held and the airline's manager for Europe will be having further talks in Moscow, but there is no certainty yet that traffic rights will be obtained.

One-Eleven Demonstration Tour of Australia is planned for March. It may be extended to New Zealand. A BAC technical sales mission was in Australia last month.

New Passenger Facilities At Luton are to be provided by April 1966 in the form of a single-storey £750,000 terminal capable of dealing with 12,000 passengers a day.

Two Boeing 707-320Bs have been ordered by Transportes Aéreos Portugueses. First will be delivered early in 1966. These are the first long-haul jets to be ordered by Portugal's flag carrier.

US Domestic Trunks carried 60.7m passengers in 1964—an increase of 13.7 per cent on the 1963 total. Revenue passenger-miles totalled 41,800m—or a 14.8 per cent increase. Cargo ton-miles increased by 24.7 per cent.

A Flying Tiger Line L-1049 crashed into the San Bruno mountain near San Francisco in the early hours of December 24 while on a cargo flight from San Francisco to New York. Three crew members, the only occupants, were killed.

A Fleming Air Services DC-3 operating on a domestic service in the Philippines, crashed into a lake in the southern Aklan province. The captain was killed; the 35 passengers and three other crew members escaped.

Application for London (Gatwick) - Brussels Services has been made by British United Airways. If approved, the service will be started, using BAC One-Elevens, in the spring. BUA originally applied for approval on this route in 1961, but the request was then refused.

Capt W. B. Caldwell, one of BEA's very senior pilots, retired from the corporation's service on December 31, his 60th birthday. Capt Caldwell had been flying for 32 years and had logged about 20,000hr. He plans to continue commercial flying.

Increase in BAC One-Eleven Orders is being considered by Mohawk Airlines. According to *Aviation Week* a decision on future re-equipment leading to an all-turbine fleet will be made by the airline in February. Mohawk has five One-Elevens on order and two on option.

Improved Passenger Handling Facilities are, according to Mr Anthony Milward, writing in the current *BEA Magazine*, urgently needed by the corporation. The chairman said that the airline's traffic department was developing new ideas and had, among other things, built a prototype powered passenger gangway to be used in conjunction with Heathrow's new piers.

Two Turboprop Potez 842s have, according to *Aviation Daily*, been ordered by German companies for executive work. First is due for delivery soon and the second in September. An initial order for this P & W PT6A-6-engined transport was given by the French Ministry of Public Works recently (*Flight*, December 31, 1964, page 1107).

AIR-CARGO CLOSED SHOP IN AUSTRALIA

PERMISSION for two road haulage companies in Australia to import DC-4s for all-cargo services has been refused by the Director-General of Civil Aviation, Mr D. G. Anderson. IPEC Air Pty had proposed to import five aircraft and Comet Pty asked to be allowed to import three.

IPEC Air is a wholly-owned subsidiary of the Interstate Parcel Express Co and its plan was to operate all-freight charters serving Sydney, Melbourne, Brisbane, Adelaide, Perth and Launceston. Its application for a charter licence has also been refused by the Government. IPEC's argument has been that Ansett-ANA and TAA were not doing all that could be done to develop air freight in Australia and that an operator for whom freight carriage was a total business, rather than a sideline to passenger carrying, would be much better able to develop the market (see "Presenting a Case," *Flight*, November 5, 1964, page 778).

Comet Pty had proposed to operate freight services between Brisbane, Sydney, Melbourne and Adelaide.

TREE-BRUSHING INCIDENT EXPLAINED

THE incident on September 2, 1963, when an Iberia L-1049G (EC-AMQ), operated by Aviaco, brushed trees on a night approach to Gatwick in bad weather is the subject of a full, published report by the Ministry of Aviation Accidents Investigation Branch. For an incident involving a foreign aircraft, and in which there were no casualties or injuries among the seven crew and 75 passengers, this is a praiseworthy development. It also demonstrates the continuing good effect of the Cairns Committee report, in which it was recommended that full information on all accidents and incidents should be published.

The L-1049G was on a charter (IT) flight from Barcelona to London (Gatwick) and the approach was being made in poor weather conditions with 6/8 cloud at 600ft, 8/8 cloud at 700ft and visibility of 4 n.m. at about 01.50hrs GMT. Radar positioning for an ILS approach to runway 09 was provided by approach control. When the aircraft was on base leg its captain reported that his glidepath equipment was inoperative. During the ILS approach the L-1049G brushed through the tops of trees on Russ Hill—which is about 220ft above and 1¾ n.m. from the runway threshold. The aircraft was slightly damaged—including the loss of about 6in from a blade of No 3 propeller—but a safe landing was made.

The accident report comments that in view of the availability of PAR at Gatwick, it would have been "good airmanship" on the part of the captain to have requested this facility when he became aware that his ILS glidepath receiver was unserviceable. A decision to continue the approach on the localizer only was not one which warranted criticism, but the decision did make it important for him to watch his altitude. The report also suggests, that, though responsibility for asking for the use of PAR lay with the aircraft captain, the ATC officer "might reasonably, as a matter of prudence, have reminded him of its availability." The captain apparently assumed, incorrectly, that the progress of his approach was being monitored in elevation by radar.

In its conclusions the accident report suggests that the cloud base and visibility in the vicinity of Russ Hill were probably lower than those reported for the aerodrome, but points out that the captain did not maintain the notified minimum height (490ft) over the middle marker and descended below his "personal" critical height (400ft) without having visual reference. The airline's operation manual did not specify weather minima for an approach using ILS without glidepath information—and this fact is given as a contributory factor in the incident.

PLEA FOR FLIGHT-CHART CO-ORDINATION

UNNECESSARY multiplication of effort, increased cost and loss of overseas business are arguments being put by International Aeradio in a campaign for the rationalization of the production of flight documentation such as navigation charts.

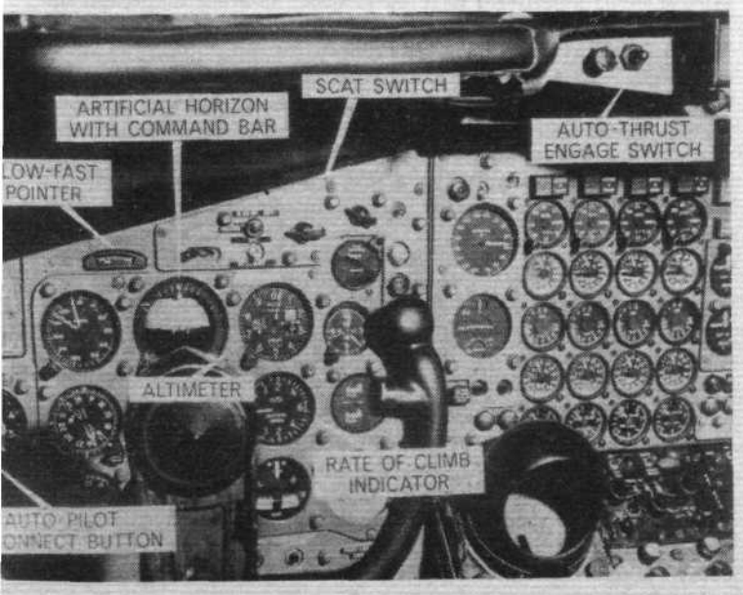
In addition to commercial producers there are three other sources of charts—Government departments, the Services and individual airlines—and the products vary in coverage, specification and means of amendment. In IAL's view, better and cheaper results would be obtained by combination of effort.

TWA's AUTO-SCAN

APPLICATION has been made to the FAA by TWA for approval of the airline's new Auto-Scan landing aid for use in conditions down to the agency's category 2 minima of 1,200ft runway visual range (RVR) and 100ft cloudbase. The system has been under development by TWA in co-operation with Boeing, Safe Flight and Bendix for about three years. Pan American and United are each working on their own systems and are about to apply for approval, while, according to an FAA official, American Airlines is not far behind.

TWA has fitted Auto-Scan to three of its Convair 880s and three 707s. Initial approval will be for minima of 1,600 RVR and 150ft decision height; then, after six months if proved successful, 1,200ft/100ft may be approved.

The main elements of TWA's Auto-Scan system in a 707-130B



Auto-Scan consists of four integrated components: an advanced autopilot embodying automatic capture of the ILS beam; improved dual flight directors (to compute and indicate the aircraft's position along the ILS glidescope and localizer beams); a speed control device to give a continuous indication of the speed which should be maintained during the approach; and, finally, auto-thrust, a device receiving the same inputs that go to the speed control unit which are then used to control the throttles. The speed control-altitude/target (SCAT) was developed by Safe Flight, and consists of an angle-of-attack sensor under the wing which detects the fundamental changes that result in subsequent speed variations. The signals from the sensor appear on a "slow-fast" dial on the instrument panel. The auto-thrust system, tied in with SCAT, is capable of coping with landing-gear and flap trim changes. The pilot can override the auto-thrust with normal manipulation of the throttles.

In addition to the refined airborne equipment and flight crew expertise necessary to cope with the split-second decision and transfer to visual flying at the critical height, airports, too, must have special equipment. At the moment only Washington's Dulles and Oakland, California, meet the requirements in the latter respect, which are: a high-precision ILS; standard approach lights with sequenced flashers; high-intensity runway edge lights; touchdown zone and continuous centreline lights; all-weather runway markings; and RVR measuring equipment. A further 20 or so airports are believed to be planning for the necessary installations, and 50 airports are eventually expected to be equipped.

The evaluation programme for the final step down to 1,200/100 requires at least 300 demonstrations to the critical height for each type of aircraft fitted. At least three ILS facilities must be used.

This is the first of Air Canada's Vanguards to be re-styled. Five of the carrier's DC-8s have already been re-painted in the new colour scheme. The picture was taken at Malton Airport, Toronto, late last month

AIR TRANSPORT...

ICING CAUSE OF SLICK DC-4 ACCIDENT

ACCUMULATION of clear ice on the tailplane caused a Slick Airways DC-4 to go out of control during an ILS approach, in bad weather and at night, to Logan International, Boston, on March 10, 1964. The DC-4 was at a height of about 450ft, and was 7,500ft from the displaced threshold of runway 4R when it pitched sharply nose-down and crashed in a lumber yard on Castle Island. All three crew members, the only occupants, were killed.

In the words of the CAB accident report "the probable cause of this accident was loss of balancing forces on the horizontal surface of the aircraft's empennage, due to ice accretion, causing the aircraft to pitch nose-down at an altitude too low to effect recovery." Weather at the time was: scattered clouds at 400ft, overcast at 700ft, surface visibility 1½ miles in moderate sleet and fog, temperature 32°, dewpoint 32°. When over Castle Island the DC-4 was, according to the PAR controller, on course and glide-path, but the target suddenly disappeared from both elevation and azimuth scopes. The investigators believe that the DC-4 had previously accumulated ice and that in the final stages of the flight "moderate to heavy rime icing conditions continued." Investigations showed that the TAS was about 130kt—an excessive approach speed such as would be demanded by a known build-up of ice on the wings.

The CAB concluded that 15° of flap was used from the outer marker and that 30° were selected when the runway approach lights could be seen. The increased downwash after this flap extension changed the tailplane angle of attack to one which, coupled with the ice formation, destroyed the tail lift and disrupted the necessary balancing tail loads of the aircraft.

BATTLE FOR NEW YORK-FLORIDA RIGHTS

THE US Civil Aeronautics Board has once again denied, by a three-to-two majority, Northeast Airlines' right to operate over the New York - Florida route. This second decision not to renew Northeast's temporary certificate for the route was the last by the board under its present membership. Mr Chan Gurney—one of the three members (including the chairman, Mr Alan Boyd) who ruled that there was no need for a third carrier on the Florida route—retired at the end of 1964.

The original decision by the CAB to terminate Northeast's certificate was made on August 15, 1963. Northeast then filed a petition with the US Court of Appeals which eventually, in May 1964, set aside the orders of the CAB and referred the case back to it for "further proceedings consistent with the Court's opinion." Meanwhile the Court retained jurisdiction. Under the new CAB ruling Northeast's certificate will be terminated 60 days after any final judgment by the Court in approval of the board's findings.

In its latest opinion the CAB says that Northeast's Florida operations have led the carrier towards "economic ruin" and have also "been accompanied by deterioration in its service in New England." The board found "no reasonable prospect" that future operations over the Florida route would become financially successful and that renewal of Northeast's certificate "would merely perpetuate a fundamentally and seriously uneconomic situation." The board majority also expressed the opinion that the return to two-carrier competition over the route would be beneficial to Eastern Air Lines—but added that this belief played no part in the decision not to renew Northeast's certificate.

The dissenting members of the CAB considered, among other things, that the adverse decision should not have been made without "reopening the record to consider, *inter alia*, such favourable changed circumstances as the increased traffic in the markets . . . and the proposed improvements in Northeast's debt structure."

According to *Aviation Week*, Northeast's president, Mr James Austin, said that the termination date was "a long way off" and that the airline will "continue to use every legal means" to retain its rights to the route.

IMPLEMENT OR ELSE...

IN its December news bulletin IFALPA again takes up the subject of inadequate airport, navigation and other ground facilities in various parts of the world. The point is made that where pilot groups have pressed unfalteringly for improvements these have been rapidly forthcoming. An opposite example is cited in the case of Peruvian DC-3 operations to remote townships on the rain-sodden eastern slopes of the Andes. Here pilots had tolerated indifferent and potholed runways until a propeller of a DC-3 struck the ground as the undercarriage fell into a pothole, killing the pilot.

For a time—perhaps as a result of the Peruvian incident—Mexican pilots refused to operate into the similarly rough Guadalajara Airport. Here runway 10/28 was potholed and covered with loose debris to the extent that two jet engines suffered ingestion failures, several aircraft had burst tyres, and many flaps and propellers were damaged. One airline was obliged to withdraw its jet equipment. IFALPA understands that the runway was then resurfaced in a matter of days. Mexican pilots have also refused to operate jets into Acapulco international airport at night until VASI lights are installed. Other IFALPA members are being asked to follow suit.

In Europe a big trouble spot is Naples Capodichino. Here general safety conditions have never really been adequate and the Italian Pilots Association, failing to get satisfaction from the Ministry, called on IFALPA support for an "implementation campaign." As a result of a study of the situation it was decided that, from December 15, IFALPA members should exercise their pilots' prerogative by declaring the comparatively high weather minima of 2,800ft cloudbase, and 3,000 metres visibility.

Some of the reasons for this action are that the Pomigliano and Naples NDBs are frequently affected by atmospheric conditions and interference from various sources to the point at which they can no longer be relied upon for bad-weather navigation; that the VDF let-down service has been officially declared unsafe; and that the ILS approach procedures do not conform to ICAO standards in the matter of minimum terrain clearance on the base turn and the outer marker of the ILS has officially been declared to be unmonitored.

Other objections to Capodichino are the obstacles, in the form of high-voltage cables, within 300 metres of the main runway threshold—effectively reducing the length of this runway. In addition to the technical inadequacies IFALPA claims that the ATC procedures themselves are unsatisfactory in that the whole area contains a mixture of IFR and VFR traffic, including helicopters and civil and military jets, and there is no surveillance radar.

AIRPORT ADMINISTRATION

A Guide to Organization and Information Sources

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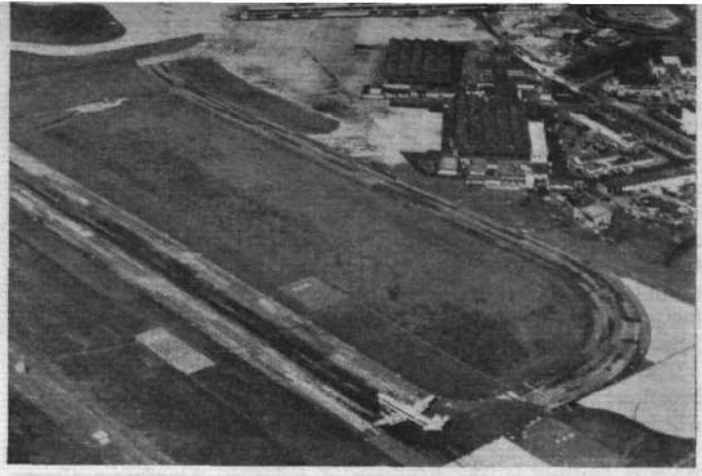


Manchester Airport Airviews (Manchester) Ltd photograph

Most aspects of the transport industry are well served by organizations providing information facilities and with a considerable body of literature which is easy to obtain; but as a relatively small branch of the air transport industry, airport administration is not, on first sight at least, so well served. The facilities and literature, though quite considerable, are not always obvious and need to be carefully sought. This article lists the organizations which provide information services to those interested in airport administration: a second instalment will examine the literature available for study.

INTERNATIONAL ORGANIZATIONS

Commonwealth Air Transport Council, *Shell-Mex House, Strand, London WC2* The Committee for Air Navigation and Ground Organization (CANGO) was established in 1945 under the ægis of the council, though it is not constituted as an official committee of the Council. Although the committee has no executive powers it does make recommendations to the council's member-governments, designed to produce a greater measure of co-ordination and safety. The committee functions largely through regional organizations, SPCANGO and SACANGO, established under the ægis of the CATC regional organizations South Pacific Air Transport Council and the South African Air Transport Council.

Institute of Transport Aviation, *4 Rue de Solférino, Paris 7e* The Institute is an international non-profit-making organization which studies the economic, technical and policy aspects of air transport on behalf of its members throughout the world. It provides a consultancy service, a study centre and information service and an extensive library. ITA issues a large number of publications containing the results of research studies carried out on behalf of members; many of these publications are issued on limited circulation to members only. The principal interest for persons concerned with airport administration is the possibility of obtaining special research studies from the study centre and the availability of statistical material from the information service. Several periodical publications which are issued will be mentioned in Part 2.

Western European Airports Congress Held annually in various countries, each Congress is organized by the civil aviation authority in the host country. The British representation is usually by senior officers of the Ministry of Aviation, and they are responsible for passing on a résumé of the Congress proceedings to interested parties in this country.

NATIONAL ORGANIZATIONS

Aerodrome Owners Association, *Artillery Mansions, Victoria Street, London SW1* Founded in 1934, the Association is the officially recognized national organization which represents the interests of owners and operators at non-State-controlled airports throughout the United Kingdom. In 1954 a new grade of membership was introduced to encourage local authorities to take up membership and to select and reserve sites for possible future use as helicopter stations.

Membership ranges from the owners of large airports to the operators of small grass fields. The Association advises and assists members in all aspects of aerodrome maintenance, equipment and operation, and it works in close co-operation with the Air Ministry, the Ministry of Aviation and other Government departments.

The Association's executive committee consists of 16 members equally representative of municipal and independent airport operators.

An annual two-day conference is held at different centres in late September or early October. An annual general meeting is held towards the end of February; an annual report considered at this meeting is later published, and there is also an irregular *Newsletter* which is distributed freely to members.

Membership is available in three grades: (1) Ordinary members who are owners and operators of airports. (2) Associate members, who are current or potential owners of helicopter landing sites. (3) Affiliate members, who are companies and bodies having connections with civil aviation. Total membership in the three categories at the end of 1963 was 114, divided as follows: Category 1, 42; category 2, 27; category 3, 45.

The Association, which has two standing sub-committees—(a) Fees and Charges, (b) Technical—is represented on the following bodies: The British Standards Institution Aircraft Industry Committee; Civil Aircraft Control Advisory Committee; National Civil Aviation Consultative Council; and the Royal Aero Club Aviation Committee.

Association of Municipal Corporations Airports Sub-Committee, *Victoria Station House, Victoria Street, London SW1* This sub-committee was established by the General Purposes Committee of the Association of Municipal Corporations in 1953 as a replacement for the Municipal Aerodromes Committee set up in 1935. It is the forum wherein are discussed matters of interest to corporations who are the owners of airports or who are contemplating the establishment of an airport. Reports of its meetings are summarized in the Association's official organ, *Municipal Review.*

The Association of Sea and Airport Health Authorities, *c/o The Health Department, Civic Centre, Southampton* Health control at the principal civil airports in the United Kingdom is administered by certain local authorities designated "responsible authorities" by the Minister of Health. In the case of national airports the administration is carried out by virtue of powers delegated by the Minister, in that other categories of airport the authority maintaining the service, or the authority in whose area the airport is situated (if it is a privately owned one) is designated the "responsible authority." Expenditure by the "responsible authorities" is entirely reimbursed by the Government.

The principal aims and objects of the Association are: (1) The promotion of improvements in the laws of public health relating to sea and airports, for which purpose the Association is constantly in contact with the Ministry of Health, the Board of Trade and other Government departments. (2) To watch over the interests of port health authorities. (3) To obtain and disseminate information on matters affecting the interests of such authorities.

There are two main committees, General and Medical. An annual conference, lasting two days, is held at various centres throughout the country.

National Civil Aviation Consultative Council, *Shell-Mex House, London WC2* This body was established in January 1947 by the then Minister of Civil Aviation. Its terms of reference were "to be a forum for the review of developments in civil aviation," and

AIRPORT ADMINISTRATION . . .

among its 40 or so members are representatives of aerodrome operators. Matters relating to landing fees, airport policy and accident investigation were some of the questions examined by the Council when it was in regular session. Although the Council is nominally still in existence, it has not met since 1955; consultation between various bodies represented on the Council and the Minister are now usually carried out on an *ad hoc* basis.

The Council did not issue annual reports and most of its deliberations were confidential. There are, therefore, no publications which can be directly ascribed to the Council.

The principal agency of the Government now dealing with Airport matters is **The Ministry of Aviation, Aerodrome Group,** *Shell-Mex House, London WC2.* The Group is headed by an Under-Secretary (Management).

Royal Aeronautical Society: Rotorcraft Section, *4 Hamilton Place, London W1* In January 1960 the Helicopter Association of Great Britain merged with the Royal Aeronautical Society and became the Rotorcraft Section of the Society.

Until the end of 1959 the Helicopter Association produced its own journal, most of the back issues of which are still available from Wm. Dawson Ltd of 16 West Street, Farnham, Surrey. Several significant articles on heliport operation which appeared in the journal have been issued as reprints which are also available from Messrs Dawson, for example: *The Design of Helicopter Operating Sites* and *Engineering Aspects of Helicopter Bus Stations in City Centres.*

Reprints of the papers read at meetings of the Rotorcraft Section in the period since 1960, e.g., *Experiences with an Operational Heliport*, are also available from the same source.

Air Transport Advisory Committees Under the provisions of the Air Transport (Licensing) Act 1960 and regulations made thereunder, three regional advisory committees were set up with the following terms of reference: "To advise the Air Transport Licensing Board on matters relating to the Board's function under the 1960 Act, with particular reference to the circumstances and requirements of Scotland, Wales and Northern Ireland." A fourth committee set up under the provisions of the White Paper on the North-East (Cmd 2206) was established in 1964 to take account of the North-East of England.

The Ministry of Aviation provides the secretariat for the committees, which meet approximately three times a year. They consider, among other things, matters relating to aerodromes in their respective regions, and make recommendations to the Minister.

These committees superseded three advisory councils established in 1949 under the terms of the Civil Aviation Act 1946, which also set up the three corporations, British European Airways, British Overseas Airways Corporation and British South American Airways Corporation (later merged with BOAC). The purpose of the councils was to advise the corporations on matters affecting their particular regions.

Addresses of the Air Transport Advisory Committees are as follows: Scottish Advisory Committee for Civil Aviation, Government Office Block M.1, Broomhouse Drive, Saughton, Edinburgh; Northern Ireland Advisory Committee for Civil Aviation, Ministry of Commerce, Chichester Street, Belfast 1; Civil Aviation Committee for Wales, County Hall, Newport, Mon; North-East England Advisory Committee for Civil Aviation, c/o Ministry of Housing and Local Government (N. E. Regional Office), Wellbar House, Gallowgate, Newcastle upon Tyne 1.

There are similar, though independent, organizations in the Channel Islands and in the Isle of Man, viz: The Channel Islands Air Advisory Council, States Greffe, Jersey (or States Offices, Guernsey); The Isle of Man Airports Board, Ronaldsway Airport, Isle of Man.

There is a separate London Airports Consultative Committee (at Middlesex Guildhall, London SW1) which was established in 1948. The then Minister of Civil Aviation established it to assist him in the discharge of his duties under the Civil Aviation Act 1949. This Act, which replaced the earlier section 38(1) of the 1946 Act, allowed for the provision of machinery whereby consultation could take place between the Airports Authority and the local authorities.

The committee is purely consultative in character and is expected to be ready to advise on any matters referred to it by the General Manager, London Airports. It can make suggestions on its own initiative on matters which fall within its terms of reference, which are: (1) To advise the General Manager, London Airports, on any matter which he may refer to them. (2) To consider any question in connection with the problems of the Airports as they affect the communities represented. (3) To make suggestions to the General Manager, London Airports, on any matter connected with the administration of the Airports which can further the interests of the communities represented. (4) To stimulate the interests of the local population in the activities of the Airports.

If the General Manager, London Airports, is unable to accept a committee recommendation there are arrangements whereby the Minister's decision may be sought. The constitution of the committee allows for the representation of all local authorities within whose boundaries the airports are situated. In addition, there can be not more than four persons appointed by bodies, other than the local authorities, which are considered to be representative of London as a whole—for example, chambers of commerce and chambers of trade.

The Civil Air Transport Employer's Secretariat, *Terminal House, Grosvenor Gardens, London SW1* This organization, which was established in 1948, has the task of co-ordinating the activities of the employers' side of the National Joint Council for Civil Air Transport (*q.v.*). The secretary of this body is also the employers'-side secretary of the Council and the National Sectional Panels.

Employers represented on the Council as at January 1964 were BOAC, BEA, British Eagle, British United, International Aeradio, BKS Air Transport, Cambrian Airways, Channel Airways, Dan-Air, Derby Aviation, Morton Air Services and Skyways.

National Sectional Panels concerned specifically with airport ground staffs upon which the Secretariat is represented are: Supervisory engineering and technical; catering; engineering and maintenance; surface transport and goods handling; general service workers; clerical and clerical administration.

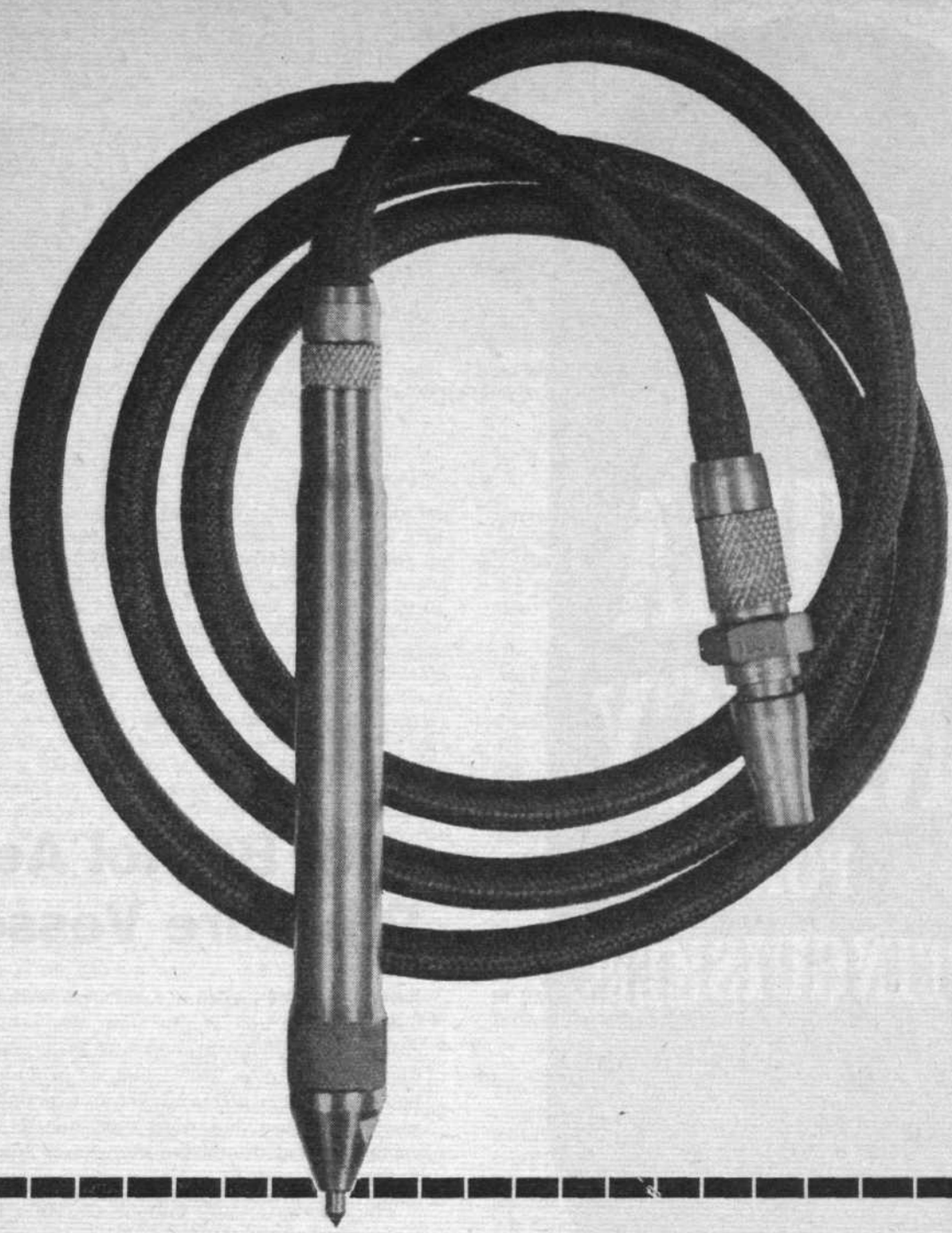
Guild of Air Traffic Controllers, *14 South Street, London W1* The Guild was founded in 1951 as a result of the desire of many air traffic controllers to ensure that the dignity, standards and future of their profession should be safeguarded. It is in the pattern of a craft guild and aspires to the ultimate acceptance as such by the City of London livery companies. It is not, therefore, a trade union and does not intend to take any part in political or sectarian activities, and it maintains a non-profit-making programme. Its objects include the following: (1) To enable persons engaged in the profession of Air Traffic Controller for the time being, or retired therefrom, to federate or co-operate by becoming members of the Guild. (2) To promote honourable practice and maintain in the profession a high standard of efficiency and integrity dedicated to the safety of those who seek their livelihood or pleasure in the air. (3) Generally to watch over, protect, improve and advance the profession. (4) To collect, collate, and publish in the form of journals, papers, pamphlets or otherwise, information of service or interest to members of the Guild. (5) To constitute a body of experienced Air Traffic Controllers who will be available to act as members of, or to hold seats on, or to give evidence before Royal Commissions, Courts of Inquiry, Committees or Boards of any description whatever, or governing, examining or other bodies official or otherwise, and who will be available for advice or consultation on all questions affecting the business of its members in relation to Air Traffic Control, or judicial, commercial, scientific, educational, technical or legislative matters relating thereto.

These are but a selection of the 14 stated aims of the Guild as given in their membership leaflet. A bulletin published every six months is known simply as *The Journal.* Every two years an Air Traffic Control Convention is held, usually in Bournemouth. The Guild is a member of the International Federation of Air Traffic Controllers Associations; and by this means, as by others, it maintains close relations with organizations similar in function to its own.

The British Airline Pilots Association, *81 New Road, Hayes, Middlesex* This organization is a true trade union and while it has no direct connection with airport administration several of its study groups keep a close watch on matters concerning the use of such ground aids as beacons and approach lighting.

National Joint Council for Civil Air Transport: *Employers' Secretary: Terminal House, Grosvenor Gardens, London SW1. Workpeople's Secretary: 110 Peckham Road, London SE15* Several of the 12 sectional panels of the council take account of matters concerning the administration of airports.

[To be continued]



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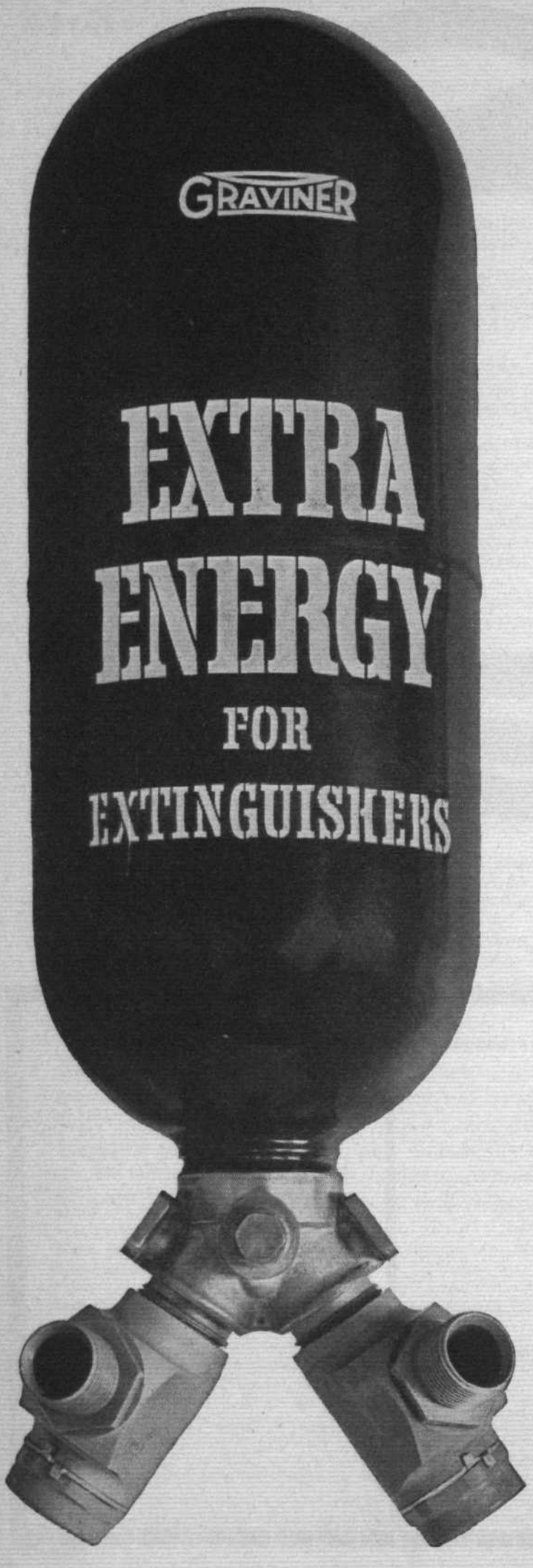


with Bristol Aerojet Pressure Vessels

Bristol Aerojet pressure vessels pack more energy into less space for less weight than any other type of gas storage vessel. They also operate with great reliability at high stress levels. These factors provide considerable benefits in every airborne system which depends upon a reservoir of gas, but most particularly where gaseous energy is used to operate emergency equipment—such as fire extinguishers.

The internationally famous Graviner Company uses large numbers of Bristol Aerojet pressure vessels in its fire extinguisher systems for military and civil aircraft, the most recent being the TRIDENT and VC 10. One type of vessel, which was specially made from deep drawn pressings, was not only much lighter but also increased the working pressure to 1,500 psi—600 psi more than the vessel previously used.

Made of chrome molybdenum steel, heat treated to a minimum ultimate strength of 80 tons per sq in, Bristol Aerojet pressure vessels range from 10 to 2,000-cubic-inch capacity and are made in a large number of shapes to conform to special applications. They have been ordered by many of the leading British airframe and weapon constructors and auxiliary equipment manufacturers.

For further information, please write to: P. W. Lawson, Civil Sales Manager, Bristol Aerojet Limited, Banwell, Weston-Super-Mare, England. Telephone: Banwell 250.

BRISTOL AEROJET

The new Cessna Super Skylane displaying its "jet flow" engine nacelle. This middle-price 285 h.p. six-seater cruises at 177 m.p.h. and costs $23,995 ex-works. (See "Cessna Singles for '65," below)

SPORT AND BUSINESS

Cessna Singles For '65 continue substantially unchanged from last year. Smallest in the range, the two (occasional three)-seat 150E (100 h.p. Continental O-200) has been altered least following the introduction of omni-vision last year. Changes include a neater panel, form-fitting bucket seats, and optional rear-view mirror. Next size up are Cessna's cheapest true four-seaters, the popular 172 and Skyhawk de luxe version (both with 145 h.p. Continental O-300s), which have been made easier to use and more comfortable. Switch-operated electric flaps replace the cumbersome big lever, and a revised panel and central pedestal house the fuel tap, leaving a flat floor and more leg room. Over eight thousand 172s have been built, including over 100 assembled in Europe by Reims Aviation (the 100th is illustrated on the next page).

In the medium price range, the 182 and Skylane, powered by 230 h.p. engines and capable of carrying four adults plus two children, are joined for 1965 by a new model, the 285 h.p. full six-seat Super Skylane. This machine (illustrated above), costs $23,995 ex works, is powered by an IO-520-A and cruises at 177 m.p.h. The range is claimed to be 825 miles on 65 gallons of fuel with 1,510lb useful load. Gross weight of the Super Skylane is 3,300lb compared with 2,800lb of the 230 h.p. models. All three have the new "jet flow" nose (Cessna's answer to Piper's tiger shark nacelles); claimed advantages for the change are better engine cooling, less drag, quieter and smoother cruising. Other structural changes are a thicker one-piece windscreen and bigger span tailplane and elevators. An all-new optional oxygen system is available with individual outlets for each seat (the Super Skylane has a service ceiling of over 16,000ft). Other engineering features of the latest models are: a central vacuum filtering system that will operate up to 500hr without replacement; new gyro bearings; 52 amp alternator which delivers 20 amp at tick-over speeds; and a set of seven optional static dischargers.

Cessna's retractable-undercarriage single 210 Centurian (from which the Super Skylane has been developed) continues in production with the same detail engineering changes applied to the middle-price range. The retraction mechanism is improved to make it vibration-free.

The range of three work-a-day freighters continue and are modified in detail according to their pure passenger equivalent model. The biggest, the Super Skywagon, is equivalent to the new Super Skylane but for the big double side doors. The 185D Skywagon and 180H have fixed tailwheel undercarriages, and 260 h.p. and 230 h.p. engines respectively.

Super Skymaster is the designation given by Cessna to the push-pull Skymaster's successor which, they say, is to be virtually a new aircraft. To be introduced on the market during February, the also push-pull Super Skymaster has Continental O-360 engines continuously rated for 210 h.p., a retractable undercarriage rather like that of the Cessna 210, a restyled nose improving visibility, cruising speeds up to 200 m.p.h., thickened and double-layer windows and improved soundproofing and vibration damping. Single-engined performance is better than that of any other unsupercharged light twin. Optional features are "color-styled" panel and control wheels, and reclining seats with electric vertical adjustment. It is also reported that wing incidence has been altered to improve the flight attitude. Ex-factory price at Wichita is $39,950 (about £11,200).

The turbo-supercharged Cessna 411 six- to eight-seater, though not yet fully publicly shown, already has an order backlog of more than $10,000,000.

Max Conrad's Latest Record Attempt started from Cape Town at 07.15 local time on December 24. The plan to beat his own FAI Class 4 straight-line distance record (by covering 8,316 miles to New Orleans) was successful even though he was forced to land the Twin Comanche at St Petersburg, Florida, due to bad weather, shortage of fuel, and (it was reported) mechanical difficulties. Nevertheless Conrad did beat his previous best (7,668 miles between Casablanca and Los Angeles set up in 1959 in a Comanche) and is claiming a new record for this 7,848 mile flight.

The exact times of the flight were not available as this issue went to press but it was expected before take-off to have lasted around 60hr. The Twin Comanche's take-off from Cape Town took over 5,000ft of runway with the gross weight 3,000lb over the production aircraft's normal permitted 3,600lb. The 632 US gal of fuel was disposed in two 15gal tip tanks, a 120gal nose tank and further cabin tanks including a 40gal tank forming Conrad's seat.

The Isle of Man Air Race If a fat purse is the spice of competition there should be no reason why the first announcement of this year's Royal Aero Club sporting calendar should not interest practically every pilot in Britain. From May 28 to 30 there is to be a round-the-Isle of Man air race with prize money totalling at least 1,000 guineas. Donors of this handsome bounty are Cambrian Airways and Crockfords, who control the island gambling casino. The race is also being organized as a rally and competitors are invited from all countries. The event should go far towards satisfying continentals' pleas for a good British rally. The ex-RAF airfield at Jurby in the north of the island is expected to be the focal point.

Max Conrad at St Petersburg, Florida, after his record flight from Cape Town

The 100th Cessna 172 to be assembled in Europe by Reims recently left the production line, destined for Finland. Rate of production is now 11 aircraft per month. Britain's share in the venture is, of course, the Rolls-Royce-built O-300 engine

SPORT AND BUSINESS

Lear Jet Round Up With three Lear Jets delivered, 83 on order, and a target of 100 to be flying this year, prospects for this go-ahead newcomer could hardly be better. Latest news is that a strong factory-supported organization has been formed to maintain contact with customers, and, on the technical side, automatic landing capability is expected to be available by the end of this year.

First, the new support organization. Mr Robert S. Hagan has been appointed manager of customer relations, and he will be supported by two service engineers, a spare parts manager, and the head of the company's ground and flying personnel training centre. In addition to co-ordinating efficient deliveries of aircraft Mr Hagan's responsibilities include insuring prompt factory and field service, keeping agents and customers supplied with the latest performance and maintenance data, and relaying field experience back to the factory for action as necessary. Lear Jet has already appointed six US regional and seven international distributors—the most recent in the latter category being Aviones in Mexico City.

The newly proposed automatic landing system is important as it is the first time such a capability has been firmly talked about in relation to business aircraft. Heart of the system is a smaller and lighter development of the autopilot installed and widely demonstrated in the Caravelle. Lear say the equipment will be fitted as standard as soon as it is certificated and that existing aircraft will be capable of being fitted retrospectively.

Deliveries of the first three Lear Jets were made towards the end of last year. The third (actually the fifth Lear Jet) was handed over to the Rexall Drug and Chemical Co, who were the first customer to sign an order for the aircraft (in February 1962). Rexall will receive two more this year. The first Lear Jet went to the Chemical & Industrial Corporation of Cincinnati and the second to Robert Graf Inc of Fort Lauderdale, both in November.

A new possible outlet for the Lear Jet was explored early in December when a demonstrator was operated by Solar Airlines of Roswell, New Mexico, on flights between four communities on its regular network. The third-level airline had the aircraft with an eight-seat interior and flew it for a week on the routes linking Dallas, Roswell, Albuquerque and El Paso.

The Fan Jet Falcons Are Coming By the time this issue appears the first production Fan Jet Falcon, alias Dassault Mystère 20 and destined for Pan American, the US distributor, should have begun its flight trials. Certification test flying of this biggest of the competitive executive twin jets started in May 1963 when the P & W JT12-powered prototype first flew. This aircraft has since been re-engined with the GE CF700, powerplant for production copies. The prototype has been used primarily for systems development.

The test schedule is aimed simultaneously at French and United States type certification by May 1. This date has been calculated on the basis of, among other things, 50 hours' flying per month per aircraft. The second Mystère 20 is to fly in mid-February.

Documentation supporting each stage of the certification programme is being submitted at the same time to the French and US airworthiness authorities. The FAA has special representatives in Paris working under the regional office in London. Once a week Dassault teams brief the FAA on progress. Aiding the manufacturer with certification is Mr Robert Schroers of Boeing under the terms of the technical interchange agreement between the two manufacturers. Mr Schroers was chiefly responsible for seeing the 727 tri-jet airliner through its trials.

On the sales side of things 40 Fan Jet Falcons are, of course, the subject of a firm order by Pan American for sale in America. The Business Jets Division of the airline is also understood to be close to taking up its option on a further 120 aircraft. Business Jets based in New York and their sales associates, Pacific Airmotive in Burbank, California and Field Aviation in Toronto have received deposits on most of the first 40 and it is understood that there are less than ten delivery line positions still available for potential US customers this year. Dassault are believed to have booked further orders in Europe and elsewhere for some 15 Mystère 20s.

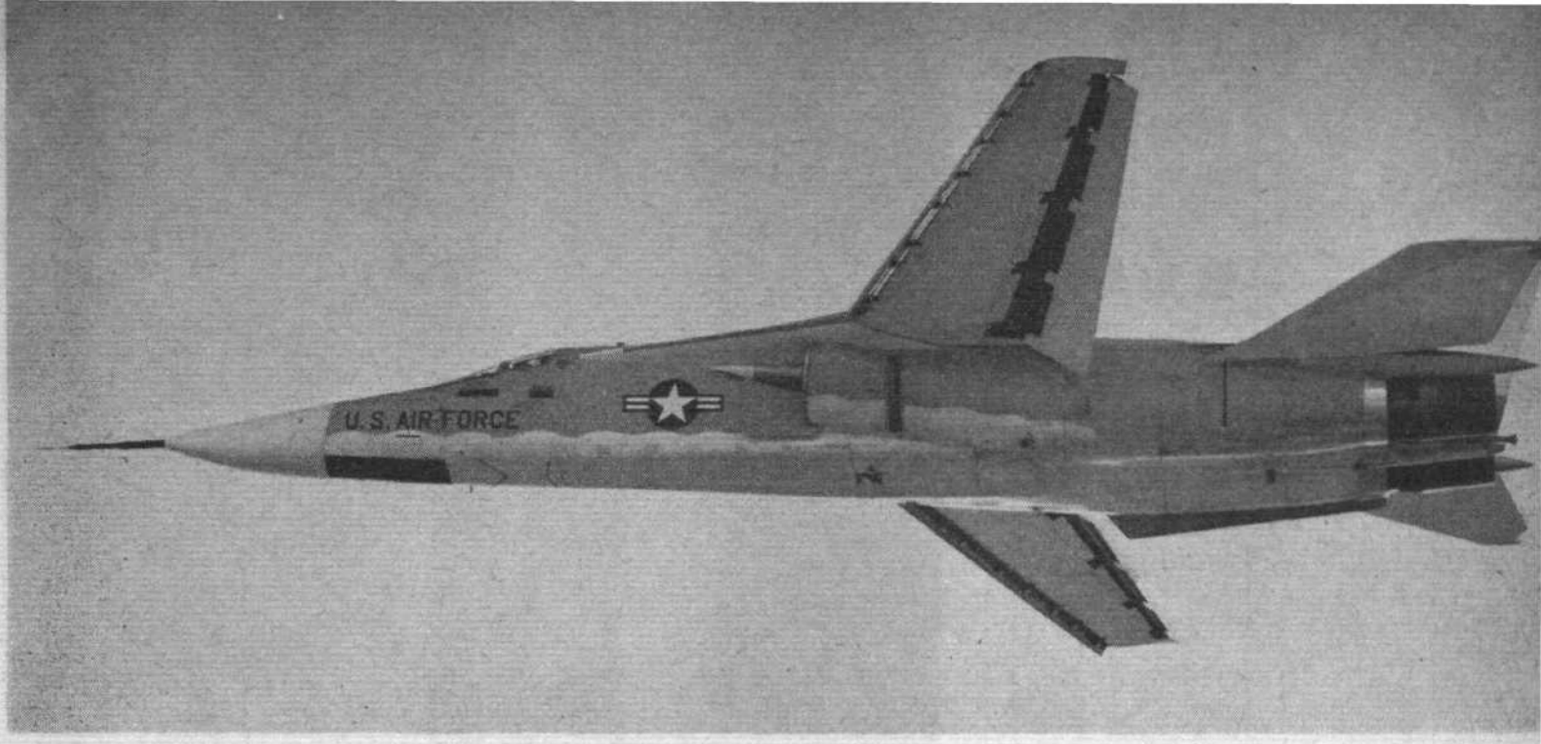
After widespread confusion that Pan American was leasing Fan Jet Falcons this is now being strenuously denied. Business Jets' sole object is to sell Fan Jet Falcons. Until a production demonstrator is available the company is booking orders and delivery dates on the basis of returnable deposits of at least $10,000. Interested customers will not be expected to firm up on their option (which includes a guaranteed delivery date) until they have flown in the aircraft on the routes for which they intend to use it.

Jupiter Milestone The prototype of France's only piston-engined executive twin, the push-pull Moynet Jupiter, has been handed over to the Government flight test centre at Bretigny following completion of manufacturer's tests. The project is still not firmly committed to production though Sud-Aviation is closely associated. A second prototype is being built and expected to be ready for the Le Bourget Salon in June. Major differences in the new aircraft will be the fitting of more powerful 290 h.p. engines, a revised fuselage design suitable for optional pressurization and seating up to six passengers. Sud-Aviation's Nantes-Bouguenais and Rochefort works are involved building Jupiter components together with Matra, who built the prototype alone.

Gregory Air Taxis of Denham, Luton and Plymouth have been appointed Piper agents by CSE Aviation Ltd, sole UK and Benelux distributors for Piper.

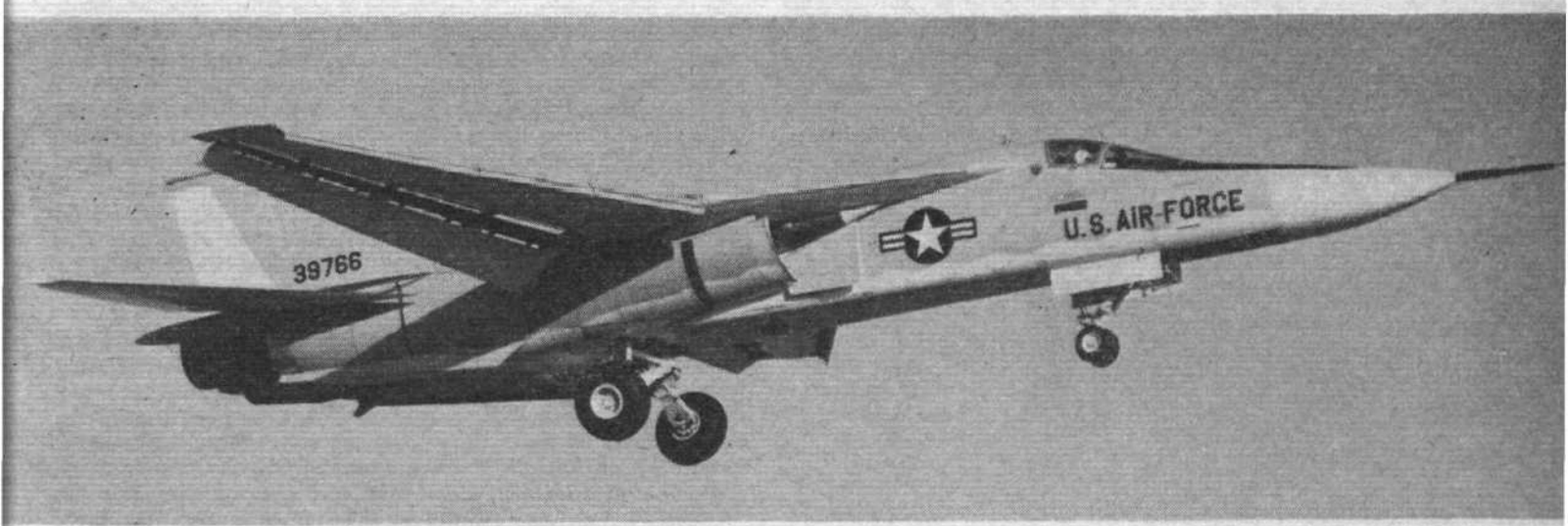
More Potez 840 Sales In addition to the recent sale of an Astazou X powered Potez 842 to the French Ministry of Public Works and Transport, two of the P & W PT6A-powered 841 version have been ordered by two German industrial concerns. The first 841 will be delivered shortly, the second next September. A batch of 25 840s (some 841s and some 842s) are being built.

BEAS Directorship Change Mr Rex Smith, managing director of British Executive Air Services for three years, has resigned owing to pressure of other work, and his post has been taken by Mr Robert Carr, a former wing commander in the RAF. During Mr Smith's term of office BEAS developed in many directions, noticeably in the use of light helicopters. Mr Smith will remain vice-chairman of the BEAS Board; his other posts are executive director of CSE (Aircraft Services) and CSE Aviation, and Principal of the Oxford Air Training School.



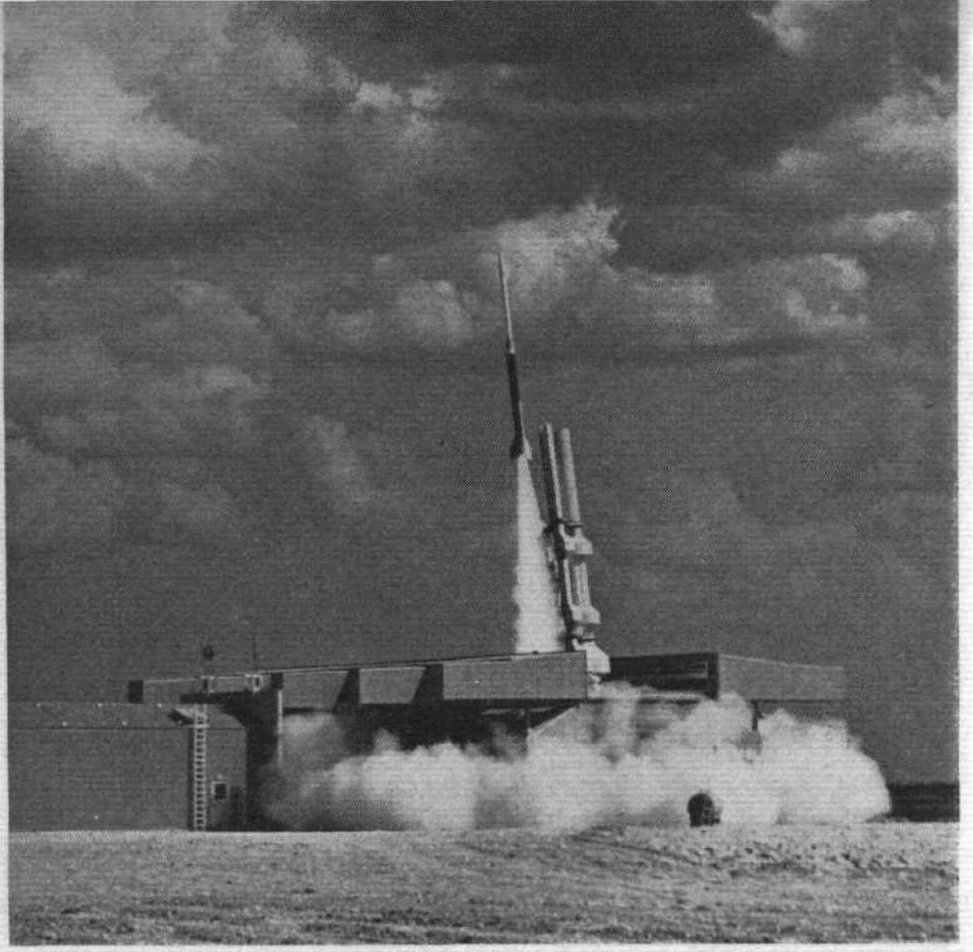
F-111A TAKES THE AIR

ON December 22, ten days ahead of the production schedule, the F-111A prototype made its first flight from Carswell AFB, Fort Worth, Texas, with R. L. Johnson and Val Prahl at the controls. Though it is reported—and has elsewhere been denied—that failure of the flaps to retract curtailed the flight from its intended one hour to 24min and only 200kt, General Dynamics state that the exercise was successful. Take-off weight was 58,000lb and the wing was locked at 26° sweep—10° aft of full forward. Information and drawings of the F-111 appeared in "Flight" for December 24. Notable features revealed in the accompanying pictures are that the curved intake lip moves some 10in forward to leave an auxiliary intake at low speed: and the extent of the full-span leading-edge slats and double-slotted flaps. Lateral control at low speed is by differential tailplane movement supported by wing spoilers. The extreme negative tailplane angle used during the ground run is evident below. Approach and take-off angle of attack appears moderate. The undercarriage rear door moves down and back on a parallelogram linkage to lie aft of the gear when extended. The main-gear axles also droop considerably when unloaded.



BLACK BRANT

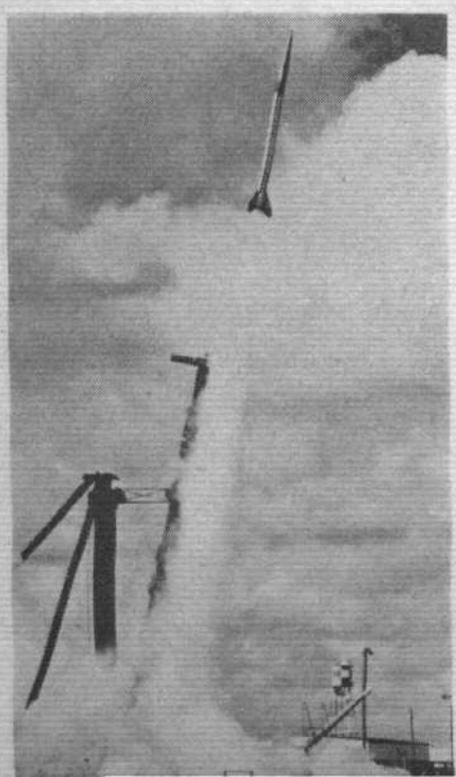
Canadian Bristol Aerojet's Family of Sounding Rockets



First launch of the two-stage Black Brant IVA from Churchill, Manitoba, on June 24, 1964

A PROMISING family of single-stage and two-stage sounding rockets has been developed and is now being flight-tested by Canadian Bristol Aerojet of Winnipeg. As well as the development of the rockets themselves, the programme has provided a joint Government/industry rocket-propellant facility and a number of by-products such as research instrumentation now adopted for other programmes.

The project began in 1958, when the Winnipeg factory of Bristol Aircraft (Western) Ltd decided to enter the space field. One reason for this was a desire to utilize the specialist techniques and skills in working with high-tensile and heat- and corrosion-resistant metals that had been acquired in the company's aircraft and missiles programmes. Canadian sounding-rocket background included the successful development by the Canadian Armament Research and Development Establishment (CARDE) of a solid-fuel engine (15KS25000) which was later used in both the Black Brant I propellant test vehicle and the Black Brant IIA research rocket. Hardware for the Black Brant I had been supplied by Bristol's Canadian and UK companies. At that time, also, Canadian scientists were planning an increased activity in upper-atmosphere research, since many types of measurement could be made more effectively from Canadian soil than from any other region, because of the proximity of the North Magnetic Pole.



Third launch of the single-stage Black Brant III from Wallops Island, Virginia, on June 19, 1962

Following an extensive market survey by both Government (Department of Defence Production) and Bristol (Winnipeg) personnel, in which the available technical support in Canada and the potential market in Canada and USA were examined, a proposal for the development of a new family of sounding rockets was made to the Canadian Government in November 1959. A contract was issued in December 1960, and design and development work began in earnest.

The contract listed three rockets which were to be designed and developed to the prototype stage in the following sequence. First, Black Brant III, capable of launching a 40lb payload to a height of 110 miles. Secondly, Black Brant IV, a two-stage rocket carrying 40lb to 600 miles. Thirdly, Black Brant V, a large single-stage vehicle to carry 150lb to a height of more than 200 miles. This work was subsequently transferred to Canadian Bristol Aerojet, a new company formed to develop and produce rockets, solid fuel and rocket devices.

The Black Brant* programme has had a relatively low-cost and short development history. One of the reasons was the technical support available in Canadian Government departments and establishments. CARDE was to contribute its experience in the development of two types of engines, aeroballistic tests, design assistance, environmental test and other rocket checkout facilities, range support, data-reduction assistance and technical guidance in the design and operation of the solid-propellant plant which the company set up. The Radio and Electrical Engineering Division of the National Research Council undertook to design a number of telemetry devices for use with the rockets, and to provide further checkout and data-reduction facilities. As well as general design assistance on flutter and aero-elastic criteria, the National Aeronautical Establishment completed supersonic wind-tunnel tests of Black Brant models. The National Research Council's Division of Pure Physics and the Defence Research Telecommunications Establishment gave guidance on user requirements and instrumentation aspects.

In the design of the three vehicles, the basic requirements stemmed

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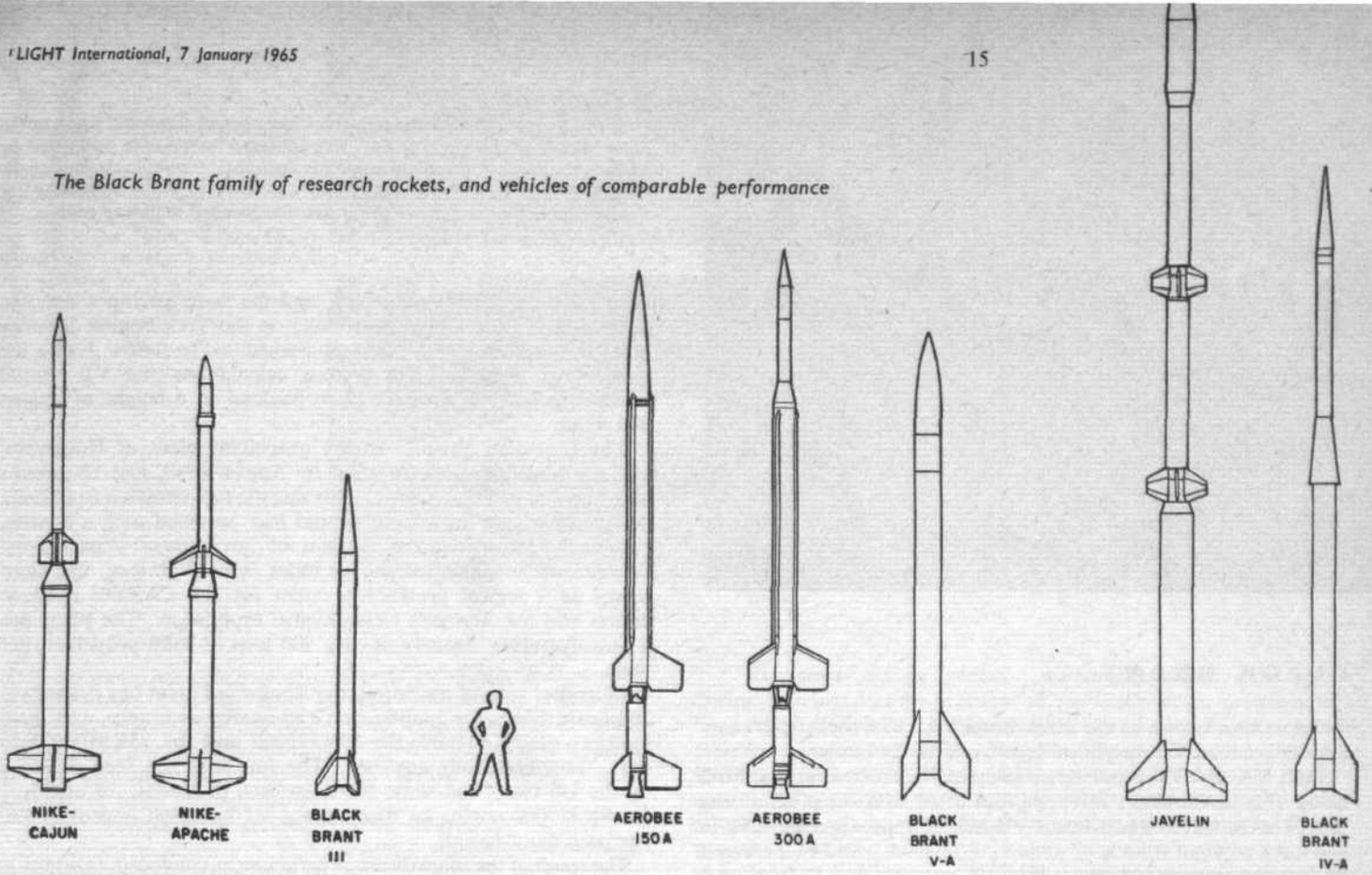
* *The rocket is named after the black brant, one of several species of geese of the genus* Branta *and commonly found on the eastern coasts of North America.*

The Black Brant family of research rockets, and vehicles of comparable performance



from the needs of potential users and the environment to which the research instruments would be subjected. The scientists wanted a minimum-cost, highly reliable rocket able to carry payloads of 10-300lb to heights of 80-1,000 miles, with little dispersion in performance. The environmental conditions limited the acceleration load on the instruments to 40g and the temperature to 125°F (with a higher permitted temperature for skin sensors). Compromises were obviously necessary.

At the beginning of the design the maximum desired altitude was reduced from 1,000 miles to 600 miles, and it was decided to use as a basis the Black Brant I motor and propellant. In the development of the three-rocket family, overall design requirements were established for a lightweight structure with high strength and stiffness, insulating materials to withstand the erosive and heating effects of high-speed flight at low altitudes, a low-drag profile (which in general meant slender bodies with low stiffness characteristics) and acceptable dynamic characteristics with a demand for variable roll rates. The effect of these requirements was to introduce steels with ultimate tensile strengths of 250,000lb/sq in; ablative coatings of glass-fibre and Avcoat; magnesium, titanium, and composite aluminium-honeycomb structures, which have provided the maximum rigidity-to-weight ratio.

Black Brant III is an unguided, single-stage sounding rocket using a 9KS11000 solid-propellant motor, 10in in diameter and approximately 18ft 8in long. The nose fairing encloses a payload volume of 1.4 cu ft and is made of light-gauge stainless steel with either an external glass-fibre ablative coating or an internal insulation blanket. The motor casing is of 0.057in AMS6435 high-tensile steel into which is cast the CARDE-developed ammonium perchlorate-polyurethane propellant grain, with a central longitudinal star-shaped cavity. The ceramic-coated steel nozzle attached to the rear end of the motor casing has a carbon throat; outside the nozzle the motor casing carries a magnesium aft-body with three Avcoat-covered, solid-aluminium fins bolted to it.

Design objective was a vehicle capable of carrying a 40lb payload to a height of 110 miles, based on a structure weight of 164lb with a motor delivering a total impulse of 101,000lb-sec. Performance achieved to date represents 51.5lb carried to 93 miles, with a structure weight of 161lb and total impulse of 99,000lb-sec. It would be possible to reduce the structure weight further and increase the motor performance to achieve the higher altitude.

This performance is the outcome of 53 static firings of the full-scale engine, 20 static tests (both structural and aerodynamic) and nine dynamic flights (table, p.17). Of the nine flight vehicles, four were of the final configuration: all reached the projected altitude and their impact-points fell within a circle of seven miles radius from the calculated point (compared with a theoretical radius of 30 miles). Telemetry was good. This vehicle is now in production and is being supplied to customers.

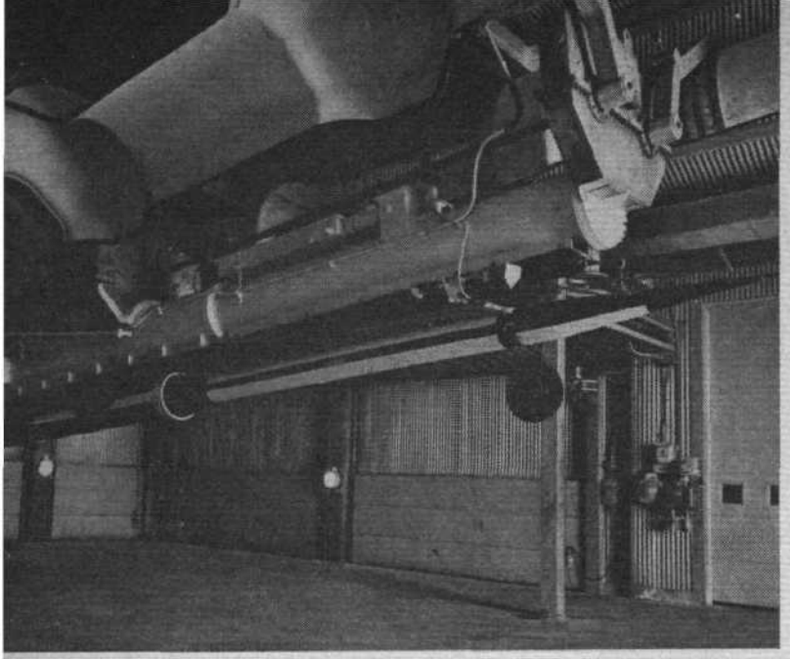
With the development of Black Brant III complete, the next logical step was to make it a two-stage vehicle, using the proven and reliable Black Brant I engine as booster. This engine has a near-perfect record in some 40 flight tests. Alternative boosters such as the US Nike and Terrier were investigated as possible first stages, but the predicted performance of these combinations, although attractive in many respects, was only half as good as that of the Black Brant I/Black Brant III vehicle. A particular application of this vehicle, which is designated **Black Brant IVA,** is to study the Van Allen layer of radiation, which descends to a relatively low level over northern Manitoba.

The Black Brant IVA vehicle comprises the 10in diameter Black Brant III, fitted with a conical stabilizer in place of fins and boosted by the 17in diameter 15KS25000 motor. The conical stabilizer is made of titanium, protected from aerodynamic heating by an ablative coating. The second stage is supported by an aluminium spigot structure on the booster through contact at the nozzle throat and at the bottom of the stabilizer.

Construction of the first-stage motor is generally similar to that of the Black Brant III and the same propellant is used. The two-stage vehicle is stabilized by three fins fabricated from a composite aluminium sandwich structure. The complete vehicle weighs about 3,100lb and is 36ft 2in long.

In the first two development flights of Black Brant IVA, made from the Churchill range in Manitoba in June and July last year, premature separation of the two stages occurred. The flight records were analysed and modifications have been designed to be incorporated in the next two launchings, scheduled for early this year. The performance of the combination vehicle appeared satisfactory, and there was a radar indication that the dynamic behaviour of the second stage was reasonably good. The defect appeared to be in the detail design of the stage attachment and separation components.

To cover the intermediate height-band between the low-altitude Black Brant III and the high-altitude Black Brant IV, a third vehicle has been designed to reach altitudes of 200 miles or more. This will be accomplished by the **Black Brant VB** rocket, using an improved version of the 17in diameter 15KS25000 engine. The improvements consist of the use of AMS6435 high-tensile steel for the motor case, and a high-energy propellant of Aerojet-General composition. The existing 15KS25000 engine, as used previously to power the Black Brant I and IIA vehicles, will be utilized in an



First Black Brant IVA on the universal launcher at Churchill prior to the firing shown at the top of p. 14. This enclosed launcher is connected by surface tunnel to the vehicle assembly building. Two plastic half-shells form a sheath around the rocket into which warm air is directed after the launcher is raised to the firing position through a sliding roof

BLACK BRANT . . .

initial version known as the **Black Brant VA.** This rocket will carry a 150lb payload to a height of approximately 140 miles.

Both VA and VB versions are identical in external appearance, being 17in in diameter, 24ft long and fitted with three stabilizing fins. The complete Black Brant VB weighs approximately 2,640lb and has a payload volume of some 8 cu ft (which could be increased by using extension sections). The VB motor casing is fabricated from .075in AMS6435 high-strength steel sheet and end forgings, and the ammonium perchlorate-polyurethane propellant is case-bonded with a cylindrical longitudinal core cavity. The nozzle is made of graphite impregnated plastic while the fin structure is similar to that of Black Brant IVA.

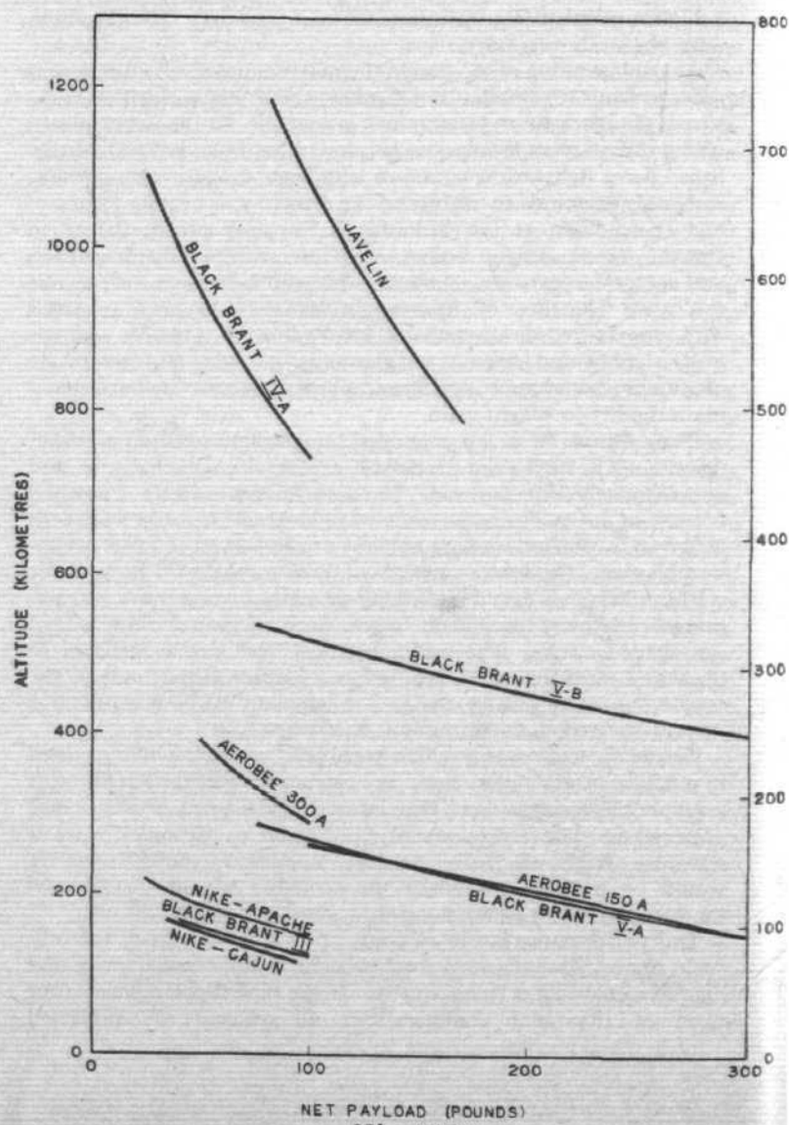
All structural components of the Black Brant VB rocket have been fully developed and tested, and the nose assembly and fins have already been flown successfully on the VA. Engine development is under way, with flight tests scheduled to follow during the next three months. On present calculations the VB should be able to carry a nominal 175lb payload to a height of almost 300 miles.

The Canadian Bristol Aerojet propellant plant at Rockwood was completed and in operation by August 1963, just 12 months after the first sod was turned. This was the first occasion in Canada on which private investment capital had provided such a facility, previously considered the domain of government departments. Located on a 3,000-acre site 18 miles from Winnipeg, the plant serves as a logical production outlet for the CARDE research efforts and for Aerojet's technological experience. The plant has a manufacturing capacity of over 200 tons of solid propellant per year.

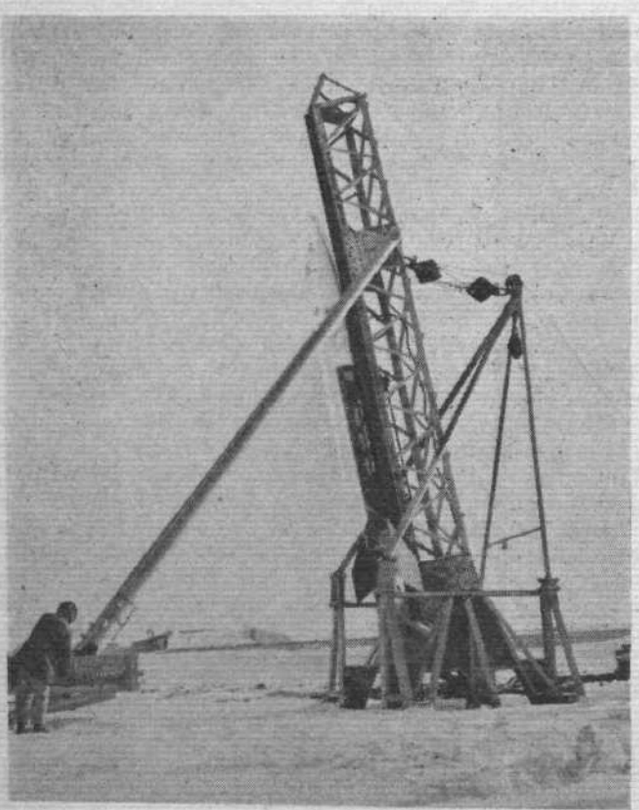
In its first year of operation, the Rockwood plant has made over 200 static firings for qualification and quality assurance, and three motors—the 9KS11000, the 15KS25000 and the 15KS1000 Jato unit—have been fully qualified. The Jato unit has been accepted by the US Navy and some 500 have been produced. In addition, the 9KS11000 engine of Black Brant III has been improved and has been flight-tested.

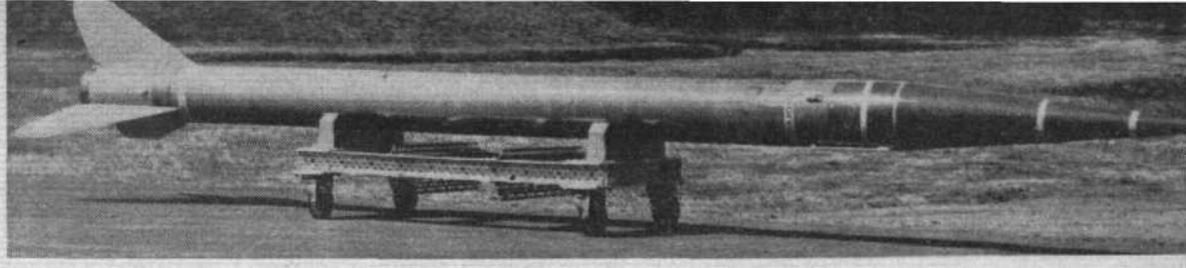
The result of the Black Brant programme has included, in addition to the establishment of Canada's only solid-propellant production facility, the building-up of a competent rocket design team. A high level of technology has been generated in the use of high-tensile steels, ablative and heat-resistant materials, high-stiffness composite structures, plastic fabrication techniques and rocket and instrumentation design, development and manufacture. In addition,

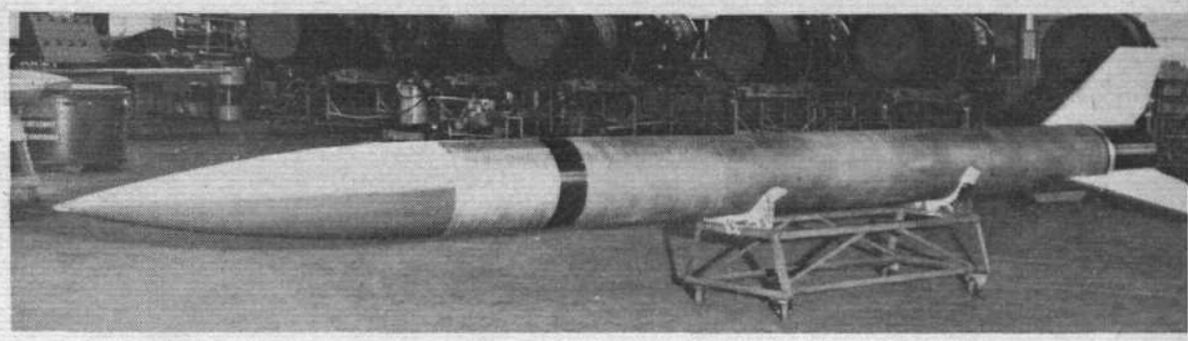
Right, performance of Black Brant vehicles and of comparable research rockets



Black Brant VA (below) on launcher at Churchill research range prior to successful 107-mile firing on April 16, 1964. Note plastic bag containing heated air within which the rocket is enclosed; typical ambient temperature is around 4°F







Black Brant III (right), now in production at Canadian Bristol Aerojet's Winnipeg plant, is 18ft 8in long and can carry a 50lb payload to heights approaching 100 miles. Black Brant VB (below), 24ft in length, is scheduled to make its first flight soon; it should carry 175lb to a height of almost 300 miles

the programme has produced a number of promising ideas, several of which have been the basis for new products and hardware thoroughly evaluated in the Black Brant flight programme. Some of these items already have been sold to US and European customers, and the company expects that they will constitute a modest export business for some years to come.

Among the specific by-products are the following:—

1. *Cosmic-ray altimeter* This is a light, compact and economical instrument carried aboard the rocket to determine accurately the time and height of apogee without reference to extensive ground-based equipment. It is particularly valuable for rocket flights where radar tracking equipment is marginal, such as at some of the newer European and Asian ranges, or where back-up information is required as an insurance against the loss of radar tracking.

2. *Attitude-measuring system* A magnetometer and solar sensor, developed as by-products of the Black Brant programme, have been combined to form a simple and economical aspect-measuring system for rockets or ballistic projectiles. Considerable interest in this approach has been shown by US agencies and a special high-g version recently provided the first meaningful data on projectile attitude yet obtained in the Martlet gun-launched project of McGill University.

3. *Telemetry devices* The Radio and Electrical Engineering Division of the National Research Council has designed a number of units for Black Brant III. These include a reliable and efficient solid-state telemetry transmitter, an aerial system capable of withstanding the high temperatures and mechanical forces of Mach 7 flight, and the associated power feeding and monitoring networks

BLACK BRANT III FIRINGS

Vehicle No	Launch site	Date	Payload (lb)		Apogee (miles)		Range (miles)	Max velocity (ft/sec)	Changes to vehicle	Remarks
			net	gross	actual	est.				
01	Wallops	June 15, 1962	58.2	92.9	61.1	68.8	60.9	5,618	nil	Max altitude 11 per cent less than estimate; lateral disturbance at 6.5sec; full telemetry to splash
02	Wallops	June 15, 1962	59.7	95.1	57.9	63.3	85.4	5,596	nil	Lateral disturbance in excess 5g at 7sec; vehicle trimmed-out at lower elevation angle to smooth flight; full telemetry to splash
03	Wallops	June 19, 1962	35.9	70.9	—	78.7	—	—	extra Inconel fin cuffs	Telemetry and radar track lost during disturbance at 7sec: tracking films indicate vehicle recovered and proceeded to stable flight
04	Wallops	June 28, 1962	57.6	89.3	7.9	71.1	14.9	4,620	vehicle deliberately spun; Inconel fin cuffs; heavy nozzle	Lateral disturbance at 7sec produced abrupt change in azimuth and elevation angle with reduced velocity; full telemetry to splash
05	Wallops	Dec 13, 1962	72.5	103.8	61.3	61.6	75.5	5,460	new, stiffer fins, using Avcoat insulation; increased alignment accuracy	No evidence of any significant sudden lateral disturbance; achieved 99 per cent estimated performance; full telemetry to splash
06	Wallops	Dec 13, 1962	70.5	102.6	56.6	58.1	76.4	5,500	new, stiffer fins using Avcoat insulation; increased alignment accuracy; symmetrical launch lugs	Smooth flight similar to 05; achieved 97 per cent of estimated performance; full telemetry to splash
07	Pt Mugu	July 1, 1963	49.3	84.2	—	80.7	—	—	lightweight fins insulated with filament-wound glass-fibre; increased alignment accuracy, locked nose	Lateral disturbance commencing 7.4sec; loss of telemetry and nose assembly at 8.25sec; tracking films indicate vehicle recovered and proceeded in stable flight to unknown altitude
08	Pt Mugu	Nov 7, 1963	66.1	96.9	72.5	71.5	69.4	5,758	fins identical to vehicles 05 and 06; nose assembly spin-balanced; increased alignment accuracy, locked nose	Build-up of lateral acceleration to about 5g at point of max dynamic head; flight otherwise excellent, negligible coning motion; vehicle reached 101.5 per cent of predicted apogee; full telemetry to splash
09	Churchill	April 21, 1964	51.5	81.6	93.2	93.2	39.9	6,250	fins identical to 05 and 06; parallel section of nose fairing eliminated, volume now 1 cu ft; new, lighter nozzle; motor external insulant eliminated, 10lb more propellant, new internal motor liner, propellant made and motor filled at CBA (Rockwood); payload statically balanced; increased alignment accuracy, locked nose	Smooth flight except 5g build-up at peak dynamic head, then heavily damped; vehicle reached predicted apogee, impacted 3,000ft from calculated point; large coning angles due to roll-yaw resonance above 150,000ft; motion eliminated at re-entry; full telemetry to splash

Letters

Letters for these columns are welcomed, though "Flight International" does not necessarily endorse the views expressed. Name and address should be given, not necessarily for publication in full. Brief letters will have a better chance of early publication.

ATLB and the Minister

SIR,—In referring [leading article, December 24] to my proposal that the ATLB should be required to act in accordance with policy directives issued by the Minister of Aviation, you say that I suggested that this is what the Board wants. I have never made any such suggestion, but I did point out that the Board has been critical of the present arrangements. May I draw your attention to Paragraph 6 of their annual report for 1963-64:—

"As we said in previous Reports, the Act does not provide positive guidance on policy for the Board to follow in deciding whether or not to grant an application and it appears to have been the intention of the legislature to leave the Board unfettered as regards the general policy they should pursue."

House of Commons ERIC LUBBOCK

Homeless Spey Phantoms?

SIR,—Regarding the proposed Spey-Phantom for the Royal Navy, unless I am very much mistaken only the *Eagle* will be able to use the outstanding American aircraft operationally; *Ark Royal* could do so, but needs major structural alterations.

Victorious, *Hermes* and *Centaur* are too small and in my view are capable only of anti-submarine duties or, equipped with COIN aircraft, of supporting the commando carriers in bush-fire actions.

Is it, then, worthwhile to redesign and licence-produce the Phantom when we have only the one carrier available?

Gorebridge, Midlothian DAN MCMAHON

End of a Martinet

SIR,—I read with interest Mr Peter M. Thomas's letter (December 3), concerning the Skyfame Museum, and am delighted to hear of his two prospective Beaufighters.

I regret to inform those interested that the Irish Air Corps' last Martinet, 145, the last of approximately 1,700 built, was sold to a scrap merchant last August 22, and has now been "reduced to produce."

I enclose a photograph of the Martinet lying in the scrap-yard at Baldonnel, to which it was evicted in December 1963. It is reported that it was moved there by crane, and was dropped about 10ft on to its final position. Before taking the enclosed photograph I first had to tack up the Air Corps roundel with an old nail.

Dublin 14 PAUL R. DUFFY

Hush-hush Dakotas

SIR,—Your recent correspondence on the "Hush-hush B-24s" operating from Leuchars brings memories of a service which operated between Dyce (Aberdeen) and Sweden in the earlier years of the Second World War. The mysterious comings and goings of yellow-painted Dakotas, liberally covered with Swedish identification marks, in English, German and Swedish, excited my interest as a youthful spotter, but I have never seen any reference to the operation in print. Perhaps some of your readers could give details of this service, which, from the damaged state of some of the aircraft, attracted attention from at least one of the opposing sides!

Fairlie, Ayrshire W. LAING

Scrap-yard Martinet (see letter from Mr P. R. Duffy, above)

Wrong Fuel

SIR,—As a member of that ill-defined section of the populace which is described collectively as "the travelling public" I was much encouraged to read in your December 24 issue of the formation of the Air Safety Group.

Not being especially keen on the habit of peering into the mouths of gift-horses (which seems thoroughly unhygienic anyway) I would not presume to question the benefits that the new group will bestow on us. Even so, I am not entirely happy about its aim to take "immediate action on the superior safety of JP.4 gasoline in comparison with JP.1 kerosene airliner fuels."

It seems to me that, following the modern aeronautical trend, this particular gift-horse has got itself at the rear of the vehicle.

London W1 F. THOMAS

[*We purged ourselves of this inflammatory slip-up in our issue of December 31. Our renewed apologies to those airlines who stick to kerosene despite the cost.*—Ed]

Bacon Grilled

SIR,—A close perusal of Roger Bacon's four pages in your issue of December 24 would seem to show that he has not written a word worth repeating in the past two years, and only seven lines in 1962.*

To be paid his enormous salary for such masterly inactivity must surely entitle him to a place in some Ministry where he could rest in peace and good company, and not suffer those faint twinges of conscience which the sight of his hard-working colleagues in the *Flight* editorial office must arouse.

Failing this you might have him stuffed and mounted on a pile of brochures in the entrance hall.

London NW3 ALAN F. HUTH

* *Aide-memoire: RB confined his selection mainly to 1958-61.* —*Ed*

DIARY

Jan 7	*RAeS: Young People's Lecture, "Ground-effect Vehicles," by R. Stanton Jones.*
Jan 7	*RAeS Belfast Branch: "Service in the Skies," by a BOAC stewardess.*
Jan 7	*RAeS Southend Branch: "History of Channel Airways," by B. F. Collins, and symposium, "Air Traffic Control."*
Jan 12	*RAeS Luton Branch: "The Wright Brothers," by C. H. Gibbs-Smith.*
Jan 13	*Society of Environmental Engineers: "Methods of Measuring Cushion Performance," by D. C. Allen.*
Jan 13	*Kronfeld Club: "Lighter than Air," by Dixie Kidd.*
Jan 13	*Institution of Mechanical Engineers: James Clayton Lecture, "The Scientific Investigation of Aircraft Accidents," by P. B. Walker.*
Jan 13	*RAeS Chester Branch: "A History of Airlines," by R. E. G. Davies.*
Jan 13	*RAeS Southampton Branch: "Hovercraft," by A. E. Bingham.*
Jan 14	*Institution of Electronic and Radio Engineers Southern Section and IEE joint meeting: "Attitude Control of the Skylark Sounding Rocket," by J. F. M. Walker.*
Jan 14	*RAeS Halton Branch: "The Concorde," by G. L. Auty.*
Jan 15	*Institute of Navigation: "Visual Factors in Aircraft Navigation," by E. Heap.*

AERO ENGINES

A "Flight International" Survey

In this and the following 15 pages we present features which, taken together, provide a guide to current progress in world aero engine development and production. They begin, below, with an article on helicopter powerplants, followed by a new assessment of turbojets for advanced subsonic transports (page 22). A review of production and development by countries begins on page 23 and is followed by tabulated figures on pages 33-34.

Typical of current US developments to increase the speed capability of helicopters is the Lockheed XH-51A, powered by a Canadian PT6B turboshaft and P & W J60-P-2 auxiliary turbojet, which reached a record 242 m.p.h. during November

Helicopter Powerplants: The World Scene

BY G. DOBSON*

THE helicopter is the only type of VTOL aircraft in world-wide operation today despite intensive efforts on many other VTOL forms. Various types of helicopter are used in many countries, chiefly for military purposes, and the recent growth pattern has been determined by pressure in the United States. The role of the helicopter has greatly expanded during the last 20 years because of military need for mobility by the French forces in Algeria, by the United Nations and the US forces in Korea and in Vietnam. Very large orders have been and are being placed in the USA for military helicopters of all sizes where the US Army alone now operates about 4,000 helicopters. The number of helicopters in active service will be doubled by 1970. Further, helicopters at sea fill an important need in anti-submarine warfare carrying sonar equipment for detection and homing torpedoes for destruction.

The commercial use of helicopters has not expanded in the same way, but operators in various countries provide regular airline services, and oil drilling at sea calls for increased helicopter use. Future civil expansion depends on faster, operationally cheaper and quieter helicopters. The need for engines is therefore growing.

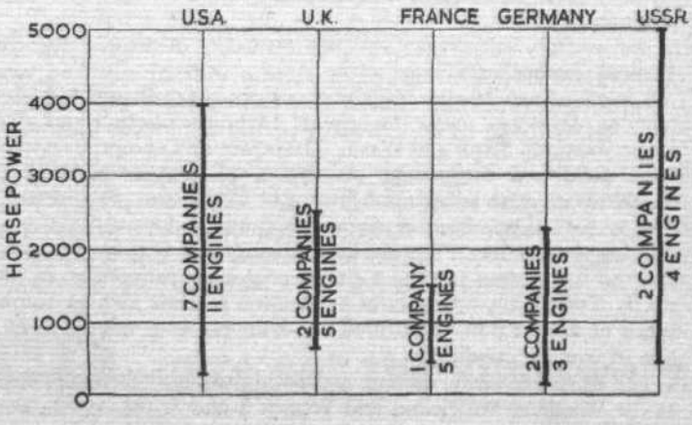
The majority of helicopter engines provide a shaft drive through reduction gearing to the main rotor system. Early power units were of the piston engine type and many manufacturers participated but, during the last six years, the turboshaft engine with its undoubted advantages has almost eliminated the piston engine. Lycoming and Continental still supply piston engines for light helicopters mainly because of low first cost, but the turboshaft engine offers low weight and volume, high reliability, simple maintenance, vibration free running and high efficiency. Such advantages are now forcing the use of turbines into the smaller engine sizes. Continuing efforts are made in driving the rotor by tip-jet reaction using either cold or hot gas, but only the Sud-Aviation Djinn powered by a Turbomeca Palouste air-bleed engine was produced in any quantity.

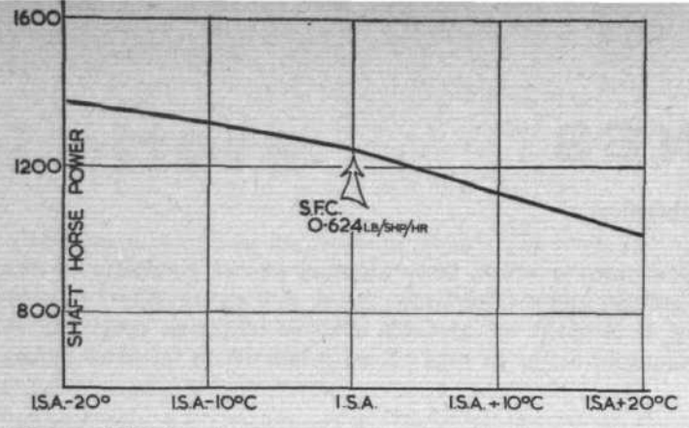
**Chief Projects Engineer, Bristol Siddeley Engines Ltd, Small Engine Division.*

The United States has seven engine companies producing turboshaft engines ranging from 250 h.p. to 4,000 h.p. AiResearch produce the 500 h.p. fixed-shaft TSE 331. Allison produce the 250 h.p. T63 free-turbine engine flat-rated to an ambient temperature of 38°C and installed in the LOH types. Boeing produce the T.50 free-turbine engine of 330 h.p. and a T.60 free-turbine engine of 600 h.p. used in drone helicopters. Continental have a 250 h.p. T65 free-turbine engine flat-rated to 38°C and also a 625 h.p. T72 free-turbine engine.

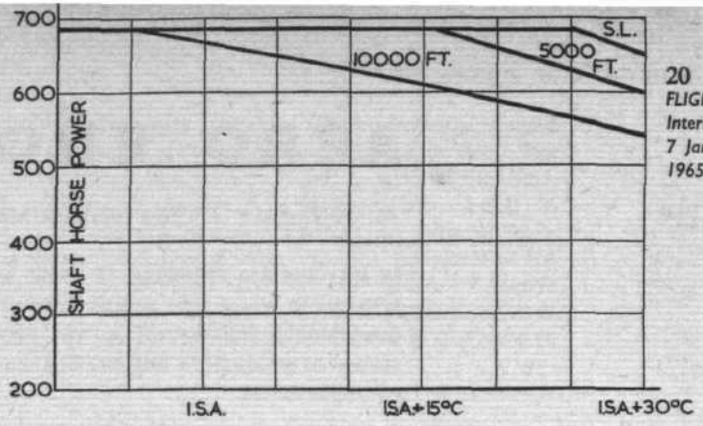
General Electric produce the 1,250 h.p. T58 free-turbine engine for the Sikorsky S-61 and S-62, the Boeing Vertol 107, the Bell UH-1F and the Kaman UH-2A and also the 2,850 h.p. T64 free-turbine engine for the Sikorsky CH-53A. Lycoming produce the T53 engine of 1,100 h.p. and the T55 engine of 2,500 h.p., both free-turbine types and used in the Kaman Huskie, the Bell Iroquois and the Boeing Vertol Chinook. Pratt & Whitney have the 4,050

Distribution of turboshaft engines and power among the main producers



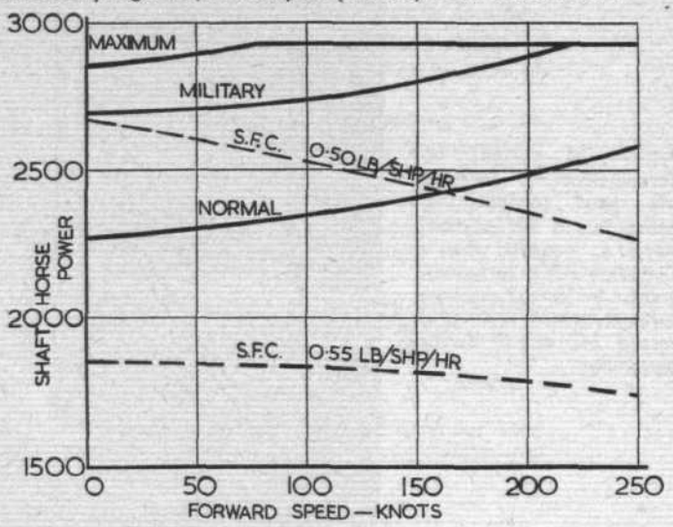


BS Gnome H.1200 one-hour power against temperature at sea level



BS Nimbus one hour power against ambient temperature

GE T64 s.h.p. against forward speed (in knots) at sea level and i.s.a.



AERO ENGINES

HELICOPTER POWERPLANTS: THE WORLD SCENE . . .

h.p. free-turbine JFTD-12 engine for the Sikorsky S-64 while the associated company in Canada produce a free-turbine PT6B engine of 550 h.p. for the experimental Hiller 1099 and the Kaman Huskie.

In the United Kingdom there are two companies producing engines ranging from 650 h.p. to 2,500 h.p. Bristol Siddeley produce the free-turbine Nimbus engine flat-rated at 685 h.p. to 40°C ambient temperature and the free-turbine Gnome H.1000 and H.1200 of 1,050 h.p. and 1,250 h.p. respectively. The Coupled Gnome is a special variant complete with coupling gearbox giving 2,500 h.p. output. Bristol Siddeley hold licence rights with General Electric and also with Turbomeca for their turboshaft products. Rolls/Napier produce the free-turbine Gazelle engine of 1,650 h.p. for the Westland Wessex 1 and 3 and Belvedere.

In France there is one company, Turbomeca, producing engines ranging from 400 h.p. to 1,500 h.p. The Astazou II is a fixed-shaft engine of 530 h.p. The Artouste IIC and IIIB are also fixed-shaft engines of 400 h.p. and 550 h.p. respectively, both being flat-rated to about 40°C ambient temperature and used in the Sud-Aviation Alouette 2 and 3. The Bi-Bastan is a coupled engine of 1,800 h.p., similar in concept to the Coupled Gnome but using fixed-shaft engines. The Turmo III free-turbine range gives powers from 1,200 h.p. to 1,500 h.p., variants being fitted in the Super Frelon and the SA.330.

In Germany two companies are producing or developing engines ranging from 100 h.p. to 2,300 h.p. BMW produce the fixed-shaft 6012 of 100 h.p. for the Dornier Do32 and also the 6022 of 250 h.p. for the Bölkow 105. Daimler Benz are busy on the 1,000 h.p. free-turbine PTL.6 and the 2,300 h.p. PTL.10

Although information on Russia is somewhat speculative, two companies produce engines ranging from 700 h.p. to 5,000 h.p. A team led by Izotov produce turboshaft engines of 400 h.p., 700 h.p. and 1,300 h.p. while the Soloviev design team are responsible for TB-2B turbines ranging from 4,600 h.p. to 5,000 h.p. These engines are used in various Mil and Kamov helicopters of gross weights from 5,000lb to 85,000lb.

It can be seen that the free-turbine engine emerges as the most effective type for general helicopter use. Compressor types vary, but the axial-cum-centrifugal is used most widely. Turbines are all axial. The fully annular combustion chamber is widely used. General Electric and Lycoming are the major US producers of helicopter turbines. In Europe, Turbomeca have consistently played a leading part, but recently Bristol Siddeley, by a judicious blend of licensing and native development, have emerged as a large producer.

Typical Turboshafts

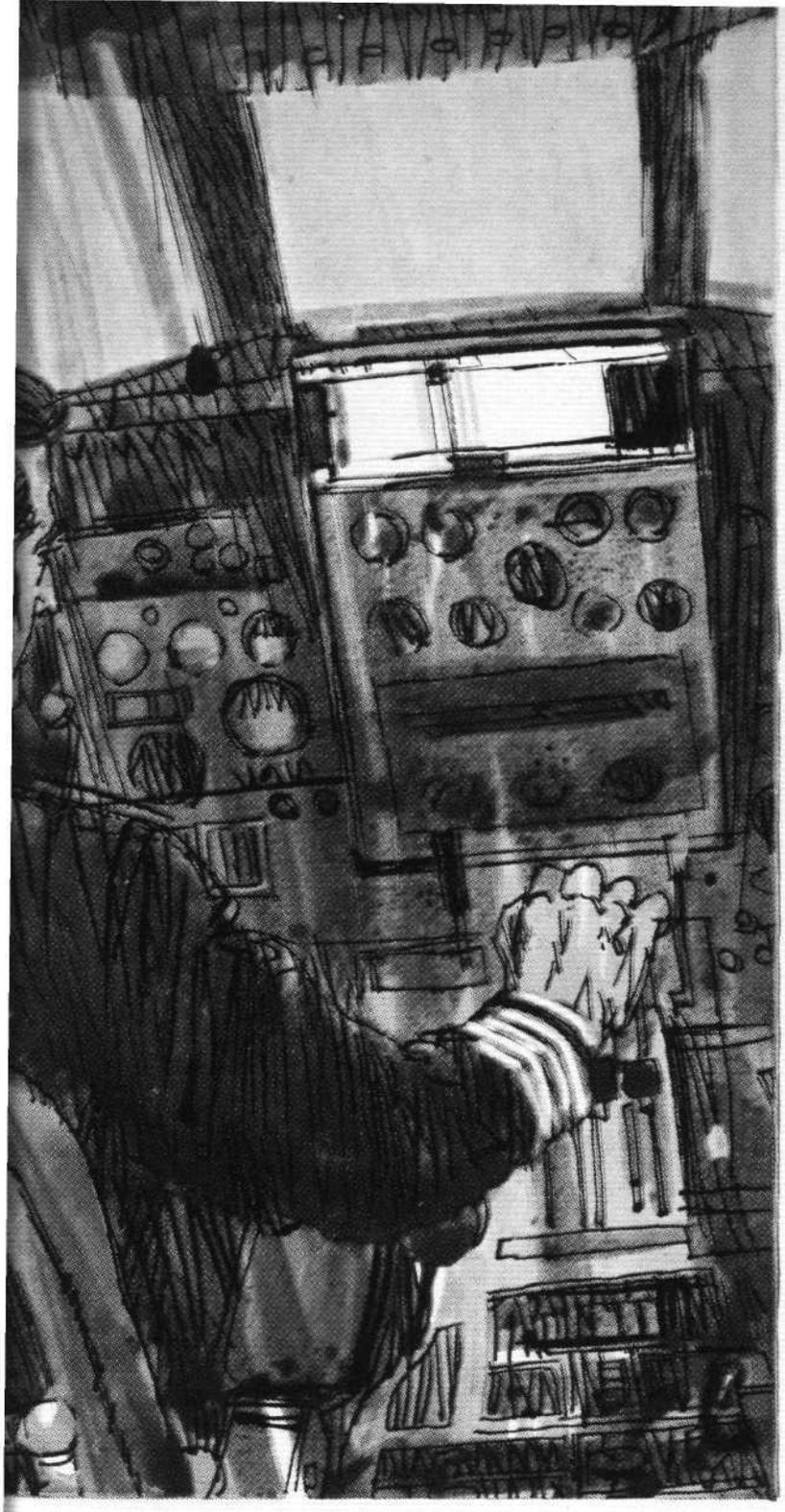
Typical of present-day helicopter engines is the Bristol Siddeley Nimbus, developed under the original Turbomeca licence and used in the Westland Scout and Wasp. The power unit comprises a two-stage axial and single-stage centrifugal compressor running at 35,000 r.p.m., with an air mass flow of 11.1lb/sec and pressure ratio of 6.4 : 1. The combustion chamber is fully annular with a central rotating fuel sprayer. The gas generator turbine is two-stage axial and the free output turbine a single axial stage running at 28,700 r.p.m. The engine incorporates a reduction gearbox with an output speed of 2,150 r.p.m. Flat-rated one-hour power is offered at 685 h.p. to tropical conditions.

The Bristol Siddeley Gnome is used in medium helicopters such as the Westland Whirlwind and Wessex 2 and 5, the Agusta Bell 204B and the Boeing Vertol 107. The engine uses a ten-stage axial compressor running at 26,300 r.p.m. with an air mass flow of 12.8lb/sec and a pressure ratio of 8.25 : 1. The combustion chamber is a fully annular type with 16 downstream simple sprayers. The gas generator turbine is a two-stage axial type and is followed by a single free axial power turbine running at 19,500 r.p.m. The engine is offered in two versions giving as one-hour powers either 1,050 h.p. or 1,250 h.p. The General Electric T64, licensed by Bristol Siddeley, is used in the heavy Sikorsky CH-53A and the Hughes XV9A research helicopter. The engine incorporates a 14-stage axial compressor running at 17,000 r.p.m. with an air mass flow of 24.5lb/sec and a pressure ratio of 12.6 : 1. The combustion chamber is a fully annular type with 12 downstream duplex sprayers. The gas generator turbine is a two-stage axial type followed by a two-stage free output turbine running at 13,600 r.p.m. This engine gives 2,850 h.p., can be supplied as a turboshaft, turboprop or gas generator and is designed to incorporate suitable reduction gearboxes giving output speeds appropriate to each application.

Various kinds of helicopters have specific engine installation requirements. In the light/medium helicopter, reliability is at a premium because it will often operate in all weather conditions away from fixed bases. Engine maintenance must be straightforward and easy. Preventive inspection could well take the place of long overhaul life, because long life implies part replacement, which could be difficult in the field. Light weight is essential and a typical 250 h.p. turbine complete with gearbox can weigh as little as one-quarter of the equivalent piston engine. The helicopter itself can therefore be smaller and lighter. Turbine engines have to meet "hot and high" requirements and, because the decay of power with ambient temperature is greater for turbines than for piston engines, more power has to be installed. But this factor is overborne by the lower engine net dry weight. Although s.f.c. is important, mission length is generally such that the advantage remains with the turbine despite operation at around 50 per cent design power.

In the smaller gas turbines there has been great debate on the merits of fixed and of free power turbines. The French have operated hundreds of Alouette 2 and 3 helicopters successfully with the fixed-shaft Artouste and Astazou. Their great virtue lies in the rapid response so essential for manœuvring. The fixed-shaft engines run more or less at constant speed, and power is varied by change of gas temperature alone. The acceleration delay in increasing turbine speed is thereby overcome and the power response is almost instantaneous. A clutch is necessary for starting.

Continued on page 21



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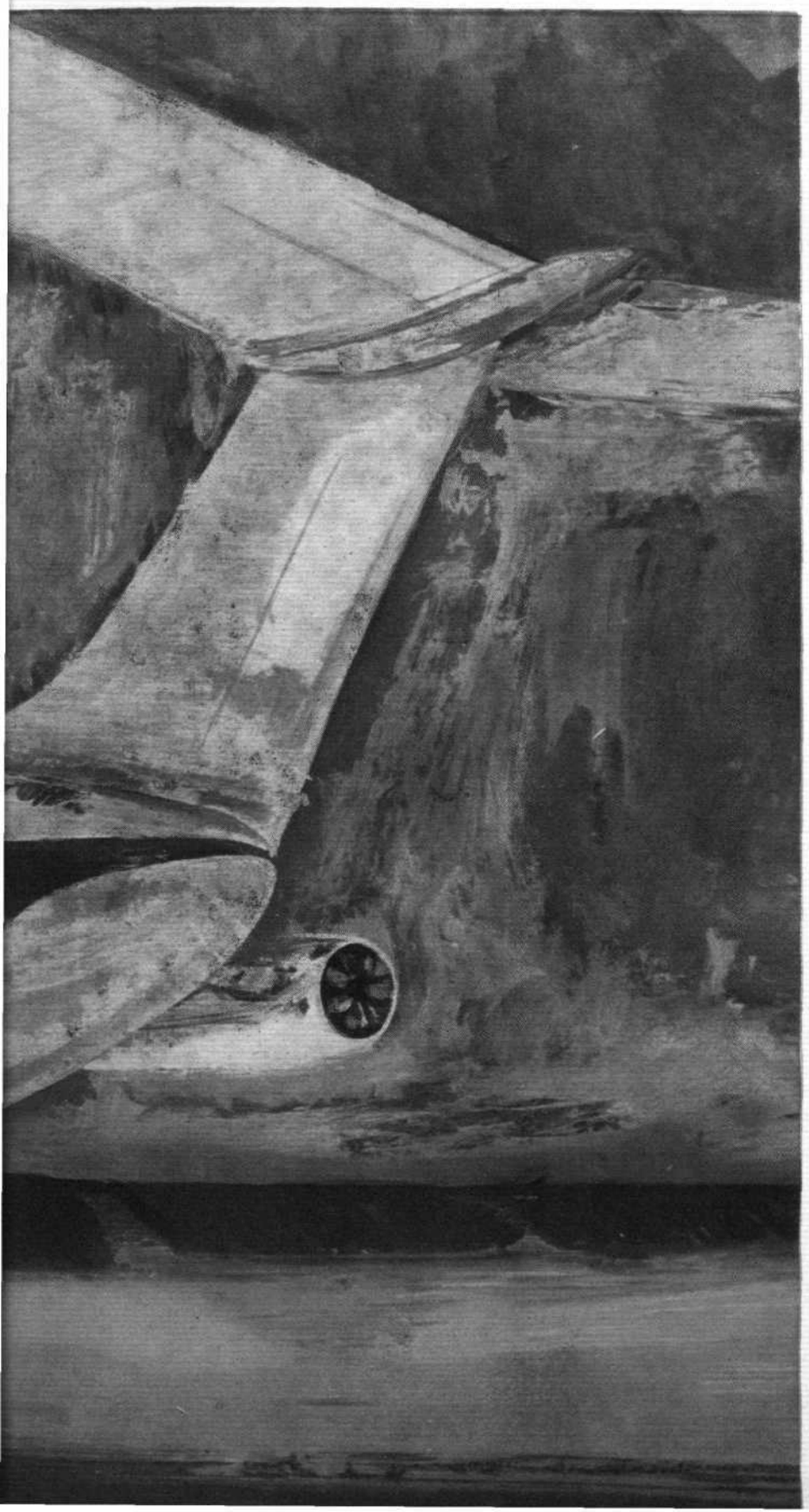

The Aircraft Equipment Group comprises four Divisions

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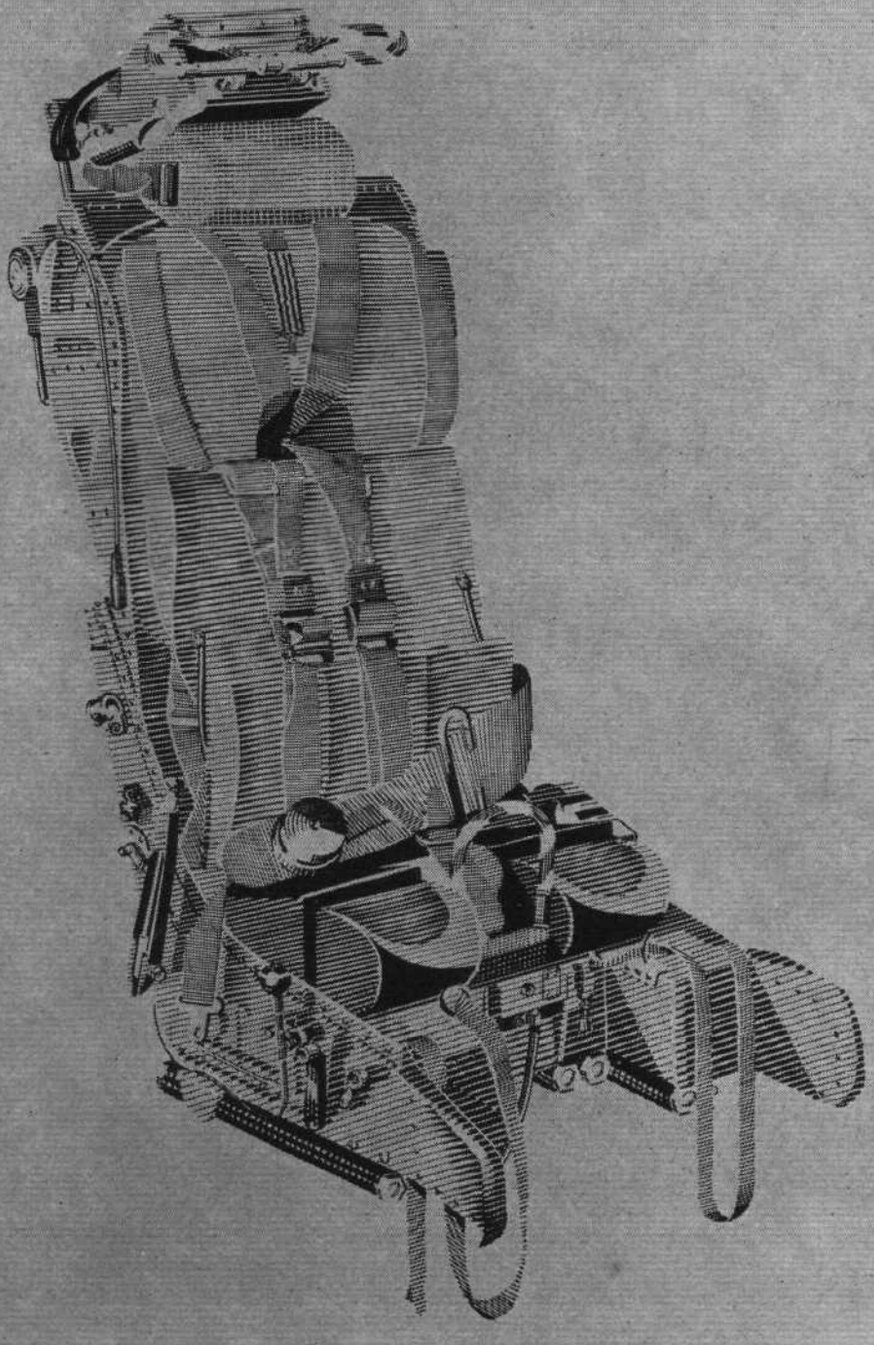

Fitted in the Hawker Siddeley Kestrel, the Mk. 6HA rocket assisted ejection seat is one of the latest range of Martin-Baker seats capable of bringing about safe escape from a zero-speed/zero altitude emergency. Particularly valuable for VTOL operation, these seats are installed in the EWR.VJ-101C, Mirage 3V and are under evaluation for several other types of aircraft.

MARTIN-BAKER

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HELICOPTER POWERPLANTS: THE WORLD SCENE . . .

On the other hand, the torque/r.p.m. relationship gives an unstable type of drive necessitating adequate power reserve. The free-turbine engine is more flexible, offers choice of output speed to suit conditions and gives an inherently stable drive. No clutch is needed. Because gas generator speed is proportional to power demand, rapid acceleration is more difficult to achieve, and variable vanes and blow-off are used.

Helicopters operate in ice, rain, dirt and sand and, when hovering near ground or sea, the engines must withstand erosion, corrosion and foreign object damage. Much research is being carried out on intake protection. Everyday protection against foreign object damage is essential, but the power-loss penalty must not be too great. Effective anti-icing is generally achieved by compressor-bled hot air. Satisfactory erosion protection is difficult to achieve, but both axial and rotational momentum separators, felt filters and porous filters are all being investigated. Corrosion is extremely penetrating and the use in compressors of high-grade steels, titanium and protective coatings is being explored. Bristol Siddeley have laid down a technique of daily washing for turbine engines operating over sea, with excellent results.

In the larger helicopters multi-engine powerplants must be considered. Twin-engined helicopters are quite common, but the Super Frelon has three Turmos and the Agusta AZ.101 has three Gnomes. The case for multi engines lies, of course, in engine-out capability. For hover cases, the loss of 50 per cent of the installed power in a twin-engined helicopter could lead to difficulties in recovery. Obviously, the greater the number of engines the lower the proportionate power loss, but cost and complexity must increase with the number of engines. Contingency ratings have been developed in the United Kingdom to provide a margin of power for the engine-out case.

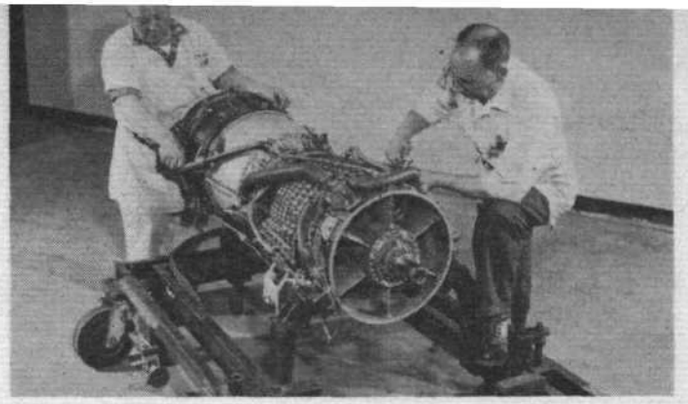
Front or rear drive from the engines depends on the relative importance of intake or exhaust losses in the installation concerned. For the Bristol Siddeley Coupled Gnome for the Wessex 2 and 5 the engine company has to supply a coupling gearbox as well as the twin engines. Present-day trends, however, favour all reduction gearing being incorporated in the helicopter rotor gearbox with engine supply finishing at the high-speed drive shaft. The excess power available demands an accurate light torquemeter and research on various types applicable to high-speed shafts is under way.

Control

In the helicopter powerplant, power is transformed directly into lift by virtue of the rotor. The method of control that has evolved is to allow the pilot to vary rotor pitch while rotor speed is maintained within the narrow limits dictated by aerodynamic and mechanical considerations. In the piston engine days, the pilot manipulated both engine throttle and collective pitch lever and, by careful anticipation, maintained r.p.m. almost constant, but rotor governing was introduced with the turbine so relieving the pilot of a difficult task. In the Gnome free-turbine engine there is a simple flow-control fuel system, automatically regulated for height change, with the throttle set by an electric motor in response to signals from an electronic computer. The computer acts to maintain constant free-turbine speed no matter what load is imposed by collective-pitch change. Input signals to the computer are taken from free-turbine speed, compressor speed, gas temperature and air inlet temperature. Protection circuits safeguard against overspeed, overtemperature and surge. The rotor governor works on a droop law sufficient to ensure stability and allow adequate load-sharing in the multi-engine case. In order to cater for rapid manœuvres a mechanical link can be introduced between governor datum and collective pitch, thus giving a degree of anticipation, and also eliminating static droop. The pilot can select a 15 per cent range of governed speeds. Transmission failure is covered by a separate overspeed governor which rapidly cuts off the fuel.

There is no doubt that rotor governing systems have helped helicopter pilots, but any automatic device must have good reliability. Full-authority governing demands such reliability, particularly in single-engined helicopters operating in difficult conditions; and opinion is growing on the need for easy reversion to manual control in such single-engined types.

The gas turbine-powered helicopter is now an important world-wide machine with large production orders and will continue as such for at least a decade. Design groups throughout the world



Basic gas generator section of the GE T64, a unit which can serve as turboprop or turboshaft and represents the basic power units referred to by the author. Bristol Siddeley hold the production licence

are studying types of aircraft to supersede helicopters, maintaining VTOL characteristics but offering greater productivity by increased forward speed. Experiments in the United States on the addition of turbojet thrust engines to Bell and Lockheed helicopters show that speeds in the region of 200kt are possible. This method, however, must be extremely wasteful in fuel consumption because of the poor efficiency of the turbojet at such relatively low forward speeds. Propulsive efficiency can be improved with turbofans, but the helicopter rotor imposes considerable stress and performance problems at high speeds. Rotor loading can be reduced by fitting small wings, so partially eliminating Mach number effects on blade-tips. In Germany, the Bölkow 46 with Derschmidt lead-lag high-speed rotor system is being flight tested and promises speeds of 200kt. Another method, typified by the ill-fated Fairey Rotodyne, is the use of a rotor driven by hot or cold gas for take-off and by turbo-propellers for normal flight.

In the United States the Hughes hot cycle research helicopter is a variation on this theme. Exhaust gases from two T64 gas generators are ducted directly through the rotor head to tip-jets. A further step is the tilt-wing aircraft in which the whole wing, engine and propeller rotate through 90° to provide necessary vertical thrust for take-off and then back to the more conventional position in the transition to forward flight. The Chance-Vought Hiller Ryan XC-142A using four T64 engines is now in active flight development and promises to combine hovering performance with increased forward speed.

Tilting rotor and tilting ducted-fan aircraft such as the Curtiss Wright X-19A and the Bell Aerosystems X-22A illustrate two other methods of approach. The flying crane helicopter is another type which could grow from machines such as the Sikorsky S-64. For the huge lifts needed one can consider the installation of jet engines at the tips of the rotor blades to give the necessary power drive, so eliminating the heavy reduction gearing otherwise needed.

There is, therefore, a need for engines to grow, not only in their present form, but also in different forms for varying applications. Because development of new engine types requires large financial investment there is great pressure to develop successful engines in various growth forms. The proposed pattern of development for the Gnome engine takes the original 1,000 h.p. turboshaft in steps, by the use of a compressor zero-stage, a two-stage power turbine, and a cooled gas-generator turbine to much greater power output in the same scantlings and with reduced s.f.c. A co-ordinated General Electric/Bristol Siddeley programme is being pursued with exchange of components to make the programme possible. Again the growth pattern for the T64 will very materially improve the initial rating of 2,850 h.p. largely through the use of a cooled turbine and higher airflow. High gas temperature is essential for improving power and thermal efficiency of future turboshafts.

At Turbomeca, the original centrifugal engines have been improved some 30 per cent in power and fuel economy by the addition of a high pressure-ratio single axial compression stage. Later developments, with the addition of another zero axial stage will give additional improvements of up to 15 per cent. Engine weight and first cost must be reduced, and items such as cast rotors are accordingly being developed. Heat exchangers are being examined in several countries, because high thermal ratio leads to a simple engine cycle. Considering the varied roles of helicopters, a "bolt-on" heat exchanger for use during long-range flights may be attractive. Helicopter engines are therefore being developed as basic growth units and in new forms to meet present and future requirements, offering lower weight, improved efficiency and reduced first cost.

AERO ENGINES

Engines for Advanced Subsonic Transports

BY L. G. DAWSON, BSC*

THERE is no doubt that a large amount of future passenger and cargo business will be carried subsonically. From the passenger's point of view, the most important feature of future air travel is lower fares in relation to his or her wages. For many years the volume of fuselage which can be used efficiently on the supersonic transport will be limited. This will reduce the number of passengers which can be carried compared with the subsonic aircraft. At the moment, the chance of reducing fares seems to be greater with a subsonic civil transport.

Air freight is of increasing importance. Safe handling and speed of delivery may accelerate the business more rapidly than the direct cost would suggest is likely. The predictions of subsonic passenger and freight business have encouraged us to study transport engines especially designed for this field. Estimated traffic growth is illustrated by Figs 1 and 2. With a background of four-and-a-half years of commercial operation of the Conway, we feel the service problems of the long-range transport engine are well understood. For several years, we have carried out feasibility studies of various cycles, by-pass ratios and new mechanical constructions leading to a new design of long-range transport engine.

In assessing the technical factors which are important in long-range engines we are considering fuel consumption, engine cost and spare parts cost, and weight. Naturally the engine must be designed for long time between overhauls. In considering fuel consumption, the tacit assumption is usually made that ever increasing by-pass ratio is a good thing, but this is not necessarily true, and it might be as well to review the fundamentals of the subject.

The fundamental qualities in the engine are related by the following equation:—

$$\frac{\text{Forward speed (ft/sec)}}{\text{Specific fuel consumption}} = 4{,}000 \times \text{thermal efficiency} \times \text{propulsive efficiency}$$

To improve fuel consumption we can only improve the thermal and propulsive efficiency.

The propulsive efficiency normally considered is the Froude efficiency. However, this is not the whole story; we should consider the effective propulsive efficiency which takes account of pod drag. This may be written:—

$$\text{Effective propulsive efficiency} = \text{Froude Efficiency.} \left\{1 - \frac{\text{Pod drag}}{\text{Thrust}}\right\}$$

Froude efficiency may be defined as:—

$$\eta_p = \frac{2}{2 + \dfrac{\text{Thrust}}{\text{Intake Momentum Drag}}}$$

For purposes of the argument this is a more useful form than the normal:—

$$\eta_p = \frac{2\ Vo}{Vo + V_j}$$

The intake momentum drag is:—

$$\text{lb/sec air consumed} \times \frac{\text{forward speed}}{g}$$

We write the effective propulsive efficiency as:—

$$\eta_p^1 = \frac{2}{2 + \dfrac{\text{thrust}}{\text{intake momentum drag}}} \times \left[1 - \frac{\dfrac{\text{pod drag}}{\text{intake momentum drag}}}{\dfrac{\text{thrust}}{\text{intake momentum drag}}}\right]$$

This is illustrated in (Fig 3) overleaf by the graph for various values of pod drag against intake momentum drag. It will be seen that pod drag is of great importance. Various typical Rolls-Royce installations are shown for comparison.

Consideration of installation drag leads one to aim for a value of thrust over intake momentum drag between 0.8 and 0.9. For aircraft which cruise at between Mach 0.8 and 0.86 in the stratosphere, the corresponding value of the thrust/lb of air is about 20.

Thermal efficiency may be improved by increasing cycle pressure ratio and, to some extent, turbine inlet temperature. Consider, as an example, a cycle pressure ratio of 20. If we plot, for a selected flight condition, specific fuel consumption against by-pass ratio for a constant thrust/lb of air, the curve shown in Fig 4 is obtained. Because the forward speed is fixed and the thrust/lb of air is chosen, the propulsive efficiency is constant. The change in specific fuel consumption is entirely associated with a change in thermal efficiency. Up to a turbine inlet temperature of 1,200° K and a by-pass ratio of two-and-a-quarter the thermal efficiency improves fairly rapidly. Beyond a turbine inlet temperature of 1,200°K the improvement in thermal efficiency and specific fuel consumption is small. At constant thrust/lb of air, increasing the turbine inlet temperature and by-pass ratio reduces the size of the gas producer, and may reduce the weight of the engine, but the complication required at higher by-pass ratios is increasing, and the value chosen is a compromise between cost and weight.

* *Chief engineer (projects), Rolls-Royce Ltd.*

Fig 1 Estimates of passenger traffic growth until 1975

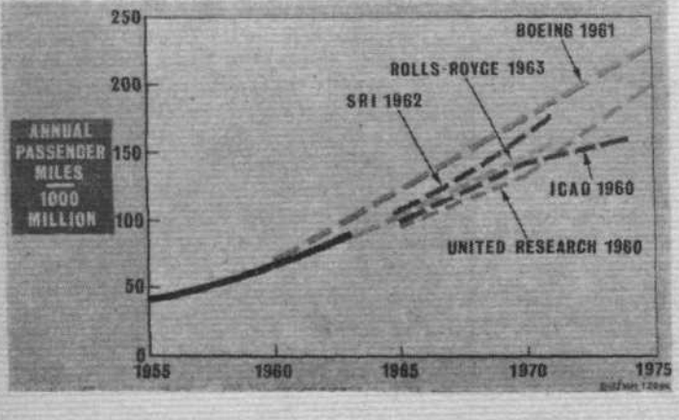
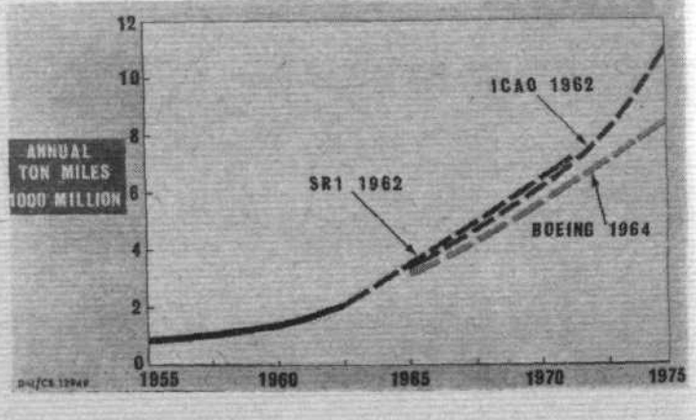
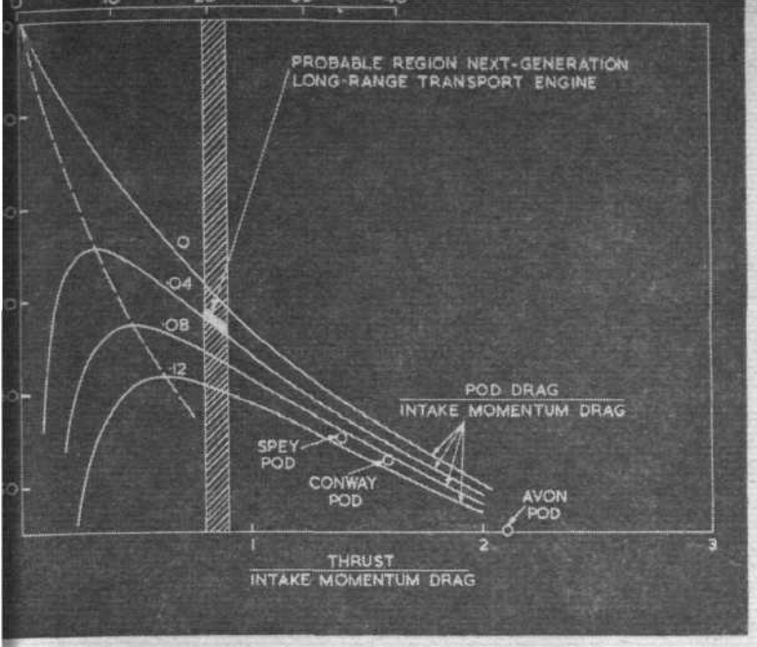


Fig 2 Estimates of freight traffic growth until 1975





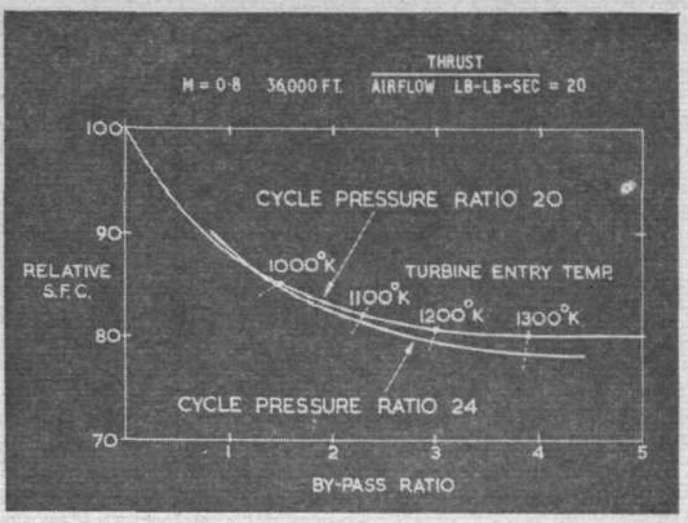
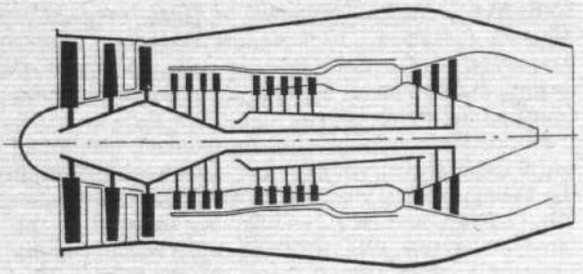


Fig 3 (above) Propulsive efficiency against pod drag

Fig 4 (above right) By-pass ratio against relative s.f.c.

Fig 5 (below) Hypothetical cycle for a twin-shaft subsonic transport turbojet with a pressure ratio of 20 and by-pass ratio of 2 to 3



Fundamentally, the number representing thrust over intake momentum drag is of more importance than by-pass ratio, in deciding the propulsive efficiency. At a chosen forward speed, this number is directly proportional to thrust/lb of air.

When one considers that the thrust transmitted from the engine to the aircraft is less than the intake momentum drag, it is obvious that pod drag is of considerable importance. Fortunately, at higher by-pass ratios it has become possible to hide the auxiliaries in the by-pass duct. In this way, a pod for a by-pass ratio of between two and three is no bigger in diameter than one which would have been required for a by-pass ratio of one in the past. Advances in pod aerodynamics have made the passing of the greater airflow possible without a proportional increase in pod drag, even though the intake is larger in relation to the maximum cross-section area of the pod.

The foregoing considerations indicate that at the present state of the art one can produce a very satisfactory long-range transport engine with a by-pass ratio of between two and three. The engine would be a two-shaft engine with a pressure ratio of about 20, and could have a cycle similar to that shown in the illustration (Fig 5).

Aero Engines Reviewed

Australia

CAC *Commonwealth Aircraft Corporation Pty Ltd, Lorimer Street, Port Melbourne, Victoria.* Production effort is concentrated on licence manufacture of SNECMA Atar 9C turbojets for Australian-built Mirage IIIO fighters for the RAAF. Support and overhaul services are provided for RAAF and RNZAF Avons, Nenes and P & W radials.

Belgium

FN *Fabrique Nationale d'Armes de Guerre SA, Herstal-lez-Liège.* Licence-manufactured General Electric J79-GE-11A turbojets and Rolls-Royce Tyne 21 and 22 components, for NATO F-104G Starfighters, Breguet Atlantics and Transall C-160s, now occupy FN's production lines. In addition, Avon and other powerplants are overhauled and repaired for the Belgian Air Force.

Canada

ORENDA *Engines Division of Hawker Siddeley Canada Ltd, Malton, Ontario.* Two variants of the General Electric J79 turbojet, J79-OEL-7 and J79-OEL-11A, are being manufactured under licence by Orenda, to power Canadair-built CF-104 Starfighters. A version of the General Electric CJ610 turbojet, designated J85-CAN-40, is also being produced for the Canadair CL-41 trainer. Additionally, support is maintained for Orenda designed turbojets, numbers of which are still in service in CF-100's and Sabres of Western air forces.

UNITED AIRCRAFT *United Aircraft of Canada Ltd, PO Box 10, Longueuil, Quebec.* A subsidiary of United Aircraft Corporation of the USA, United Aircraft of Canada was renamed from Canadian Pratt & Whitney Aircraft Company Ltd in February 1963. Originally concerned with the production of the parent company's radial engines and parts, United Aircraft of Canada have now developed to their own design a small turboprop, the PT6A, and a turboshaft, the PT6B, both of which promise wide potential in aircraft and helicopter applications. The production turboprop PT6A-6, is specified for the Beech King Air, DHC Turbo Beaver and Twin Otter, GD Model 48 Charger, Potez 841, and other similar aircraft. The turboshaft PT6B-9 powers the Hiller 1099 and TL5, Piasecki 16H Pathfinder, and Lockheed XH-51A helicopters. Higher-rated versions, PT6A-8 (680 e.h.p.) and PT6B-12 (660 s.h.p.), with similar configurations to the engines in current production, have been announced, and a Kaman K1125 Huskie III is flying with two 770 s.h.p. PT6B-11s.

Czechoslovakia

OMNIPOL *Foreign Trade Corporation, Washingtonova 11, Prague 1.* Limited production continues of the reliable Walter Minor series of inverted in-line, air-cooled, supercharged, fuel-injection engines. The four-cylinder 140 h.p. Minor M332 powers the L-40 Meta Sokol, and two 210 h.p. six-cylinder M337s the Morava L200A and D. Two horizontally-opposed air-cooled engines have also been developed for helicopter application. The 270 h.p. six-cylinder M108H powers the prototype HC-3 and the

AERO ENGINES

120 h.p. four-cylinder M110H, is fitted in the HC-2 Heli-Baby. Czechoslovakia's first turbine is the M701, a single-stage, centrifugal turbojet, bearing superficial resemblance to the Rolls-Royce Dart, which powers the L29 Delfin basic jet trainer.

France

ARDEM *Avions Roger Druine, 20 Avenue du Général Clavery, Paris 16e.* The 30 h.p. Ardem 4CO2, developed by the late Roger Druine from the standard Volkswagen car engine, powers the Turbulent and is licence built in Britain by Rollason Aircraft and Engines.

HISPANO SUIZA *Société d'Exploitation des Matériels Hispano Suiza, Bois-Colombes (Seine).* Largest of the four partners in the NATO Tyne programme, Hispano Suiza manufacture 44 per cent of the components, and share final assembly and testing with MAN. Current delivery of these turboprops for Atlantics and Transalls is 14 per month, to a total of 120 engines in the initial series.

Production also continues of contract-built SEPR 840 and 844 rocket packs for the Mirage III fighter, and Hispano Suiza provide support and overhaul services for French, Israeli and Indian Air Force Nene and Verdon turbojets, as well as Air France Caravelle Avons.

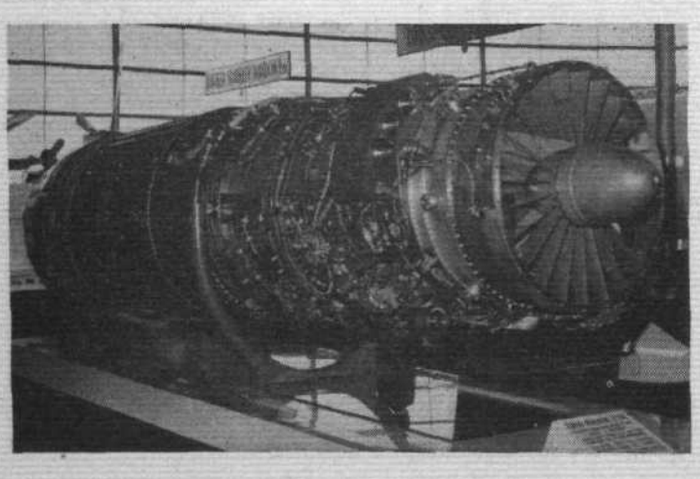
POTEZ-AVCO SA *Potez-Avco SA, Argenteuil (Seine-et-Oise).* Formed jointly by Henry Potez and the Avco Corporation, USA, parent company of Lycoming, Potez-Avco produce the successful horizontally-opposed, air-cooled engines which were developed by the Engine Division of Henry Potez, the 105 h.p. four-cylinder 4E-20, its 116 h.p. fuel injection development, 4E-30, and the 175 h.p. six-cylinder, fuel-injection 6E-30. Parts support is provided for Potez 4D-34s in the Nord 3202 and 3400 aircraft.

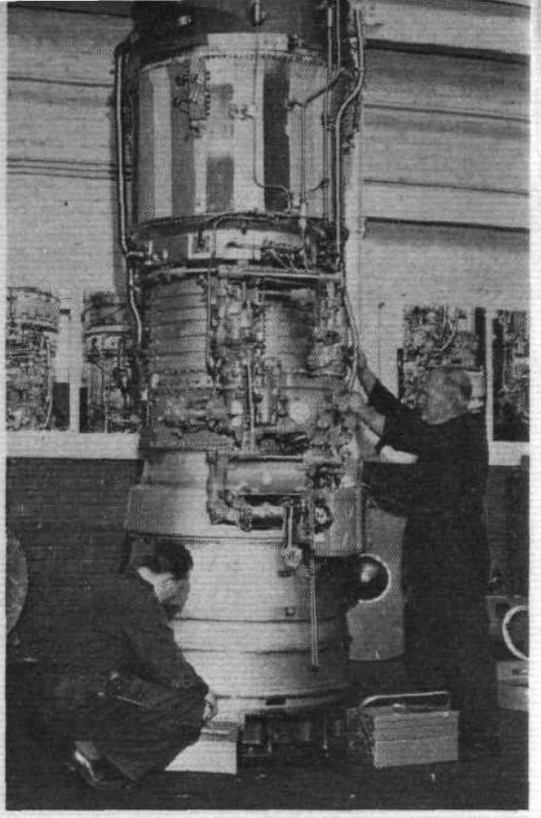
Licence production is starting, on a selected range of Lycoming piston engines for which Potez-Avco hold distribution rights in Europe, Africa and the Middle East. Distribution rights also cover Lycoming turbines in Europe, Africa, Middle and Far East and South America, and Potez-Avco have started overhaul and servicing of the T53 and T55 turbines.

SEPR *Société d'Etude de la Propulsion par Réaction, Villejuif, (Seine).* Founded in 1944 to design and develop solid and liquid rocket engines for manned aircraft and missiles, SEPR now has the largest facilities in Europe devoted to rocket propulsion. SEPR motors have been fitted in many research and development aircraft since the SEPR 25 was flown in the first French rocket-powered aircraft, the SO 6025 Espadon, in 1952.

The 841 and 844 are the only motors currently in production for aircraft, numbers of which are being built under contract by Hispano Suiza, as pilot-controlled boosters for the Mirage III. Both are pump-fed, single regeneratively-cooled thrust chamber packages, the turbopump being driven by an auxiliary shaft from the aircraft's Atar turbojet. Oxidant for both motors is nitric acid. The 841 is automatically controllable to deliver either 1,650lb or 3,370lb sea-level thrust, and uses TX-II furaline as fuel. The 844 delivers a fixed thrust of 3,370lb, and uses JP1 or JP4.

SNECMA TF-106





Bristol Siddeley Olympus 593

SNECMA *Société Nationale d'Etude et de Construction de Moteurs d'Aviation, 150 Boulevard Haussmann, Paris 8e.* With a payroll of 12,600, SNECMA is now the largest engine manufacturer in Continental Europe. Aero engine activities are concentrated on four main efforts.

Production continues with the ultimate versions of the Atar 8 and 9 single-shaft turbojets. The Atar 8, of 9,700lb thrust, powers the French Navy's Etendard IVM carrier-based fighter. The Atar 9B, 13,200lb, and 9C, 14,110lb, are installed in the Mirage III family, and two 9Ks, 15,430lb with reheat, in the Mirage IV supersonic strike aircraft. Atar 9s are fitted with an approach control system which maintains constant airspeed by automatic variation of the nozzle area, thus adjusting engine power. Atar 9Cs are manufactured under licence in Australia and Switzerland.

The M45 Mars is a new series of medium-thrust powerplants, now under development at SNECMA in both turbojet and turbofan versions. Designed with aircraft such as the Mystère 30 in mind, the M45A turbojet has been planned for civil or military applications in the 4,400-5,500lb thrust range. The M45B, 6,600-7,700lb, is competing for adoption for the Ecap supersonic trainer/close support aircraft. The third version so far announced is the M45AF, an aft-fan engine for civil applications, in the 6,600-7,700lb class.

Since 1959, there has been an agreement with United Aircraft whereby SNECMA are licensed to manufacture Pratt & Whitney products, and to benefit from the research and development activities of the American company. Within the realm of this agreement, SNECMA are developing from the Pratt & Whitney JTF10, a turbofan to power the Mirage IIIV. The initial stage of this development is the TF104, 10,500lb thrust, which has been modified from the JTF10 and test flown in the Mirage IIIT. Further development has resulted in the TF106, 11,240lb cold and 19,840lb with reheat in both hot and cold flows, which is being installed in the first prototype Mirage IIIV. The definitive engine, designated TF316, should be installed in the second prototype during 1965. Additional applications are possible to the Mirage IIIF and to a development of the Mirage IV.

The fourth major engine activity is SNECMA's contribution to the Concorde propulsion system, which amounts to everything aft of the turbines of the Olympus 593, namely the afterburner, nozzle, silencer, and thrust reverser. Development proceeds, in co-operation with Bristol Siddeley, at SNECMA's Melun-Villaroche Test Centre using an Olympus 301. Although afterburning may be used during acceleration to supersonic speed, the primary requirement for increased thrust is for a few seconds only at take-off. Minimum in-flight drag and thrust loss are therefore highly important, and an aerodynamic flame holder is now being investigated as a possible solution to the problem. A full-scale version of

the silencer, based on the accepted peripheral mixing-duct pattern is undergoing bench test. A conventional pattern clam-shell reverser for the Concorde, to exhaust above and below the wing, has been tested on an Atar.

SOVERINI *Soverini Frères et Cie, Argenteuil (Seine-et-Oise).* This company has developed a small four-cylinder radial, air-cooled two-stroke engine, suitable for ultra-light aircraft and powered sailplanes, in the 40 h.p. class, designed by M Marcel Echard. The Soverini-Echard 4D and 4DR engines have a separate pressure lubrication system, fed by a conventional oil pump.

TURBOMECA *Société Turbomeca, Bordes (Basses-Pyrénées).* With 2,000 employees and a factory area of more than half a million sq ft at Bordes and Mezières, plus a new plant under construction at Bayonne, Turbomeca have a capital of NF 22m, and a sales turnover of NF 115m in 1963, of which more than half was in exports. Turbomeca engines have been fitted in 50 types of aircraft, and 6,500 French-built engines have flown more than 1,500,000hr in 45 countries. An additional 5,000 engines have been built under licence by Bristol Siddeley, Continental in the USA, ENMA in Spain, and a State factory in Yugoslavia. Present production by Turbomeca totals 80 engines per month, and there is an adequate backlog of orders covering the next two years, with the main effort still concentrated on the Marboré turbojet and the Artouste turboshaft.

A remarkable degree of interchangeability exists among the entire range of Turbomeca engines, and more than 30 different types have been built of which 15 have gone into production, including ten under foreign licence.

The Marboré 2 has been followed into production by the Marboré 6. Orders for this engine amount to 550, and some 200 have already been built. Ultimate capacity is 30 Marboré 6s per month, compared with 70 Marboré 2D of which 3,900 were made—in addition to 3,700 by Continental under the designation J79. The 6 is specified for the Super Magister, Paris II and III, and the Potez-Heinkel CM191.

In the Artouste turboshaft series, 1,800 Artouste 2s have been built for Alouette 2s, and more than 500 3s are on order for the Alouette 3. Many more 2s have been made by Bristol Siddeley, and licence production is also planned by HAL in India.

Various versions of the Turmo 3 free-turbine engine, are in current production or under development and 100 engines are now on order. The 3C3 has been developed for the Super Frelon to a maximum rating of 1,500 s.h.p., and the 3D3 to 1,450 e.h.p. for the Breguet 941.

More than 100 Bastan 6 turboprops have been ordered for the Nord 262, in the B2 version, and a further 50 have been bought by the Argentine Government for the Guarani.

The Astazou, like the Artouste 3B and the Bastan, is a second generation Turbomeca engine, characterized by a two-stage axial-centrifugal compressor. Most significant features are very low s.f.c., and a unique control system based on constant r.p.m. of engine and propeller with automatic fuel-input response to propeller pitch-change and flight loading. The Astazou 2, which has been built in both turboprop and turboshaft versions, has been flown experimentally in many aircraft and the Alouette-Astazou helicopter. Orders amount to some 250 engines to date.

The 678 h.p. Astazou 10, which was type approved in January 1964 has an s.f.c. of 0.513, comparable to that of piston engines of equivalent power. The future of this engine at present depends mainly on the fortunes of the Turbo Skyvan, although it is specified as an alternative to the PT6 for the Potez 842.

Announced in the spring of 1964, the Turbomeca-Agusta TM251, also known by the Agusta designation TAA230, is a turboshaft which powers the Agusta 105 light helicopter. The basic engine, produced by Turbomeca, incorporates components developed from Astazou parts. Reduction gearbox, clutch, oil filter and pumps are manufactured by Agusta.

The Gascogne is an airborne a.p.u. which has been completed in prototype form. Another new project, still in the design stage, is the Tourmalet turbofan, a departure for Turbomeca into the 5,500-6,600lb thrust class, which is being developed initially as a potential powerplant for the French jet trainer/close-support aircraft, in competition with the SNECMA Mars.

Pioneers of the turbofan, Turbomeca have developed the Aubisque, a 1,543lb thrust engine, 300 of which have been ordered for the Saab 105. Initial development troubles with the variable inlet guide vanes should have been overcome by now, and full production is expected in 1965.

German Federal Republic

BMW *BMW Triebwerkbau GmbH, Munich-Allach.* BMW began in 1957 the licence manufacture and support of Lycoming piston engines for Do27s and Piaggio P.149Ds. Since 1960, 50 per cent of BMW's capital has been held by MAN.

First stage of BMW's re-entry into turbine power, was a technical assistance contract with Orenda for the Luftwaffe's Sabre powerplants. More recently, BMW have been sharing licence production of the GE J79-11A with FN and Fiat for the European F-104G programme.

BMW's own designs have been developed over the past ten years into a range of small turbines remarkable for their simplicity and economical performance. The 100 h.p. 6012 turboshaft is suitable for light aircraft and helicopters, but is also used in a.p.u.s. Developments of this basic design, are the 6012L, two-stage centrifugal air generator for the Do32E helicopter; and the 8026 turbojet, a tiny 121lb thrust unit with augmenter requiring virtually no maintenance in service.

Succeeding the 6012, the 6022 is a 250 s.h.p. turboshaft, deliveries of which are due shortly. Two 6022s will power the Bölkow Bö105 light helicopter, and one will be installed in the two-seat Do32Z.

DAIMLER-BENZ *Daimler-Benz AG, Stuttgart-Unterturkheim.* Daimler-Benz are developing the 1,330 e.h.p. DB720/PTL 6 turboshaft intended for light transport and training aircraft and helicopters. A turbofan version, the 1,345lb thrust DB730/ZTL 6, is also projected.

The rear free-power turbine of the DB720/PTL 6 drives an output shaft through a single 3.62 : 1 spur gear. Addition of a further stage of gearing produces a front or rear-drive turboprop. There is a power turbine overspeed governer, and a single lever controls fuel feed to the annular combustion chamber of the gas generator. In the DB730/ZTL 6, the free power turbine and shaft drive assembly are replaced by small diameter aft fan unit.

KHD *Klöckner-Humboldt-Deutz AG, Koln-Deutz.* KHD have produced more than 100 licence-built Orpheus 803 turbojets at their Oberursel works for the Fiat G91 programme. The Orpheus 803 D11 version, assembled from mainly KHD-manufactured parts, has an increased-output generator, additional fire protection, and a larger oil tank as the chief differences. KHD have also acquired a licence to manufacture GE T58 turboshafts for aircraft, marine and industrial applications.

Deutz have themselves produced a tiny 100 h.p. turboshaft, designated T16B, suitable for a.p.u. applications. This unit, 32½in long and weighing 154lb, comprises a front gearbox with hand starting drive, single-stage centrifugal compressor, tangential combustion chamber, and single-stage centripetal turbine operating at 50,000 r.p.m.

MAN *M.A.N.-Turbomotoren GmbH, Munich 68.* In collaboration with Rolls-Royce, Hispano Suiza, and Fabrique Nationale, MAN manufacture 28 per cent of each Tyne for Atlantics and Transalls, sharing final assembly and powerplant testing with Hispano Suiza.

MAN are also associated with Rolls-Royce in development of lift engines, notably the RB.145 for the VJ101C-X1, and the afterburning RB.145 for the -X2 version.

Further collaboration with both Rolls-Royce and Bristol Siddeley is directed towards the powerplant for the VAK-191B V/STOL strike fighter. Designated RB.193, this lift/cruise engine in the 10,000lb thrust class is a development of the RB.153 and will incorporate Bristol Siddeley's swivelling nozzle experience.

India

HAL *Hindustan Aeronautics Ltd, Bangalore.* The first aero engine designed and built in India was Hindustan's 90 h.p. PE-90H, an air-cooled flat four run in 1959 and destined for the Pushpak light aircraft. Certain accessories such as carburettor and magnetos have been imported, but the engine should eventually be 100 per cent Indian.

The HJE-2500 is a small turbojet in the 3,000lb class, which HAL Engine Division are developing for the HJT-16 Kiram basic

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trainer. Orpheus 701 and 703 turbojets are being made under Bristol Siddeley licence, respectively for the Gnat F1 and HF-24 Maruta Mk 1.

Further licence agreements enable HAL to manufacture Dart 531 turboprops for the IAF-built HS 748s, and Artouste 2Cs for licence-built Alouette 2s.

Italy

AGUSTA *Agusta Meccanica Verghera SA, Gallarate.* Agusta have produced a range of horizontally-opposed piston engines from 40 to 140 h.p., a flat twin and a flat four suitable for light aircraft, and two vertical-crankshaft fours for helicopters.

Reduction gears and other components are also produced for the Turbomeca-Agusta TM251 (TAA 230) turboshaft for the A.105.

ALFA ROMEO *Milan.* Alfa Romeo are overhauling Wright radials and J65 turbojets, Rolls-Royce Darts, Avons and Conways, and Bristol Siddeley Gnomes. They also share with Fiat, FN and BMW in production of GE J79-11A turbojets for the F-104G and are Italian distributors for GE J85 and CJ610 turbojets.

FIAT *Fiat SpA, Turin.* Some 200 Orpheus 803 turbojets (Fiat designation 4023 and 4024), have been made since 1960 under Bristol Siddeley licence for the G.91. In collaboration with Alfa Romeo, FN and BMW, Fiat manufacture and assemble the GE J79-11A for the F-104G. Fiat also provide overhaul and service support for a variety of piston engines and earlier turbojets.

Fiat have developed a variety of small units from their own 4002 turbojet. The 4700 vertically mounted gas generator was made for the Fiat 7002 cold-jet helicopter, now abandoned. A shaft-drive version, the 4301 and the 4004 turbojet have also been built.

METEOR *Meteor SpA, Costruzioni Aeronautiche, Trieste.* Meteor have produced a series of small two-stroke, single-row, four-cylinder, and two-row, eight-cylinder, radial piston engines which range in power from 120 to 320 h.p. All versions are basically similar, with common components, and are less than 23.6in in diameter. Scavenging is by Rootes type blower. Some are rated for target drone applications, with a power/weight ratio of 0.85lb/h.p.; others are certificated for light aircraft, with a TBO of 1,000hr. Various models are rated to maintain constant power up to 8,000, 20,000 or 26,000ft, and one target drone version is capable of operation at 32,000ft. Vertical crankshaft versions are also available.

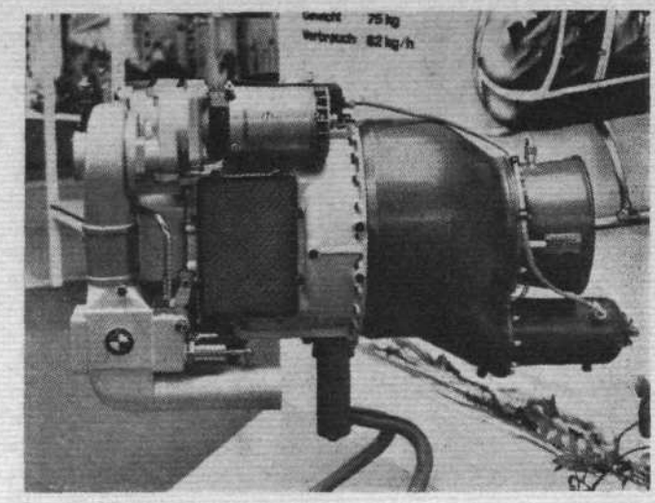
PIAGGIO *Rinaldo Piaggio SpA, Genoa.* Piaggio's engine division continue with licence production and service support of a variety of Lycoming flat six piston engines. They are also manufacturing the BS Viper 22-1 turbojet under licence for the Macchi MB.326 trainer.

Japan

IHI *Ishikawajima-Harima Heavy Industries Co Ltd, Aircraft Engine Division, Kitatama-Gun, Tokyo.* Under licence from General Electric, IHI manufacture J79-11A turbojets for the F-104J, and T58 turboshafts for helicopter and other applications.

Of IHI's own design is the J3-7, a simple 3,000lb thrust axial flow turbojet intended for the Fuji T1B trainer, and the J3-F, a 3,750lb turbofan version with a rear-mounted large-diameter, single-stage free turbine fan. The XJ11, scheduled to complete its performance tests during 1964, is being developed as a V/STOL powerplant.

IHI also have a contract from the Aeronautical Engineering Institute of the Science and Technology Agency to manufacture the prototype of an experimental turbojet designated JR100. This is the first of three stages of a four-year development programme for a V/STOL aircraft engine with a thrust-to-weight ratio of 20 : 1. The initial JR100, due for delivery last October, has a six-stage axial flow compressor, mainly steel parts in compressor and turbine, and a 10 : 1 thrust/weight ratio at 3,153lb thrust. This will be improved to 15 : 1 when steel is replaced by light alloy in the compressor, and titanium in the turbine. The second JR100, to be



BMW 6022 250 h.p. turboshaft

delivered this year, is expected to achieve a thrust/weight ratio of 18 : 1. The third engine should have the 20 : 1 ratio in 1966.

Poland

OKL *Osrodek Konstrukeji Lotniczych, Warsaw-Okecie.* Few details are known of the two small turbojets developed by the jet engine design team of OKL, which was established in 1957. The 882lb thrust TO-1 is a centrifugal flow turbojet for light aircraft. An axial flow engine of about 2,000lb thrust, thought to have a seven-stage compressor, annular combustion chamber and single-stage turbine, has been produced for the T5-11 Iskra trainer.

Narkiewicz-designed piston engines developed by OKL for Polish light aircraft and helicopters include the 330 h.p. WN3 seven-cylinder radial, the 68 h.p. NP1 and 125 h.p. WN7 flat fours, the geared 145 h.p. WN7R and the 195 h.p. WN6B flat six, developing 220 h.p. as the geared WN7R, and 200 h.p. for helicopters as the WN6S.

OKL makes a number of Russian-designed turbojets and radial piston engines under licence, including the Klimov VK1 and 1A turbojets (Polish LIS2A and 5), for the Polish Air Force.

Spain

ENMA *Empresa Nacional de Motores de Aviacion SA, Madrid.* ENMA continues to produce its own 93 h.p. Flecha flat four, 125 h.p. Tigre inverted in-line four, and the 275 h.p. Alcion geared supercharged, seven-cylinder radial. The Turbomeca Marboré 2 is made under licence, as the Marboré M21, for the Hispano Saeta.

Sweden

SFA *Svenska Flygmotor AB, Trollhättan.* RM6C is the designation of the Rolls-Royce Avon 301 turbojet being produced under licence and fitted with an SFA-designed afterburner and nozzle, for the Saab Draken. Maximum thrust approaches 17,000lb.

Lack of British Government support at the time for development of the Rolls-Royce Medway forced the Royal Swedish Air Board to turn to the USA for the powerplant for the Saab 37 Viggen. This will be the RM8, a licence-built development of the P & W JT8D-22 turbofan, which will be extensively modified for supersonic performance and fitted with a Flygmotor-developed afterburner, variable nozzle and reverser.

United Arab Republic

HELWAN *Helwan Air Works.* Furthering their bid for status and some degree of independence in military aviation, the United Arab Republic is developing a small 7,000lb thrust afterburning turbojet as part of the HA-300 fighter programme. Designated E300; this engine, which is dimensionally similar to the Bristol Siddeley Orpheus, is being built to the design of Prof Brandner, an Austrian who also contributed to the development of the Kuznetsov NK12M and other Soviet turbines. The E300 was expected to fly in 1964, and may further be flight tested in the Indian HAL HF-24 Maruta as a possible powerplant for the supersonic Mk 2.

United Kingdom

ALVIS *Alvis Ltd, Coventry.* The 640 h.p. long-stroke Leonides 531/8B, latest version of the geared, supercharged nine-cylinder radial, powers the Series 3 version of Scottish Aviation's Twin Pioneer, with a TBO of 800hr. The 800 h.p. 14-cylinder, vertical-crankshaft Leonides Major 755/1, is installed in the Westland Whirlwind Series 2.

In December 1962 Alvis established approved overhaul facilities for Lycoming piston engines.

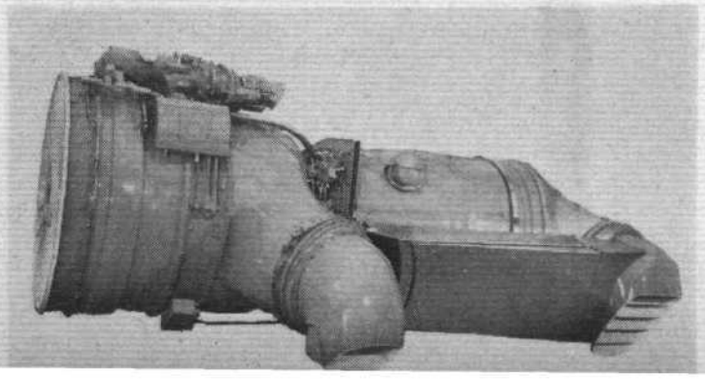
BRISTOL SIDDELEY *Bristol Siddeley Engines Limited, London SW7* The activities of Bristol Siddeley are now concentrated in three divisions. The Aero Division at Bristol is responsible for the supersonic Olympus, Pegasus, BS.100, Orpheus and Viper, while the Parkside factories at Coventry, cover service support of earlier engines such as Sapphires, Double Mambas, and the Proteus turboprop, which now has a TBO of 3,600hr in Britannias. The Power Division at Ansty, near Coventry, is responsible for rocket motors, industrial and marine versions of the Proteus and Olympus and hovercraft power. British hovercraft turbine power is, incidentally, 100 per cent Bristol Siddeley. The new Small Engine Division, centred in the North London area and comprising the old de Havilland Engine establishments, has been formed to emphasize Bristol Siddeley's interest in helicopter powerplants and a.p.u.s. This Division also supports countless Gipsy piston engines and Goblin, Ghost and Gyron Junior turbojets.

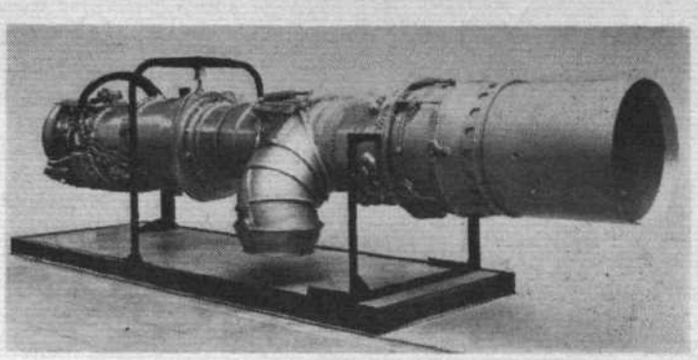
Bristol Siddeley is developing a range of vectored thrust turbofans for V/STOL aircraft. The initial engine, the BS.53 Pegasus, which from its inception has received support under the US Mutual Weapons Development Programme, first ran in September 1959 at around 13,000lb thrust and flew in the prototype P.1127 in October 1960. Flight development of the Hawker Siddeley Kestrel continues with the 15,500lb BSPg.3. The BSPg.5, could give the Kestrel 18,000lb thrust. There are various versions of this engine, one of which will power the Dornier Do31. A flight development engine has been flown under a Valiant, and a pair of BSPg.5s is due to fly in the second Do31 hover rig, together with eight Rolls-Royce RB.162s. The Pegasus has also been used for preliminary trials of plenum chamber burning (p.c.b.) for the BS.100, both in a modified Sapphire cell at Ansty, and on an open air rig at Aston Down. Further developments of the Pegasus could incorporate p.c.b. as an integral part of the design.

The compact BS.59 lift fan, first run in 1962, provided development experience for future lift engines. Although several development BS.75 turbofans of 7,500lb thrust have been built, this project is inactive at the moment. West Germany's VAK-191 V/STOL strike fighter was originally designed round the BS.94, a vectored derivative of the BS.75, the design thrust of which has risen from 7,500lb to the 9,000-10,000lb range. Current proposal for the VAK-191B is the Rolls-Royce/MAN/Bristol Siddeley RB.193, a joint project which incorporates Bristol Siddeley's swivelling nozzle experience.

Among three major current projects, each in the 30,000lb-plus range with thrust augmentation, the BS.100 is one of the largest aero engines in existence, and the first vectored thrust turbofan designed for supersonic flight. Two examples have now run on the bench and the type is destined for the Hawker Siddeley P.1154 strike fighter, under a contract placed in 1963. Initial flight testing is to be carried out under a V-bomber. Because the by-pass air is at a relatively low temperature, a thrust increase of up to 30 per cent at zero speed and 200 per cent at Mach 2, can be achieved with only a modest increase in s.f.c. and at an outlet temperature about the same as that in the rear nozzles. A retractable ramp on each side of the engine increases the exit area of the front nozzles when in the horizontal position to permit maximum boost during supersonic flight.

Bristol Siddeley BS.100





Rolls-Royce RB.153 lift/cruise turbojet

Beyond the BS.100 is the BS.111, no details of which are at present available.

The Olympus, one of the most important turbojets in aviation, forms the basis of the other two major Bristol Siddeley projects. After progressing, with exceptional reliability, from the Olympus 100 installed in Vulcans in 1956, to the 200 and 300 series now giving 20,000lb thrust in the latest Vulcan B2, the 22R version is now flying as the 33,000lb Olympus 320 in the TSR.2.

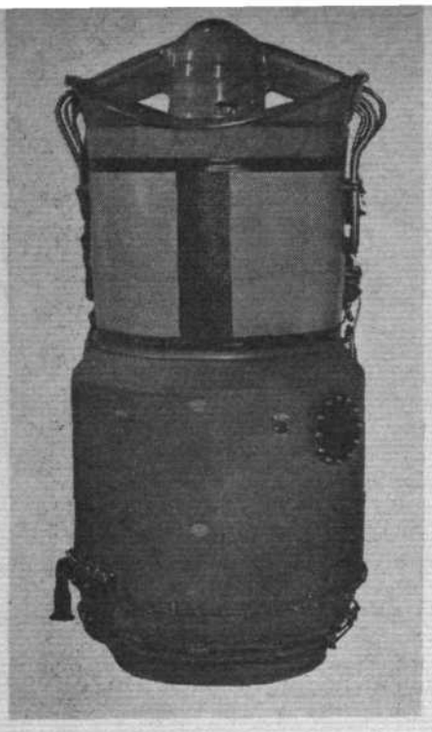
Even more recent in Olympus succession is the 593, the powerplant for the Concorde. The initial engine in this series was the 593D which first ran in July 1964, and the second, an enlarged variant of the 593D, ran in October 1964 as the 32,500lb thrust 593B. Ultimately, take-off thrust of the Concorde powerplant will be increased to about 35,000lb with SNECMA-designed reheat. SNECMA's contribution (q.v.) includes the afterburner, silencer and thrust reverser. They will receive an Olympus 593D during this year. Facilities have also been provided by the NGTE, for testing TSR.2 and Concorde engines in the variable speed and altitude test cells of their Pyestock establishment.

The versatile Viper turbojet has been developed from a target drone engine in the Jindivik, into a most successful engine for a wide variety of civil and military aircraft. More than 1,000 Vipers had been built by early 1964. A major outlet today is the HS.125 which is powered by two 3,120lb thrust Viper 521s. United States operators of the DH.125 will benefit from a pay-by-the-hour overhaul scheme for their Vipers. In the same class as the HS.125, Piaggio's PD-808, which first flew in August 1964, is fitted with two 3,000lb thrust Viper 525s. Thrust improvements which enable the Viper 521 and 522 to deliver 3,120lb and 3,310lb respectively at i.s.a., and 3,000lb each at i.s.a. + 10°C, have been achieved with no increase in s.f.c. Vipers have been ordered by the US Navy for target drones, and are exported to Jugoslavia for the Sokol Galeb, and to India for the HJT-16, which first flew in September 1964. Rinaldo Piaggio make 200 series Vipers under licence for the MB.326.

With the Orpheus and Viper together, Bristol Siddeley have extensive experience of power for primary and secondary jet trainers, eight types in all including the recently announced BAC 145. More than 100 Orpheus turbojets each have been completed by KHD in Germany (803s), and HAL in India (701s) and total licence output from Fiat has reached about 200 (803s). Unspecified versions of the Orpheus, presumably developments of the BOr.12, which has eight compressor and two turbine stages, have a static thrust of more than 9,000lb with reheat.

The Gnome turboshaft, anglicized and developed version of the GE T58, is a major product of the Small Engine Division. More than 500 have already been built, with many orders still to be fulfilled. The 1,250 s.h.p. Gnome H.1200, uprated version of the H.1000, is supplied for single installation, and as a coupled pair driving through an aft gearbox. Maximum potential output is 2,500 s.h.p. which, in the Wessex HC2, is limited to 1,550 s.h.p. at the rotor head. Should either engine stop, the other will automatically increase power to the desired output, up to the maximum H.1200 emergency rating of 1,350 s.h.p. General Electric and Bristol Siddeley are jointly continuing development, with GE aiming at a 1,400 h.p. and BS a 1,600 h.p. version, which has already run in turbojet form. Yet higher powers are envisaged.

The T64-BS is a free-turbine engine licensed in 1964 from GE and available as a turboshaft or a turboprop for helicopters, fixed-wing and V/STOL aircraft. The same basic gas generator, develop-



Rolls-Royce RB.162 lift engine

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ing 2,550 s.h.p., is used in all versions of the T64-BS. Compressor and turbine casings are split and allow "in-the-field" replacement of blades without rebalancing the rotor.

The 1,050 s.h.p. Nimbus turboshaft has been developed from earlier Bristol Siddeley/Turbomeca designs, with a two-stage axial compressor, steel centrifugal compressor, and redesigned blading on the turbine which has a second stage, driving the rear output shaft located between the bifurcated exhaust. The Nimbus 102 is torque limited to 685 s.h.p., thus conferring outstanding "hot-and-high" performance on the Westland Scout and Wasp. Four Nimbus 1000 Series in coupled pairs power the SR.N2 hovercraft.

Bristol Siddeley's interest in free-turbine engines at the lower end of the power range has resulted in a selection of turboshaft and turboprop powerplants covering virtually any shaft-driven V/STOL aircraft.

Auxiliary power units include the Palouste turbo-compressor, and its lighter and more powerful derivative the Cumulus, which additionally provides shaft power for an alternator. The Cumulus is installed in the TSR.2; and the Artouste, basically a Palouste with a drive extension from the rotor to a 100 h.p. output gearbox, is fitted in the Trident, Victor B.2 and CL-44. Development of these units continues in close association with Turbomeca.

In addition to the 170lb thrust PR.37 miniature rocket booster installed in the Jindivik, Bristol Siddeley have developed the BS.605, a retractable twin-chamber motor using kerosine and hydrogen peroxide, and believed to be intended for SAAF Buccaneers.

Bristol Siddeley have technical collaboration agreements with Svenska Flygmotor (ramjets), Marquardt Corporation of California (interchange of information on hypersonic air-breathing engines) and hold licences to manufacture Solar afterburners and associated equipment, and SNECMA thrust reversers.

Finally, looking ahead, two obvious engines offering a high-by-pass ratio for projects such as air bus, strategic freighter or maritime reconnaissance aircraft are a straight turbofan, unvectored BS.100 or a "fanned" Olympus. These would take advantage of today's higher turbine entry temperatures to provide by-pass ratios of four or five, giving exceptionally low fuel consumption 5 to 10 per cent less than that of existing transport engines. Because addition of a normal front or aft fan would make it too large, a "fanned" Olympus is more likely to have one or two remote exhaust-driven fans. Other high-by-pass engines and designs competing with the RB.172 and GE J1 are also projected.

ROLLASON *Rollason Aircraft and Engines Ltd, Croydon.* Rollasons produce their own developments of the French Ardem 4CO2 conversion of the Volkswagen car engine for their licence-built Druine Turbulents. Latest versions of the 4CO2, the 45 h.p. Mk 4 and 55 h.p. Mk 5, both based on the 1,500 c.c. VW, are specified in the current racer design competition sponsored by Rollasons.

ROLLS-ROYCE *Derby.* Rolls-Royce continue to hold their pre-eminent position in spite of all the vicissitudes of aviation, civil and military. Grand total of aviation production has passed 205,000 engines—170,000 piston engines including 150,000 Merlins, and 35,000 gas turbines including 29,000 military and 6,000 civil. Rolls-Royce aero engine manufacture employs more than 34,000 people in Derby, Glasgow, Barnoldswick and Crewe. Research, design and development occupies 9,000 people and 2,300,000 sq ft, nearly one-third of the total factory area. More than 11,000 Rolls-Royce engines have been built under licence abroad, and licence agreements continue in Belgium, France, Germany, India and Sweden.

Twenty-nine separate Rolls-Royce-powered military aircraft in 12 countries have entered service and eight more are under development for service during the next five years. Thirty-six armed forces of 30 countries are currently operating Rolls-Royce powered military aircraft. Sixteen different types of civil aircraft, produced by seven countries (the total ordered exceeds 1,500 aircraft) are powered by Rolls-Royce turbines. Two more types are in design, and the recently initiated Dart Convair conversion brings the total to 19.

Rolls-Royce gas turbines have completed more than 50m hours, nearly 40m of which have been in civil aircraft—an indication of the much higher utilization of civil aircraft. When the Dart entered service with a TBO of 400hr, piston engine TBOs were around 1,000hr. Today, the Dart has reached 5,000hr, the Avon and Conway over 4,000hr and the Tyne more than 3,000hr, compared with 2,000hr on typical piston engines. With a shop check at approximately half-life the Conway has reached 6,700hr, the highest TBO yet achieved.

Large numbers of Avons continue in service throughout the world, with 35 civil operators and 27 different types of military aircraft. The 12,690lb thrust RB.146 Avon 300 is an advanced version having an improved compressor with a zero stage and increased mass flow. The 16,000lb Avon 301 with reheat powers the latest marks of Lightning. Licence built in Sweden by Svenska Flygmotor, and equipped with their own design of afterburner, the RB.146 Mk 60 is rated at 17,110lb. Latest on the civil side, is the 12,725lb Avon 533, or RA.29/6. The 533R with reverser is rated at 12,600lb in the Caravelle 6R. These engines have a 17th "00" compressor stage and a two-position nozzle for improved cruise performance.

The exceptionally reliable Conway turbofan powers, in addition to the Victor B.2, three types of four-engined transport of which 117 examples have been ordered to date. The Conway first ran in 1952, flew in 1955 and was the first turbofan to enter airline service in 1960, as the 17,500lb 508 and 509 in the Boeing 707-420 and DC-8-40. It has since set the pattern for subsonic commercial turbojets. Most powerful military Conway so far announced, is the 20,600lb 201 series, the RCo.17 for the Victor B.2. With h-p compressor, outlet casing and turbine discs strengthened for higher operating pressure and temperature, the 21,825lb Conway 550, or RCo.43, is the version in production for the Super VC10, shortly to enter BOAC service.

Few details are available of the proposed Conway successor, the RB.178, a high-by-pass-ratio turbofan rated at 25,000lb take-off thrust at 9,260 r.p.m. in i.s.a. at sea-level. Weight of a complete pod applicable, for example, to the twin-jet Sud/BAC Galion, is reported to be 6,300lb.

Designed initially for short- and medium-range transports, the RB.163 Spey turbofan first ran in December 1960, and began commercial service in BEA's Tridents in March 1964. The number of Spey-powered transports on order has already reached 116. The 11,400lb Spey 511 (RSp.25), specified for the Trident 1E (511-5) and One-Eleven 300 and 400 (511-14), has an additional fifth stage added to the low-pressure compressor. It first flew in the Trident 1E in November 1964, and full ARB clearance is expected early this year. The Spey 511-5W incorporates water injection to maintain full take-off power at high ambient temperatures. One-Eleven tropical trials were completed last November at an airfield height of 2,000ft and ground temperatures up to i.s.a. +35°C, with 10,410lb water injection Spey 506-14Ws. British Government financial support for Spey 25 development includes the military Spey, RB.168, which is fundamentally similar to the civil series,

but incorporates modifications for operation in the Buccaneer S.2 and F-4 Phantom. The changes include provision for bleed air for the Buccaneer's boundary layer control system, and reheat for the supersonic F-4.

Announced in July 1962, the 8,740lb thrust RB.183 Spey Junior is a lightened and simplified Spey using some 90 per cent of the standard components, the same number of compressor and turbine stages and the flame tubes of the 505 and 506. By-pass ratio will be 1.0, and weight has been saved by deletion of features necessary for the higher rating of the standard engine. Dry weight is 2,025lb. The first development engine is due to run this month, and development will be integrated with that of the larger version, thus benefiting immediately from 50,000hr of development already completed. Target for type test is April 1966, followed by full certification later the same year, in time for the first flight of the Fokker F-28 Fellowship. The Spey Junior is presumably also intended for the Grumman Jet Gulfstream.

The 17,300lb thrust Medway turbofan with switch-in deflection nozzle is currently under development for the Hawker Siddeley HS.681 STOL tactical transport for the RAF. As the RB.141, this engine, which was the second turbofan designed by Rolls-Royce, was conceived to power the original version of the Trident, and first ran in 1959. It is therefore directly related to its scaled-down derivative, the Spey. More than 1,500hr of testing have already been completed and the Medway has a low s.f.c. in comparison with other engines in its thrust class.

Smallest engine in the current range of Rolls-Royce turbofans, the 6,000lb thrust RB.172, which has been under development for about four years, is proposed for small short-haul transports, and may power the Dassault Mystère 30. With a length of 82in, and a diameter of 31.8in, this engine weighs 1,331lb. Designed for simplicity and low cost, the RB.172 has no inlet guide vanes or de-icing equipment, variable stators or bleed valves, and only two bearings for the h.p. rotor and four for the l.p. rotor. The first three stages of the six-stage l.p. compressor form the large-diameter fan. The six-stage h.p. compressor is driven by a single-stage and the l.p. compressor by two-stage turbines. The combustion chamber is annular. Military versions may have reheat.

The Rolls-Royce/MAN/Bristol Siddeley RB.193 twin-shaft turbofan, is the most recent result of Rolls-Royce/MAN technical collaboration begun more than five years ago. It is probably to be adopted by the German Defence Ministry for the VAK-191B VTOL strike fighter, together with RB.162 lift engines. Experimental manufacture and production will be shared between MAN, Rolls-Royce and Bristol Siddeley. Two-thirds of the British contribution will come from Rolls-Royce and one-third, in the form of the thrust vectoring system, from Bristol Siddeley. The two British companies have further agreed to explore the possibility of co-operation in exploiting export markets for British V/STOL techniques.

Rolls-Royce has pioneered the design of specialized lift engines. The RB.108, first run in May 1955, with a thrust of 2,210lb and 8 : 1 thrust : weight ratio, powered the Short SC.1 and Dassault Balzac research aircraft, and is installed in four hovering rigs on the Continent. By last September the first Dornier rig with four RB.108s had completed 63 free hovers, and the EWR rig 117 free hovers with three RB.108s. Hovering tests should also have been started by now with the VFW rig (five RB.108s) and the Fiat rig (two RB.108s).

The 2,750lb thrust RB.145 is a lightweight lift/cruise turbojet (thrust/weight ratio 6 : 1) based on the RB.108, with a nine-stage axial compressor, at least one zero stage, annular combustion chamber and two-stage turbine. Starting is hydraulic, an oil tank is mounted on the front casing and considerably more accessories are fitted than on the RB.108. The first RB.145 ran in April 1961 and six MAN-developed versions are installed in the EWR-Sud VJ101C. The VJ101C-X1 completed 35 take-off and landing transitions, and achieved its first supersonic flight in July 1964. Reheat versions of the RB.145, with 3,650lb thrust, are installed in the Mach 1.4 -X2, which is to fly very shortly.

The phase 1 development contract covering the RB.162-1 (10 per cent bleed) and RB.162-4 (non bleed) lift jets, under a tripartite agreement between Britain, France and Germany, has been completed ahead of schedule. The RB.162 special category engine, completed in August 1964, achieved a thrust and s.f.c. respectively 2½ per cent and 3½ per cent better than contract figures. The thrust of the initial RB.162 was set at 4,400lb (thrust/weight ratio 16 : 1) to match various European VTOL projects. Changes in requirements have led to increases in aircraft weight, and as a result the RB.162-30 series is being developed initially for 5,500lb and eventually for 7,000lb thrust. RB.162s are specified for the Mirage IIIV, VAK-191B, Do31 and G.222. A front (top) fan version of the RB.162, designated RB.175, is under study.

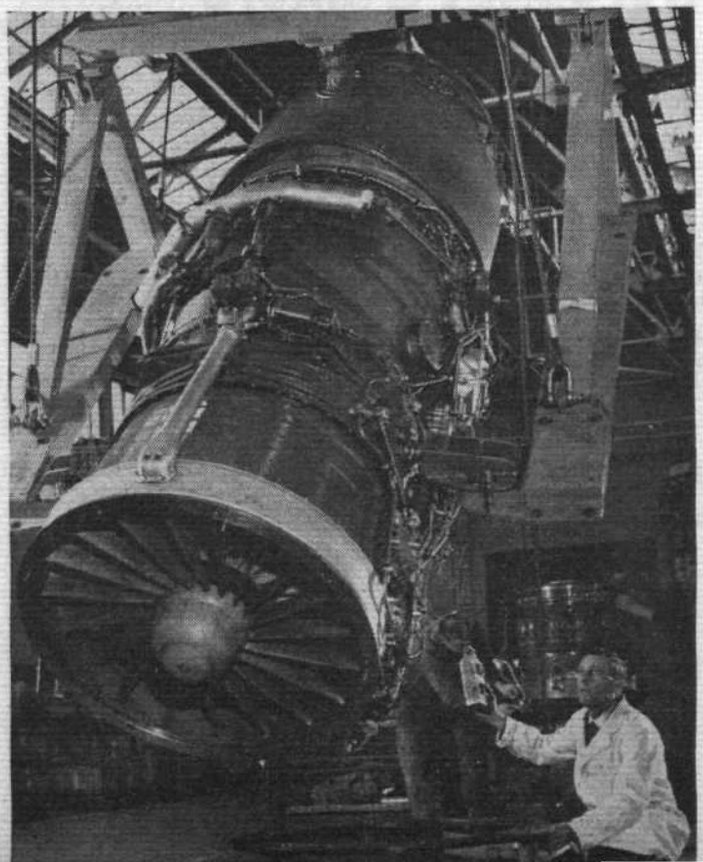
Latest version of the ubiquitous Dart, the RDa.12 Series 201 is to give 3,245 e.h.p. with water/methanol injection, in the Andover. A new Dart market (for the 2,550 e.h.p. Dart RDa.10) is the Convair-Liner conversion starting with 35 aircraft and a potential of 1,000.

Existing production Tynes have powers up to 6,100 e.h.p., and development up to 7,630 e.h.p. is projected. Engines for the Atlantic and Transall are manufactured by Rolls-Royce, FN, Hispano Suiza and MAN.

Rolls-Royce are responsible for production and service support of the Napier Gazelle for the Westland Wessex Mk 1 and 31, and Belvedere. The 1,540 s.h.p. Gazelle NGa.18 Mk 165 is under development for the Wessex 3.

Rolls-Royce currently produce the Continental 95 h.p., 100 h.p., and 145 h.p. Licence production of the 310 h.p. GIO-470-A is planned.

Rolls-Royce Spey



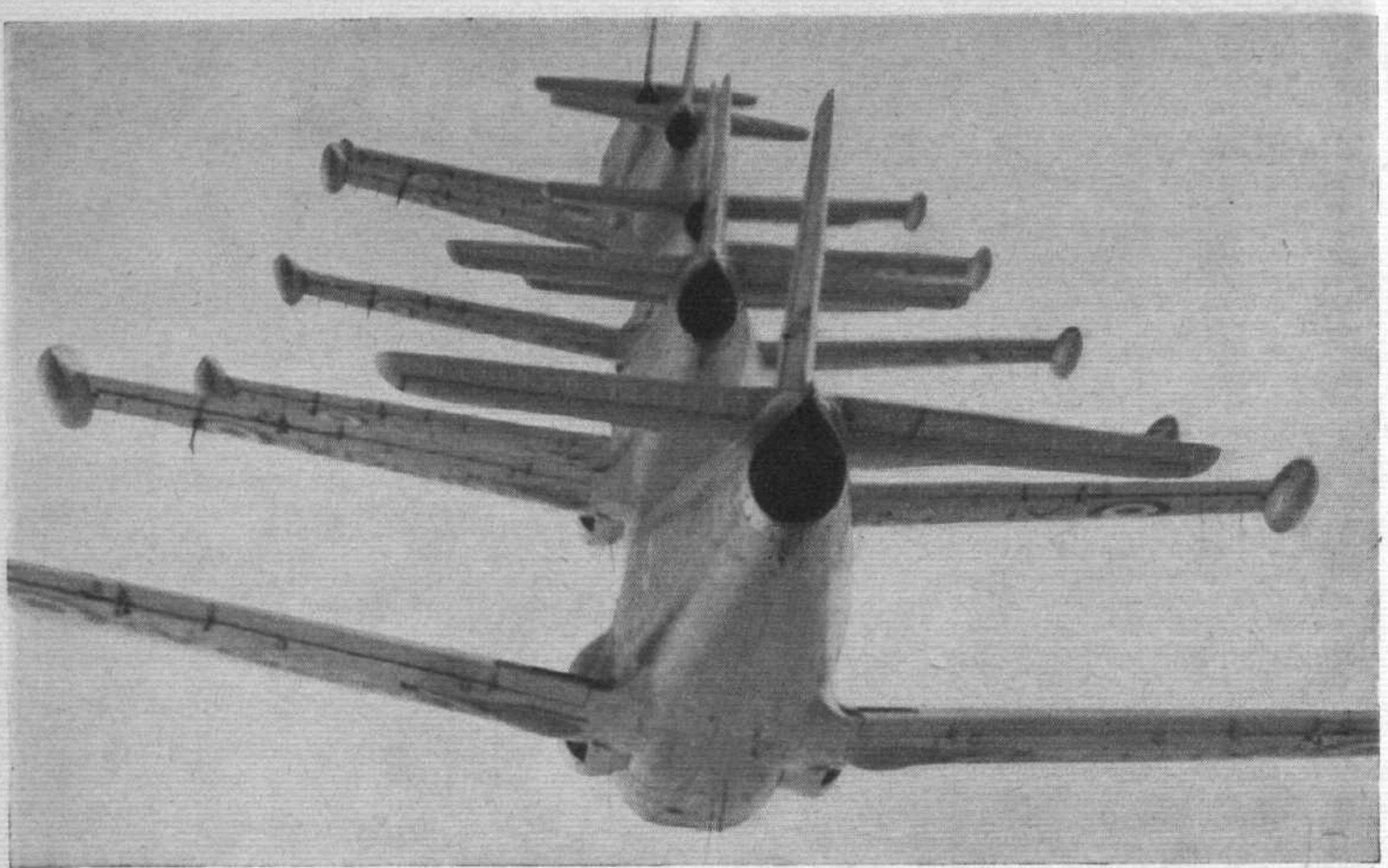
ROVER *Rover Gas Turbines Ltd, Solihull.* Rover a.p.u. turbines are installed in the HS Argosy C.1 and Vulcan B.2. Latest application announced is a 150 h.p. unit weighing only 90lb, developed in conjunction with Rotax, for the HS.1154. Also projected is a light, small 150 h.p. development of the TP.90.

United States of America

AIRESEARCH *AiResearch Manufacturing Company of Arizona (Division of The Garrett Corporation), Phoenix, Arizona.* AiResearch has produced more than 10,000 ground and airborne a.p.u.s from 30 to 850 h.p., and first flew the 500 s.h.p. Model TSE331 turboshaft in a Republic Lark (licence built Alouette 2) in October 1961. The 600 s.h.p. TPE331 turboprop is now being flight tested in a Helio Stallion and is specified for at least nine new aircraft. With the military designation T76-G6 and rated at 660 s.h.p. it is selected for the NA.300 COIN aircraft.

ALLISON *The Allison Division, General Motors Corporation, Indianapolis 6, Indiana.* Allison's T56 turboprop continues in production for the Orion, Hercules, E-2A and C-2A. Most powerful of the series is the 4,910 e.h.p. T56-A-15 with air-cooled first stage turbine blades. More than 170 Lockheed Electras and Convairliners have flown with the 3,750 e.h.p. civil Allison Model 501-D13.

The Allison Model 250-C10 or T63, is a lightweight free-turbine



British BAC Jet Provost (Viper)

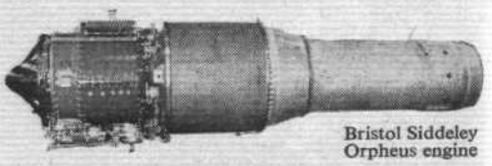
A flying start for pilots of 14 nations —Bristol Siddeley powered jet trainers

Fourteen nations have chosen Bristol Siddeley powered jet trainers to give their pilots the vital experience needed to fly the sophisticated civil and military aircraft of today.

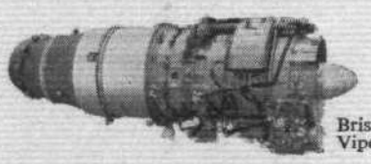
The Bristol Siddeley Viper and Orpheus turbojets have been specifically developed over the past ten years to meet the stringent requirements of trainer aircraft. This development has brought them to the peak of reliability and ruggedness — proved during more than 500,000 flying hours.

Seven of the world's foremost jet trainers are now powered by Orpheus or Viper engines. In addition to being manufactured in the United Kingdom, the Orpheus is made under licence in Germany, Italy and India and the Viper in Italy.

Bristol Siddeley Engines Limited. Executive Office: Mercury House, 195 Knightsbridge, London SW7.



Bristol Siddeley Orpheus engine



Bristol Siddeley Viper engine

BRISTOL SIDDELEY SUPPLY THE POWER

COVENTRY, NORTH LONDON AND BRISTOL.

Japanese Fuji T1A (Orpheus)

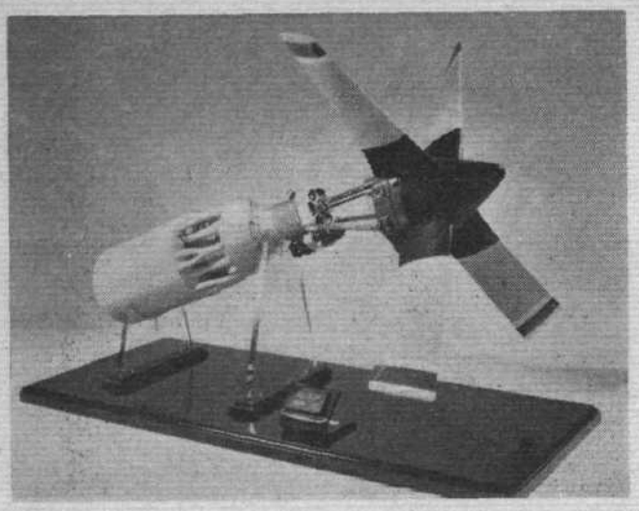
Italian Fiat G 91 Trainer (Orpheus)

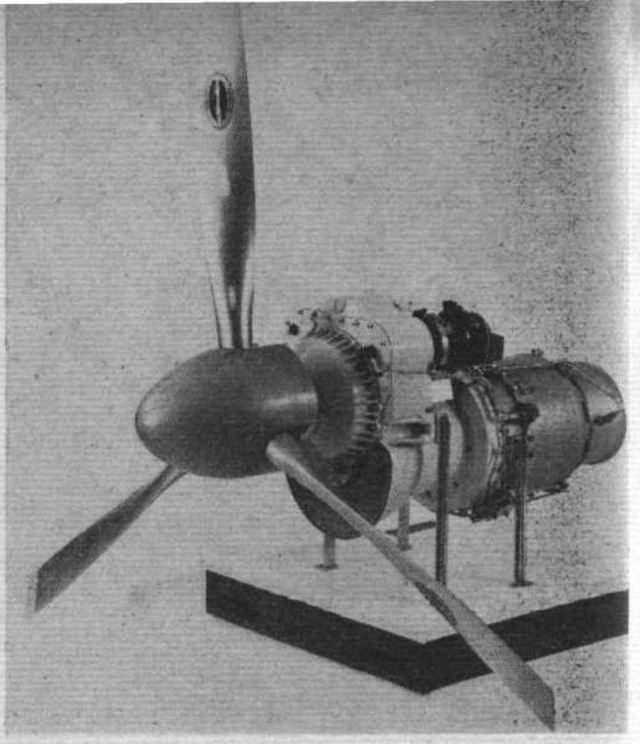
Italian Aero Macchi MB 326 (Viper)

British Hawker Siddeley Gnat Trainer (Orpheus)

Yugoslav Soko Galeb (Viper)

Indian Hindustan HJT 16 (Viper)





Above, Allison T78 regenerative turboprop. Right, AiResearch TPE331

AERO ENGINES

250 s.h.p. turboshaft, certificated by FAA in December 1962. Major application is the US Army's Light Observation Helicopter (LOH).

A significant current development is the 4,000 s.h.p. T78 regenerative turboprop fully described in *Flight* for November 12, 1964.

BOEING *The Boeing Company, Industrial Products Division, Seattle 24, Washington.* Boeing have produced more than 1,200 Model 502, T50 g.p.u. turbo-compressors. The Model 550 is a new turboshaft in two versions: 330 s.h.p. 550-1 (T50-BO-IO) for the US Navy QH-50D Gyrodyne anti-submarine drone helicopter; and the 425 s.h.p. 550-1-22C for commercial helicopters.

CONTINENTAL *The Continental Motors Corporation, Aircraft Engine Division, Muskegon, Michigan.* More than 50,000 of the world's aircraft are Continental powered. The current range of light aircraft engines includes horizontally opposed, air-cooled fours and sixes from 65 to 390 h.p., with variants geared, supercharged, turbo-supercharged, fan cooled, and fuel-injected. Rolls-Royce have acquired the licence to manufacture and sell Continental piston engines in Europe.

CONTINENTAL *Continental Aviation and Engineering Corporation, Gas Turbine Division, Detroit 15, Michigan.* A subsidiary of Continental Motors, this division has produced 6,000 Turbomeca Marborés under licence as the J69. The "long life" J69-T-25, 1,025lb thrust, powers the Cessna T-37B, and a "short life" version in its most powerful form, the 1,700lb J69-T-29, is in production for the Ryan BQM-34A Drone.

Two free-turbine engines have also been developed. The 310 s.h.p. T65-T-1 turboshaft completed acceptance tests in 1964 and has an output drive gearbox mounted at the rear between bifurcated exhaust ducts. The front drive T72 Model 217 turboshaft, available as a single 700 s.h.p. unit for helicopters, was first flown in a Republic Lark, but may be a turboprop. The Model 217A-2A, scheduled for a 60hr pre-flight rating test in late 1964, comprises two Model 217s coupled to a common reduction gearbox and output shaft. Rotor shafts in both T65 and T72 have three flexible, hydrodynamically damped bearing supports.

FRANKLIN *Franklin Engine Company Inc (Subsidiary of Aero Industries Inc) Syracuse 8, NY.* The company is returning to aviation with an expanding series of horizontally opposed air-cooled piston engines—and a twin-turbine powerplant—for light aircraft and helicopters. Of 12 piston engines from 60 to 260 h.p. ten models use the same cylinders. Reduction gearing, turbosupercharging, fuel injection and vertical-crankshaft versions are included.

GENERAL ELECTRIC *General Electric Company, Flight Propulsion Division, Lynn, Massachusetts.* The J47 still operates in B-47s and Sabres. Its successor, the J79, was the first US production engine capable of Mach 2 operation. The J93 powers the B-70. Five military and five civil turbines are in production.

The 17,000lb thrust afterburning J79 was the first high-compression variable-stator turbojet in America. It is at present the most important engine in Western Air Defence, powering the Starfighter, Phantom, Hustler and Vigilante. The 15,800lb J79-7 and -11A, which power the F-104C, D and G and CF-104 Starfighters, are built under licence in Canada, Belgium, Germany, Italy and Japan. The CJ805-3 is a commercial version of the J79 developed as a private venture to power the Convair 880-22 and -22M. Although the majority of components are common between the two engines the CJ805 incorporates a number of detail changes designed to extend life, and reduce maintenance costs for civil operation. The 11,650lb CJ805-3A and 3B incorporate a stator vane feedback reset mechanism, which partially closes the inlet guide vanes during thrust reversal, to minimize re-ingestion of hot gases.

The gas generator of the CJ805 is used in the free aft turbofan, 16,100lb thrust CJ805-23B for the Convair 990; and existing CJ805s can be converted.

Several models of the J85 lightweight turbojet are in large-scale production at the Small Aircraft Engine Department. With reheat, the J85-13 develops 4,080lb in the Northrop F-5A and B. The J85/LF2 lift fan propulsion system comprises two J85-13 turbojets without reheat, each rated at 2,960lb, two hydraulically-operated diverter valves, two 76in-diameter lift fans with tip-turbine drive; and one 41in diameter pitch trim and control fan. The complete system weighs 2,420lb, and total lift is 16,835lb, including 1,820lb from the pitch fan which is driven by 10 per cent of the exhaust gas flow. The s.f.c. is 0.34 at hover. The prototype J85-5/X353-5B system is installed in the Ryan XV-5A lift-fan research aircraft.

Essentially similar to the J85 without reheat, the 2,850lb CJ610 turbojet, which weighs 381lb, is designed as a powerplant for commercial, executive and military aircraft of 12,500 to 14,000lb weight, and for heavier four-engined aircraft. Twin applications include the Jet Commander 1121, Lear Jet, HFB-320, Fairchild C-123H in boost pods and Cessna YAT-37D COIN (J85/J2). A single CJ610 is specified for the Canadair CT-114 Tutor.

Following the development pattern of the CJ805-23 from the basic J79, the CF700 (military TF37) consists of a single aft-mounted, free-turbine fan with annular air intake. This small turbofan develops 4,200lb thrust, for a dry weight of 670lb. A thrust reverser can be incorporated. The engine is vertical in the LEM simulator rig. FAA type certification was awarded last July, and the CF700 is fitted in the Mystère 20 Fan Jet Falcon.

Six 30,000lb YJ93 turbojets power the Mach 3 XB-70A. The YJ93 produces nearly twice the thrust of the Mach 2 J79 with a weight increase of about 1,500lb, thus achieving a thrust/weight ratio above 5 : 1. The moderate pressure ratio, single axial flow compressor with variable stators, drives a two-stage turbine.

Controls and accessories are contained in a removable fireproof honeycomb pod suspended under the compressor. Fuel and oil line couplings are brazed. Overall length with afterburner is nearly 20ft. Testing has covered more than 4,500hr under sea level and simulated altitude conditions, including over 660hr at more than Mach 2 and 18hr at Mach 3 with afterburning.

The 1,250 s.h.p. T58 turboshaft is in service in large numbers throughout the world and is manufactured under licence by Bristol Siddeley as the Gnome, and in Germany and Japan. A 1,400 s.h.p. version, interchangeable with the T58-8B, is under development, and was scheduled for certification in late 1964. Commercial version of the T58-8B is the 1,250 s.h.p. CT58-110 which powers the S-61, S-62 and 107 Model 2 helicopters.

The free turbine T64, also to be licence-built by Bristol Siddeley, is in production as a turboshaft and turboprop. The basic engine, designated T64-6 or -1 (2,850 s.h.p.), is installed in the Sikorsky CH-53A, and Vought-Hiller-Ryan XC-142A. Helicopter version is the T64-2 of 2,810 s.h.p. The turboprop T64-4 (2,850 e.h.p.), has the gearbox below the engine centreline, and the T64-8 or -10, above. Two 2,850 s.h.p. T64-10s power the DH Canada Buffalo. T64 gas generators power the Hughes XV-9A hot-cycle research helicopter.

JACOBS *Jacobs Aircraft Engine Co, Subsidiary of Barium Steel Corp, Pottstown, Pa.* The Jacobs R755-A2M1 may power the Grumman Ag-Cat, with a new Sensenich ground adjustable propeller.

LYCOMING *The Lycoming Division of Avco Corporation, Stratford, Connecticut.* Progenitor of the growing family of small turbines, the T53 free-turbine turboshaft accounts for 90 per cent of the Division's current production of small engines.

Three versions of the T53 are in production, and four developments are to follow. The 1,150 e.h.p. T53-L-7 turboprop powers the Grumman Mohawk and has been submitted for FAA certification as the T53-07A with a recommended 1,000hr TBO. Similar performance and reliability are available from the T53-L-9 series of helicopter turboshafts.

Lycoming's biggest order, announced in December and worth $42.8m, is for the 1,100 s.h.p. T53-L-11 (LTC1K-5), a multi-fuel version of the L9 for the Bell UH-1D Iroquois. LTC1K-3 is an improved version of the L-11 for operation at high ambient temperatures.

The 1,400 s.h.p. LTC1K-4 turboshaft is a company venture with increased mass-flow and pressure ratio and four turbine stages. Two variable attitude K-4Bs power the Canadair CL-84.

Principal differences in the T55, the other basic engine, are a seven-stage axial compressor and two-stage free turbine. This series will include a turbofan, and some turboprop models will employ Lycoming's split-power propeller reduction gear system. T55-L-7, now in production, is a high-speed output direct drive turboshaft, rated at 2,650 s.h.p., with a 300hr TBO, which supersedes the -L-5 in the Vertol CH-47A and Curtiss Wright X-19.

YT55-L-9 is a turboprop, the production version of which will be the 2,695 e.h.p. LTC4G-4 with potential of over 3,000 e.h.p. Two LTC4G-3S rated at 2,529 e.h.p. are undergoing evaluation in YAT-28Es. Further developments in the T55 programme are the LTC4B-11 to give 2,300 s.h.p. at 95°F and 6,500ft, and another turboshaft, the 3,400 s.h.p. LTC4K-2. The 3,413 e.h.p. LTC4M-1 is a turboprop variant of the LTC4K-2.

Basically a T55-L-7 with a front fan, the PLF1A-2 is a 6 : 1 by-pass turbofan rated at 4,320lb for a weight of 825lb. The production PLF1B-2 will have an A-2 fan with a more advanced gas generator. The B-2 will weigh 880lb, have a thrust of 5,220lb, and an s.f.c. of 0.364.

Lycoming is investigating regeneration, engines with high-reduction ratio gearing for direct rotor drive, high-temperature materials, blade coatings, improved blade cooling, and high-temperature combustion chambers.

Lycoming's Williamsport plant is responsible for the famous horizontally-opposed piston engines, ranging from 108 to 400 h.p., with reduction gearing, fuel injection, supercharging and turbosupercharging applied in various combinations for aircraft and helicopters.

McCULLOCH *McCulloch Corporation, Los Angeles Division, California.* The company has supplied 50,000 two-stroke piston engines for US armed forces radio-controlled target drones, the four-cylinder 72 h.p. model also being fitted in the Bensen Gyrocopter. The turbosupercharged six-cylinder TC6150 gives 120 h.p. for a weight of 142lb. There are reports of plans to produce certificated aircraft engines as well.

NELSON *Nelson Aircraft Corporation, Pittsburgh, Penn.* The H-63 four-cylinder, horizontally opposed, air-cooled two-stroke piston engine is produced by Nelson as the 43 h.p., FAA certificated H-63C, complete with clutch, cooling fan and shroud for helicopters and as the 48 h.p. H-63CP, also FAA certificated, and tested in a Hummingbird sailplane. The H-63CP is to be available in March

PRATT & WHITNEY *The Pratt & Whitney Division of United Aircraft Corporation, East Hartford 2, Connecticut.* Pratt & Whitney have made 28,000 turbines since 1948, supplied engines for 1,200 jet transports and are competing for the American SST powerplant. Their turbines and developments therefrom are manufactured under licence by SNECMA in France, and Svenska Flygmotor have acquired a licence to produce the JT8D for the SAAB 37. Licence agreements cover the manufacture of piston engine components in Australia, Italy and Japan.

Much of the United States offensive strength in the air, and many Boeing and Douglas transports, are powered by the JT3 (military J57) whose current output is in the 13,500lb class, and 18,000lb with reheat in supersonic fighters. The JT3D (military TF33) turbofan, powering later variants of the B-52 and the Boeing and Douglas transports, is basically a JT3 with large diameter two-stage front fan, and a fourth turbine. The JT3D produces 50 per cent more thrust at take-off and 20 per cent more in cruise than the JT3 with a 15 per cent better s.f.c. Air mass flow is 2.5 times greater and pressure ratio is 16 : 1 in the later versions. The Lockheed C-141-A is powered by 21,000lb TF33-P-7s.

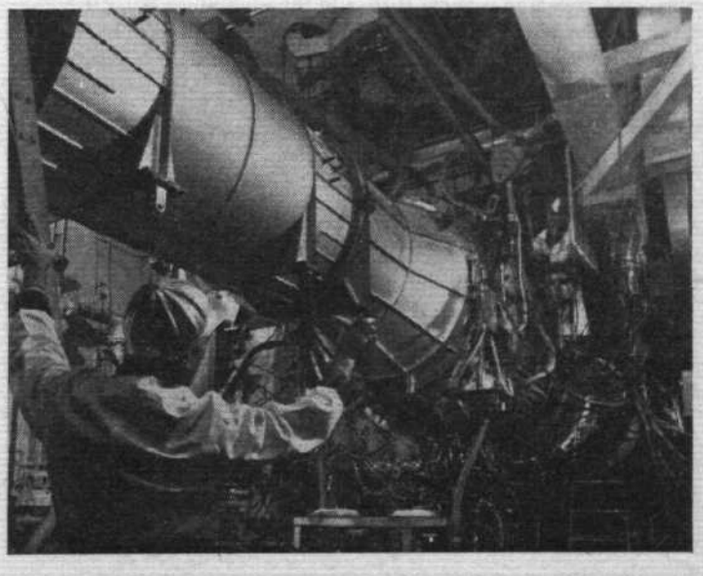
The JT4 (military J75) is basically an enlarged J57, capable of 26,500lb with reheat and powers intercontinental versions of the 707 and DC-8, at 16,800lb and 17,500lb thrust with a TBO of 5,600hr. The J75-P-19W with reheat powers the F-105D.

Designed for the US Navy the 8,500lb JT8 (military J52) is a medium-sized two-spool turbojet with provision for reheat and powers the Grumman A-6 and Douglas A-4E.

The turbofan JT8D was developed principally for the Boeing 727 and is largely made of steel and titanium with an annular full-length by-pass duct. Production deliveries to Boeing of 14,000lb JT8D-5s began two years ago. The same engine with SNECMA-designed thrust reverser will be installed in the Caravelle Super B. Two 12,000lb JT8D-5s will power the DC-9. A Svenska Flygmotor development of the JT8D-22 has been selected to power the SAAB 37 Viggen.

Both the Lockheed A-11 or YF-12A Mach 3 high altitude aircraft, and the SR-71 strategic reconnaissance aircraft, announced last year, are powered by two 30,000lb JT11 (military J58)

GE YJ93 for the B-70 Valkyrie



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single-shaft turbojets. This advanced engine is fitted with a Hamilton Standard control system which automatically governs the variable intake, fuel supply and variable-area nozzle.

The JT12 (military J60), designed by United Aircraft Canada, is a small 3,000lb turbojet which powers the JetStar and Sabreliner. The JT12A-21 prototype achieves 4,025lb with reheat. A JFTD12 rear drive turboshaft version has been developed from the JT12, and two 4,050 s.h.p. JFTD12A-3s power the Sikorsky S-64 Skycrane.

The US Navy-sponsored TF30-P-1 (JTF10A-20) is a high-compression two-spool turbofan developed for the F-111A and B. With fully modulated afterburning in both hot and cold flows, maximum thrust will exceed 19,000lb. An early version, probably a 10,500lb JTF10A-7 was flight tested under a B-45. The cycle is a two-stage fan plus 14 compressor stages, 8-can-annular combustion system and four-stage turbine. Pressure ratio is 16 : 1. SNECMA are producing a TF316 afterburning development of the JTF10, for the Mirage IIIV.

The STF-200C turbofan, under study for the C-5A (CX-HLS), started static running last April. With a by-pass ratio of 2, it develops 31,000lb unaugmented at sea level and weighs about 5,500lb. The two-stage large-diameter front fan is driven by a three-stage low-pressure turbine, while a two-stage high-pressure turbine drives the nine-stage compressor. Already under consideration is the STF-200D with a by-pass ratio of 3 and about 36,000lb thrust without augmentation. The STF-200F, an even more advanced development with a by-pass ratio of 4, would have an unaugmented thrust of about 39,000lb, and an s.f.c. of about 0.66 at Mach 0.8 and 30,000ft. Diameter would be more than 7ft, length about 9½ft and weight about 6,600lb. Titanium is extensively used.

SOLAR *Solar (Subsidiary of International Harvester Company), San Diego, California.* The Solar 80 h.p. T62 Titan has been used to power one-man helicopters, and is installed as an a.p.u. in a number of military aircraft and helicopters.

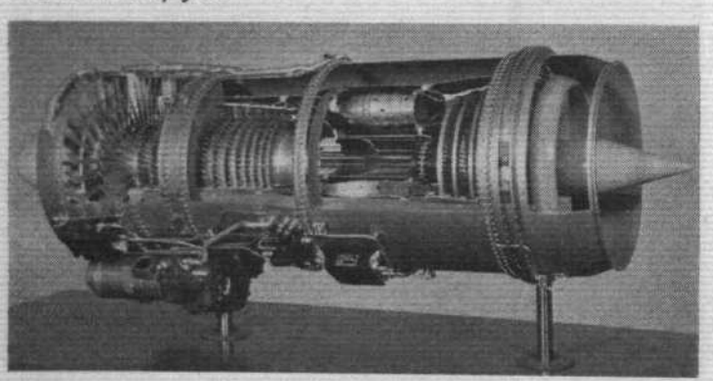
USSR

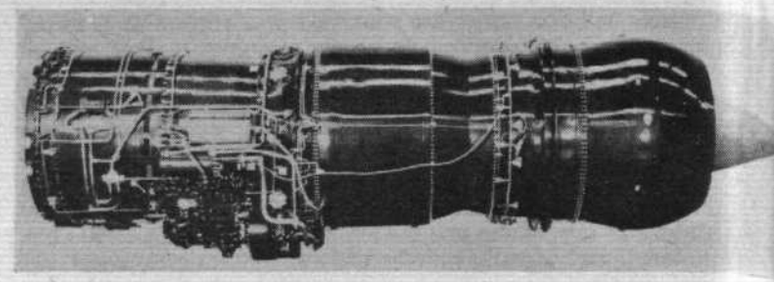
A variety of successful engines has been produced to the designs of Ivchenko under the AI designation. Seven- and nine-cylinder radials from 260 to 300 h.p. power a number of helicopters and utility aircraft. Ivchenko's design bureau is also responsible for the majority of Russia's turboprop transport engines. Ten-stage, axial compression, automatically controlled AI 20s of 4,000 e.h.p. power the An-10 and I1-18, and 2,535 h.p. AI 24s the An-24.

ASH radials, evolved by A. D. Shvetsov from early Wright and P & W designs, are still widely used in the Communist countries, in transports and helicopters.

Mikulin turbojets under the designation M209 (RD3 and AM3) have also appeared outside Russia in the ubiquitous Tu-104 series; large numbers of Mikulin M11 five-cylinder radials have been built in Russia and Poland, to power light aircraft and helicopters.

Pratt & Whitney JT8D





Pratt & Whitney J58 (JT11)

N. D. Kuznetsov's design team specializes in very large turbines. The 21,000lb thrust NK8 turbofan powers the I1-62, and the 14,795 e.h.p. NK12M turboprop, the most powerful in existence, with a fourteen-stage axial compressor and five-stage turbine, drives the 18ft 4in diameter contra-rotating propellers of the Tu-114, and Bear bomber. The rotor weighs about one ton, maximum compression ratio is 13 : 1, and mass flow is reported to be 137lb/sec.

S. K. Tumanskii is responsible for the Tye 29 lightweight turbojets which have been used in record attempts by the Yak-30 and 32. Ratings are reported to be 1,875 and 2,315lb thrust for the Yak-30 engine, and 1,764lb for the Yak-32.

Soloviev's design team is reported to be responsible for the 11,000lb thrust turbofans fitted in the Tu-124, the first Soviet transport to employ such powerplants. The rear-engined Tu-134 is also, presumably, similarly powered. Soloviev engines in the 30,000lb class dry (45,000lb with reheat) are believed to be installed in the inboard positions of the mixed turbofan/turbojet four-engined Bounder. The same team has developed the 4,635 s.h.p. TB2BM and 5,622 s.h.p. TB2 turboshafts, which respectively power the Mi-6 helicopter and the Kamov Ka-22 Vintokryl convertiplane.

The late V. Y. Klimov's design team developed the Rolls-Royce Nene, along much the same lines as Rolls-Royce themselves, to the VK1, Russian equivalent of the Tay. More than 20,000 of this 7,590lb thrust afterburning turbojet were built in the late 1950s for early Mig fighters and I1-28 bombers. A similar quantity of VK5 (or M205) axial flow turbojets in the 6,500lb class (8,818lb with reheat) has been produced for the Mig-19 and Yak-25. Two type 37V turbojets of the same output, and possibly VK5s under another designation, were fitted to the RV aircraft which set up two payload-to-height records in 1959. The VK7 small diameter axial flow turbojet, comparable in size with the Bristol Siddeley Orpheus 12 and rated at 6,700lb thrust dry, is said to be a development of the VK5 and was at one time regarded as a possible powerplant for the production version of the Hindustan HF-24.

There are, of course, several engines of design origins unknown outside Russia. Two 14,330lb thrust turbojets designated Type AL-7PB power the Beriev M10 flying-boat. The 28,660lb thrust D15 turbojet is one of the most powerful yet known to have flown. Four of these engines were fitted in the 103M and 201M aircraft, which set up a number of closed-circuit and payload to height records in 1959.

The E66, believed to be a developed Mig-21, and another speed and height record holder of 1959-61, was fitted with a 13,117lb thrust R37F turbojet. The prefix R may indicate reheat, and the engine is possibly a development of the VK5, M205 or 37V referred to above. The record breaking E66A was also fitted with a 6,615lb thrust GRD Mk U2 rocket motor.

P166 is the designation given to the 22,046lb thrust turbojet fitted in the delta wing E166 which holds the world's absolute speed record. The same rating is quoted for the TRD31 turbojet fitted in the T431 aircraft, implying that the designation is related to the aircraft in which the engine is installed. TRD Mk P166 and TRD31 are presumably versions of the same turbojet.

The 400 s.h.p. turboshafts fitted in the Mil V2 helicopter, have been designated GTD350 in Soviet record claims, and are reported to have been designed by a team led by S. Izotov.

The Russians must be credited with the world's smallest piston radial—if reports via America are correct of the existence of VP760. This is a very small 22 h.p. five-cylinder radial, with a cubic capacity of 46.4 cu in and a dry weight of 53lb, which has allegedly been designed for use in powered gliders, ultra-light aircraft and helicopters.

AERO ENGINES 1965...

Data for Representative Engines

UNLESS otherwise stated, performance is based upon standard-day conditions, and the maximum power is the sea-level static figure. Airflow and pressure-ratio figures are for this condition. It is clearly impossible to adopt a common standard of quoting performance, but most major manufacturers give guaranteed-minimum figures, and these have been used wherever available. It is no easier to tar every engine with the same brush even in such superficially simple matters as giving a figure for its length or weight; but the values quoted are those provided by the manufacturers, and careful inspection shows that some firms are more honest than others in allowing for the external dressing which a bare engine has to wear before it can be put into an airframe. The column headed TBO gives the maximum time between overhauls authorized for the engine; many operators may not yet have attained this life with the same powerplant. The column "Engine configuration" describes the basic geometrical layout: the numbers indicate how many stages there are of fan blading f, axial compression a, centrifugal compression e, turbine stages t, compressor-turbine stages ct, and power-turbine stages pt, and a plus-sign means that the portions so linked rotate together; the piston-engine configurations are simpler, O4, inj signifying four opposed direct-injection cylinders, R9,g,s meaning a nine-cylinder radial, geared and supercharged, turb being short for a turbosupercharger, I4L being an inverted four-in-line and 2 str, two stroke.

TABLE 1: TURBOJETS

Designation		Engine configuration	Length (in)	Height (in)	Width (in)	Equipped weight (lb)	TBO (hr)	Max. s.l. static rating lb thr.; r.p.m.; s.f.c.; mass flow (lb/sec); press-sure ratio	Remarks
Manufacturer's	**Military**								
BMW 8026	—	1c, 1t	23.6	—	14.95	84	—	101; 45,000; 1.05; —; —	Sailplanes. Augmenter increases thrust to 121lb
BS Olympus 301	B.OI.21	6a, 7a, 1t, 1c	128	44.5	44.5	—	—	20,000; —; —; —; —	Vulcan B2
Olympus 320	B.OI.22R	—	—	—	—	—	—	33,000*; —; —; —; —	TSR2
Olympus 593 B	—	—	138.22	50	47.85	5,000?	—	32,500*; —; —; —; —	SNECMA reheat. Concorde
Orpheus 803	BS.Or.3	7a, 1t	75.5	38	32.4	850	—	5,000; 10,000; 1.08; 84; 4.4	BAC.H.126, G91. Orpheus 805. Fuji TIA.701, Gnat FI. 703R, HF24
Viper 200	BS.V.11	7a, 1t	63.9	27	24.5	580	—	2,500; 13,800; 1.07; 44; 4.1	Jet Provost; BAC145; Jindivik 3; MB326; Sokol Galeb
Viper 521	—	8a, 1t	66.6	28	24.5	628	—	3,120; 13,800; 0.98; 52.8; 5.09	HS125. Viper 525, PD808
GE —	J79-5B	17a, 3t	202.17	—	38	3,635	—	15,600; 7,460; —; 167.9; 13	B58A
—	J79-11A	17a, 3t	207.96	—	38.31	3,530	—	15,800; 7,460; —; 167.9; 13	F.104G
—	J79-15	17a, 3t	207.96	—	38.31	3,685	—	17,000; 7,685; —; 167.9; 13	F4C
—	J85-5	8a, 2t, ab	108.8	—	20	559	—	3,850*; 16,500; —; 44; 7	T38. J85-13, F5A/B
CJ610	—	8a, 2t	40.5	—	17.7	381	—	2,850; 16,500; 0.99; 44; 7	Aero 1121, Lear Jet, HFB320, YAT-37D, CT114
IHI	J3-7	8a, 1t	72.85	—	28.35	915	—	3,085; 12,700; 1.055; —; —	Fuji T-1B
JR100	—	6a, 1t	—	—	—	—	—	3,153; —; 1.15; —; —	V/STOL
Mikulin AM-3M/RD-3M	M209	8a, 2t	200	—	54	5,500	—	19,180; —; —; 278; 6.8	TU104A & B
OKL TO-1	—	1c, 1t	—	—	—	—	—	822; 22,000; 1.2; —; —	TS-11
Omnipol M701	—	1c, 1t	81.38	36.53	35.28	728	—	1,962; 15,400; —; 37.25; 4.3	L-29
Pratt & Whitney JT3C-6	—	9a, 7a, 1t, 2t	136.77	—	38.88	4,234	4,000	13,500; 8,200; —; 180; 12.5	707-120, DC-8-10, JT3C-7, 720
JT3C-26	J57-20, 20A	9a, 7a, 1t, 2t, ab	220	—	38.88	4,750	—	18,000*; 8,000; —; 180; 12.5	F8U-2N
JT4A-11	—	8a, 7a, 1t, 2t	144.1	—	43	5,100	5,600	17,500; 8,000; —; 300; 12	707-320, DC-8-30
JT4A-29	J75-P-19W	8a, 7a, 1t, 2t, ab	259.3	—	43	5,960	—	26,500*; —; —; 300; 12	F105
JT8B-3	J52-8	—	—	—	30.15	2,118	—	9,300; —; —; —; 13	—
JT11	J58	—	—	—	—	—	—	30,000+*; —; —; —; —	YF12-A, SR71
JT12A-6	J60-3A	9a, 2t	74.2	—	21.9	448	—	3,000; —; —; —; 6.5	JetStar, T39, T-2B
JT12A-21	—	9a, 2t, ab	126	—	21.9	651	—	4,025*; —; —; —; —	—
Rolls-Royce Avon 200	R.A.24R	15a, 2t, ab	134.6	—	41	—	—	14,370*; —; —; —; —	Lightning F.1, T4. Without ab Scimitar, Sea Vixen. Variants in Valiant K1, Canberra PR9 and late Hunters
Avon 301 RB146R	60 Series	16a, 2t, ab	138	—	44	—	—	16,000*; —; —; —; —	Lightning F3 and 5, Draken
Avon 520	R.A.29/1, 3	16a, 3t	126	42	39	3,343	4,100	10,250; 8,050; 0.786; 173; 9.1	Avon 524, 525, 350, Comet 4, 4B, 4C. 522, 526, Caravelle 1, 1A. 527 (11,400lb), Caravelle 3
Avon 530	R.A.29/6	17a, 3t	134	—	39	3,491	2,200	12,725; 8,150; 0.802; 185; 10.3	Caravelle 6
RB145	—	9a, 2t, ab	50	24	15.5	457	—	3,650*; —; —; —; —	VJ101C-X2
RB162	—	6a, 1c	37	26	26	275	—	4,409; —; —; —; —	Mirage III-V, G222, VAK191B, Do31
SNECMA	Atar 9C	9a, 2t, ab	234	—	40.2	3,025	—	14,110*; —; —; —; —	Mirage III
	Atar 9K	9a, 2t, ab	239.36	—	40.16	3,153	—	15,435*; —; —; 159; —	Mirage III, IV
Mars	M-45B	—	—	—	21.7	—	—	7,700*; —; 1.95; —; 16	Development
Turbomeca Marbore 6	—	1c, 1t	55.74	24.84	23.35	370	—	1,058; 21,500; 1.09; 21.6; 3.84	Super Magister, Paris II, III, CM191

* With reheat

TABLE 2: TURBOFANS

Designation		Engine configuration	Length (in)	Height (in)	Width (in)	Equipped weight (lbs)	TBO (hr)	Max s.l. static rating lb thrust; r.p.m.; s.f.c.; total mass flow (lb/sec); pres-sure ratio; by pass ratio	Remarks
Manufacturer's	**Military**								
BS.53 Pegasus	BS.Pg.5	2f, 7a, 1t, 2t, 4n	98.8	54	48	—	—	15,500; —; —; —; —; —	P.1127, Do31
BS.100	—	—	—	—	—	—	—	30,000*; —; —; —; —; —	With PCB front nozzles
DB 730/ZTL 6	—	4a + 1c, 2ct, 1pt, 1f	—	—	20.3	—	—	1,345; —; —; —; —; —	Development
GE CJ 805-23B	—	17a, 3t, 1f	130.9	—	53.3	3,800	1,600	16,100; 7,310; 0.56; 426; 13; 1.54	CV990
CF 700	TF 37	8a, 2t, 1f	74	—	32.2	670	—	4,200; —; 0.69; 128; 7; 1.9	Mystère 20
I.H.I. J3-F	—	8a, 1t, 1f	93.7	—	33.46	—	—	3,748; —; 0.75; —; —; —	Development
Kuznetsov NK8	—	—	—	—	—	—	—	20,940; —; —; —; —; —	IL-62
Lycoming PLFIB-2	—	1f + 7a, 1c, 1t, 1t	66.28	—	40.68	880	—	5,220; —; 0.364; 183.4; —; 6	WFG 614
P & W JT3D-3	TF33-5,9	2f + 6a, 7a, 1t, 3t	136.5	—	53	4,170	3,200	18,000; 8,000; —; 480; 12.5; 1.42	707-120B, 720B, DC8-50, DC8-F. TF33-3 (JT3D-2), B52H, C135B. JT3D-3B, 707-320B, C
JT3D-5A	TF33-7	2f + 7a, 7a, 1t, 3t	138	—	53	4,605	—	21,000; —; —; —; —; —	C141A, Starlifter
JT8D-1	—	2f + 4a, 7a, 1t, 3t	122.5	—	44.5	3,041	—	14,000; 11,000; —; 316; 16; 1.1	727, 727C, Caravelle 10BIR, Sup Caravelle, Saab 37. JT8D-5 (12,000lb) DC-9
JTF10A-20	TF30	3f	—	—	—	3,550	—	19,500*; —; —; —; —; —	F111A, B
Rolls-Royce Conway 200	R.Co 17	—	136	48	42	—	—	20,600; —; —; —; —; —	Victor B2
Conway 508, 509	R.Co 12	7f, 9a, 1t, 2t	136	48	42	4,542	6,700	18,000; 10,410; 0.735; 285; 14; 0.3	707-420, DC8-40
Conway 540	R.Co 42	4f + 3a, 9a, 1t, 2t	154	53	50	5,001	1,200	20,370; 9,966; 0.656; 367; 14.8; 0.6	VC10
Conway 550	R.Co 43D	4f + 3a, 9a, 1t, 2t	154	53	50	5,101	—	21,825; 10,712; —; 375; 15.8; 0.6	Super VC10
Medway RB.141	—	—	—	—	—	—	—	17,300; —; —; —; —; —	HS 681
Spey 505	—	4f, 12a, 2t, 2t	110	40	37	2,200	600	9,850; 12,490; 0.560; 203; 16.8; 1.03	Trident 1C
Spey 506	—	4f, 12a, 2t, 2t	110	40	37	2,288	—	10,410; 12,530; —; 208; 16.9; 1.08	One-Eleven 200
Spey 511	R.Sp.25	5f, 12a, 2t, 2t	114.6	—	37	2,312	—	11,400; 12,390; 0.612; 206; 19.1; —	One-Eleven 300, 400, Trident 1E
Spey Junior	—	4f, 12a, 2t, 2t	110	40	37	2,023	—	8,740; —; —; —; —; 1.0	F-28
RB.172	—	3f + 3a, 6a, 1t, 2t	82	—	31.8	1,331	—	6,000; —; —; —; —; —	Mystère 30?
RB.178	—	—	—	—	—	—	—	25,000; 9,260; —; —; —; —	Conway successor
SNECMA TF106	—	3f + 6a, 7a, 1t, 3t, ab	198	—	50.4	3,357	—	19,840*; 14,500; —; 230; 16; 1.5	Mirage III-V. Developed from P & W JTF10
Mars M45-AF	—	—	—	—	—	—	—	6,600-7,700; —; 0.53; —; —; —	Development
Turbomeca Aubisque	—	1f, 1a + 1c, 2t	80.63	29.53	25.59	640	—	1,543; 32,500; 0.60; 49; 6.9; —	Saab 105
Tourmalet	—	—	—	—	—	—	—	5,500-6,600; —; —; —; —; —	Development

* With reheat

AERO ENGINES

TABLE 3: TURBOPROPS

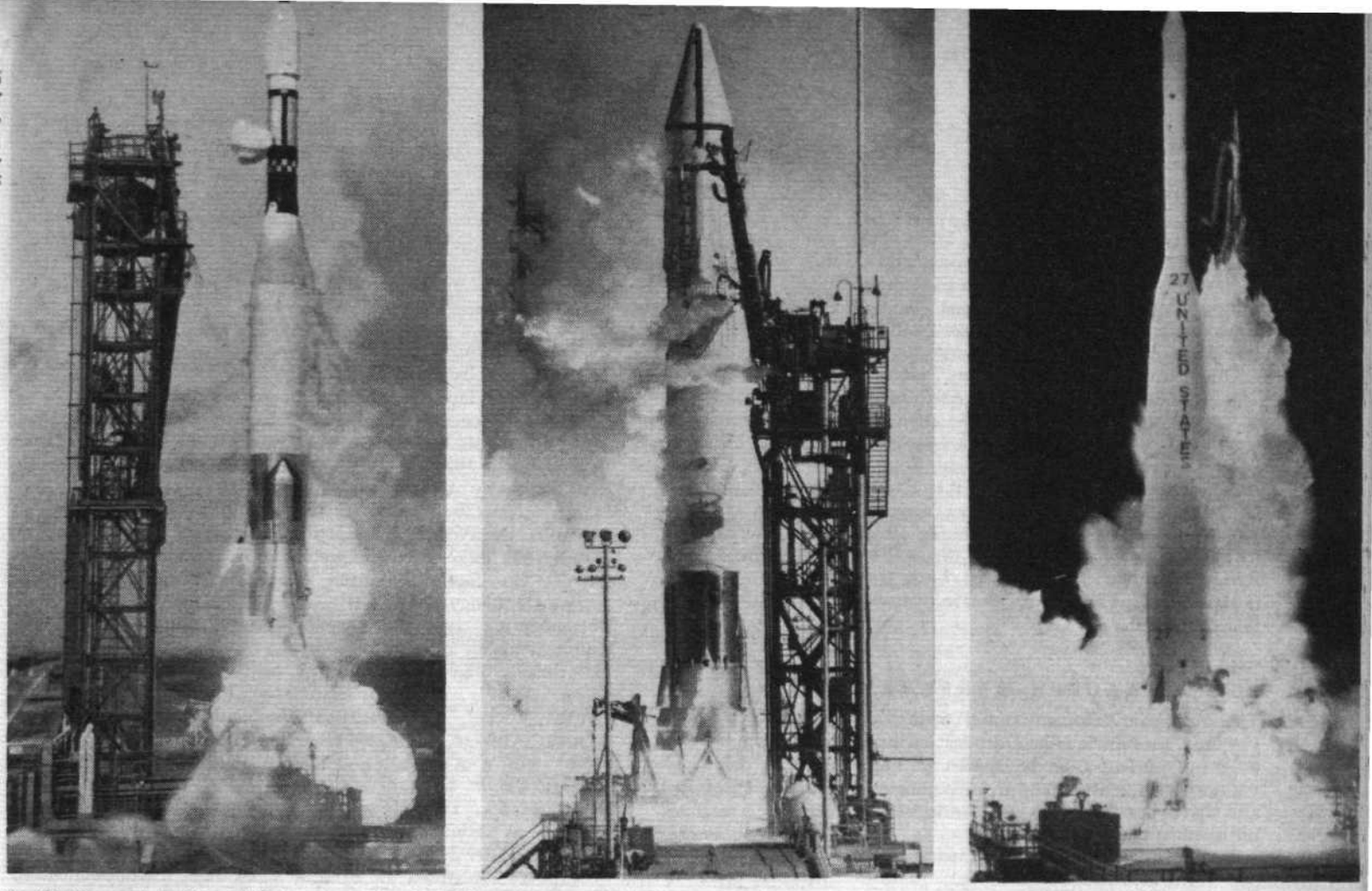
Designation: Manufacturer's	Designation: Military	Engine configuration	Length (in)	Height (in)	Width (in)	Equipped weight (lb)	TBO (hr)	Max Power: s.h.p.; e.h.p.; r.p.m.; s.f.c.; mass flow; pressure ratio	Remarks
AiResearch TPE 331	T76-G-6	2c, 3t	46	24.5	16.5	255		600; —; —; 0.614; 5.6; 7.9	NA 300 COIN; Beech Super 18 conv.; Turbo Commander; Stallion; Porter; Mitsubishi MU2
Allison 501-D13	T56-A9	14a, 4t	145.2	42	30	1,756	2,200	3,460; 3,750; 13,820; 0.54; 32.5; 9.25	Electra; CV340/440 conv; C130A T56-A-7, 8 (4,050 e.h.p.), C130B, E, Grumman E2A, C2A
—	T78	—	—	—	—	—	—	4,000; —; —; —; —; —	Development: regenerative engine
General Electric	T64-10	14a, 2ct, 2pt	113	46	29	1,167		2,850; —; 15,590; 0.49; —; —	Buffalo T64-1, XC142A
Ivchenko AI-20	—	10a, 3t	—	—	—	—	500	—; 4,000; —; —; —; —	An-10, IL-18
AI-24	—	—	—	—	—	—	250	—; 2,500; —; —; —; —	An-24
Kuznetsov NK-12M	—	14a, 5t	236.2	—	45.3	5,070		—; 14,795; —; —; 137; 13	Bear, Tu-114, 18ft 4in contra props
Lycoming LTCIF-2	T53-L-7	5a + 1c, 1ct, 1pt	58.4	—	23	555		1,100; 1,150; 26,000; 0.641; 10.7; 6	OV-1
LTC4G-3	YT55-L-9	7a + 1c, 1ct, 1pt	62.2	—	24.25	795		2,445; 2,529; 18,750; 0.61; —; —	Development
Rolls-Royce Dart 7	RDa.7	2c, 3t	98	38	38	1,227	4,800	1,910; 2,100; 15,000; 0.656; 23.5; 5.6	Viscount 800; Herald, F-27, Argosy 220, Gulfstream
Dart 101	RDa.8	2c, 3t	97	38	38	1,237		2,470; 2,690; 15,000; 0.658; 23.5; 5.6	W/m boost, cooled blades; Argosy C.1
Dart 10	RDa.10	2c, 3t	98	38	38	1,377		2,750; 3,025; 15,000; —; 27; 6.35	NAMC YS-11; Convair 240/340/440
Dart 12	RDa.12	2c, 3t	99.5	38	38	1,378		2,970; 3,245; 15,000; —; 27; 6.35	Andover C.1
Tyne 512	RTy.11	6a, 9a, 1t, 3t	108.7	44	43.2	2,275	3,600	4,850; 5,325; 15,250; —; 46.5; 13.5	Vanguard 952: Tyne 506 Vanguard 951, 953
Tyne 101	RTy.12	6a, 9a, 1t, 3t	108.7	44	43.2	2,219	3,600	5,095; 5,505; 15,250; 0.499; 46.5; 13.5	Belfast, CL-44
Tyne 20	RTy.21.22	6a, 9a, 1t, 3t	108.7	44	43.2	2,218		5,440; 5,855; 15,250; 0.439; 46.5; 13.5	RTy.21 Atlantic; RTy.22 Transall, licence-built
Tyne 31		6a, 9a, 1t, 3t						7,870; 8,400; 15,250; —; —; —	Under development: Short SC5/31 Belfast
Rover TP/90		1c, 1t	35.44	27.6	20	190		118; 118; 47,000; 1.38; 1.88; 2.8	Development
Turbomeca									
Turmo 3D		1a + 1c, 2ct, 2pt	75.6		37	694		—; 1,450; 33,500; 0.657; 13; 5.5	Breguet 941
Bastan 6		1a + 1c, 3t	61.05	30.53	26.97	465		1,000; 1,072; 33,500; 0.584; 9.8; 5.5	Nord 262, Guarani
Astazou X		2a + 1c, 3t	75.27			281		640; 678; 43,000; 0.513; —; 7.5	Turbo Skyvan, Potez 842: will give 715 e.h.p.
UA Canada PT6A-6	T74	3a + 1c, 1ct, 1pt	62		19	270		550; 578; 37,500; 0.65; 5.3; 6.3	PT6A-8 (680 e.h.p.) under development. King Air, Charger, Potez 841, DHC types

TABLE 4: TURBOSHAFTS

Designation: Manufacturer's	Designation: Military	Engine Configuration	Length (in)	Height (in)	Width (in)	Equipped weight (lb)	Max Power: s.h.p.; r.p.m.; output r.p.m.; s.f.c.; mass flow; pressure ratio	Rated on 1hr power: alt (ft); speed (kt); s.h.p.; s.f.c.	Remarks
AiResearch TSE 331	—	2c, 3t	35	19.5	18.5	200	500; 39,000; 6,000; 0.619; 4.4; 6.5	—; —; 400; 0.651	Development
Allison	T63-A-5	6a + 1c, 2ct, 2pt	40.81	22.5	19	136	250; 35,000; —; 0.71; 3; 6.2	—; —; 159; 0.82	LOH
BMW 6012A	—	1c, 1t	27.5	—	14.95	100	100; 45,000; 3-8,000; 125lb/hr; —; 3	—; —; —; —	6012L, Do32E
6022	—	—	—	—	—	—	250; —; —; —; —; —	—; —; —; —	Bö105; Do32Z
Boeing 550-1-22C	—	1a + 1c, 1ct, 1pt	37.5	22.5	22.5	211	425; —; 6,000; 0.75; 4.46; 5.92	—; —; —; —	T50-BO-10, 330 s.h.p.; QH-50D
BS Gnome H1200	Mk 101	10a, 2ct, 2pt	54.8	27.2	17	350	1,250; 26,750; 19,500; 0.65; 12.3; 8.1	10,000; 100; 950; 0.602	AB.204B, 205, etc
Nimbus 750	Mk 100	2a + 1c, 2ct, 1pt	61.6	21	20.1	390	1,050; 35,300; 2,150; 0.68; 11.0; 6.5	5,000; 0; 770; 0.705	Scout; Wasp
Continental									
Model 217-2A	—	2 × 2a + 1c, 2ct, 1pt	52.0	—	37.96	519	1,400; 32,400; 6,600; 0.57; 6.45; 7.0	—; —; —; —	Coupled T72
Model TS-325-1	T65-T-1	1a + 1c, 2ct, 1pt	34.2	19.06	18.25	136	310; —; 6,017; 0.66; 3.3; 6.0	—; —; —; —	
DB.720/PTL6	—	4a + 1c, 2ct, 1pt	64.6	—	20.3	485	1,250; 21,200; 6,100; 0.604; —; 5.5	0; 0; 800; 0.70	
GE.CT58-110	T58-8	10a, 2ct, 1pt	59	—	16	304	1,250; 26,300; 6,000; 0.64; 12.4; 8.3	—; —; —; —	S61; S62; Vertol 107 Model 2
	T64-6	14a, 2ct, 2pt	83	30	24	724	2,850; 13,600; 13,600; 0.495; 24.5; 12.6	15,000; 100; 1,750; 0.485	
KHD T 16B	—	1c, 1t	32.5	32.1	24.2	154	100; 50,000; —; 0.41; —; 2.8	—; —; —; —	a.p.u.
Lycoming LTCIK-5	T53-L-11	5a + 1c, 1ct, 1pt	47.6	—	23.0	496	1,100; 26,000; —; 0.652; 10.7; 6	—; —; —; —	UH-1B, D, E
LTC4B-8	T55-L-7	7a + 1c, 1ct, 2pt	44.04	—	24.25	580	2,500; 14,550; —; 0.59; —; —	—; —; —; —	CH-47B
P & W JFTD12A-3	—	9a, 2ct, 2pt	—	—	21.9	870	4,050; —; —; —; —; 6.5	—; —; —; —	S64
R-R Napier Gazelle 162	N.Ga 13	11a, 2ct, 1pt	74.5	33.5	33.5	875	1,575; 19,900; 2,500; —; 16.2; 5.9	0; 0; 1,330; 0.695	Wessex 31
Turbomeca									
Artoust 3B	—	1c, 2t	71.46	24.68	19.96	287	550; 33,500; 6,000; 0.716; 9.5; 5.2	3,280; 0; 405; 0.81	Alouette 3
Turmo 3C	—	1a + 1c, 2ct, 2pt	77.8	28.2	27.3	485	1,500; 33,700; 5,700; 0.595; 13; 5.5	—; —; —; —	Super Frelon
Agusta TM251	—	1c, 2t	46.85	24.8	14.57	280	310; 43,000; —; —; —; —	—; —; —; —	A.105
UA of Canada									
PT6B-9	—	3a + 1c, 1ct, 1pt	59	—	19	245	550; 6,230; —; 0.665; 5.3; 6.3	0; 0; 485; 0.69	Hiller Ten 99; TL5

TABLE 5: PISTON ENGINES

Designation	Engine configuration	Length (in)	Height (in)	Width (in)	Equipped weight (lb)	Bore (in)	Stroke (in)	Capacity (cu in)	Compression ratio	Fuel grade (Oct)	Maximum power s.h.p.; r.p.m.; s.f.c.
Continental A65-8F	O4	27.5	27	31.5	169	3.875	3.625	171	6.3	73	65; 2,300; —
C90-12F	O4	23.34	29.3	31.5	190	4.0625	3.875	201	7.0	80/87	95; 2,475; —
O-200-A	O4	30.53	23.18	31.56	190	4.0625	3.875	201	7.0	80/87	100; 2,750; —
O-300-A	O6	38.38	27.41	31.5	268	4.0625	3.875	301	7.0	80/87	145; 2,700; —
IO-346-A	O4, inj	30	22.48	33.38	296.5	5.25	4	346	8.5	91/96	165; 2,700; —
IO-360-A	O6, inj	34.6	24.33	31.4	327	4.4375	3.875	360	8.5	100/130	210; 2,800; —
GIO-470-A	O6, g, inj	45.22	25.77	33.56	447	5	4	471	8.6	100/130	310; 3,200; —
GTSIO-520-A	O6, g, turb, inj	60.15	24.42	33.56	508	5.25	4	520	7.5	100/130	390; 3,400; —
Franklin 2A-120	O2	23.7	22.7	30.7	130	4.625	3.5	118	9.5	100/130	60; 3,000; 0.49
4A-235	O4	30.5	25.1	31.5	228	4.625	3.5	235	7.0	80/87	125; 2,800; 0.49
6AGS-335	O6, g, turb, inj	41.0	21.25	31.6	410	4.5	3.5	335	7.0	100/130	260; 3,200; 0.50
Lycoming O-235-C1B	O4	29.81	22.4	32.0	240	4.375	3.875	233	6.75	80	108; 2,600; —
IO-320-B1A	O4, inj	33.59	17.22	32.24	287	5.125	3.875	319.8	8.5	91/96	160; 2,700; —
IO-360-A1A	O4, inj	29.81	21.61	34.25	323	5.125	4.375	361	8.7	100/130	200; 2,700; —
TVO-435-B1A	O6, vert, turb	34.73	35.65	33.58	478	4.875	3.875	434	7.3	100/130	270; 3,200; —
GO-480-B1A6	O6, g	39.84	28.02	33.12	432	5.125	3.875	480	7.3	80/87	270; 3,400; —
IO-540-B1A5	O6, inj	38.62	19.6	34.25	437	5.125	4.375	541.5	8.7	100/130	290; 2,575; —
IGSO-540-B1A	O6, inj, g, s	48.5	20.29	34.25	532	5.125	4.375	541.5	7.3	100/130	380; 3,400; —
VO-540-C2A	O6, vert	34.73	25.57	34.70	442	5.125	4.375	541.5	8.7	100/130	305; 3,200; —
IO-720-A1A	O8, inj	46.08	22.53	34.25	400	5.125	4.375	722	8.7	100/130	400; 2,650; —
McCulloch											
Model 4318A, O-100-1	O4, 2 str	34.5	12.3	22.0	114	3.1875	3.125	100	7.8	100/130	110; 4,100; —
Meteor Alfa 2	R4, s	34.25	—	23.46	220	4.133	3.071	164.76	6.5	—	120; 2,900; —
OKL NP-1	O4	28.23	23.42	31.57	—	3.86	3.54	165.7	6.5	—	68; 2,600; —
WN-6R	O6, g	48.81	16.53	32.67	—	4.92	3.7	421	6.5	72	220; 3,000; —
Omnipol M110-H	O4, inj	31.5	32.28	30.48	295	4.33	3.43	201	7	72	120; 3,100; —
Potez-Avco 4E-30	O4, inj	27.5	23.3	30.3	238	4.33	3.54	209	8	100/130	117; 2,850; 0.51
Rollason-Ardem 4CO2 Mk 5	O4	—	—	—	—	3.27	2.72	91.2	7.8	80	55; —; —



Possibly the most significant US space launching in 1964 was that of the Atlas Agena carrying Mariner 4 (left), made from Cape Kennedy on November 28. Other important launches towards the end of the year included those of the Atlas Centaur AC-4 vehicle (centre) from Cape Kennedy on December 11, and Explorer 26 (right) by Delta vehicle from Cape Kennedy on December 21. Mariner 4 had completed over 50 million miles of its journey to Mars by the end of the year

Spaceflight

THE YEAR IN SPACE

A total of over 100 spacecraft launched by 87 rocket vehicles into Earth orbit or beyond made 1964 the most active year in space exploration to date. The exact total is uncertain: the US Defense Department does not always reveal the number of satellites placed in orbit on occasions when more than one spacecraft are launched by a single rocket. According to contemporary reports in *Flight* the US Defense Department orbited at least 45 payloads from 35 launches, including at least five multiple launchings. Unofficial US sources have given the total from the same number of launchings as 50 payloads, including nine multiple shots.

The US National Aeronautics and Space Administration launched 23 spacecraft from 22 vehicles during the year, while the Soviet Union launched 35 craft using 30 vehicles. This brings the grand total to 103 known satellites, or 108 using the US sources. It is possible that the true total is even higher, since further unannounced USAF pick-a-back satellites may also have been orbited.

The NASA total, detailed below, included two Rangers launched towards the Moon, two Mariners launched towards Mars and the Italian San Marco orbital flight. The Soviet total included two twin launchings of Electron satellites; the triple launch of Cosmos 38, 39 and 40 and double launch of Cosmos 42 and 43; and the three-man Voskhod orbital flight. It included also the mysterious Zond 1 which appeared to be heading for Venus, and Zond 2, now on its way towards Mars.

Annual totals for spacecraft launched into orbit or beyond since 1957 are as given in the following table: these figures do not include rocket bodies, fragments or unannounced pick-a-back satellites.

Year	USSR	USA
1957	2	—
1958	1	7
1959	3	11
1960	4	17
1961	7	31
1962	21	57
1963	17	55
1964	35	68 (or 73*)
Total	90	246 (or 251*)

* Totals according to unofficial US reports.

NASA'S YEAR

The successful launch of Explorer 26 from Cape Kennedy on December 21 brought the National Aeronautics and Space Administration's record for the year to 28 successes out of a total of 33 major space launchings. This total comprised 22 Earth-orbital attempts, four space probes and seven suborbital flights.

Among the failures were Ranger 6, which hit the Moon but failed to send back pictures on January 30; and Mariner 3, launched towards Mars on November 5, which failed to jettison its fairing and is transmitting no data. On December 9 the second mission (GT-2) in the Gemini programme was attempted: the Titan failed to leave the pad because of a defect in the hydraulic system. An attempt to launch an ionospheric beacon Explorer satellite into orbit on March 19 was unsuccessful, and the interplanetary monitoring platform, Explorer 21, was placed in an orbit lower than planned on October 3.

Most spectacular success was that of Ranger 7, which transmitted 4,316 high-quality pictures of the lunar surface on July 31,

Spaceflight

1964. Mariner 4, now *en route* to Mars, is also a success so far and is expected to fly past the planet on July 14, 1965.

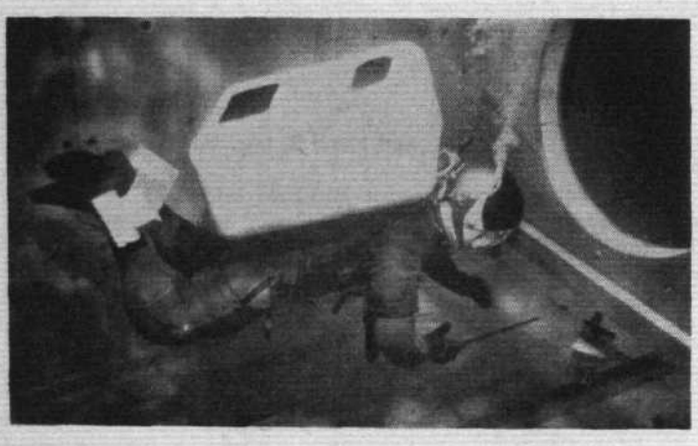
In six further launchings, seven Explorer spacecraft were successfully orbited: Explorer 20 (August 25), Explorer 21 (October 4), Explorer 22 (October 10), Explorer 23 (November 6), Explorers 24 and 25 (November 21) and Explorer 26 (December 21).

Other successes comprised Relay 2 (January 21), Echo 2 (January 25), fifth Saturn 1 (Janaury 29), Ariel 2 (March 19), GT-1 Gemini (April 8), suborbital RAM radio attenuation measurement craft (April 10), suborbital Project Fire (April 14), suborbital Little Joe 2/Apollo abort test (May 13), sixth Saturn 1 (May 28), Centaur AC-3 (June 30), suborbital SERT 1 space electric rocket test (July 20), suborbital Scout re-entry (August 18), Syncom 3 (August 19), Nimbus 1 (August 28), Orbiting Geophysical Observatory 1 (September 4), seventh Saturn 1 (September 18), suborbital Scout RFD-2 (October 9), suborbital Little Joe 2/Apollo abort test (December 8), Centaur AC-4 (December 11) and San Marco 1 (December 15).

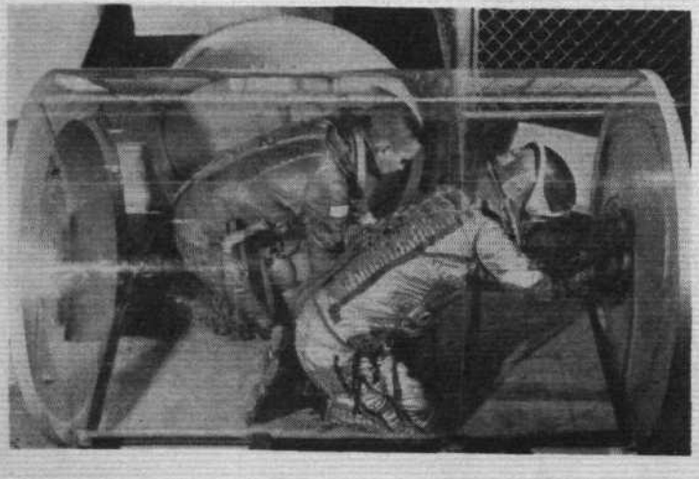
COMSAT LAUNCH AGREEMENT

The National Aeronautics and Space Administration and the Communications Satellite Corporation have signed an agreement covering the launching by NASA of Early Bird, the first communication satellite intended for commercial use. The agreement also covers possible subsequent launchings of synchronous satellites of the same type.

NASA will launch Early Bird as soon as possible after March 1, and will provide a backup launch should the first attempt fail. At the option of the corporation, NASA will also provide further launches after July 1. The space administration will provide thrust-augmented Delta vehicles and use them to launch synchronous satellites into low-inclination transfer orbits and provide telemetry and tracking data, and backup calculations, during the transfer orbits.



Above, zero-gravity effects are investigated in the underwater research laboratory at Boeing's aerospace division. The experimenter carries a backpack which provides breathing air and keeps the space suit pressurized (water is pumped into the suit to achieve neutral buoyancy) and weights are attached to his ankles. Below, NASA engineers at Langley Research Center test airlock systems and techniques which might be used in the transfer of crews between spacecraft in the Gemini and Apollo programmes



DECEMBER ORBITS

The following list covers all the artificial Earth satellites known to have been launched during December 1964. It follows on from the "Recent Orbits" feature in our December 17 issue. Orbital elements quoted normally refer to the initial values.

December 4. 1964-79. USAF satellite launched from Western Test Range by Atlas Agena at about 18.58 GMT. Orbit 160-355km (100-220 miles), inclination 97.02°, nodal period 89.69min. Decayed in the Earth's atmosphere on December 5, lifetime one day. Only component 79A, Agena satellite (cylinder 5ft 2in diameter, length about 30ft, weight and transmitting frequency unknown).

December 9. 1964-80. Cosmos 51 launched from the Soviet Union at about 23.00 GMT. Orbit: satellite 260-539 km (162-335 miles), 48.76°, 92.45min; rocket, 258-536km (160-333 miles), 48.77°, 92.43min. Estimated lifetime: satellite, six months; rocket, 3½ months. Components: 80A, Cosmos 51 (domed cylinder, estimated length 7ft, diameter 4ft, weight 900lb); 80B, rocket body (cylinder, estimated length 37ft, diameter 8ft, weight 4,500lb); 80C, D, E and F, four fragments.

December 10. 1964-81. USAF satellite launched from Cape Kennedy at about 16.52 GMT using a Titan 3A booster. Orbit 167-181km (104-112 miles), 32.15°, 87.7min. Decayed in Earth's atmosphere December 13, lifetime three days. Component 81A, Titan 3A Transtage. According to DoD launch announcement a 3,750lb payload was ejected into separate orbit.

December 11. 1964-82. Centaur 4 launched by NASA from Cape Kennedy at 14.25 GMT using Atlas Centaur AC-4 vehicle. Orbit 160km (100 miles) circular, 32°, 87.5min. Decayed in Earth's atmosphere December 12, lifetime one day. Only component 82A, Centaur 4 (cone-cylinder 10ft diameter, length (rocket) 30ft plus (payload) 16ft; weight (rocket) 4,400lb plus (mass-model Surveyor) 2,100lb; transmitted on 5765Mc/s).

December 13. 1964-83. USAF multiple launch from Vandenberg by Thor Ablestar at about 00.08 GMT. Orbit: satellites 1,030-1,075km (640-669 miles), 89.97°, 106.3min; rocket 1,018-1,068km (632-664 miles), 89.99°, 106.06min. Estimated lifetime 700 years. Components: 83A, Ablestar (1,000lb cylinder about 16ft long, 4½ft diameter; containing transmitting payload?); 83B, Transit satellite? (weight 130lb?); 83C, APL radiation satellite? (weight 135lb?); 83D, fragment.

December 15. 1964-84. San Marco 1 launched by Italian crew from Wallops Island at 20.20 GMT using NASA Scout booster. Orbit 200-843km (124-524 miles), 37.77°, 94.94min. Estimated lifetime: satellite, nine months; rocket, six months. Components: 84A, San Marco 1 (sphere 26in diameter, weight 254lb; transmitting on 20.005Mc/s for ionospheric studies, 136.530Mc/s for telemetry and 136.740Mc/s for tracking; 84B, Altair rocket.

December 19. 1964-85. USAF satellite launched by Thor Agena from Vandenberg at about 21.12 GMT. Orbit 187-414km (116-257 miles), 74.99°, 90.53min. Estimated lifetime two weeks. Only component 85A, Agena satellite.

December 21. 1964-86. Explorer 26 launched by NASA from Cape Kennedy at 09.00 GMT using a Thor Delta. Orbit 309-26,200km (192-16,800 miles), 20.14°, 456min. Estimated lifetime ten years? Components: 86A, Explorer 26 (octagon 17in high, 27in diameter with 34in tube and four paddles; weight 101lb); 86B, Altair rocket.

December 21. 1964-87. USAF satellite launched from Vandenberg by Thor Agena at about 19.12 GMT. Orbit 227-268km (141-167 miles), 70.08°, 89.50min. Estimated lifetime two weeks. Only component 87A, Agena satellite.

Seven more fragments have been discovered in the orbit of Explorers 24 and 25; they are designated 1964-76D to 76J. Two objects which decayed in the Earth's atmosphere recently are the Zond 2 carrier satellite (1964-78A) on December 1 (lifetime one day), and the rocket body (1964-78B) on December 2 (two days).

President Chiang Kai-shek reviewed Nationalist Chinese Air Force F-100 Super Sabres during the annual year-end ceremony at a base near Taipei last month. F-86 Sabres and F-104A Starfighters also featured in firepower demonstrations

DEFENCE

Amberley Prepares for F-111s

AT RAAF AMBERLEY, near Brisbane, work has begun on a £2.75m programme to adapt the base for the twenty-four GD F-111 swing-wing strike aircraft ordered by the RAAF. The first RAAF F-111s are due for delivery in 1968, but the remodelling of Amberley is to be completed well before then. Amberley is at present the home of the RAAF's Canberra bomber force.

The programme does not at present provide for the extension of the 8,000ft runway. The RAAF is reported still to be awaiting from the USA detailed specifications of various aspects of F-111 operation, including air and ground crew training and maintenance requirements.

"Triumph" in New Role

AFTER A FOUR-YEAR CONVERSION in Portsmouth Dockyard, the former light fleet carrier HMS *Triumph* is to re-commission today, January 7, as an escort maintenance ship. In her new role *Triumph* will provide facilities for almost any type of work aboard the complex destroyers and frigates now in RN service and in addition to her ship's company will house four maintenance units, with a total staff of 285.

Although the *Triumph's* former flight deck has sprouted an unsightly collection of cranes and deck houses, the foredeck has been kept clear as a helicopter landing area and there is a hangar alongisde the former island. Since a Wasp helicopter is now part of a modern frigate's standard equipment *Triumph* will be able to undertake helicopter maintenance work and numbers air trades men among her engineering elements.

Triumph was accepted into RN service in 1946, saw action in the Korean War, later served as the cadet training ship and subsequently spent four years in the moth-ball fleet before beginning her conversion.

HJT-16 Production Under Way

THE HINDUSTAN HJT-16 Viper-powered trainer, the first wholly Indian-designed jet aircraft—which recently made its first flight—has been named the Kiran by Mr A. M. Thomas, Indian Minister of State for Defence Production.

Production of the first batch of 24 Kirans has begun at the Bangalore division of Hindustan Aeronautics, and the company aims to deliver all these to the IAF before the end of 1966.

Deliveries are reported to have begun last month from Bangalore of 30 Krishak Mk 2 light aircraft, which are to replace Austers as India's standard AOP equipment.

Mr Thomas recently announced in the Delhi Parliament that the bulk of the machinery to be imported for Avro 748 production at the Kanpur division of Hindustan Aeronautics has been installed and that the performance of the first Kanpur-built machines, now in service, has proved satisfactory.

Flight understands from a very reliable source that the IAF is closely watching the development of the 748MF Andover rear-loading version of the 748, but a decision on the licence production of this tactical transport at Kanpur will await the results of the RAF's full evaluation of the definitive Andover in Britain.

Blowing Hot and Cold at IAM

THE RAF INSTITUTE OF AVIATION MEDICINE at Farnborough is to receive a £250,000 thermal environment simulator to expand the range of its climatic work. The first installation of its kind in Europe, the simulator is basically a 17ft-diameter cylinder 60ft long, which can be supplied by air at rates varying between one-tenth and one-half of a ton a minute and at temperatures varying between −18° and 121°C. Altitudes of up to 60,000ft and radiant heat effects of up to 232°C will be simulated.

Any combination of these conditions, and rapid changes to reproduce transient aerodynamic heating situations, will be possible and the simulator will also be used as a cold chamber to investigate high-level ejection problems, with temperatures down to −50°C.

Work on heat stresses has hitherto been confined mainly to experiments at normal atmospheric pressures and has not given a true picture of what happens at high levels, where the effect of radiant heat is much greater and assumes a greater importance when convection exchange is reduced.

The simulator platform will seat four men, whose reactions will be monitored electronically. Supervision will be through special optical viewers and closed-circuit television.

Besides facilitating the study of present-day problems arising from high altitude and high speed flight the simulator is intended to cover future studies arising from military aviation development, though for this purpose the altitude range, to 60,000ft, seems rather limited.

The simulator is the work of the Scientific Apparatus Department of AEI and of Carrier Engineering.

RAF Honours

MAJOR HONOURS bestowed upon serving RAF officers in the New Year Honours List include the KCB for Air Marshal B. K. Burnett, VCAS, and Air Marshal P. G. Wykeham, Air Commander Far East; a KGBE for Air Chief Marshal Sir Walter Cheshire, Air Member of Personnel; and KCBs for Air Marshal P. H. Dunn, AOC-in-C Flying Training Command, and AVM D. J. Pryer, Commandant, RAF Staff College, Bracknell, and Air Member for Personnel designate.

First Swiss Mirage Flies

THE FIRST SWISS-ASSEMBLED DASSAULT Mirage III made its first flight from Emmen recently. As Swiss production builds up, the proportion of Dassault-supplied components will decrease and later airframes will be virtually entirely Swiss-built.

Swiss Air Force acquisition of Mirages was recently cut back from the intended 100 to 57, following a major Parliamentary conflict over inaccurate estimates and rapidly spiralling costs.

Buffalo Production Beginning Immediately

PRODUCTION of the 15 DHC Buffalo tactical transports to be ordered for RCAF Air Transport Command—the order was announced on this page last week—is to begin immediately and first deliveries will be made in the spring of next year. DHC has been canvassing orders for the Buffalo with the promise of deliveries 16 months after the placing of the first production order. The RCAF order is the first.

Five-hundred pound bombs drop from a South Vietnam Air Force Skyraider, right, in a strike against Viet Cong guerillas. Note the South Vietnam markings, which are simple adaptations of US markings. Ex-USN Skyraiders (still hook-equipped) have been in use in South Vietnam for some months, replacing armed T-28 trainers in strike duties. The US maintains the attitude that its forces are simply "advisers" to the South Vietnamese, with one US and one Vietnamese flier crewing every aircraft but, below, it is the "adviser" who is checking the fragmentation bombs on a Skyraider before departure from Bien Hoa air base near Saigon. Also carried by the Skyraiders are 20mm cannon, rockets, napalm tanks and 250lb bombs. In the bottom picture Skyraiders break to attack another Viet Cong position. Photographs by Associated Press photographer Horst Faas

Australian Build-up in New Guinea

PAPUA - NEW GUINEA is to be made a full military command, equal to any in Australia, the Federal Government has decided. Military preparedness in the area has been much increased since the assumption by Indonesia of sovereignty over "West Irian"—formerly Dutch-ruled West New Guinea, and major military construction works are being undertaken in Papua - New Guinea.

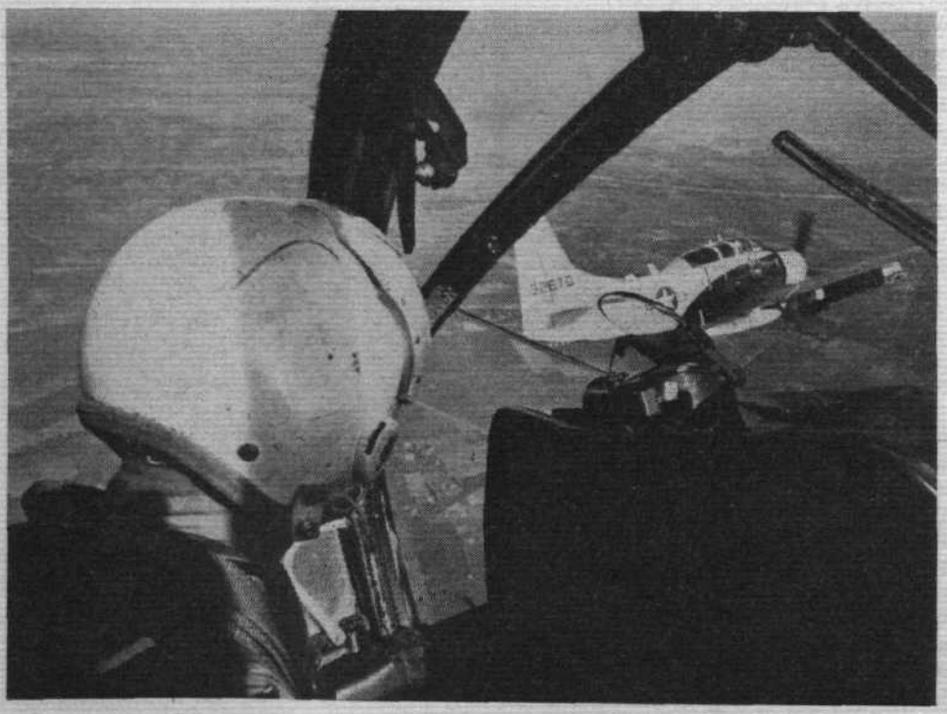
Top priority is to be given to the development of Boram airfield, in the Northern Highlands, which will become Australia's largest strike base outside mainland Australia. The Australian Army is building hundreds of miles of roads through virgin bush in the Northern Highlands, near the West Irian border, using bulldozers flown in by RAAF C-130s. Army helicopters are surveying the bush between Vanimo and Telefomin and along the Sepik river, using fuel dumps set up along the river by an Army landing craft and operating from abandoned wartime airstrips.

"Ark Royal" Line Book Unearthed

THE "LINE BOOK" of the earlier carrier HMS *Ark Royal*, which was sunk in 1940, has been found, after being missing for over 20 years, in a St Alban's, Herts, public house. The line book covers the period from 1938 to after the sinking.

The finder is the now retired Lt Cdr Norman Manley-Cooper, who served in *Ark Royal* as a midshipman observer in one of her Swordfish squadrons. The book had apparently been left in the pub by a customer about nine months ago.

Through Lt Cdr Manley-Cooper it has been returned to the present *Ark Royal*, which re-commissions this year after a refit at Devonport.



THE TWENTY-FIFTH ANNIVERSARY of the arrival in Britain of the first RCAF squadron to be posted overseas, on February 27, 1940, is to be marked with a dinner in Toronto on the same day next month. The squadron was 110 Sqn, RCAF, which has since been redesignated 400 (City of Toronto) Sqn (Auxiliary) and which now flies C-45 Expeditors and DHC Otters from RCAF Downsview, Ontario.

The CO of 400 Sqn, Wg Cdr G. E. Gilroy, is anxious to contact all members of the original 1940 contingent, together with all officers who have served with 110 or 400 Sqn, and with 10 Sqn, as the unit was known on its foundation in 1932.

Straight and Level

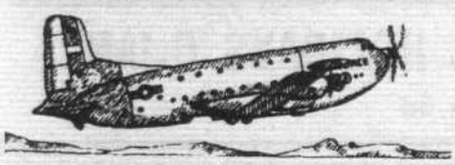
THIS year I not only had stacks of Christmas cards from people I've never heard of, but quite a lot also from people who I am pretty sure have never heard of me.

Thank you all, anyway.

● IATA, whose laws—as is well known—transcend all others, has decreed—

"The airlines have relaxed their regulation regarding the six nights sleeping accommodation to the extent that they now regard a car with fully reclining front seats as providing sleeping accommodation in itself."

Gad sir, jolly decent of them! Reminds me of the day Neddie Carruthers drove off with the Colonel's daughter in me two-seater convertible. Dashed roof was ripped to pieces by his spurs!



—from a "Sunday Times" drawing of the Globemaster, the radome of which proved too much of a temptation for the retoucher's brush

● From a Shell advertisement on fuel fungus, to be read out aloud in a David Frost voice:—

"The growth was easily identifiable as a fungus—but what fungus? Shell turned this question over to the Commonwealth Mycological Institute at Kew.

"Back came the answer: *Cladosporium resinae (Lindau) de Vries,* a species usually found living on creosoted telegraph poles . . .

"Some water had been found in drain samples taken from aircraft fuel tanks. The most practical solution, therefore: avoid water contact with the fuel and the fungus cannot grow . . ."

● "If I were in the airplane business, I'd skip the champagne and fancy meals but break my neck to provide planes that arrived and left exactly on time."—US rail chief Ben Heineman quoted by *Life.*

● *From a Comet incident report:*—"Examination showed that the port main gear door rear hook operating spring strut plunger tube had fractured."

Had *what*?

● Changes are often hard to identify while they are actually happening, but it is not hard to perceive the abrupt halt in the supersonic-airliner race.

This week two years ago the race was well and truly on. "We must grab this opportunity with both hands and dash away with the prize," cried Mr Neil Marten about the Concorde. This week one year ago the Americans were within eight days of final design submissions in the American SST programme; and so frenzied had all the airlines become that even BOAC and Air France had joined the lengthy queue for the entirely imaginary American pseudonic airliner.

How different it all looks now. The Concorde will go ahead, but on a prototype basis and much extended timescale —1974 for production deliveries instead of 1970, and possibly no production at all. The American SST programme now looks as though it has been stuck on the wall, and the go-ahead has been given by the President to the monster 700-troop C-5A (or CX-HLS), which has got Lockheed, Boeing and Douglas in a lather of excitement.

Everyone is relieved that on both sides of the Atlantic the supersonic throttle has been pulled back. What worries me is the idea that the 700-seat passenger subsonic airliner is the alternative. As I suggested on November 12, air transport develops by stages, not by gigantic leaps. A 700-seat airliner operated at competitive frequency in the seventies will produce a hopeless amount of empty seats, even on the densest routes, quite apart from its incompatibility with airport terminals and runways.

The next stage of development will be the 250-seater subsonic jet, and it is time that Britain was doing something about the super Super VC10. The greatest blessing of the supersonic respite is the opportunity that it gives for investment in a new breed of really efficient subsonic jets.

From an advertisement in a US magazine

● "The member airlines of the European Air Research Bureau have completed a programme on baggage handling and are just starting on lost baggage . . ."

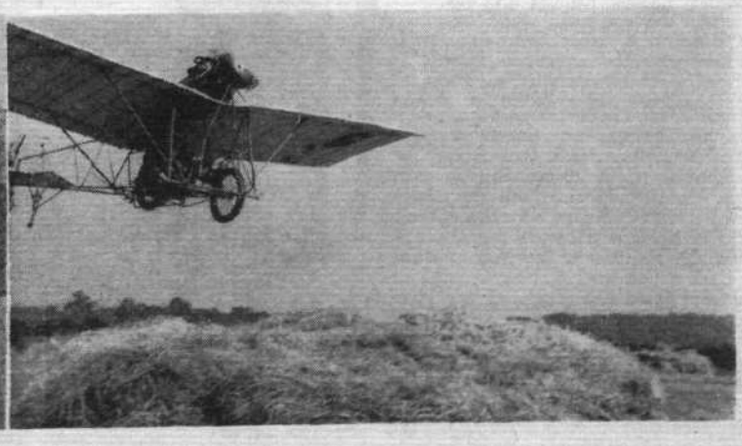
—*Flight,* December 24.

Mine was a hand-tooled coach hide Gladstone with brass knobs on.

ROGER BACON

If we really try we might . . .
Westland Wapiti of 603 Sqn, September 1933

. . . just make it
Demoiselle replica film-making, 1964



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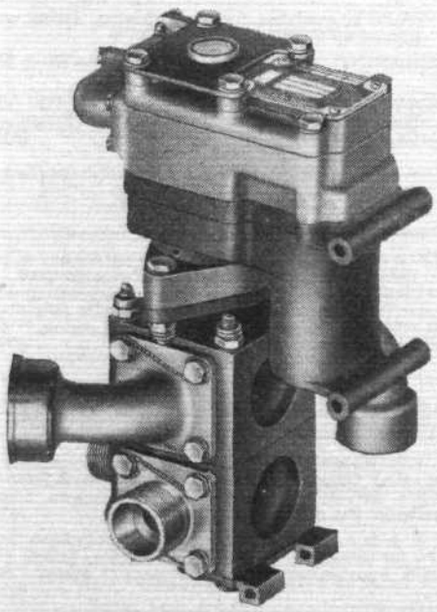
MOT/18

Versatility of Saunders Spherical Plug Valve solves a control problem on Nimbus Engine



On the Scout helicopter the Nimbus Engine is equipped with this motorised coupled unit evolved for the mult-purpose control of hot air to the guide vanes, fuel heater and generator cooling.

The Unit comprises an ON/OFF valve and a Multi-way valve operated by a common control through heat brake by the motor unit.

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The Planning Manager will be directly responsible to the Managing Director for producing both long and short term appreciations in the field of new aircraft requirements, economic and commercial research investigations and other similar aspects of airline operations.

The post requires a person of sound and mature judgement; of necessity the successful applicant will hold an appropriate Degree and will have had practical experience of economic analyses and research together with a good working knowledge of statistics and accounts. It would obviously be of great advantage if such experience had been gained in the aviation industry.

The salary for the post will depend upon the qualifications and experience of the successful candidate.

Application marked "Confidential" should be made to the Company Secretary, Cambrian Airways Limited, Cardiff (Rhoose) Airport, Near Barry, Glamorgan. [5928

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INDUSTRIAL RELATIONS OFFICER, to be based in London, is required by The British Independent Air Transport Association. Experience in negotiations with Trade Union representatives, preferably at National level, essential. Salary would be according to experience and qualifications. Written applications to be addressed to the Secretary, British Independent Air Transport Association, 51, Victoria Street, London, S.W.1. [5907

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CALEDONIAN AIRWAYS requires Captains, First Officers and Flight Engineers, preference will be given to those with Britannia, DC6B or DC7C experience. Apply Chief Pilot, Caledonian Airways, Imperial Buildings, Victoria Road, Horley, Surrey. [0534

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