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Our new solid state equipment can help an airliner talk, listen, identify itself, see storms, measure distance, find position and stay on the glide slope.

RELIABILITY: in some cases ten times greater than conventional equipment. POWER DRAIN: greatly reduces power necessary to operate even high-output transmitters. SIZE AND WEIGHT: solid state circuitry reduces the size of the black boxes as well as cutting weight, and with all these advantages, there is lower price.

Our solid state avionic gear is all new, designed specifically for jet air transport requirements, rather than adapted from military models. This means a lower price for better equipment. Our DME system for example, the DMA-29, costs 27% less than the next best DME. And it has precise accuracy from 0 to 192 miles, a self-checking circuit that continuously monitors all measuring circuits and can fit in a ½ short ATR case.

Our new RTA-41 VHF transceiver comes in a ½ ATR case too, only weighs 17 pounds, and has a self-test circuit for pilot confidence checks. Built to ARINC 546 requirements, the RTA-41 has 680 crystal controlled channels (50 kc spacing) and circuit provisions for 25 kc spacing when required. The Bendix RDR-1E weather radar is new too, and with a 50 KW output and 200 cycle pulse rate, our picture is sharper at 180 miles than other units at 150. It's sensitive enough to see dry snow at high altitudes. Like all Bendix solid state equipment, it has a self-test feature.

The Bendix TRA-61 ATC transponder system is a completely modular unit with plug-in circuit boards. Designed to accommodate all four civil aviation modes (A,B,C, & D), it's fully compatible with FAA three-pulse and ICAO two-pulse side lobe suppression. An optional plug-in circuit board is all that's needed to add automatic altitude reporting.

To fill out our solid state line, there is the GSA-25 glide slope receiver and the ultra-small MKA-28 marker beacon receiver. For data on our solid state avionics, write us at 605 Third Avenue, New York 16, N. Y. or cable BENDIXINT.

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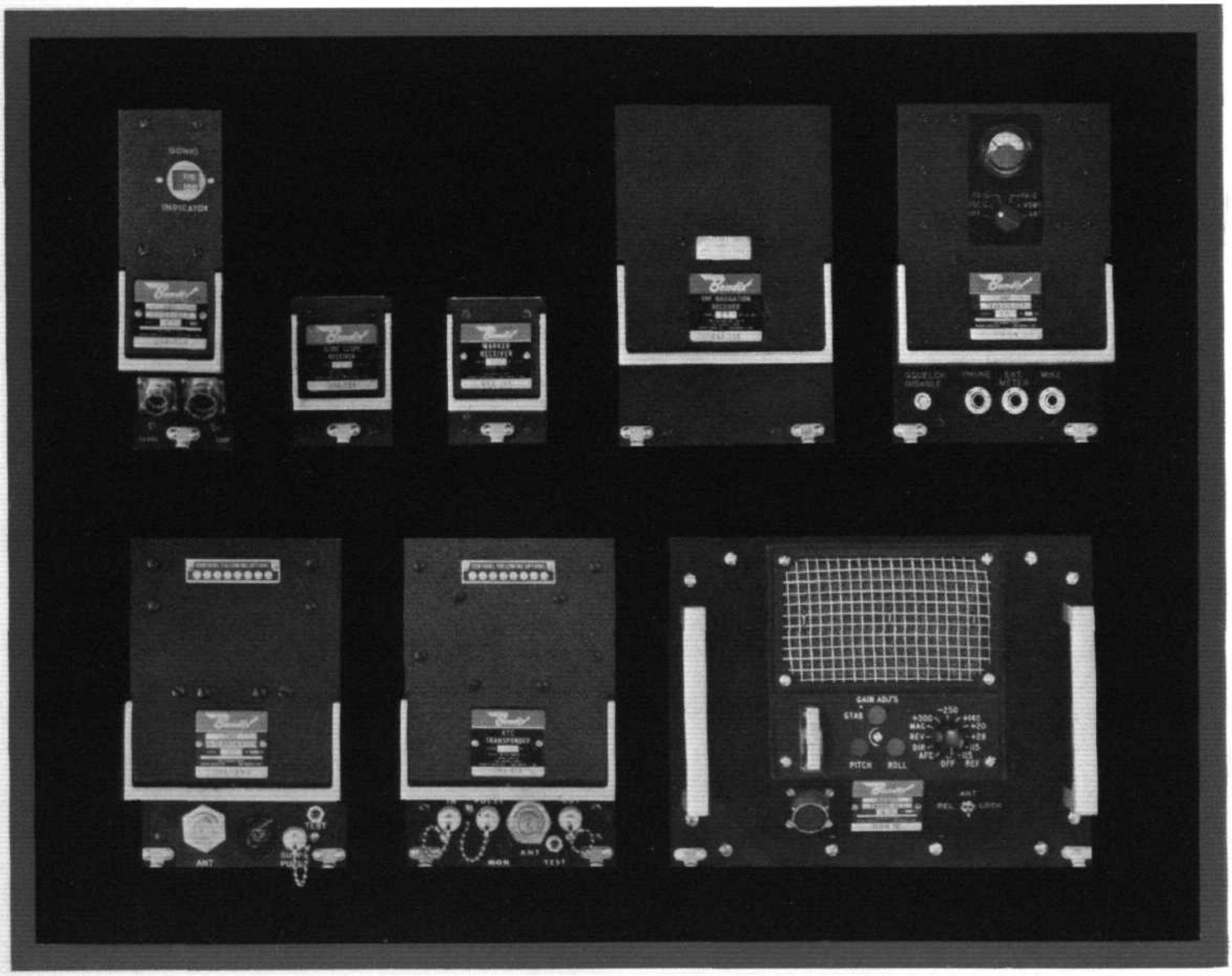

Bendix International Operations

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'64 Dollar Questions

AMID the sprawling fields of aerospace how shall we be travelling in 1964? What new projects will be coming forward? Will our efforts always be justified? Technical, financial, military and moral issues array themselves in massive challenge; the year will be a stern one for the timid and the tired.

Among the technical problems is that of how to build the supersonic transport. Techniques which have sufficed for military applications will be of limited help because a longer airframe life-span is required. Systems and servicing methods will also differ. While the integrity of the Concorde's structure seems fairly well assured, the welded stainless steel honeycomb of the B-70 is not directly transferable to an SST. As for finance, the money put up by the US Government is considered inadequate by the US aircraft-builders, who calculate a possible loss of nine hundred and fifty million dollars if the SST programme is terminated before certification, and of one thousand five hundred million if it is axed later through lack of orders. A consortium appears to be the only answer, and even so the firms must face a frightful risk. In any case, an entirely new engine will be demanded.

Jet-lift will see new advances by the Bristol Siddeley/Hawker Siddeley and Rolls-Royce/Dassault alliances, and increasingly these will penetrate into the transport field. Reinforced plastic construction for light aircraft still seems far away.

Is it Worth It?

The view of the missiles industry is not a cheerful one for the purse-string holders. Every system now in contemplation poses immense technological and cost/effectiveness difficulties. A better ICBM could be built; but the only way to achieve it at a reasonable price is to improve Minuteman. By the same token a defence against the ICBM could be developed; but only at crippling cost. As each week passes the question "Is it worth it?" intrudes more insistently.

We in Britain will be entering the space business with Blue Streak; and doubtless we shall launch the annual quota of new space committees. Meanwhile the USA will continue to develop satellite applications, with communication satellites no longer a novelty. America's programme to hurry on up to the Moon will progress, perhaps, with fewer dollars and less hysteria. The USSR will continue to play its enigma variations on the theme of space, and Europe will embark on realistic co-operative programmes.

In the vast air transport industry the precepts of safety, economy and comfort must be increasingly everyone's concern. The year 1963 was the safest yet; but there must be no complacency about the behaviour of jets in turbulence (see page 9) and more money must be spent on aids and met. reporting. We may hope for reduced European fares (they have not come down for six years), and we trust that these will come about without cramming in seats beyond the limits of comfort, and possibly even of safety.

Increasingly this year the alert executive will be chasing up business either jet- or turbo-propelled.

No year, as we say, for the timid or the tired.

WORLD NEWS

Belfast First Flight

As these words went to press the first flight of the Short Belfast was being delayed only by a capricious wind. Slow-taxying trials were completed on Christmas Eve and fast runs during last Saturday and Sunday, the nosewheel being lifted off the runway for the first time. The aircraft was cleared and ready to fly, but an easterly wind was needed to allow take-off from Short's airfield at Queen's Island to be made clear of the City of Belfast. To avoid an approach across the city, the first flight was to terminate at Aldergrove.

C-141 Makes First Flight

Sixty years of aeronautical progress were fittingly, if coincidentally, marked on December 17, anniversary of the Wright brothers' first powered flight, by the maiden flight of the Lockheed C-141 StarLifter heavy logistic transport for the USAF.

Latest four-jet leviathan to appear, the C-141, with an all-up weight of 316,600lb, is 422 times as heavy as the fully laden Wright Flyer; and its payload : range capabilities are such that, in terms of weight, it could lift about 42½ fully-laden Flyers (some 32,000lb) from a 6,000ft runway at San Francisco and deliver them direct to London in about 11hr. Both its span, 160ft, and length, 145ft, are greater than the distance covered in the Wrights' first flight.

Maximum payload capability of the C-141 is over 70,000lb and will be 96,000lb for the projected L-300 commercial version. It is indicative of Lockheed's hopes in the civil field that the aircraft is to be certificated to both USAF and FAA requirements. Civil certification is expected in 1965. Initial military orders are for 132 aircraft.

Powered by four 21,000lb-thrust P & W TF33-P-7 turbofans, the StarLifter is the work of the Lockheed-Georgia Co, of Marietta, from where chief engineering test pilot Leo Sullivan flew it for its 55min maiden flight. It is a state-of-the-art aeroplane involving no radical technical advances, a fact reflected in its commendably short gestation period, only 32 months from go-ahead to first flight.

BAC Rationalized

A legal step towards the consolidation of British Aircraft Corporation Ltd—and the retirement of the famous names Bristol, English Electric, Hunting and Vickers-Armstrongs, as far as aircraft manufacture is concerned—was taken recently when Mr Justice Pennycuick in the Chancery Division confirmed reductions in the capital of these member or subsidiary companies of BAC. Yesterday, January 1, they emerged as (respectively) the Filton, Preston, Luton and Weybridge divisions of the Corporation. The Corporation has a separate Guided Weapons division.

Australian Alouettes

Three Sud Alouette IIIs have been ordered by the Australian Government for communications work on the Woomera weapons range. This brings to 181 the number of Alouette IIIs ordered and to 38 the number of countries using Alouettes of all types.

Instrumentation for High-speed Flight

"Instrumentation and Test Techniques for Manned High-speed Flight" is the subject of the third flight-test instrumentation symposium to be held at the College of Aeronautics, Cranfield, during April 13-16, 1964. Contributions from six countries will include papers on the X-15 research aircraft and the Concorde supersonic transport. Details are available from Mr M. A. Perry, Department of Flight, The College of Aeronautics, Cranfield, Bletchley, Bucks.

Home for Christmas

The two youngest pilots ever to make the England - Australia - England flight reached home for Christmas. Mr Charles Masefield, 23 years-old son of Mr Peter Masefield, managing director of Beagle, and Lord Trefgarne, also 23, landed at Gatwick on December 23. They had left Sydney on December 1, flying a 1936 D.H. Dragonfly which has recently been restored and was test flown at Sydney by Charles Masefield. The outward flight had been made in a Beagle Airedale they were delivering.

Evacuated from Djarkarta

Decca Radar, Westland Aircraft and International Aeradio are the three British firms affected by the Government's request to suspend work on military contracts with Indonesia. About 50 employees and dependants of these companies were evacuated from Djarkarta just before Christmas.

Decca engineers, together with others from International Aeradio, were setting up a defensive radar system. Most of the equipment had been delivered but it is reported that installation work was incomplete and the chain was not operational. Westland employees were concerned with the servicing of 18 Gannet ASW aircraft

Second BAC One-Eleven *is seen here making its first flight—on December 19, at Hurn, as recorded last week. A number of subsequent flights have been made, and by the time this issue appears the aircraft should be based at Wisley, BAC's main flight test centre. Further details of One-Eleven progress are given on page 7* supplied in 1960, for which spares are now being denied.

It is ironic to recollect that delivery of the Gannets was made in the face of strong Australian and Netherlands protests but it is the British Government that has had first cause to regret it. On the day following the announcement that service backing was to be withdrawn, the Indonesian Acting Chief of Armed Forces Staff, Rear Admiral Martadinata, said that the Indonesian Naval Air Force had ordered naval aircraft "from another country whose planes are much better than the British Gannet."

Herald's All-up Weight Drops by Nearly a Quarter *as 4½ tons of supplies take the quick way out. Thirty-two panniers, each weighing 300lb and coupled, were released in less than ten seconds through the double doors of a production Herald series 400 for the Royal Malaysian Air Force in a demonstration at Watchfield, Berks, last month. The panniers were lined on a roller conveyor with a banked exit section. Among those watching were representatives of the RCAF, Canadian Army and RAF Transport Command*

SBAC Appointments

The Society of British Aircraft Constructors announces that Mr H. W. Goodinge, formerly assistant director, has been appointed deputy director, while Mr M. H. Harris has been appointed assistant director. Chief executive and director of the Society is Mr Edward Bowyer.

NATO Air Defence

A critical stage has been reached in the determination of the ground environment to be adopted for the control of supersonic intercepters in NATO airspace. Though the NATO Air Defence Ground Environment specification has been in existence for some time, the whole concept is so complex, and so vastly expensive, that no hardware has yet emerged to satisfy it. The specification can hardly keep pace with technical developments, and F-104Gs for interception are meanwhile accumulating without any ground control system which can effectively direct them.

Elliott-Automation have now proposed an answer to the problem in the form of their Firebrigade system, based on the MCS 920 miniature digital computer—and on wide experience with the ARCH type of industrial automation. The first Firebrigade system, based on an off-the-shelf Elliott 803 computer, has been giving extremely satisfactory service at an RAF fighter control station and has for the first time in Europe provided a degree of automation making the sure control of supersonic fighters possible. The Netherlands Government is about to receive an MCS-920-based Firebrigade system and has stated that it would acquire a second on condition that NATO funds were provided for its purchase. This brings to a head the question of a standard NATO control system, for which Elliott, Litton and Hughes are in competition. Some decision was to have been taken at a NATO meeting immediately before Christmas but no result has yet been announced.

Elliott Firebrigade, in its basic form, is capable of facilitating the control of supersonic intercepters with existing radar and infrastructure, but it is also capable of virtually unlimited expansion, both in terms of the number of targets handled and in the services and geographical extent of the overall system. Thus, the initial control capability can be established at very moderate cost and rapidly, and the growth determined in the light of practical operational experience—a simpler and surer procedure than going straight to an "all-in" system.

The Firebrigade system for the RAF was delivered two months ahead of schedule—in seven months instead of nine—giving a measure of Elliott's claim that simplicity and the use of many production components make Firebrigade quickly available. The MCS-920, also now in production, is small enough to permit use in mobile fighter control cabins. A basic twelve-target system costs about £150,000.

Elliott are sufficiently well connected with subsidiaries and associates on the Continent to offer extensive joint production and the use of a quantity of components of American origin. The company has also shown very considerable determination to obtain the order and is in a relatively good position to do so, even in the face of the customary intensity of American competition.

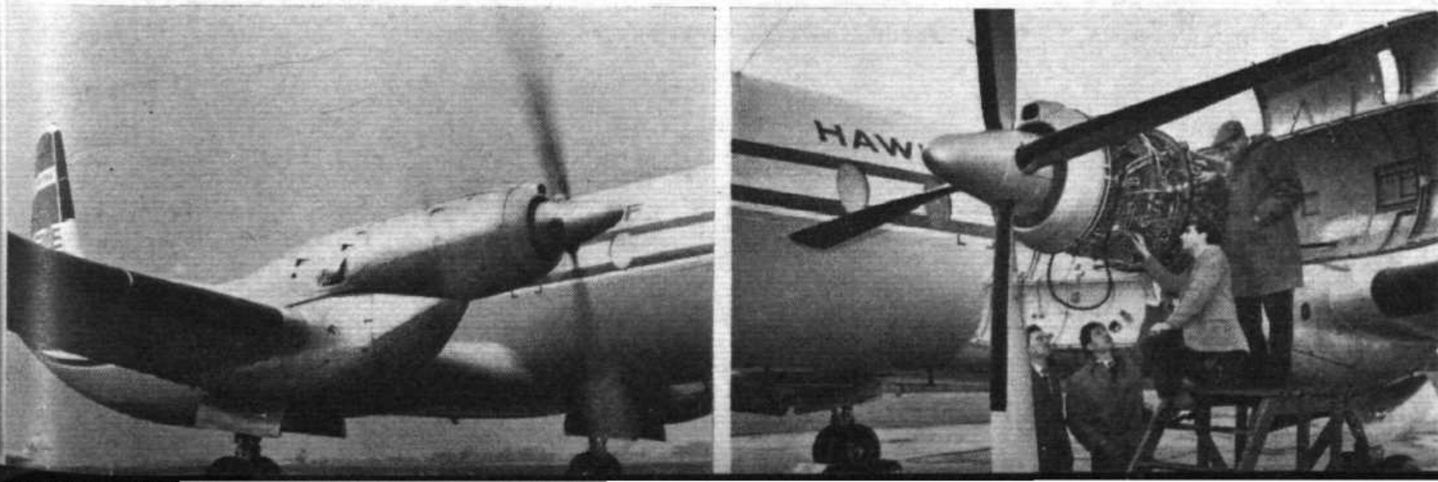
Pictures on page 33 indicate the layout of various portions of Firebrigade.

Jane's : a Postscript

The staff writer who reviewed the 1963-64 edition of *Jane's All the World's Aircraft* on page 1017 last week writes: In one of those aberrations which journalists dread to dream about I wrote last week that "illustrations and informed conjecture" about the TSR.2 were excluded by the press date, for the aircraft section, being September 1. In fact, an illustration and all known information about the TSR.2 *are* included —in addenda which are correct until November 20, 1963 and which, for good measure, include an illustration of the Soviet anti-missile missile displayed on November 7 and another of the Egyptian Helwan HA-300 fighter.

Believing it was impossible that *Jane's* could be more up to date than it first appeared I missed the addenda in the hour I had to scan the book before writing my review. The fact that Mr John Taylor, the editor, and the publishers find it possible to include information only a month or so before publishing day makes *Jane's*, of course, an even better reference book than the magnificent one it appeared to be last week.

More Power for the Troops *Though still slimly clad, each of the Dart RDa.12 engines which power the Hawker Siddeley 748 STOL tactical transport develops no less than 3,245 t.e.h.p. These two photographs show ground running and inspection by Rolls-Royce service engineers before the prototype's first flight on December 21. They also show the reversing Dowty Rotol propeller developed for the engine. A 150hr MoA type-test on the RDa.12 will start within the next few weeks*



AIR COMMERCE

Air Safety in 1963

LAST year was the fifth in succession that was safer for the users of air transport. The 1963 accident rate per 100m passenger-miles on scheduled services appears to have fallen 20 per cent, from 0·94 in the previous year to an all-time low of 0·75.

This provisional *Flight International* estimate is based on a record compiled during the year up until December 30, when this issue closed for press. The main source of information was the *Lloyd's List* of aircraft casualties; and ICAO's provisional traffic figures for the year provided the basis for the estimate of the accident rate. The list covers all transport aircraft revenue flights incurring fatalities to occupants.

During 1963 some 678 passengers were killed (up to December 30) in a total of 27 accidents while travelling on scheduled services. This compares with 765 killed in 28 accidents during 1962; as in 1962, the total does not include fatalities incurred by Aeroflot or by other non-IATA Communist-country airlines. Nevertheless, this is an extremely satisfying trend which, as has already been shown, is further improved statistically because it was achieved in a year when traffic has been estimated to have risen 11 per cent, to 90,000m passenger-miles.

After the alarming rise which occurred in 1962 in the number of fatalities on non-scheduled operations, when some 400 passengers were killed, the 1963 non-scheduled figure of about 150 is a notable improvement. But the record of this type of air transport operation casts its shadow over the industry as a whole, though it is now more in proportion to the scale of charter operations.

Date	Carrier	Aircraft	Location	Fatalities Pass.	Fatalities Crew	Circumstances
Jan 14	Wien Alaska Airlines	Beechcraft 18	Barter Island, Alaska	4	1	Crashed on approach
Jan 15	Cruzeiro do Sul*	Convair 240	Congonhas Airport, Sao Paulo, Brazil	5	1	Attempting emergency landing on one engine. Seven people killed on ground
Jan 29	Continental*	Viscount	Kansas City	5	3	Swerved on landing and struck dyke
Feb 1	MEA*	Viscount	Collided over Ankara	11	4	Viscount approaching to land, on course, when collision occurred. C-47 on instrument flight. Approx 60 people killed on ground
	Turkish AF	C-47		—	3	
Feb 3	Slick	Super Constellation	San Francisco International	1	3	Crashed in fog
Feb 12	Northwest*	Boeing 720B	Everglades Swamps, 46 miles West of Miami	35	8	Crashed 8min after take-off
Mar 2	PAL*	DC-3	Mindanao	24	3	Crashed in poor visibility
Mar 15	Trans-Mediterranean	York	7 miles SE Karaj, Iran	—	4	*En route* Teheran-Beirut. No passengers carried
Mar 15	Lloyd Aereo Boliviano*	DC-6B	Tacora Volcano, 10 miles W of Arica - La Paz railroad	36	5	Crashed in Andes at about 14,500ft
Mar 30	Itavia*	DC-3	*En route* Pescara - Rome	5	3	Crashed into mountain in storm
Apr 14	Icelandair*	Viscount	Isle of Nesoy, near Fornebu Airport, Oslo	7	5	Crashed into hill on approach
May 1	Nitto* Airlines	Otter	Awaji Island	9	—	Hit mountain
May 1	Aerotaxi	Beaver	Medellin, Colombia	3	—	Unknown
May 4	Air Afrique*	DC-6	Mt Cameroon, 40 miles W of Douala	46	7	Crashed 6,500ft up mountain
May 4	Cruzeiro do Sul*	Convair 440	Sao Paulo	28	3	Crashed 15min after engine failure on take-off
May 6	TCA*	Vanguard	50 miles W of Rocky Mountain House at 21,000ft	1	—	Hit severe turbulence, landed safely
May 12	UAA*	DC-3	Ayayda, *en route* Cairo - Alexandria	30	4	Crashed in flames after take-off
June 3	Indian Airlines Corp*	DC-3	Nr Pathankot	25	4	Disintegration?
June 4	Northwest	DC-7	Over Gulf of Alaska	95	6	Crashed into sea
June 10	Union of Burma Airways*	DC-3	Between Myitkyina and Putao	15	6	Attempting to land in monsoon
Jul 1	Varig*	DC-3	Bela Vista, Rio Grande do Sul State, S Brazil	12	3	Attempting to land in bad weather, *en route* Porto Alegre - Passo Fundo
Jul 2	Mohawk*	Martin 4-0-4	Rochester Airport, NY	5	2	Take-off in bad weather
Jul 3	NZNAC*	DC-3	Lost between Auckland and Tauranga	20	3	Hit mountain during let-down
Jul 15	Air Madagascar*	DC-3	Farafangana, Madagascar	2	4	Crashed on take-off
Jul 17	Air America	C-46	Northern Laos	—	6	Hit high ground on rice-dropping mission
Jul 28	UAA*	Comet 4C	Off Madh Island, Nr Bombay	54	8	Crashed into sea during bad weather let-down
Aug 12	Air Inter*	Viscount 708	Near Lyons-Bron Airport	11	4	Struck pylon on bad weather approach, killing one man on ground
Aug 14	Aaxico Airlines	C-46F	Great Falls, Montana	—	1	Crashed *en route*, cause unknown
Aug 17	Fujita	Heron	Nr Hachijo Island, south of Tokyo	16	3	Hit mountain *en route* Hachijo Island Tokyo
Sep 4	Swissair*	Caravelle	Duerrenaesch, Nr Zurich	74	6	Explosion following hydraulic system fire
Sep 5	Air America	C-46	*En route* Savannakhet - Vientiane	—	7	Hit high ground on rice-dropping mission
Sep 11	IAC*	Viscount	Nr Lalitpur, S of Agra	13	5	*En route* Nagpur-New Delhi
Sep 11	Airnautic	Viking	In Pyrenees nr Perpignan	36	4	Hit mountain
Oct 9	Air Systems	Globemaster	Nr Marignane Airport, Marseilles	3	3	Crashed on hilltop (Cattle-carrying)
Oct 14	New York Airways*	Boeing Vertol 107B	Idlewild International	3	3	Mechanical failure of rotor-drive system
Nov 8	Finnair*	DC-3	Mariehamn, Aland Islands	19	3	Crashed in fog
Nov 29	TCA*	DC-8F	St Therese de Blainville, Montreal	111	7	Take-off
Dec 8	PAA*	Boeing 707	*En route* Baltimore-Philadelphia	72	8	Lightning?
Dec 12	Trans-Mediterranean	DC-4	Near Kabul?	—	3	Missing
			Passenger and crew fatalities 1963:	826	159	
			Total	985		

* Scheduled

C OF A FOR THE 727

THE Boeing 727 has been awarded its United States FAA certificate and is now fully approved for passenger service. The certification has been awarded just three years after Boeing decided to go ahead with the project, and less than a year since the first flight.

Certified performance of the 727 is as much as ten per cent above original Boeing guarantees. Cruising speed is higher than predicted, field length requirements less, and air miles per pound of fuel greater. Take-off weight is 152,000lb and maximum landing weight 135,000lb. At normal weights the 727 will operate from a 5,000ft runway.

Boeing has delivered six 727s under an earlier, provisional, certificate for crew training, and 20 have been flown to date.

Sales figures stand at 147 to nine airlines. In the certification programme four test 727s flew 1,100 hours since February 9, 1963, when the first aircraft made its initial flight. Tests include maximum-speed shallow dives at more than .95 Mach, take-offs at 160,000lb, numerous two-engine take-offs and maximum-energy landings in less than 900ft.

IFALPA's 19th Annual Conference will be held at Manila from March 10-17.

Can Lightning be Lethal? Next Wednesday, January 8, the health and safety sub-committee of the US House of Representatives is due to review the state of knowledge about the effects of lightning and turbulence on transport aircraft.

Nigerians to Train in Israel Under the terms of an Israeli-Nigeria technical assistance agreement, some Nigeria Airways staff are to be trained in aeronautical engineering in Israel, the Israeli Ambassador in Lagos announced recently. The first trainees will leave for Israel next month.

SUPERSONIC AMERICANS

TEN United States airlines have notified the Federal Aviation Agency of their intention to evaluate manufacturers' proposals for the supersonic transport. Three airframe and three engine manufacturers are preparing initial design proposals for submission to the FAA and airlines for evaluation. Deadline for submission of these design proposals is January 15.

The ten are: American Airlines, Braniff Airways, Continental Air Lines, Delta Air Lines, Eastern Air Lines, National Airlines, Northwest Airlines, Pan American World Airways, Trans World Airlines, and United Air Lines. Each of these airlines will conduct a separate evaluation of the manufacturers' proposals.

The government evaluation will be conducted by a group made up of technical experts from five government agencies under the overall management of FAA. The agencies will be NASA, the Department of Defense, the CAB, and the Department of Commerce. At the head of this group will be the FAA deputy administrator for supersonic transport development, Gordon M. Bain. Government and airline evaluation will be formally reviewed in joint government-airline discussions scheduled for March 25 and 26, 1964, in Washington. FAA Administrator N. E. Halaby will announce selection of contractors to proceed with development of the United States SST, or to continue through a year-long phase of detailed design competition, by May 1.

The three airframe manufacturers preparing SST initial design proposals are Lockheed, Boeing, and North American. The three engine builders are General Electric, Curtiss-Wright, and Pratt & Whitney.

THE TRUTH ABOUT CORBETT

LORD LINDGREN, in the House of Lords debate on BOAC just before Christmas, said of the Corbett report: "My working-class decency would never get me to ask another person to rat on his chief."

While it is not quite clear why class should be dragged in to the Amery-Corbett business, the reply made by Lord Chesham was astonishing. Justifying the confidential nature of the Corbett report, he said: "I do not know how the Government could have gone behind anyone's back when it makes an announcement to Parliament. An announcement was made to Parliament before Mr Corbett went to work."

The truth is that Mr Amery, Minister of Aviation, commissioned Mr Corbett in July 1962, and did not tell Parliament until November 1962, a full three months after Mr Corbett had started work.

THE LONGEST FLIGHT

A LITTLE friendly controversy has broken out over what is the world's longest scheduled air service. As already reported in these pages Pan American are now operating a non-stop service between New York and Buenos Aires with Boeing 707-320Bs. This is a 5,445 st miles flight, and is the longest on an *all-the-year-round* basis.

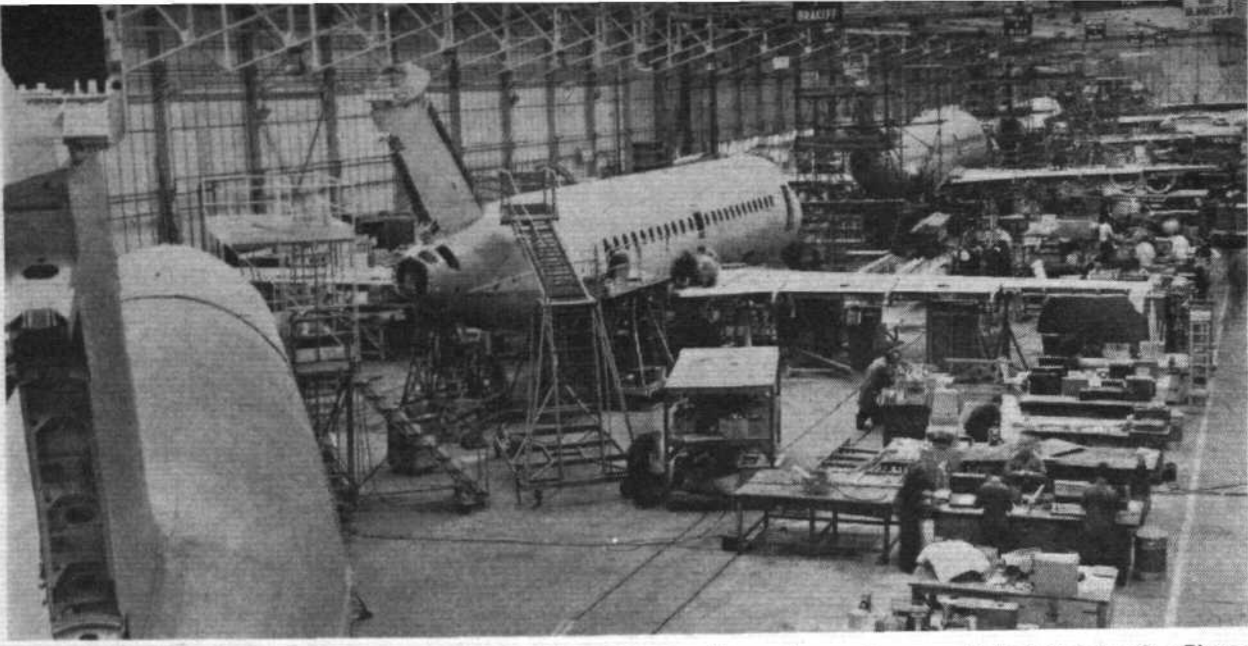
It still does not beat El Al's *seasonal* (April-October) non-stop flight eastbound from New York to Tel Aviv, a distance of 5,760 st miles. El Al uses Boeing 707-420s.

SIR BASIL WAS WINNING

IN his last message to staff in *BOAC News*, the outgoing managing director, Sir Basil Smallpeice, expresses his appreciation of all the efforts which have enabled him and his chairman, Sir Matthew Slattery, "to hand over the corporation in such a healthy shipshape condition."

During the first 32 weeks of the current financial year (starting

A DH-operated Trident at Nice on one of its pre-C of A proving flights. On December 19 at Hatfield BEA took delivery of their first Trident, G-ARPF, on which they will complete crew-training in time for first services next April



Five BAC One-Elevens are nearing completion on the final assembly line at Hurn. Nearest the camera is the first export One-Eleven, one of 12 ordered by Braniff International Airways. Beyond it are four aircraft for British United Airways, including—at the head of the line—G-ASJA, the first production One-Eleven, which has started its flight trials. In the left foreground another fuselage is ready for wing mating

AIR COMMERCE...

April 1, 1963) an operating profit of £3.1m has been made—compared with a £3.1m loss at the same time last year. If BOAC can "hang on to that £3m operating profit during the winter months," says Sir Basil, "by the end of March we can meet the full year's interest payment on active capital." So far this year £51m out of a total of £71.5m revenue has been earned in overseas currency.

Sir Basil Smallpeice records that BOAC engineering costs are now not much more than 4d per ctm compared with 10½d six years ago. On London - New York the corporation is, he says, breaking even at less than a 40 per cent passenger load factor (at present fares). System break-even load factor he says—"even with Britannias and Comets still providing a third of our capacity"—is now down to 49 per cent. He does not, however, want to leave the staff with the idea that "all is now plain sailing." No one can afford to slacken, says Sir Basil, who wishes the corporation the "best of good fortune in 1964 and the years beyond."

BOAC's NEW GENERAL MANAGER

AS reported last week Mr David Craig, BEA's reservations manager, has been appointed by Sir Giles Guthrie, BOAC's new chairman, as senior general manager with effect from yesterday, January 1.

In a recent letter to BOAC's management, Sir Giles said: "To avoid prolonging unnecessarily any uncertainty there may be about my intentions towards the present structure and composition of the corporation's executive management, I am hoping by arrangement with Sir Matthew Slattery to speak to you all on Thursday afternoon, December 19. First, I want you to know that, when I become chairman on January 1, I intend to invite all members of executive management to continue in their existing appointments while I get to know them and gain experience of working with them.

"On the other hand, I am planning that one new appointment should be made as soon as I join the corporation. I am proposing that Mr David Craig should rejoin BOAC as an additional member of executive management in a new post of senior general manager. In that position, he will work closely with me in the next few months in a study of the corporation and its problems leading to the preparation of the plan I have undertaken to submit to the Minister within a year. As a result of the various investigations and enquiries, executive management has been so close to its problems for many months that I feel a new mind will be useful in ensuring a completely objective approach.

"Consequently Mr Craig will contribute a fresh view to the valuable experience that is already employed in the management of the corporation's commercial affairs. Some of you will already know Mr Craig, who has been in civil aviation for 21 years and served for four years with BOAC before joining BEA. As BEA's nominee he was a member of the Board of Alitalia for 15 years and one of its four-man executive committee from the very beginning of that airline in 1946. At this time I do not expect to bring anyone else with me from BEA."

Mr David Craig is 49 and his most recent responsibility with BEA has been the £5m reservations computer being installed at the West London terminal. Born in Rome of a Scottish father and a Venetian mother, Mr Craig was educated in various parts of the world including Jamaica, Italy and Austria. By the time he was ten he could speak four languages—English, French, German and Italian. Today he speaks seven.

Always interested in aviation, he studied aeronautics at Zurich University, Switzerland, from which he graduated. He then became a post-graduate research student in aerodynamics at Jesus College Cambridge, and a member of that University's Air Squadron. He learned to fly at Zurich and gained his Private Pilot's Licence in 1937. In the early part of the war he was employed by the Air Ministry on jet-propulsion research at the Royal Aircraft Establishment, Farnborough, and later became scientific assistant to the Director of Scientific Research at the Air Ministry.

To gain more practical engineering experience and become more closely connected with aircraft production, Mr Craig joined General Aircraft Ltd as assistant to the works manager. Then he moved to the Technical Development Department of BOAC and soon became superintendent of No 1 line, then operating Dakotas to the Middle East and West Africa. He was later appointed superintendent of No 3 line which ran the "ballbearing" service of Dakotas and Mosquitoes to Stockholm. He gained his first-class Civil Air Navigator's ticket and once radio-navigated a Mosquito to Sweden from the bomb bay.

At the end of the war, when No 3 line closed, Mr Craig returned to No 1 line which was concerned mainly with flying European services and was ultimately taken over by BEA.

Mr David Craig, who took up his post yesterday, January 1, as senior general manager of BOAC, and about whom a note appears on this page. His responsibilities are thought likely to include many of those previously carried by the managing director

Nigeria Airways' fine new £900,000 engineering base at Lagos was opened by the President of Nigeria, Dr Nnamdi Azikiwe, on December 13. It incorporates an office block and a training school

BACK IN BUSINESS

THE second BAC One-Eleven, G-ASJA, made a successful first flight lasting 25min from Hurn Airport on December 19. The aircraft was piloted by Mr Jock Bryce, chief test pilot of British Aircraft Corporation, with Mr D. Glaser, the corporation's senior test pilot at Hurn, as co-pilot. Take-off weight of the aircraft was 60,000lb, and the flight took place on a perfect winter's day—sunny and cloudless.

Before take-off Mr Bryce made one low-speed taxi run down the runway, followed by a high-speed return run. A few minutes later, without refuelling, G-ASJA took off.

G-ASJA is being used mainly for aircraft systems development. The three One-Elevens which follow G-ASJA (BUA's second, third and fourth aircraft) will also be fully instrumented and will undertake performance, flight resonance, and final stability and control work, together with autopilot trials. These aircraft are now in final assembly at Hurn and will be in the air by the spring.

Design changes will be incorporated progressively in the test fleet as required. As already stated, these will consist primarily of alterations to the wing leading edge shape and modifications to the elevator linkage to permit a more direct mechanical connection between the pilot's control and the elevator.

RUNNING IN THE VC10

INITIAL experience with the VC10 flying on typical BOAC routes has, claim the manufacturers, shown an excellent standard of reliability and serviceability. Since the overseas route-proving programme began on October 17 the aircraft has averaged more than 8.2hr flying a day, excluding a period on the ground for routine maintenance.

The proving programme is being flown by G-ARVF, the fifth of 12 standard VC10s for BOAC. It is intended to occupy approximately 1,000hr in flying under typical service conditions, allowing initial operating snags to be identified and overcome before regular passenger-carrying flights begin next spring.

Up to December 9 the VC10 had flown 346hr on overseas flights plus a further 72hr on local crew training at London Airport. It is now completing a routine maintenance check plus a modification programme to permit operations at the higher gross weight, 312,000lb, which is now to be the initial certificated figure. The route-proving programme is being resumed early in January with further flights to Africa, followed by a series of transatlantic flights to Montreal, Toronto and Vancouver for cold-weather experience.

VC10 G-ARVF was delivered to London Airport from the British Aircraft Corporation's flight test centre at Wisley on October 1, at which time it had flown a total of 112hr. Since then it has been occupied as follows:—

October 3-14 BOAC crew training from London Airport. Twenty-three flights and 193 landings, totalling 72hr 20min.

October 17-29 Initial overseas proving flights. Eleven round trips, London - Beirut - London, totalling 104hr 20min. One flight cancelled by alternator unserviceability. The aircraft was on the ground for routine maintenance from October 30 to November 7.

November 7-December 9 Second series of overseas proving flights, to Beirut, Lagos, Kano, Accra and Nairobi (by way of Rome, Khartoum and Aden). Fifty-nine sector flights, plus local flights from Nairobi and London Airport, totalling 260hr. One flight cancelled by aircraft unserviceability.

The overseas flights have been scheduled on a realistic basis each day, and the programme has operated punctually. Of the 32 scheduled departures from London Airport, 27 operated without significant delay attributable to aircraft unserviceability. Enroute turnrounds have been made in as little as 30min, helped by the high refuelling rate of 1,000gal per minute achieved through the two pressure refuelling points.

Routine maintenance has been undertaken at London Airport by BOAC personnel aided by a small team of the manufacturer's service engineers. The BOAC maintenance staff are said to have been impressed by the small number of defects which have needed to be cleared at the end of each flight—experience in this respect has been significantly better than with other jet types put into service by BOAC, including those which were already operated by other airlines at the time of their introduction.

The overseas flights are providing information which will help towards the smooth and trouble-free introduction into service of the VC10. This information is being analysed and, where necessary, modifications are being introduced to overcome operating snags.

Total flying hours on the VC10 by December 16 were 2,051 in 862 flights. Contributing to this total were seven aircraft of the BOAC fleet and G-ARTA, the original VC10 which is owned by British Aircraft Corporation. Two of these VC10s, G-ARVG and G-ARVH, have been delivered on loan to BOAC for crew training, based at Shannon in Ireland.

The ninth VC10, G-ARVI, made its first flight on December 20 and this aircraft, which is to full production standard, will be used for a 200hr programme of representative route flying early next year, prior to certification of the VC10 by the Air Registration Board.

THE POPE AS PASSENGER

CURRENTLY facing up to problems of protocol which no airline has ever met before is Alitalia, which will convey Pope Paul on his pilgrimage to the Holy Land on Saturday. It will be the first time a Pope has travelled by air. The last time a Pope left Italy was for the coronation of Napoleon.

The Alitalia DC-8 which will make the flight on January 4 will retain its national markings but the Papal flag, in yellow and white with the crossed keys of St Peter, will adorn its sides. The cabin has been refurnished and, it is reported, is lined with red material embossed with the Papal seal.

Stewards will replace stewardesses in the crew. The route will be either via Athens and Beirut or via Rhodes and Tel Aviv, to Amman. It is expected that the aircraft will be escorted in turn by fighters of the countries along the route.

AIR COMMERCE...

THE BRITISH EAGLE APPEAL

(Continued from page 1022 of last week's issue)

TO an observer, the well ordered and unhurried three and a half day British Eagle appeal against the Air Transport Licensing Board's refusal to grant any of their domestic trunk route applications was in striking contrast to the unfortunate haste and procedural confusion of the Board's hearing in August. Sir Arthur Hutchinson, who was appointed by the Minister of Aviation to hear the appeal, is now an experienced Commissioner with a knowledge of the basic technicalities, and he brings a sharp and alert mind to bear on evidence presented. To some of those present, the proceedings were a reminder of the advantages of having an examiner's hearing first and only a Board hearing afterwards if necessary—a procedure evolved by the American CAB where the Board compares the presented evidence with its own independently prepared study of the situation.

The cornerstone of the ATLB's decision to refuse British Eagle a truly competitive licence on the domestic trunk routes was the financial plight of BEA's domestic services. Mr S. B. R. Cooke, QC, for British Eagle, argued that the alleged losses had not been proved, and that if they did exist it was a situation calling for the widest possible enquiry.

Following the British Eagle case, which was reported fully in last week's issue, Mr A. J. Lucking presented a case in support of the appeal because he had been heard by the ATLB at the original hearing. Mr Lucking, speaking as a private citizen and a business user of air transport, said that the Board had recognized its duty to investigate the adequacy of the services, but had been wrong not to recognise the different degrees of seat availability from the travelling public's point of view: "The present situation on domestic air services is more akin to that on long-distance coaches whereas it should be more like that existing on trains." In Mr Lucking's view, rather than accept BEA's assertions the Board should have examined the actual flight-by-flight load factors. Although the BEA exhibits had shown a falling load factor up to 1962, these had become out of date by last summer when the situation was sharply reversed. The reason for this was a reduction in scheduled capacity on the Belfast and Manchester routes, a fact which, according to Mr Lucking, BEA attempted to obscure by quoting figures for empty seats.

Mr Lucking repeated his view that a 53 per cent average load factor meant no problems of seat availability from the traveller's point of view, and that 80 per cent average a "complete lack of bookable seats on occasion." He went on to claim that inadequacy and unprofitability were the "two sides of a single coin," and supported Mr Cooke's call for the widest possible enquiry into the alleged losses. The Commissioner had earlier ruled out evidence on the cause of the losses which Mr Lucking had sought to introduce.

Before beginning his presentation of the BEA case for rejecting the appeal, Mr Marking erected a special lectern which made it clear that he had a lengthy task ahead of him, with a lot of reference to words contained in the transcripts of previous hearings. He said that surprisingly little new evidence had been put forward.

Commenting on the first ground of appeal—that the Board had been inconsistent with their wish to introduce effective competition on to UK trunk routes by not granting British Eagle's application for more frequency, Mr Marking quoted extensively from the Board's findings in both 1961 and 1963. One of the important principles to emerge was that the Board favoured the established operator when his economic health was threatened by a newcomer. Ground two was that the Board had not fully considered the extra traffic that would be generated by a second operator. Eagle had claimed that of their traffic about half would be new and generated by them. According to Mr Marking, who was quoting from the August hearing, "these figures were plucked from the air." He similarly attempted to dismiss Mr Gotch's figures, saying they could be explained by the fact that the CAB would tend to licence competition where market growth was faster and justified it.

Ground three of the appeal had been that the Board were wrong in saying that British Eagle could have arranged a contract with BOAC for the purchase of Britannias that would have a release clause in the event of Eagle's not getting the necessary traffic licences. Mr Marking said that British Eagle could have obtained an option, and he presented a letter from BOAC which stated that they did grant options for aircraft sales against payment, though confirming that a sale would not be made subject to grant of a licence.

Ground four concerned the suitability of the Britannia for these routes, and Mr Marking pointed out that British Eagle's own figures had shown that on the Glasgow route a 64-seat Viscount would have achieved a 28 per cent load factor in the first month of operations (16 per cent achieved in the Britannias) instead of the 25 per cent anticipated in a 1961 document. Mr Curtis had testified that the Britannia was the best aircraft for British Eagle's diverse operating pattern, and yet, Mr Marking said, he clearly did not know what British Eagle's trooping contracts were, and thus his assertion was valueless.

Ground five of British Eagle's appeal concerned BEA's capital investment in domestic services in the form of operating losses incurred since 1961. To justify lumping much of the heavy Vanguard development expenditure on to these services, Mr Marking said, the aircraft had been specially developed for short-range high density traffic routes, and that it was now widely used on the UK domestic trunk routes. Ground six was that even with effective British Eagle competition, BEA would still have their present level of traffic, plus a substantial proportion of the growth. Mr Marking said that on the Belfast and Dublin routes this was clearly wrong on British Eagle's own estimates, and that with regard to the other routes a distinction must be drawn between the Board's principle developed for the international routes and that applied to the domestic routes. It could not simply be said that 38.9 per cent diversion or less was permissible; this was demonstrated by the fact that the Manchester route calculation gave only 19.8 per cent diversion.

Ground seven of British Eagle's appeal was the Board's acceptance of BEA's four main arguments. Additional comments by Mr Marking were that in the first place BEA's traffic estimates in the 1961 hearing had been high rather than low, the exception being Dublin where BEA had secured a higher proportion of the traffic than forecast; secondly that British Eagle would divert more traffic than anticipated by the Board because they were using Britannias instead of Viscounts; thirdly, that the financial position had improved but was not yet on the credit side; fourthly, the adequacy of service, which Mr Marking said had not been convincingly disproved.

Ground eight concerned the advantages to the public of a second operator which Mr Marking thought was a philosophical argument. He referred to the limited evidence tabled and to the Board's findings in the fares case that BEA's operating efficiency was above rather than below average.

Ground nine referred to the swamping and sandwiching of British Eagle's daily service on each route. Mr Marking said: "BEA had perfectly good reasons for operating services at substantially the same times as British Eagle, who incidentally, did not consult BEA before publishing their timetables. Mr Milward's offer of collaboration remains open and there is no reason why the silly dispute which has blown up cannot be settled in a business-like way. In any event British Eagle seem to be carrying as much traffic as they originally expected." With regard to swamping and the allegations made by both British Eagle and Mr Lucking, counsel for BEA thought it was unreasonable to complain that the corporation were putting on too much capacity. Competition meant that the competitors took every legitimate move they could to succeed.

* * *

In review, the BEA reply can be seen as a careful underlining of the evidence which they had already put to the Board, and reference to the complimentary remarks on the corporation's efficiency contained in the Board's fare decision. Although there were plenty of evidence showing the high load factors on all BEA domestic services, there was still some dispute whether they were high enough to cause significant inadequacy. The Board found the BEA services "reasonably adequate"; probably the strongest point of contrary evidence was the unprecedented action of the chairmen of the two civil aviation advisory councils in giving evidence in support of British Eagle.

C.C.J's COLUMN

JETS AND TURBULENCE

WE have now had some 20 catastrophic jet accidents, and about as many serious incidents, in which that mystic trilogy—handling technique, turbulence and lift margin—joined in various proportions to form an obscure but diabolical confederacy. Of these only the first is usually associated with a name—that of the pilot; the second, turbulence, used to be regarded as an act of God but now the meteorologist seems to have been called in as a deputy; the third, lift margin, remains largely anonymous.

Meteorologists have been reviled throughout the ages, and no doubt of course they have their lapses; but is it reasonable to put upon them the burdens they are now being asked to undertake in the field of high-level and low-level turbulence measuring and forecasting?

The heat has been on for high-level turbulence forecasting since 1950 when a few large blown-up fuselages began to float about over 30,000ft; now there are quite a lot of them up there and the inexorable law of probability cuts in with something more than a noticeable severity. As one turbulence accident piles upon another, "Where's the forecaster? Why aren't these boffins doing their job and keeping the aircraft out of such conditions?" goes the cry from the design office. And so we see the pressures building up from manufacturer to operator, to the governmental met service and so on to ICAO.

Now it might not be too unreasonable to look to turbulence prediction as the saviour if there were a good chance of success, but what really are the chances of the met man drawing a high-level turbulence chart with firm lines? And if the lines are not at least as firm as those of the pressure system or of a frontal position (and they are infirm enough), how can the pilot make an intelligent flight plan to avoid all risk of severe turbulence? Some advance has of course been made in associating high-level turbulence with the jet stream, but the stream itself can shift with some rapidity in a horizontal or a vertical plane; 2,000ft upwards and the level at which turbulence was expected (and therefore circumnavigated in the flight plan) is now as smooth as a mill-pond; a shift of 30 miles to the side and the fixed-wing aircraft, having planned to go about its business with a well established angle of attack, now finds itself required to play the role of the ornithopter with an angle of attack which is entirely unpredictable. Additionally, of course, high-level turbulence can occur quite independently of the jet stream and so prove even more elusive.

ICAO is launching a world-wide campaign of turbulence analysis, and currently aims at four periods* of intensive reporting by all turbine aircraft flying over 20,000ft. Obviously the more we know about the incidence, magnitude and spectra of gusts the better and such a campaign deserves the full support of the whole industry. However, my fear is that the manufacturer, pushed as he is to mill off more aluminium and to increase the Mach number, will sit back and wait for this campaign to demonstrate how a better met service (which would permit a refined flight-planning system), plus perhaps better navigational aids (which would permit more flexible flight paths), can justify the retention of existing formulæ for structural integrity and satisfactory flying qualities.

I do not think that even a very successful attack on high-level turbulence reporting and forecasting (or on low-level for that matter) will remove the need to increase structural strength at critical points, to design more lift at the wing-tip and to eliminate all cross-coupling of controls (as in the Dutch roll). Nor do I think that the problem of irrecoverable upsets is entirely solved simply by increasing the recommended penetration speed from the minimum margin above the stall to the maximum speed associated with the design limit load —an increase of about 60kt recently recommended by Boeing.

At the design limit load the safety factor of 1.5 compares doubtfully with that of 2.5 of ICAN days or 5.0 with the bridge builder. Even with meticulous design, scatter effects remain high, an inadvertent increase in speed will eat rapidly into the margin, especially at levels below 20,000ft, and one should not have to fly at Vmo save in an emergency. Turbulence, in my opinion, is not an emergency. Further, any substantial increase in the penetration speed will, in the modern jet, tend to bring on a separate set of problems in that it takes the aircraft near or into the high speed buffet regime. Admittedly the onset of buffet with speed and altitude is likely to be gradual but nevertheless it brings with it a definite degeneration of the lift and, with the modern swept wing, lift margins in this regime are already small.†

As far as I am concerned, therefore, it is absolutely no use putting the responsibility for the wing-over type of accident on the met man and telling him to find out more about turbulence. To me the wind is always likely to blow to a large extent where it listeth; but aeroplanes should be flyable even though the wind listeth vertically at 66ft/sec. Further, if an upset does occur, the controls should respond in such a way that the average pilot can effect a quick recovery: no lag, no over-control, no cross-coupling. And (to bring up to date the old adage) aeroplanes should fly in turbulence safely and not break up.

The fault is not in our stars but in ourselves that we are underwinged.

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* March 11-15, June 10-14, September 9-13, December 9-13.

† More especially so if they are derived from a basic stall which has been undervalued in the first place—see "Minima & Manœuvrability I—IV," *Flight International*, March 7, April 4, April 18 and June 13, 1963.

IAC's Jet Programme

UP to ten Caravelles may be bought by Indian Airlines Corporation, according to the airline's general manager, Mr S. Mullick, in an interview with *Flight International*. The first of four 6Rs so far ordered was handed over to IAC's president at Paris Orly on December 12.

By 1966-67, when all ten Caravelles will be fully extended (at 3,000hr a year) meeting trunk route needs, IAC may be in the market for Trident/727 class jets. A fleet of six would be needed to supplement the ten Caravelles in the period 1967-1971, according to IAC's present best estimates. An order for the Trident or 727 would thus probably have to be placed before the end of 1964.

Mr Mullick says that IAC has no requirement for the 748 Series 1, which falls short of IAC's performance specification, but he feels that the 748 Series 2 would fulfil IAC's need to augment regional route capacity at present provided by Friendships. He estimates that up to four 748 Series 2s—Indian-built of course—would adequately supplement the fleet of ten Friendships over the period 1966-1970. IAC would for obvious reasons prefer to standardize on a one-type fleet of F.27s, but recognize the need to encourage the Indian aircraft industry. In any case, foreign exchange might not be available for importing further Friendships as well as Tridents or 727s—especially as IAC also have to replace their 12 Viscounts with jets of the One-Eleven/DC-9 class.

A fleet of 14 One-Elevens or DC-9s will, Mr Mullick estimates, been needed to replace IAC's 12 Viscounts and to meet the fast-increasing regional and trunk route traffic at present carried by these aircraft. The One-Elevens (or DC-9s) would begin to take over from Viscounts in 1966-67, by when six would have been delivered. A decision between the One-Eleven and the DC-9 would have to be taken before the end of 1964 to meet these delivery

AIR COMMERCE...

dates. All 12 Viscounts should be completely retired by 1967-68.

Thus by the end of this decade IAC may be expected to have a fleet of ten Caravelles and six Trident/727 aircraft for trunk routes; 14 One-Eleven/DC-9 aircraft for high-density regional routes; and ten F.27s and four 748 Series 2s for other regional routes. All of IAC's 29 DC-3s will have been retired from passenger service by 1966, when 15 may be transferred to the IAF and the remainder allotted solely—together with DC-4s—to the corporation's night air mail services and to cargo and charter work. Total new capital investment required would be of the order of £25m with spares.

So far as British and American salesmen are concerned, at stake in India over the next few years is a £7m order for new medium jets and a £12m order for new short-haul jets.

There is one big unknown, namely the very real possibility of a merger between IAC and Air-India, which could be within two years. There is no secret about Air-India's objections to IAC's Caravelle order, on the grounds that IAC's major trunk routes could be handled (as Bombay - Delhi already is on a charter basis) by Air-India's Boeing 707s. But nothing is likely to alter the fact that the demand for Indian domestic air transport is growing at an insatiable rate. Load factors on trunk routes are well into the 90s, the highest in the world. "I have to open up this country," says Mr Mullick, "and I need much more capacity. I can see such potential, with still not much more than a million passengers a year out of India's total population of 450m." He estimates that of the million a year at present carried, 55 per cent is business and Government traffic, 20 per cent foreign tourists, and the balance family traffic.

J. M. R.

BACKACHE IN THE COCKPIT

A BOURNEMOUTH osteopath, Dr John Hope Robertson, claims to have discovered a crippling muscular ailment which brings temporary disablement to airline pilots. According to Dr Robertson, "a number of senior pilots are coming to me secretly for treatment. They are suffering from acute postural fatigue, caused by long flights in badly designed seats. It is fatuous and amazing, but I have found that passengers' seats are often better designed and more comfortable than pilots' seats."

Dr Robertson has examined a number of airliner cockpit seats and has found that "without exception they are all very uncomfortable and poorly designed. Most were of American manufacture." One senior pilot has told him that he was so stiff and cramped after a flight to Trinidad that he could not leave the aircraft for a time.

BOAC's director of personnel and medical services, Mr K. G. Bergin, has replied to Dr Robertson, saying: "It appears that the seats fitted to our older aircraft were not designed in accordance with the proper anatomical requirements. We have rectified this as far as possible but seats still cannot be regarded as entirely satisfactory. I am happy to say, however, that in our new aircraft further attention has been given to the anthropoemtric and other relevant factors involved."

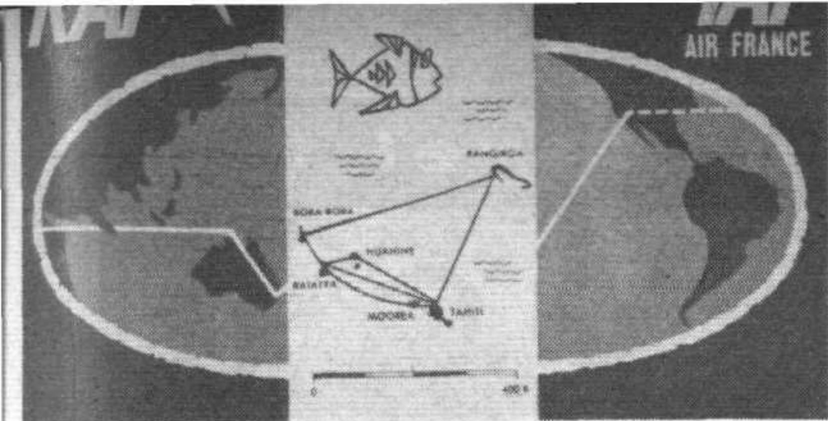
Dr Robertson says that existing pilots' seats have straight backs without any real support for the lumbar curve, with fore and aft adjustment but with none up and down. "Big and hefty pilots have to use the same seat as much smaller chaps," he says, "and this is ridiculous. After a period of reaching forward to adjust throttles and other controls pilots are susceptible to a lumbar kink. Even minor defects in seat design can cause acute fatigue and discomfort on long flights."

IMPROVEMENTS AT WOOLSINGTON

A DECCA Type 424 Mk 2 airfield control radar was recently installed at Woolsington, Newcastle upon Tyne's municipal airport, where it replaces the prototype Type 424, installed there in 1954. The Mk 2 incorporates a variable circular polarization system, instead of the linear polarization of the Mk 1, and gives a far better performance in bad weather conditions. With the sea only ten miles away, easterly winds often bring low cloud and poor visibility to Woolsington.

The new radar is only one step in a phased expansion programme which will include new terminal buildings, runway extensions, additional landing aids and improved airfield lighting. Used by over 10,000 commercial and business aircraft last year, Woolsington can expect substantial increases in traffic to result from the Government and regional authorities' plans for the revivification of NE England.

A VC10 has been BOAC route flying from Heathrow since mid-October (see page 7). By December 9, when the aircraft entered a planned maintenance and modification programme, it had completed 364hr on overseas flights. The picture shows work in progress on VC10 G-ARVF in the BOAC maintenance hangar at Heathrow. The route flying is scheduled to resume in a few days' time



By Flying-boat to the Sleepy Lagoons

By Gp Capt T. F. U. Lang, AFC

TAHITI, France's tourist paradise in the Pacific, has become the centre of a controversy about traffic rights. The French, who want trans-Tasman rights between Australia and New Zealand for their DC-8 airline UTA, have just revoked the Tahiti landing rights of the NZ airline TEAL—potentially a serious blow to the latter's hopes next year of operating DC-8s from Auckland to Los Angeles via Tahiti. Here are a passenger's impressions of the flying-boat service—one of the few such services left in the world—that links Tahiti with some of the other Society Islands.

ONE of the few remaining flying-boat services still in existence—*and* one making a profit—is operated by RAI (Reseau Aérien Interinsulaire) from Tahiti to several of the numerous islands that form the archepelago of the Society Islands. The islands are Bora Bora, Raiatea, Huhahine and Rangiroa, and they are served by a Bermuda-class Short Sandringham, F-BOIP, which is also on call for air/sea rescue and casualty services when required.

The Sandringham is mainly used for the tourist trade, although some local Tahitians use it for suburban island-hopping. From the tourist's viewpoint, Bora Bora offers the greatest attraction; there one can swim, fish, sail or just beachcomb to one's heart's content. There is still something very romantic about a flying-boat, and especially, perhaps, in the area of Tahiti, where it has opened up so much glorious atoll scenery which would otherwise be denied to the normal traveller.

My wife and I, on our travels last year, had flown by TAI's* DC-8 service from Los Angeles on the night of August 10, a flight of 4,240 miles at a speed of 543 m.p.h. Just after dawn we had swept over sleepy Papeete and on to the coral airstrip at Faaa. Nearby the flying-boat floated quietly at her moorings. On August 11 we rose very early, at 5.30 a.m., as the departure time was at 7 a.m. The wharf was alive with activity at that early hour, and baggage was being loaded into a small launch until it looked as though there was no space left. Then the little craft chugged happily over the green lagoon to the Sandringham, followed a few minutes later by two launch-loads of passengers, mostly for Bora Bora.

On reaching the gleaming boat, painted in the typical TAI/RAI white with its broad stripes of green along the hull and a huge "RAI" on its fin, we entered the main passenger compartments. In this case there were five cabins of varying sizes and seat configurations, with a total capacity for 45 passengers. We chose two red-leather seats in the front cabin, under the starboard wing, but had only just settled down when Captain D. Wertman (ex-RAF 209 Squadron) appeared and invited us both to the flight deck. We were thus given a unique opportunity of seeing the whole area and also the operation of the boat under the very capable hands of the captain and his co-pilot, Paul Duval, a delightful, portly Frenchman.

At exactly 0700hr, with 36 passengers on board, we slipped our mooring and one by one the four engines came to life. A preliminary warm-up took us over the calm waters of the lagoon, while the French fire control boat kept station ahead. Engines tested, we faced into the soft wind and with full throttle surged forward into the sun. At 0703 we were airborne, turning on to a course of about 250° for the flight to Raiatea. Soon afterwards we passed Moorea on our left, and about 45min later the atoll of Raiatea came in view through the fleecy clouds. We swept in over the reef, made a half-circuit and headed into a strong easterly wind. Soon we felt the clatter of the waves on the hull as we smoothed on to the lagoon and taxied slowly to the mooring off the main jetty. Within seconds the launch had appeared, ten Tahitian passengers were unloaded, and we were on our way again, an elapsed time of only 21min between landing and take-off (refuelling on this flight is not necessary). It was only a very short stage to Bora Bora, a mere 30 miles—14 minutes' flying-time—away.

Having unloaded our passengers and taken on an even greater number, we were airborne after 48min with a load factor of 100 per cent. Our third leg took us back round the island, out over the reef and on to a course of 55° for the flight to Rangiroa, a distance of 285 miles. Estimated flying time was 2hr, but we were heading into an easterly wind of over 25 m.p.h. and our actual landing was to be 14min late. From time to time Paul left the co-pilot's seat and came back to the navigator's table to take drift readings and make the necessary calculations, all in French. Although there is a short-wave beacon at Bora Bora, and naturally a long-range beacon on Tahiti, all navigation on this leg must be by dead-reckoning. We flew through occasional rain clouds, with the seat-belt signs glowing in the cabins, but F-BOIP rode the bumps solidly as the rain spattered heavily against the windscreen for a few minutes at a time. After an hour we ran into clear weather just before we came to the main line of atolls which stretch for hundreds of miles from west to east in this area.

Idyllic Luncheon

Eventually the atoll of Rangiroa came in sight, the blue of the ocean being broken by the silver and gold reef and then by the clear turquoise of the lagoon, an area about 40 miles in length and 20 miles wide, with the tiny village of Tiputa standing in a palm grove at the northern entrance. The water was rough inside the reef, with a long swell, though this had subsided considerably since the previous trip two days earlier, when the call had had to be missed out. However, all was well; Capt Wertman put down the Sandringham along the swell and slightly out of wind, with Paul raising the flaps immediately and cutting both the inboard engines as soon as we were waterborne. This time we were all unloaded as there was a stop-over of almost 4hr.

At the village wharf we were met by the local guitar orchestra and choir; one of the musicians was plucking at a "double-bass" made from a Mobiloil drum, a long piece of bamboo and a length of thick cord, but the end-product was very pleasing. As soon as we had all been garlanded with floral hats, and suitably greeted in typical Tahitian style, we were led through the village arm-in-arm, preceded by the orchestra. Eventually we reached the Club Méditarrané, whence we had all been invited to lunch as guests of RAI and offered facilities for bathing, fishing or just beachcombing. In due course, after a drink at the local open-air bar, we sat down to a three-course lunch: marinated fish, curried chicken, and the inevitable figure-ruiner *poi*, a popular dessert with the Tahitians.

Time passed all too quickly with the orchestra playing and the choir singing their native songs, while small children and the local dogs wandered hopefully round our tables set under a canopy of palm leaves and open to the trade-winds. It was now time to depart and once more we sped out to F-BOIP in several launches, embarked through the forward door, and in a few minutes were again airborne, this time heading on a course of 205° with a strong tail-wind for Tahiti, a distance of 210 miles. After 20min we passed the mineral island of Makatea, completely different in shape from the other islands in the area; no atoll surrounds it, and it rises with precipitous cliffs straight out of the sea for over 100ft.

About 20min later we saw the silhouette of Tahiti's peaks, Orohena and Aorai, rising above the clouds. Paul's ETA had been correct this time, much to his delight, and we made our final turn into wind and put down parallel to the main runway on schedule. A few minutes later we were finally attached to our mooring and off-loaded into a waiting launch for the short run to the wharf. Our visit to the outer islands was over for a year. Next time, with the prospect of other areas being opened, we shall return to enjoy the simplicity of these Polynesian islands, so far unspoilt by commercialized tourism.

* *TAI merged last summer with the other French independent airline UAT to become UTA.*

The High-speed Shape

PITCH-UP—AND PALLIATIVES ADOPTED ON SWEPT-WING AIRCRAFT

By K. G. Hecks (Hawker Siddeley Aviation Ltd)

THE widespread adoption of the swept-back wing for high-speed aircraft during the past 20 years achieved a partial solution to the problems of drag and buffet due to air compressibility at high subsonic speeds. At the same time it brought with it a formidable array of problems of its own, both aerodynamic and structural. Some of these have carried over into the supersonic age, in cases where wing sweep has shown itself to have substantial advantages beyond Mach 1. One such problem is a form of longitudinal instability, known as pitch-up, which frequently limits flight performance.

An aircraft is stable longitudinally (i.e., in the pitching plane) if the net effect of the aerodynamic forces and moments produced on it by an inadvertent small change of incidence is such that the aircraft tends to return to its original incidence. Fig 1 shows a typical pitching-moment : incidence curve for an aircraft which is stable over the range of incidences shown. If the aircraft is trimmed to fly at the C_L corresponding to point A, then a small increase in incidence (to B, say) will give an untrimmed nose-down moment (C_M negative) which will make the aircraft revert to its original incidence.

For stability the slope of the line in Fig 1 must always be negative, and if the required stability level is to be maintained throughout the usable incidence range the pitching-moment variation with incidence must be approximately linear. The latter requirement involves keeping the position of the overall centre of lift of the wing approximately constant under all flight conditions (except perhaps those with very low incidences when wing lift is small). Further, to reduce trim drag, and to keep trimming and control requirements within the capabilities of a tailplane of reasonable size, this centre of lift position must be close to the aircraft c.g.

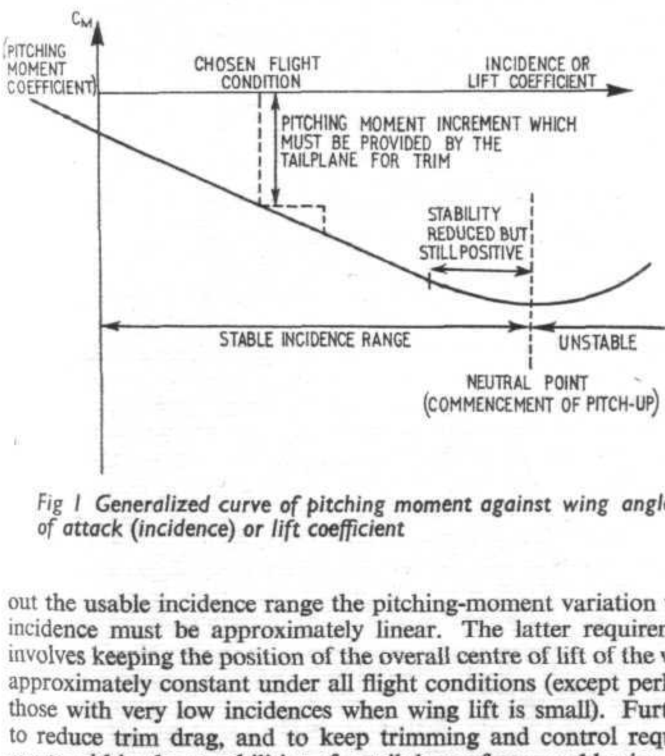


Fig 1 Generalized curve of pitching moment against wing angle of attack (incidence) or lift coefficient

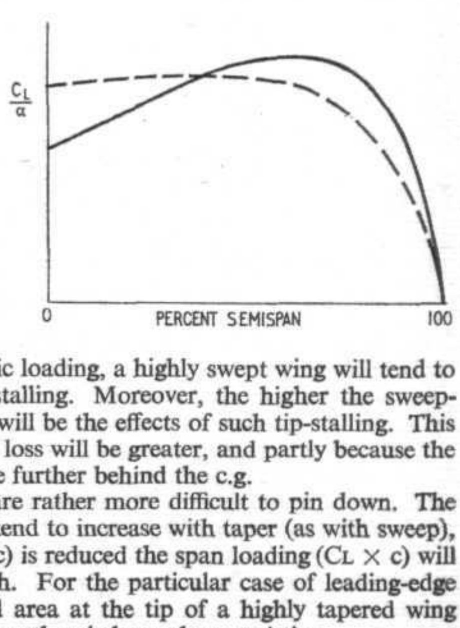
As far as a swept wing is concerned this means that the wing position along the fuselage must be such that lift achieved in the wing-root region (well forward of the c.g.) must be balanced by lift at the wing-tip region (well aft of the c.g.), and for stability this balance must be closely maintained at all times. Unfortunately an inherent characteristic of a swept wing is that under certain conditions, which may well fall within the desired flight envelope of the aircraft, the airflow separates from the upper surface at or near the tip. The resulting loss of lift, appearing as a reduction in lift-curve slope, is of little consequence in itself since it can readily be restored by a slight increase in incidence. But the position of the lift decrement is of great importance, for the longitudinal lift balance is upset by the lift aft of the c.g. being considerably less than that forward of the c.g. At incidences where this first occurs stability may be reduced but not lost; the load increment at the tailplane may still be sufficient to restore the balance and maintain stable flight. As the incidence is raised, however, the separated-flow region increases in extent by spreading inboard and eventually the nose-up moment due to this tip loss becomes too great for the tailplane. The aircraft then undergoes a rapid, uncontrolled nose-up movement which constitutes the phenomenon of pitch-up. The divergence feeds upon itself, and the separation swiftly spreads right in to the wing root—at which time stability may return.

If stability does not return of its accord considerable difficulty may be met in unstalling the wing. In the case of the prototype BAC One-Eleven, a stall with aft c.g. and flap slightly deflected led to pitch-up developing into a stable "super-stall" with very high angle of attack. In this condition the servo-tab elevator had insufficient power to get the nose down and unstall the wing.

Several other undesirable phenomena may take place as a result of separation at the tip, among them buffeting, loss of aileron efficiency, and even aileron reversal. The latter effect is an aerodynamic one, and is essentially different from the familiar case of aileron reversal due to aeroelastic distortion of the wing. Also, if the tip loss is asymmetric (occurring on one wing before the other) the aircraft will experience wing dropping or "roll off," possibly in combination with an uncontrolled yawing manœuvre. This was a characteristic of the F-86 Sabre, one of the first swept aircraft. The degree to which these effects limit the performance of a wing depends largely on the planform.

Increasing the sweep distorts the spanwise load distribution in that more and more lift is carried by the outboard region (Fig 2). Therefore, since the onset of flow-separation is strongly dependent on the local aerodynamic loading, a highly swept wing will tend to be prone to early tip stalling. Moreover, the higher the sweep-angle, the more critical will be the effects of such tip-stalling. This is partly because the lift loss will be greater, and partly because the region of lift loss will be further behind the c.g.

Fig 2 Outward distortion of the lift distribution on a swept wing: broken line, curve for unswept wing; full line, curve for 45° sweep, no twist, aspect ratio 3.0



The effects of taper are rather more difficult to pin down. The local C_L at the tip will tend to increase with taper (as with sweep), but because the chord (c) is reduced the span loading ($C_L \times c$) will probably not alter much. For the particular case of leading-edge separation, the reduced area at the tip of a highly tapered wing may substantially improve the pitch-up characteristics.

A different planform effect arises from the fact that the local chordwise centre of lift, normally at about 25 per cent chord in subsonic flow, shifts rearwards to near mid-chord when the airflow separates. If the aspect ratio is sufficiently low, this rearward shift of the centre of lift in the stalled region may, as far as pitching moment is concerned, compensate for the reduction in magnitude of the tip lift. However, the low lift-curve slope and high induced drag associated with such a low aspect ratio makes the elimination of pitch-up in this way generally impractical.

After planform geometry the most important factor to be considered is tailplane position, since the stability contribution of the latter must be suitably matched to the wing/fuselage characteristics to give the required overall stability level. The present trend towards low-set tailplanes or, in some cases, high "T-tails" (Fig 3), is an attempt to get the tailplane as far as possible clear of the intense downwash field which exists behind the wing at high incidence. This increases the incremental load produced at the tailplane by a

Fig 3 One of the largest examples of the "T-tail" yet built is that of the Lockheed C-141A StarLifter military transport, which rises almost 40ft from the ground

THE HIGH-SPEED SHAPE...

change of incidence; i.e., the tailplane contribution to stability is increased, and the aircraft can go to a higher incidence before overall stability is lost.

However, for the case of a tail position above the wing wake, an increase in incidence will give a reduction in the stability contribution of the tailplane, because the latter will be moving down into the intense downwash field. This will aggravate the pitch-up problem unless the tailplane is either (a) still above the wing wake or (b) well through it and out the other side, when wing flow-separation occurs. This state of affairs does not apply to a low-set tailplane, which can be expected to achieve a greater stability contribution as incidence increases by virtue of its movement downward and *away* from the severe downwash region. Thus, making due allowance for the possibility of a reduced moment arm, a low-set tail is generally preferable to a high- or mid-set one as far as pitch-up is concerned.

The chosen aircraft layout may not allow the use of a low tail, but in many cases where this is so (e.g., transport aircraft) the problem is in any case less severe because of the reduced downwash field obtained with a wing of relatively high aspect ratio. Further, judicious use of dihedral or anhedral can give a substantial improvement in the stability contribution of a tailplane where the attachment point has already been fixed by layout requirements. Thus, for a mid-set tail position, dihedral will help keep the tailplane above most of the downwash from a high-aspect-ratio wing, while anhedral will take it through the intense downwash from a low-aspect-ratio wing at a lower incidence (Fig 4).

It is important to note that the way the downwash over the tail varies with incidence determines not only the increased effectiveness which can be obtained by a change of position, but also the extent to which this increased effectiveness can be utilized.

An increased stability margin under less severe flight conditions may be undesirable from a control standpoint, because of the exchange rate between stability and manœuvrability. It is also true that buffeting from the separated-flow region at the tip may prevent high incidences from being used, even though the tailplane position is such that pitch-up has not yet occurred; in this case the increased range of incidences for stable flight provides a very desirable safety margin but does not extend the flight envelope of the aircraft.

Bearing in mind these various qualifications to the magnitude of the instability, it can be said that in the general case the onset of pitch-up on a swept wing sets an upper limit to the incidence (and therefore the C_L) which can be used at a given speed. This limit is less than the lift theoretically obtainable—and also usually less than that required for reasonable operation, particularly at low speeds. In the latter case the net effect is that the take-off and approach speeds used by a swept-wing aircraft are appreciably higher than they would be otherwise. At high speed, the onset of pitch-up severely restricts manœuvrability and altitude.

In view of these effects, there is often a strong case for modifying a basic swept-wing design so that its pitch-up characteristics are improved—even if its other characteristics are compromised in the process. Exceptions to this general rule result mainly from the presence of other limitations on usable incidence and C_L. Apart from the related case of severe buffeting preceding the actual pitch-up, such limitations can arise from (a) pilot's view, (b) ground clearance of rear fuselage, (c) the lateral instability of swept wings at high incidence, and (d) speed instability when approaches are made at less than V_{MD}. In most cases pitch-up is the dominant problem, and hence much of the research work on swept wings carried out since 1945—millions of man-hours in all—has been devoted to the alleviation of pitch-up and the related phenomena described previously.

Early attempts to improve actual aircraft were necessarily of a rather hit-or-miss nature, because so little was known of the mechanisms of tip flow breakdown. Extensive wind-tunnel and flight testing over the years has gradually resulted in a fairly comprehensive picture of the way the flow pattern over a swept wing varies with Mach number, incidence and section. Consequently, the suppression or control of tip flow separation has in recent years become amenable to treatment in a more logical (if still largely empirical) manner; in this connection the work of Newby of RAE Farnborough is particularly noteworthy.

A great advance was made when it was realized that, at subsonic speeds, flow separation from the surface of a wing of low t/c ratio is fundamentally different from that of a thicker wing. In the case of a thicker wing used for high-subsonic flight (e.g., the 11 per cent t/c wing of the F-86 Sabre), boundary-layer separation is turbulent, and occurs first at the trailing edge near the tip.

Since a swept wing tends to carry a substantially increased load over the outboard part of the span, the low-energy boundary layer has to travel against a much steeper chordwise pressure-gradient in this region than it would do on a corresponding straight wing. Moreover, the boundary-layer thickness is aggravated by the spanwise flow induced within it by the spanwise pressure-gradient which exists on a swept wing (Fig 5). Unlike the relatively fast free-stream air passing over the wing, the slow-moving boundary layer acquires a substantial spanwise velocity component which increases with distance outboard (Fig 6). The adverse effects of spanwise flow were a factor in the choice of transverse-tip ailerons for the Lightning. The spanwise flow and boundary-layer thickness increase with incidence, until the flow separates from the wing surface.

Since the onset of this separation is largely a function of incidence, a beneficial effect can be obtained by giving the outer wing a built-in downward twist relative to the rest of the wing (wash-out). In this way the effective tip incidence is reduced, and separation is delayed to a higher overall C_L. As will be described later in connection with shock-induced separation, a high-subsonic wing may

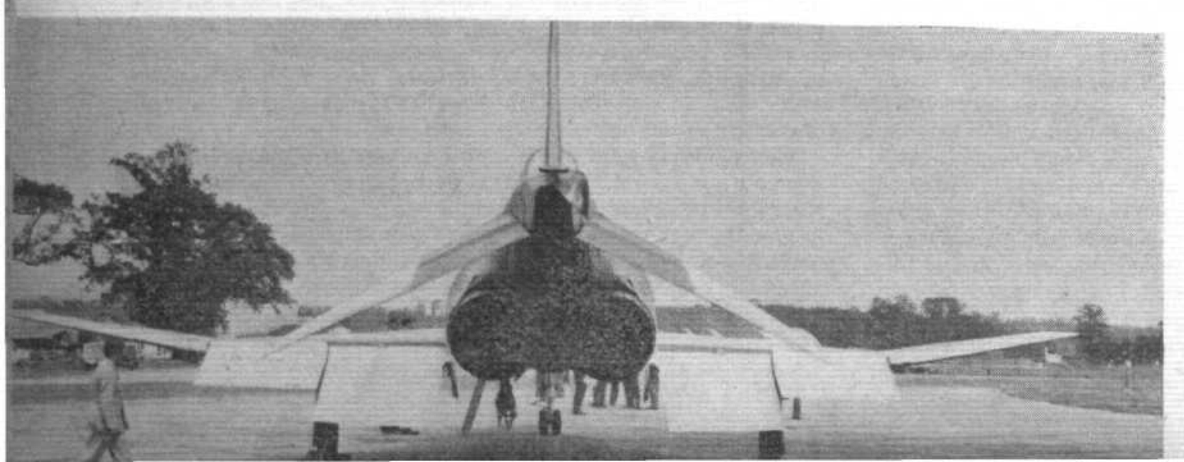
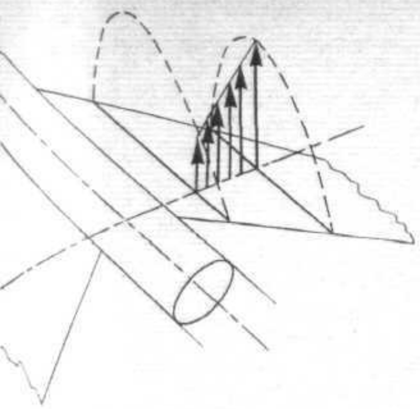


Fig 4 One of the most remarkable combinations of exceptionally high flight performance with good handling qualities has been achieved by the McDonnell F-4 Phantom series. These Mach 2.6 multi-mission aircraft have sweep, kinks, dog teeth, droop, blown flaps, dihedral on the outer wings and anhedral on the tailplane



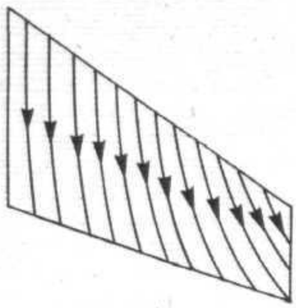


Fig 5 (left) Spanwise pressure-gradient on a swept wing; the vertical ordinates represent negative pressure, the shortest one representing the highest pressure. Fig 6 (right) Build-up of spanwise flow in the boundary layer over a swept wing

well be washed-out in this fashion anyway. In such a case the primary aim is to raise the M_{crit}-C_L boundary of the aircraft by spreading the load more evenly across the span (constant C_L); low-speed pitch-up improvements are a useful related side-effect. An extension to this concept may be used if design to attain constant C_L across the span results in substantial upward twist in the root region. With the help of some negative camber, if necessary (Fig 7), a high-incidence root can be made to stall at the same time as the tip; this maintains overall stability, although usable C_L may not be increased. An essentially similar effect may be employed if slats or flaps are used at the leading edge to give high lift at low speeds. In this case (e.g., VC10) the slat or flap is not continued

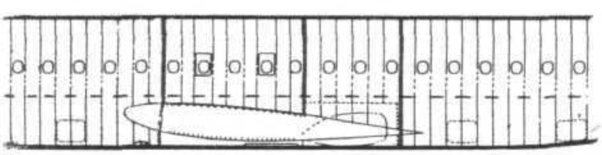


Fig 7 One of the most pronounced negative-camber wing root profiles is found on the Douglas DC-8. The section is almost a conventional aerofoil upside-down

right in to the root, which therefore stalls at high incidence as required.

Sweep being the other prime factor causing flow separation at the tip, it can be inferred that pitch-up might be delayed by decreasing the sweep over the outer wing. Such a modification was carried out on a number of aircraft (e.g., Swift and Javelin) in conjunction with, if necessary, a reduction in thickness/chord ratio to make good any loss in drag-rise Mach number. It also forms part of the philosophy behind the crescent wing, of which much was expected at one time. Reducing the sweep in this way certainly can have beneficial effects; for example, in reducing l_v, the rolling moment due to sideslip. However, as far as pitch-up is concerned, results have been rather disappointing in that the onset of separation, effectively delayed at the tip, begins to occur in the vicinity of the crank. Tunnel tests on the Supermarine 545 crescent-winged fighter suggested that an improvement at both high and low speeds would be obtained if the sweep on the outer panel were increased rather than decreased. The crescent wing as such seems to have disappeared from the scene; but its other chief characteristic, increased sweep at the root to raise M_{crit}, is still very much with us.

Once the tip has stalled the separated-flow region spreads forward and inboard as incidence increases. It is generally aggravated by downward deflection of the aileron, since this increases the effective camber of the rear part of the aerofoil and hence worsens the adverse chordwise pressure gradient; the reverse effect is also true in that the flow tends to stick when the aileron is raised, thus giving the aileron-reversal effect mentioned earlier. The use of spoilers for roll control obviates any such reversal or loss of effectiveness; inboard ailerons may also be used since, by virtue of their location, they avoid the separated-flow region. If outboard ailerons are retained their effectiveness can be improved, at the expense of a small base-drag penalty, if they are thickened to give a blunt trailing edge. This reduces the pressure gradient over the rear part of the aerofoil by reducing the curvature of the surface, but blunt ailerons are primarily to alleviate shock-induced separation which will be dealt with later.

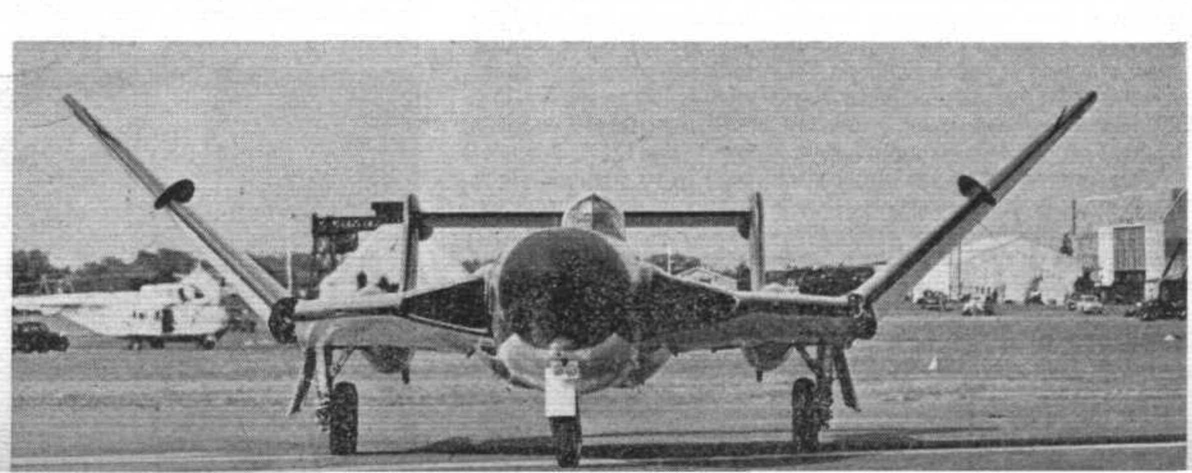
For dealing with the type of separation already considered, the most familiar methods are perhaps the airflow fence and the vortex generator or turbulator, one or other (sometimes both) having been used on many swept-wing aircraft. Usually a single fence per wing is sufficient, situated at around two-thirds span (Fig 8), although other arrangements are frequently used. In addition to the more familiar outboard fence, the early Trident prototypes were experimentally fitted with a fence close to the wing root. This simply acted as a fairing at the inboard end of the drooping leading edge and was deleted when proved unnecessary. The outboard fence gives substantial benefits and has been retained on the Trident 1E and 1F, for which the drooping leading edge has given way to Krüger flaps inboard and slats outboard.

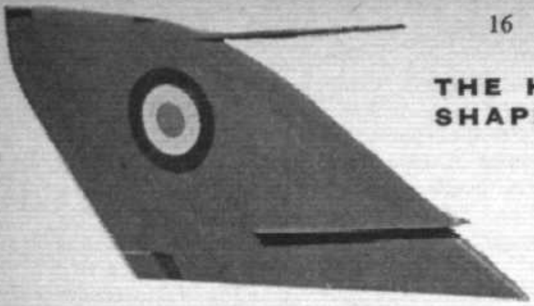
The action of a fence is rather more complex than a superficial examination suggests. Obviously, a fence across the rear part of the chord provides a physical barrier to the spanwise boundary-layer flow and, later, to the inwards spread of separation. Secondly, and particularly at high incidence, the local distortion of the flow due to a fence projecting well forward tends to cause the formation of a separated-flow region just inboard of the fence and a vortex just outboard. The flow separation is unlikely to spread and is therefore unimportant, except that the drag penalty may be substantial for a multi-fence installation, like that on the Mig-15 and Mig-17.

The vortex is generated from the free stream over the forward part of the fence, and can be quite powerful. It lies back across the wing upper surface, and acts as a kind of aerodynamic fence by sweeping away the boundary layer in that region. A very important additional effect is that the rotational speed of the air in such a vortex, when added to the normal chordwise component, gives an exceptionally high velocity over the wing surface beneath; hence the suction, and therefore the lift, in this region is increased, thus tending to compensate for the loss of lift in the separated-flow region outboard. A similar vortex, giving equivalent benefits, is shed from a discontinuity in the leading edge. Usually this is achieved by extending the wing chord forward over the outboard part of the wing, since the resulting reduced t/c ratio confers additional benefits at higher Mach numbers. The required vortex is then generated at the sawtooth junction so formed, and is sometimes reinforced by the addition of a short fence at the junction (Fig 9).

The vortex generator proper is usually a small vane, perhaps 1in to 2in high depending on the expected boundary-layer thickness in its neighbourhood. A series of these devices is fitted on one or more rows across the wing span, each vane inclined to the local airflow and usually toed-out on a swept or delta wing. Behaving like

Fig 8 An aircraft subjected to extensive development, the Hawker Siddeley Sea Vixen finally went into production with a dog tooth and single deep (but fairly short) fence at about two-thirds span on each wing. The leading edge outboard of the discontinuity is slightly drooped





THE HIGH-SPEED SHAPE . . .

Fig 9 Subjected to aerodynamic development as extensive as that of its partner the Vixen, the Scimitar has a wing with considerable sweep and low aspect ratio, with dog tooth and low fence

miniature aerofoils they generate a series of small vortices similar to the trailing vortices from a wing, and these decrease the likelihood of boundary-layer separation by injecting higher-energy air from the free stream. A row of vortex generators placed just forward of the ailerons will improve control effectiveness; but maximum C_L may not be increased because, at high incidence, separation will probably take place forward of the generators. When this happens they will be enveloped in separated flow and will cease to function; the remedy is a second row of generators further forward (Fig 10).

Under flight conditions in which the vortex generators do their required job, the improved flow over the wing surface will give reduced drag. Under other conditions, where they become superfluous, a drag penalty must be expected; in practice this will generally be negligible for a row of generators mounted well aft on the chord, but a row further forward will raise the aircraft profile drag by perhaps five per cent. Weight and complexity considerations have so far ruled out both retractable and featherable types of vortex generator; the same can be said of arrangements in which the vortices are generated by air jets issuing obliquely from a row of small holes in the wing surface.

As aircraft cruise performance penetrates further into the transonic range, wing sweep must increase and thickness/chord ratio decrease in order to raise the drag-rise Mach number. As the thickness/chord ratio decreases, a stage is reached when the trailing-edge separation typical of thick wings at subsonic M gives way to laminar separation from the leading edge. For supersonic speeds wing sections of 5% t/c or less are inevitable, because wing wave-drag is proportional to the square of the thickness/chord ratio; so leading-edge separation will occur on these wings also. Such thin profiles, often uncambered (i.e., symmetrical) and with fairly sharp leading edges, are basically unsuited to subsonic flow except at very low incidences; the airflow cannot negotiate the sharp leading edge and it therefore separates (Fig 11). In the case of a wing with an outboard crank this will probably occur at the kink, since a high suction peak is induced at this point. For a straight-leading-edge swept wing the highest suction peak and surface airflow velocity appear near the tip, so separation normally occurs there first.

Initially, there is a tendency for the separated flow to re-attach to the wing surface further back, at perhaps 15 per cent chord, the laminar flow having become turbulent. When this happens there is a bubble of separated flow over the upper surface near the leading edge; the external flow is not greatly affected, and lift and pitching-moment effects are small. At slightly higher incidences, however, the bubble bursts; a strong vortex is then formed by the rolling-up of the vortex sheet between the separated-flow region and the free stream directly above it.

This vortex lies back across the upper surface of the wing, and has an effect similar to that generated by a fence or notch. Because of the increased lift produced in the region of such a vortex, one close to the tip actually increases the lift in the tip region. Thus, the onset of separation on a thin wing causes an increase in the overall lift-curve slope, and may give an initial pitch-*down* moment. As the incidence is increased the vortex moves inboard along the leading edge, at a rate which depends on the latter's sharpness and sweep. A substantial area of low-lift separated flow is left at the tip; the lift slope decreases again, and the slight pitch-down moment changes rapidly to a strong pitch-up moment (Fig 12).

This form of separation can be countered by two methods which are essentially complementary. One is to attempt to suppress the separation; the other is to ensure that it is controlled in such a way that overall stability is not lost. Suppression involves assisting the airflow to negotiate the sharp leading edge, by (for example) reducing the effective incidence at the tip with 2° to 3° of downward twist. A second method is to make the leading edge less sharp, and therefore less sensitive to incidence; tunnel tests show that, provided the blunting is slight and confined to the tip region, there may be little or no drag penalty.

A more effective method is to increase the camber of the forward part of the wing. The cambered, or "drooped," leading edge is seen on many contemporary aircraft, though its primary purpose may be different from that suggested here. Thus the pronounced conical camber fitted to the wings of General Dynamics deltas is designed to improve the leading-edge suction and hence the lift : drag ratio for high-subsonic cruise; pitch-up improvements are a useful by-product. A limit to the amount of camber is imposed by a rise in supersonic drag, because at very low incidence the flow tends to separate from the underside of the drooped region. Variable camber, in the shape of a nose flap which can be lowered when required is an obvious remedy; but this increases weight and complexity. The same can be said of the leading-edge slat, which gives similar benefits.

Unlike the trailing-edge flap, the nose flap and slat have little effect on the lift attainable at a given incidence; rather they increase the range of incidence, and therefore lift, which can be used. In this connection it is necessary to consider the effects of boundary-layer control (for high lift rather than for laminar flow), since this is fitted to a number of current military types. When used at the leading edge, or at the knee of a nose flap, BLC by either blowing or suction delays leading-edge separation by helping the flow to adhere to the surface. Similarly BLC in front of the ailerons prevents trailing-edge separation and improves control effectiveness; in neither case is lift, as such, greatly affected. On the other hand BLC blowing applied to deflected trailing-edge flaps greatly increases the lift obtainable at low speed.

BLC is at present used not so much to boost the overall lift obtainable but rather to reduce the incidence required for a given lift.* This not only alleviates the wing pitch-up problem but also reduces the pitch-up contribution due to the fuselage, which in the case of a long-nosed aircraft is very destabilizing. The same effect is obtained with the variable-incidence wing on the F-8; when the pilot operates the jacks on the approach, the fuselage rotates nose-down about the wing.

The effects on aircraft pitching characteristics of the high local lift induced by blown flaps are similar to those of unblown flaps but more pronounced. If the flapped region is close to the aircraft c.g., the pitching moment can be trimmed out by a modest-sized tailplane, particularly one of the all-moving variety; thus inboard flaps are acceptable on most swept planforms. On the other hand, the outboard parts of a full-span flap give lift well behind the c.g. and impart pitching moments which may be intolerably high for a normal tailplane. Similarly, for inboard flaps, the lower the trailing-edge sweep and aspect ratio, the farther behind the c.g. will be the region of high flap lift and again the greater will be the tailplane power required. Because of these effects, the tailplane will have to be either very large (TSR.2 and A-5 Vigilante) or fitted with BLC (Buccaneer). In general, if no tailplane is fitted, flaps (blown or unblown) cannot be used.

If leading-edge separation is suppressed by section changes, or leading-edge devices as described above, it may happen that separation over the rear part of the chord occurs first. If this is the case a fence will help considerably, while blunt trailing-edge ailerons can be used for greater control effectiveness (Lightning, Javelin). However, the problem of aeroelastic distortion on very thin wings is causing greater use of inboard ailerons, spoiler controls and rolling

* *Reducing the incidence in this way makes landing easier, particularly on a carrier; pilot view is improved and the "hook to eye" distance is reduced, as is the distance the nosewheel has to move through at touchdown (the nosewheel slam problem).*

Fig 10 Possibly the ultimate example of "palliatives" is the wing of the Hawker Siddeley Javelin. This FAW Mk 9 has a leading-edge kink (extreme right), droop, and three rows of vortex generators

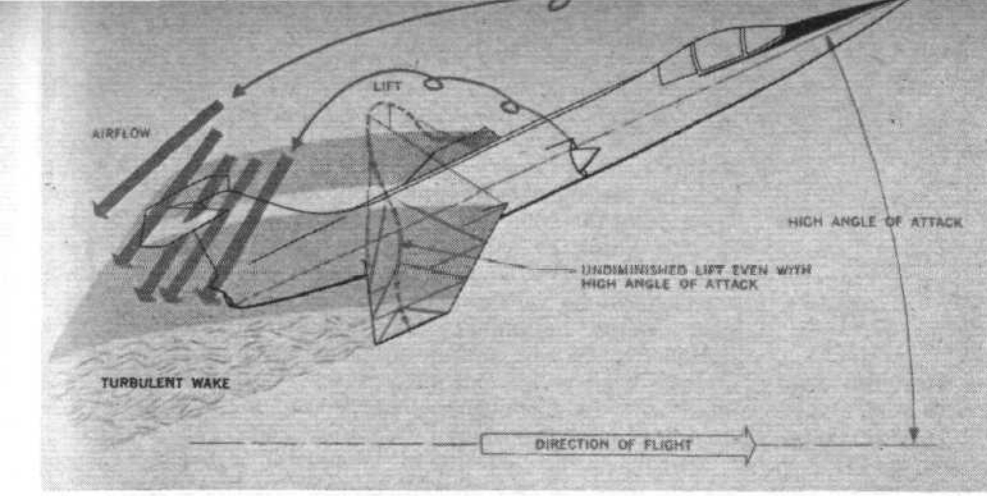


Fig 11 This sketch by the Lockheed California Co suggests the unusual pitch-up behaviour of the F-104; at extreme angles of attack the problem is aggravated by a download on the tailplane. Nevertheless, say Lockheed, the wing lift does not fall away

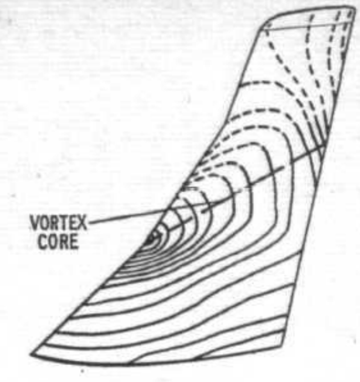


Fig 12 Leading-edge separation from a crank wing: the vortex has moved inboard to the inner crank, leaving a region of separated flow (streamlines shown dotted) at the tip

tailplanes (tailerons). Wave-drag penalty would appear to prohibit the use of vortex generators for suppressing trailing-edge separation on supersonic aircraft; moreover they have not proved very effective for preventing leading-edge separation, even when mounted right at the leading edge.

Once the wing vortex has formed it is necessary to delay its progress along the leading edge with the aid of a kink or fence and/or to counteract its effects with a second, artificially generated vortex. The latter is achieved by means of the fence if fitted (as on most current Russian supersonic aircraft), the saw-tooth junction of an extended leading edge, or a notch cut in the leading edge. The extra lift induced on the outboard panels by the secondary vortex balances the lift lost due to the onset of separation, the main vortex having moved inboard towards the root. It may be necessary to prevent the main vortex from moving right into the root, otherwise it may cause pitch-up by overriding the effects of the secondary vortex with high lift in the root region. If this is the case, downward camber applied to the leading edge in the root region (Lightning) will hold the vortex out, as will a crank in the leading edge near the root. Once the main vortex has moved inboard as far as it can, a stable flow pattern is reached with the lift from the two vortices giving a fore-and-aft balance. However, pitch-up is not entirely eliminated, because the secondary vortex will lift off the wing surface at a much lower incidence than the main vortex, thus ceasing to give the required induced lift. The fact that the main vortex, now at the root, remains stable and attached to the surface to quite high incidences is of great importance, in that it forms the basis of slender-wing aerodynamics.

Something must now be said on the subject of shock-induced separation on swept-wings. This is essentially a transonic-flow phenomenon, with the occurrence and severity strongly dependent on wing planform, section geometry (particularly thickness and trailing-edge angle), Mach number and incidence. As such it is of relatively little importance on most supersonic aircraft having very thin wings and operating only transiently in this flow regime (and then only at low incidences). But it must be suitably accounted for in the design of high-subsonic and transonic aircraft—which look like being around for a long time, at least in the form of transports.

Airflow becomes transonic when the local velocity somewhere over the aircraft surface reaches Mach 1.0. However, since the wings form the most important aerodynamic component, penetration into the transonic regime can be said to begin effectively when a sonic velocity-component is reached normal to the isobars at any point on the wing surface. Beyond M_{crit}, so defined, the appearance of shock-waves causes a rapid increase in drag, which appears as pressure drag and is due to the energy absorbed from the airstream by the shock-waves. The drag increase with Mach number is so large* that for economy/range reasons, a subsonic aircraft will not usually operate for any length of time at a speed substantially beyond its drag-rise Mach number, even if it has the power available to do so. However, a high-speed dash or an abrupt increase in C_L while manœuvring at speeds close to M_{crit} can take the aircraft well into the transonic regime, and it is therefore necessary to ensure that any adverse stability effects are delayed and minimized as far as possible. Delay of pitch-up thus becomes an extension to the overall problem of raising the C_L-M_{crit} boundary of the wing, the present tendency being to design for a suitable safety margin over and above the drag-rise Mach number.

Since the criterion is Mach number normal to the isobars, rather than free-stream Mach number, an improvement in M_{crit} can be obtained by reducing the t/c or, more effectively, by increasing the sweep. Both measures tend to be undesirable, the first from a structure/weight standpoint, the second from lift and stability considerations, particularly at low speed. In practice then, for a reasonable all-round performance without the use of BLC or variable geometry, a compromise wing of moderate sweep will be chosen; all present knowledge of transonic flow about swept wings will then be applied to the detail design of the wing such that the drag rise and flow separation are delayed as far as possible.

Usually stability itself is not much affected by the presence of shock-waves until the latter become strong enough to induce flow separation by interaction with the boundary layer. This can occur because the boundary layer will suffer a substantial loss in energy (and rise in pressure) when it passes through a shock; also the flow may be diverted in a more spanwise direction as a result of the shock reducing the chordwise velocity component while leaving the spanwise component unchanged. When separation does take place behind a shock it tends to develop a vortex form; thus the flow pattern at transonic speeds is further complicated by the possibility of interaction of shock-waves both with this type of vortex and, at high incidence, with the normal leading-edge vortex.

As has been shown earlier, the boundary layer on a swept wing tends to be thickest in the tip region; unfortunately, when the Mach number and/or incidence is raised, shocks of significant strength first appear in this region also. Accordingly, when separation does occur it will probably take place at the tip, giving a pronounced pitch-up tendency. Because the flow and shock patterns change rapidly with even slight changes in incidence or Mach number, buffeting will probably occur when flow separation takes place; in addition there is a possibility of rapid control-surface oscillations (aileron buzz) occurring.

Since the condition of the boundary layer is a dominant factor causing shock-induced separation, BLC can be very effective in suppressing, or at least delaying, it. This has been proved many times in wind-tunnel tests; but, as yet, the incorporation of BLC has found no practical application because it would be a heavy price to pay for the suppression of a phenomenon which is encountered only transiently, the wave-drag alone being a sufficient deterrent to flight in the transonic regime. The penalty associated with vortex generators is of course much less, and these devices have been used with varying success on many aircraft.

In transonic flow, the effectiveness of a row of vortex generators is very much dependent on its position with respect to the shock-waves which form. The vortex generators need to be placed a short distance ahead of the shock in order to re-energize the boundary layer before it passes through the shock; hence the optimum positioning and spacing have to be found more or less by trial and error, because of the considerable variation of shock pattern with incidence and Mach number. A beneficial effect of a different kind may result if the shock attaches itself to a row of vortex generators; when this happens, as it does on the Javelin, the normal forward progress of the shock (with incidence) is inhibited and the spread of flow-separation is curtailed.

* *Typically, the drag of a Hunter rises by a factor of five through the transonic speed range.*

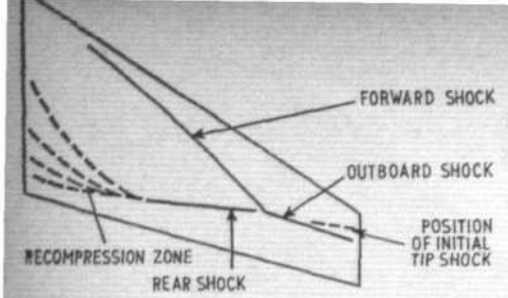


Fig 13 Shock patterns over the upper surface of a swept wing showing the location of the "initial tip shock" (after Rogers and Hall)

THE HIGH-SPEED SHAPE . . .

Attempts to delay or weaken the shock-waves themselves are, at least in the design stage, a rather more promising field of endeavour. This is especially so nowadays, in view of the great advances made in recent years towards a complete understanding of the transonic flow phenomena associated with swept wings. Following on from Pearcey's work on wing sections, the most important contributions in this field have come from the experimental and interpretive work of Rogers, Hall and others at the Aerodynamics Division, NPL.

Using the notation of Rogers and Hall, the earliest shock-wave to form is the "initial tip shock" (Fig 13). This occurs fairly well forward near the tip, and is due to the steep pressure gradient behind the abnormally high suction peak in this region. If necessary it can be delayed or weakened by reducing either the suction peak itself or the Mach number normal to isobars behind it. In the first case this involves either off-loading the tip with downward twist, or cambering the section to give a drooped leading edge. In the second case it involves reducing the t/c ratio (e.g., by extending the chord forward), or increasing the sweep by curving the leading edge backward to give a curved tip. The tip shock is, however, relatively weak and is soon overshadowed in importance by the appearance of the "rear" shock.

On a finite swept wing the rear shock occurs very early, as a direct result of the distorted pressure field which exists at the wing root. The latter effect is due to the airflow being constrained by the fuselage to flow parallel to the free-stream rather than follow its natural course over the wing. Leading-edge modifications over the outboard part of the wing have relatively little effect, but some improvement can be obtained by reducing the t/c and curvature of the outer section (e.g., by blunting the trailing edge), or by unloading it with twist. A more effective method is to modify the pressure distribution over the wing root region such that the isobar sweep is maintained right into the root. This is done either by altering the wing section in the root region or by relaxing the flow constraint noted above.

In the first case the section change involves moving the point of maximum thickness well forward, to around 15 per cent chord; such root sections can be seen on most high-subsonic transports. Maintaining isobar sweep in this way is helped by increasing the geometric sweep at the root (Fig 14). In the second case the fuselage is shaped to conform to the curve of the natural airflow streamline over the root. It is a fortunate coincidence that the indentation so formed is in many cases approximately equivalent to the waisting required by the Area Rule to minimize wave-drag due to volume. Thus, perhaps with some help from root section changes, the two effects can be achieved at the same time.

Further delay or reduction in strength of the rear shock can be obtained by the use of anti-shock bodies designed on a local area-rule basis. Though they proved ineffective when tested on a Javelin, such bodies are now being used with success (Fig 15), and appear as engine nacelles for certain of the American SCAT designs. The anti-shock body can be considered as a method of reducing the effective t/c ratio and curvature of the wing surface without incurring a large base-drag or structure-weight penalty.

With further increase in Mach number, the rear shock is followed by the "forward shock" which forms close to, and almost parallel with, the leading edge. It is relatively unimportant by itself; on a low-aspect-ratio wing it can in fact be beneficial since it weakens the rear shock by reducing the flow velocity ahead of it. For higher aspect ratios, however, the forward shock tends to intersect and augment the rear shock, giving a very strong "outboard shock" which almost invariably causes flow separation near the tip. Fortunately, because the forward shock is so strongly dependent on leading-edge conditions its formation can be readily delayed by means of a reduction in leading-edge radius, or, better still, by drooping the leading edge.

Note that for efficient (high L/D) cruise at high-subsonic speed, a swept wing will be cambered and twisted to spread the lift load evenly across the span. If isobar sweep is maintained on a constant-C_L wing of this nature, shock-waves will appear over the whole span at the same Mach number—which will be substantially higher than that for a corresponding unwarped wing. However the condition of constant C_L will be achieved only at one particular incidence, normally designed to be that corresponding to the cruise C_L of the aircraft. Hence if higher C_L is used, as in a manœuvre, the spanwise loading distorts outwards and one is then right back to the problem of shock-waves appearing first on the outer part of the wing.

A brief comment on the longitudinal stability of aircraft at supersonic speeds will serve to terminate and complete this article. As before, it is necessary to distinguish between supersonic flow which behaves supersonically and supersonic flow which behaves sub- or transonically. A quasi-subsonic flow pattern can be maintained on a highly swept wing to a Mach number of at least 1.2. Such a wing would exhibit transonic flow characteristics until much higher Mach numbers, and in such cases the possibility of shock-induced separation will persist through a large part of the speed range.

A wide usable incidence range with no likelihood of shock-induced separation will be attainable only when the flow at the trailing edge begins to behave supersonically; i.e., when the trailing-edge sweep becomes less than the sweep of the Mach cone from the trailing-edge apex. This, however, will occur at Mach 1 on a delta or straight wing and at low supersonic speeds on most other contemporary planforms since trailing-edge sweep is usually fairly low. In other words, only on a highly-swept wing will separation effects persist.

The problem is further minimized by several other factors. In the first place, leading-edge separation will continue to be the main pitch-up problem until it is suppressed by compressibility effects. Secondly, at the very high speeds involved the wing C_L (and incidence) needed to reach the aircraft "g" limit will be very small, though of course increasing with altitude. Thirdly, the wing can be given a suitable camber and twist distribution which, in addition to improving the supersonic lift : drag ratio will delay separation to a higher C_L. Finally, as supersonic flow spreads over more and more of the wing surface, the rearward shift of the local centre of pressure will begin to increase stability and counteract any flow-separation effects. When a completely supersonic flow pattern exists over the wings the aircraft will be appreciably more stable (and less manœuvrable) than it was subsonically.

In practice, the wing geometry and tail configuration of a supersonic aircraft will be based mainly on supersonic and low-speed requirements. Unless wind-tunnel tests indicate that transonic effects are likely to be particularly bad, the tendency will be to accept what comes in the way of usable C_L at transonic speeds.

Fig 14 One of the major aerodynamic modifications introduced on the later types of Sud-Aviation Caravelle is a sharp increase in sweep at the leading-edge root

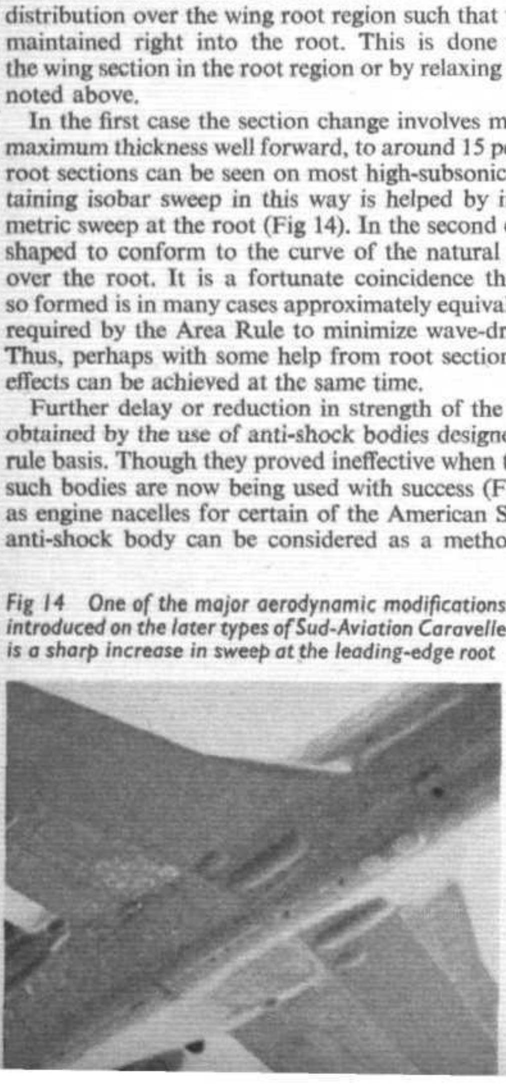
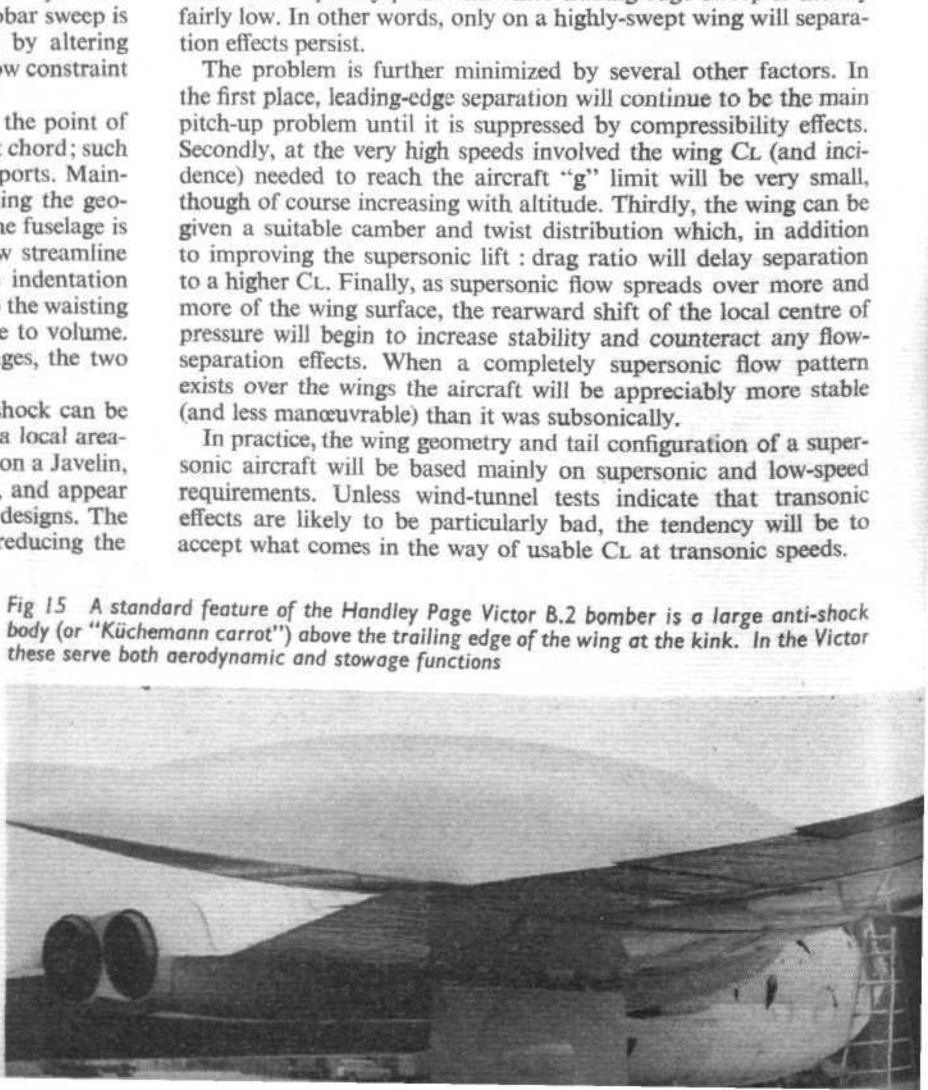
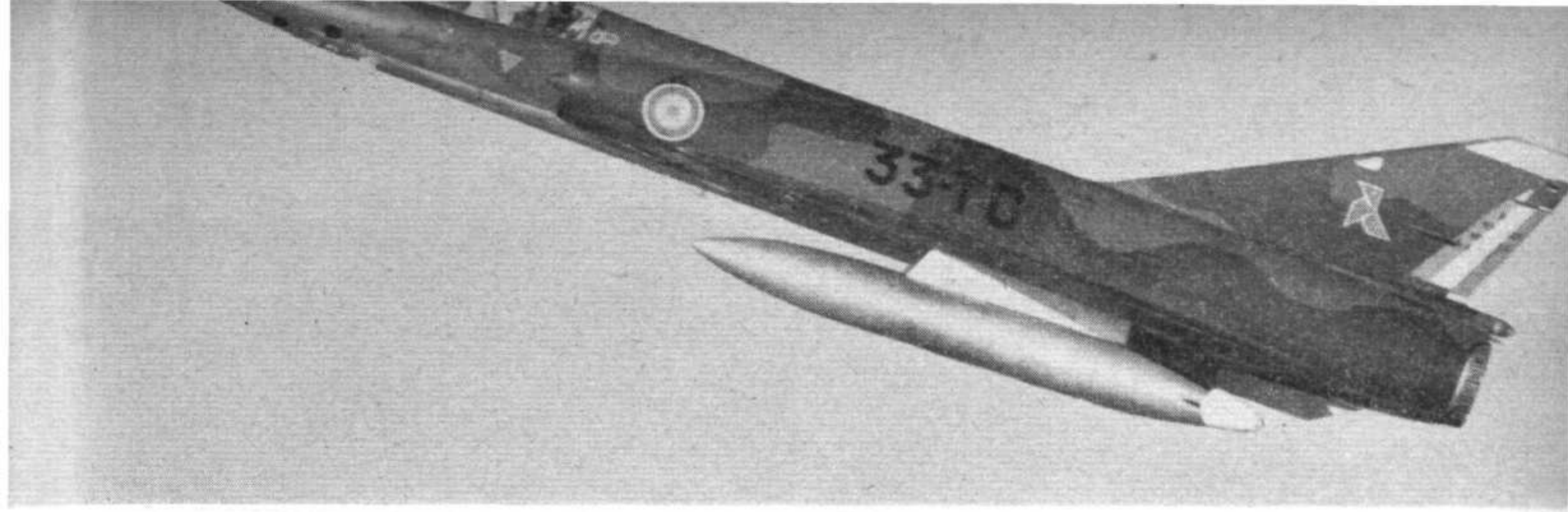
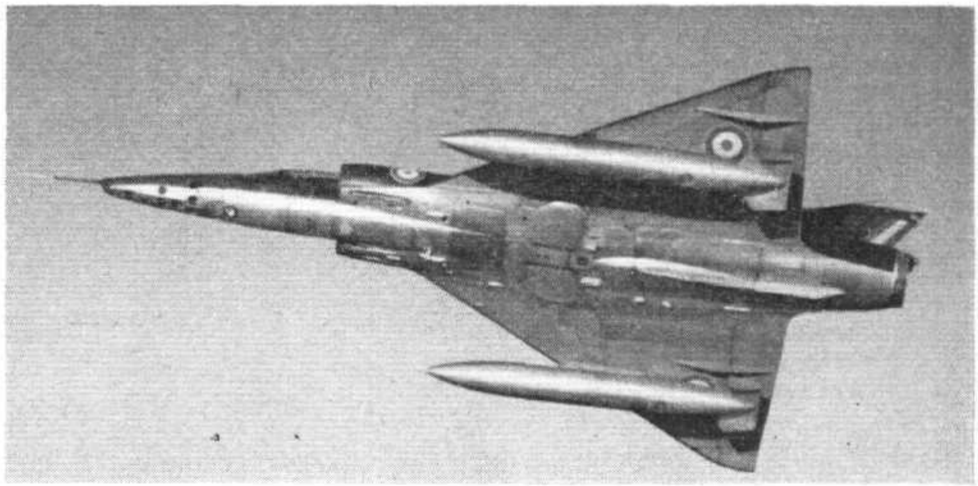


Fig 15 A standard feature of the Handley Page Victor B.2 bomber is a large anti-shock body (or "Küchemann carrot") above the trailing edge of the wing at the kink. In the Victor these serve both aerodynamic and stowage functions





COUP D'OEUIL TACTIQUE



Now operational at Strasbourg with the 33e Escadre, l'Armee de l'Air, are the first of 50 Dassault Mirage IIIRs ordered for the French Air Force. As the title indicates, *they are for tactical strike-reconnaissance.* No 33 Escadre, an element of the 4th ATAF, has converted to the Mach 2 Mirages from transonic RF-84Fs.

The Mirage IIIR marries the air-to-surface armaments of the standard Mirage IIIC strike aircraft with the longer fuselage and increased fuel tankage of the IIIE long-range intruder version. Unlike the IIICs now in squadron service, it is camouflaged. It can operate from grass fields as well as from surfaced runways. It was in a production Mirage IIIR last June that Mme Jacqueline Auriol set the new women's air speed record over a 100km circuit of 1,261 m.p.h., which awaits homologation.

In the space occupied by Cyrano fire-control radar in the purely strike versions, the Mirage IIIR carries a set of OMERA cameras: one forward-facing oblique in the extreme nose, two vertical and four side-ways-facing obliques with a choice of ports.

TIGER, TIGER, BURNING BRIGHT

. . . 'burners blazing, two English Electric Lightning F1s of 74 "Tiger" Squadron, RAF, surround the cameraman in the warm, pungent vapours of burned Avtur and roar off to paint four spots of fire on the depression-grey canvas of an English winter sky. Already blurring in the murk, the leader pulls up into a rocketing climb which will thrust him into a sunlit realm before the vapours drift away. On the Lightning behind, a tardy nosewheel lags . . .

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.

Accident Prevention

SIR,—Much has been written lately about the causes and prevention of aircraft hitting the ground. Here are a few points concerning the prevention and detection of human and other errors which cause many of these accidents.

The incidence of human error in navigation may depend on the method of presentation of the current navigational information on the instrument panels on the flight deck. For instance, ILS cross needles with small failure-warning flags may (or may not) be more liable to misinterpretation than a full integrated flight system with situation display and demand indicator and with conspicuous warning flags; but the latter may be more liable to human faults in setting up the equipment, since it may need as many as seven actions to prepare it for use.

The incidence of human error in navigation may also depend on the allocation of tasks to the crew members and on the degree of mutual monitoring. The following questions may be important:

(*a*) What is the relative rank, status and degree of training of the crew members and under what conditions may they exchange duties?

(*b*) Does one pilot do both the instrument and visual part of an approach and landing?

(*c*) Has the co-pilot explicit instructions to monitor the flight instruments after take-off and on descent and approach?

(*d*) Has the navigator (if any) explicit responsibility for terrain clearance from take-off to touchdown?

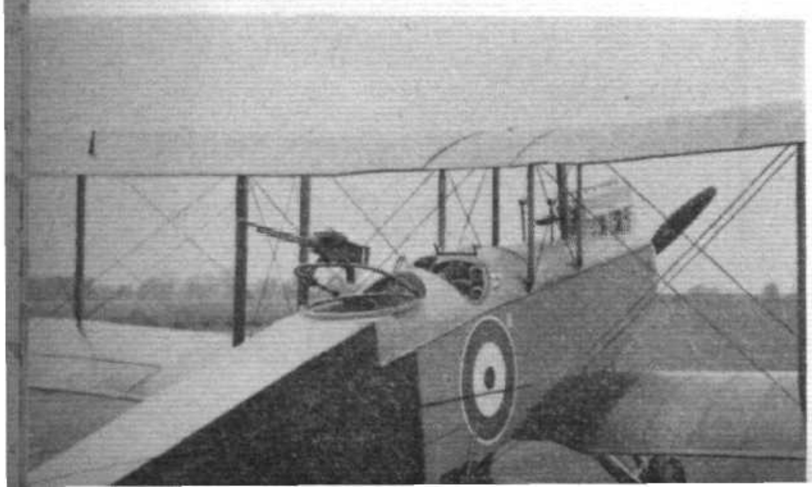
These human factors might be examined by a body such as the Institute of Aviation Medicine, Farnborough.

Several accidents have occurred with either (i) a very inexperienced first officer or (ii) co-pilot in left-hand seat, or (iii) both pilots captains. Statistics might show whether these circumstances are coincidental or causal.

Once a dangerous mistake has been made, a reliable direct warning of the proximity of ground ahead, given at the time, would seem the best method of combating the human or other error. If the TSR.2 can fly at supersonic speeds very close to the ground and avoid it safely by means of its terrain-clearance radar, perhaps a cheap "box of magic," similar but simpler, could be developed for civil aircraft.

J. D. PROCTOR,
(*Captain*)

[*Although relative crew status is very probably taken into account during individual accident inquiries, a statistical analysis of this factor would indeed be interesting. As for the terrain avoidance radar, it seems highly unlikely that the airlines would accept the cost and maintenance burden of even the relatively lightweight but untried systems available.—Ed*]



Not quite what it seems to be. This D.H.9, apparently in full First World War fighting trim, is actually a radio-controlled model, described in a letter on this page

Press Sensationalism

SIR,—At a time when the airlines of this country are trying to attract more passenger traffic, and the aircraft industry to sell their "bus stop" jets, why must they fight against the outdated sensational attitude of the popular press, and for that matter, the high rate of mental instability found in the ranks of "television aircrew?"

The particular front page item that triggered this little outburst was headed:—


27 FLEE FROM BLAZING AIRLINER

It continued by giving the impression that these fortunate persons managed to escape from the aircraft just before it was enveloped in flames. However, the final paragraph told us that ". . . Five of the passengers refused to reboard the airliner two hours later after the fault had been repaired." Confronted with what must have been a charred wreck, the other 22 passengers must have been mad!

Boscome Down, Wilts B. DAVIES, LIEUTENANT RN

Ten-channel D.H.9

SIR,—In the issue of *Flight International* dated June 15, 1961, you published a photograph of my radio-controlled flying scale model of the Sopwith 1½-Strutter.

Having noted your interest, I now enclose a photograph of my recently completed D.H.9. The model is built to 1/6th scale, giving a span of 6ft. Weight is 7lb and power supplied by a glow-plug ignition engine of 7c.c. capacity. The ten-channel radio gear, having a range of approximately one mile, provides selective and simultaneous control of rudder, ailerons, elevator, trim elevator, and progressive throttle settings.

Sutton Coldfield, Warwicks D. E. THUMPSTON

Slow Comfort v Fast Danger?

SIR,—As a customer of the aircraft industry (I fly many thousands of miles a year in the way of business), I naturally do not feel elated to discover that the very latest in transport aircraft is just as vulnerable as any of its predecessors. Arising out of this, I am compelled to wonder whether designers and operators should not be constrained by suitable Ministry instructions to devote their efforts to making aircraft safer rather than quicker.

With regard to modern jet aircraft being quicker, it is of course true enough that flight times are considerably reduced. It is only this factor that makes the journeys bearable, for I can imagine nothing more uncomfortable than the seating arrangements in the tourist cabin of a jet liner. This so-called high-density seating is almost an insult to the passengers, the majority of whom board the plane with apprehension and leave it with a sigh of relief. In contrast to this I can remember actually enjoying my flights in DC-6s and similar aircraft. Plenty of room to stretch one's legs, a leisurely service of meals (instead of a tray thrust under one's nose) and even an opportunity to see the ground and enjoy the scenery. And best of all perhaps, no feeling of inferiority on being herded into a tourist compartment after watching others having VIP pretensions (or more ample expense accounts) marching with lordly gait to the first-class entrance.

The penalty one paid for all this was that it took, say, six hours to fly from São Paulo to Buenos Aires as against two hours now. One must also admit that at times one had rather too good a view of the Andes when flying from

Buenos Aires to Santiago de Chile, whereas today we hop this journey in little over an hour, and the peaks always seem far enough away—until we begin to descend, which is a protracted and often uncomfortable procedure when the aircraft lets down from thirty thousand feet or so at a very shallow angle through never-ending layers of cloud.

I have referred to the saving in flying time as the justification of the jet. Sometimes, however, the overall time from door to door means that the reduction in flying time has little significance, except as already noted to enable one to endure the physical and mental strain involved.

For example, on a typical Sunday journey from São Paulo to Buenos Aires, I leave my apartment at 0630hr and take a taxi to Congonhas airport, just on the outskirts of the city. From there I am transported by a bus leaving Congonhas at 0715 and arriving at the international airport of Viracopos (95km distant) at 0900. A flight is due to leave at 1020 and frequently does. The arrival time in Buenos Aires is around 1230, and usually one is not unduly delayed in the Customs. The airport is about 40km outside the city, and if all goes well one can reach one's hotel at 1400hr. Thus the elapsed time of the trip under good conditions is 7hr 30min. In the old days of piston-enged aircraft the overall time would be as much as 12hr. One flew from Congonhas (not Viracopos) after an early breakfast on Sunday and arrived in Buenos Aires for dinner. The whole day was devoted to the trip, which now I can do in seven or eight hours. No doubt this is a tremendous advantage. Or is it?

The majority of people who use air transport for business or pleasure want something safer and more comfortable rather than something quicker and more dangerous. But they won't get it!

Sao Paulo, Brazil JAMES E. SAXTON

LAP at Fairlop

SIR,—I find Air Cdre Payne's *Air Dates* a most valuable reference book, but am surprised that he makes no reference to that eventful date November 18, 1946, when the Nene-engined Lancastrian made the first jet-engined international transport flight between Heathrow and Le Bourget (returning to Heathrow on November 22).

One item in *Air Dates* intrigues me—the entry that on December 16, 1937, the Court of Common Council agreed to buy nearly 1,000 acres for £289,700 at Fairlop, near Ilford, for a new City of London Airport.

When and why was a decision taken not to proceed with this project?

Leigh-on-Sea, Essex LESLIE HUNT

Names for Numbers

SIR,—Why does the British aircraft industry continue to give its new types numbers instead of names? I can list nine recent aircraft which have been numbered: Bristol 188, VC10, P.1127, P.1154, BAC One-Eleven, H.P. 115, D.H.125, Short SC.1 and TSR.2. The industry has only been doing this recently—I believe it's an American habit. There are only two new aircraft with names, Trident and Concorde. It seems to me that if tanks and ships and missiles can be named, aircraft should be. One name I have heard applied to the 188 is Flaming Pencil, and to the One-Eleven, Challenger.

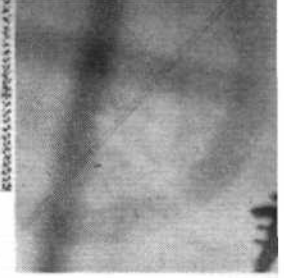
Lymington, Hants. C. J. TALLACK

[*Most aircraft start out with numbered designations, then receive names when they enter service. Thus the Hunter was the P.1067, the Lightning the P.1 and the Viscount the V12. The British aircraft industry is in fact a minority in naming its aircraft, other countries sticking to numbers—e.g. Boeing 707, Douglas DC-8, Tupolev Tu-114, etc.—Ed*]

Two War Fakes

SIR,—Reference your report about Mr Carr's fake picture (page 946, December 12), readers may be interested to see some fake work I did early in 1945 with a box camera.

The subjects—a B-17 Flying Fortress and a P-51 Mustang—were arranged thus: a cleft stick held the wing tips (hence the B-17's missing port wing tip and the P-51's starboard



Again, not quite what they seem to be. Two of Mr C. R. Elliott's fake air-fighting shots

wing tip), a rough cardboard gunsight was similarly held, and the wireless aerial in my garden became the aerial of an accompanying Fortress whose mid-upper gun hatch was used by the photographer. The Fortress depicted had just been hit and was going down: the Mustang, as it flashed by, had a damaged port wing tip.

Mr Carr, I note, used proper models. I simply cut my aircraft from magazines and mounted them flat. Some of my Fortress friends—experienced air fighters too—were taken in by both. The gunsight foxed them more than anything else, as did the aerial: although, it will be noted, the aerial is the wrong side of the gunsight.

London, SW19 CHRISTOPHER R. ELLIOTT

Backing the Wrong VTOL Horse?

SIR,—Newspaper reports indicate that the basic Hawker P.1154 design does not possess sufficient range for the Navy's purposes, especially when converted to a two-seat variant.

Since the proposal to use a joint RAF/RN aircraft is not new, it is surprising that the Government did not continue to develop the composite VTOL system which, among other things, claimed a longer range than the single-engined type. The composite system has been successfully developed abroad, after initial work had been done in this country, in the Dassault Balzac, but perhaps the best combination so far proposed is for the EWR-Süd VJ 101D, which is to carry (if it is built) three engines only for purely vertical flight—a weight penalty of around 7cwt. Rolls-Royce and Dassault claim that the weight of eight lift engines is less than the extra weight of fuel required for the single lift/thrust engine, and of course there would be an even greater saving in the case of the VJ 101D.

It is surprising, therefore, that a composite powerplant aircraft—the feasibility of which has been proven in flight by the Short SC1, the Dassault Balzac and the EWR-Süd VJ 101C—was not originally selected as a joint RAF/RN aircraft, as it has the added advantage of being multi-engined, as the Navy prefer, instead of an aircraft with a completely different and at the time untried system on which development work had to start again from scratch.

Grey College, Durham T. N. ALLEN

FORTHCOMING EVENTS

Jan 2	*RAeS Young People's lecture: "Man-powered Flight," by Prof T. R. F. Nonweiler.*
Jan 2	*RAeS, Yeovil Branch: "The P.1127," by A. W. Bedford.*
Jan 7	*RAeS, Belfast Branch: Film evening.*
Jan 7	*Combustion Institute, British Section: Colloquium on Decomposition and Ignition of Peroxides, Oxford.*
Jan 8	*RAeS, Chester Branch: "Airliners of the Future," by G. H. Lee.*
Jan 8	*RAeS, Christchurch Branch: "Airfield Construction and Layout," by R. F. Lloyd Jones.*
Jan 8	*RAeS, Swindon Branch: a.g.m. and films.*
Jan 8	*Institution of Mechanical Engineers, Internal Combustion Engines Group: "Estimating Effects of Altitude, Ambient Temperature and Turbo-charger Match on Engine Perfomance," by N. D. Whitehouse, A. Stotter and M. S. Janota.*
Jan 8	*RAeS, Southend Branch: Main lecture, "The VC10—Project Design and Development," by E. F. Maighall.*
Jan 8	*Kronfeld Club: "1963 Regional Gliding Competitions at Dunstable," by Ron Watson.*

FLIGHT International

JANUARY 1964

AIRLINER CENSUS

No 6 OF THE SERIES

THIS is the sixth *Flight International* Airliner Census to be published and, as before, is a very extensive revision of the previous edition, which appeared in our issue of December 20, 1962. As usual, great care has been taken to ensure that the Census is as complete and accurate as possible, a task which involves checking and cross-checking several sources of information—sources which sometimes contradict each other.

This contradiction is perhaps most in evidence regarding the types used by Aeroflot: the Russian airline's Il-18 and Tu-104 totals are based on registrations for which there is definite evidence, but some observers estimate that Aeroflot has at least 200 of each of these types. It may be significant, though, that the figures quoted in this year's Census are much closer to the 1962 ICAO estimates of 60 Il-18s and 130 Tu-104s quoted in the 1962 Census than to the figure of a couple of hundred each. As in past years, any additions or deletions to the Census that readers can suggest—whether to Russian or other types—will be welcome for the reason that perfection in a compilation such as this, involving as it does literally hundreds of separate totals, is never entirely possible.

The usual method of presentation has been adhered to: numbers of aircraft now in service (with any still to be delivered in parenthesis) are listed according to the nationality of their manufacturers, and each column has regional sub-divisions for ease of reference. In several instances the appropriate mark number or sub-variant designation appears against the airline's name: the letter "B" indicates Boeing 720B or Fokker/Fairchild F-27B; "F" and "CF" indicate DC-7F and DC-7CF; "C" indicates L-188C Electra, and "A" indicates Fokker/Fairchild F-27A. The letters FS after a number indicate that the aircraft in question are known to be up for sale, while the letter L denotes that the airliners are leased to the carrier, usually by another airline. Other abbreviations are: FS = Flying Services, AS = Air Services, A/W = Airways; an airline's full title can in most cases be obtained by referring to this journals' World Airlines Survey of April 11, 1963. Where aircraft have been modified to a later model—e.g., Convair 340s to 440 standard—they are listed under their original type.

UNITED KINGDOM

Airspeed (now Hawker Siddeley)

AMBASSADOR: No built 21, in airline service 14.

N. and S. America	Europe	Mid-East and Africa	Asia and Australasia
	Autair 1		
	BKS 5		
	Dan-Air 6		
	Globe Air 2		
	14		

Avro (now Hawker Siddeley)

ANSON/AVRO XIX: No built 11,020, in airline service 20.

N. and S. America	Europe	Mid-East and Africa	Asia and Australasia
Atlantic 1	BKS Air Survey 1	Afric Air (Algeria) 3	Brain & Brown 1
Austin 2	Derby 1	CGT en Algerie 1	Southern Scenic 3
Kenting 2		SGAAAF (Algeria) 2	
Trans-Air 3			
8	2	6	4

YORK: No built 257, in airline service 5.

N. and S. America	Europe	Mid-East and Africa	Asia and Australasia
Trans-Air 1	Dan-Air 1	Trans-Mediterranean 1	
	Skyways 2		
1	3	1	

Aviation Traders

CARVAIR: No of DC-4 conversions on order 36, in airline service 11(25).

N. and S. America	Europe	Mid-East and Africa	Asia and Australasia
	Aer Lingus 2(1)		
	Alisud 1(L)		
	Interocean/Intercontinental 2		
	BU Air Ferries 6(24)		
	11		

Bristol (now BAC)

BRISTOL 170: No built 214, in airline service 53.

N. and S. America	Europe	Mid-East and Africa	Asia and Australasia
Wardair 1	Air Frêt 3	TAG (Gabon) 2	Ansett-ANA 1
	Air Transport 3		Ansett-MAL 1
	Aviaco 2		Straits AFE 7
	Iberia 2		TAA 2
	SCAL 1		
	Spantax 1		
	BKS 2		
	BU Air Ferries 21		
	Channel 2		
	Dan-Air 2		
1	39	2	11

BRITANNIA 100: No built 15, in storage 14.
BRITANNIA 300, 310, 320: No built 45 (excl. 23 milit. 252/253), in airline service 36(4).

N. and S. America	Europe	Mid-East and Africa	Asia and Australasia
CPAL (310) 5	BKS (100) (1)	El Al (310) 1	
Aeronaves de Mexico (300) 2(FS)	BOAC (100) 14*	Ghana (300/310) 2	
Cubana (310) 3	BOAC (310) 10		
	BUA (300/310) 8 †		
	British Eagle (310/320) 3(4)		
	CSA (310) 1(L)		
	Globe Air (310) 1		
10	37(4)	3	

* In storage. † Includes two on long-term lease from BOAC.

Airspeed (now Hawker Siddeley) Ambassador

de Havilland (now Hawker Siddeley)

RAPIDE: No built 697, in airline service 92.

N. and S. America		Europe		Mid-East and Africa		Asia and Australasia	
Errecaborde (Argentina)	1	Aer Turas	1	Aero-Sahara	2	Madras Presidency	2
SATGA	2	Air Affairs (Belgium)	1	Aero-Sud (Algeria)	2	Air Charter	1
TAASA (Argentina)	6	Air Caen	1	Air Brousse	5	Alpine	1
Taxader (Brazil)	4	Dragon (Sweden)	1	Air Frêt	5	NZNAC	2
		Nor Flyselskap	1	Air Madagascar	4	Southern Scenic	3
		Svenska Aero	1	Caspair	4	Transpac	1
		Air Navigation & Trading	3	Air Saoura	1	West Coast	1
		Bardock AS	1	Euraf-Air	1		
		BEA	3	Owenair	1		
		Bournemouth Air Taxis	1	Rhodesia United	3		
		Mayflower AS	1	CSTA (Senegal)	1		
		Morton	1	Seychelles Kilimanjaro	2		
		Solair	2	SNATA (Algeria)	2		
		Stramsway	1	STA (Angola)	3		
				STRAC (Tunisia)	3		
				TAGP	2		
				TA de Cabo Verde	1		
				TAG (Gabon)	4		
				Victoria Falls	3		
	13		19		49		11

DOVE: No built 534, in airline service 62+.

N. and S. America		Europe		Mid-East and Africa		Asia and Australasia	
Executive	1	Aero Transport	1	Arkia	1	All Nippon	3
Golden Isles	?	Balair	1	Gulf	1	TA de Timor	2
Grand Canyon	1	Falcks	1	Iraqi	1	Air Charter	1
Hawaiian Air Tours	?	Itavia	1	Bristow Helicopters	1	Exec-Air Taxis	1
Inlet	?	Martins	1(FS)	CSTA (Senegal)	2(L)	MMA	1
Reading AS	2	SATA (Azores)	2	DETA	1	Robby's	1
TAG Airlines	2	Schreiner Aero Contractors	1	Rhodesian Air Services	1	TAA (Flying Doctor)	3
Timmins	1	Veens Air Services	1	Sudan	3		
Tropical	5	BU Air Ferries	1	TA de Cabo Verde	3		
Yankee Airlines	1	Dan-Air	2				
RETA (Brazil)	1	Derby	1				
TAN (Venezuela)	1	Channel	2				
		Morton	4				
		Metropolitan	1				
		Sky Charters	1				
	15+		21		14		12

HERON: No built over 150, in airline service 62(2).

N. and S. America		Europe		Mid-East and Africa		Asia and Australasia	
Inlet	?	Air Paris	1	Gulf	4	All Nippon	9
Ocean Shores	2	Falcks	3	THY (Turkey)	7(FS)	Fuji	1
Leeward Is. AT	2	Malta Metropolitan	(2)	Aero-Sahara	1	Transpac	2
		Scan-Fly	1	Air Afrique	2	Associated	1
		Sudflug	2	Ghana	2	Connellan	2
		BEA	2	Sierra Leone	1	Fiji	4
		BUA (CI)	2	STA (Angola)	1		
		Dan-Air	1	TAGP	1		
		Executive	3				
		Morton	3				
		Mercury	2				
	4		20(2)		19		19

COMET 4, 4B & 4C: No ordered 69 (exc. 7 milit. and executive), in airline service 59(3).

N. and S. America		Europe		Mid-East and Africa		Asia and Australasia	
A. Argentinas(4)	3	BOAC (4)	19	MEA (4C)	4		
A. Argentinas (4C)	1	BEA (4B)	13	Kuwait (4C)	1(1)		
Mexicana (4C)	3	Olympic (4B)	4	EAAC (4)	3		
				Sudan (4C)	2		
				UAA (4C)	6(2)		
	7		36		16(3)		

Handley Page

HERMES: No built 25, in airline service 1.

N. and S. America		Europe		Mid-East and Africa		Asia and Australasia	
		Air Links	1				
			1				

HERALD: No on order 34 (including milit.), in airline service 19 (8).

N. and S. America		Europe		Mid-East and Africa		Asia and Australasia	
Eastern Provincial	4	BEA	3	Arkia	(2)	Cruz	(2)
Sadia	(2)(L)	BUA (CI)	6				
		BUA	1				
		Globe Air	2(2)				
		Itavia	2				
	4(2)		14(2)		(2)		(2)

Hawker Siddeley 748 Series I

Hawker Siddeley

748 Series I & 2: No on order (excl. military, executive and Indian production) 20, in airline service 15(5).

N. and S. America		Europe		Mid-East and Africa		Asia and Australasia	
A. Argentinas	10(2)	BKS	2			Thai	(3)
		Skyways	3*				
	10(2)		5				(3)

* One leased to BKS from June, 1963.

ARGOSY 100: No built 10 (exc. 56 milit.), in airline service 10.

N. and S. America		Europe		Mid-East and Africa		Asia and Australasia	
Capitol	5	BEA	3				
Zantop	2						
	7		3				

Scottish Aviation

TWIN PIONEER: No built about 50 (excl. 50 milit.), in airline service 13.

N. and S. America		Europe		Mid-East and Africa		Asia and Australasia	
		Bristow Helicopters	1	BOAC Associates	2	Borneo	1
		Fjellfly	1	Sierra Leone	1	Garuda	3
						PAL	4
			2		3		8

Short

SANDRINGHAM: No built 33, in airline service 8.

N. and S. America		Europe		Mid-East and Africa		Asia and Australasia	
CAAA (Argentina)	5					Airlines of NSW	1
						Ansett-ANA	1
						RAI	1
	5						3

Vickers (now BAC)

VIKING: No built 166, in airline service 38.

N. and S. America		Europe		Mid-East and Africa		Asia and Australasia	
LADE	2	Aero Transport	2	Iraqi	3		
		Air Inter	2				
		Airnautic	5				
		Condor-Flugdienst	2				
		Mediteravia	1				
		Air Ferry	3				
		Autair	6				
		BUA	1				
		Channel	7				
		Eros	3				
	2		32		3		

VISCOUNT 700 series: No built 285, in airline service 227 (7).

N. and S. America		Europe		Mid-East and Africa		Asia and Australasia	
Aloha	3	Air Inter	6	Aden	2	IAC	12
Hawaiian	2	Alitalia	14	Iraqi	4	PAL	3
TCA	47	Flugfelag	1	Iranian	3	UBA	2
Timmins	1	BOAC Associates	1	Jordanian	2(L)	Ansett-ANA	3
Trans-Air	1	British Eagle	2(FS)	MEA	4	TAA	9
United	47	BUA	4	Kuwait	3		
Bahamas	4	Cambrian	5	THY	4		
BWIA	5	Channel	1(7)	CAAC	5		
LAV (Venezuela)	4	Starways	2	UAA	5		
PLUNA	3						
TACA Internat.	3						
VASP	10						
	130		36(7)		32		29

VISCOUNT 800 series: No ordered 145 (exc. executive versions), in airline service 131.

N. and S. America		Europe		Mid-East and Africa		Asia and Australasia	
Continental	11	Aer Lingus	8	Ghana	3	All Nippon	8
VASP	5	Austrian	5	SAA	8	CAAC (China)	3(3)
		Condor-Flugdienst	3			PIA	3
		KLM	9			Ansett-ANA	6
		LOT (Poland)	2			TAA	3
		Lufthansa	8			NZNAC	4
		BEA	39				
		BUA	6				
	16		80		11		24

VANGUARD: No built 44, in airline service 43.

N. and S. America		Europe		Mid-East and Africa		Asia and Australasia	
TCA	23	BEA	20				
	23		20				

COMMONWEALTH

de Havilland Australia

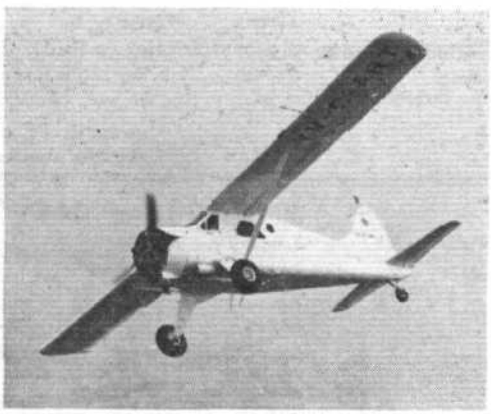
DROVER: No built 20, in airline service 11.

North America	Latin America	Europe	Elsewhere
		Air Navigation & Trading 2	Fiji 2
			New Hebrides 1
			TAA 1
			TAA (Flying Doctor) 5
		2	9

de Havilland Canada

DHC-2 BEAVER: No built over 1,500 (including milit.), in airline service 118.

North America	Latin America	Europe	Elsewhere
Petrcleum Helicopter Service 1	Aero Chaco 2	Spantax 1	CAAC 6
Wien Alaska 1	Aerotaxi 16		DETA 1
Aklavik 1	Aerovias CA		World Wide Helicopters 5
Athabaska Airways 1	Servicios Apure 1		Aigle Azur 1
Austin 6	Empresa Taboy		Aramco 3
BC Air Lines 10	Taxader Boyaca ?		Garuda 3
BC Yukon 2	Falkland Islands Govt AS 2		Nitto 1
Baie Comeau AS 1	Lineas Aereas Taxader 2		Air Charter 1
Bertrand Airways 1	RANSA 3		Avmar (Australia) ?
Bradley 1	Taxader (Brazil) 2		Fieldair 3
Coast Range A/W 2			Robby's 1
Connelly-Dawson 2			
Eastern Provincial 8			
Fecteau 13	29	1	25
Fredericton Aviation ?			
Gagnon 2			
Gateway Aviation 1			
Gold Belt AS 2			
Hollinger Ungava 1			
Ilford 1			
Island Airlines 1			
Kapuskasing FS 1			
LaSarre AS 1			
Laurentian 6			
Manitoba Govt. AS 6			
McMurray 1			
Nanaimo Air Lines 1			
Newfoundland Air Transport 1			
Northern Mountain 1			
Northern Wings 4			
Omineca AS 1			
Ontario Central 2			
Pacific Western 16			
Rainy Lake A/W 1			
Saskair 5			
Sept-Iles AS 1			
Sherritt Gordon 1			
Sioux Narrows A/W 3			
Sproule Projects 2			
Taylor A/W 1			
Thomas Lamb A/W 1			
Trans-Air 3			
Trans-Provincial 2			
Wardair 1			
West Coast AS 1			
Wheeler 4			
White River AS 1			
126			



de Havilland Canada DHC-2 Beaver

DHC-3 OTTER: No built about 500, in airline service 42.

North America	Latin America	Europe	Elsewhere
Eastern Provincial 5	Lineas Aereas Taxader ?	Solbergfly 1	Aigle Azur 4
Fecteau 3		Wideroes 2	PAL 3
Hudson Bay 3			TAA 2
Laurentian 1			
Manitoba Govt. AS 2			
McMurray 2			
Northern Wings 1			
Pacific Western 5			
Saskair 1			
Thomas Lamb A/W 2			
Wardair 3			
Wheeler 2			
30	?	3	9

DHC-4 CARIBOU: No on order 218 (including milit.), in airline service 2.

North America	Latin America	Europe	Elsewhere
			CAT (Formosa) 2
			2

Canadair

DC-4M: No built 46 (excl. 25 milit.), in airline service 32.

North America	Latin America	Europe	Elsewhere
International Air Freighters 3	LAUMSA 8	Flying Enterprise 4	Aden 3
World Wide Airways 3	SA Medellin 6	Derby 3	EAAC 2
6	14	7	5

CL-44: No on order 24 (excl. 12 milit.), in airline service 21(3).

North America	Latin America	Europe	Elsewhere
Flying Tiger 10		BOAC 1(L)	Japan Cargo A/W (3)
Seaboard 6			
Slick 4			
20		1	(3)

Noorduyn

NORSEMAN: No in airline service 102.

North America	Latin America	Europe	Elsewhere
Interior 3	Rapsa (Chile) 2	Boras (Sweden) 1	Aero-Sahara 3
Arctic 1	SOTA (Colombia) 2	Fjellfly 2	Transgabon 1
Aurora 2	Taxi Aereo Columbiano 2	Jamtlands Aero 1	New Bengal Airways 1
Austin 5	TA Orientales 1	Lapplandsflyg 3	Ansett-MAL 1
BC Air Lines 2		P. Riitaoja 1	Southern Cross Airfreighters ?
Bradley 1		Thor Solberg 1	
Bullock Wings 1		Wideroe's 4	
Chiupka Airways 2			
Clearwater 1			
Cross Lake AS 1			
Gagnon 3			
Georgian Bay 3			
Gold Belt AS 2			
Green Airways ?			
Harrison A/W 2			
La Tuque AS 1			
Lynn Lake AS 1			
McMurray 2			
Mattagami Skyways 1			
Northern Quebec 1			
Northern Wings 3			
Ontario Central 8			
Parsons 5			
Rainy Lake A/W 1			
Rusty Myers FS 3			
Saguenay AS 1			
Saskair 5			
Sept-Iles AS 1			
Theriault AS 1			
Thomas Lamb A/W 4			
Trans-Air 7			
Wheeler 2			
76	7	13	6

USA

Aero Commander Inc.

AERO COMMANDER: No built over 1,200, in airline service 47+.

North America	Latin America	Europe	Elsewhere
Bison Airlines 2	TA Lider (Brazil) ?	Aero-Nord Sweden 1	Yemen 4
Commuter 2	TA Neuquen ?	Alpine Lufttransport 1	Air Gabon 1
Executive 3	Varig 2	Escadrille Mercure 2	Campling Bros. 1
Hagerstown Commuter 1		Falcks 1	Libyan 1
Hi-Plains ?		Fenwick ?	National Airways 4
Islip Airlines ?		Lentohuolto O/Y 1	Suidwes Lugdiens 1
Kenting 1		Sudflug 2	All Nippon 1
Mid-Hudson ?		Varmlandsflyg 1	Nitto 1
Petroleum Helicopter Service 1		World Wide Helicopters 2	North Japan 1
Reading 1		Scillonian 1(1)	
Trans Air Lines 5			
Bahamas 2			
18+	2+	11+	15

Aero Commander 560F

Beechcraft

MODEL 18: No built over 9,000, in airline service 129.

North America	Latin America	Europe	Elsewhere
Apache 2	Aeromisiones (Argentina) 1	Air Esterel 2	Africair 1
Aspen Airways ?	Cayman Brac 1	Air Sud 2	Air Brousse 11
B & K Airways 1	CEDTA (Ecuador) 4	Bavaria Flug. 1	Air Centrafrique 1
Carco AS 2	COHATA ?	Cogea 2	Air Madagascar 1
East Coast FS 1	Cruzeiro 4	Escadrille Mercure 5	DTA 2
Hagerstown Commuter 1	Imperial Transportes Aereos 2	Swedair 2	Libyan 1
Inlet ?	LANICA 1	TASSA (Spain) 1	Pan African (Nigeria) 3
Johnson FS 6	SAN (Ecuador) 2	TRANSair (Denmark) 1	Transgabon 1
Mackey 1(L)	Surinam 5	UTA 1	CAT 2
Reading AS 1	TA Buenos Aires 4	World Wide Helicopters 1	Foshing 2
Southeast 2	VASP 1		All Nippon 2
Southern AT 1			Fuji 1
Standard 1			JAL 1
N. Consol. 1			Connellan 3
Wien Alaska 7			Flinders Island 1
Aklavik 1			
Bradley 2			
Canadian Nickel 2			
Chinook 1			
E. Provincial 1			
Foothills Aviation 1			
Halls AS 1			
Ilford 1			
Kenting 1			
Kingston F. C. 1			
Laurentian 1			
Millard Air 1			
McMurray 2			
Pacific Western 1			
Parsons 1			
Personal AT 1			
Rainy Lake A/W 1			
Saskair 1			
Silver Wings 1			
Sioux Narrows A/W 1			
Sky Harbour AS 1			
Thomas Lamb A/W 1			
Timmins 1			
World Wide Airways 1			
54	24	18	33

Boeing

B.307 STRATOLINER: No built 10, in airline service 4.

North America	Latin America	Europe	Elsewhere
		Airnautic 1	Aigle Azur 3
		1	3

B.377 STRATOCRUISER, B.377PG: No built 56 (excl. 888 C-97/KC-97), in airline service 7.

North America	Latin America	Europe	Elsewhere
Aero Spacelines (377PG) 1	RANSA 6		
1	6		

707-120, 707-120B, 707-220: No built 88 (excluding over 600 KC-135, C-135 and VC-137), in airline service 83 (7).

North America	Latin America	Europe	Elsewhere
American 23*			Qantas (-138) 7*
Braniff (-220) 4			Qantas (-138B) 4(2)
Continental 4			
PanAm 8			
TWA (-131) 15			
TWA (-131B) 18(5)			
72(5)			11(2)

*Converted to turbofan power

707-320, 707-320B, 707-320C, 707-420: No built 136, in airline service 131 (27).

North America	Latin America	Europe	Elsewhere
American (-323C) 1(3)	Varig (-441) 2	Aer Lingus (-320C) (1)	El Al (-458) 3
Northwest (-320B) 5(3)		Air France (-328) 17	SAA (-344) 3
PanAm (-321) 20		Air France (-328B) 6	Air-India (-437) 6
PanAm (-331) 6		BOAC (-436) 10	Air-India (-337B) (1)
PanAm (-321B) 5		BOAC-Cunard (-436) 10	Qantas (-320C) (3)
PanAm (-321C) 3(9)		Lufthansa (-430) 5	
TWA (-331) 12		Lufthansa (-330B) 1(1)	
TWA (-331B) 5(1)		Sabena (-329) 6	
TWA (-331C) 2(5)			
World (-373C) 3			
62(21)	2	55(2)	12(4)

720, 720B: No built 125, in airline service 122 (9).

North America	Latin America	Europe	Elsewhere
American (B) 22	Avianca (B) 2	Aerlinte 3	El Al (B) 2
Braniff 5		Lufthansa (B) 7	Saudi Arabian (B) 2
Continental (B) 5(1)			Ethiopian (B) 2
Eastern 15			PIA (B) 3
Northwest (B) 13(1)			
Pacific Northern 2			
PanAm (B) 3			
United 29			
Western (B) 7(3)			
101(5)	2	10	9

Boeing 720B

Convair 990A

Convair

CATALINA/CANSO: No built 2,140, in airline service 44.

North America	Latin America	Europe	Elsewhere
Alaska Coastal-Ellis 4	Aerovias Hoffman 2	Flugfelag 1	Airways (India) 1
Austin 1	Panair do Brasil 4		CAT 2
Canspec 5			Foshing 1
Eastern Provincial 5			RAI 1
Kenting 1			TAA 2
Northern Wings 2			Trans-Oceanic 2
Ontario Central 1			
Quebecair 1			
Timmins 1			
Trans-Air 4			
World-Wide A/W 3			
28	6	1	9

CV-240: No built 176 (excl. 395 milit.), in airline service 104 (10).

North America	Latin America	Europe	Elsewhere
American 11	Cruzeiro 8	Aviaco 2	Ethiopian 2
Central 6	Lineas Aereas Paraguayas 3	LOT 4	Fuji 3
Mohawk 17	Varig 10		Garuda 6
Ozark 7			Nitto 1
Trans-Texas 12(10)			North Japan 5
CPAL 5			Toa 2
58(10)	21	6	19

CV-340: No built 209 (excl. 108 milit.), in airline service 141 (1).

North America	Latin America	Europe	Elsewhere
Alaska 2	Avensa 7	Aviaco 2	Aramco 2
Braniff 15	Cruzeiro 3	Finnair 4	Saudi Arabian 10
Caribair 5	LACSA 1	JAT 1	All Nippon 2
Delta 12		KLM 3	Garuda 8
Frontier 11*		Linjeflyg 8	
Hawaiian 4		Lufthansa 4	
Lake Central 5		Martins (1)	
North Central 13			
Ozark 2			
United 17			
86	11	22(1)	22

*Four to be re-engined with Allison 501-D13 turboprops.

CV-440: No built 186 (excl. 26 milit.), in airline service 156.

North America	Latin America	Europe	Elsewhere
Allegheny 19	Avensa 2	Aviaco 6	Air Katanga 1(L)
Braniff 4	Cruzeiro 4	Finnair 3	All Nippon 2
Delta 8	LAN 4	Iberia 10	Garuda 3
Eastern 20	Varig 1	JAT 5	Airlines of S. Australia 1
Fairways 1		Kar-Air 2	
Hawaiian 2		Linjeflyg 1	
Mohawk 5		Lufthansa 7	
North Central 5		Sabena 8	
Ozark 2		SAS 19	
		Swissair 11	
66	11	72	7

880, 880M, 990A: No ordered 95, in airline service 93 (1).

North America	Latin America	Europe	Elsewhere
Alaska (880M) 1	Aerolineas Peruanas 1(L)	SAS (990A) 1(L)	Ghana (990A) 1(L)
American (990A) 20	Varig (990A) 3	Swissair (990A) 4	CAT (880M) 1
Delta (880) 16	VIASA (880M) 3		Cathay Pacific (880M) 1
Northeast (880) 4			Garuda (990A) 2(1)
TWA (880) 26			JAL (880M) 8
			Thai Int. (990A) 1(L)
67	7	5	14(1)

Curtiss

C-46: No built 3,181, in airline service 344+.

North America	Latin America	Europe	Elsewhere
Aaxico 22	Aereo Carga 2	Olsen 3	Air Cameroun 3
ASA Int. 1	Aerunion 2	SAM 2	Pan African (Nigeria) 2
Braniff 2	A. Carreras ?	Transair Sweden 9	Air America ?
Cal. Air Freight 1	A. Chilenas ?		CAT 17
Capitol 19	Aerovias Amazonas 2		Foshing 1
Cont. Charters 3	Aerovias Condor 5		
Cordova 1	Aerovias Halcon ?		
Delta 5	Aerovias Int. Balboa 1		
Federated 2	Aerovias Panama 5		
Golden State 1	AISAA (Argentina) 1		
Great Circle A/W 1	Aquilas Venezolanas 1		
Interior 3	AT Entre Rios 1		
Johnson FS 2	Austral 5		
L & J Trading Co 3	Avensa 3		
Mercury 1	Aviateca 1		
Modern AT 2	CAUSA 2		
Pacific Internat. 1	CBF 2		
Reeve 3	CDA 5		
Riddle 28	CEA 2		
Saturn 4	H. Sebastian y Gomez 3		
Seaboard 1	LA Colombiano 2		
Skyvan 2	LACSA 4		
Skyways 2	LANICA 2		
Southern AT 3	LA Paraguayo 2		
Trans-Caribbean 2	LA Patagonias 2		
Trans-Global 2	LA Taxader 3		
Vance Int. 1	LAUMSA 2		
Westair 4	LAV (Venezuela) ?		
Whesport Air Cargo 2	LEBCA 5		
Wien Alaska 5	LA La Urraca ?		
Zantop 15	Lineas Inter-americanos 3		
Eastern Provincial 4	LA Sud Americana (Chile) 3		
Nordair 5	Mercury (Argentina) ?		
Pacific Western 5	Paraense 3		
Quebecair 1	RANSA 12		
Southern Provincial 1	Sadia 2		
World Wide A/W 5	SAHSA (Honduras) 2		
	SA Medellin 3		
	SATCO (Peru) 3		
	TAN (Honduras) 4		
	Taxi Aereo Panama 2		
	Tigres Voladores 1		
	Turismo Aereo 1		
	Varig 24		
	VASP 14		
165	142+	14	23+

Curtiss C-46

Douglas DC-3

Faucett

FAUCETT-STINSON F.19: No built 30, in airline service 4.

North America	Latin America	Europe	Elsewhere
	Faucett 4		
	4		

Douglas

DC-2: No in airline service 7.

North America	Latin America	Europe	Elsewhere
Johnson FS 1	Cruzeiro 1	Airnautic 1	Marshall 1
Mercer 1	Transaer 2		
2	3	1	1

DC-3, C-47: No built in USA 10,928, in airline service, 1,265+.

North America	Latin America	Europe	Elsewhere
Air-Oasis 1	ALA (Argentina) 5	Aer Lingus 4	Aden 6
American Flyers 4(L)	A. Abaroa 1	Air France 28	Air Liban 3
Avalon 1	A.Argentinas 8(FS)	Alitalia 3	Aramco 5
Cal. Air Charter 1	Aeronaves de Mexico 22	Austria Flugdienst 1	Arkia 5
Cal. Pacific 1	Aeronorte 4	Austrian 3	Gulf 4
Capitol 1	ANHSA (Honduras) 2	Aviaco 2	Iranian 6
Carco AS 4	AREA(Ecuador) 2	Bavaria Flug. 2	Jordanian 1(L)
Caribair 2	Avensa 10	Braathens 1	MEA 3
Central 10	Avianca 19	European AT 3	Saudi Arabian 10
Civil AT 1	Aviateca 4	Faroe Island 1	Syrian Arab 3
Cont. Charters 1	Avispa ?	Fairways 2	THY 19
Consolidated 2	Bahamas 5	Finnair 4	Yemen 4
Cordova 2	BWIA 3	Flugfelag 4	Aerotechnique 6
East Coast FS 1	British Guiana 3	Gibair 1	Africair 12
Edde 2	Cayman Brac ?	Iberia 17	Air Algerie 2
East-West Air 1	CDA 2	Itavia 4	Air Congo (ex-French) 1
Executive AT 2	COHATA 3	JAT 12	Air Congo (ex-Belgian) 9(L)
Fairways Corp. 1	COPA 2	Kar-Air 4	Air Katanga 2
Farr Air, Inc 1	Cruzeiro 26	KLM 4	Air Madagascar 6
Fast-Way Air 1	Empresa Taboy Taxader Boyaca ?	Linjeflyg 2	Air Mali 3
Frontier 22	Faucett 12	Loadair (Sweden) 1(L)	Air Mauritanie 2
Hawaiian 5	Jamaica AS 2(L)	LOT 8	CAAC 6
Hawthorne Nevada 1	LA Boliviano 7	Martins 2	CSTA (Senegal) 1
Inlet ?	LA Colombiano 1	Olympic 13	DETA 6
Interior 3	LACSA 1	Sabena 4	DTA 7
Interstate ?	LADE 2	SAM 3	EAAC 7
Johnson FS 2	LADECO 2	SATA (Azores) 1	Ethiopian 7
Kesterton 1	LA Taxader 5	SAS 1	Ghana 4
Lake Central 20	LAN (Chile) 16	Schreiner Aero 2	Liberian 3
Mackey 2	LANICA 6	Spantax 7	Libyan 6
Mercer 1	LAUMSA 3	Swissair 3	Linair 6(L)
Nevada AT 1	LAV ?	TAI 2	Nigerian 7
North Central 29	LEBCA 2	TASSA (Spain) 4	Royal Air Maroc 2
Northeast 6	Mexicana 7	Transair (Sweden) 1	Rhodesian AS 2
Ozark 24	PLUNA 5	Wideroe's 2	SAA 5
Pacific 2	Rutas Aereas Panamenas 3	Autair 1	Sudan 4
Pacific Northern 3	Sadia 2	BKS 3	Suidwes Lugdiens 1
PanAm 2	SAHSA 5	BUA 2	TAG (Gabon) 3
Piedmont 4	Santafesina 1	BU Air Ferries 7	Tunis Air 2
Purdue 5	SATCO (Peru) 8	BUA (CI) 8	UAA 3
Reeve 2	SAVAG 6	British Westpoint 3	United Libyan 1
Samoan ?	Surinam 1	Cambrian 5	Air Ceylon 3
Southern 25	TA Catarinense 2(L)	Channel 7	Air Vietnam 5
Standard 1	TACA de Honduras 10	Dan-Air 3	Airways (India) 3
Stewart AS 4	TA Jalisco 2	Derby 7	All Nippon 8
Trans Global 1	TA Salvador ?	Morton 1	Ariana 4
Trans Sierra 1	Taxader 1	Skyways 4	Borneo 2
Trans-Texas 23	Tigres Voladores 1	Starways 3	CAT 4
Vance Int. 1	Varig 52		Cruz 2
Viking 2	VASP 15		Dharbanga ?
West Coast 14			Fleming A/W 1
Wien Alaska 2			Foshing 2
Zantop 1			Garuda 20
Air Gaspe 1			IAC 42
Austin 2			Iranian 6
Connelly-Dawson 1			Jamair 2
CPAL 3			Kalinga 5
Canadian Aero Services 1			Korean 4
Eastern Provincial 5			Malayan 7
Eldorado 1			Nagasaki 1
Hollinger Ungava 3			North Japan 2
Matane 3			PAL 27
Northern Wings 2			PIA 4
Nordair 9			Royal Air Cambodge 1
Pacific Western 4			Royal Air Lao 3
Quebecair 4			Royal Nepal 3
Saskair 1			Thai 7
Southern Provincial 1			UBA 7
Trans-Air 4			Airlines of NSW 3
World-Wide A/W 1			Airlines of NZ 3
			Airlines of S. Australia 4
			Ansett-ANA 9
			Ansett-MAL 11
			Brain & Brown 2
			East-West 4
			James Aviation 1
			MMA 7
			Mount Cook & Southern Lakes 2
			NZNAC 19
			Papuan 2
			Polynesian 1
			Queensland 2
			TAA 18
296	301	210	458

Douglas DC-8 Series 20

DC-4, C-54: No built 1,163, in airline service 269.

North America	Latin America	Europe	Elsewhere
Alaska 1	A.Argentinas 4(FS)	Air France 18	Trans-Med. 8
ASA Int. 2	Aeronaves de Mexico 2	Airnautic 1	Saudi Arab. 3
Carco AS 1	Aeronaves de Panama 1	Balair 2	Syrian Arab. 2
Central 1(L)	Aerovias Condor 2	BIAS 3	Africair 3
Island 1	Aerovias Panama 4	Braathens 1	Air Afrique 11
Lancia 1	AREA(Ecuador) 2	Flugfelag 2	Air Algerie 10
Mackey 2	ATSA (Mexico) 1(L)	Gronlandsfly 1	Air Cameroun 1
PanAm 5	Austral 1	Iberia 7	Air Congo (ex-French) 1(L)
Puerto Rico American 1(L)	Avianca 11	Interocean 6	Air Congo (ex-Belgian) 7
Reeve 1	Aviateca 2	Luxair 1	Air Guinee 2(L)
Skytrain ?	CDA 2	Malta Metropolitan 1	Air Madagascar 2
Slick 5	Faucett 5	Martins 1	Air Mauritanie 1
Standard 1	H. Sebastian y Gomez 1	Olympic 2	Atlanta (Liberia) 1
Stewart AS 2	Guest 1	Spantax 1	Pan African (Nigeria) 1
Trans-Alaskan 2	Ini 1	TAI 2	Rhodesian AS 1
TWA 1	LADE 2	TAP 3	SAA 5
20th Century 4	LA Taxader 2	Air Ferry 2	Tunis Air 2
US Overseas 7	Mexicana 2	Channel 1	Ariana 1
Westair 1	Paraense 1	Lloyd Int. 2	CAT 2
Zantop 1	SA Medellin 3	Starways 3	IAC 3
Eldorado 1	SATCO (Peru) 2	Trans-Meridian 2(L)	JAL 9
Nordair 5	TACA Internat. 2		Korean 1
Pacific Western 2	TA Mirleni 1		Royal Air Cambodge 1(L)
Southern Provincial 1	VASP 8		Royal Air Lao 1
Trans-Air 6			Thai 1(FS)
World-Wide A/W 1			Ansett-ANA 3
			Qantas 2
			TAA 2
56	63	62	87

DC-6: No built 175, in airline service 140.

North America	Latin America	Europe	Elsewhere
American 31	A.Argentinas 2(FS)	Alitalia 1	Air Liban 1
Braniff 9	Aeronaves de Mexico 9	BIAS 1(L)	Iranian 2
Delta 11	Aerovias Condor 1	Nordair 6	Trans-Med. 1
International 3	Aerovias Panama 1	Sveaflyg 3	Air Congo 2(L)
Mackey 3	Aerolineas Peruanas 1	TASSA 2	CAAC 1(L)
United 31	Guest 3	Transair Sweden 3	Air Vietnam 1
	CEA (Ecuador) 1		
	Ini 1		
	Mexicana 9		
88	28	16	8

DC-6A and **DC-6C:** No built 75 (excl. 167 milit. **DC-6A**), in airline service 59.

North America	Latin America	Europe	Elsewhere
Aaxico 8	RANSA 1	Braathens 1	Air Afrique 1(L)
Hawaiian 1		KLM 1	Ariana 2
Los Angeles AS 2		Transair Sweden 1	JAL 3
Purdue 2		UAT 2	
Slick 4		BUA 2	
Southern AT 3		British Eagle 3	
Trans-Caribbean 2			
United 7			
US Overseas 2			
World 8			
CPAL 2			
Wardair 1			
42	1	10	6

DC-6B: No build 287, in airline service 245.

North America	Latin America	Europe	Elsewhere
Aaxico 1	Aerolineas Peruanas 2	Adria 4	Iranian 1
American 12	Aerovias Panama 5	Airnautic 2	Syrian Arab 3
Braniff 1	Avensa 2	Alitalia 1	Trans Arabia 3
Continental 1	Aviateca 1	Aviaco 2	Trans-Med. 1
Mackey 2	CDA 2	Balair 2	Ethiopian 3
Northeast 15	CEA (Ecuador) 1	Braathens 1	Air Vietnam 1
Northwest 9	Faucett 1	Flugfelag 1	CAT 1
PanAm 22	Ini 1	JAT 1	JAL 5
Reeve 1	LA Boliviano 1	Kar-Air 1	Thai Int. 1
Saturn 2	LACSA 1	KLM 1	Ansett-ANA 3
Southern AT 1	LAN (Chile) 7	Loftleidir 5	TAA 3
Standard 2	Varig 5	Olympic 3	
United 40		Sabena 4	
US Overseas 4		SAM 6	
Western 19		Sterling 5	
Zantop 1		Swissair 1(FS)	
Pacific Western 1		Transair Sweden 5	
Wardair 1		UTA 10	
		BUA 1	
135	29	56	25

DC-7, DC-7F: No build 120, in airline service 67 (1).

North America	Latin America	Europe	Elsewhere
American 8		Flying Enterprise 1(1)	Lebanese Int. 4
American (F) 14			
Delta 9			
Lance AT 1			
Overseas Nat. 6			
Standard 1			
United 17			
United (F) 6			
62		1(1)	4

DC-7B: No built 97, in airline service 88.

North America	Latin America	Europe	Elsewhere
American 6	Panama Aeronautica 1	Flying Enterprise 1	SAA 4
Continental 2			
Delta 10			
Eastern 47			
National 4			
Panagra 5			
Panagra (F) 1			
PanAm 7			
82	1	1	4

DC-7C, DC-7CF: No built 121, in airline service 105.

North America	Latin America	Europe	Elsewhere
Braniff 5	Panair do Brasil 4	Alitalia 3	JAL 3
Northwest 2		Alitalia (CF) 2	JAL (CF) 1
Northwest (CF) 4		KLM 8	
Overseas Nat. 3		KLM (CF) 4	
Overseas Nat. (CF) 1		Martins (1)	
PanAm 9		Sabena 4	
PanAm (CF) 14		Sabena (CF) 1	
Riddle (CF) 11		SAS 8	
Saturn 3		SAS (CF) 1	
		Spantax 2(L)	
		Sudflug 2	
		BOAC 5	
		BOAC (CF) 2	
		Caledonian 3(L)	
52	4	45(1)	4

DC-8 Series 10 and **20:** No built 63, in airline service 60.

North America	Latin America	Europe	Elsewhere
Delta (10) 6*			
Eastern (20) 15			
National (20) 3			
United (20) 15			
United (10) 21			
60			

*Converted to Series 50s.

DC-8 Series 30, 40 and 50, DC-8F: No built 128, in airline service 124(24).

North America	Latin America	Europe	Elsewhere
Capitol (8F) 1	Aeronaves de Mexico (50) 2(1)	Alitalia (40) 10(2)	Air Afrique (50) 1(1)
Delta (50) 4(6)	Panair do Brasil (30) 2	Iberia (50) 6	JAL (30) 4
National (50) 6		KLM (30) 7	JAL (50) 3
National (30) 3(1)		KLM (50) 7	PAL (50) 1
Northwest (30) 1		KLM (8F) (2)	TEAL (50) (3)
Panagra (30) 4		SAS (30) 7	
PanAm (30) 18		SAS (50) (2)	
Riddle (8F) (2)		Swissair (30) 3	
Seaboard (8F) (1)		Swissair (50) 1	
Trans-Caribbean (50) 2		UTA (30) 6	
Trans-Caribbean (8F) 1(1)			
Trans-Int. (50) 1			
Trans-Int. (8F) 1			
United (50) 3			
United (8F) (3)			
CPAL (40) 5			
TCA (40) 11			
TCA (8F) 3(1)			
64(15)	4(1)	47(6)	9(4)

Fairchild

C-82A PACKET: No built 224, in airline service 18+.

North America	Latin America	Europe	Elsewhere
Wien Alaska 1	Aviateca 1	TWA 1	
	A. Chilenas ?		
	Aerovias Helices 2		
	Cuzeiro 8		
	Expreso Aereo Peruano ?		
	Guest 2		
	LA del Caribe 1		
	LACE (Colombia) 2		
1	16+	1	

FRIENDSHIP—*See Fokker/Fairchild Friendship, page 31.*

North America	Latin America	Europe	Elsewhere

Grumman

GOOSE: No built 345
MALLARD: No built 61
WIDGEON: No built 286
No in airline service 73+.

North America	Latin America	Europe	Elsewhere
Alaska Coastal-Ellis 15	Bahamas 1	Morefly 1	TA de Cabo Verde 1
Avalon 5	Bahamas Air Traders 1	Tirkkonen 1	Naka Nihon 1
Catalina Channel 5	British Guiana 3		Nitto 5
Cordova 2			NZ Tourist Air Travel 5
Kodiak 5			TAA 1
Reeve 1			
Trans Air Lines ?			
Western Alaskan ?			
BC Air Lines 4			
Bertrand Airways 4			
BNP 3			
Hudson Bay 1			
Laurentian 1			
Millard Air 2			
Ontario Central 2			
Pacific Western 2			
Sioux Narrows A/W 1			
53+	5	2	13

Lockheed

L-10: No built 148, in airline service 19.

North America	Latin America	Europe	Elsewhere
Inlet 2	Santafesina 3		Marshall 1
Midwest 4	Taxis Aereos Nacionales 1		
Prov.-Boston 2			
Air Gaspe 2			
Matane 4			
14	4		1

L-12: No built 114, in airline service 8+.

North America	Latin America	Europe	Elsewhere
Stagecoach ?	Aero Transportes Vitoria 1	Escadrille Mercure 2	
Western Alaskan ?	Taxis Aereos Nacionales 1	Scan-Fly 3	
		Zone-Redningskorpset 1	
?	2	6	

L-14: No in airline service 4.

North America	Latin America	Europe	Elsewhere
Kenting 4			
4			

LODESTAR: No built 625, in airline service 17+.

North America	Latin America	Europe	Elsewhere
	Aero Transportes Vitoria ?	Air Sud 1	CAS (S. Africa) 2
	Norsur 3	Kar-Air 1	DETA 3
	Santafesina ?	Loadair (Sweden) 1	Fieldair 3
		Swedair 3	
	3+	6	8

L-049, L-149 CONSTELLATION: No built 88, in airline service 31.

North America	Latin America	Europe	Elsewhere
American Flyers 4	Cia. Ciatra 1	Aero Transport 1	Royal Air Burundi 1
ASA Int. 2		Euravia 5	
Consolidated 1			
Edde 1			
Futura 5			
Magic City A/W 1			
Modern AT 5			
Paradise Airlines 2			
Standard 2			
23	1	6	1

L-649, L-749, L-749A: No built 133 (excl. 12 milit.), in airline service 84.

North America	Latin America	Europe	Elsewhere
Cala 1	Avianca 4	Aero Transport 2	Air Afrique 1(L)
Capitol 1	CAUSA 2	KLM 6*	Royal Air Maroc 3
Pacific Northern 6	Panair do Brasil 11	Euravia 3	SAA 2
Standard 2			Trek 2(L)
Trans-California 1			Korean 1
TWA 36			
47	17	11	9

* In storage.

L-1049A, 'C, 'D, 'E: No built 102 (excl. about 320 milit.), in airline service 55.

North America	Latin America	Europe	Elsewhere
Capitol 3	Avianca 2	Air France 9	PIA 3
Eastern 27		Iberia 2	
Seaboard 3			
South Pacific 2			
Standard 1			
TWA 3			
39	2	11	3

L-1049G: No built 130, in airline service 78.

North America	Latin America	Europe	Elsewhere
Capitol 2	Avianca 1	Air France 12	
Eastern 9	Cubana 3	Iberia 4	
Standard 1	Varig 5	Lufthansa 7	
TWA 24		KLM 5*	
		TAP 5	
36	9	33	

* In storage.

L-1049H: No built 54, in airline service 43.

North America	Latin America	Europe	Elsewhere
Capitol 10	Varig 4		PIA 2
Flying Tiger 12			
Inter-continental 1(L)			
Seaboard 1			
Slick 5			
Trans-Int. 3			
World 5(L)			
37	4		2

L-1649A STARLINER: No built 43, in airline service 36.

North America	Latin America	Europe	Elsewhere
Alaska 2(L)		Air France 9	
TWA 21			
World 4			
27		9	

L-188, L-188C ELECTRA: No built 172, in airline service 160.

North America	Latin America	Europe	Elsewhere
American 25	Varig 5	KLM (C) 11	Cathay Pacific 2
American Flyers 2			Garuda 3
Braniff 9			Ansett-ANA 3
Eastern 32			Qantas (C) 4
Eastern (C) 7			TAA 3
National 17			TEAL (C) 3
Northwest (C) 16			
Pacific Southwest 6			
Western 12			
126	5	11	18

Martin

2-0-2, 2-0-2A: No built 43, in airline service 22+.
4-0-4: No built 101 (excl. 2 milit.), in airline service 60.

North America	Latin America	Europe	Elsewhere
Allegheny (202) 16	COPA (404) 1		
ASA Int. (404) 1	LAN (202) 4		
East Coast FS (404) 2	LAV (202) ?		
Mohawk (404) 13			
Pacific (202) 2			
Pacific (404) 10			
Piedmont (404) 20			
Southern (404) 13			
77	5		

EUROPE AND RUSSIA

N. and S. America	Europe	Mid-East and Africa	Asia and Australasia

Breguet

DEUX PONTS: No built 16, in airline service 12.

N. and S. America	Europe	Mid-East and Africa	Asia and Australasia
	Air France 12		
	12		

Nord-Aviation

NORD 260, 262: No built 13, in airline service 2(7).

N. and S. America	Europe	Mid-East and Africa	Asia and Australasia
	Air Inter. (262) (4)		Nitto (262) (1)
	Wideroes (262) (2)		
	Wideroes (260) 2		
	2(6)		(1)

Sud-Aviation

CARAVELLE 3, 6, 6N, 6R, 10B: No on order 173, in airline service 148(21).

N. and S. America	Europe	Mid-East and Africa	Asia and Australasia
United (6R) 20	Air France (3) 41	Air Liban (3) 1	IAC (6N) 1(2)
A. Argentinas (6R) 2	Alitalia (6N) 16(2)	MEA (6N) 2	
Cruzeiro (6R) 4	Austrian (6R) 2	Air Algerie (3/6N) 4	
LAN (6R) (3)	Finnair (3) 4	R. Air Maroc (3) 3	
PAdB (6R) 4	Finnair (10B) (6)	Tunis Air (3) 1(1)	
Varig (3) 2	Iberia (6R) 6(2)		
Varig (6R) 1	JAT (6) 2(1)		
VASP (6R) (4)	Sabena (6N) 8		
	SAS (3) 14		
	Swissair (3) 7(L)		
	TAP (6R) 3		
33(7)	103(11)	11(1)	1(2)

Dornier

Do 27: No in airline service 22.

N. and S. America	Europe	Mid-East and Africa	Asia and Australasia
	Air Lloyd 8	Aero-Sahara 4	
	Ostermans 3	Basutair 2	
	Schreiner Aero Contractors 1	Ducor AT 1	
	Swissair 1	STRAC (Tunisia) 1	
		TAGP 1	
	13	9	

Do 28: No built about 60, in airline service 16.

N. and S. America	Europe	Mid-East and Africa	Asia and Australasia
Windward Island A/W 1	Aero Taxi 1	Aero Contractors (Nigeria) 1	
	Air Lloyd 6	Aero-Sahara 3	
	Ostermans 2	Cameroons AT 1	
	Schreiner Aero Contractors 1		
1	10	5	

Junkers

Ju 52/3m: No built 3,234, in airline service 1.

N. and S. America	Europe	Mid-East and Africa	Asia and Australasia
TA Orientales 1			
1			

Aermacchi-Lockheed

AL-60: No built about 50, in airline service 11.

N. and S. America	Europe	Mid-East and Africa	Asia and Australasia
Alaska 3	Air Neige 2	Air Guinee 1	
	Falcks 1	Basutair 2	
	Air Navigation & Trading 1	Wilken AS 1	
3	4	4	

Piaggio

P.136L: No built over 80, in airline service 4.

N. and S. America	Europe	Mid-East and Africa	Asia and Australasia
	Alisud 2		Macao AT 1
	Olympic 1		
	3		1

P.166, P.166B PORTOFINO: No in airline service 14.

N. and S. America	Europe	Mid-East and Africa	Asia and Australasia
	Air Lloyd 3		Air Charter 1(L)
			Airlines of S. Australia 1
			Ansett-ANA 2
			Ansett-MAL 3
			Associated 1
			Papuan 2
			Queensland 1
	3		11

Piaggio P.166B Portofino

Fokker/Fairchild Friendship

FOKKER F.27 Series 100, 200, 300, 400: No on order 143 (excl. 12 milit.), in airline service 108(22).

FAIRCHILD F-27, F-27A, F-27B: No built 104, in airline service 57.

N. and S. America	Europe	Mid-East and Africa	Asia and Australasia
Aloha 5	Aer Lingus 7	DETA (A) 3	All Nippon (A) 14(4)
Bonanza (A) 12	Alitalia (A) (3)	DTA (A) 2	IAC 10
Northern Consol. (B) 3	Braathens 6(1)	EAAC (A) 3(1)	Korean (2)
Ozark 8	Condor-Flugdienst (2)	Nigeria (A) 5	Malayan (A) 5
Pacific (A) 6	KLM (B) 2	Sudan (A) 3(1)	PAL 5(4)
Piedmont 8	LTU (B) 3		PIA (A) 4
Quebecair 3	Luxair 2		PIA (B) 1
West Coast 8	Schreiner Aero (A) (1)		UBA (A) 1(2)
Wien Alaska (B) 2	THY 8		Airlines of NSW (A) 5
			Ansett-ANA (A) 3
			East-West 2
			MMA (A) 1(1)
			NZNAC 7
			Queensland (A) 1
			TAA 7
			TAA(A) 2
55	28(7)	16(2)	68(13)

Tupolev Tu-124

Pilatus

PORTER and TURBO-PORTER; No built over 50, in airline service 14(1).

N. and S. America	Europe	Mid-East and Africa	Asia and Australasia
Northern Consol. 4	Aerodrome Regional de Montreux 1	Aero-Sud (Algeria) 1	
Northern Consol. (T) 1	Air Alpes (T) 2		
Wien Alaska 1	Alpine Lufttransport 1		
Wien Alaska (T) 1	Gregory Air Taxis 1		
	KLM 1		
	Kunnallistekniika 1		
7	7	1	

(T) = Turbo-Porter

Saab

SCANDIA: No built 18, in airline service 14.

N. and S. America	Europe	Mid-East and Africa	Asia and Australasia
VASP 14(FS)			
14(FS)			

Antonov

An-10A, An-12 UKRAINA: No in airline service about 26.

N. and S. America	Europe	Mid-East and Africa	Asia and Australasia
		Ghana Airways 1	Aeroflot 25*
		1	25

* ICAO estimate of 1962

An-24: No in airline service at least 4.

N. and S. America	Europe	Mid-East and Africa	Asia and Australasia
			Aeroflot at least 4
			4+

Ilyushin

Il-14, AVIA 14: No in airline service 124 (excl. Asian countries).

N. and S. America	Europe	Mid-East and Africa	Asia and Australasia
Cubana 13	CSA 23	Yemen 2	Aeroflot ?
	Interflug 25	Air Guinee 7	CAAC (China) 25?
	JAT 6	Air Mali 3	Mongolian ?
	LOT 12		Ukamps (N. Korea) ?
	Malev 10		
	TABSO 7		
	TAROM 16		
13	99	12	?

Il-18: No in airline service at least 120.

N. and S. America	Europe	Mid-East and Africa	Asia and Australasia
Cubana at least 3	CSA 6	Air Guinee 3	Aeroflot at least 78
	Interflug 5	Air Mali 3	CAAC (China) 3?
	LOT 3	Ghana 4	
	Malev 4		
	TABSO 3		
	TAROM 5		
3+	26	10	80+

Tupolev

Tu-104, Tu-104A, Tu-104B: No in airline service at least 145.

N. and S. America	Europe	Mid-East and Africa	Asia and Australasia
	CSA (Tu-104A) 5		Aeroflot at least 140
	5		140

TU-114: No in airline service at least 30.

N. and S. America	Europe	Mid-East and Africa	Asia and Australasia
			Aeroflot at least 30
			30

TU-124: No in airline service estimated as at least 42.

N. and S. America	Europe	Mid-East and Africa	Asia and Australasia
			Aeroflot at least 42
			42

This Auster J.1N has been acquired by Diantella Ltd of Plymouth and is flown by company pilot Michael Anderson. In the picture is Miss Teresa Stevens, a director of Diantella

SPORT AND BUSINESS

ABAC Elections At the annual general meeting of the Association of British Aero Clubs and Centres on December 11, Mr R. A. Smith was elected chairman of the Association. Mr Smith is managing director of British Executive Air Services, operators of the Oxford Air Training School and Oxford Aeroplane Club. He has been a member of the ABAC Council for two years, and during the past year was chairman of the Pilotage Committee. Wg Cdr R. J. Pearse, last year's chairman, was elected vice-chairman. Council-members comprise P. S. Clifford, representing Portsmouth Aero Club; E. Thurston, Herts & Essex Aero Club; D. F. Ogilvy, Midland School of Flying; R. R. Paine, London School of Flying; and L. V. Worsdell, Cambridge Aero Club. The Association's new *Handbook of Flying Training* is now almost complete, and *Handling Notes* for Chipmunk, Tri-Pacer, Colt, Auster J.1N and Tiger Moth have been brought up to date.

In its annual report for 1962-63, the ABAC Council has this to say on the subject of collaboration with other bodies: "This has been particularly effective during the past year, and representatives have continued to sit on the Aviation Committee of the Royal Aero Club and have attended numerous meetings with the Ministry on the revised licensing proposals, medical standards, use of airspace, etc. The formation of a completely new body to represent sporting and private flying has been proposed and its sponsors have in fact approached the Association. The Chairman and Vice-chairman have had a long discussion with our President on this matter, at which the strong position of the Association has been emphasized. The matter is still under discussion and before any decision is made a special meeting will be called. New premises will soon be required for the Association offices and in this matter, at least, we can probably combine with advantage with one or more of the other aviation bodies." Membership of the Association, at June 30, 1963, consisted of 149 clubs, centres and groups. This total was made up of 44 members, 90 associate members, 13 affiliate and two auxiliary members.

Turbulent Accident Report A fatigue failure of the crankshaft of the Ardem engine in Turbulent G-APIZ, which crashed near Guildford on May 26, was disclosed in the Ministry of Aviation report on the accident, published on December 20. The pilot, Flight Cadet J. P. S. Larbey, RAF, was seriously injured. Owned by Mr Norman Jones and operated by the RAF College Flying Club (on loan from the Tiger Club), the aircraft was on a flight from Cranwell to Redhill.

The report states: "The aircraft took off from Cranwell at 1230hr. About 1425hr it was observed over Well House Farm, about three miles south-east of Guildford. It had approached from the direction of Guildford, flying at a height of 70-100ft. As it passed the farmhouse it banked steeply to the left, turning towards a field forming one of the two steep slopes of a valley. During the turn the engine was throttled back and the aircraft lost height rapidly. It straightened out on a north-westerly heading to glide across the field up the slope. It continued to descend, but less rapidly, to a height of about 30ft, and then dived to the ground a few yards from the further boundary of the field. The fuselage forward of the cockpit disintegrated and the wings became detached. There was no fire. The unconscious pilot was released from his harness and extricated from the wreckage by rescuers from the farm."

Inspection of the wreckage, the report continued, confirmed that the aircraft had dived into the ground at an angle of about 45°. There was no evidence of pre-crash damage or malfunction of the airframe. When the engine was dismantled the crankshaft was found to have fractured. The faces of the fracture were typical of a low-stress, long-life, fatigue fracture, and there was no evidence of mechanical damage, surface defects or dimensional errors which would have initiated failure by fatigue. Micro-examination showed that the steel was not fully hardened below the outer surface; the plain carbon steel used for the crankshaft had an inherently low hardenability which would preclude the possibility of obtaining a fully heat-treated structure in a component of this mass by conventional methods.

Under "Observations," the report states: "(1) The airframe and engine of the Druine D.31 were not built to British Civil Airworthiness Requirements and the aircraft is not eligible for a certificate of airworthiness. Instead, a permit to fly was issued by the Ministry of Aviation on the recommendation of the Air Registration Board. The scheme under which permits to fly are issued to ultra-light aircraft was introduced in 1948. It provides for airworthiness safety control by limiting the conditions under which the aircraft may be flown.

"(2) The motor-car engine of which the Ardem engine is a development now has a crankshaft of improved design. This should increase the fatigue resistance of the crankshaft of the engine in its aircraft application.

"(3) In this instance the failure of the crankshaft resulted in engine vibration; loss of oil through the rear oil seal was a consequence and hot oil carried back in the propeller slipstream and covering the windscreen severely restricted the pilot's forward vision. A forced landing became a matter of urgency but the terrain over which the aircraft was flying was wooded and hilly and the most suitable field available was on the slopes of a valley. These difficulties combined to prevent a successful landing."

The report concluded that the documentation of the aircraft was in order; the pilot was properly licensed; the engine crankshaft failed by fatigue; there were no surface defects or dimensional errors on the crankshaft which would have initiated failure; and the failure of the crankshaft made it necessary for the pilot to attempt a forced landing in difficult circumstances. In the accident inspector's opinion, the accident "was the result of loss of control during a forced landing in difficult circumstances arising from the failure of the engine crankshaft by fatigue."

Rogers/ARC Agreement The Aircraft Radio Corporation of New Jersey have appointed W. H. and J. Rogers (Aviation) of Bedford as UK agents for the supply, sale and installation of ARC aircraft radio and other electronic products.

Swiss Sportsmen The Uetz company of Fehraltolf, near Zurich, maker of the Pelikan tourer, has acquired a licence to build the Volmer VJ.22 Sportsman amphibian. The first of two aircraft ordered will fly next spring.

INDUSTRY International

Products

Company News

Great Britain

Valves and Actuators A brochure issued by Teddington Aircraft Controls Ltd gives details of hot air and gas valves, and electrically and pneumatically operated actuators, designed and manufactured by the company. This information, of considerable interest to aircraft and aero-engine designers, is presented in the form of 39 loose-leaf data sheets, which will be revised as development proceeds.

Copies of the brochure may be obtained on application to the Technical Liaison Manager, Teddington Aircraft Controls Ltd, Cefn Coed, near Merthyr Tydfil, Glam.

New MD for G.E.C. (Electronics) Mr R. J. Clayton, former general manager of G.E.C. (Electronics) Ltd, has been appointed managing director of the company. Mr Clayton, a Cambridge physics graduate, joined G.E.C. in 1937 and was appointed director and general manager of G.E.C. (Electronics) in 1961. He is a former chairman of the SBAC Guided Weapons Technical Committee.

W. H. Brooks We regret to learn of the death, which occurred suddenly on December 14, of Sqn Ldr William Henry Brooks, research and development sales director of Aircraft Materials Ltd.

Cossor Communications Appointment Mr R. R. Roper, who has had wide commercial and engineering experience in electronics, including service with Solatron, de Havilland Propellers, STC and the GPO, has joined the Cossor Communications Co at Harlow, Essex, as general sales manager. He will be responsible for the promotion and sales of Cossor land-based VHF r/t, military communications, microwave and broadcast equipment.

USA

Crusader Tactics Simulator Goodyear Aerospace Corporation is producing under US Navy contract a tactics simulator for attachment to the flight simulator to be used for training French Navy pilots to fly the F-8E Crusader.

Narco Becomes Class 1 The ARB has issued Class 1 certification to the Narco Mk 12 "one-and-a-half" VHF radio and the associated VOA-4 and VOA-5 converter indicators. The Mk 12, which comes in 90- or 360-channel versions, has proved so popular in the US that production is now running at the rate of 40 units per day. Distributor and warranty service agent for Narco in Britain is A. J. Whittemore (Aeradio) Ltd, Biggin Hill Aerodrome, Kent.

Co-ordinating Salesman Mr Henry Gagliano has been appointed sales co-ordinator for Helicopter/Aviation Sales Inc of New York, to co-ordinate activities between the parent company and its branches in Denmark, Spain, Germany and Argentina.

NASA Patents The US National Aeronautics and Space Administration has published a list of 76 of its patents which are available for commercial licence and use. Any number of commercial firms may obtain royalty-free licences to exploit NASA-held patents during the first two years after issue by the US Patent Office. The list of patents is freely available from the Administration at 400 Maryland Avenue SW, Washington 25, DC.

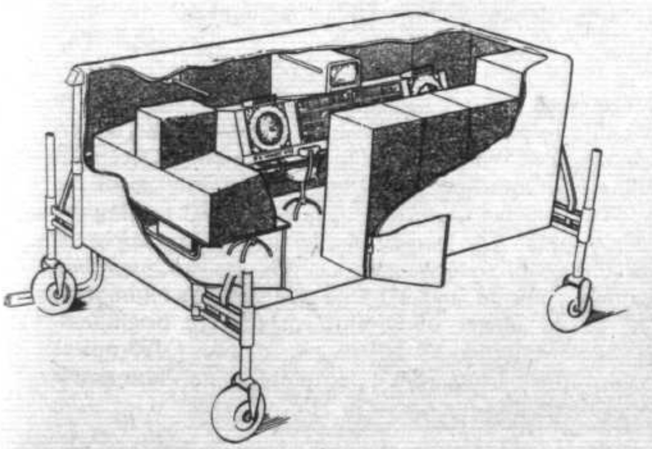
Canada

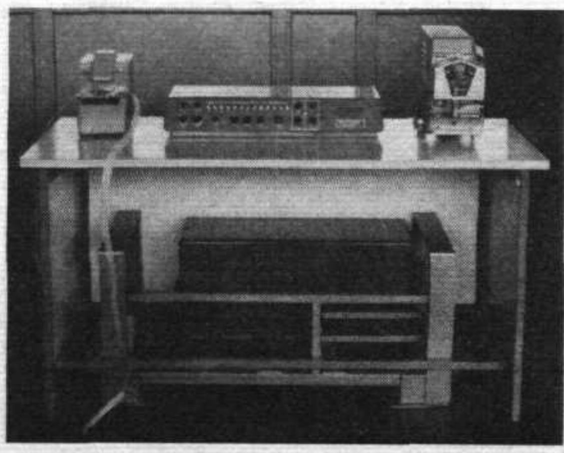
HSC Lance Contract According to Mr C. M. Drury, the Canadian Minister for Industry, Hawker Siddeley Canada Ltd (7 King Street East, Toronto 1) has been awarded a contract from the US Army to develop a lightweight launcher for the Lance mobile battlefield missile. The amount of the contract is $1.5m (£535,000), and the money will be provided by the Canadian Defence Production Department. Hawker Siddeley Canada will work under subcontract to Ling-Temco-Vought's Michigan Division, prime contractor for the Lance system.

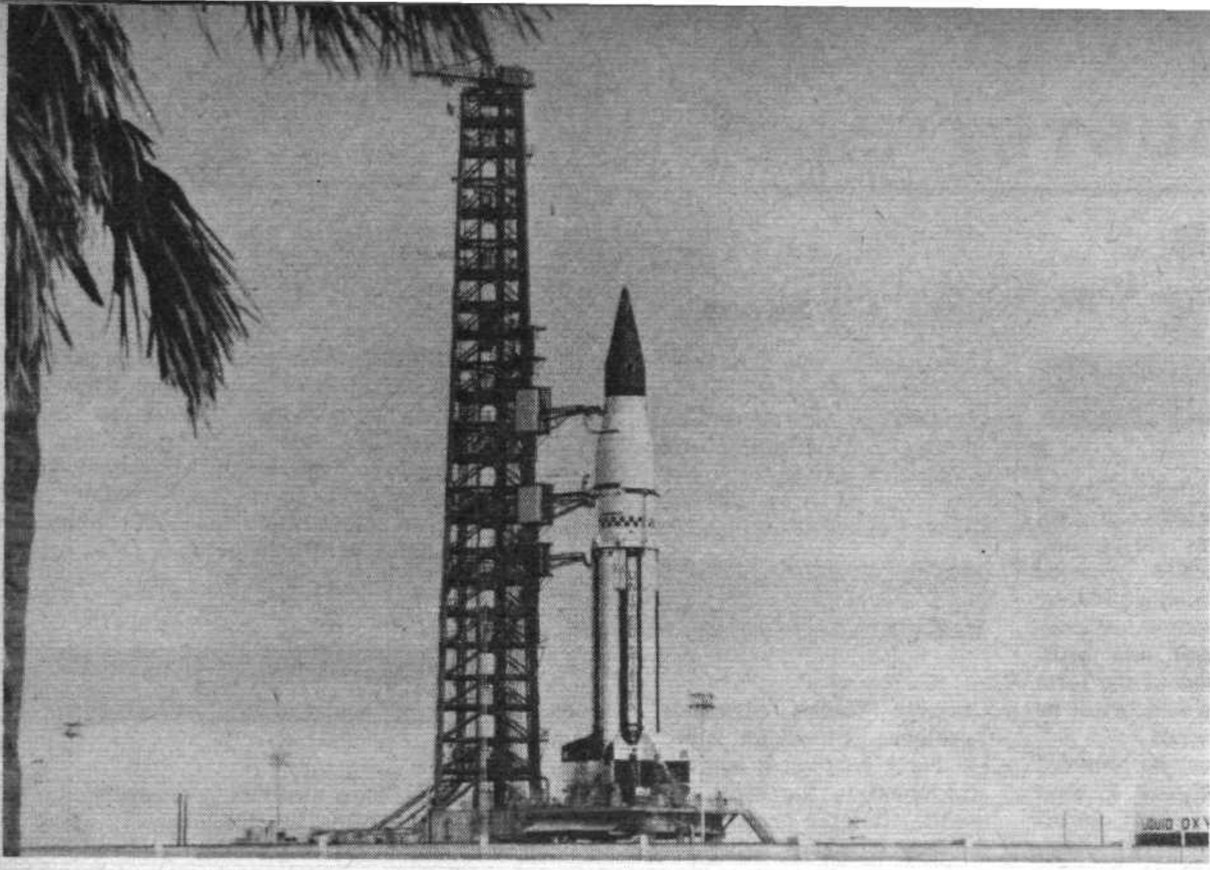
Concurrent with this announcement came the revelation that the Lance is being developed in a joint US/Canadian programme. As described in our November 7 issue, the 20ft missile uses storable liquid propellants and is intended to replace the "John" series of artillery rockets and the Lacrosse guided missile.

Another company of the Hawker Siddeley Group, de Havilland Aircraft of Canada Ltd (Downsview, Toronto), is already engaged in missile work for the US Army. The company is responsible for the infra-red homing guidance system of the Mauler mobile surface-to-air weapon system.

Below, left, a transportable cabin containing several interception control positions and the MCS-927 digital computer cabinet of the Elliott Firebrigade fighter control system referred to on page 3 of this issue. Nerve-centre of the equipment is the very small computer (centre), seen mounted inside a desk-sized console. Controls and tape input-output units are on top of the desk. Right, a technician operating the input keyboard on an interception officer's tabular display. The various panels detail the stages of interception missions, recovery procedures and diversion bases. The figures on the upper central panels give the time-to-go to interception. The computer programmes the complete mission, from climb profile and initial turns and acceleration, to the attack and return to base







View of the Saturn SA-5 space vehicle on the newly constructed Launch Complex 37 at Cape Kennedy, Florida. Height of the rocket is 163ft 7in

Missiles and Spaceflight

ESRO ACCELERATES

The European Preparatory Commission for Space Research, predecessor of the European Space Research Organization, is recruiting engineers, physicists and mathematicians and is letting contracts for a variety of rocket and satellite projects. In particular, project engineers are being sought for sounding rocket and satellite work at the European Space Technology Centre, Delft.

Preliminary design study contracts for an astronomical satellite have been placed by the Commission with the West German government research establishment DVL, with the French National Centre for Space Studies, and with the UK Ministry of Aviation. In each case part of the work is being subcontracted to industry.

Other design study contracts for small satellites, such as could be launched by Scout, have been placed, or are being negotiated, in Belgium, Italy, Sweden and Switzerland. Further study contracts have been placed or are under discussion in Spain, Austria and Denmark. In these preliminary studies, prior to the formation of ESRO, the Preparatory Commission is attempting to involve all its member-States, partly in order to make contact with industrial firms in the various countries.

In the future the method of working will be directly with industry in the member-States on the basis of tenders. This process has already begun with possible contractors in connection with a design study for a large vacuum chamber with solar simulator for heat-balance studies; and with consultant engineers and architects for planning the ESRO sounding rocket range at Kiruna and the European Space Technology Centre in Delft.

TIROS 8 TESTS NEW CAMERA SYSTEM

Initial results from the automatic picture transmission (APT) system aboard NASA's Tiros 8 meteorological satellite, launched from Cape Kennedy on December 21, were reported to be good. Cloud pictures were received directly from the satellite at Wallops Island, Virginia; Princeton, New Jersey; and the Goddard Space Flight Center in Maryland.

The launching marked the eighth consecutive success in the Tiros series of satellites and the 21st consecutive orbital success for the Delta vehicle. The 265lb satellite was reported to be in orbit at 436-468 miles, with an orbital period of 99min.

Unlike the television subsystem carried in the earlier Tiros satellites, the APT system transmits pictures on a slow-scan principle similar to that used to transmit radio photographs. Meteorologists can observe cloud-cover photographs of their areas as images form on the facsimile machines at their stations. Each APT station can receive up to three photographs during one pass by the satellite, each complete photo cycle taking 208sec.

The 108° lens used in the APT system is a 5·7mm f1.8 Tegea Kinoptic which can photograph an area 820 miles square when the satellite is looking directly towards the Earth. A three-millisecond exposure of the electromagnetic shutter produces an 800-line picture on the photo-sensitive surface of a special 1in dia. vidicon. A timer is used to programme the equipment for continuous cycles of prepare, expose, develop, and direct readout for approximately 30min of each orbit. Preparation, exposure and developing account for the first 8sec of each 208sec cycle; the remaining 200sec is used to read out the photograph at a scan rate of 4 lines/sec.

Among the ground stations to be used in connection with Tiros 8 are the main Tiros stations at Wallops Island, Point Magu and Fairbanks, Alaska; and a large number of APT stations including one which is to be set up by the USAF at High Wycombe, Bucks. The Alaska station became operational last September.

Explorer 19 Observed First sighting of NASA's Explorer 19 air-density satellite in orbit was made by members of the Baker-Nunn camera station at Woomera, using binoculars, on December 20. The satellite was launched from Point Arguello by Scout the previous day. Two objects were observed, the second trailing the first by about 150 miles. The leading object, the satellite, appeared at a steady brightness of sixth magnitude. The second, identified as the instrument package and satellite canister, was tumbling and appeared as an object of seventh magnitude brightness. Orbital elements were quoted by NASA as: apogee, 1,490 miles; perigee, 365 miles; inclination, 78·6°; period, 116min. (Photograph of satellite, opposite page.)

NASA'S LAUNCH SCHEDULE

The National Aeronautics and Space Administration's launch schedule for the next five years in the field of scientific, weather and communication satellites is summarized in the following list:—

Delayed from late 1963 S-52 United Kingdom 2 (Scout, Wallops); S-66 ionospheric beacon (Scout, California); S-55c micrometeoroid satellite (Scout, Wallops); APL-5E (radiation satellite resembling 1963-38C).

January-March 1964 S-52a UK-2 back up (Scout, Wallops); S-48 US topside sounder (Scout, California); S-66a ionospheric beacon back-up (Scout, California); A-12 Echo 2 (Thor Agena B, California); A-16 Relay B (Delta C, Kennedy); San Marco (Scout, Wallops); S-17 Orbiting Solar Observatory B (Delta C, Kennedy); A-4 Nimbus A (Thor Agena B, California); A-19 Relay C (Delta C, Kennedy); S-74A interplanetary monitoring platform B (Delta C, Kennedy).

April-June 1964 S-3c radiation belt satellite (Delta C, Kennedy); S-49 Orbiting Geophysical Observatory A (Atlas Agena B, Kennedy); A-54 Tiros 1 (Delta C, Kennedy); S-74b IMP-C (Delta C, Kennedy); A-27 Syncom C (thrust-augmented Delta, Kennedy).

July-December 1964 S-57 OSO-C (Delta C, Kennedy); A-55 Tiros J (Delta C, Kennedy); S-50 OGO-B (TA Thor Agena B, California); Nimbus 1 (Thor Agena B, California); S-6a atmospheric structures satellite (Delta C, Kennedy); IMP-D (Delta C, Kennedy); Syncom D (TA Delta, Kennedy); S-55d micrometeoroid satellite (Scout, Wallops).

1965 A-56 Tiros K (Delta C, Kennedy); A-5 Nimbus B (TA Thor Agena D, California); French VLF satellite (Scout, California); S-27a 30a prototype international satellite for ionospheric studies (Thor Agena B, California); OSO-D (Delta C, Kennedy); S-49a OGO-C (Atlas Agena B, Kennedy); Nimbus 2 (TA Thor Agena D, California); Tiros L (Delta C, Kennedy); IMP-E (Delta C, Kennedy); S-18 orbiting astronomical observatory A (Atlas Agena D, Kennedy); A-6 Nimbus C (TA Thor Agena D, California); S-50a OGO-D (TA Thor Agena D, California); IMP-F (Delta C, Kennedy); A-30 advanced Syncom A (Atlas Agena D, Kennedy); S-58 OAO-B (Atlas Agena D, Kennedy); OSO-E (Delta C, Kennedy).

1966 Nimbus 3, 4 and D (A-7) (TA Thor Agena D, California); OGO-E (Atlas Agena D, Kennedy); S-60 OGO-F (TA Thor Agena D, California); IMP-G (Delta C, Kennedy); atmospheric monitoring satellite A (Delta C, Kennedy); A-31 and 32, advanced Syncoms B and C (Atlas Agena D, Kennedy); UK-3 (Scout, Wallops); artificial comet A (vehicle and site uncertain); radio astronomy satellite (Delta, Kennedy); OSO-F (Delta C, Kennedy); OAO-C (Atlas Agena D, Kennedy).

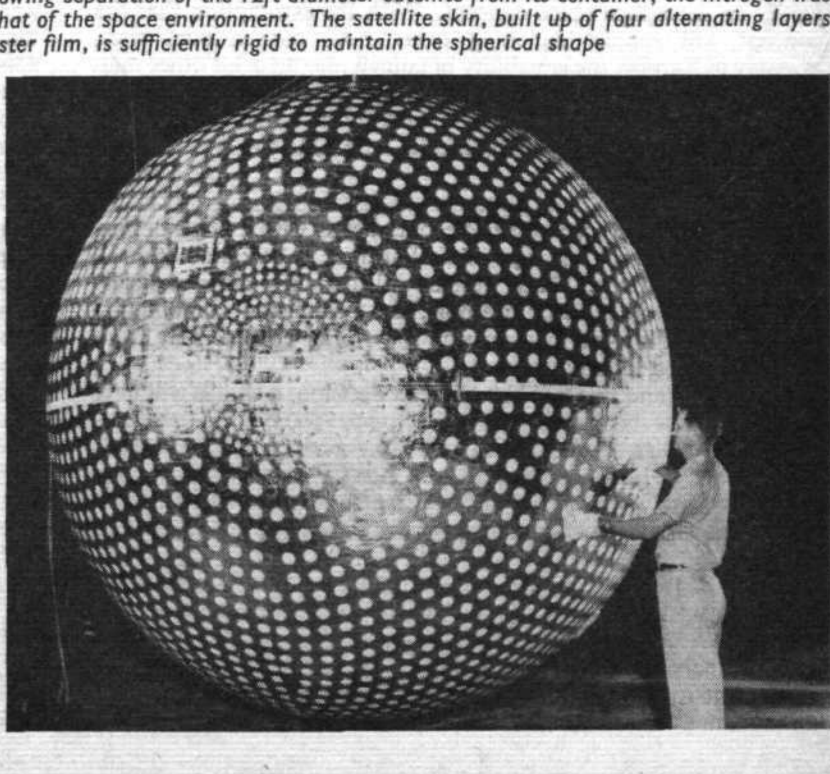
1967-68 Nimbus 5 (TA Thor Agena D, California); ISIS A, B and C (Delta C, Kennedy); artificial comet B vehicle and site uncertain); A-33 advanced Syncom D (Atlas Agena D, Kennedy); atmospheric monitoring satellite (Delta C, Kennedy); S-9 and 79, OGO G and I (Atlas Agena D, Kennedy); S-70 OGO H (TA Thor Agena D, California); OSO G and H (Delta C, Kennedy); advanced OSO A and B (TA Thor Agena D, California); OAO-D S-78 (Atlas Agena D, Kennedy).

Cosmos 24 The launch of the 24th satellite in the Russian Cosmos series was announced by the Tass news agency on December 19. Principal orbital elements are quoted as: initial period, 90.5min; apogee 408km; perigree 211km; inclination 65°. A radio transmitter working on 19.995Mc/s was included in the payload and, the agency added in the accustomed phrase, all equipment aboard the satellite was functioning normally.

Moscow Conference A three-day scientific conference on the optical tracking of artificial Earth satellites, attended by representatives of Bulgaria, Hungary, East Germany, Poland, the USSR, Rumania and Czechoslovakia, opened in Moscow on December 17. According to Prof Alla Masevich, chairman of the organizing committee, the most important problem to be discussed consisted of the results of the first sessions of synchronous photographic observations of artificial Earth satellites. This method, Mrs Masevich said, was indispensable in compiling exact geographical maps of localities difficult of access, where conventional geodesical and cartographic methods were inadequate. She added that all work on space triangulation was co-ordinated on an international scale by the Astronomical Council of the Soviet Academy of Sciences, and Pulkovo Observatory. The improvement of specialized instruments and methods for photographic observation of satellites was stated to be among the topics of discussion at the conference.

US/Swedish Firings US and Swedish scientists launched two sounding rockets from White Sands Missile Range, New Mexico, on December 13 in a co-ordinated study of ion and electron concentrations in the D-region of the ionosphere. A 12lb Swedish payload was fired to a height of 60 miles by an Arcas vehicle, and a 100lb payload devised by NASA's Goddard Space Flight Center was intended to achieve a height of 110 miles aboard a Nike-Apache. The Nike-Apache did not achieve the desired altitude because of a malfunction in the launch vehicle. Its payload included a camera supplied by the University of Leicester.

NASA's Explorer 19 air-density balloon satellite was successfully launched into orbit from Point Arguello by Scout vehicle on December 19. Left, a technician inspects the telemetry package, with the deflated sphere folded inside the foreground tube. After injection into orbit, the satellite was inflated (right) by nitrogen gas. Following separation of the 12ft diameter satellite from its container, the nitrogen was allowed to escape, reducing the internal pressure to that of the space environment. The satellite skin, built up of four alternating layers of 0.0005in aluminium foil and 0.0005in Mylar polyester film, is sufficiently rigid to maintain the spherical shape



Missiles and Spaceflight

ASPECTS OF THE AEROSPACE PLANE

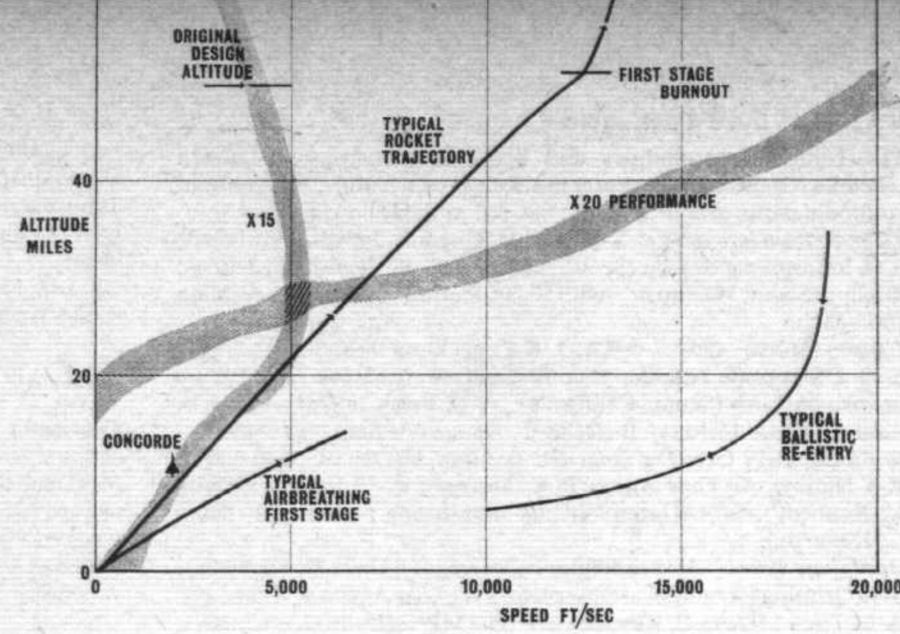


Fig 1 Aerospace vehicle performance

This article is based on extracts from "Some Fundamental Aspects of the Aerospace Plane Concept," presented at the recent British Interplanetary Society symposium on aerospace vehicles by C. R. Turner of Hawker Siddeley Aviation Ltd. Other papers from the symposium were abstracted in our issues of December 19 and December 26, 1963.

THE major mission envisaged for the aerospace plane is that of ferrying supplies and personnel between the Earth and satellites in near-Earth orbit. For this type of mission an operating height above the Earth's surface of the order of about 200 miles should suffice. This ferrying operation might be used for the assembly of interplanetary missions, or alternatively off-loading them on return to near-Earth orbit, and also for setting up scientific space laboratories. All this implies provision for rendezvous and docking, and to this end the capability of the vehicle for pre-orbital manœuvre might be an important design factor when assessing the comparative features of a rocket first stage or an airbreathing first stage.

Other foreseeable missions include the conducting of scientific experiments and the inspection and possible servicing of communication, navigation and meteorological satellites. For some of these missions the operating heights would have to be greater than 200 miles, unless considerable orbiting manœuvre is built into these satellites for such a purpose, involving a payload penalty, more severe guidance and control requirements and would in fact imply a more advanced concept. Also, in general, any manned mission where information is required with the minimum of delay might justify an aerospace plane concept. With the assumption that the concept will enable launching from more conventional sites, possibly in Europe, the capability of launch into an orbit other than through its point of launch is a very important aspect of an aerospace plane operation. Could it be used, for instance, to undertake those missions for which an equatorial launching site is considered necessary?

It must be realized that this range of missions with corresponding payloads cannot be accomplished economically with a single design. One does not expect one type of civil airliner to be suitable for all operating conditions. These designs will certainly differ radically one from the other. For example, the propulsion combination required for a low-payload mission may differ considerably from that requiring a high payload.

Ultimately, and this will be a difficult decision, a choice will have to be made, for the first generation aerospace plane at least, regarding the particular missions and payload range on which it is best to concentrate. It has been suggested that the payload might be in the region of about five tons so as to compete neither with payloads associated with large US rockets, nor with the large US spaceplane concepts.

Regarding most of these missions, the inclusion of a man in the system seems imperative, in particular for the requirements of rendezvous, docking and landing at a specified site. It is realized that the inclusion of a man in a space system requires additional equipment to provide life support and more duplication than for an unmanned mission. Obviously the man must not be taken along just for the ride, but must be justified as an essential part of the system.

Basic Design Considerations Bearing in mind these missions, let us attempt to define the principal characteristics of an aerospace plane. These must be such as to show positive advantages over any existing conventional systems or developments thereof. As it is inconceivable that, on this side of the Atlantic, any project based on this concept will be completed in under ten years, the problem of creating a system that will not be superseded before it is operational is very important.

To my mind the basic characteristics of an aerospace plane should be the following:—

(*a*) The vehicle's stages should be recoverable whether rocket or airbreathing.

(*a*) The final stage should be capable of entering an orbit of at least 200 miles in the first instance; this may be extended in the light of experience and requirements.

(*c*) It should be capable of considerable sub-orbital manœuvre. To attain orbital planes that periodically pass through the launching point, manœuvrability that would effectively reduce the time delay should be a capability. Regarding orbital planes inclined to the equatorial plane at an angle less than the launching latitude, manœuvring capability to enter these orbital planes should exist, although this will depend on the latitude of the launching site.

(*d*) It should be capable of a limited manœuvring capability in orbit. It must be realized that manœuvring operations such as orbit changing, repositioning in orbit, etc, involve a very large weight penalty. It can be calculated, based on a 5,000lb payload, that even a 1° orbit change can involve a weight penalty of about 350lb, a 30° orbit change about 5,000lb. To "catch up" a 30° lag in a 200-mile circular orbit by direct orbit transfer requires again about 850lb. However, these figures do imply a reasonably quick manœuvre time, for the weight penalties can often be considerably reduced if a longer time is acceptable. The point, however, is that within the present capabilities the idea that the spaceplane in orbit can enjoy the manœuvring capabilities of a fighter should be dispelled. Finally, the vehicle should be able to rendezvous and dock as required by the missions.

(*e*) Re-entry should be possible whenever required and the vehicle should have the aerodynamic capability (moderately high hypersonic L/D) and good subsonic characteristics to enable it to glide and land, with power when required, to a pre-determined site. The main problems encountered here are high deceleration, heating rates, total heat input, and acceptable landing speeds, etc.

(*f*) The vehicle, in its final form at least, should be manned; this will undoubtedly suggest a minimum orbital weight of at least 4,000lb.

(*g*) To enable reasonably fit, but not specifically trained, personnel to engage in these missions the maximum vehicle acceleration and deceleration should be restricted to a value between 1.5g and 2g, although this will depend on the rate of change of acceleration, and its duration.

These requirements represent to my mind the desirable features of an aerospace plane and those which taken as a whole should lead to a concept which would compare favourably with any conventional system or simple development of it. Undoubtedly, in the long run, as the mission requirements are better understood, more emphasis may be placed on one particular characteristic. Whether recovery is considered of the lower stages, either by parachute or manned control, for example, must depend on the number of firings or take-offs envisaged.

General Proposals

Single-stage Vehicles This represents the ideal solution, but a simple calculation, assuming a value of 25,000ft/sec for the characteristic velocity plus 5,000ft/sec combined drag and gravity losses, of the mass ratio required to orbit such a vehicle (a value of about 9) even assuming a specific impulse of 420sec, indicates that with conventional propulsion methods this is beyond current technological development. Thus either a power system with an inherently large specific impulse is required, and this must be maintained during the whole boost phase, and not only up to relatively low Mach numbers as in the case of airbreathing engines, or some method of overcoming the staging problem is necessary.

The first possibility may be met by considering nuclear propulsion, but this is obviously looking a long way in the future, and introduces severe protection weight penalties, as well as possibly insurmountable safety problems. With regard to the second proposal, a considerable amount of work is already going on, particularly in the USA, in the field of air-scooping techniques. In this concept, to reduce take-off weight, air is collected during the ascent phase, the oxygen extracted, liquefied, and used as an oxidizer with liquid hydrogen fuel.

The problems arising from this suggested technique cannot be over-exaggerated. They include the study of complex internal aerothermodynamic systems coupled with requirements for low-weight liquefying plants, etc, trajectory studies involving air-collection requirements, intake drag losses, etc. This system, of course, could equally be considered for rocket-boosted and air-breathing stages, although there may be difficulties in collecting sufficient air in the former case without substantially modifying an otherwise optimum trajectory.

Multi-stage Vehicles Under this heading can be considered conventional rocket stages, airbreathing propulsion stages and combinations of these propulsion systems. From the point of view of using well-tried systems, the use of a multi-staged rocket to carry the final vehicle into orbit is attractive. These stages could be winged and manned and so recoverable. For an orbiting vehicle using three rocket stages, liquid oxygen and liquid hydrogen propellants, assuming 5,000ft/sec drag and gravity losses, its weight could be about 6 per cent of the initial take-off weight.

The use of airbreathing propulsion systems is obviously attractive because of the high specific impulse compared with rocket propulsion, arising from its ability to use the atmosphere as part of its propellant systems.

At the present time, however, airbreathing systems can only be considered feasible up to about $M = 5$ although, within the time schedule considered, supersonic compression development should allow operation to above $M = 7$. In any event, airbreathing systems will be confined to the lower stages as, with increasing altitude, their SI advantage decreases. Thus a possible configuration is the use of an airbreathing first stage coupled with rocket upper stages. Preliminary estimates give encouraging results but they are dependent on assumptions such as structure weight, fuel consumption, gravity and drag losses, etc, which need more experience to support.

Assisted Take-off It is, of course, possible to consider an assisted take-off procedure to reduce the take-off weight and thrust, using some type of catapulting device. If an initial speed of about 1,000ft/sec was imparted at ground level by a catapult or similar means, in connection with a first stage velocity requirement of about 7,000ft/sec, the take-off weight could be reduced by about 4 per cent for the same payload in orbit.

Payload The composition of the payload will obviously depend on the missions envisaged and will be geared to the requirements of the space programme. In the early design phase "payload" is, perhaps, a word to be avoided as it may be difficult to define which equipment, personnel, etc, are payload, and which are basic structure. For certain missions part of the orbiting weight might be off-loaded, e.g., supplying materials and men for building-up space stations, while in others no such transfer will occur, e.g., servicing satellites and scientific observations. It is probably more realistic at this stage, therefore, to think in terms of the weight in orbit, especially as it is related directly to take-off weight and power requirements.

There may be some advantage in designing for an orbital weight that will avoid competition with known US systems. Thus an upper limit of seven or eight tons might be a reasonable target. For missions involving the servicing and replacement of small satellites, scientific observations, etc, this weight should be ample. The ferrying of material and personnel could be accomplished within the above weight criterion but obviously an economic study comparing the use of a number of small vehicles and a single vehicle for a same total payload would be required.

Re-entry and Landing The concept should include the capability of landing at a pre-determined site. This requirement is a major factor and would be related to lateral range capability, waiting time in orbit for the selection of a more favourable landing plane, etc. As a rough approximation the lateral range varies from about 200 miles for an L/D of 0.5, through about 2,500 miles for an L/D of 2.0, and 10,000 miles for an L/D of about 6 or 7.

Conclusions If the conception of a European space programme materializes, the civil justification for an aerospace plane appears reasonable. It is a field in which the USA at the moment appears to be hesitating and thus might afford a good opportunity for Europe to seriously involve itself in space.

The technical problems associated with the concept cannot be over-emphasized, however, and it certainly is impossible at the present time to consider it other than as a vast research programme, apart from indicating some possible lines of approach. On the other hand, if Europe is to make some impression in the space field there is little time to lose.

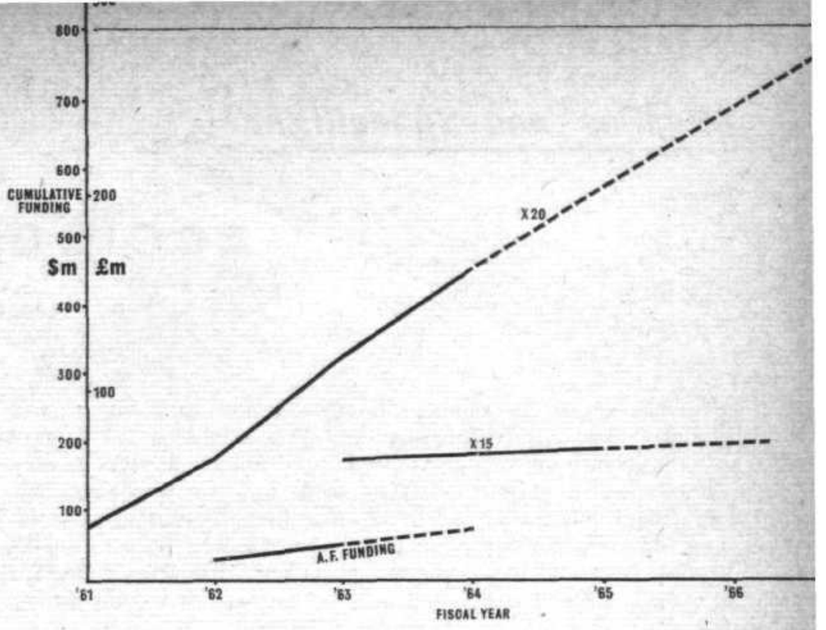
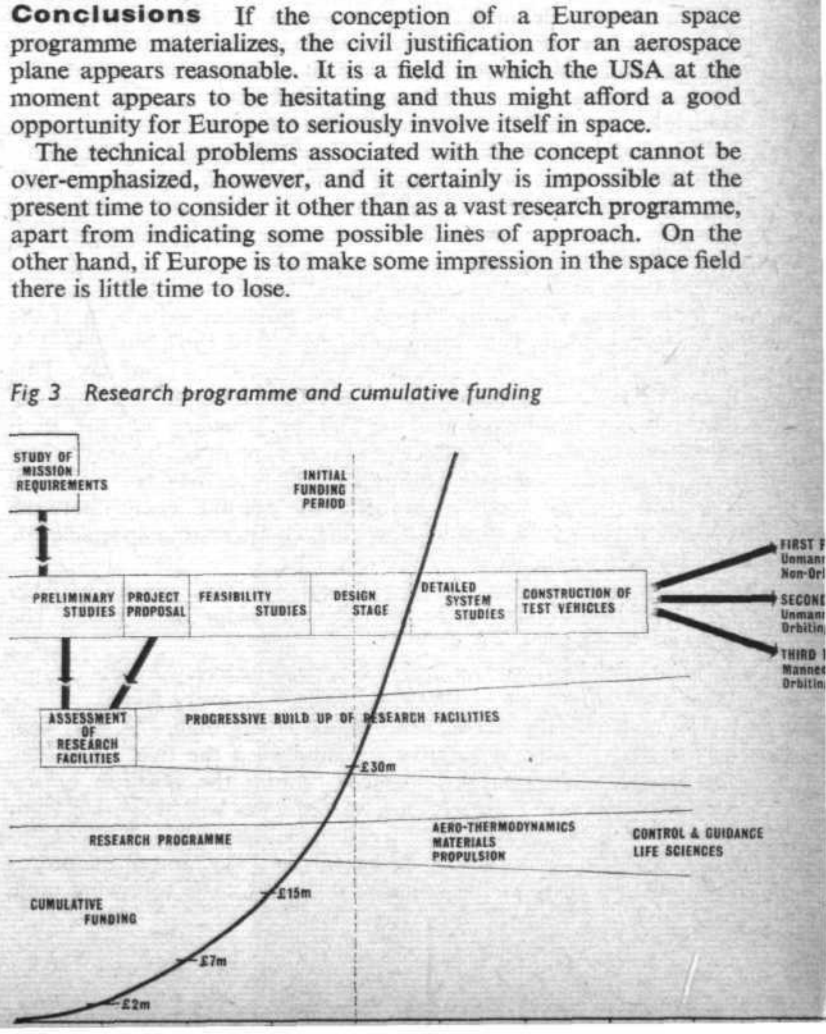


Fig 2 US aerospace plane funding (prior to X-20 cancellation)

Fig 3 Research programme and cumulative funding



Missiles and Spaceflight

ACCIDENTAL RENDEZVOUS

By J. A. PILKINGTON, BSc

IN their plans for manned lunar landing, both Soviet and American scientists envisage the use of rendezvous in orbit—the joining together of two separate orbiting satellites as they circle the Earth. The last four Vostoks have shown by virtue of their orbits that the Russians are already attempting rendezvous, and the plans for American astronauts to join their Gemini spacecraft to an orbiting Agena D have received great publicity. Rendezvous is, of course, difficult enough to achieve between two co-operating spacecraft; near-rendezvous by two US satellites, however, will be unintentionally achieved next month. The minimum distance between them may be about 10km, which is approaching the proximity attained by the Vostoks.

The two satellites in question, known as 1963-03A and 1963-27A, are part of a USAF project whose purpose is classified. Both are Agena D second-stage rockets measuring about 5ft in diameter and 30ft long, which were launched by Thor boosters from Vandenberg AFB, California, on January 16 and June 29, 1963. They may be part of either the Discoverer or the Samos programme, but have probably ceased transmitting by now. At 0824hr GMT on October 16, 1963, they had the orbital elements listed in the table below.

Orbital Elements

Satellite	1963-03A	1963-27A
Inclination (deg)	81.88	82.30
Nodal period (min)	94.60	94.79
Right ascension of ascending node	218.12	210.22
Change per day	−1.083	−1.022
Argument of perigee	167.1	353.0
Change per day	−3.454	−3.476
Perigee height (km)	460	490
Apogee height (km)	545	535

From the table of elements, we see that the difference between the right ascensions defining the orbital planes of the two objects was 7.9° on October 16. This difference is decreasing at a rate of 0.061° per day and will become zero 129.5 days later—on February 22, 1964. Although the ascending nodes of both satellites will be coincident on that date, the longitudes on their crossing latitude 50°N will be 0.5° apart because of the difference in inclinations. Coincidence of the orbital planes at this latitude will occur eight days later for Northbound and eight days earlier for Southbound passages. The two points of coincidence will be between 50°S and 50°N from February 15 to March 2.

Having considered the orbital planes, the position of the satellites in their orbits is of some interest. The satellites were both at the same point in their orbits at noon on October 19, 1963, but 1963-03A was "catching up" 1963-27A at a rate of 2.92min per day. This means that 27A is lapped by 03A every 32.45 days and four laps will be completed 129.8 days later—in fact, by February 26, 1964. Both satellites are affected slightly by atmosphere drag, however, and these estimates, made some months in advance, may prove slightly inaccurate. The lapping nevertheless should occur between February 23 and 29, and will provide an interesting spectacle for all who care to watch it.

To the observer on the Earth, both satellites appear to flash regularly, occasionally as bright as stellar magnitude +1.5. The average brightnesses are:–

1963-03A from +3.2 to +6.2, flashing every 2.1sec

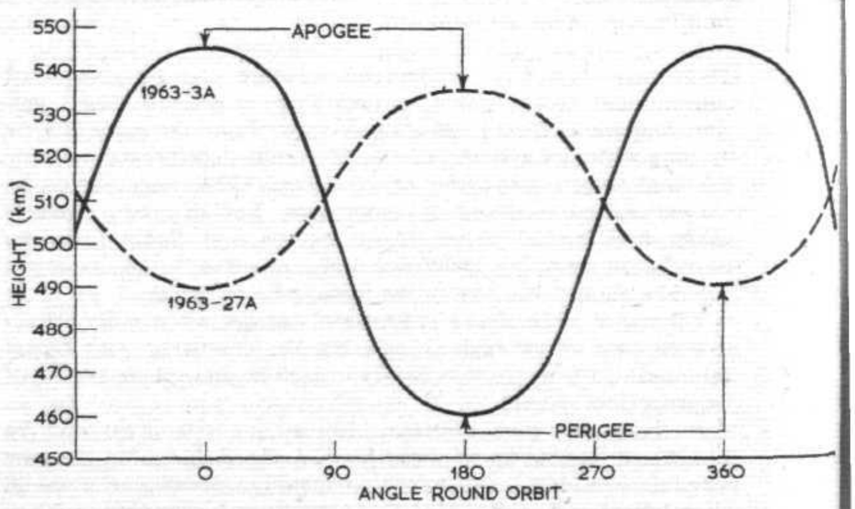
1963-27A from +3.1 to +5.6, flashing every 1.1sec.

The fact that 1963-03A flashes more slowly than 27A may well be the only means of differentiating between the two when they are seen crossing the sky together. From the position of the orbital planes next February, the two satellites will be visible from the British Isles. In the evenings after twilight they will appear to travel from the southern sky to the northern sky, and in the mornings before sunrise in the opposite direction. The following table gives the times when the orbital plane will cross the Greenwich meridian at latitude 50°N:—

Date 1964	Northbound GMT	Southbound GMT	1963-27A precedes 03A by about:—
Feb 21-22	19.45	06.23	+12 mins
22-23	19.37	06.15	+9
23-24	19.29	06.07	+6
24-25	19.21	05.59	+3
25-26	19.12	05.50	0
26-27	19.04	05.42	−3
27-28	18.56	05.34	−6
28-29	18.48	05.26	−9
29-1 Mar	18.39	05.17	−12

Observers should make the above times 4min later for every degree they are west of Greenwich, to obtain the time the orbit crosses their longitude. The separation of the satellites may prove to be slightly different to that suggested in the last column.

The satellites are unlikely to be overhead at the same time as the orbital plane, and so the observer would have to search for them as the plane moves westwards across the sky due to the Earth's rotation. However, individuals wishing to observe this rendezvous without undertaking a search may refer to a table to appear next month in an issue of *Flight International.*



The orbital heights of the satellites 1963-3A and 1963-27A

Finally, let us examine exactly how close the two satellites will be. Although the orbits of both objects are fairly circular, the arguments of perigee will differ by about 176° in late February. This means, that while one is at its apogee, the other is at perigee. They will only be close at two points in their orbits when both their heights are about 508km (see figure). Under the best circumstances possible, they would be within 9km of each other for only 6min since, at the two approaches, one satellite would be changing height at about 2km per minute and the other at about 1km per minute in the opposite direction. If the arguments of perigee had been almost equal, the satellites would have remained very close to each other for several revolutions, the maximum separation in height being 30km at perigee, and the minimum perhaps only a few kilometres. So it appears that 1963-03A and 1963-27A will come together only to travel their separate ways in the years to come. Unless, of course, their restartable motors are still capable of bursting to life on a command from the Earth. . . .

SERVICE AVIATION

Air Force, Naval and Army Flying News

The RAF's newest tactical transport, in the hands of FEAF's newest transport unit, 215 Sqn, based at Changi, Singapore, is now supplementing Hastings, Beverleys and Valettas in the air support of the security forces engaged in Borneo; but in this photograph one of the unit's Argosies was embarking troops for an exercise during which they were airlifted from Changi to Kuantan, on Malaya's east coast

An Eventful Christmas Week

THE DISASTROUS FIRE aboard the liner *Lakonia* and the emergency airlift of troops to Cyprus after civil strife broke out there last week gave some Service elements a much busier Christmas period then they had expected.

Following distress calls from the *Lakonia*, first transmitted at 2327hr GMT on December 22, two 224 Sqn Shackletons took off from RAF North Front, Gibraltar, early on December 23 and dropped Lindholme gear to survivors in the water near the burning liner. Another Shackleton, of 42 Sqn, flew direct from St Mawgan to drop more dinghies and then landed at Gibraltar to deliver additional survival gear carried in the fuselage. This aircraft returned to Britain the following day, Christmas Eve, visiting the rescue area on the way back.

A Transport Command Britannia of 99 Sqn was, coincidentally, at the Coastal Command station of Ballykelly when news of the disaster came through early on Monday; it took off within a few hours carrying extra stocks of rescue and survival equipment for Gibraltar.

HMS *Centaur*, which left Portsmouth for the Far East on December 21, had aircraft standing by for search on December 23, when she was off Finisterre, but they were not required.

Altering course to head for the *Lakonia*, *Centaur* had her Whirlwind planeguard helicopters operating in the area at first light on December 24 and she took over control of the whole rescue operation for its later phases. She docked at Gibraltar on the afternoon of Christmas day with survivors and bodies.

Transport Command's unseasonal activity started on Christmas Day, when two Britannias flew to Cyprus carrying men of the Foresters' Regiment. Three more flew out on Thursday and three on Friday (one of them carrying Commonwealth Relations Secretary Mr Duncan Sandys). Altogether 750 passengers, 12 Land-Rovers, five trailers and about 50 tons of freight were carried on this three-day lift.

On December 28 140 men of 16 Sqn, RAF Regiment, flew to Nicosia in Britannias. Five Beverleys of 47 Sqn had flown from Abingdon to Libya to pick up a Ferret scout car squadron of the 14/20 Hussars and fly them to Akrotiri. Despite thick fog over Southern England during the airlift there were no major delays.

New Homes for Navy Aviators

NAVAL AVIATION will figure in another type of ship when HMS *Fearless*, launched at Harland and Wolff's Belfast shipyard on December 19, is commissioned.

Fearless herself is something completely new—the first of a new class of assault ships, designed to land heavy tanks, troops and Marine commandos, and their vehicles, by means of landing craft which will themselves be carried in the ship's dock and launched by flooding a compartment in the ship's open stern.

Fearless will be equipped with a small helicopter flight deck, enabling carrier-based assault helicopters to ferry her military force ashore on a "cab-rank" basis. She may herself carry one or two helicopters, although there will be no hangarage. Her assault operations room will be equipped to control aircraft engaged in an assault.

Among her defensive armament, the 10,000-ton, 520ft-long *Fearless* will have four Short Seacat anti-aircraft missile launchers. A sister ship, HMS *Intrepid*, is at present being built by John Brown on Clydeside.

RCAF to Withdraw from France?

INTERNATIONAL TALKS were held in Paris and elsewhere last month to avert, it is believed, a decision by the Royal Canadian Air Force to withdraw its CF-104 equipped tactical strike-reconnaissance squadrons based at Gros Tenquin and Marville, in eastern France, to bases in other NATO countries, probably Germany. The question is bound up in the higher realms of international politics and has arisen from the French insistence that there must be French control of all nuclear warheads based in France.

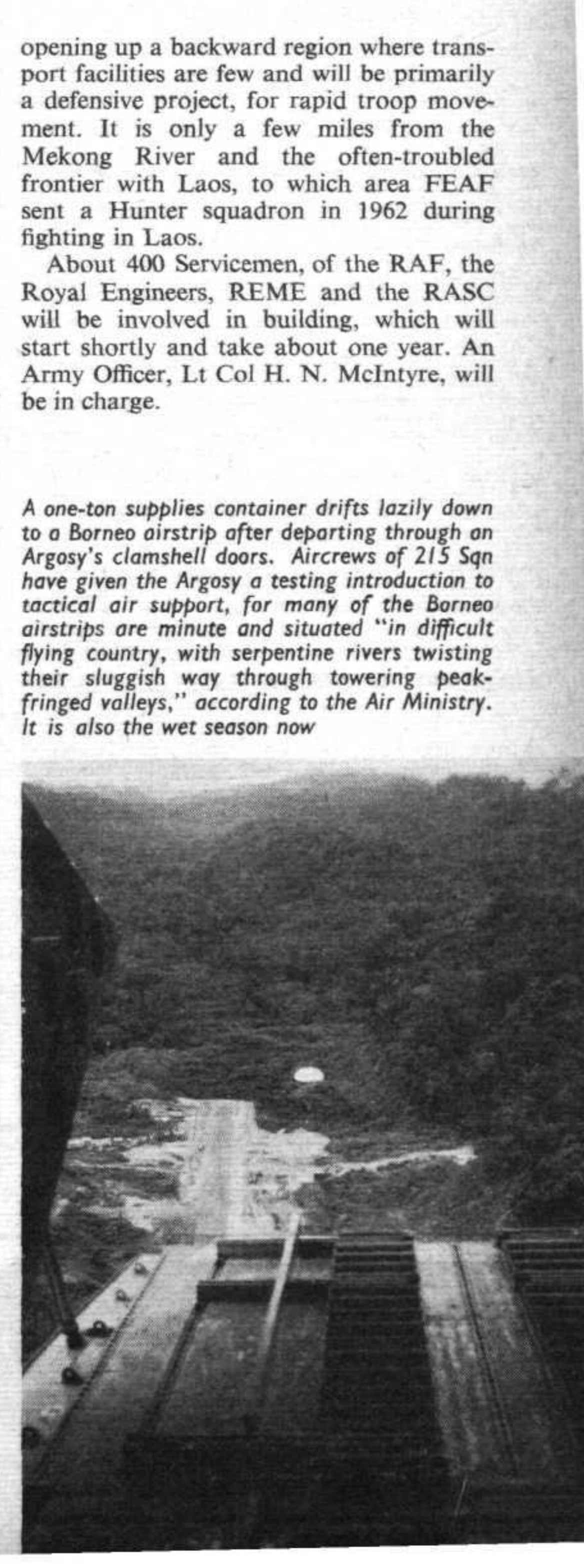
RAF Airfield Builders for Thailand

THE FAR EAST AIR FORCE's civil engineers, No 5001 Airfield Construction Squadron, based at RAF Seletar, is the RAF unit most likely to be engaged on the new airfield in North East Thailand which, the Foreign Office announced last month, Britain will build for the Thailand Government. Britain and Thailand are allies in SEATO.

The Foreign Office announcement said that the airfield, near Mukdahan, will "improve military logistic facilities in Thailand." It will have a civil value, in opening up a backward region where transport facilities are few and will be primarily a defensive project, for rapid troop movement. It is only a few miles from the Mekong River and the often-troubled frontier with Laos, to which area FEAF sent a Hunter squadron in 1962 during fighting in Laos.

About 400 Servicemen, of the RAF, the Royal Engineers, REME and the RASC will be involved in building, which will start shortly and take about one year. An Army Officer, Lt Col H. N. McIntyre, will be in charge.

A one-ton supplies container drifts lazily down to a Borneo airstrip after departing through an Argosy's clamshell doors. Aircrews of 215 Sqn have given the Argosy a testing introduction to tactical air support, for many of the Borneo airstrips are minute and situated "in difficult flying country, with serpentine rivers twisting their sluggish way through towering peak-fringed valleys," according to the Air Ministry. It is also the wet season now



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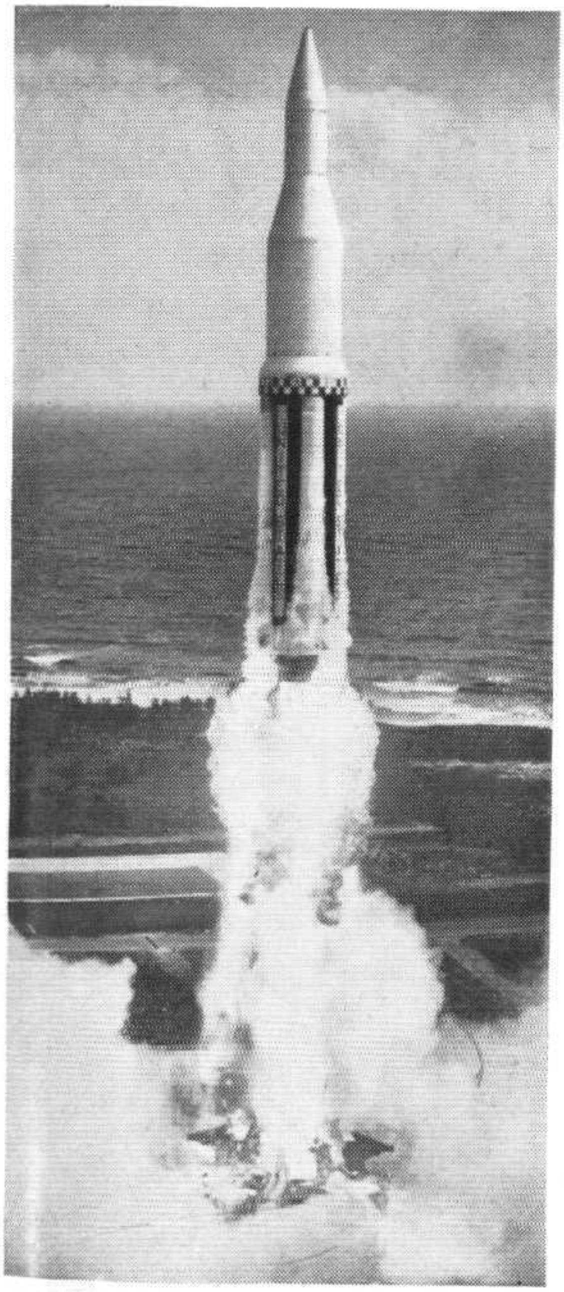

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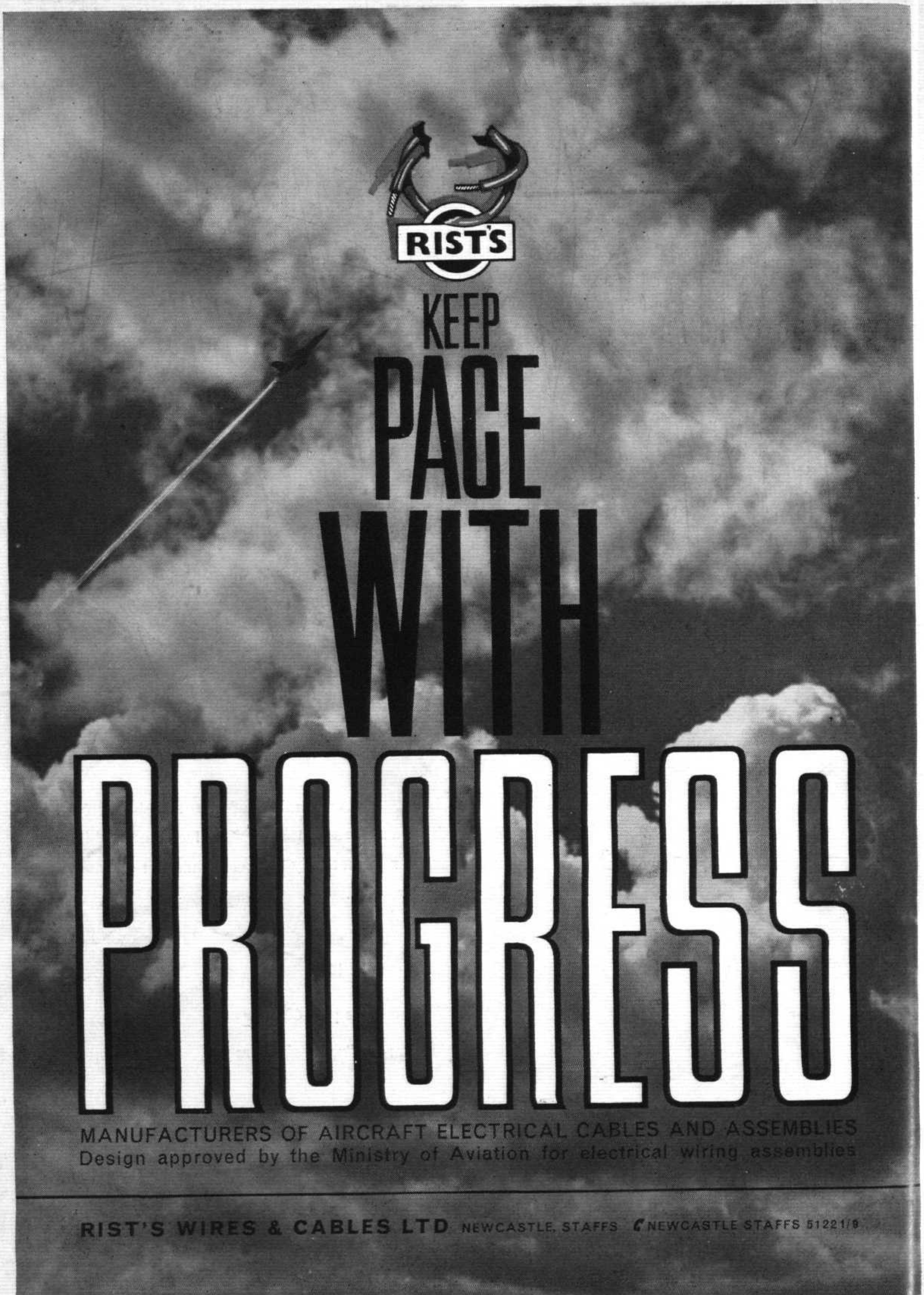
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