252

GE IN GENERAL

and film techniques, using a continuous flow of compressor bleed air. The guide vanes incorporate nose holes, several rows of chordwise gill holes and trailing-edge slots. They are coated with Codep, a GE-developed compound, to improve resistance to erosion and oxidation.
Tip sealing of the two-stage h-p turbine is provided by rubbing surfaces and "squealer" tips on the blades. The four-stage 1-p turbine has tip shrouds. The 1-p turbine case is cooled by a system of external impingement air which is bled from the fan and distributed around the casing by an external manifold. The arrangement was developed from that of the TF39 and helps to provide improved turbine efficiency by controlling clearances, and is not needed to ensure the life of the turbine case.

Thrust reversers are provided for both hot and cold streams. To effect fan-flow reverse the rear portion of the fan outer cowl translates aft to uncover cascade vanes. There are 16 blocker doors which lie flush with the cowl during normal thrust conditions. To provide reverse, these are rotated inwards to uncover the inner face of the cascade and divert the fan stream. Turbine flow reverse is also provided by cascades and a translating cowl. Two cascade screens are mounted aft of the turbine exhaust on the exhaust centre body and these open across the nozzle exit and divert the hot flow. Acoustic treatment is applied where necessary to reduce noise levels.

Wide range of activities

Aerospace, of course, only forms part of the General Electric Company's range of activities, which include steam turbines, industrial gas turbines, electrical generators, nuclear power stations, locomotives, electronics and space vehicles. Sales of aerospace products were valued at $1,514 million in 1972 and accounted for 13 per cent of the company's total sales and five per cent of earnings. The increasing output of commercial aircraft engines (primarily the CF6) only partially offsets the downward trend in defence-related products, and 1972 was the fifth successive year that aerospace sales had declined. The Aircraft Engine Group's biggest accomplishment for share-holders, says Gerhard Neumann, vice-president and group executive, was to stay profitable while writing off the costs of concurrently developing the CF6-6 and CF6-50.
The initial version of the CF6—the CF6-6D for the DC-10-10—was certificated at a take-off thrust of 40,0001b, 179kN, which corresponded to a turbine entry temperature of 2,365°F, 1,300°C and a steady-state exhaust gas tem-perature (EGT) of about 1,652°F, 900°C. GE says that the first 276 GF6-6Ds shipped from Evendale exhibited an average take-off EGT margin of 110°F, 61°C and a specific fuel consumption 1-8 per cent below specification. Modifications to produce the 49,0001b-, 218kN-thrust CF6-50A for the DC-10-30 brought a slight increase in turbine entry temperature and the engine was certificated at 1,665°F, 908°C steady state and 1,692°F, 922°C transient EGT. The first 117 engines demonstrated an average take-off steady state EGT some 95°F, 53°C below the certificated figure. Specific fuel consumption was 5-2 per cent below specification.
The demonstrated EGT of 1,571°F, 855°C is maintained on the CF6-50D, which has a stronger 1-p shaft, turbine rear-frame and engine mounting to allow the fan to be run up to 3,900 r.p.m., compared with about 3,600 r.p.m. for the -50A. The 51,0001b, 227kN-thrust CF6-50D is flat-rated to 77°F, 25°C. Improved hot-section cooling and an increase in turbine temperatures allow the -50C, also rated at 51,0001b, 227kN, to be flat-rated to 86°F, 30°C with a EGT raised to 1,602°F, 872°C. This engine will power the A300B, and kits for uprating the -50A to -50C standard will be made available according to the schedule outlined by Brian H. Rowe, vice-president and general manager of
the Commercial Engine Division, in Flight for June 14, page 914. The uprating to 52,5001b, 235kN for the CF6-50E

FLIGHT International, 9 August 1973

CF6-50A CF6-50C CF6-50D CF6-50E CF6-50F

Take-off
Thrus t 49,0001b 51,0001b 51,0001b 52,5001b 52,5001b
Flat-rated temp 87°F 86°F 77°F 78°F 86°F Maximum climb
Thrus t 11,5001b 11,5001b 12,0001b 12,0001b 12,1001b
s.f.c. -664 -664 -680 -680 -662
Maximum cruise
Thrus t 10,8001b 10,8001b 11,1001b 11,1001b 11,2001b
s.f.c. 654 -654 -657 -657 -652

Take-off performance—uninstalled, ideal nozzle, sea-level static.
Climb and cruise performance—uninstalled, real nozzle, Mach 0.85/35,000ft, ISA.

and the 747-300 is obtained at the same EGT but at th expense of flat rating which, in line with the pattern adopted for the -50A and -50D, is restricted to 78°F, 25°C It is planned to extend this flat rating to 86°F, 30°C on the GF6-50F, which will also have a take-off thrust of 52,5001b, 235kN but with an EGT of 1,643°F, 895°C. Looking to the future, the CF6-50 project manager doe not agree with those in the airframe industry who believe that an American SST will be revived at an early date. GE continues to brief Senators on the subject, but, following the rough ride given to the Boeing aircraft, Pirtle does not think there will be a new proposal, perhaps for a second-generation design, for about seven years. He h no doubts, however, that air transport needs an SST a says that long-range, non-stop flights provide the answe to those who doubt this proposition. While the developmen of a variable-, or flip-flop-, cycle engine might be needed to meet the side-line requirement of FAR Part 36, Pirtle says that the Olympus probably has the best cycle availab within present technology for a first-generation SST.

Aviation fuels

Despite talk of a shortage of aviation fuels (see Fligh for July 12, page 59), Pirtle does not think that aircraf engines will move away from using hydrocarbon fuels during his career. The use of liquefied natural gas woul be practical even if it did pose difficulties with refrigera-tion and the provision of sufficient volume. The specia problems of aircraft design may require air transport to be last on the list for the use of alternative fuels. The energy crisis, he says, is the product of bad manageme rather than a lack of resources. High-energy boron-base fuels were tested with the GE J93, the engine for th supersonic XB-70 Valkyrie, and the company's facility at Peebles, Ohio, was built for this purpose. This fuel gave rise to formidable storage problems, while the exhaus produced a white cloud of borax.
A computer is used to keep track of all CF6 modules A complete engine is built up from serialised parts and records of each part kept from the "cradle to grave. Unscheduled removals and in-service incidents with CF6 are closely monitored by GE engineers at Evendale, an correlated with component life and previous reports. The company claims that "management is never more than on day behind an individual engine." Product-support per-sonnel and senior engineers hold a meeting each mornin to review the pattern of incidents, and the company say that its communications are so good that, when a DC-10-3 belonging to KLM was involved in an incident at Tokyo recently, Evendale knew about it while the aircraft was still burning off fuel before landing. In Europe, KLM and Air France carry out CF6-50 overhauls for the DC-10-30s of the KSSU and Atlas groups. It seems likely that these groups will provide overhaul facilities for smaller airlines operating the DC-10 and 747-300. Conversion of the CF6-50A and C to CF6-50E standard will only involve changes to the engines' external plumbing and all th major modules will be interchangeable. GE plans to sen a delegation to China, given State Department clearance to back up McDonnell Douglas presentations of the DC-10 GE has already held talks with British Airways engineers at Treforest to discuss the provision of overhaul facilities should BOAC buy the CF6-powered 747-300.