

Aircraft type and registration: Boeing 747-136 G-AWNG

No & Type of engines: 4 Pratt and Whitney JT9D-7 cn turbofans

Year of Manufacture: 1971

Date and time (GMT): 21 April 1987 at 1027 hrs

Location: 1 nm west of London Heathrow Airport

Type of flight: Public Transport

Persons on board: Crew — 17 Passengers — 319

Injuries: Crew — None Passengers — None

Nature of damage: Severe damage to the engine cowlings and ancillary attachments

Commander's Licence: Airline Transport Pilot's Licence

Commander's Age: 54 years

Commander's Total Flying Experience: 11,200 hours (of which 4700 were on type)

Information Source: AIB Field Investigation

During departure from Heathrow's Runway 28R on a scheduled flight to New York, whilst passing 1200 feet on the initial climb, the crew heard a loud bang which was rapidly followed by the No 2 engine fire warning bell and lights. The co-pilot was handling the aircraft and continued to do so whilst the commander and the flight engineer carried out the appropriate drills. Whilst jettisoning fuel prior to making a precautionary landing, the commander was informed that one of the passengers was suffering a developing medical emergency and so he discontinued jettisoning the fuel and elected to make a slightly overweight landing. This was accomplished without incident and the aircraft was brought to rest on the runway whilst the Airport Fire Service and the company engineers carried out an inspection. As no fire remained and there was no further emergency situation, the aircraft taxied back to the terminal and the passengers disembarked in the normal fashion. The passenger who had been ill had fully recovered.

During the engine fire drill, the lights, which show that each fire extinguisher has successfully functioned, failed to indicate and the fire warning lights remained illuminated for the remainder of the flight. Subsequent investigation revealed that a wire from the pressure sensor to the extinguisher indicator lights had become disconnected but the reason for the fire warning light remaining on could not be determined because of fire damage to the wiring looms in the engine nacelle.

EXAMINATION OF NO 2 ENGINE

The hinged side cowlings of No 2 engine, although remaining attached to the pylon by the top hinges, had broken apart at the bottom fastenings and suffered gross distortion due to airstream effects. They showed signs of severe scorching, some burning, and mechanical damage.

The engine itself showed signs of fire predominantly on the upper surface under the forward edge of the hinged side cowls. Scorching and melting of non-metallic components of the engine-mounted systems had occurred in many locations.

In order to locate any combustible fluid leaks, the booster pumps were switched on and the low pressure and high pressure fuel valves were opened, whereupon a large fuel leak could be seen in the region of the apparent seat of the fire described above. Investigation revealed that a fuel servo pressure pipe P/No 711256 had fractured adjacent to the end fitting connecting it to the Air-Fuel Converter Valve. In addition a compressor delivery air pressure signalling pipe, of similar diameter and located close to the fuel pipe, had also fractured.

Metallurgical examination of these pipes showed that the fractures were almost completely of a fatigue nature, with regular striations equating to approximately 10—12,000 cycles to failure. These were considered to indicate the presence of severe vibration and other indications were also found on the engine systems which supported this view. However, initial examination, including a borescope inspection, failed to reveal any fundamental discrepancies within the basic engine which could account for such vibration.

HISTORY OF NO 2 ENGINE

The engine, serial number 662857 had undergone extensive overhaul work prior to its fitment to G-AWNG. During the test bed run prior to its release to service, it had recorded vibration levels well within the overhaul agency's limits, which were more stringent than those recommended by the engine manufacturer.

After being installed on the aircraft, it had undergone routine ground running, during which time two pipes failed. These were an oil pressure feed pipe and an air signalling pipe, both located on the right hand side of the engine. Following replacement of these and other rectification work on the engine it was cleared for flight, although the ground crew had noted 'murmuring' and vibration but were apparently satisfied that it was acceptable. The aircraft was not fitted with on-board vibration monitoring equipment.

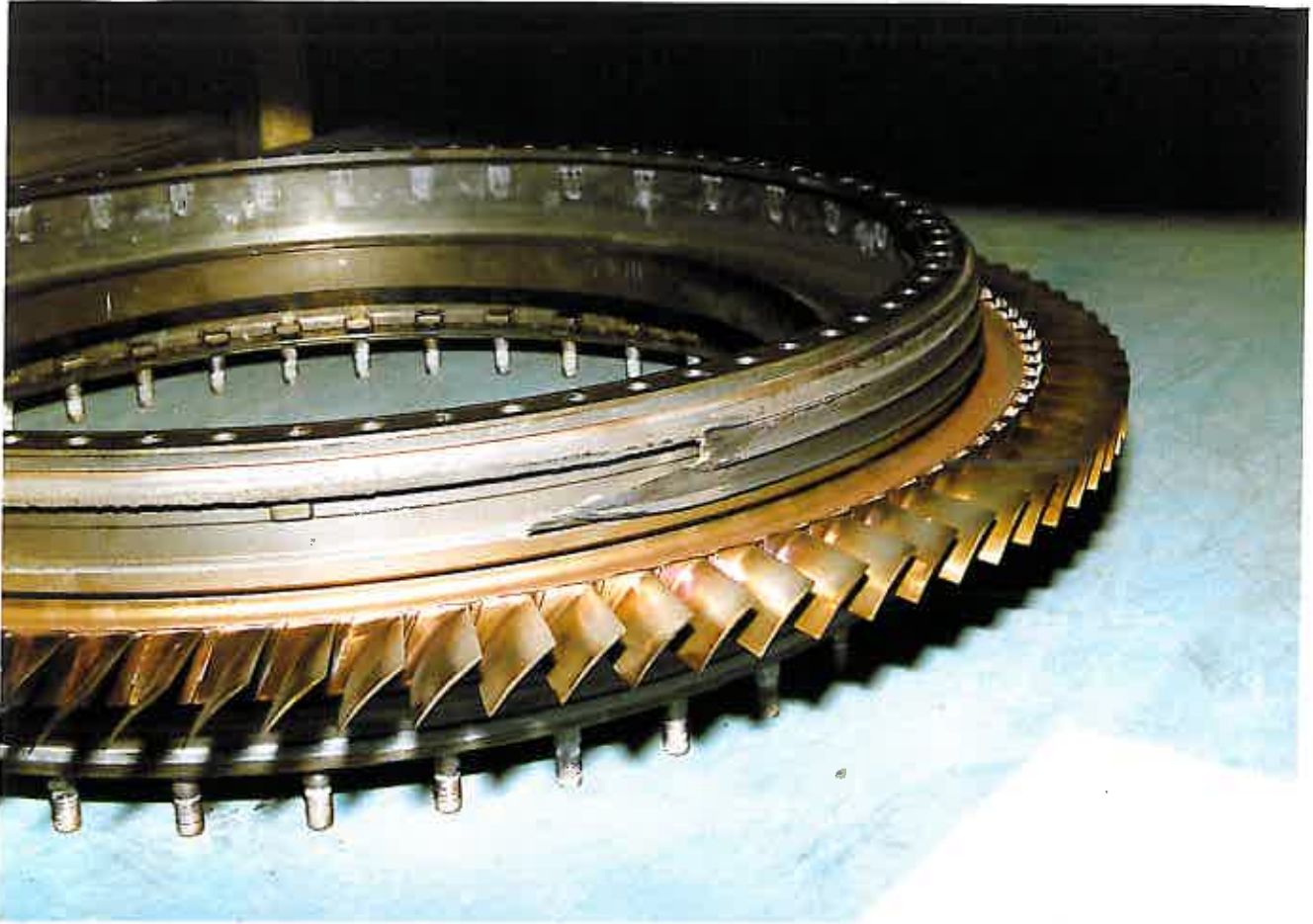
The fire incident occurred on the first take-off of the engine after installation.

POST-INCIDENT TESTING

Despite the considerable fire damage and after extensive component replacement and repair, the engine was run for a short time on a test bed. Severe vibration levels were recorded during this run, evidently associated with High pressure (N₂) rotor speed. The modules were then separated and tested individually, during which the HP compressor module was found to have an apparent imbalance of about 140 ounce-inches.

Upon disassembly of this module it was found that the 13th stage stator rotating air seal, P/No 787428 had a considerable amount of material missing from its circumference over an arc of about 90°. See attached photograph. The material had evidently been abraded away and there was severe wear on the mating static air seal. Although the amount of material lost due to abrasion seemed to preclude any meaningful metallurgical examination of the seal ring, the observed damage would appear to be consistent with some form of partial failure of the ring. High centrifugal forces would tend to force a free end of the ring against the static seal, causing progressive wear and overheating such as that observed. This would also be consistent with the apparently increasing magnitude of the vibration, since the out-of-balance moment would increase as the material was lost. The final amount of metal lost from the ring was 13.8 ounces, equating to a moment of about 162 ounce-inches.

The engine manufacturer reports several cases of severe abnormal wear occurring on the 13th stage stator air seal which had been discovered after test running newly overhauled HP compressor modules. A problem with maintaining seal clearances has been cited as a possible cause. The affected parts from G-AWNG's No 2 engine have been despatched to the manufacturer for further investigation.



G-AWNG No engine — view of 14th stage rotor disc with 13th stage stator rotating air seal showing material lost due to abrasion against static seal