No: 12/92 **Ref: EW/C92/8/1** **Category: 1a**

Aircraft Type and Registration:	Boeing 767-200ER, N610UA	
No & Type of Engines:	2 Pratt & Whitney JT9D-7R4D turbofan engines	
Year of Manufacture:	1982	
Date & Time (UTC):	11 August 1992 at 1340 hrs	
Location:	On departure from London Heathrow Airport	
Type of Flight:	Public Transport	
Persons on Board:	Crew - 12	Passengers - 163
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Damage to No. 1 engine, and fire damage to cowling	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	52 years	
Commander's Flying Experience:	15,619 hours (of wich 931 were on type) Last 90 days - 115 hours Last 28 days - 48 hours	
Information Source:	AAIB Field Investigation	

History of the Flight

The aircraft took-off from London Heathrow at 1326 hrs for a direct flight to New York. During the take-off, smoke was seen by a ground observer to be coming from the left engine. This smoke was described as similar in appearance to that emitted by 'old technology' engines such as those installed in Boeing 707 aircraft and was seen to persist until the aircraft entered cloud. As the aircraft was passing FL180 in the climb, the left engine fire warning system operated twice for very short periods. All engine instrument indications were normal but the commander detailed a member of the cabin staff to make a visual inspection of the left engine from the main cabin. As the aircraft was approaching FL210 and before the commander had received a report from the cabin attendant, the left engine fire warning system operated once more and this time persisted. The left engine was shut down in accordance with the appropriate drills followed by an uneventful single engine landing back at Heathrow. After landing, the emergency services confirmed that there was no sign of fire and the aircraft proceeded to its stand for normal disembarkation of passengers. Subsequent examination

revealed a hole burned into the right hand side of the No.1 engine cowling (see Fig. 2), and some small fragments of metallic debris were recovered from the tail pipe.

Flight Recorders

The Flight Data Recorder (FDR), a Sundstrand UFDR, was removed by the operator, a copy tape was supplied to AAIB and a replay carried out using the AAIB replay facilities. The Cockpit Voice Recorder was not replayed.

The aircraft was climbing through 17,800 feet at 288 kt CAS and 0.6 M when a fire warning occurred. Figure 1 covers the period of the engine fire warnings and engine shutdown. The intial warning lasted for less than four seconds, which is also the sampling period for the fire warning discrete, and returned 2 minutes 52 seconds later; the fire extinguisher switch operated up to 4 seconds later. The second fire warning lasted for 17 seconds. The No 1 Engine was throttled back and shutdown; there was a loss of 2 seconds of data following the engine shutdown, as shown in the Figure, due to the transfer of electrical bus connections . The EGT on No 1 Engine rose after shutdown to 629°C before decreasing.

Examination of engine

The engine was taken to United Airlines' maintenance and engine overhaul facility at San Francisco Airport, where it was subjected to a strip examination in the presence of representatives from the operator, engine manufacturer, Federal Aviation Administration (FAA) and the AAIB. The debris from the tail pipe was subjected to a metallurgical examination, which included hardness tests. The results revealed a large degree of scatter in the hardness values, which suggested that the material had been cold worked during the break-up process.

Engine details

The engine was a Pratt and Whitney JT9D-7R4D (Package A), Serial No. 707521. The 7R4D designation indicates that the Nos. 3 and 4 bearings are equipped with carbon seals, as opposed to labyrinth seals. Package A refers to a modification status regarding electronic engine control and turbine cooling features. This variant of the engine has been in service for approximately ten years.

The engine had accumulated 31,376 hours and 10,171 cycles since new, although this information is of little value, as most of the modules in the engine had been replaced with overhauled units. The engine had achieved 2,418 hours since being refurbished by United. Not all modules were zero lifed at the time of refurbishment; for example, the low pressure turbine had achieved a total of 19,140 hours, and the fan case had achieved the "data plate time" of 31,376 hours.

Initial examination

The initial examination was conducted with the engine mounted on a strip rail, and the only visible external damage was solidified molten alloy spatter on the right hand side of the engine casing. It was evident that this had been ejected from two holes that were burned into a short length of ducting between the deaerator (air-oil separator) and the exterior of the nacelle (see Fig. 3). The deaerator was mounted on the right hand side of the aft face of the accessory gearbox, and when the cover was removed, it was apparent that a severe fire had occurred inside, with the impeller (which performs the separating function on the air-oil mist drawn from the No. 3 bearing) having been completely destroyed. The impeller shaft could still be moved within the gear train backlash, suggesting that the impeller bearing was still intact. The breather ducting between the engine casing and the deaerator was intact.

The LP shaft could be rotated with ease, but the HP shaft could not be turned until the accessory gearbox was disconnected. Although it was initially thought that the gearbox was seized, it was later found that it could be turned with difficulty. The chip detectors, together with the oil filter, had been removed at Heathrow. The impression gained at that time was that the debris was insufficient to indicate a major failure within the gearbox, and that it was probably associated with some bearing distress as a consequence of the oil contents becoming exhausted. Subsequent examination of the gearbox itself revealed no internal failure, although the remnants of the oil were black and viscous, and had clearly been subjected to high temperatures.

The engine was subjected to a boroscope examination which revealed blade impact damage on the second stage HP turbine. It was also apparent that there had been contact on the shroud and platform areas. Solidified molten metal spatter was evident on the third stage nozzle guide vanes. It was noteworthy however that no blades, or parts of blades, were missing, leading to the conclusion that the debris in the tail pipe was other than blade material.

Strip examination

Having concluded from the boroscope examination that the compressor was undamaged, attention was concentrated on the removal of the hot section of the engine. No untoward features were observed on the LP turbine module; in particular, the No 4 bearing was in good condition. However, there were indications of intense heat between the second stage HP and the first stage LP turbines. Dumbell shaped locking tabs on the rear face of the second stage disc had been virtually melted by hot gases from adjacent holes (see Fig. 4). It was also apparent that the labyrinthe-type rotating seal between this disc and the next stator stage had been completely destroyed by a combination of heat erosion and machining, resulting in the debris found in the rear of the engine (see Fig. 5). The stator stage was close to coming adrift as a result of this damage. Other heat damage included a scalloping effect on the HP shaft retaining nut; this appeared to have been caused by hot gases emanating from a ring of cooling holes near the centre of the disc. The nut can just be seen in Fig. 4.

The HP shaft nut was retained by a locking ring. This was intact and had not been disturbed as a result of the engine problem. However the nut itself, which usually requires special tooling for removal due to high assembly torque, was found to be little more than "finger tight". Further disassembly revealed extensive heat damage to the No 3 bearing housing heat shield. Inside the housing, it was found that the front carbon seal assembly and the classified spacer located ahead of the front seal plate on the HP shaft, had broken up. The spacer was in 15 pieces, and its loss from the shaft accounted for the loss of assembly torque in the HP stack. The bearing itself, and the rear carbon seal, were in fair condition especially in view of the heat damage that had affected the area. The diagrams in Fig. 6 show the general layout of the relevant engine components.

The break-up of the forward seal would have allowed 15th stage compressor discharge air into the bearing housing, and the consequent ignition of the oil mist therein. It appears that the resulting fire was then drawn into the external deaerator via the breather ducting. Hot gases would also have been able to exit via the less damaged rear end of the compartment, and be drawn into the gas path via the damaged seals, thereby causing a rise in EGT.

Additional examination

The air seal ahead of the classified spacer was later examined and found to bear an imprint that appeared to have been made by a raised section of the spacer. In order for this to have happened, the spacer would have to have suffered a radial fracture, thereby allowing part of its circumference to lift clear of the shaft.

The fragments of the spacer, Part No 783439CL15, and manufactured from AMS 5668 (Inconel X-750) were taken to Pratt and Whitney's headquarters at East Hartford, Connecticut, for specialised laboratory examination. The company has not yet reached a conclusion as to the cause of the spacer failure.

The CAA have been informed of the details of the incident and they are in turn monitoring the problem with the FAA. This variant of the engine is not currently fitted to any UK registered aircraft.

FIGURE 1

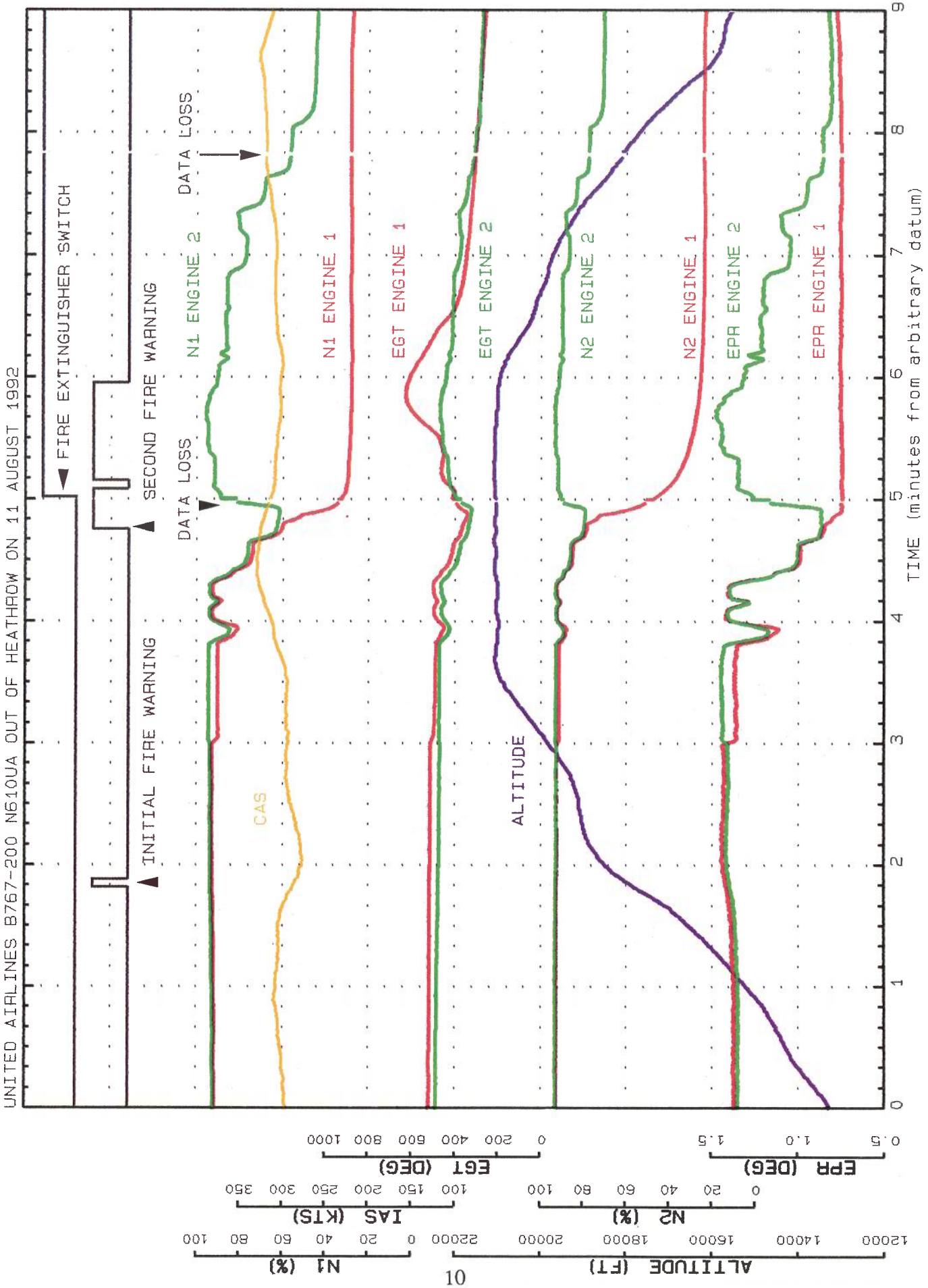

UNITED AIRLINES B767-200 N610UA OUT OF HEATHROW ON 11 AUGUST 1992
FIRE EXTINGUISHER SWITCH
SECOND FIRE WARNING
INITIAL FIRE WARNING
DATA LOSS
DATA LOSS
N1 ENGINE 2
N1 ENGINE 1
EGT ENGINE 1
EGT ENGINE 2
N2 ENGINE 2
N2 ENGINE 1
EPR ENGINE 2
EPR ENGINE 1
CAS
ALTITUDE
TIME (minutes from arbitrary datum)
0 1 2 3 4 5 6 7 8 9
N1 (%)
IAS (KTS)
EGT (DEG)
ALTITUDE (FT)
N2 (%)
EPR (DEG)

Fig.2. External view of No. 1 engine showing fire damage

Fig.3. Right hand side of engine showing fire-damaged deaerator

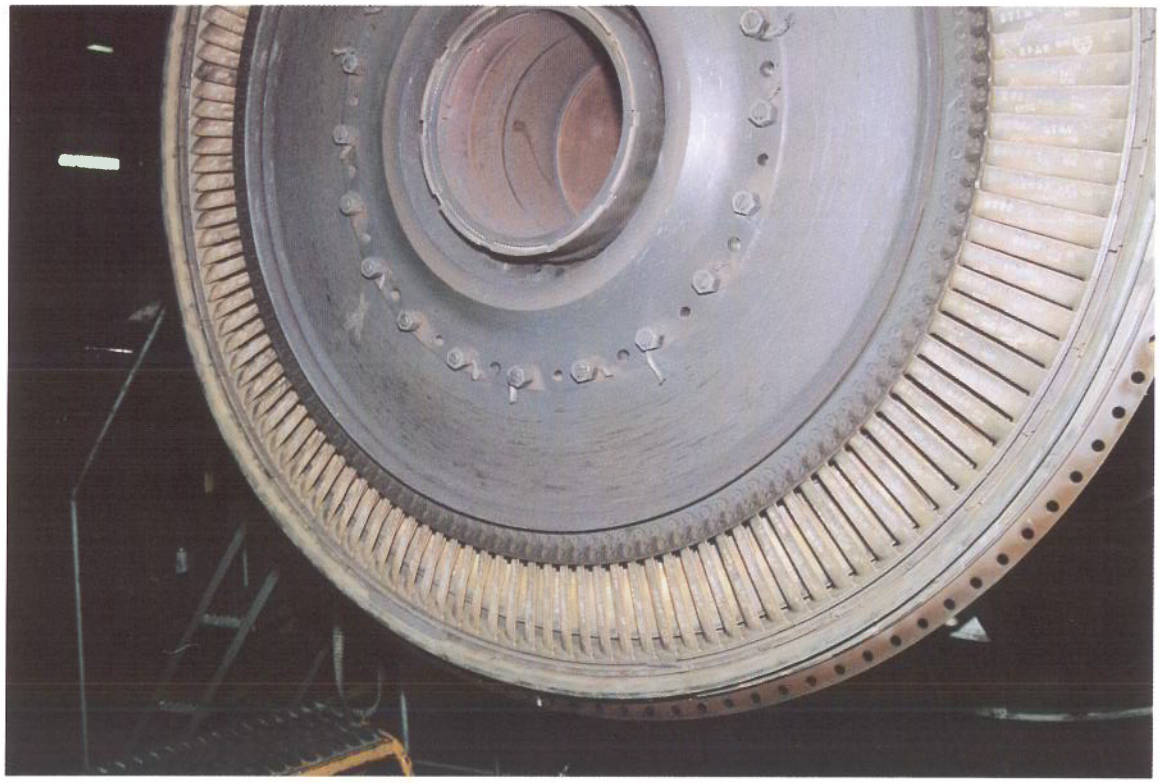
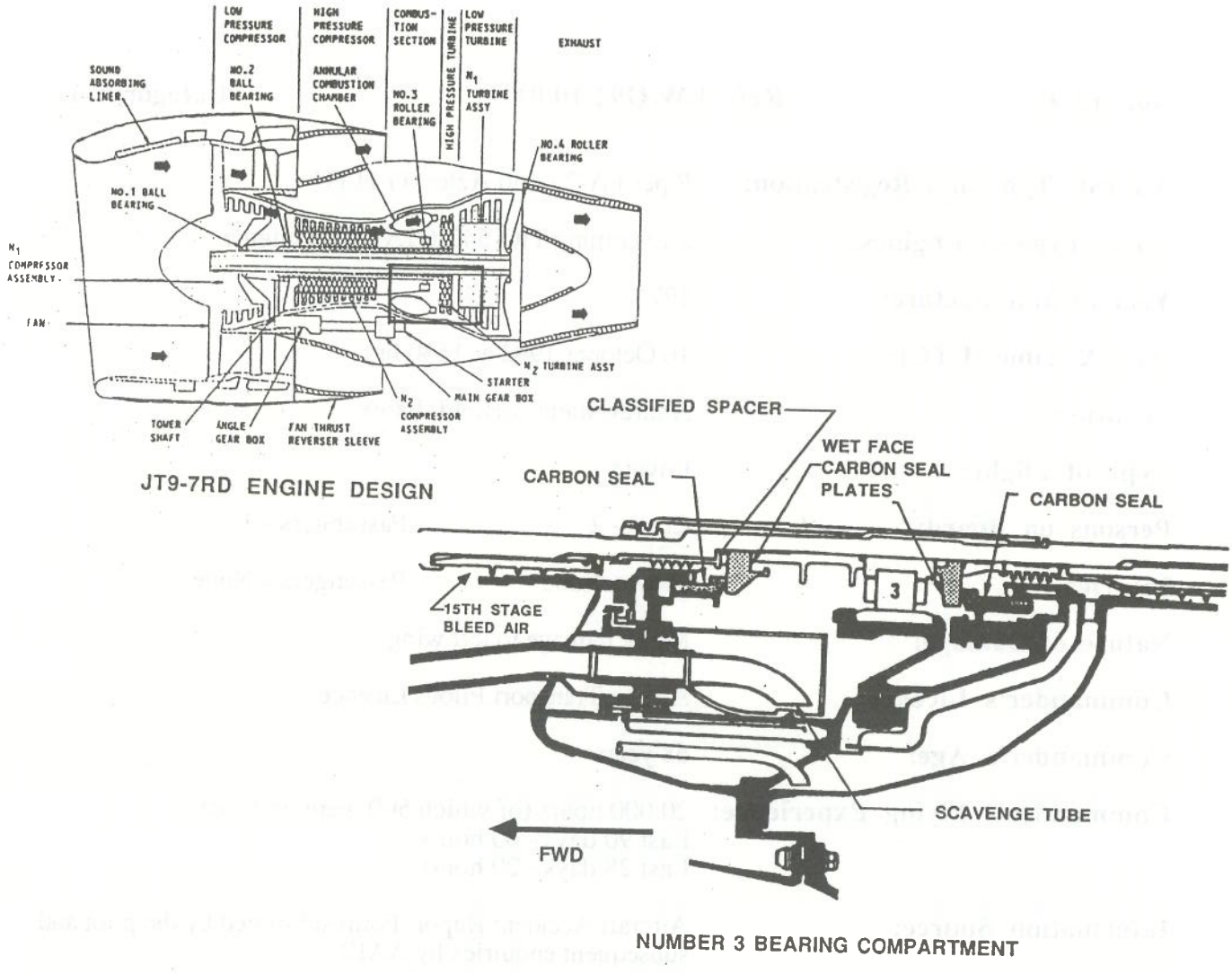


Fig.4. Rear face of second stage turbine disc. Note melted locking tabs. Scalloping on HP shaft retaining nut (close to inner ring of cooling holes) can just be seen

Fig.5. View looking aft onto damaged third stage NGV shroud



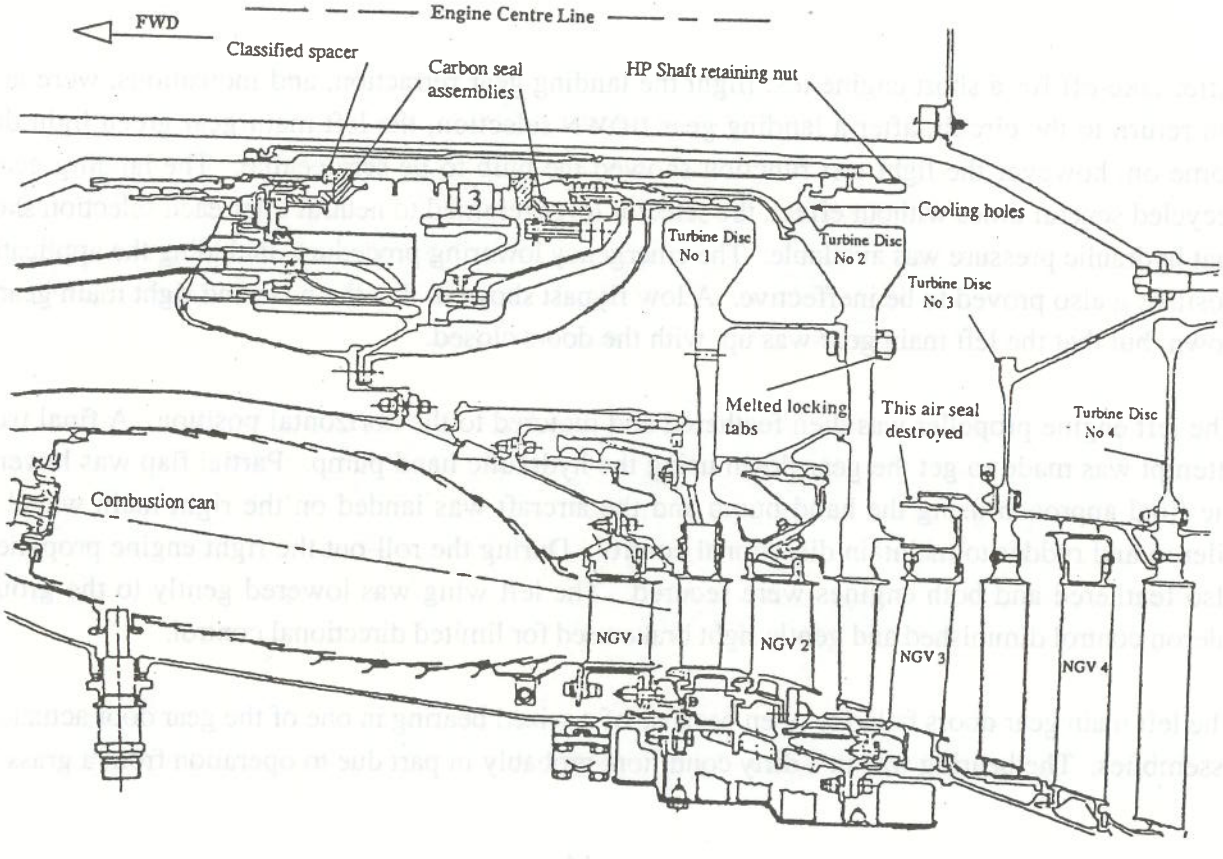


Fig. 6 Details of engine hot section and No. 3 bearing compartment