



Rolls-Royce

Engine Investigation

Allison
M250-C20J
Engine CAE 832989

Bell 206B
Registration: N5743W



Model 250-C20B/J

Fly Hanger 13
Cresco, IA

David Riser

David Riser
Senior Air Safety Investigator

Accident date: August 18, 2015
Investigation date: August 26, 2015
At Rolls- Royce: October 5, 2015
Report date: March 15, 2017

Report Enclosures:

Report Narrative

Appendix A, Photographs at Aircraft Recovery Location

Appendix B, Photographs, Rolls-Royce Indianapolis, IN.

Appendix C, Engine Records

Background Information:

On August 18, 2015 at approximately 13:30 hour's local time, a Bell 206B helicopter, N5743W was involved in an accident near Cresco, IA. The helicopter was owned and operated by Fly Hanger 13. The helicopter was being operated for agricultural spray application. The local flight originated from an off airport location at approximately 13:25hrs. Visual meteorological conditions were reported by the pilot at the accident site about the time of the accident. The pilot reported he departed with 25 gallons of fuel and 80 gallons of chemical to spray a bean field near Cresco. About 5 minutes into the application and approximately five feet above the ground the engine lost power and the pilot initiated an autorotation to a water way on the side of a hill. Upon touchdown on the uneven terrain, the main rotor blades contacted and severed the tail boom. The pilot and sole occupant sustained no reported injuries.

Airframe Observations:

The author did not view the site but was shown photos. Wreckage examination was conducted on August 25, 2015 at the operator's hanger in Mico, TX under the auspices of FAA inspectors.

The helicopter was positioned upright on dollies with the landing skids remaining attached. The left front chin bubble had been broken out. The tail boom had been separated as a result of a main rotor blade strike and was in two sections. The tail rotor gear box remained attached to the aft section of the tail boom and both tail rotor blades remained attached and were visually normal. Both main rotor blades remained attached to the rotor head. Both blades retained their lengths and both exhibited areas of scratches, skin tears and spanwise bending. (Fig 1)

Engine Observations:

The engine had remained securely attached in the engine bay. Visual and tactile examination of all pneumatic, oil and fuel lines revealed all to be undamaged with no evidenced of leakage and all "B" nut and connectors were at least finger tight. The compressor remained in position with no external damage noted. Visual examination of the compressor inlet and visible stages of blades and vanes revealed no evidence of foreign object type damage. (Fig 2) The exhaust collector support exhibited a fracture of 360 degrees just forward of the turbine mating flange. Areas of peening were noted within the exhaust collector support with additional peening and one hole each in the base of the exhaust stacks near the mating flange. The turbine had shifted aft approximately 2 inches making the stage 3 nozzle and stage three wheel visible. All four turbine wheels and nozzles appeared present with the main visible damage noted at this time were 3-5 blades absent from the stage 3 wheel. (Fig 3) Both left and right side compressor air discharge tubes had dislodged from the forward end but remained properly seated at the OCC which displayed no visible damage. The right side air tube exhibited denting and one hole on the inboard side in line with the fracture at the exhaust collector support flange. The left side air tube displayed several dents in line with the fracture. One hole of approximately one inch in diameter was noted in the horizontal fire shield at approximately the 7 o'clock position. Multiple metal fragments were located in the bottom of the engine bay. (Fig 4) The airframe oil tank was full and the airframe employed an oil tank filter. Both the upper and lower chip detectors were removed and examined where both were void of material. At engine removal during manual rotation of the N1 drive train at the starter generator pad, rotation was smooth

through the accessory gear box but not continuous to the compressor. The N2 drive train was not manually rotatable. The engine was containerized and shipped to RR Indianapolis for disassembly and further investigation. (Fig 5)

Engine Information:

An Allison M250-C20J gas turbine engine, S/N CAE 832989, powered the helicopter. Records reflect the engine was last installed on the airframe March 8, 2015 at 10918.9 ETT following conversion from an M250-C20B to an M250-C20J. No recent heavy maintenance actions or module changes were reflected in log book records. No recent discrepancies were noted in the daily flight logs.

Manufacturer	Allison
Engine Model	250-C20J
Rating:	420 Shaft Horsepower
Serial Number	CAE 832989
Engine Total Hours	11846.9
Last 150 Hour Inspection	11695.1
Last 300 Hour inspection	11695.1

Component	Serial Number	Part Number	TSO	Total Time
Engine	CAE 832989	6899400	928.0	11846.9
Gearbox	CAG 36135	6894171	928.0	11846.0
Compressor	CAC 36240	6890550	928.0	11814.4
Turbine	CAT 36021	23069754	930.0	11875.1
Fuel Control	BR57685	23070606	1651.4	4114.1
Governor	HR47129	23086749	928.0	Unknown
Fuel Pump	T106859	6899253	3053.4	Unknown
Fuel Nozzle	AG36567	23077068	928.0	6380.1
Bleed Valve	FF296806	23053176	New	1287.6

Engine Investigation:

On October 5, 2015 engine disassembly and investigation was conducted at Rolls-Royce Indianapolis, IN under the auspices of the NTSB IIC. The following details the facts and findings of that investigation.

Compressor Section:

The compressor section exhibited no visible external damage. Following separation of the compressor from the engine, the compressor displayed free and smooth rotation from the spur

adapter gear shaft to the compressor rotor. The inlet guide vanes were visually normal and exhibited no damage. Visual inspection of the axial compressor blades and vanes revealed no visible damage. The bleed valve was in position and open and the poppet valve was free. The spur adapter gear shaft remained in position retained in the compressor. The #2 bearing was found in position, oil wetted and visually undamaged. The compressor module was not disassembled. (Fig 6)

Accessory Gearbox Section:

Following separation of the gear box from the exhaust collector rotation of both the N₁ and N₂ drive trains through the gear box were rotationally free and continuous through the gear box. There was noted continuity to all accessory drive pads and the power turbine output drive. Separation of the gear box case and cover revealed all gearing to be in position, undamaged and oil wetted. (Fig 7)

Combustion Section:

The outer combustion case exhibited no visible damage. The combustor liner was in position and visually undamaged. Removal and examination of the combustor liner revealed it to be normal in appearance with no evidence of unusual streaking or thermal damage. (Fig 8)

Turbine Section:

Both the gas producer support and power turbine supports were visually normal and displayed no damage. The aft exhaust collector support flange was cracked around the entire circumference of and separated. Both stage one and stage two nozzles and wheels were in their normal positions with none exhibiting any damage or anomalies.

The stage three nozzle remained in position but displayed evidence of impact damage to the trailing edges of multiple vanes with areas of impact damage and scoring noted to the outer rim aft face.

The stage three wheel remained mated to the stage four nozzle and wheel. Five blades were liberated from the wheel just outboard of the inner rim. The balance of the blades displayed impact damage with the majority of the outer shroud being absent. Remained portions of the shroud spanned seven blades, six blades and two blades respectively. The remaining portions of the shroud displayed rotational rub damage from contact with the blade track.

The stage four nozzle remained in position with two airfoils absent. The outboard portions of all of the leading edge surfaces were damaged and several of the trailing edge surfaces were impact damaged. The diaphragm was detached from the bore. The entire circumference of the blade track was heavily rubbed from contact against the third stage turbine wheel shroud and knife seals.

Portions of the blade track were fractured and missing. Impact damage was also noted on the eight positioning tabs around the outer diameter. The stage four wheel remained in position with all of the airfoils present however the majority displayed impact damage. (Fig 9)

Engine Shafting:

N1 shafting consisting of the spur adapter gear shaft and turbine to compressor coupling were examined where the spur adapter gear shaft was in proper position oil wetted and was visually

undamaged. The turbine to compressor coupling exhibited light score marks on the aft end but was otherwise visually normal with the internal splines appearing visually normal and undamaged. N2 shafting consisting of the power turbine inner shaft, power turbine outer shaft and power turbine to pinion gear coupling were all visually examined. The power turbine inner shaft displayed light score marks on the aft end forward of the #6 bearing race. Additional scoring was noted to the inside of the aft end of the shaft. The power turbine outer shaft was normal visually normal with no visible damage. The power turbine to pinion gear coupling was visually normal with no visible damage. (Fig 10)

Oil System and Engine Bearings:

During disassembly all engine oil lines were found in position with no visible damage noted. During removal of the lines, all lines were found to exhibit at least finger tight torque with no evidence of leakage. Manual rotation of the N1 drive train at the accessory gear box resulted in smooth rotation of the oil pump. Separation of the accessory gearbox case and cover revealed the oil pump was in normal position with no visible damage. The piccolo tube was in proper position and visually undamaged. The #4 bearing oil nozzle remained in position and exhibited light scratched across the aft surface

The inline screen at the #6/7 bearing pressure line "T" fitting was oil coated and void of material. The #6/7 bearing oil delivery tube and # 8 bearing oil delivery tube were visually normal and open. The #8 bearing oil delivery nozzle was in proper position, oil wetted and visually open. Both the upper and lower chip detectors had been removed and examined at the recovery where both were oil coated and void of material.

The # 1 bearing was not removed but rotated freely within the compressor front support. Engine bearings consisting of the #2, 2 ½, 3, 5 and 8 were all visually and tactilely examined. Each was found in proper position with each oil wetted with all balls and or rollers in position and visually undamaged. Manual rotation revealed smooth rotation of each bearing. The #6 and #7 bearings were in there normal positions and visually normal but dry. Manual rotation revealed smooth rotation of each bearing with the rollers being visually normal and undamaged.

The #4 bearing was found in positon however the retaining ring was dislodged. Visual examination revealed an aft section of the separator to have fractured and a small section to have liberated from the separator. (Fig 11)

Fuel System:

The fuel pump was in its normal position and was normal in appearance. All fuel lines between the fuel pump, fuel control unit, and fuel nozzle were in position with all "B" nuts and connectors being at least finger tight with no evidence of leakage or damage. Residual fuel was noted within the fuel pump during removal. The fuel nozzle was normal in appearance. Removal of fuel line at the fuel nozzle revealed fuel present at the nozzle. The fuel nozzle was visually normal with no excessive carbon on the outer air shroud. (Fig 12)

Engine Accessories:

The power turbine governor and fuel control unit were normal in appearance with no visible external damage. At removal of the power turbine governor the drive splines pulled off of the end of the main drive shaft and remained lodged within the accessory gear box. Removal of the fuel control unit revealed no visible damage and the main drive shaft to be rotationally free and smooth. Manual operation of both the fuel control unit throttle arm and the power turbine governor control arm resulted in correct movement with full and smooth travel from stop to stop. [\(Fig 13\)](#)

Materials Examination:

The following engine components were submitted to the Rolls-Royce Material Lab for subsequent examination.

Part Name	Part Number	Serial Number
Third stage turbine wheel	23065818	X597059
Third stage turbine nozzle	23069744A	X584325
Fourth stage turbine nozzle	23055939	X591294
Fourth stage turbine wheel	23055944F	X595256
Exhaust collector	6879879D	23435
No. 4 bearing	M250-10109E	NWH11-0632
No. 3 bearing	M250-10109E	NWH11-0725
Pinion gear	6889700	UG44227
First stage turbine wheel	M250-10223	X607813
Second stage turbine wheel	23073854A	X608397
Turbine tie bolt	23068265A	NM79371
Power turbine inner shaft	23071307	KU101317
Turbine to compressor coupling	6898977	UT21507

Summary of Findings:

- Five airfoils on the third stage turbine wheel cracked in fatigue, initiating from the trailing edge root area and progressing forward until final fracture occurred in overload. All five cracks initiated and progressed in high cycle fatigue. Two additional cracks were found in the trailing edge side of the wheel rim, consistent with thermal fatigue cracking.
- Damage observed and documented on the other components was considered secondary to the liberation of five airfoils on the third stage turbine wheel.
- At the conclusion of extensive engineering testing, a single root cause could not be identified for the liberation of the airfoils on the stage three turbine wheel.

Appendix A, Photographs at Recovery Location

Fig 1

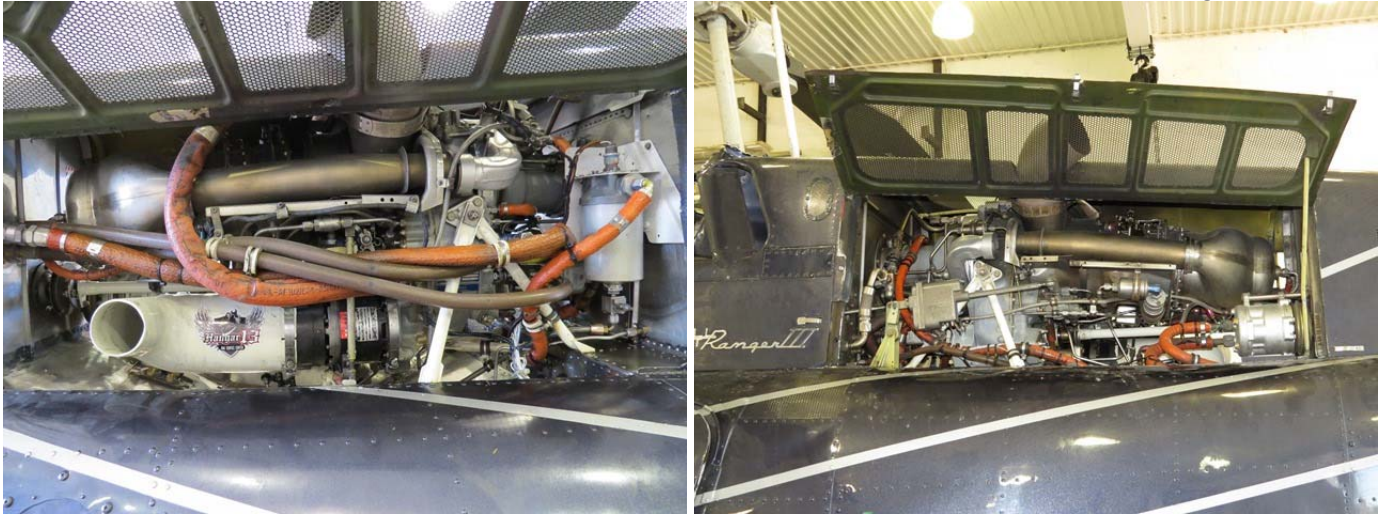


Helicopter as Recovered



(Return)

Fig 2



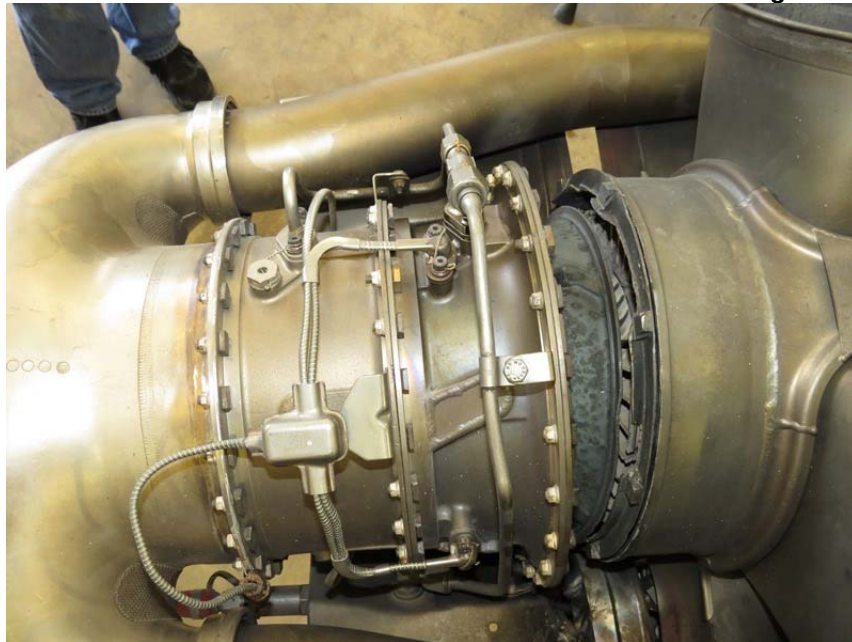
Engine as Recovered



Compressor

(Return)

Fig 3



Turbine as Recovered





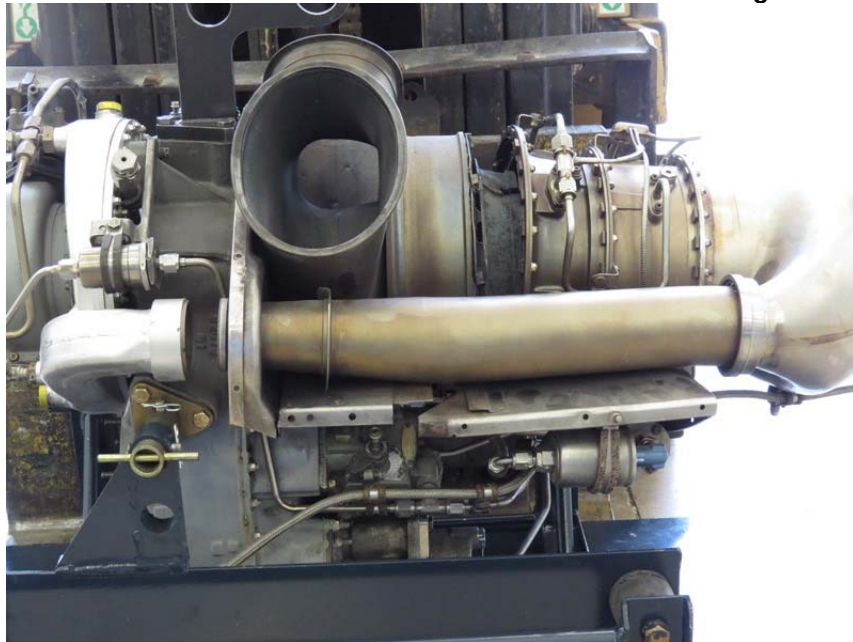
Interior of Exhaust Collector Support



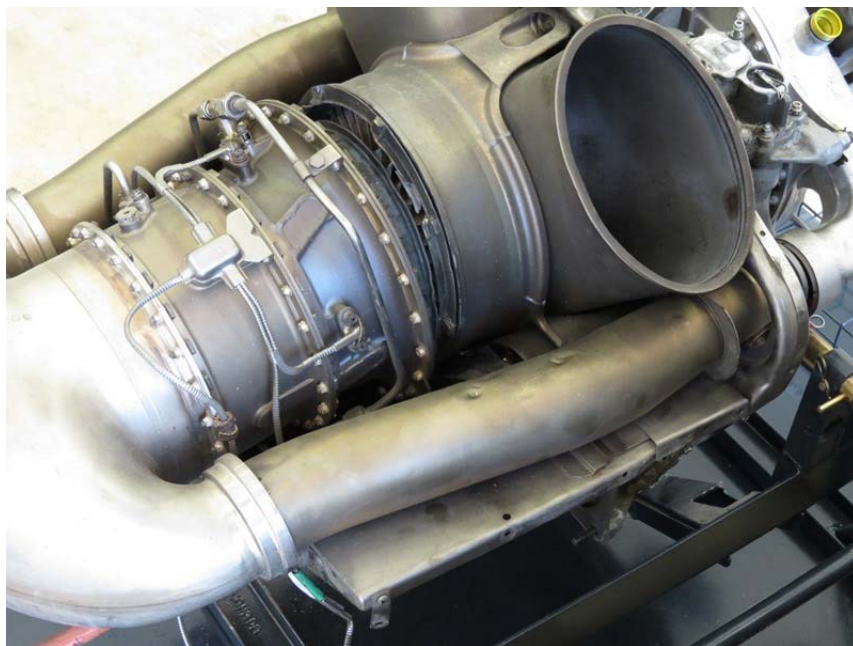
Exhaust Stacks

[\(Return\)](#)

Fig 4



Left Side Compressor Air Tube



Right Side Compressor Air Tube

[\(Return\)](#)

Fig 5



Oil Tank and External Filter

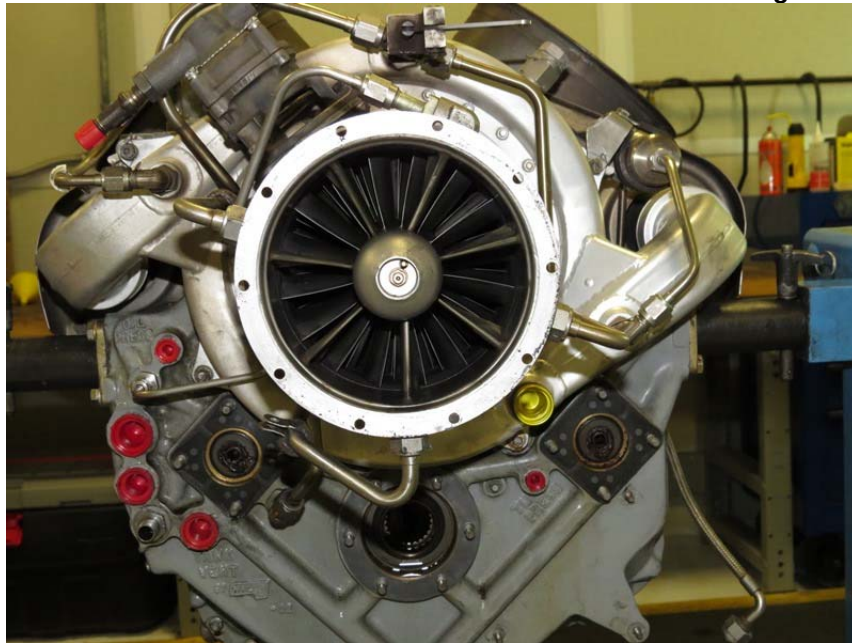


Engine Prior to Shipment

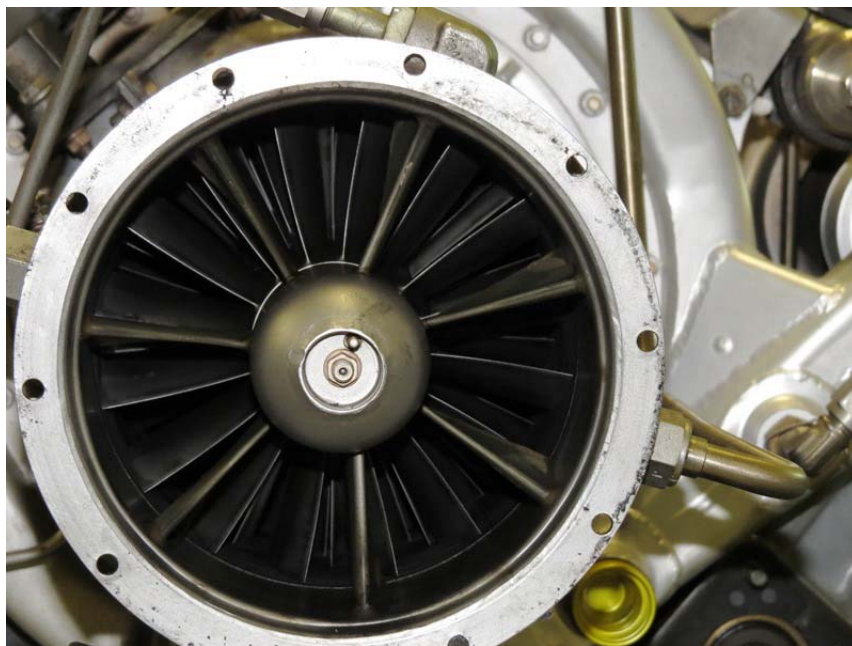
[\(Return\)](#)

**Appendix B,
Photographs at Roll-Royce
Indianapolis, Indiana**

Fig 6

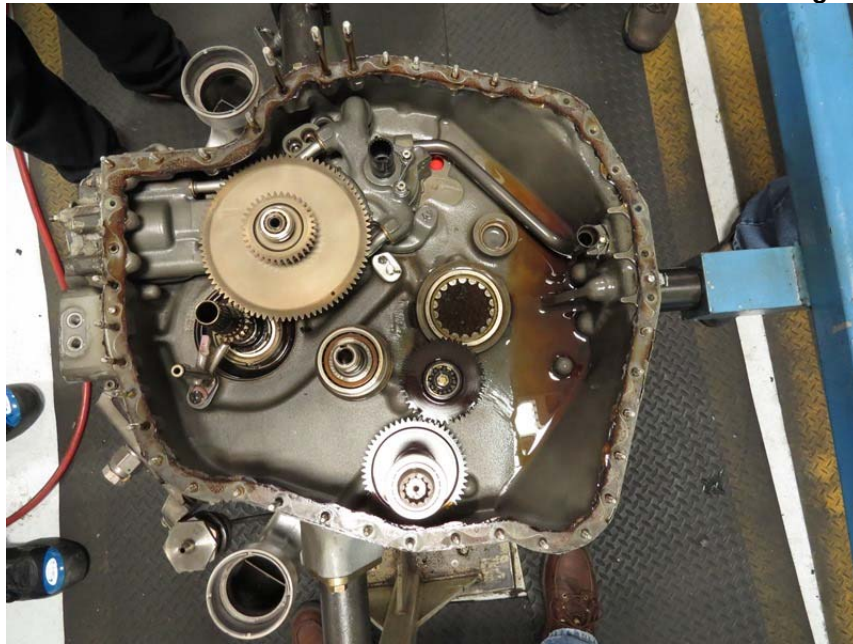


Compressor Inlet



[\(Return\)](#)

Fig 7



Accessory Gear Box



[\(Return\)](#)

Fig 8



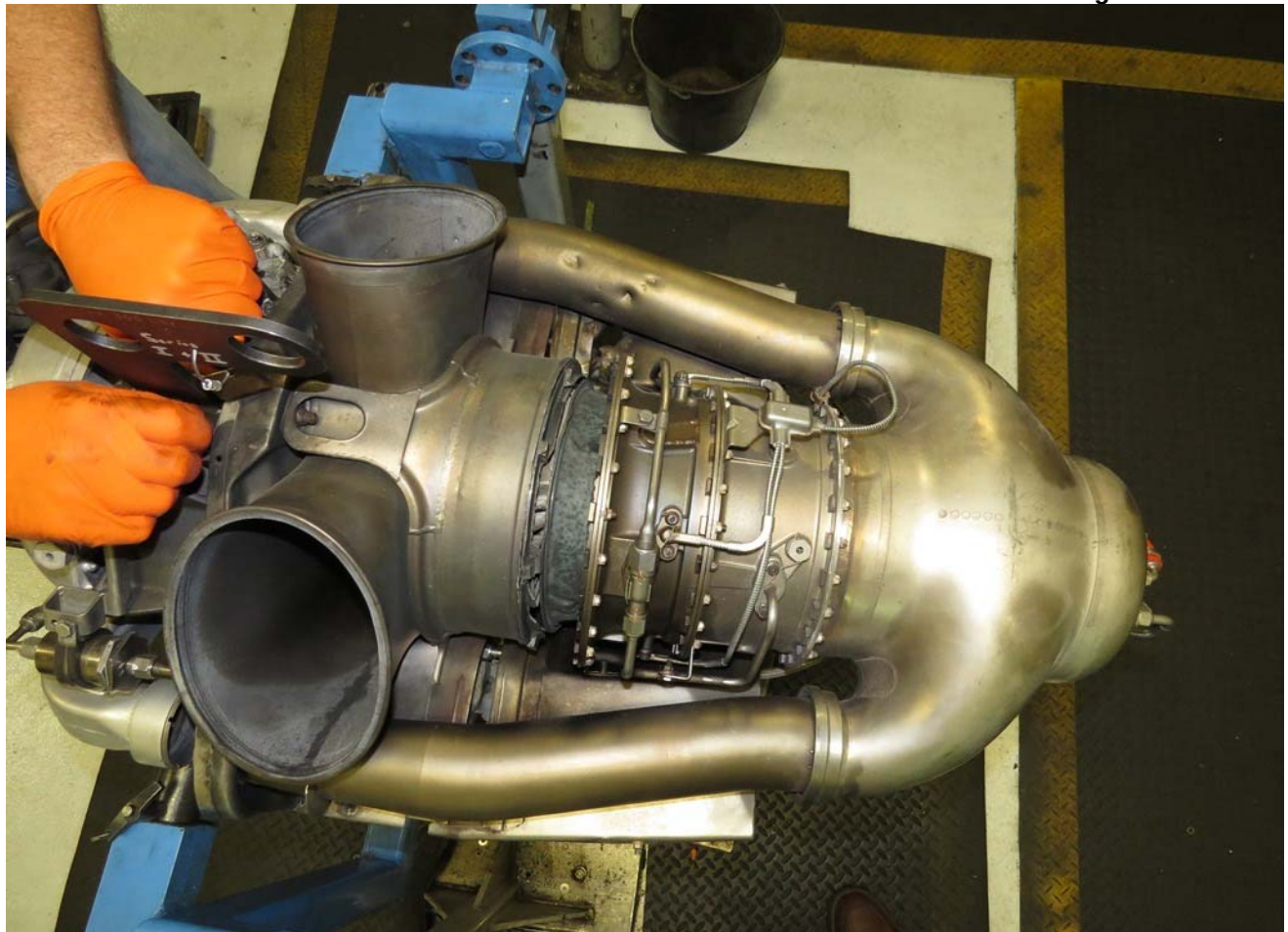
Outer Combustion Case with Liner in Position



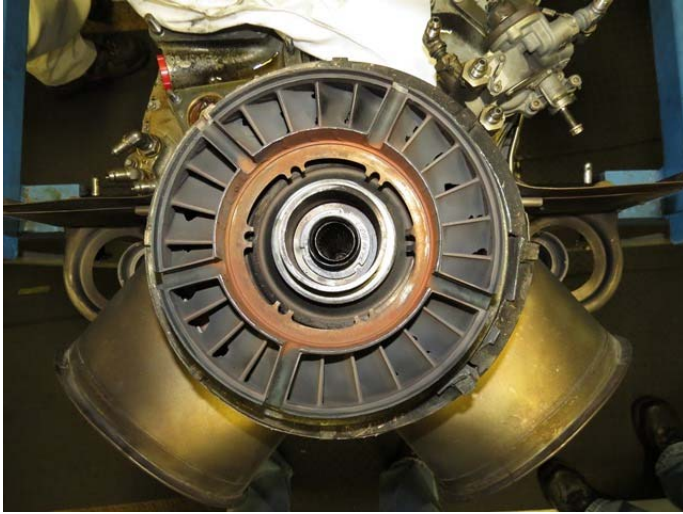
Combustor Liner

[\(Return\)](#)

Fig 9



Turbine Module in Position



Stage 3 Nozzle



Stage 3 Turbine Wheel



Stage 3 turbine Wheel



Fig 9
Turbine Continued



Stage 3 Nozzle



Stage Four Nozzle Pressure Side



Liberated Diaphragm





Stage Four Wheel Blade Track



Stage Four Nozzle Suction Side



Power Turbine Rotor Stage Four Nozzle and Wheel



Stage Four Wheel Suction Side



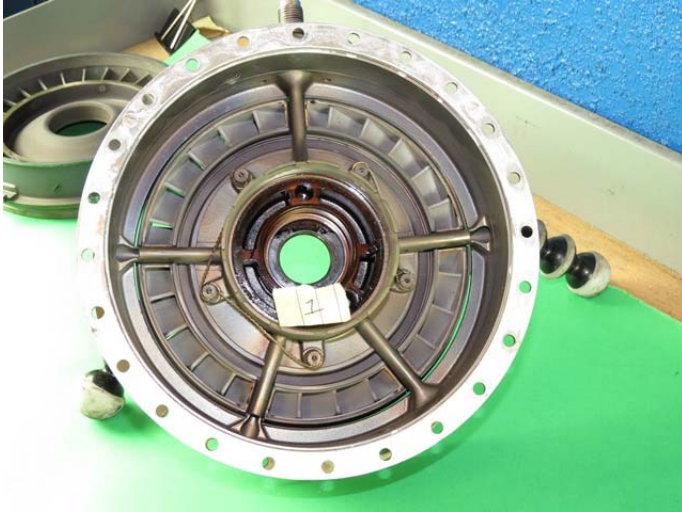
Stage Four Wheel Pressure Side



Stage Four Wheel Outer Rim



Stage Four Wheel Curvic



Stage 1 Nozzle



Stage 2 Nozzle



Stage 1 Wheel



Stage 2 Wheel

(Return)

Fig 10



Turbine to Compressor Coupling



Spur Adapter Gear Shaft in Position



Power Turbine Inner Shaft



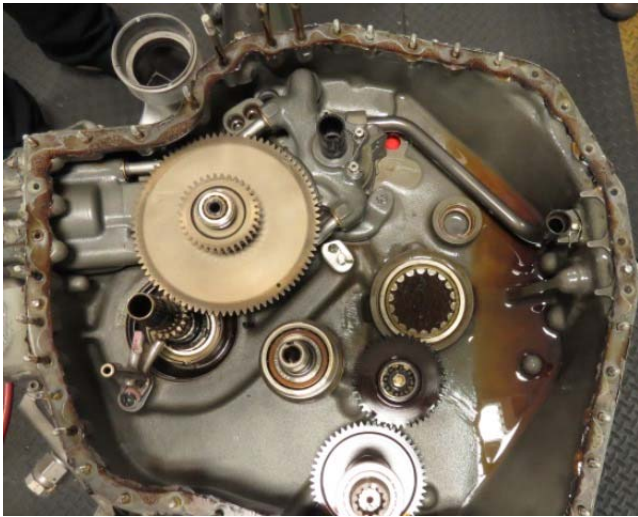
Power Turbine Outer Shaft



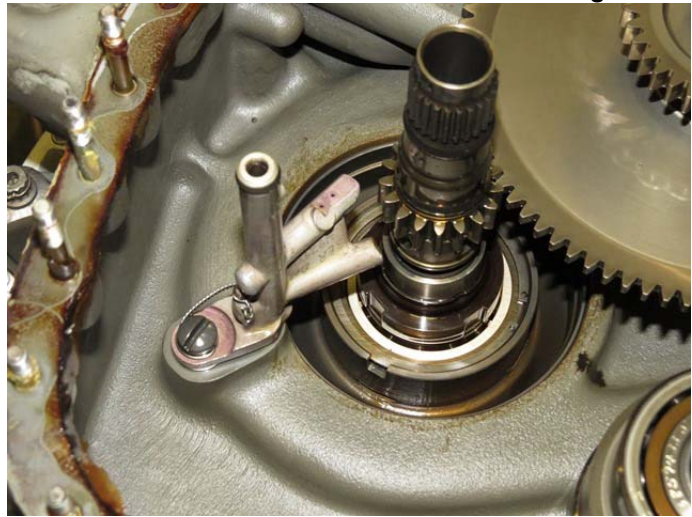
Power Turbine to Pinion Gear Coupling

(Return)

Fig 11



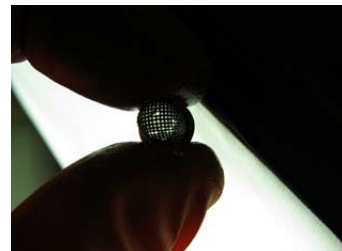
Oil Pump



Piccolo Tube and #2 Bearing



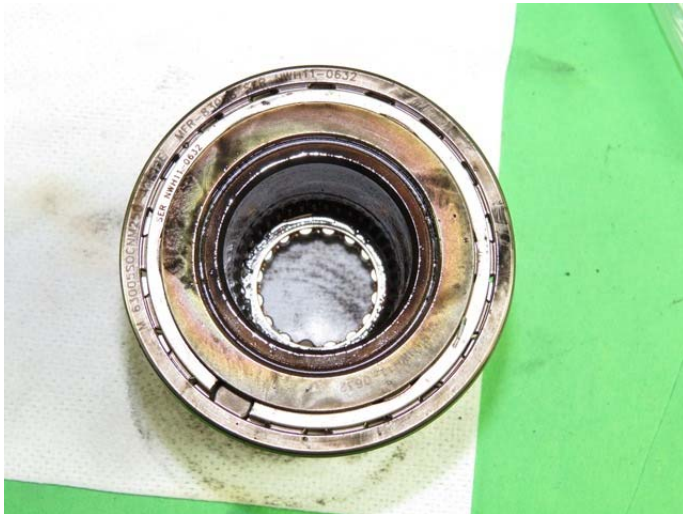
#8 Bearing Oil Nozzle



#6/7 In Line Screen



#4 and #3 Bearing on Pinion Gear



#4 Bearing



#3 Bearing with #2 1/2 Bearing in Center





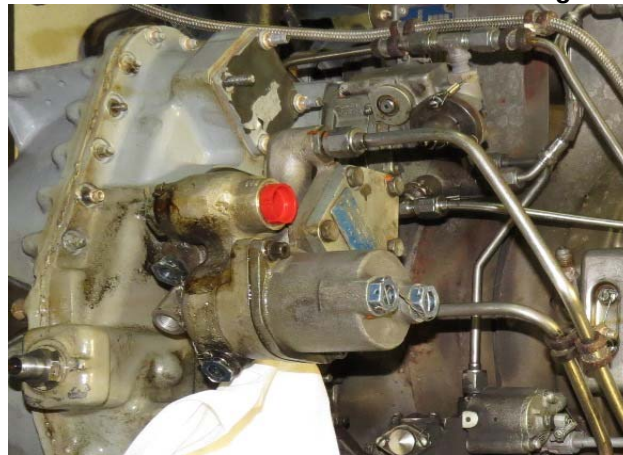
#7 Bearing



#8 Bearing

(Return)

Fig 12



Fuel Pump



Fuel Nozzle

(Return)

Fig 13



Power Turbine Governor



Fuel Control Unit

[\(Return\)](#)