Compressor 1st, 2nd, and 3rd Stage Discs and Blades: The discs and blades were intact. Please refer to photo No. 37.

Compressor 1st, 2nd, and 3rd Stage Stators and Shrouds: The stator vanes and shrouds were intact. Please refer to photo No. 38.

Compressor 1st, 2nd, and 3rd Stage Spacers: The spacers were intact.

Centrifugal Impeller: The impeller was intact. Please refer to photo No. 39.

Centrifugal Impeller Shroud: The shroud face displayed light circumferential scoring due to axial contact with the impeller. Please refer to photos Nos. 39 and 40.

Front Stub Shaft: Intact.

No. 1 Bearing and Airseals: The bearing and airseals displayed no indications of operational distress. Please refer to photo No. 41.

No. 2 Bearing and Airseals: The bearing and airseals displayed no indications of operational distress. Please refer to photo No. 42.

3.3.2 Combustion Section

Combustion Chamber Liner: The liner displayed no indications of operational distress. Please refer to photo No. 43.

Large Exit Duct: Displayed a deposit of burned oil ash at the approximate 12:00 position. The flame pattern indications appeared normal. Please refer to photo No. 44.

Small Exit Duct: The duct displayed no indications of operational distress. Please refer to photo No. 45.

3.3.3 Turbine Section

All of the turbine section components were coated in oil soot and ash.

Compressor Turbine Guide Vane Ring: Displayed no indications of operational distress. Please refer to photos Nos. 45 and 46.

Compressor Turbine Shroud: Displayed light circumferential scoring, characteristic of radial contact with the compressor turbine blade tips.

Compressor Turbine: The blade airfoils displayed no indications of operational distress. The disc downstream side outer rim displayed circumferential scoring, with frictional heat
discoloration, characteristic of axial contact with the power turbine guide vane ring and interstage baffle. Please refer to photos Nos. 47 and 49.

P&W Materials Investigation Laboratory analysis determined the blades to exhibit slight growth, and overheating at the blade tips. Please refer to the reference (A) Materials Investigation Laboratory Report.

**ITT Probes, Busbar, and Harness:** The harness was intact. The probes displayed impact deformation. Please refer to photo No. 52.

**Power Turbine Housing:** The containment ring was bulged outward at the approximate 11:00 position characteristic of contact with separating power turbine blades. The housing retaining bolts were fractured from the approximate 8:00 to 5:00 positions. Please refer to photos Nos. 50 to 52.

**Power Turbine Guide Vane Ring and Interstage Baffle:** The vane airfoil trailing edges were nicked and gouged, characteristic of contact with separated power turbine blade debris. The inner drum and interstage baffle upstream side were circumferentially rubbed, with frictional heat discoloration, characteristic of axial contact with the compressor turbine. The baffle downstream side displayed severe circumferential scoring from the approximate 1:00 to 10:00 positions, in places completely through the material, characteristic of contact with the power turbine disc. Please refer to photos Nos. 52 through 56.

**Power Turbine Shroud:** The shroud was bulged sharply outward at the approximate 11:00 position. The shroud displayed severe circumferential gouges and scoring characteristic of contact with separated power turbine blade debris. Please refer to photo No. 56.

**Power Turbine:** The blade airfoils were fractured at varying heights from the root to approximately 1-1/4 inches. Macroscopic inspection of the fracture surfaces revealed features characteristic of fracture in overload. The disc upstream side outer rim and balancing ring displayed heavy circumferential scoring, with frictional heat discoloration, characteristic of contact with the interstage baffle. Please refer to photos Nos. 57 through 59.

**Power Turbine Shaft and Shaft Housing:** The shaft housing was displaced aft and toward the approximate 6:00 position. The shaft was radially loose, but rotated freely by hand. The oil scavenge tube housing retaining bolts were untorqued, and the retaining tab washer looking tabs were deformed. The oil tube lower retaining bolt was completely liberated from its seat, and was recovered within the combining gearbox. Please refer to photos Nos. 60 and 61.

3.3.4 Accessory Gearbox

3.4 Combining Gearbox Disassembly Observations
Output Gear and Shaft: Displayed no indications of distress. The Nos. 15 though 17 bearing displayed no distress.

3.4.1 Left Hand Input Section Reduction Geartrain

1st Stage Gear Input Shaft: Displayed no indications of distress. The Nos. 5 and 6 bearings displayed no distress.

2nd Stage Idler Gear: Displayed no indications of distress. The Nos. 7 and 8 bearings displayed no distress.

Intermediate Drive Shaft: Displayed no indications of distress.

3rd Stage Helical Gear: Displayed no indications of distress. The Nos. 13 and 14 bearings displayed no distress.

Torque Meter Assembly: Displayed no indications of distress.

3.4.2 Right Hand Input Section Reduction Geartrain

1st Stage Gear Input Shaft: The input splines displayed smearing and fretting, on both the loaded and unloaded spline faces. The No. 5 bearing cover retaining bolts were untorqued. The upper three were completely liberated from the housing and located within the combining gearbox. One bolt shank was sheared from the bolt head, and was compressionally deformed. The deformation corresponded to deformation observed on one of the clutch gear teeth, and on one of the 2nd stage idler gear teeth. The cover rear plate displayed indications of fretting with the No. 5 bearing outer race. No. 5 bearing rotated freely, with slight roughness, but displayed no indications of frictional heat discoloration. The No. 6 bearing displayed no distress. Please refer to photos Nos. 62 through 63.

2nd Stage Idler Gear: Two adjacent gear teeth faces were deformed on the aft approx. ½ inch of the gear faces, and each tooth displayed an impression corresponding to the profile of a No. 5 bearing cover retaining nut. The Nos. 7 and 8 bearings displayed no distress. Please refer to photo No. 64.

Clutch Gear and Sprag Clutch Assembly: P/N 3017107 S/N 7B811 (Shaft), P/N 3019381 S/N 2H957 (Gear), P/N 3022030 (Sprag). The clutch assembly inner race displayed circumferential rubbing, with frictional heat material smearing and brinell indentations matching the profile of the sprag elements. The sprag element inner contact faces displayed frictional heat discoloration and
material smearing. The outer contact faces were intact. The outer race displayed light contact impressions matching profiles of sprag element contact faces. One clutch gear non-loaded face was deformed toward the loaded side on the aft approximate ½ inch, and displayed an impression corresponding to the profile of a No. 5 bearing cover retaining nut. The Nos. 10 through 12-1/2 bearings displayed no indications of operational distress. Please refer to photos Nos. 65 through 71.

P&W Materials Investigation Laboratory analysis determined the damage to the clutch inner race and sprag elements to be due to adhesion wear characteristic of sudden seizure. The gear and sprag material were determined to be in accordance with drawing requirements. Please refer to the reference (B) Materials Investigation Laboratory Report.

Intermediate Drive Shaft: P/N 3017108, S/N 8B373. The shaft was fractured in counterclockwise torsion at the oil vent hole approximately 1-1/8 inches forward of the oil seal groove forward land. Please refer to photos Nos. 72 through 73.

P&W Materials Investigation Laboratory analysis determined the fracture to be due to torsional overload. The shaft material was determined to be in accordance with drawing requirements. Please refer to the reference (B) Materials Investigation Laboratory Report.

3rd Stage Helical Gear: Displayed no indications of distress. The Nos. 13 and 14 bearings displayed no indications of distress.

Torque Meter Assembly: Displayed no indications of distress.

3.5 Controls and Accessories Evaluation

Torque Control Unit: Functional testing revealed that the torque equaliser was not venting No. 2 power section Pg control pneumatic pressure. Removal of the housing cover and inspection revealed the pneumatic orifice controlling the No. 2 engine to be blocked with a small amount of unidentified debris. Functional testing of the unit following removal of the debris was satisfactory, with minor variations attributable to normal field adjustment.

3.5.1 No. 1 Power Section Controls and Accessories

Oil to Fuel Heater: Functional testing was satisfactory.

Fuel Pump: The pump mounting pad was impact fractured, precluding functional testing. Disassembly of the unit revealed no operational discrepancies.

Manual Fuel Control: Functional testing was satisfactory.
Automatic Fuel Control: Functional testing was satisfactory, with normal flow variations attributable to normal field adjustment.

Flow Divider: The flow divider was not tested.

Fuel Nozzles: The fuel nozzles were not tested.

Igniters: The igniters were not tested.

Compressor Bleed Valve: Functional testing of the compressor bleed valve was satisfactory.

Nf Governor: Functional testing of the Nf governor was satisfactory.

3.5.2 No. 2 Power Section Controls and Accessories

Oil to Fuel Heater: Impact damage to the mounting pad precluded functional testing. Functional testing of the thermal element was satisfactory.

Fuel Pump: Functional testing was satisfactory.

Manual Fuel Control: Functional testing was satisfactory.

Automatic Fuel Control: Functional testing was satisfactory, with normal flow variations attributable to normal field adjustment.

Flow Divider: The flow divider was not tested.

Fuel Nozzles: The fuel nozzles were not tested.

Igniters: The igniters were not tested.

Compressor Bleed Valve: Functional testing of the compressor bleed valve was satisfactory.

Nf Governor: Functional testing of the Nf governor was satisfactory.
4. PHOTO LISTING

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No. 1 Power Section S/N 62224

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13. Compressor 1<sup>st</sup>, 2<sup>nd</sup>, and 3<sup>rd</sup> stage stators and shrouds.
14. 1<sup>st</sup> stage stator and shroud, detail.
15. Compressor centrifugal impeller and shroud.
17. Impeller shroud, detail.
18. No. 1 bearing and airseal.
19. No. 2 bearing and airseal.
20. Combustion chamber liner.

21. Large exit duct.

22. Small exit duct and compressor turbine guide vane ring, upstream side.

23. Compressor turbine guide vane ring and compressor turbine shroud housing, downstream side.

24. Compressor turbine guide vane ring and compressor turbine shroud housing, downstream side, detail.

25. Compressor turbine, upstream side.


27. Compressor turbine disc, detail.

28. Compressor turbine upstream side, detail.

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30. Power turbine housing.

31. Power turbine housing and power turbine guide vane ring and interstage baffle, upstream side.

32. Power turbine housing and power turbine guide vane ring and interstage baffle, downstream side.

33. Power turbine guide vane ring downstream side and power turbine shroud, detail.

34. Power turbine, upstream side.

35. Power turbine upstream side, detail.

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**No. 2 Power Section S/N 62059**

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38. Compressor 1st, 2nd, and 3rd stage stators and shrouds.
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55. Power turbine housing and power turbine guide vane ring and interstage baffle downstream side, detail.
56. Power turbine guide vane ring downstream side and power turbine shroud, detail.
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61. Power turbine shaft coupling, detail.

**Combining Gearbox S/N 1936**

62. Right hand 1st stage gear input shaft coupling spline and No. 5 bearing cover, in-situ.

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69. Clutch shaft and inner race, detail.

70. Right hand sprag elements and retainer.

71. Sprag elements, detail.

72. Right hand intermediate drive shaft.

73. Intermediate drive shaft, detail.
5. REFERENCE LISTING

(A) Materials Investigation Laboratory Report No. 11937FS

(B) Materials Investigation Laboratory Report No. 11940FS