

NASA HIGH TEMPERATURE TURBINE SEAL RIG DEVELOPMENT

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HITEMP C. Ginty

Turbomachinery Seal Development Objectives



- **Evaluate feasibility of advanced seal concepts and materials of meeting next generation engine speed and temperature requirements.**
- **Complete fabrication/installation of state-of-the-art turbomachinery seal test rig capable of testing seals under known/anticipated design conditions.**
- **Work with industry to assess/demonstrate performance of their seals prior to test in engine.**

High Temperature Turbomachinery Seal Test Rig



Test rig designed to test at speeds and temperatures envisioned for next generation commercial and military turbine engines.

Test rig is one-of-a-kind. More capable than any known test rig in existence at either engine manufacturer or seal vendors.

- **Temperature** Room Temperature thru 1500 °F
- **Surface Speed** 1500 fps at 40,455 RPM, 1600 fps at 43,140 RPM
- **Seal Diameter** 8.5" design; other near sizes possible
- **Seal Type:** Air Seals: brush, finger, labyrinth, film riding rim seal
- **Seal Pressure** 70 psi @ 1500 °F: Current
150 psi @ 1445 °F: with Hydrotest qualification of heater
- **Motor Drive** 60 HP (60,000 RPM) Barbour Stockwell Air Turbine with advanced digital control for high accuracy/control

Test Parameters



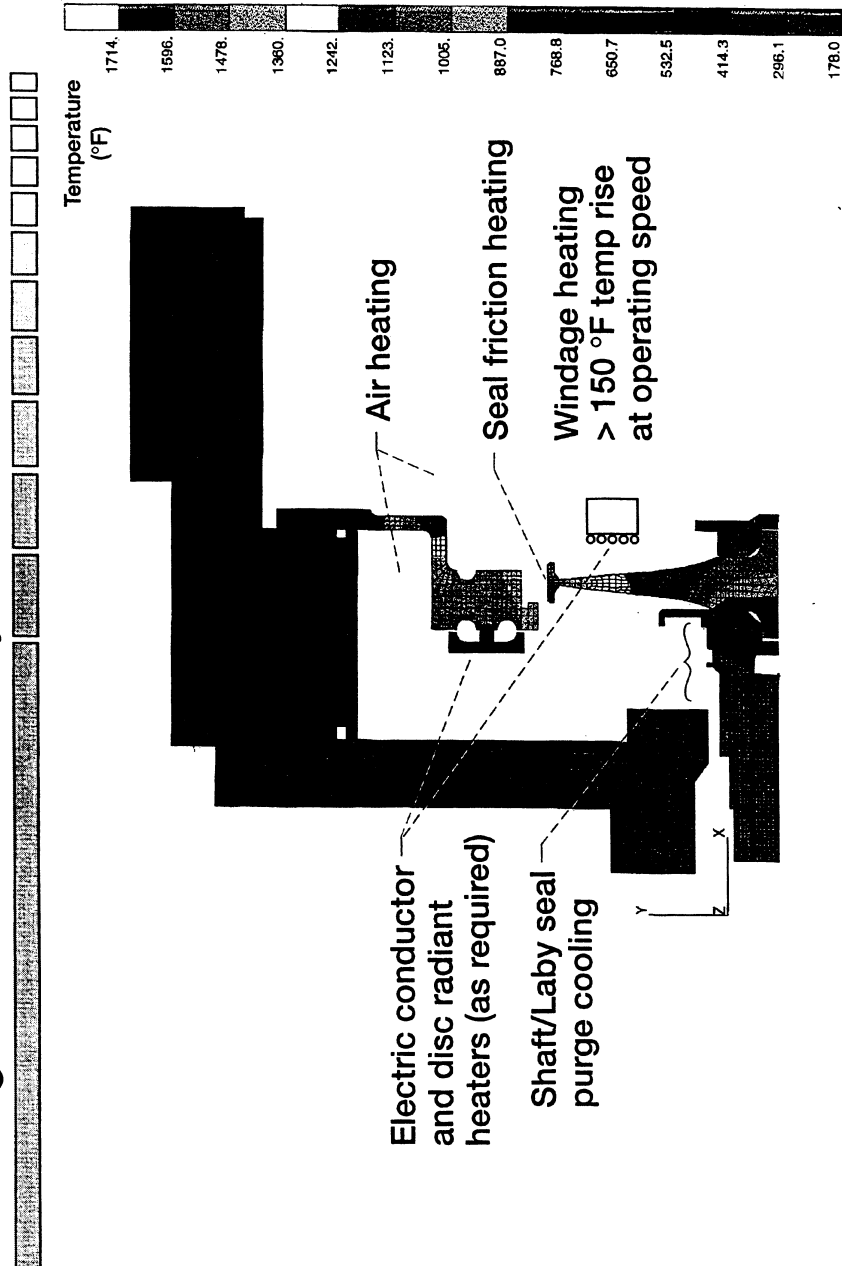
- Seal flow vs. pressure, speed, temperature
(Both test rig and test seal are heavily instrumented)
- Seal performance vs. simulated ramp cycles using new digital air turbine speed controller.
Multiple speed step mission profile capabilities.
- Seal durability vs. once-per-rev rotor runout condition
- Seal durability for prescribed seal offset condition (e.g. 3 mil seal offset)
- Accelerated life tests
- Seal and coating wear

Highlights of Engineering Calculations



- **MAR M-247 (Ni Co) cast rotor and seal holder meet LCF and creep life goals at 1500 °F, 1500 fps**
- **Tri-hub burst containment: Pressure vessel contains disc failure thru operating and overspeed conditions**
- **Pressure vessel sized and to be hydrotested to ASME pressure vessel code**
- **Squeeze film dampers damp anticipated imbalance. Less than 0.001 in. run-out for anticipated imbalance.**
- **Relative seal-holder to test-rotor thermal growths acceptable thru 1500 °F operating range**
- **Rotor windage heating: > 150 °F at 1500 fps**
- **Critical fits: rotor, bearing, bearing nuts, etc., stay "tight" during maximum speed and temperature conditions**

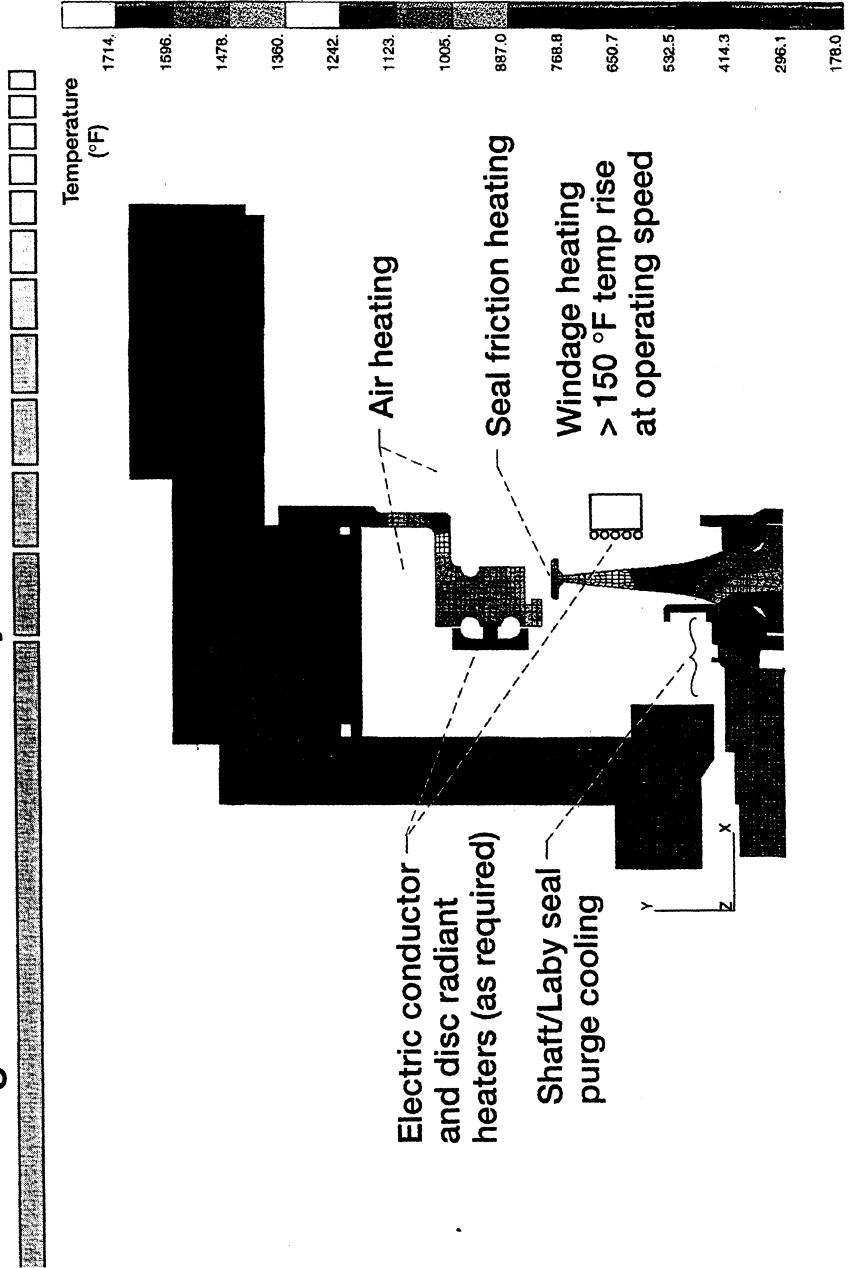
Seal Rig Global Thermal Analysis



Global thermal analysis with windage heating provides input to component stress and displacement analysis

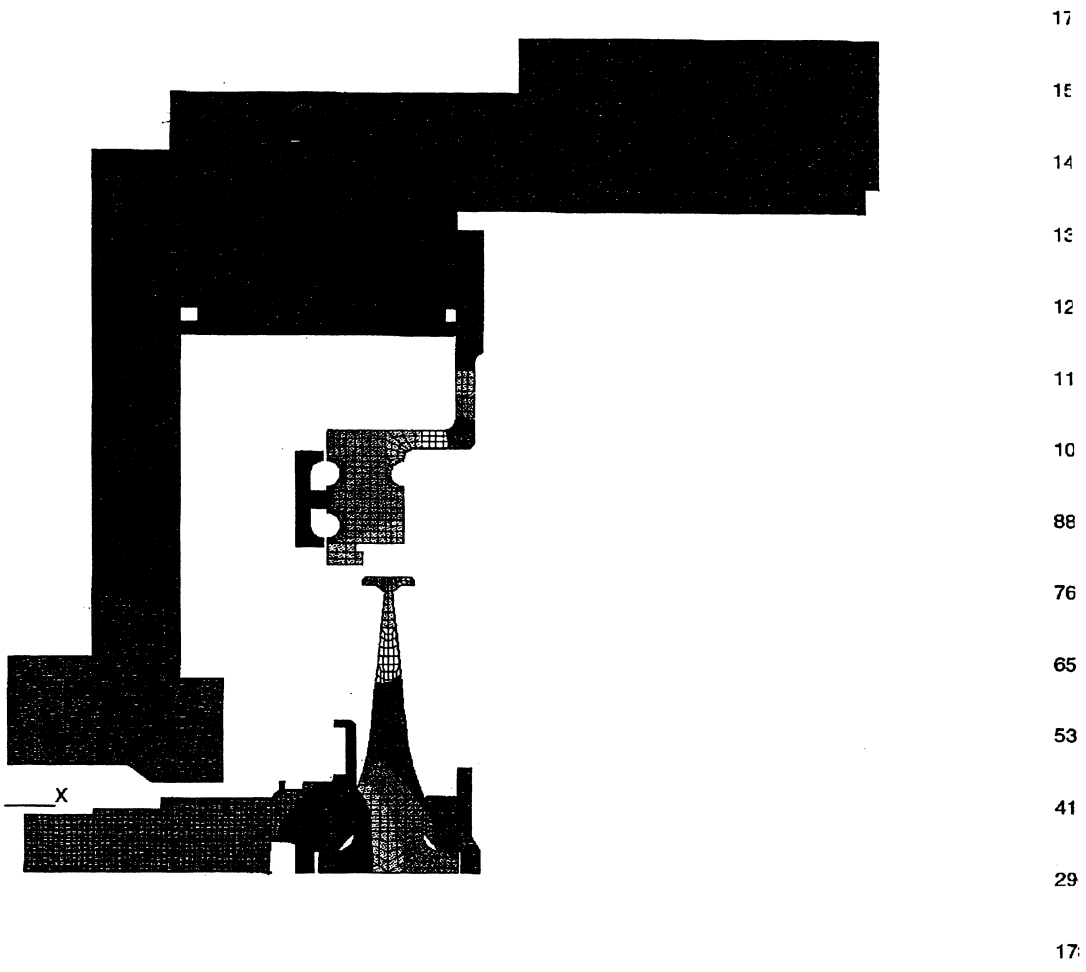
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Seal Rig Global Thermal Analysis



Global thermal analysis with windage heating provides input to component stress and displacement analysis

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Test Rig Status



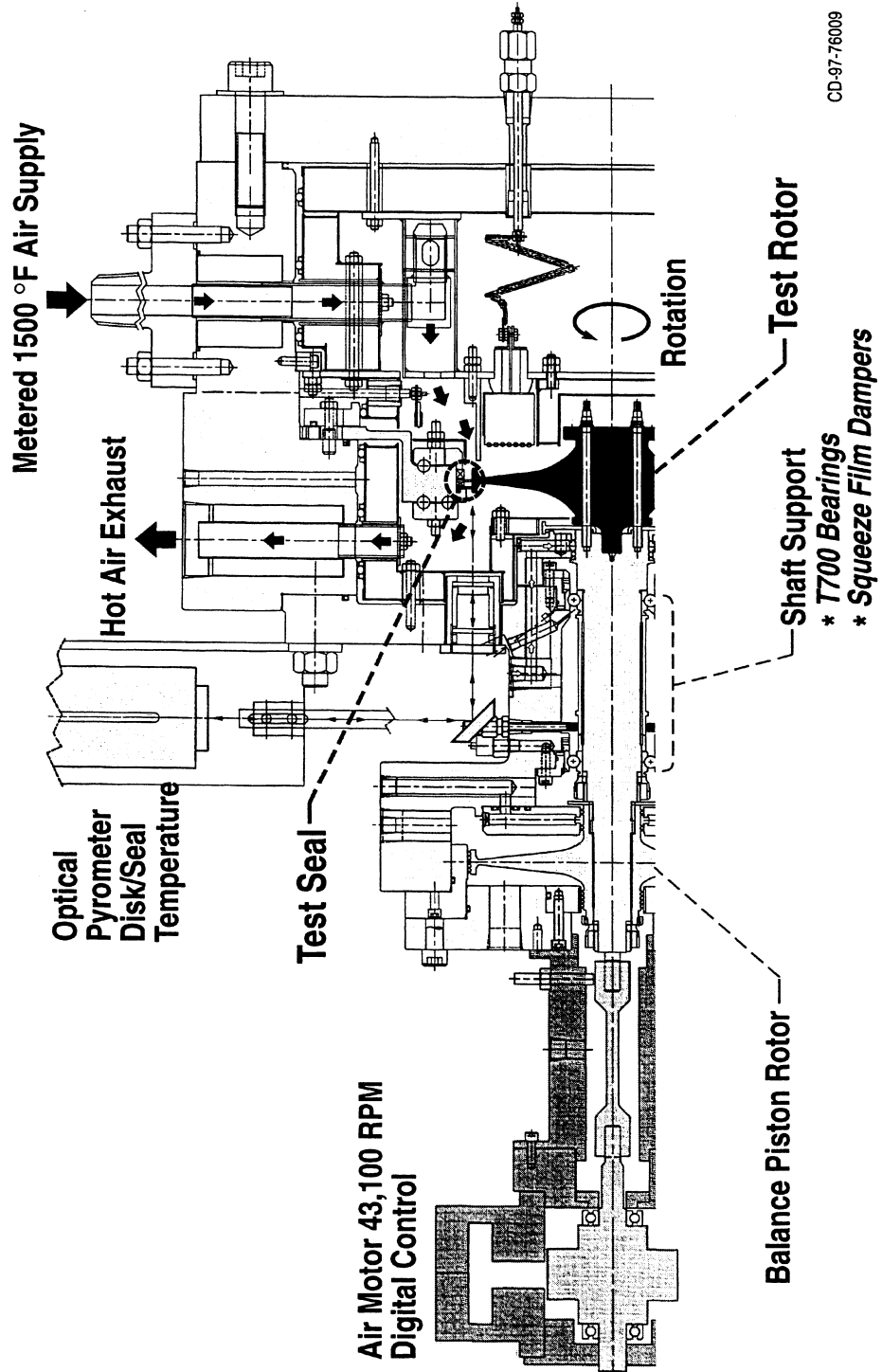
- **Engineering Calculations:**
— Rig capable of 1500 +fps/1500 °F operation **Complete**
- **Detailed Drawings:** **Complete June, '97**
- **Facility/Test Cell Preparation:** **Ongoing**
— High temperature valves/instrumentation ordered
- **Complete Rig Fabrication** **4thQ FY98 Est.**
- **Test rig ready for test** **2ndQ FY99 Est.**

Summary



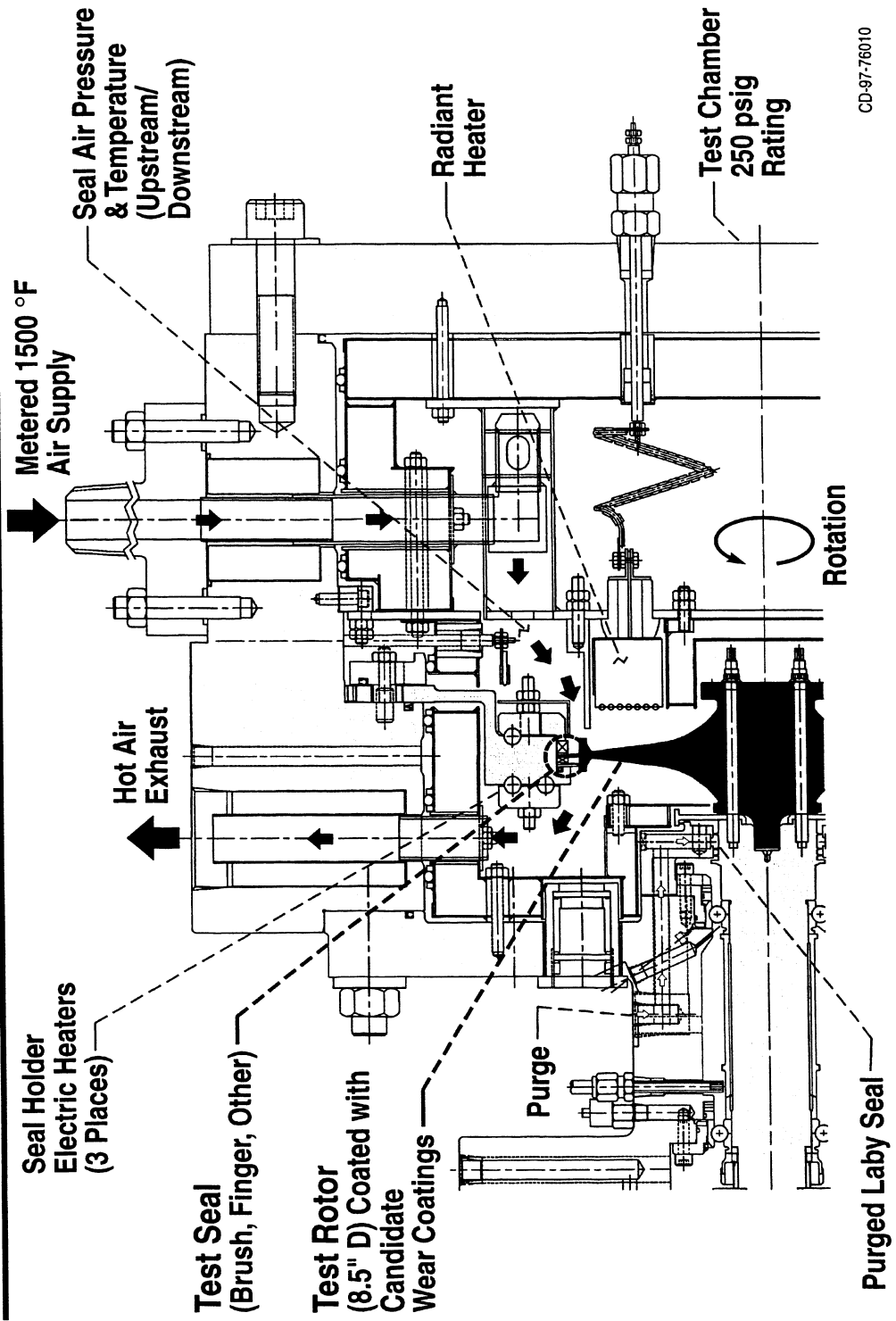
- Test rig heated by multiple conduction heaters, radiant heater and air heater to overcome significant metal heat loss permitting 1500 °F operation.
- Squeeze film dampers designed to provide smooth operation over operating range.
- MAR M-247 (Ni Co) cast alloy used for rotor and seal holder meet rotor and seal holder creep and LCF life goals.
- Test facility designed to meet anticipated IHP/TET, HSR, AST seal test requirements: significant asset for the U.S. engine/seal community.

Seal Rig Schematic



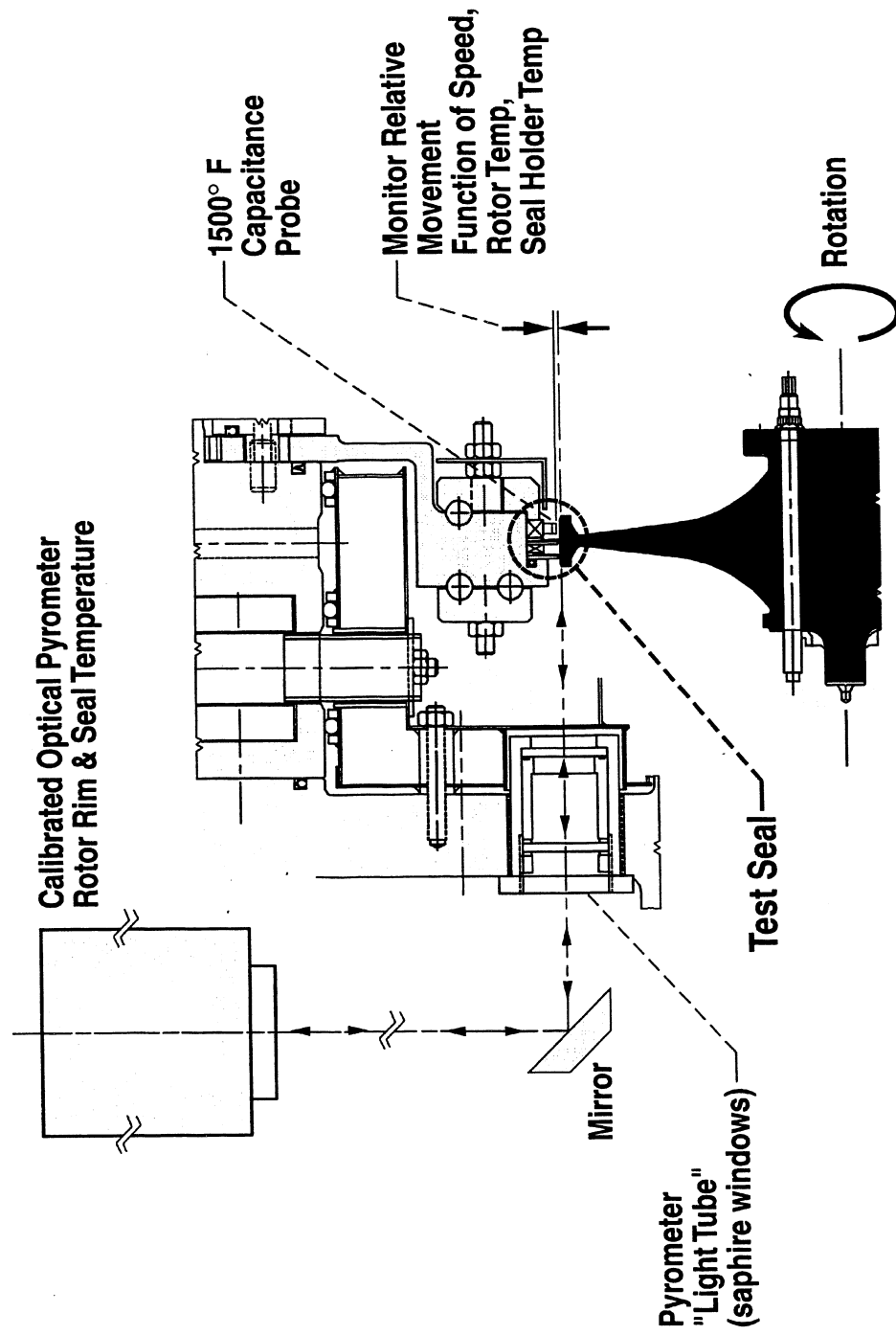
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Test Chamber Enlarged View



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Rig Features Unique Measurement Systems



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