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High Speed, Self-Acting, Face-Contact Shaft Seal Has Low Leakage and Very Low Wear

The problem:

To devise a gas turbine engine shaft seal capable of operating satisfactorily at 200 psi (138 N/cm^2) sealed pressure, 400 ft/sec (122 m/sec) sliding velocity, and 1000°F (811K) sealed gas temperature. Conventional labyrinth seals have high speed capability, little to no wear, but too high a leakage rate. Conventional face-contact seals wear rapidly at these operating conditions; at higher pressures, temperatures, or sliding speeds, both wear and leakage are excessive.

The solution:

Add a gas thrust bearing to the face of a conventional face seal. The gas thrust bearing lifts the carbon face of the seal out of contact soon after startup and establishes a thin gas film between the sealing surfaces. Rubbing occurs only at startup and shutdown substantially reducing wear. Operating pressure and speed capabilities are significantly greater than those of conventional face seals.

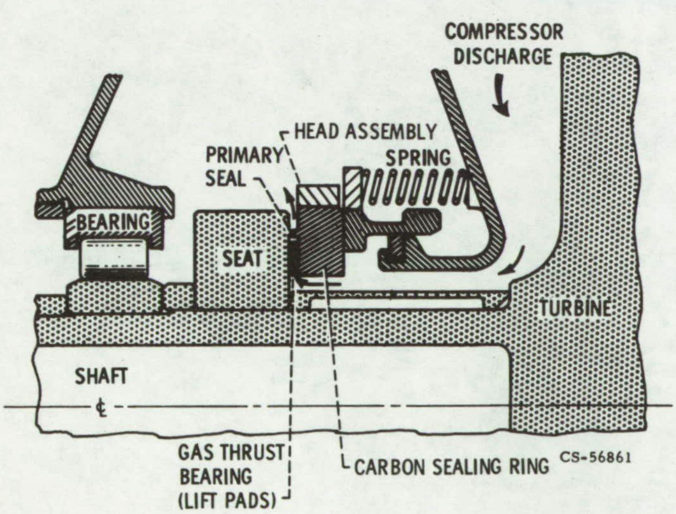

Figure 1. - Self-acting face seal.

How it's done:

Figure 1 is a schematic of a gas turbine engine shaft seal. The head assembly with the carbon sealing ring does not rotate but is free to move axially and is pressed against the rotating seat face by the springs. Good contact between these parts inhibits hot gas leakage from the inside of the seal, across the sealing face, and into the bearing compartment. Because of rubbing contact between the seal ring and seat face (which at severe conditions will be in vibratory contact), conventional face seals in turbine engines are limited to operating conditions of about 125 psi (86 N/cm^2) pressure differential and 350 ft/sec (107 m/sec) sliding velocity at 800°F (700K) sealed gas temperature. Adding a gas thrust bearing to the carbon face establishes and maintains a gas film between the sealing surfaces. Because the gas film is very thin (0.0001 to 0.0004 inch) (0.0003 cm to 0.0010 cm), leakage across the sealing face is limited. Because the self-acting lift pads develop high separating forces at operating speeds which prevent rubbing contact, wear is minimized. The positive stiffness of the gas film due to the lift pads allows the carbon face to track the movements of the rotating seat face without being in contact.

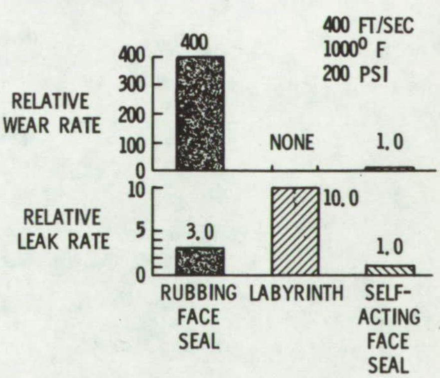

Figure 2. - Seal performance comparison.

(continued overleaf)

Figure 2 shows leakage and wear rates for the self-acting seal compared to conventional face seals and labyrinth seals. The self-acting seal has about 1/10 the leakage of labyrinth seals, and less leakage and substantially less wear than conventional face seals.

Notes:

1. The lift pads provide the following important features generally missing in conventional face seals:
   a. High-gas film stiffness that allows the head to dynamically track the seat face motions without rubbing contact.
   b. The ability to operate with divergent face deformation (due to thermal, centrifugal, etc., distortions).
2. Over 320 hours of successful performance at a multitude of operating conditions was achieved with one seal assembly with little wear. The severest operating condition was at 300 psi (207 N/cm^2) sealed pressure, 500 ft/sec (153 m/sec) sliding velocity, and 1200°F (922°K) sealed gas temperature.
3. This seal should be of interest to manufacturers of commercial compressors and gas turbines:
4. A similar concept is employed in NASA Tech Brief B72-10447.
5. The following documentation may be obtained from:
   National Technical Information Service
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.95)

   Reference: NASA TN-D-5744 (N70-24256)
   Design Study of Shaft Face Seal with Self-Acting Lift Augmentation, I - Self-Acting Pad Geomerty

   Reference: NASA TN-D-7006 (N71-11579)
   Design Study of Shaft Face Seal with Self-Acting Lift Augmentation, II - Sealing Dam

   Reference: NASA TN-D-6164 (N71-20392)
   Design Study of Shaft Face Seal with Self-Acting Lift Augmentation, III - Mechanical Components
6. Technical questions may be directed to:
   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B72-10114

Patent status:

No patent action is contemplated by NASA.

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