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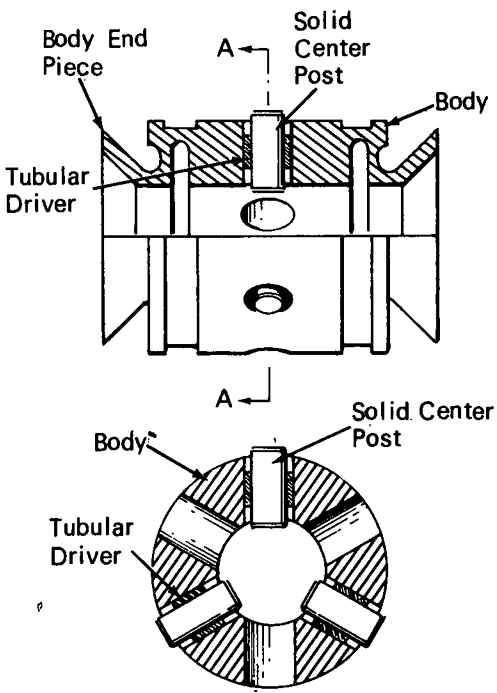
NASA TECH BRIEF

Marshall Space Flight Center

Improved Transducer for Squeeze-Film Bearings

A piezoelectrically driven, vibrating transducer for squeeze-film bearings amplifies the vibrations produced by the piezoelectric drivers, producing greater amplitudes than were possible with direct-drive devices. The drivers themselves are isolated from the bearing surfaces, resulting in a squeeze-film bearing with high axial load capacity and stiffness. As a result of these two modifications, the wear on the ceramic cylinders is considerably reduced compared to previous operation.



Section A-A

Gaseous squeeze-film bearings, commonly used in devices such as gyroscopes, where high-speed rotation is encountered, require that at least one bearing surface vibrate transversely. Because of the viscosity of the bearing fluid (commonly air) and the nonlinear nature of the squeeze motion, the gas pressure within the film rises above the ambient pressure. This pressure differential determines the bearing's load-carrying capacity, and is largely a function of the vibrational frequency and amplitude. The most critical element, then, in a squeeze-film bearing is the transducer, which must provide a high-frequency, large-amplitude squeeze motion. The transducer design (see fig.) shown in cross section uses multiple piezoelectric cylinders arranged radially around the axis of the transducer body. The shape of the body end pieces, shown conical in the figure, may be varied according to the geometry of the bearing. Circular grooves in the body produce weakened portions between the ends and the body center. These areas amplify the vibrations produced in the transducer.

Six radial 2.54 cm (1 in.) diameter holes are bored in the central plane of the transducer body. Three are shown filled with ceramic drive cylinders shrink fitted onto solid 1.9 cm (0.75 in.) diameter metal posts. The posts support the drivers, as well as providing them with one electrical contact. The drivers are slit radially to relieve hoop stress caused by the shrink fitting.

The drivers are poled in the radial direction so that they drive the body through a cyclic expansion in length. This axial excursion is amplified by flexure in the weakened portions of the body, and is then applied to the end pieces. Note that the dimensional stability of the drivers does not affect the bearing caps. Also, because the thickness of the drivers is much less than their radius, dimensional changes in the drivers do not affect the shrink fit.

(continued overleaf)

With the arrangement shown, three resonance modes exist, at 11, 18, and 27 kHz. With all six positions filled, only the two lower-frequency modes are detected. The 27 kHz mode is very powerful, yielding excursions of about 0.0015 μm (600 μin.) peak-to-peak at the cone tips, and has the additional advantage of being above the audible frequency band.

Notes:

1. Additional information on squeeze-film bearings may be found in NASA tech briefs B66-10226 and B68-10180.
2. Requests for further information may be directed to:

   Technology Utilization Officer
   Code A&TS-TU
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: TSP71-10140

Patent status:

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act (42 U.S.C. 2457 (f)), to Mechanical Technology Inc., 968 Albany-Shaker Rd., Latham, New York 12110.

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Mechanical Technology Inc.
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