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# NASA TECH BRIEF



## Environmental Study of Miniature Slip Rings

Miniature slip ring assemblies are normally used to transmit electrical information across the axes of inertial space vehicle guidance systems. Excessive electrical noise at the sliding contact strongly interferes with circuit performance, particularly the null-seeking type of circuit.

The future requirements of space vehicle systems include satisfactory performance of miniature slip rings in severe environmental conditions that could exist during extended space missions. One such condition is the high vacuum of outer space.

To obtain the needed information, a laboratory investigation was initiated to study the long term operation of miniature slip ring assembles in high vacuum of space and included the influence of ring, brush, and insulator materials on electrical noise and mechanical wear.

Previous investigation established that destructive galling and erosion effects occurred in unlubricated systems which permitted high localized temperatures. These detrimental effects are aggravated by high vacuum. The reduced heat transfer characteristics in a vacuum environment increase the possibility of localized hot spots at contact points. The increased friction and surface damage due to cold welding of microasperities result in wear and high electrical noise.

Some of the more important results of the investigation are summarized below.

### *Soft Metal Vapor Plating*

Soft metals, such as gallium and indium, were deposited in situ by a sublimation process on the slip ring while the shaft was rotating in a vacuum chamber. Shielding was provided to stop the lubricant from contaminating the system. A uniform coating of the soft metal lubricant was obtained. Tests conducted in a high vacuum to determine the effect of these soft metal lubricants on the electrical noise and wear characteristics indicated a considerable improvement in these characteristics.

During the first successful test run on indium plated slip rings, the slip rings were rotated at 200 rpm with 25 ma dc current in the brush-ring circuit. The electrical noise averaged 5 millivolts in vacuum of $10^{-7}$ torr. Force on the transducer was 2.6 grams. Sublimation continued for 10 seconds during which the force rose sharply to 7.9 grams and then came back immediately after sublimation to 2.1 grams. Noise dropped to an average level of 0.1 millivolt. After 10 minutes the force was 1.6 grams and noise 1.2 millivolts. After 7 hours, friction was up to 4.3 grams. After 360 hours, electrical noise leveled off at 4 millivolts peak-to-peak. Under similar conditions unlubricated slip ring noise levels increased to 2 volts after 364 hours.

With gallium, the initial noise was 1200 microvolts. During sublimation, noise decreased to 300 microvolts and after 900 hours at $10^{-8}$ torr the noise leveled off at 1 millivolt peak-to-peak.

### *Use of Niobium Diselenide Miniature Slip Rings*

The application of electrical sliding contacts in space environment presents a difficult operating problem because most surfaces in rubbing contact require a thin lubricating film to provide low-friction sliding. Contact materials must also be good electrical conductors. A group of composites with self-lubricating

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properties and good electrical conductivity has been developed. These materials are metal-based composites containing small percentages of polytetrafluoroethylene and a dry lubricant such as niobium diselenide. The lubricant is held in small pockets throughout the metal and forms dry films of self-lubricating material on the metal surfaces rubbing against the composites. These dry films transfer to other metal surfaces as they come into rubbing contact. Thus the film continually transfers back and forth to heal any tiny faults that may occur in the films.

Miniature slip rings made out of niobium diselenide in a silver matrix form were fabricated and evaluated in a high vacuum. The results of the test indicated that the electrical noise and the wear characteristics were superior to those of the standard gold slip rings. These rings were run-in in a vacuum of $10^{-8}$ torr. After a few hours of continuous rotation at 200 rpm with dc current of 25 ma in the brush-ring circuit, noise reached a level of several millivolts and remained at this level throughout the remainder of the test which was terminated after 408 hours. A very small amount of wear debris was found in the grooves of the slip ring. The initial noise was about the same level as that of unlubricated rings but, because of low wear, did not increase after prolonged testing to the extreme levels experienced in unlubricated rings.

**Notes:**

1. Complete details of this investigation are contained in: *Environmental Study of Miniature Slip Rings,* by J. L. Radnik, et al, IITRI, Final Report, September 1966. Copies of this report are available from:

   Technology Utilization Officer
   Marshall Space Flight Center
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**Patent status:**

No patent action is contemplated by NASA.

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