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INVESTIGATION OF SLIP-RING ASSEMBLIES

George C. Marshall Space Flight Center
Huntsville, Alabama

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5 November 1964 to 5 February 1965

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Prepared by

IIT Research Institute
Technology Center
Chicago, Illinois 60616

for

George C. Marshall Space Flight Center
National Aeronautics and Space Administration
Huntsville, Alabama 35812
Attn: PR-RDC

INVESTIGATION OF SLIP-RING ASSEMBLIES

I. INTRODUCTION

This is the seventh quarterly progress report on IITRI Project E6000, "Investigation of Slip-Ring Assemblies." This report summarizes the activities during the period 5 November 1964 to 5 February 1965 and is the third quarterly report on the twelve month continuation authorized by Modification No. 4 of Contract No. NAS8-5251. The objectives of the early tasks of this continuation were to verify the vibration, threshold and repeatibility effects that were demonstrated during the initial program and to identify the wear debris that is obtained during run-in of experimental and commercial capsules. The present tasks of the program are being devoted to evaluation of surface lubrication, investigation of precious metal hardeners for gold plating baths, and preparations for the study of vacuum operation of slip-ring assemblies.

During the quarterly period reported herein, run-in tests were performed with experimental and commercial capsules to determine the effects of surface lubrication by a heavy layer of P-38 synthetic oil. Lubrication with a graphite-oil mixture was also evaluated. In addition, special experimental capsules were fabricated to simulate the constructional features of commercial assemblies and to achieve the thermal isolation that exists between rings in an actual assembly. Also during the period, the effects of palladium additions to a gold plating bath were evaluated, and a drive system for operation in a vacuum chamber was designed.

Table 1 describes the run-in tests that were performed during this quarterly period, and Table 2 is a summary of noise measurements during the run-in tests.

TABLE 1

Run-In Tests - Quarterly Period No. 7

Capsule	Function of Test
2-40	Lubrication with graphite-oil mixture
Commercial Capsule "A"	Lubrication with P-38 synthetic oil
2-42	Effects of thermal isolation
1-43	Repeat of thermal isolation effects

TABLE 2

Run-In Noise Characteristics at 25 ma.

(db values with reference to 1μv level)

Capsule 2-40 with "Oildag"

	80° groove		90° groove	
	Peak to Peak noise-μv	RMS Noise db	Peak to Peak noise-μv	RMS Noise db
initial	4000	53	4000	56
after 132 hours	3000	50	1000	39
after 338 hours	300	30	200	27

Commercial Capsule "A" with P-38 oil

	Peak to Peak noise-μv	RMS Noise db
initial	40	10
after 432 hours	40	10

Capsule 2-42 - Thermal Isolation

	Peak to Peak noise-μv		RMS Noise db
initial	60		13
after 130 hours	150		16
after 163 hours	-	open	-

Capsule 1-43 - Repeat of Thermal Isolation

	Peak to Peak noise-μv		RMS Noise db
initial	80		17
after 96 hours	6000		50
after 110 hours	-	open	-

II. SURFACE LUBRICATION

A. Lubrication with Graphite-Oil Mixture

The effects of surface lubrication with a graphite-oil mixture were evaluated with Capsule 2-40. It was assembled with a thin coating of "Oildag" on the ring and brush contacting surfaces. "Oildag" is the tradename of a colloidal dispersion of graphite in petroleum oil manufactured by the Acheson Colloids Company. It is widely used as a lubricant for sliding contacts, particularly with heavy currents. The run-in test was carried out for 338 hours at 200 rpm. A current of 25 ma was supplied to each pair of grooves for approximately one-half of the total test time with frequent changes from the 90° pair to the 80° pair.

As indicated in Table 2, the initial noise level of Capsule 2-40 was very high (4000 μv, peak to peak). During the run-in, the fluctuations of noise were quite pronounced and random, but in general, the noise level decreased with final readings between 200 to 300 μv, peak to peak. The rms noise decreased from an initial 53 to 56 db to the final values of 27 and 30 db. No significant difference in the performance of the 80° and 90° grooves was observed. Because of the relatively high noise levels, it was concluded that the graphite-oil mixture is not an effective lubricant for the material system presently used in commercial capsules.

B. Lubrication of Commercial Capsule with P-38 Oil

To confirm that the beneficial effects of surface lubrication with P-38 synthetic oil previously demonstrated with experimental capsules also apply to commercial 80 ring capsules, a run-in test was performed with Commercial Capsule "A" after its contacting surfaces were coated with the oil. No increase in noise level above the low initial value was detected after 432 hours at 200 rpm. Disassembly of the commercial capsule after the test revealed no debris deposits and no mechanical damage to the rings and brushes. These results were in direct contrast with the run-in results obtained with an unlubricated commercial assembly. During the run-in of Commercial Capsule "B" (unlubricated), noise spikes of 200 μv peak to peak were evident after about 200 hours, and noise levels of 2000-30000 μv were measured when the test was terminated after 310 hours. Excessive debris deposits and permanent damage to the rings and brushes were observed when the capsule was disassembled and inspected.

The results obtained with the lubricated commercial assembly were similar to those obtained with lubricated experimental capsules. As reported in the previous quarterly report, Capsules 1-37 and 1-39 exhibited uniformly low noise during run-in, and no wear debris was present when the capsules were disassembled.

III. THERMAL EFFECTS

The run-in test of an unlubricated commercial capsule established that there was a significant difference in the wear characteristics of the commercial and the experimental capsules. With the commercial capsule, large flakes, chunks and granules of gold were obtained as contrasted to the black, finely dispersed deposit obtained with unlubricated experimental capsules. Microscope inspection of the commercial capsule indicated that severe galling and erosion had occurred in the grooves, apparently due to seizing between the ring and brush. This was also apparently responsible for the fatigue and subsequent fracture of one brush wiper at the point at which it was welded to its junction block.

The seizing between ring and brush in a commercial capsule is believed to be a consequence of the high temperatures that are developed at the contact interface. In the commercial capsule with the rings imbedded in the plastic rotor, each ring is thermally isolated, and heat generated at the contact surface cannot be dissipated quickly. In the experimental capsule on the other hand, the common brass cylinder upon which the rings are plated acts as a heat sink and permits rapid conduction of the heat from the contact surface.

To verify that the severe galling and erosion wear effects are thermal in origin, Capsule 2-42 was assembled to simulate the thermal isolation that exists between rings in a commercial assembly. In this special capsule, two independent gold rings were pressed onto a teflon rotor. The rings were interconnected at only one point by a single 2 mil gold wire to avoid good heat conduction paths between the rings while still permitting current flow and noise measurement. As indicated in Table 2, Capsule 2-42 exhibited increased noise after 130 hours of run-in at 200 rpm, and an open circuit developed at approximately 163 hours. Disassembly of the capsule revealed that one brush and ring had seized, causing the ring to rotate on the teflon rotor and to shear off the 2 mil gold wire interconnection between rings. A large amount of wear debris was also present.

The same experiment was repeated with Capsule 1-43, except that this assembly contained four independent rings connected into pairs by separate gold wires. Both pairs of rings exhibited very high noise after about 90 hours of run-in at 200 rpm, and open circuits developed in both pairs at about 96 and 110 hours. Inspection of the disassembled capsule again revealed that the interconnecting wires were sheared off by rotation of the rings relative to the rotor, apparently because of high friction or seizing between brushes and rings. An extremely large amount of black wear debris was found on the lands and in the grooves of the rings.

Experience with Capsules 2-42 and 1-43 indicates quite positively that high friction and/or seizing conditions are developed rapidly in the isolated ring configurations. Seizing between brushes and rings is probably a consequence of cumulative increases in temperature caused by the inter-related effects of friction and heat generation. It is planned to perform an additional experiment in which an experimental capsule containing isolated rings will be lubricated with P-38 oil and subjected to a 200 rpm run-in test.

IV. PRECIOUS METAL HARDENERS

The effects of rhodium additions to gold plating baths were reported in Quarterly Report No. 6. During this quarterly reporting period, palladium modified baths were evaluated, and samples for study of platinum additions were prepared.

Massive electrodeposits were prepared for gold bath formulations containing palladium/gold ion ratios of 0.0000, 0.0001, 0.001, and 0.01. Plating was carried out at a current density of 5 amperes per square foot and at a bath temperature of about 55°C. The specimens were rotated at about 400 rpm during plating.

Microhardness measurements were made on the deposits using standard metallographic mounting and polishing techniques in conjunction with a Ernst Leitz Duromet microhardness device. Hardness values were taken at four points (90° positions) around the circumference of the specimen at about the center of the 16 mil thick deposit. The experimental results are presented in Table 3. The results indicate that there is no significant change in hardness with the addition of palladium up to a concentration of 0.01. This is in contrast to the general decrease in hardness that was effected by additions of rhodium.

TABLE 3

Microhardness Data on Au-Pd

Ring No.	Pd/Au Ion Ratio in Bath	VHN^{*}_{15g} 0°	90°	180°	270°
48	0.0000	70.2	63.7	71.0	61.3
49	0.0001	73.2	74.7	67.5	64.9
50	0.001	64.3	67.5	68.2	64.9
51	0.01	69.5	64.3	78.7	79.5

* Vickers Hardness Number, 15 gram indentor load.

V. VACUUM OPERATION OF SLIP-RING ASSEMBLIES

Preparations have been made for evaluation of slip-ring performance in a vacuum environment. A separate drive system incorporating a magnetic coupler is being fabricated to permit run-in testing within a vacuum chamber. As presently planned, testing of basic slip-ring characteristics will continue with the existing drive assembly, and the present instrumentation will be used with both experimental set-ups.

VI. SUMMARY

Run-in tests of experimental capsules have demonstrated that destructive galling and erosion effects occur primarily in unlubricated systems which permit high localized temperatures. All unlubricated capsules containing isolated rings have exhibited severe seizing or high friction effects leading to permanent damage of the rings and brushes.

Surface lubrication with P-38 oil has been found to be effective with both experimental and commercial capsules in minimizing wear and maintaining low noise levels. Wear and noise have been found to be closely inter-related, and high noise levels during run-in are typically indicative of poor wear characteristics.

Electrodeposits from rhodium and palladium modified gold baths have not exhibited any significant increase in plate hardness. In the case of rhodium, an actual decrease was obtained.

VII. FUTURE ACTIVITIES

During the next quarterly period of this program, the following activities will be performed:

A. Additional studies of basic slip-ring characteristics will be conducted with the drive apparatus developed during the initial program.

B. Fabrication of a drive apparatus for vacuum testing will be completed, and experiments will be initiated.

C. The study of precious metal hardening agents will be completed and all experimental data will be summarized.

VIII. PERSONNEL

IITRI staff members who have contributed to the research effort described in this report are O. M. Kuritza, W. H. Graft, and M. Holzer.

Respectfully submitted,
IIT RESEARCH INSTITUTE

J. L. Radnik
Assistant Manager
Reliability and Components

Approved:

M. E. Goldberg
Manager
Reliability and Components

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