MSC-07573

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 16 MISSION

ANOMALY REPORT NO. 4

UNEVEN DRIVE RATES OF THE SCANNING TELESCOPE

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MANNED SPACECRAFT CENTER

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HOUSTON, TEXAS
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UNEVEN DRIVE RATES OF THE SCANNING TELESCOPE

STATEMENT OF ANOMALY

The scanning telescope shaft axis drive operated erratically and the operation seemed to become more erratic as the mission progressed. The condition was observed when the telescope was repositioned, using either the computer mode or the zero optics mode. The crew believed that the uneven drive rates were also related to a change in the characteristic noise level of the optics counter on the panel.

SYSTEM DESCRIPTION

The sextant and the scanning telescope are mounted in the optical unit assembly that is fixed to the guidance system navigation base. These optical instruments are in an unpressurized cavity (fig. 1) and exposed to the external spacecraft environment. The electrical signals and voltages necessary to reposition the optics are routed to the optical instruments through two feed-through connectors on the pressure bulkhead behind the optics panel.

The optics can be repositioned by three methods: First, manual drive commands can be generated by using the optics hand controller; second, the computer can be used to generate automatic drive commands; and third, the optics can be commanded to zero position by selecting the zero optics mode. Figure 2 is an electrical block diagram of the optical subsystem. As shown in the figure, all drive commands are sent to the sextant, and the telescope is slaved to the sextant through 1X resolvers.

DISCUSSION

Telemetry data did not reveal any abnormalities in optics drive commands. The telemetry pick-off for the drive commands is located in the coupling data unit digital-to-analog converter section, and erratic positioning of the optics downstream of the telemetry pick-off (fig. 2) would not have been detectable in the data. Further, since there was no problem with the sextant, the source of the erratic drive rates must have been downstream of the sextant 1X resolver.

Postflight visual inspection of the optical unit assembly, the eyepieces, and the harness assembly revealed no abnormalities. Salt-water

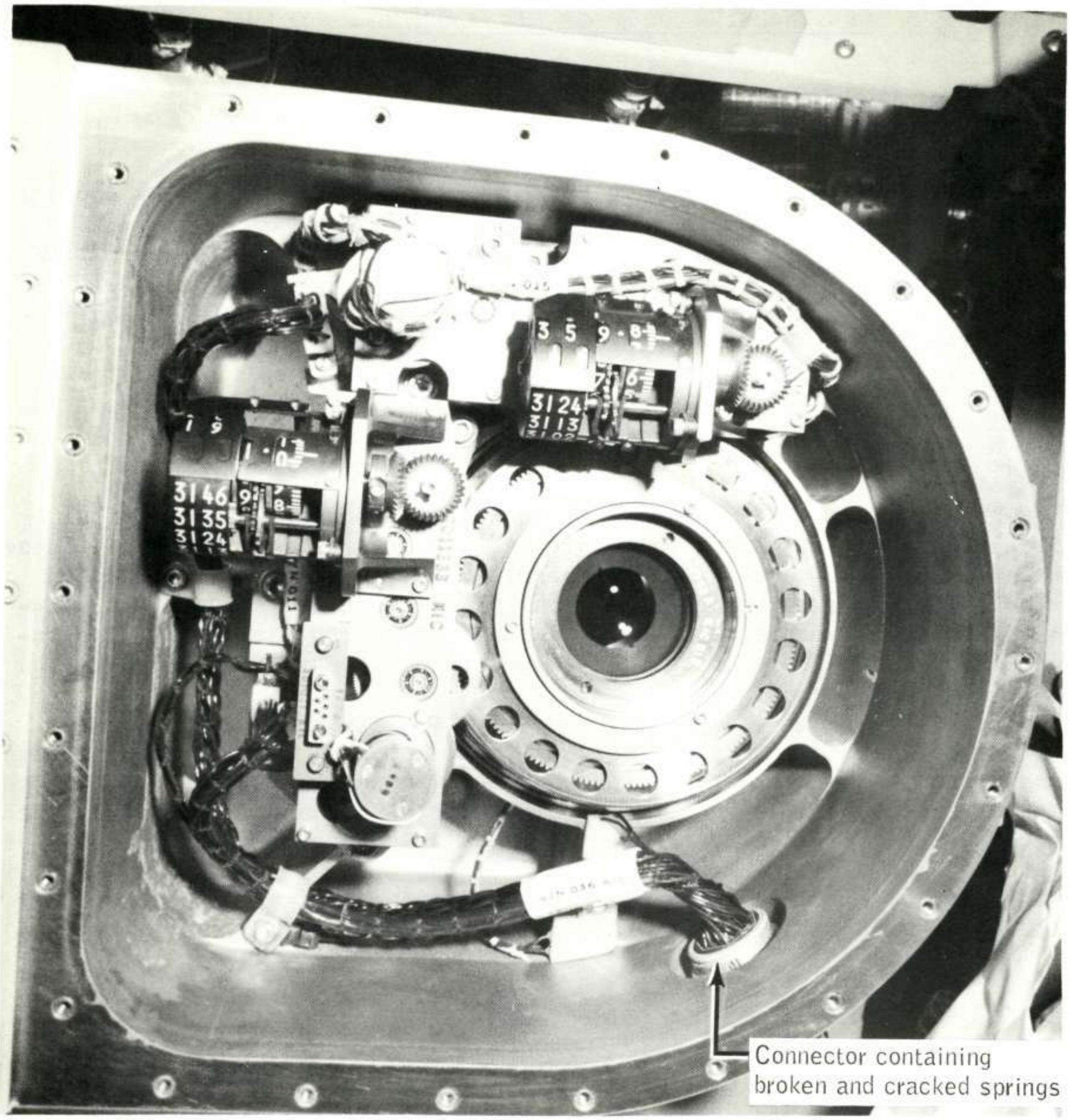


Figure 1.- Scanning telescope.

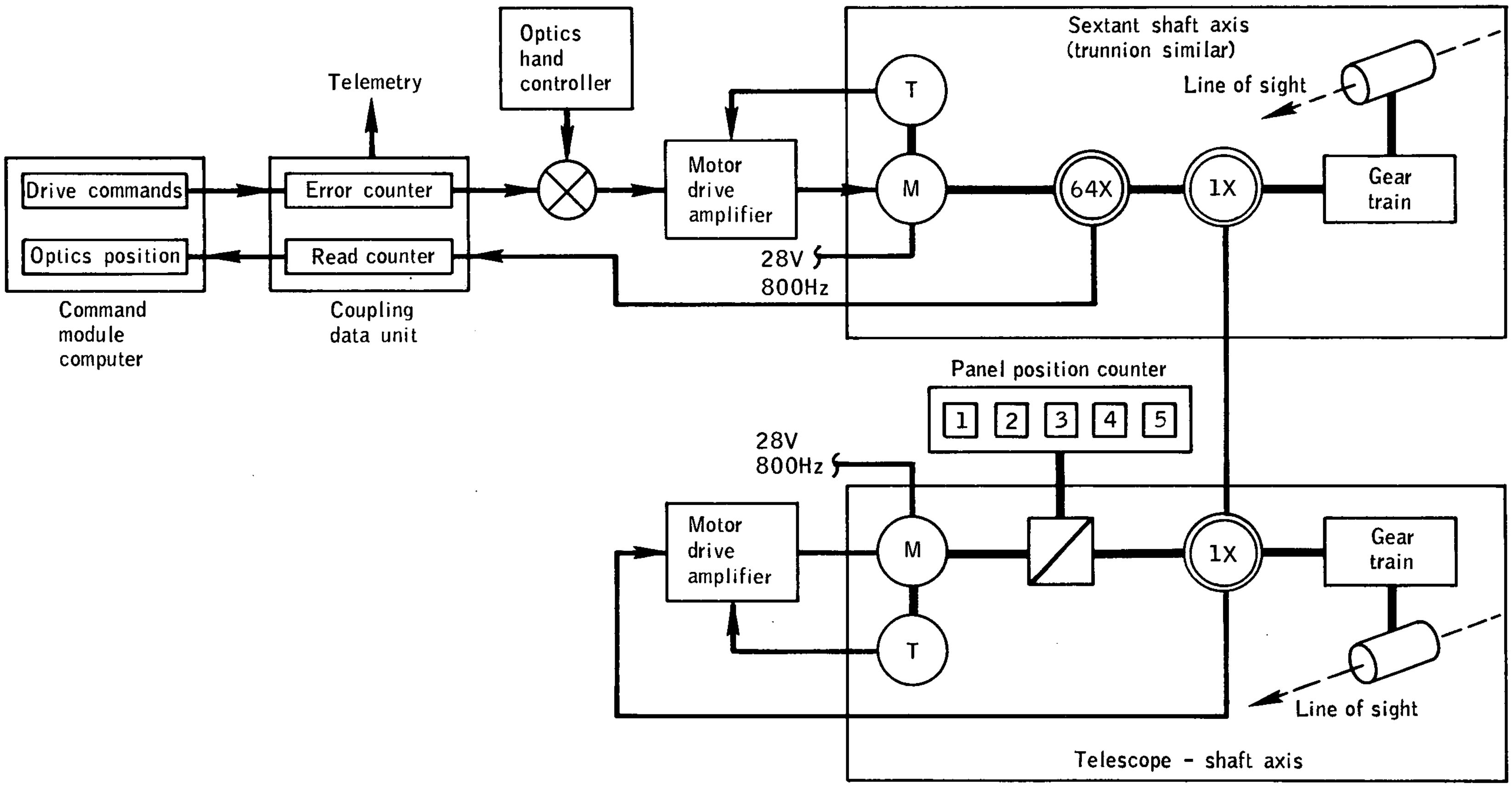


Figure 2.- Functional drawing of optical unit assembly.

corrosion was evident throughout the assembly, and all gear trains were frozen. The telescope was removed from the optical unit assembly, and separate tests of the gear box, resolver, counter, motor-tachometer, and harness showed no abnormal operation. After the gear trains were cleaned and the system was reassembled, the telescope was unsteady when it was stationary, and moved erratically when slewing.

Since the connector of the harness in the unpressurized compartment is not potted, the harness and connectors were dried and the closed-loop testing was repeated. The erratic condition was again observed and was traced to an intermittent contact in the connector. The contact provides the 28-volt, 800-hertz return voltage for the drive-motor reference winding. Vibration induced by slewing the telescope was sufficient to cause the intermittent to act as a high resistance conductor, thus slowing the motor, and causing the erratic slewing. A broken socket spring was found in the female half of the connector. Further examination showed broken springs in 9 of 61 sockets of the telescope connector and in 6 of 91 sockets of the sextant connector. Also, 25 cracked springs were found. Figure 3 shows the spring arrangement in the female socket and X-ray photographs of failed springs similar to the one which caused the uneven drive rate problem. The breaks and cracks were caused by stress corrosion, shown in figure 4.

This connector was manufactured prior to December, 1965, at which time the connector assembly procedure required the use of a pair of tweezers to hold the gold-coated copper-beryllium-base metal spring in position on the collar of the female socket while the monel sleeve was slipped over the socket and spring. The spring can be easily damaged by either scratching or gouging the gold plating using this technique, or by cracking the spring when too much force is applied with the tweezers. Automatic assembly procedures, instituted in December 1965, prevent this type of spring damage. Once the gold plating is scratched, the copper-beryllium base material is exposed to the environment and corrosion can occur. The two connectors in the optical unit assembly pressure bulkhead are not potted. Consequently, the sockets and springs of the Apollo 16 connectors have been exposed to the external atmosphere since 1965. This may have been detrimental to the springs. All other spacecraft connectors of this type are potted.

An inspection of many other spacecraft connectors which use the same socket spring configuration showed that all springs were intact. A mated connector pair, with the gold coating on some of the springs deliberately scratched, was immersed in salt water for 35 days to determine if the broken springs resulted from salt water introduced during recovery; none of the springs broke or cracked and none showed intergranular corrosion. The peculiar circumstances which caused the springs in the flight connectors to crack are unknown.

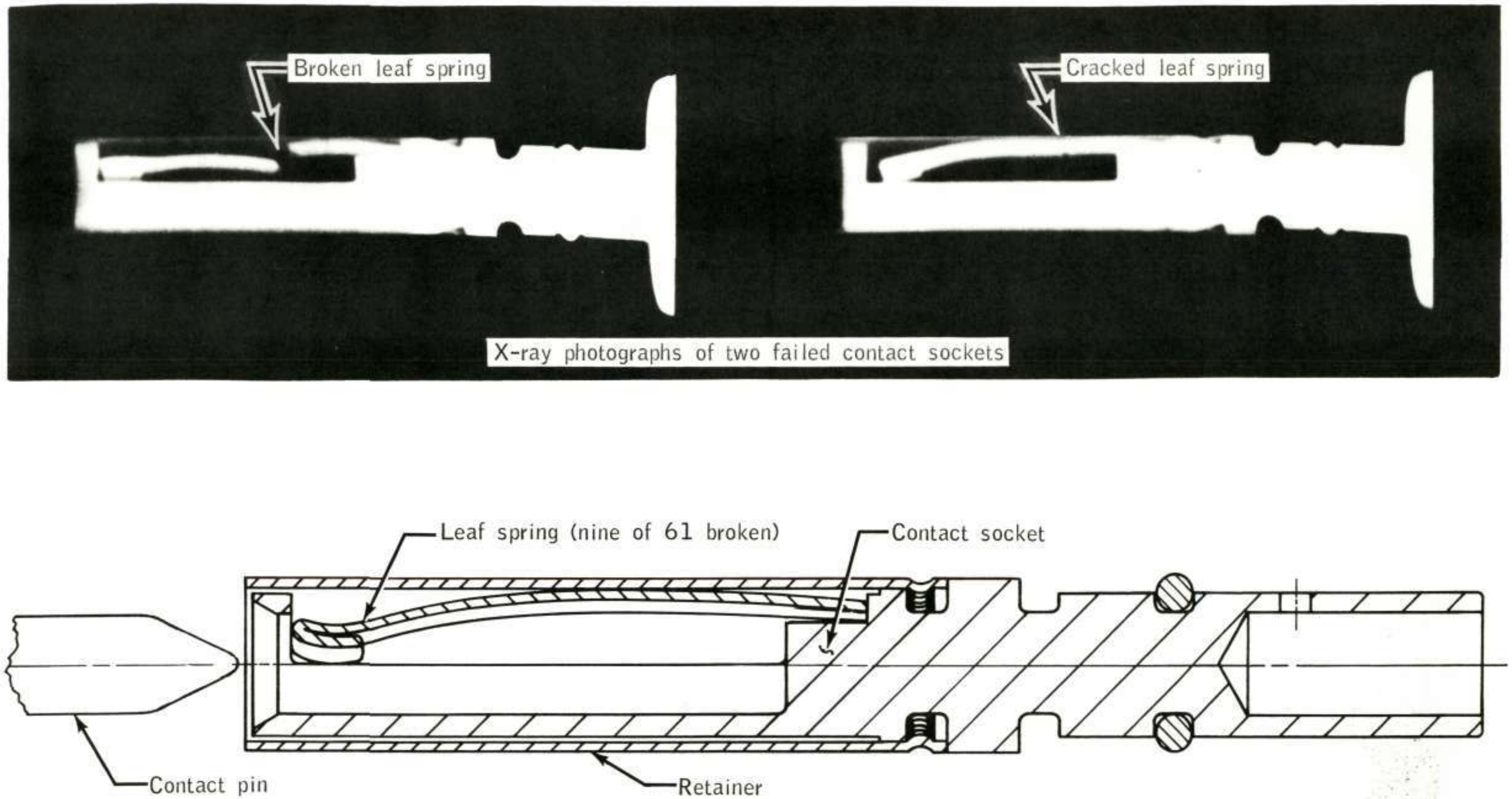
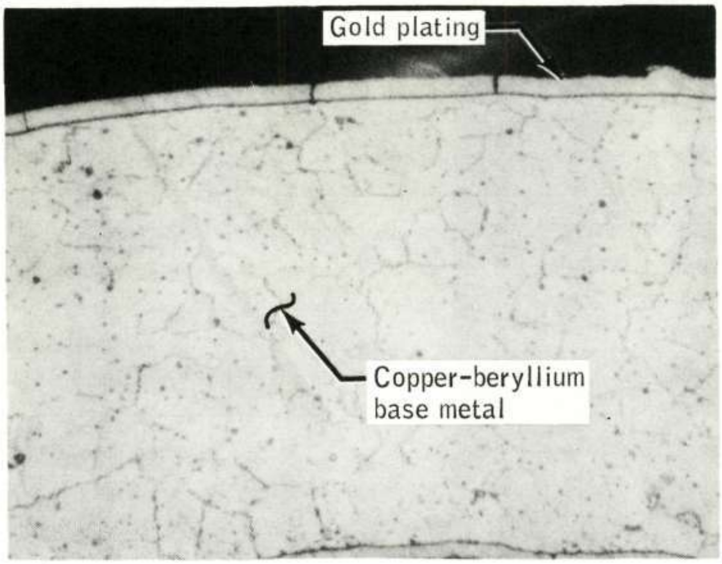
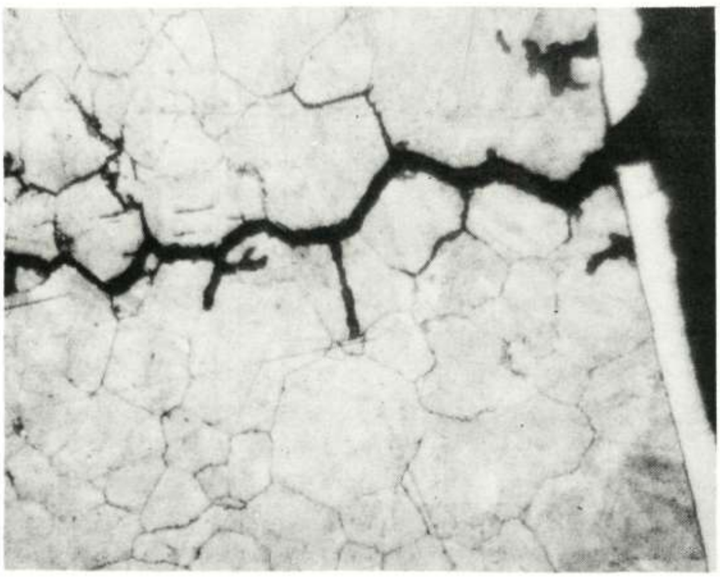


Figure 3.- Contact and leaf spring arrangement of optical unit connector.



(a) Cracks in gold coating.



(b) Intergranular corrosion into spring after crack in gold plating.

Figure 4.- Magnified photographs of spring.

CONCLUSIONS

The uneven drive rates observed through the scanning telescope were caused by a broken socket spring in the telescope harness connector. Because of manufacturing procedures used prior to December 1965, the gold plating of the spring may have been damaged, and corrosive action could have occurred and ultimately caused spring breakage.

CORRECTIVE ACTION

Harnesses which have been sealed in plastic bags since manufacture have been installed on Apollo 17. These harnesses were inspected for broken springs prior to installation. New harnesses will be manufactured for installation in the command modules to be flown in the Skylab program.