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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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APOLLO 16 MISSION

ANOMALY REPORT NO. 3

INERTIAL SUBSYSTEM WARNINGS AND COUPLING DATA UNIT FAILURE INDICATIONS

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS
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STATEMENT OF ANOMALY

The inertial subsystem warning light was observed to illuminate six times during the transearth portion of the flight. Each illumination was accompanied by a program warning of an inertial coupling data unit failure. The warning indications were intermittent; the first four cleared themselves and the last two were apparently removed by bumping an access panel in the lower equipment bay.

SYSTEM DESCRIPTION

The coupling data unit assembly contains failure detection circuits which monitor the performance of the assembly. There are individual failure detect circuits for the inertial subsystem and the optical subsystem coupling data units. Figure 1 is a functional representation of the pertinent circuits. A failure discrete is sent to the computer if a failure occurs in either subsystem coupling data unit. The failure discrete is sent to the computer if one or more of the following conditions exist:

a. Coarse error detect - A disagreement of approximately 30 degrees between a read counter and the 1X gimbal resolver.

b. Fine error detect - A disagreement of more than 0.7 degree between a read counter and the 16X gimbal resolver.

c. Cosine $(\theta - \psi)$ - Voltage less than 2 Vrms. This voltage is normally 4 Vrms when the read counter agrees with the resolver voltage.

d. Read counter limit cycle - The read counter changes the direction in which it is counting at a rate greater than 160 times a second.

e. 14-Vdc power supply - The 14-Vdc power supply in the coupling data unit decreases to 8 volts or less.

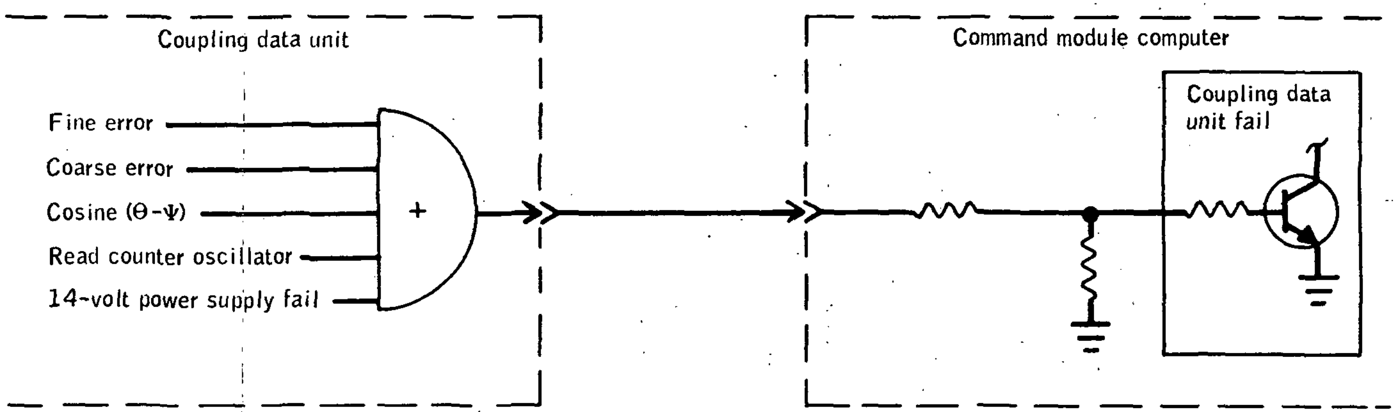

Figure 1.- Coupling data unit fail indication.

DISCUSSION

The computer logic is such that the failure discrete must exist for 5 ±2 seconds before the computer generates the appropriate failure indications. The measured time delay associated with the failure discrete was 5 seconds during the flight. The failure indications persisted for 4, 12, 16, 894, 10 and 38 seconds. All telemetry data directly or indirectly related to the coupling data unit were reviewed and no abnormalities were observed. If a real failure condition had occurred in the monitored parameters and had lasted as long as 894 seconds, it would be observable in the data. An intermittent condition was indicated, however, with the most probable locations in (1) the failure-detect circuit of the coupling data unit assembly, (2) the input logic in the computer, or (3) the "A" harness (or its connectors) between the coupling data unit assembly and the computer.

Diagnostic tests were conducted on the returned hardware before it was removed from the spacecraft. These tests consisted of continuous monitoring for inertial coupling data unit failure indications, and cycling the thrust vector enable relay to investigate the false gimbal lock anomaly. The false gimbal lock anomaly discussed in section 14.1.3 of the Apollo 16 Mission Report is not related to this anomaly, although the same hardware was involved in both anomalies. No abnormal indications were observed during the tests.

The coupling data unit, "A" harness, and computer were removed from the spacecraft. A visual inspection of the harness was performed and a meggar test was performed on the pins adjacent to the one which supplies the failure indication to the computer. The connectors were X-rayed and a chemical analysis was performed on contaminants found in the connectors. The contaminants were non-conductive and the results of all other tests were negative.

The computer was subjected to functional tests at marginal voltage levels, then the modules containing the input logic were subjected to thermal, vibration, and vacuum testing at marginal voltage levels. Finally, the computer modules were depotted and those components which could have caused the problem were X-rayed, leak tested, electrically tested, and visually inspected. No abnormalities were observed.

The coupling data unit was functionally tested and the module that contains the failure-detect circuit was removed and subjected to thermal and vibration tests at marginal voltage levels. No anomalies were observed. The module was depotted and 23 of the 30 component parts which could have caused the problem were individually tested. Seven parts were not tested for the following reasons:

a. One glass diode was broken during removal.

b. Two capacitors were damaged during removal.

c. Four resistors that would have to have shorted were verified to be good before depotting.

Only one component defect was observed. A glass-body zener diode (fig. 2) contained a loose conductive silicon particle, approximately 1 mil by 5 mils, which was large enough to short the diode. Figure 3 shows the diode with the particle in it. If this diode shorted intermittently, the flight indications would result.

This type diode was not subjected to 100-percent screening for contaminants at the component level. However, the diode did pass all module, assembly, and system level tests with no evidence of shorting. In addition, this type of diode has been widely used in the guidance systems of all manned Apollo spacecraft. There are 115 of these diodes in the lunar module and 122 in the command module. There has been no history of shorts caused by contaminants in any of these applications.

CONCLUSIONS

Conductive contamination in a zener diode in the failure-detect circuit of the coupling data unit assembly most likely caused the problem since the conductive contaminant was free to move and could have shorted the diode.

CORRECTIVE ACTION

No corrective action will be taken because an intermittent short in any of the guidance system applications of this type of diode would not create a hazard to the crew. In any event, the cost of replacement of all the diodes of this type would be prohibitive.

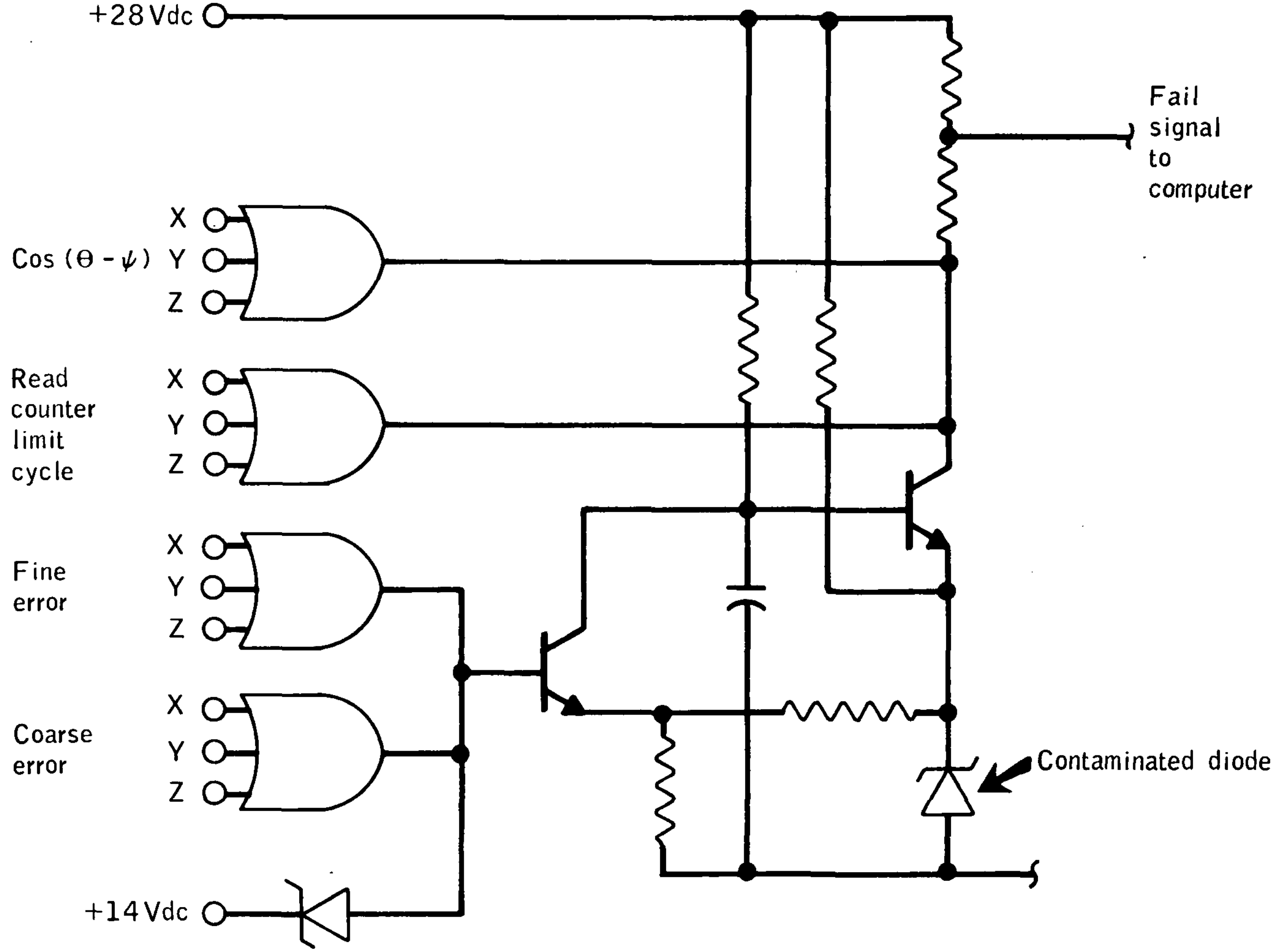

Figure 2.- Fail detection circuit.

Figure 3.- Conductive particle in glass-body zener diode.