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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 17

30-DAY FAILURE AND ANOMALY LISTING REPORT

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MANNED SPACECRAFT CENTER
HOUSTON, TEXAS
FEBRUARY 1973

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30-DAY FAILURE AND ANOMALY LISTING REPORT

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1.0 INTRODUCTION

This report contains a discussion of the significant anomalies that occurred during the Apollo 17 mission. The discussion is divided into five major sections: command and service modules, lunar module, government-furnished equipment, lunar surface experiments, and orbital experiments. All times are elapsed time from range zero, established as the integral second before lift-off.

2.0 COMMAND AND SERVICE MODULE ANOMALIES

2.1 SPURIOUS MASTER ALARMS

Several spurious master alarms without the accompanying caution and warning lights were reported after earth orbit insertion. The alarms could be initiated by tapping on panel 2, indicating a short circuit to ground in that panel.

Postflight testing is in progress to determine the cause. To date, testing of the panel shows normal operation without any spurious master alarms. The panel has been removed for further inspection.

This anomaly is open.

2.2 MISSION TIMER SLOW

The mission timer in the lower equipment bay was 15 seconds slow at 1 minute and 58 seconds after lift-off. The timer was reset and worked properly for the remainder of the mission.

Postflight testing has been performed on the timer with negative results. The circuitry has been analyzed to determine possible causes of the time loss with the result that the most probable cause is an intermittent in one of the integrated circuits within the timer.

Since there is another mission timer on panel 2 and event timers in the lower equipment bay as well as on panel 1, loss of one timer is not mission critical. Therefore, no further action will be taken.

This anomaly is closed.

2.3 RETRACT LIMIT SWITCH ON LUNAR SOUNDER HF ANTENNA BOOM 1 DID NOT ACTUATE

The retract limit sensing switch on HF antenna boom 1 failed to operate, resulting in telemetry and command module display data that indicated the boom had not fully retracted.

The boom was one of two HF antennas, each utilizing two nested 0.008-inch by 4.00-inch steel elements to form an extendable/retractable tubular antenna 410 inches in length. Two limit switches were used, one to sense extension, and the other to sense retraction. Each microswitch was operated by a cam which was rotated by a spring-loaded cam follower arm. This arm had a roller at its tip that rode on the surface of the antenna element during extension or retraction (see fig. 2-1). One element had a slot punched at its tip and another near the root. Each slot was aligned with one of the two arms so that at the appropriate extension length, the follower arm dropped into the slot and rotated the cam to actuate the limit switch.

Current data indicated that the antenna did fully retract; i.e., that the motor stalled after retracting for a nominal period. This verified the antenna motor/gear box/retractor mechanism was satisfactory and isolated the problem to the retract limit switch and its actuating mechanism. Possible failure modes of this device include the following:

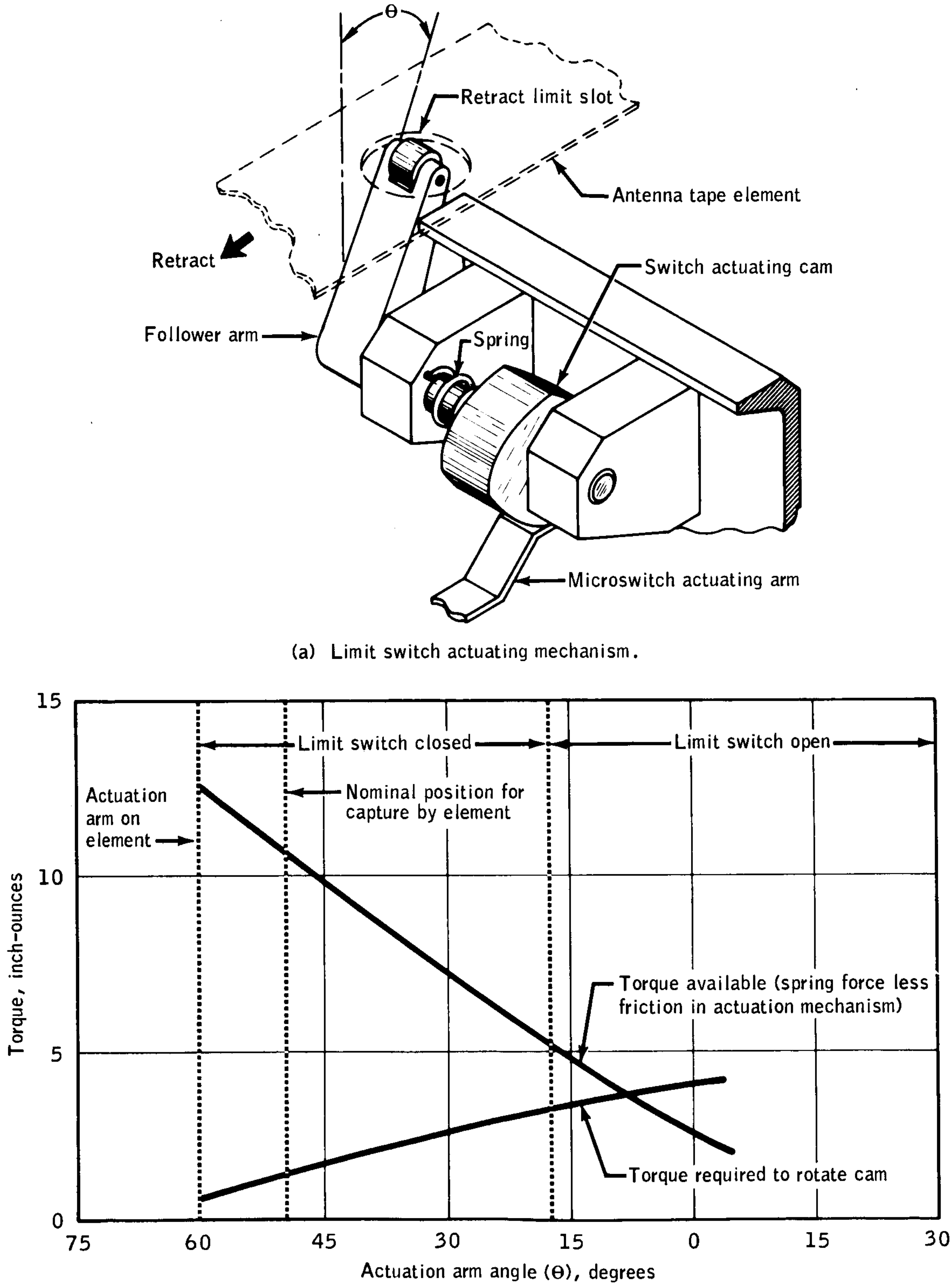
a. Friction or a defective spring on the limit switch cam follower arm.

b. Misalignment (or indexing) of the cam follower arm with the hole in the element.

c. Limit switch (microswitch) assembly malfunction.

Figure 2-1 shows the torque available in the spring and the torque required to rotate the cam. At the nominal position angle for capture by the element, there is a positive margin of 8 to 1. Therefore, increased friction is not considered a possible cause. The remaining failure modes have been investigated without establishing a most likely cause. However, since this device is not to be flown on future missions, no further action is required.

This anomaly is closed.



(a) Limit switch actuating mechanism.

(b) Limit switch actuation mechanism forces at laboratory ambient conditions.

Figure 2-1.- Limit switch.

2.4 LUNAR SOUNDER HF ANTENNA BOOM 2 DEPLOYMENT WAS SLOWER THAN EXPECTED

Extension of the lunar sounder HF antenna boom 2 at approximately 191:38 required more time than expected. The motor stalled after approximately one-half deployment. Motion was re-established by cycling power until the unit fully deployed. Subsequent extensions repeated the condition.

The two halves of the "bi-stem" antenna were stored on two spools which were simultaneously driven to extend or retract the elements through the guide/antenna forming assembly.

Current data shows that load on the motor was greater than expected. Review of the design has revealed no parts or components particularly sensitive to a thermal/vacuum environment, but the current signatures indicate that there was an additional load on the system. As the guide/antenna forming assembly is the predominant friction source in the mechanism, this is considered the most likely source of the problem. Further, the increased load resulted in an increase of motor current required which lowers the terminal voltage, motor speed, and therefore increases the friction load due to slowdown of the element unspooling. The varying high-friction loading in a thermal/vacuum environment is a phenomenon which has been experienced previously on Apollo.

No further analysis will be performed since the assembly is not programmed for use on future missions.

This anomaly is closed.

2.5 ENTRY MONITOR SYSTEM ACCELEROMETER BIAS SHIFT

The entry monitor system accelerometer null bias shifted prior to the transearth midcourse correction maneuver. Throughout the mission the bias was measured to be plus 0.01 ft/sec^2. Prior to the midcourse correction it measured plus 0.66 ft/sec^2. After the maneuver it was measured to be plus 0.20 ft/sec^2.

During step 1 of the system test prior to entry, the 0.05-g light illuminated when it should not have. This indicated an acceleration level greater than 0.05-g when no such acceleration level was present. This was caused by a large accelerometer null bias as indicated in the earlier bias tests. Entry procedures for using the entry monitor system were revised to preclude the 0.05-g light from coming on prematurely and the system worked normally during entry.

The scroll was removed from the spacecraft and found to be normal. The system will be removed and tested to isolate the fault to either an accelerometer problem or an electronics problem. The expected completion date is February 16, 1973.

This anomaly is open.

2.6 CHLORINE AMPULE LEAKED

During the daily water chlorination operations, leakage was observed in and around the casing assembly of the injector mechanism. Difficulty in advancing (rotating) the knob assembly also was noted occasionally and appeared to improve when the injector was disengaged and reinstalled. Some of the ampule bags had extruded past the base plate although none appeared to have broken.

A total of 13 chlorine ampules and 13 buffer ampules were used during the mission. Postflight testing showed that six of the expended chlorine ampules and five of the expended buffer ampules had bladder leaks. In four of these eleven ampules, the bladders were extruded past the baseplate.

Examination showed that the outer needle of the injector needle assembly was bent and possibly formed a leakage path when penetrating the ampule grommets at an angle (fig. 2-2). During postflight testing, three injections were accomplished with no leaks caused by the bent needle. Additional postflight examination of the ampules and injector system is presently in progress.

This anomaly is open.

2.7 MAPPING CAMERA REACTION CONTROL SYSTEM PLUME SHIELD DOOR FAILED TO CLOSE

Photographic data taken from the lunar module during rendezvous shows the mapping camera reaction control system plume shield door in the open position with the mapping camera apparently retracted.

The door is attached to the spacecraft with a hinge that includes a torsion spring to close the door when the camera is retracted (fig. 2-3). The door is pushed open by the camera when it is deployed. The photographs show the camera to be fully retracted which indicates that the problem is with the door itself.

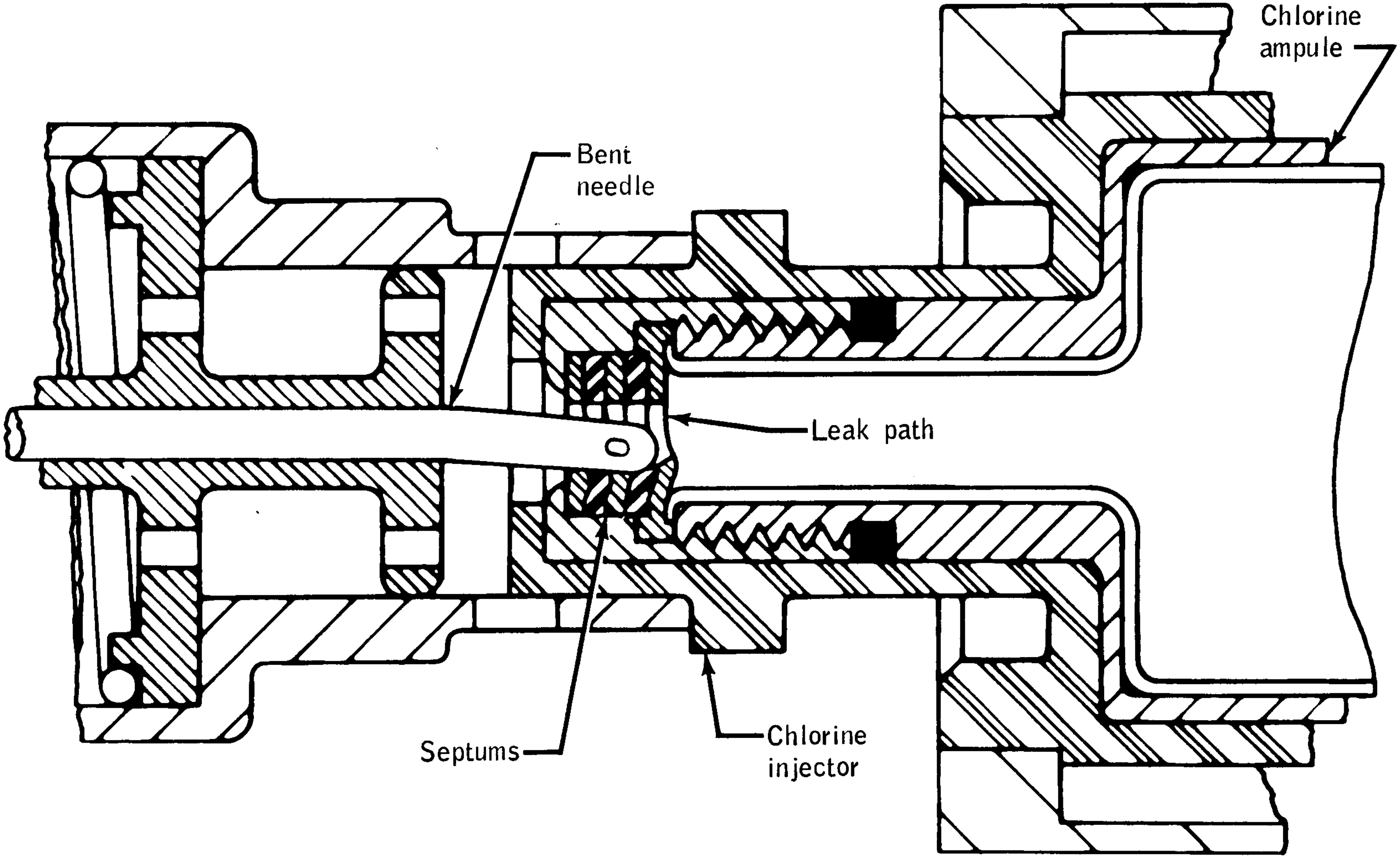


Figure 2-2.- Chlorine leak failure.

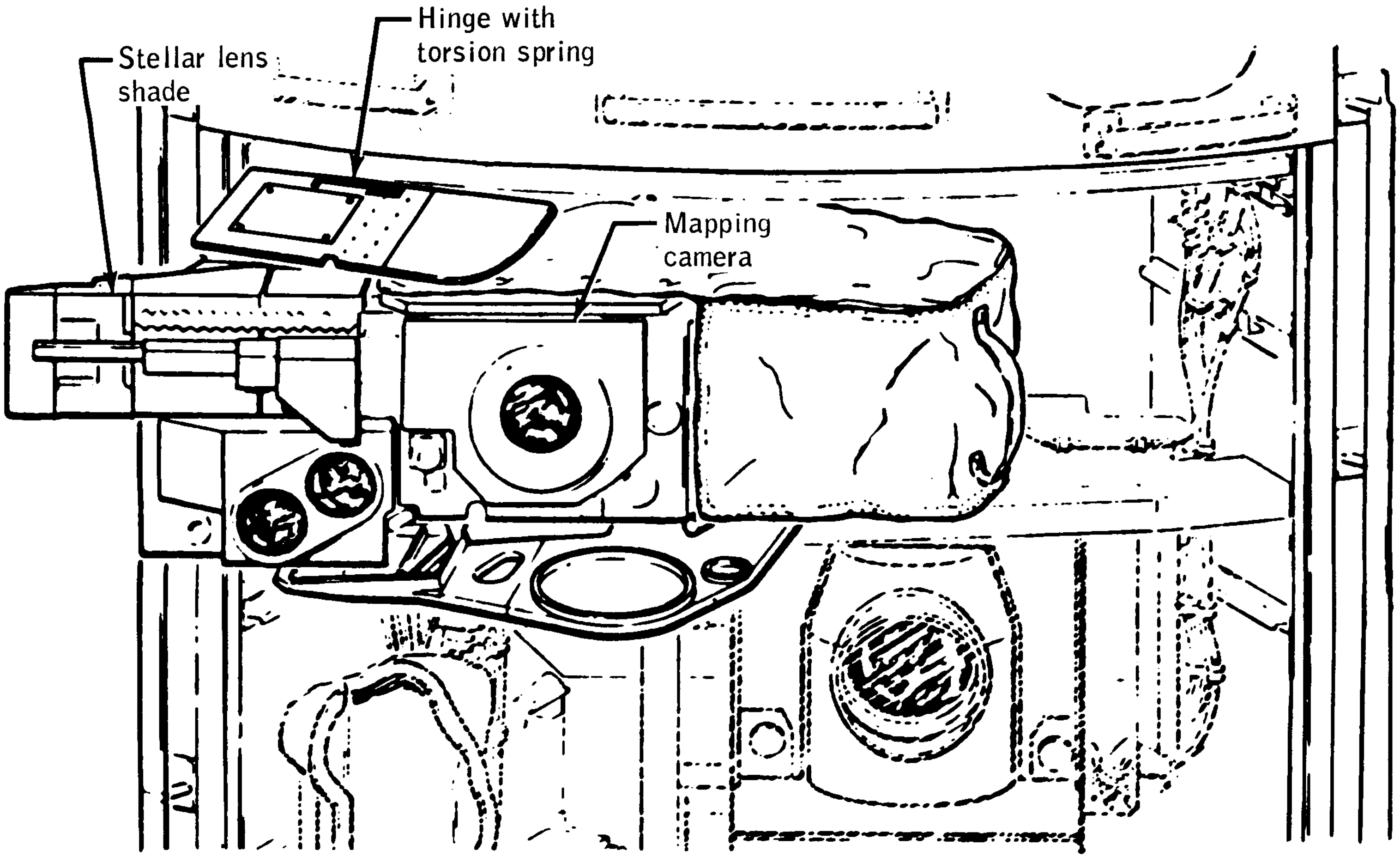


Figure 2-3.- Reaction control system plume shield door.

Other mechanical systems anomalies have occurred on Apollo 15, 16 and 17 which suggests a common factor which is as yet unknown. In all cases, some degree of sliding between metal surfaces was required, which is the case with the door hinge. It is therefore conceivable that the friction between these surfaces may have been significantly increased by the effects of the space environment, and these effects have not been duplicated in ground testing.

Since this was the last mission for this device, no further action will be taken.

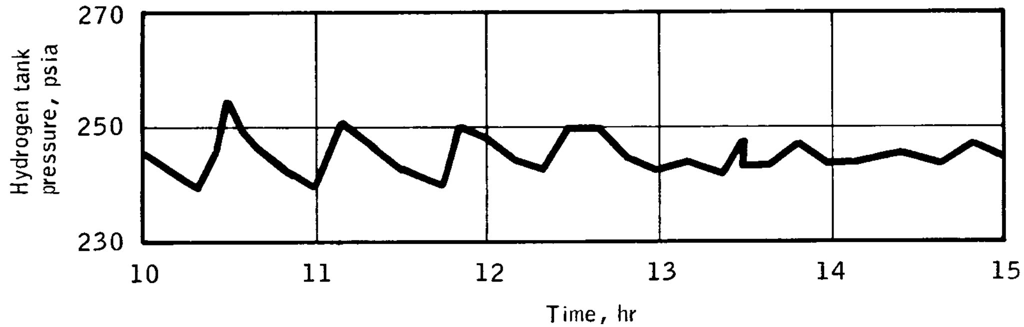
This anomaly is closed.

2.8 PRESSURE OPERATING DEADBAND FOR HYDROGEN TANKS 1 AND 2 SHIFTED

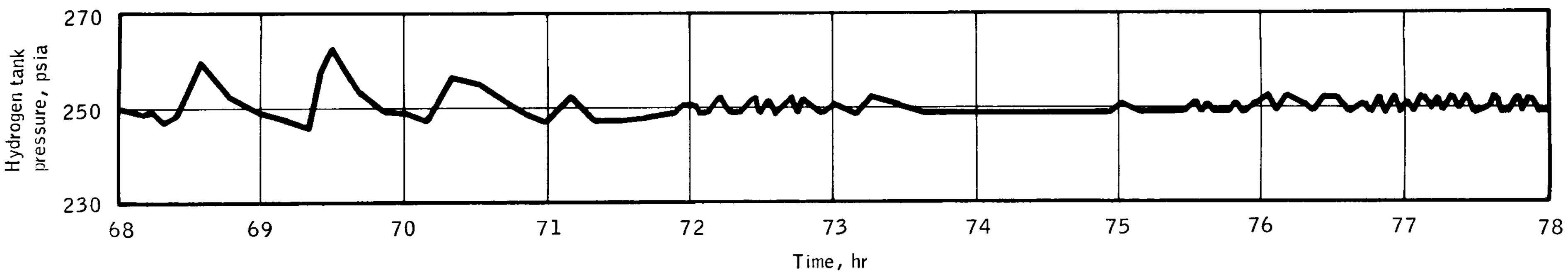
Cryogenic hydrogen system operation was normal until approximately 12 hours. The operating pressure range (deadband) after this time decreased from about 16 psi (238-254 psi) to approximatley 3 psi (244-247 psi) by 13 hours (fig. 2-4) and continued in this mode until automatic heater operation for tanks 1 and 2 was terminated at about 15 hours. Automatic heater operation was resumed in tanks 1 and 2 at about 24 hours. Only about five automatic heater cycles (all normal) occurred in tanks 1 and 2 before approximately 71 hours because the fans were in the automatic mode in tank 3, and the tank 3 pressure switch controlled at a higher pressure than tanks 1 and 2. At that time, the tank 3 fans were turned off and the operating pressure deadband again decayed to 3 psi (248-251 psi) as shown in figure 2-4. This deadband was maintained until automatic heater operation was terminated in tanks 1 and 2 at 87 hours. Hydrogen system pressure was maintained for the remainder of the mission by use of manual fan operation in tanks 1 and 2 and automatic fan operation in tank 3. Hydrogen system operation was normal in this mode.

Individual pressure switches monitor pressures in tanks 1 and 2 as shown in figure 2-5. When automatic heater or fan operation is selected, both switches must be in the low-pressure position to apply power to the heaters or fans in each tank. When either switch transfers to the high pressure position, the motor switch transfers and removes power from the heaters and fans. Figure 2-6 is a cutaway sketch of one of the pressure switches in the low-pressure position.

Decreasing or restricting the full downward travel of the stop will increase the pressure at which the shaft transfers to the upper position. Decreasing or restricting the full upward travel of the stop will decrease



(a) 10 to 15 hours.



(b) 68 to 78 hours,

Figure 2-4.- System operating pressures during anomaly periods.

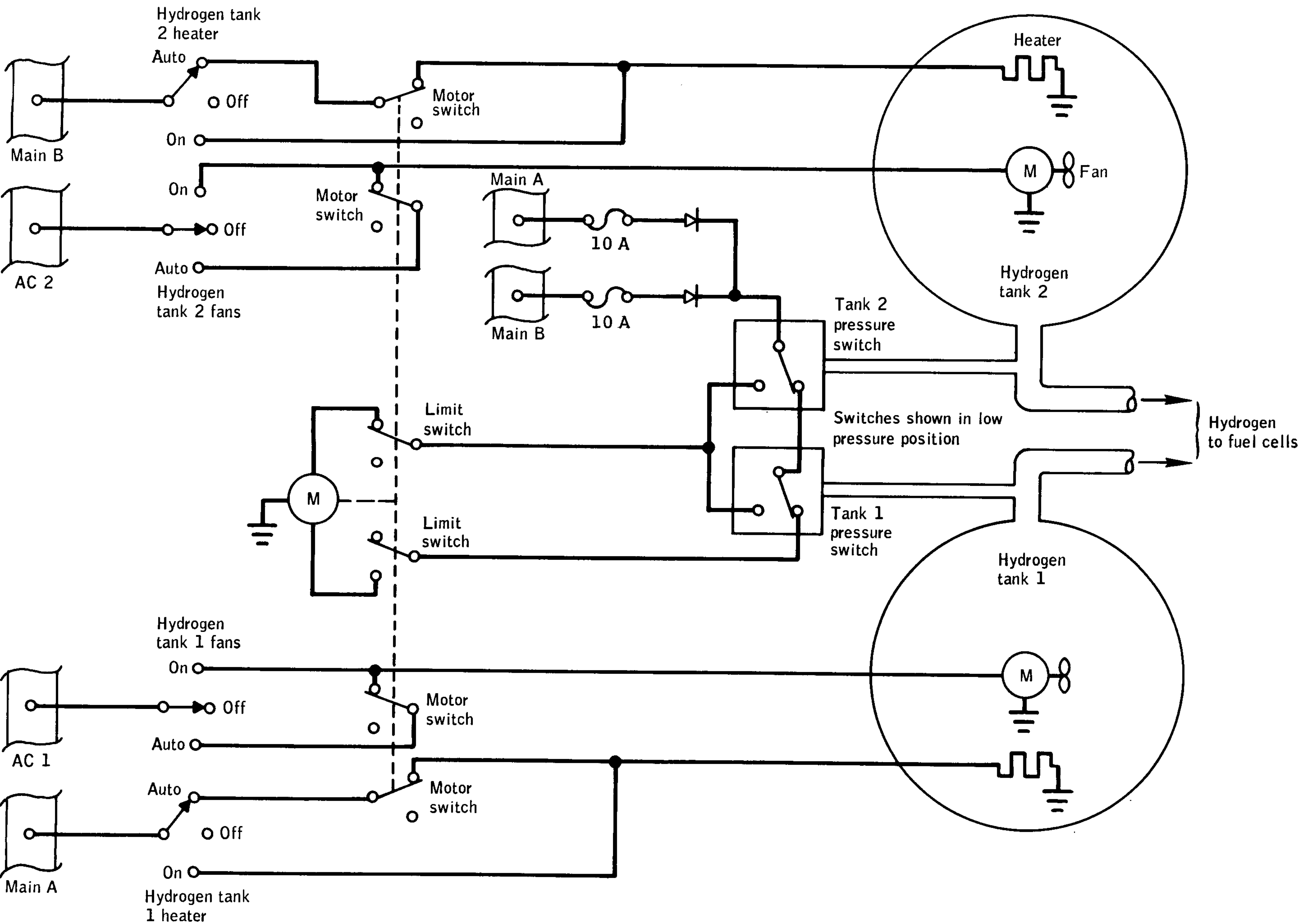


Figure 2-5.- Cryogenic system pressure control circuitry.

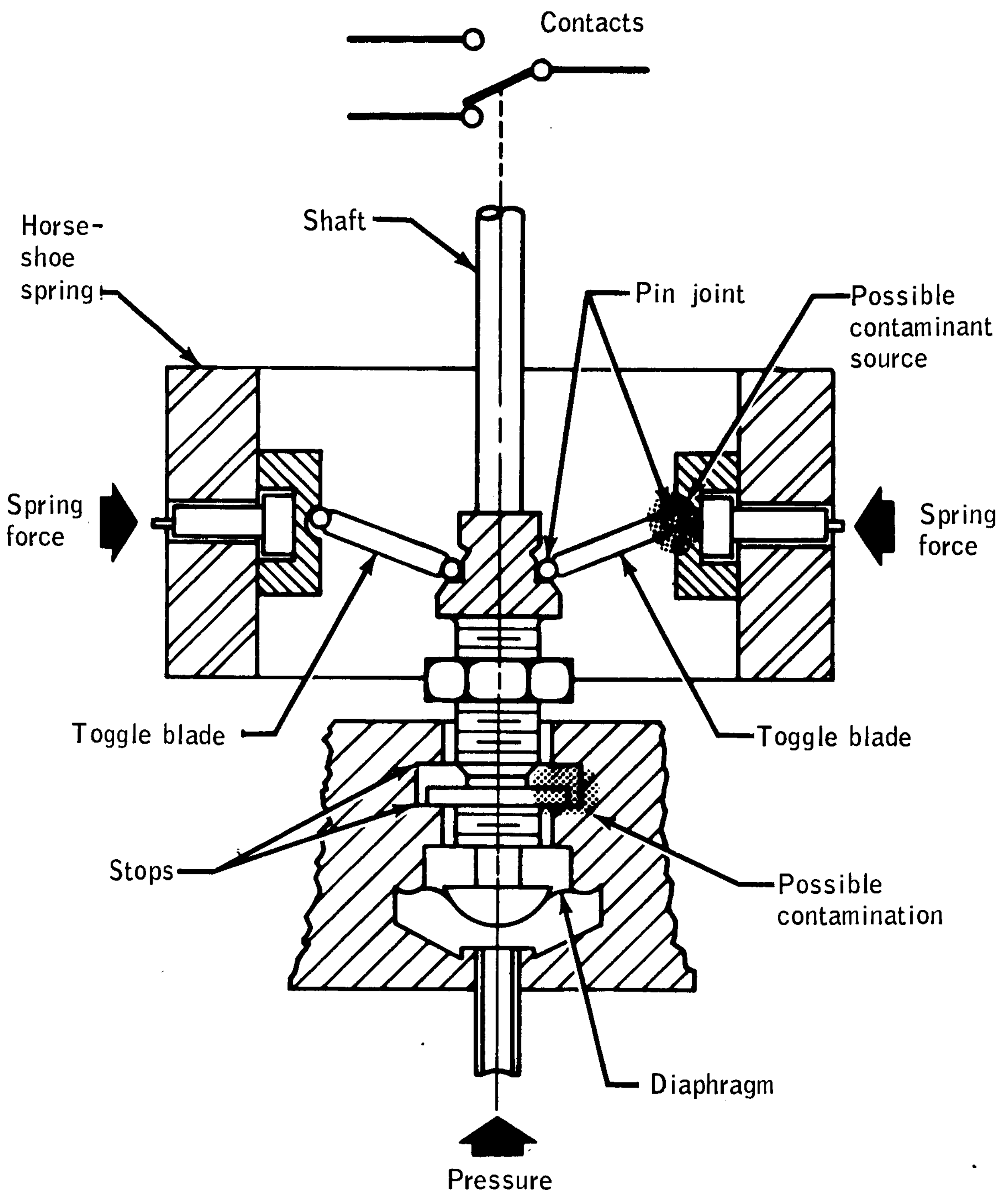


Figure 2-6.- Hydrogen tank pressure switch cutaway.

the pressure at which the shaft transfers to the lower position. Consequently, hard particles floating in the stop mechanism area shown in figure 2-6 can have a variable effect which can appear and disappear depending on the location of the floating particles.

The size of the particles required to change the pressure settings is relatively small. The full travel of the stop may be as small as 0.007 inch. The pressure change to move from one stop to the other is about 15 psi. Consequently, the upper limit can be reduced to about 7 psi with a piece of metal about 0.004-inch in size between the stop on the shaft and the upper case stop.

The toggle plates are pin-joined to the shaft at one end and to a horseshoe-shaped spring at the other end as shown in figure 2-6. Grooves are formed in the opposite edges of the toggle plates by a coining operation. Figure 2-7 shows the toggle plate taken from a switch which was disassembled for inspection. In this instance, burrs were found that were about to break off. The particles could then move around and become trapped in the stops under zero-gravity conditions.

Other possible mechanisms are being investigated; however, the particle contamination mechanism does satisfy all of the peculiar flight characteristics.

This anomaly is open.

2.9 TEMPORARY DROPOUT OF SEVERAL INSTRUMENTATION PARAMETERS

Dropout of 35 command and service module measurements occurred between 191:40:39 and 191:42:32. Data indicated the problem existed on the downlink signal. There is no commonality with these measurements in regard to pulse code modulation input connectors, instrumentation J-box, or umbilical feed-throughs. The pulse code modulation assembly will be removed from the spacecraft and tested in the laboratory, while being subjected to shock and vibration, to explore for possible particle contamination in a component part. A circuit analysis is also being performed to determine what possible failure mode could produce the problem. The expected completion date is February 8, 1973.

This anomaly is open.

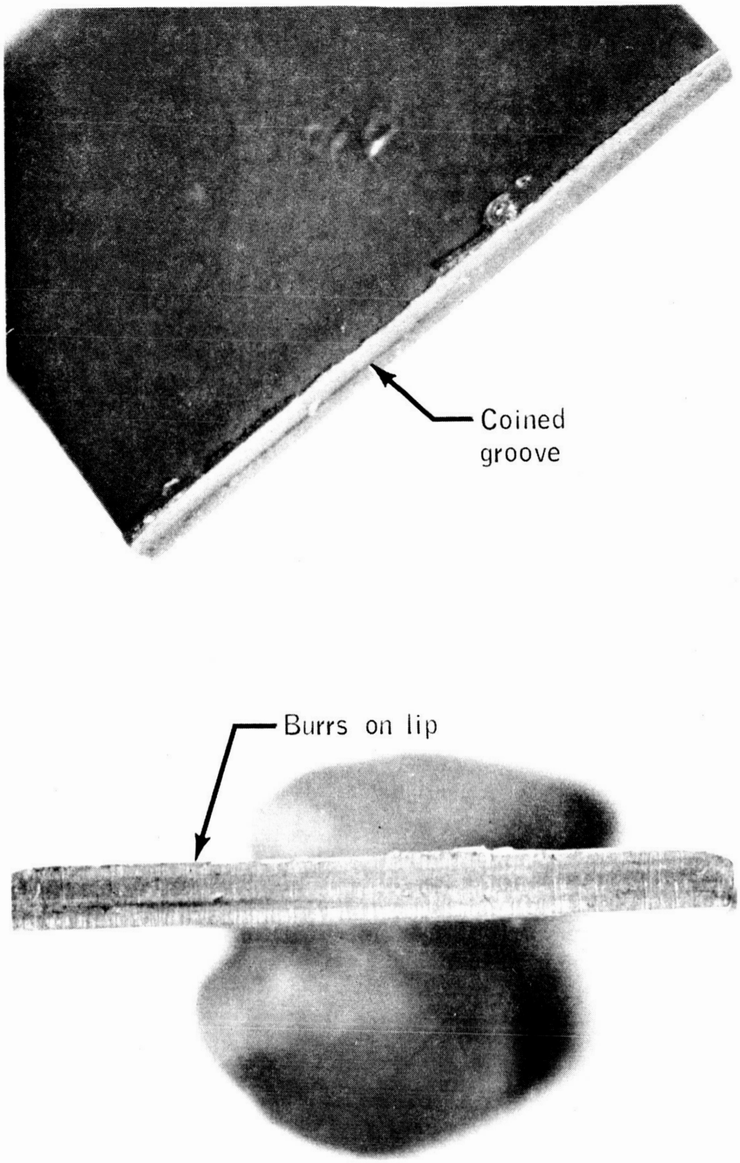


Figure 2-7.- Pressure switch toggle plate.

2.10 WATER/GLYCOL TEMPERATURE CONTROL VALVE FAILED TO MAINTAIN THE EVAPORATOR TEMPERATURE

During four early lunar orbit revolutions, the water/glycol temperature control valve failed to open properly as the radiator outlet temperature decreased. The mixed coolant temperature momentarily fell as much as 4° F below the specification control band of 42° to 48° F during mixing startup.

No corrective action was taken and initiation of mixing was proper during all subsequent lunar orbits and during transearth coast. The system behavior indicates that some slight sticking occurred in the valve gear train after having been driven hard against the full closed stop during the hot portions of the lunar orbits. A larger than normal temperature error and modulated electrical signal to the valve were required to free the gear train so that the valve would start to drive open.

During checkout on previous spacecraft, these valves have occasionally stuck when driven hard against either the full open or full closed stop. Manual disengagement of the valve clutch mechanism relieves the back pressure on the gears and frees the gear train. This occurred during checkout on the Apollo 17 valve and was accepted for flight because of the manual operation capability and demonstration of manual operation during the Apollo 16 mission.

Dimensional checks have shown that the pitch circles of two of the gear pairs in the valve gear train are not tangent (fig. 2-8). This results in sliding rather than rolling action between contacting teeth. One valve which previously experienced the same sticking has been disassembled and the gears showed no abnormal wear, although the dry lubricant was scraped off the gear teeth in the area of tooth-to-tooth contact. Sliding friction between the unlubricated gear teeth may have been high enough to cause the sticking experienced.

Since manual valve operation is satisfactory for future misssions, no further action will be taken.

This anomaly is closed.

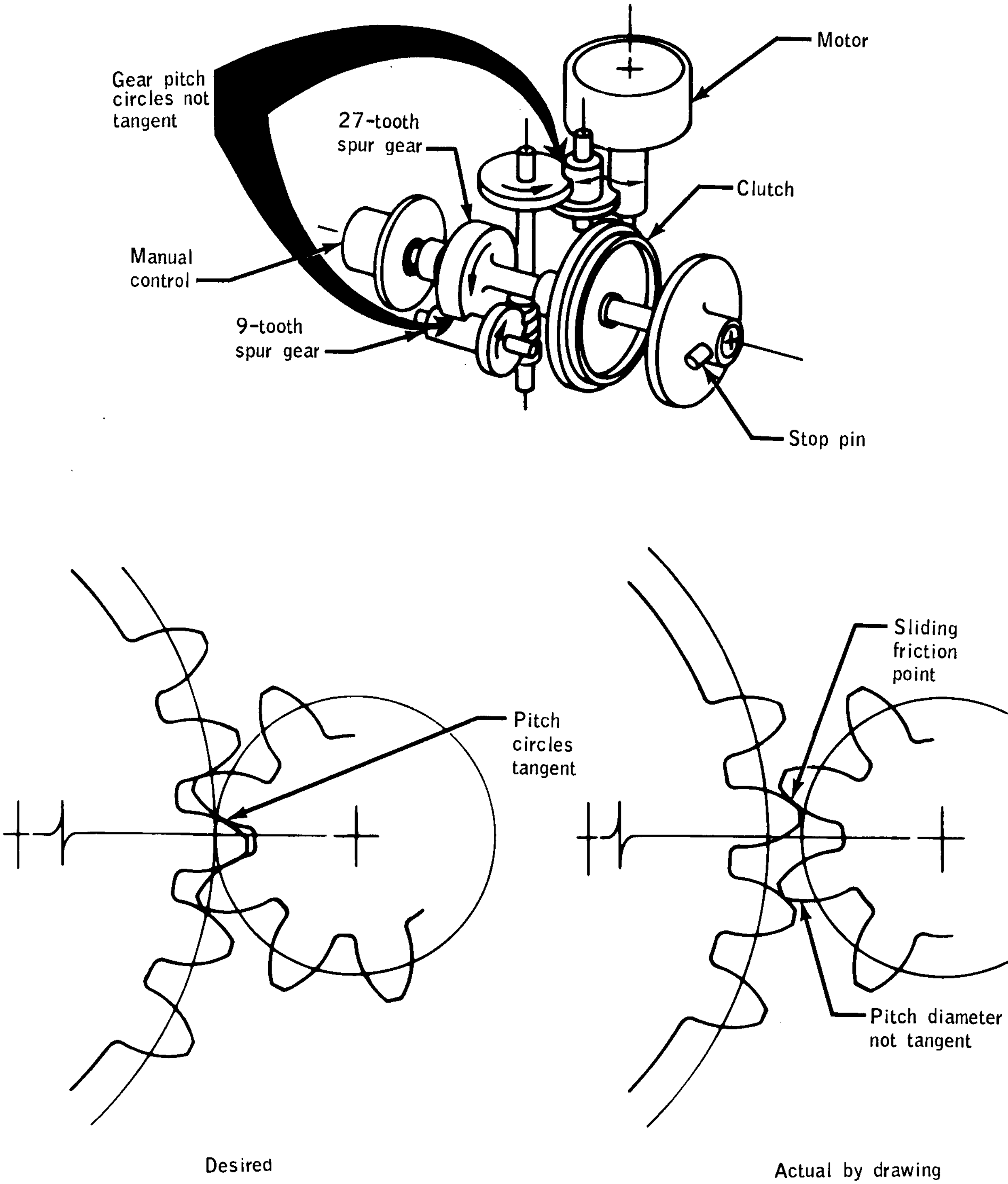


Figure 2-8.- Water/glycol temperature control valve gear drive.

3.0 LUNAR MODULE ANOMALIES

3.1 BATTERY 4 VOLTAGE READING WAS LOWER THAN THAT OF BATTERY 3

At approximately 108:06, the lunar module battery 3 and battery 4 voltage data indicated a voltage difference of approximately 0.5 volt, with battery 3 voltage greater than that of battery 4. Previously, battery 3 and 4 voltages were equal.

Batteries 3 and 4 are parallel and should reflect equal voltages. Reverse current from battery 3 to battery 4 would have been indicated by the reverse current triggering the battery malfunction light. This alarm is triggered by reverse current of more than 10 amperes for 4 to 6 seconds which was exceeded by battery 4 current readouts. The battery current measurement does not indicate current direction. Since no alarm occurred, battery 4 was delivering positive current to the bus, indicating that the battery 4 voltage readout was not a true reading. This 0.5-volt difference also appeared on the battery open circuit voltages.

The battery 4 voltage measurement is conditioned by a signal conditioner which consists of an input resistive divider network feeding a dc-to-dc converter (fig. 3-1). An increase of resistance of 1 percent in this network can account for the observed change. Another possibility of failure exists in the zero-adjust network.

This anomaly is closed.

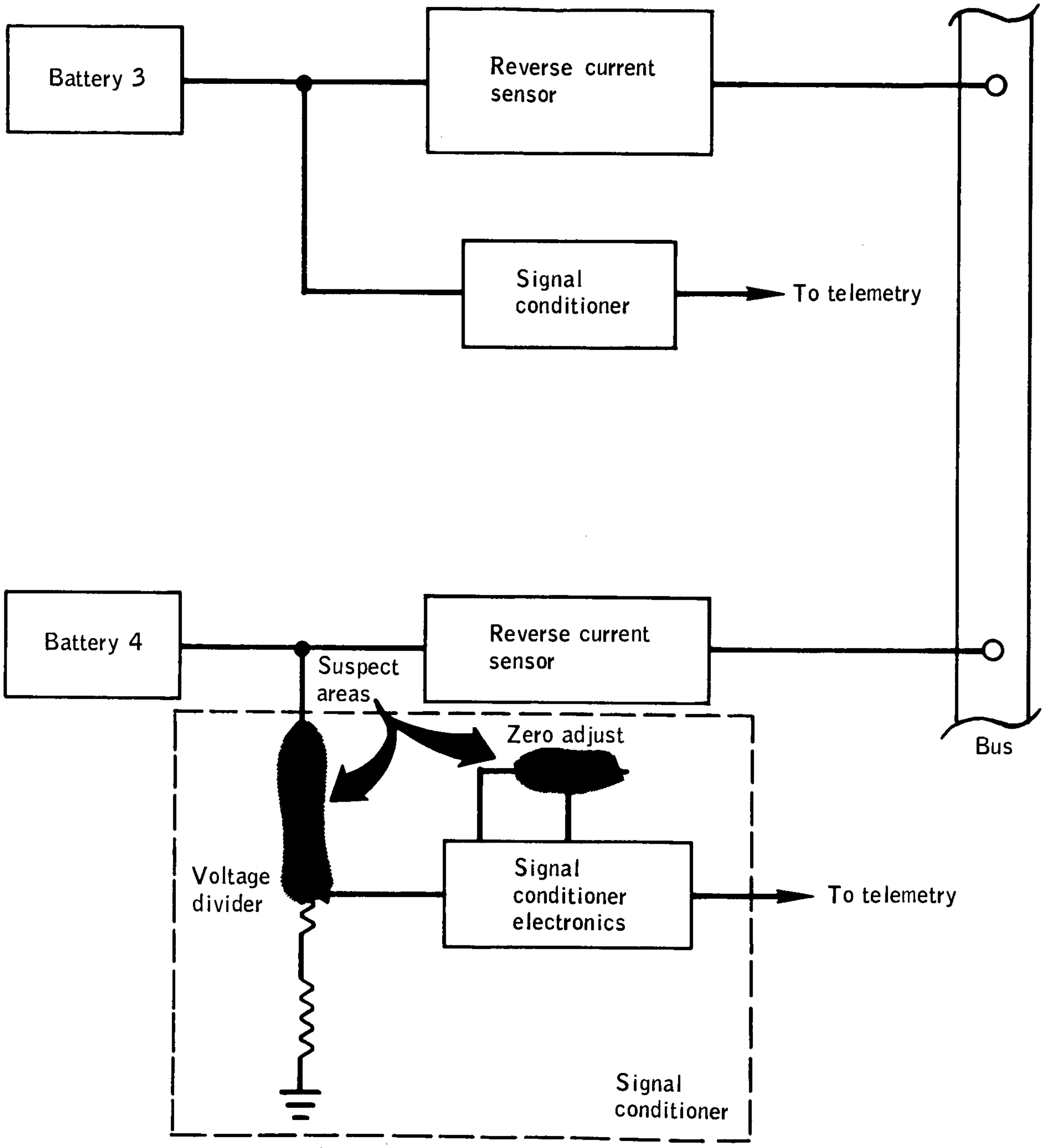


Figure 3-1.- Voltage measurement circuitry.

4.0 GOVERNMENT FURNISHED EQUIPMENT ANOMALIES

4.1 NO EXTRAVEHICULAR ACTIVITY WARNING TONE IN COMMAND MODULE PILOT'S COMMUNICATIONS CARRIER

At 253:44, during preparation and checkout for the transearth coast extravehicular activity, the Command Module Pilot could not hear the caution and warning tone in his communications carrier, although his transmission and reception were apparently normal. For the extravehicular activity, the Command Module Pilot used the Lunar Module Pilot's communications carrier which operated normally, including the caution and warning tones.

After the extravehicular activity, the Command Module Pilot partially removed the sleeve covering his communications carrier electrical pigtail and found that of the nine leads (twisted shielded pairs) making up the pigtails, two were broken (fig. 4-1).

Postflight discussions with the Command Module Pilot indicated that the pigtail lead became twisted and wound up to the point of knotting due to his twisting and turning while performing his normal cabin functions. Additionally, the Command Module Pilot did not wear the inflight coverall garment and the constant wear garment electrical harness was not restrained. In this configuration, twisting of the leads is possible and could lead to the failure observed.

Failure analysis of the returned flight item has shown that the failed wires were broken about 1/4 inch below their exit point from the potting of the flex relief attached to the lower end of the communications carrier splice block. The break occurred where these wires lay across an adjacent set of wires in a braided configuration. The functions carried by these wires were caution/warning tone and left earphone circuits.

Repeated twisting and knotting of similar wire bundles to the extent described by the crewman has demonstrated that the point of breakage was inherently the most highly loaded due to the geometry of the pigtail, and thereby was subject to flex/tensile failure.

Skylab training and flight procedures are being revised to reflect a harness configuration that prevents the twisting of the wire harness.

This anomaly is closed.

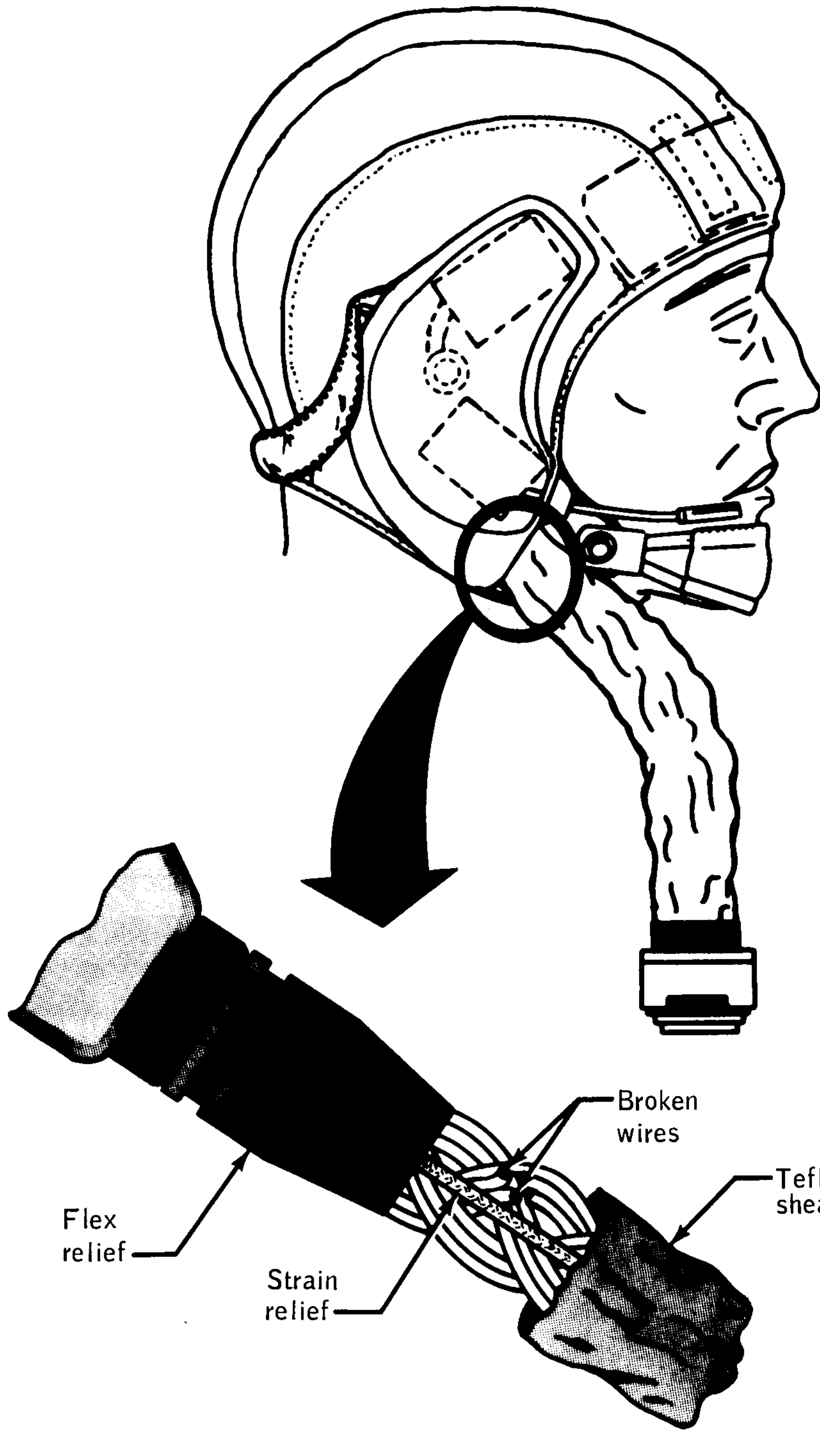


Figure 4-1.- Communications carrier wire failures.

5.0 LUNAR SURFACE EXPERIMENT EQUIPMENT ANOMALIES

5.1 LUNAR SURFACE GRAVIMETER SENSOR BEAM CANNOT BE STABILIZED IN THE NULL POSITION

Centering the sensor beam capacitor plate in the proper stable position between the fixed capacitor plates (fig. 5-1) could not be accomplished following the initial experiment turn-on. When the command was given to add any or all of the masses to the sensor beam assembly, the data indicated that the beam would not move away from the upper capacitor plate. The only way to bring the beam down was by caging it against the lower capacitor plate.

For normal operation, the sensor beam must be horizontal, with the capacitor end-plate centered between the two fixed capacitor plates. Adjustment of the suspension point of the sensor spring and the addition and removal of individual masses are provided to assist in centering the beam in its reference position, equidistant between the two capacitor plates. Small changes in the vertical component of local gravity tend to displace the beam upward or downward.

The displacement is sensed as a capacitance change between the center or beam plate and each of the two fixed outside plates. A voltage proportional to this displacement is generated by the capacitance change and integrated to supply a feedback voltage which electrostatically forces the beam plate back to the center of the gap.

Review of sensor records revealed that a mathematical error resulted in the sensor mass weights being about 2 percent lighter than the proper nominal weight for 1/6-g operation of the flight unit. The sensor mechanism allows up to only ±1.5 percent adjustment from the nominal by ground command for possible inaccuracies. The error was made in the conversion calculations from 1-g to 1/6-g mass for the flight unit by including an erroneous value in the calculations from the uncorrected calculations for the qualification unit.

Because the mass weights do not provide enough downward force, the beam has been balanced and centered by applying a load on the beam through the mass support springs. This is accomplished by special caging of the mass weight assembly with ground commands to the mass cage motor as shown in figure 5-1. In this configuration, the mass spring permits balance of the beam and function of the instrument. However, the spring constant of the mass spring considerably reduces the sensitivity of the system.

This anomaly is closed.

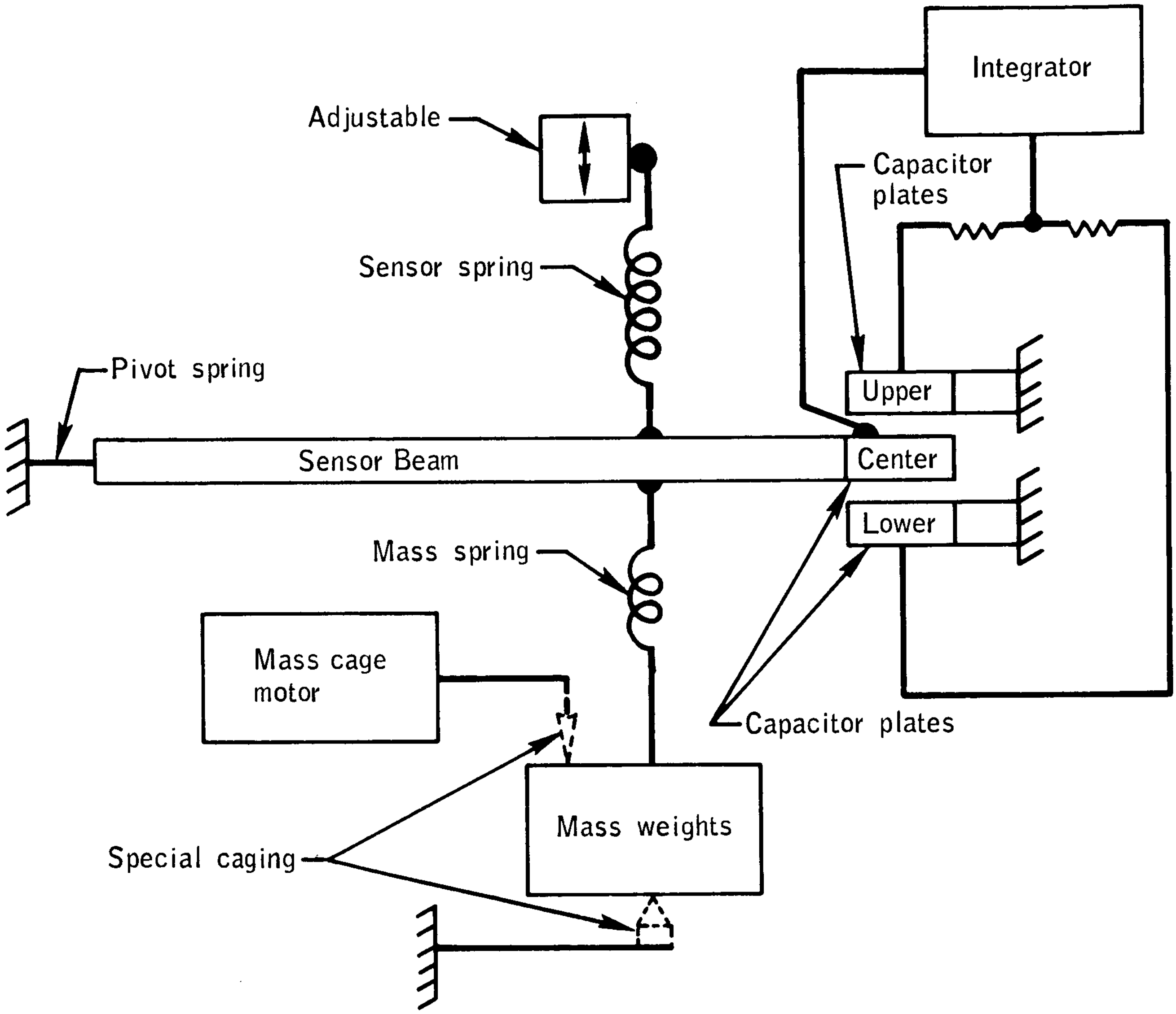


Figure 5-1.- Lunar surface gravimeter sensor beam centering.

5.2 SURFACE ELECTRICAL PROPERTIES RECEIVER TEMPERATURE HIGHER THAN PREDICTED

The receiver temperature was about 5° F less than normal at the end of the first extravehicular activity as shown in figure 5-2. However, during the rest period between the first and second extravehicular activities, the temperature rose to 80° F instead of dropping to about minus 14° F as predicted. Between the second and third extravehicular activities, the temperature dropped about 8° F instead of the expected drop of about 50° to 60° F.

The receiver was protected by a multilayered aluminized Kapton thermal bag (fig. 5-3). The thermal bag had two flaps (of the same material) which protected the optical solar reflector (mirror) on top of the receiver from lunar dust accumulation. A dust film of about 10 percent on the mirror surface could result in the indicated degradation of thermal control and a film of this amount would not normally be visible to the crew.

Folding back one, or both, flaps during rest periods was to result in cooling of the receiver by radiation of heat energy to deep space. With system normal efficiency, and the experiment turned off, opening the tab A cover (fig. 5-3) at the end of the first extravehicular activity should have resulted in the predicted temperature drop to about minus 14° F by the start of the second extravehicular activity. Opening both the A and B flaps was provided for contingencies requiring more rapid cooling. This procedure was used throughout the remainder of the mission.

Cover design depended upon Velcro straps and pads to hold the Kapton flaps tightly closed to keep out dust and sunlight (fig. 5-3). The Velcro pile pad was bonded to the Kapton bag and the Velcro hook strap was bonded to the Kapton flaps. The bond of the Velcro pads for both flaps had already failed before the Lunar Module Pilot configured the receiver at the end of the first extravehicular activity, thus resulting in dust accumulation on the mirror surface under both flaps. The bond of the Velcro pads to the Kapton failed, leaving no trace of the adhesive on the Kapton, and the pads remained attached to the straps. The polyurethane FR-127 A and B bonding material specified was supposedly acceptable for bonding Velcro to Kapton.

The bonding procedures used are being investigated.

This anomaly is open.

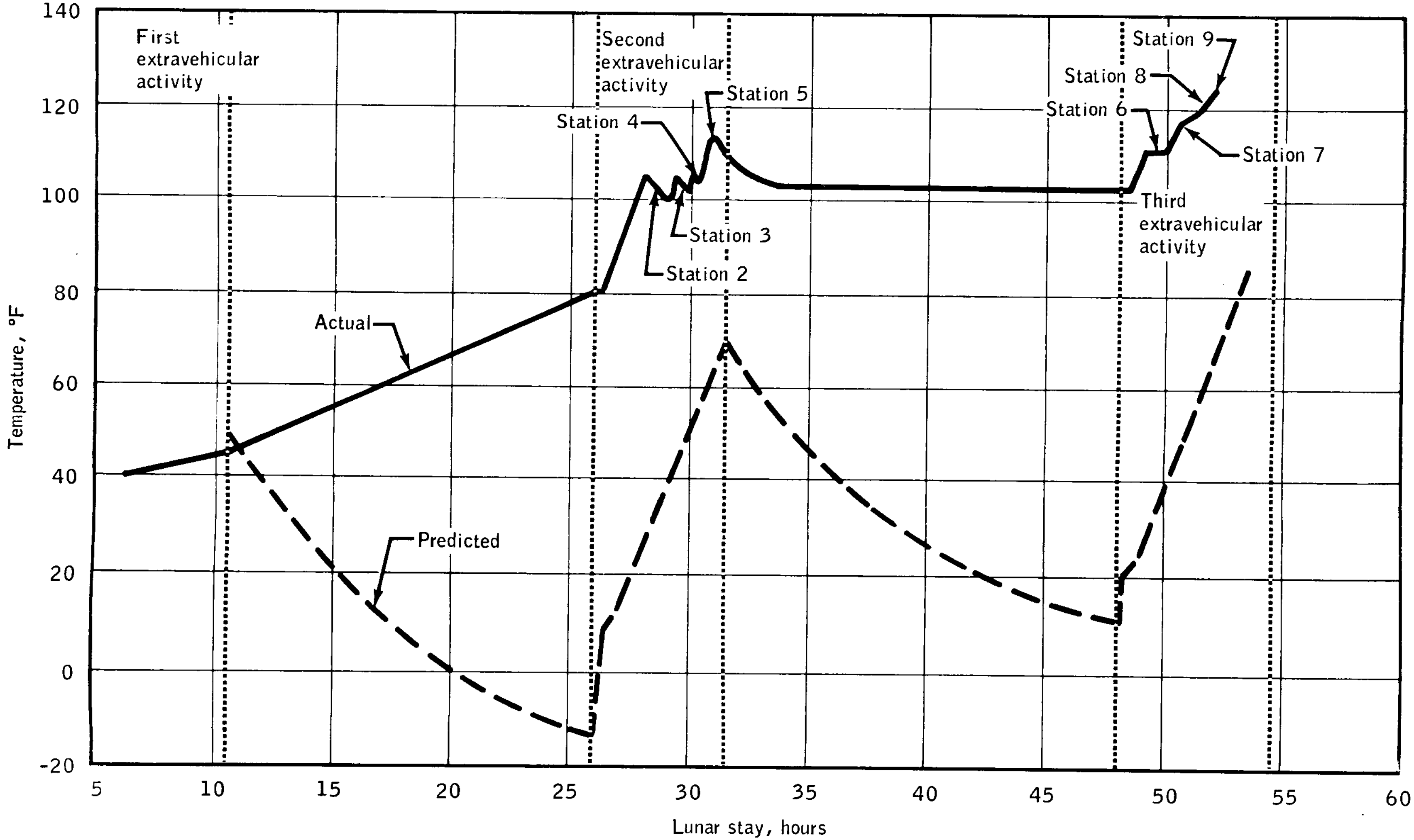


Figure 5-2.- Surface electrical properties experiment receiver temperature data.

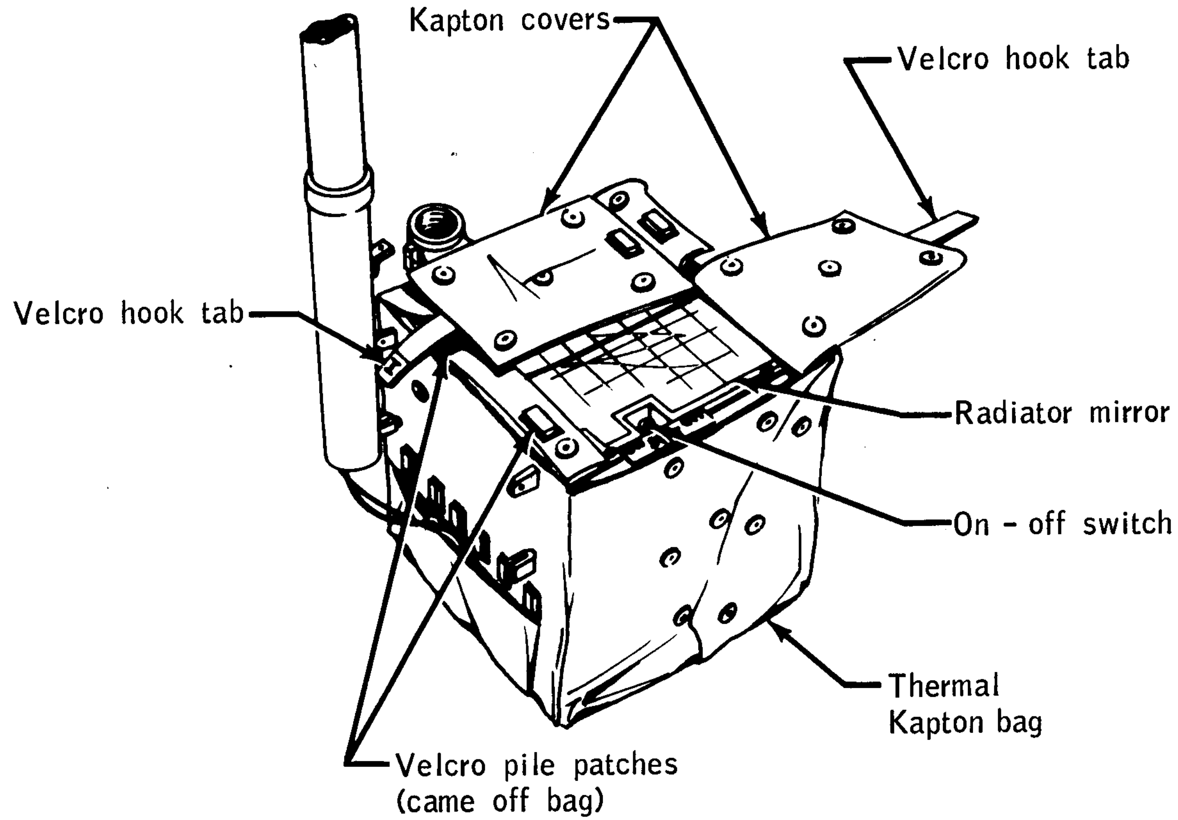


Figure 5-3.- Surface electrical properties experiment receiver.

5.3 LUNAR EJECTA AND METEORITE EXPERIMENT TEMPERATURE HIGH

The temperature of the lunar ejecta and meteorite experiment was higher than predicted during the first and second lunar days (fig. 5-4). The high temperatures occurred with all combinations of experiment modes: on, off, and standby, with all dust covers on, with only the sensor covers on, and with all covers off. Whenever the experiment was in the "operate-on" mode, the science data indicated normal operation of the experiment. The maximum allowable temperature for survival of the electronic components has not been exceeded; however, it was necessary to command the experiment from "operate-on" to "off" at a sun angle of about 153 degrees during the first lunar day and at a sun angle of about 16 degrees during the second lunar day. Following sunrise of the second lunar day, the temperature rose from 0° F at 0° sun angle to about 168° F at 15° sun angle (fig. 5-4). The instrument was commanded to standby and then to off because the temperature continued to rise. In the off mode, with no power to the instrument, the temperature rise rate was lower.

Investigations are being made of the thermal control system, cover and cover release system and possible effects on the thermal control system, effect of exposed sensor surfaces, instrumentation circuitry data from the times of cover removal commands, and possible phenomena associated with lunar sunrise and sunset and this instrument.

This anomaly is open.

5.4 CASK DOME REMOVAL WAS DIFFICULT

The Lunar Module Pilot was not able to remove the cask dome with the removal tool.

The socket on the removal tool can engage the nut on the dome before the pins on the tool lock into the recess in the dome (fig. 5-5). The Lunar Module Pilot did not verify that the pins were locked. In this configuration, rotating the tool clockwise will rotate the nut on the dome. A 90-degree rotation of the nut releases the dome retaining straps, as noted by the crew. This release allows the dome to rotate when the tool is rotated another 60 degrees, thus disengaging the threaded dome/cask interface. However, with the pins not locked into the dome recess, the dome could be cocked, but not withdrawn. The dome was easily wedged off the cask with the hammer. The sequence can be duplicated with either broken pins or by incomplete insertion and locking of the tool pins.

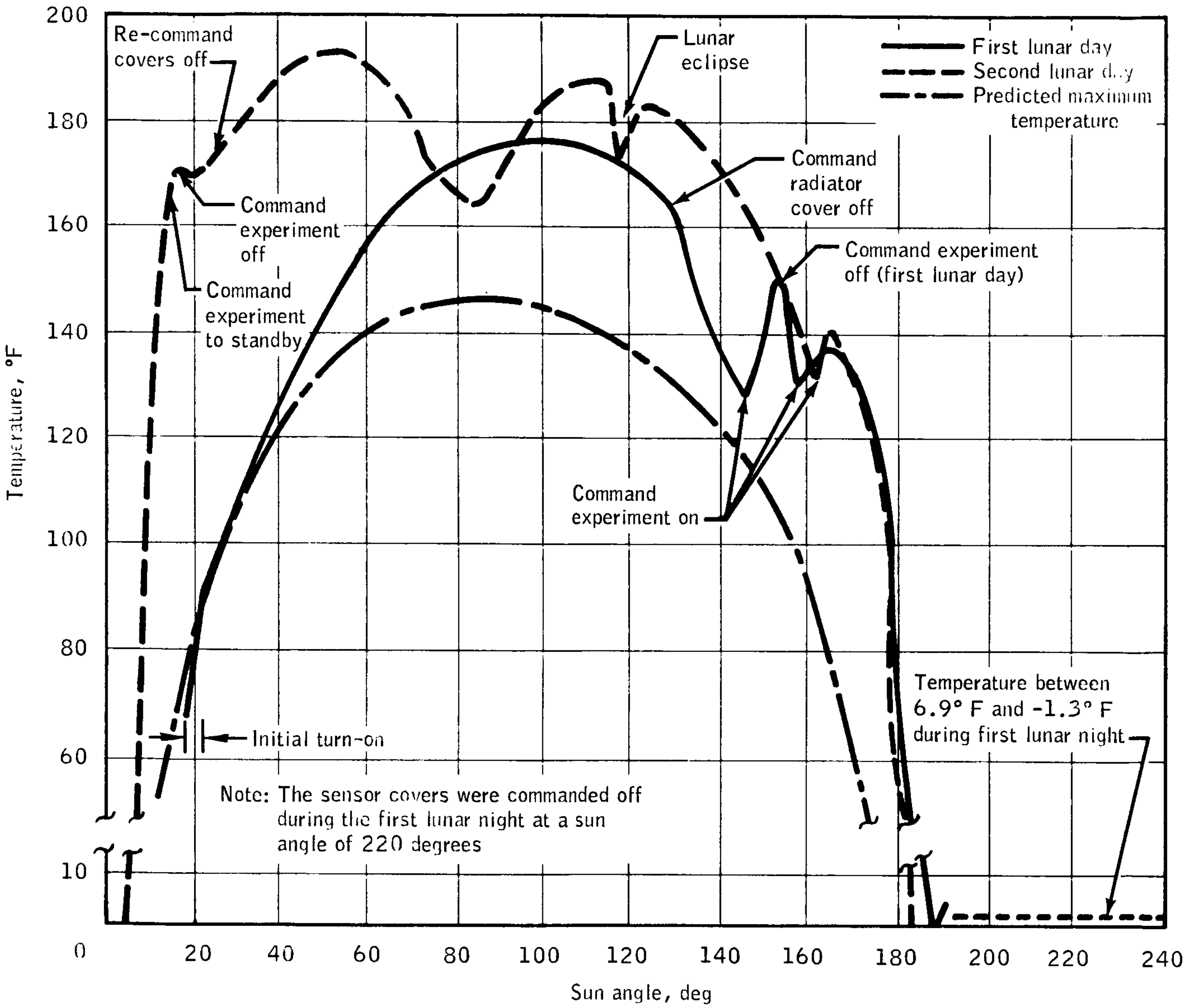


Figure 5-4.- Lunar ejecta and meteorite experiment temperature data.

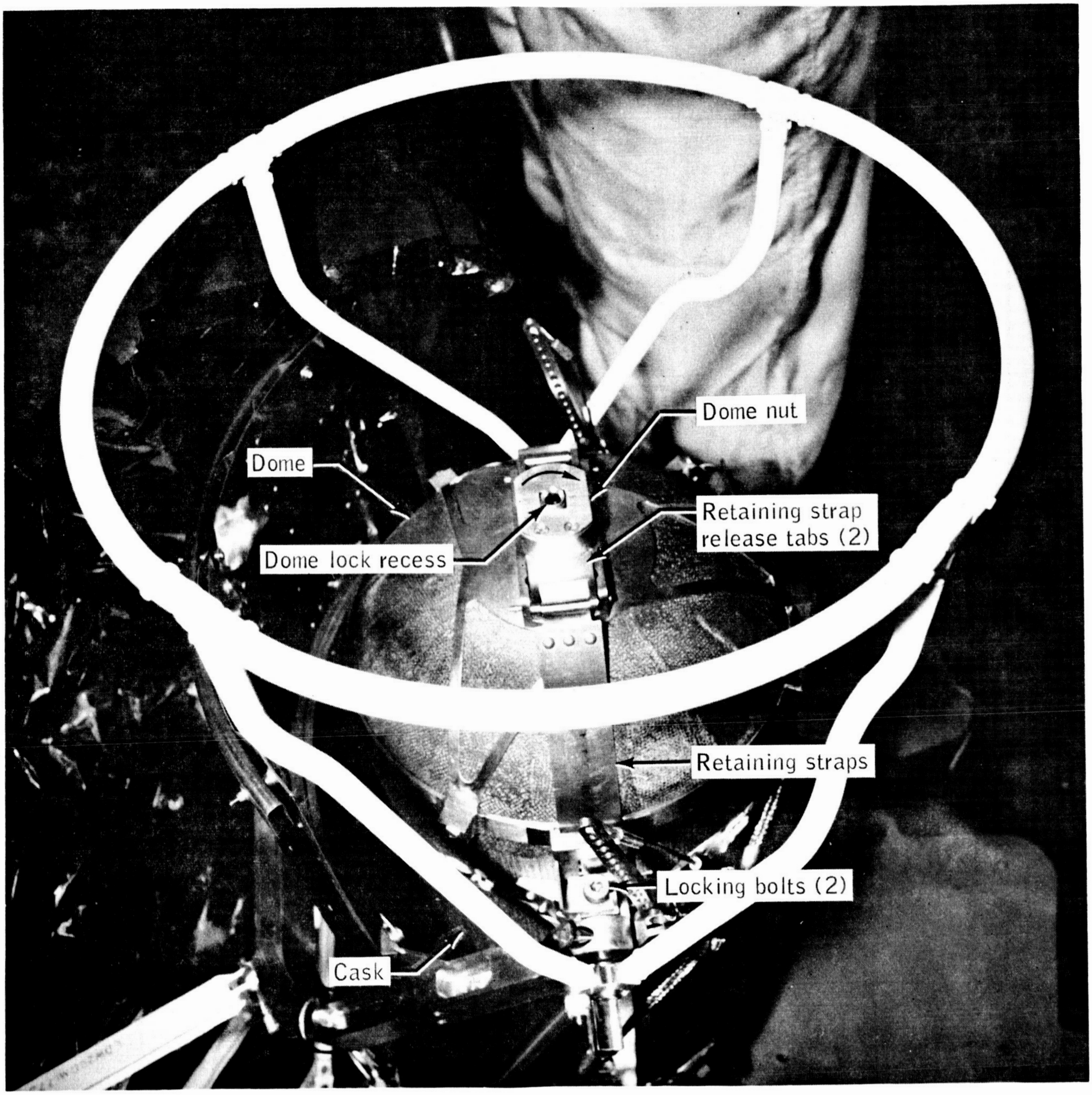


Figure 5-5.- Fuel cask dome release mechanism.

No further investigation will be performed since the cask will not be flown on future missions.

This anomaly is closed.

5.5 BACKGROUND NOISE IN THE LUNAR ATMOSPHERIC COMPOSITION EXPERIMENT DATA

A zero offset was noted in part of the lunar atmospheric composition experiment data on the mid-mass and low-mass channels (fig. 5-6). This offset was the result of background noise.

Commanding the sensor ion sources on and off, or the sensor electron multipliers on or off does not affect the condition. The presence of the offset is, however, affected by the voltage level to the sensors. The possibility of cross-coupling between unshielded high voltage wires and unshielded collectors in the sensor package is being investigated.

The problem has caused no loss of data.

This anomaly is open.

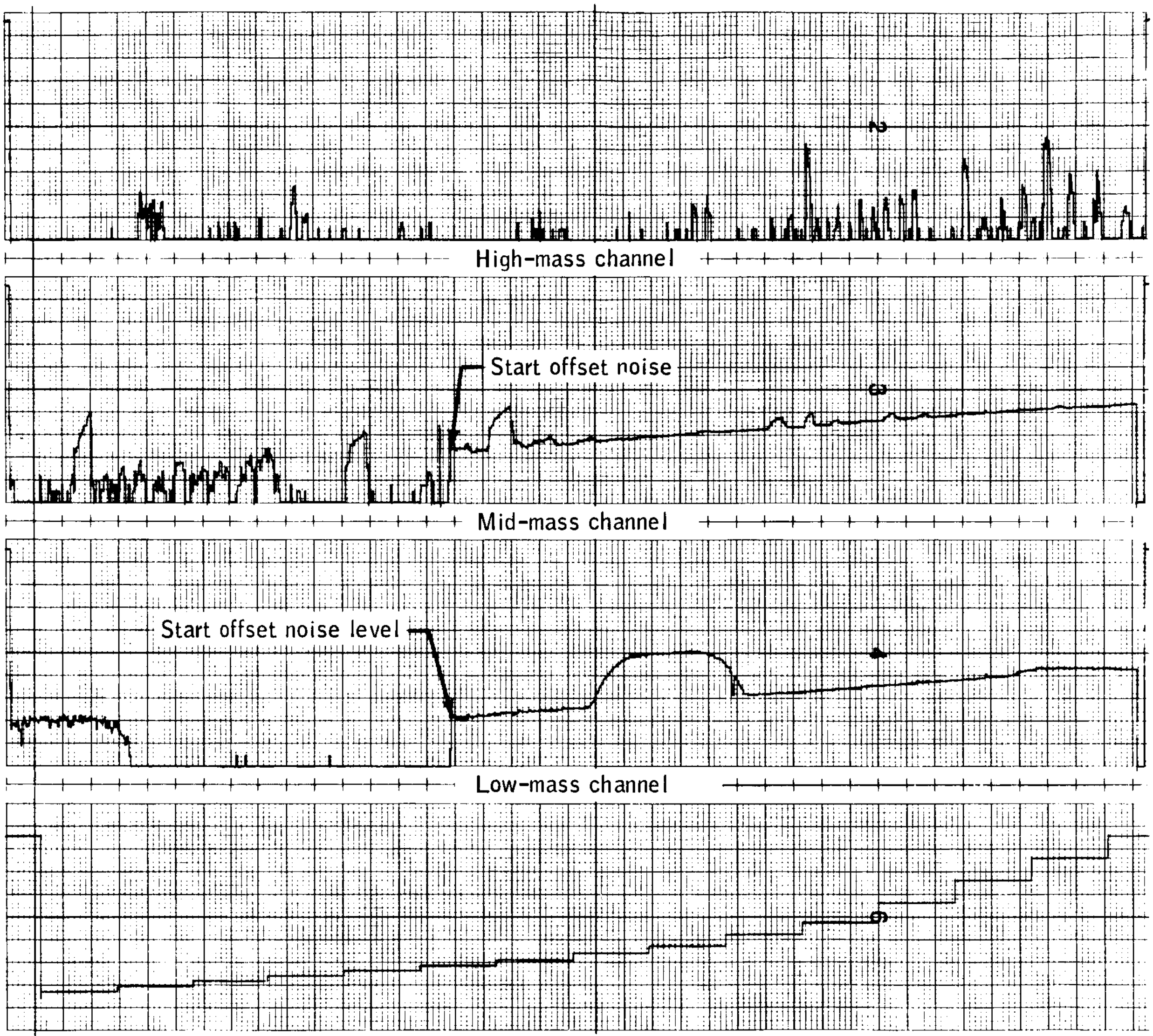


Figure 5-6.- Zero offset in lunar atmospheric composition experiment data.

6.0 ORBITAL EXPERIMENT EQUIPMENT ANOMALIES

6.1 PANORAMIC CAMERA VELOCITY/ALTITUDE SENSOR OPERATED ERRATICALLY

Telemetry data from the second panoramic camera pass on revolution 13 indicated that the velocity/altitude sensor output was erratic. The velocity/altitude sensor measured the rate of travel of the spacecraft relative to the lunar surface. The output signal from the sensor (fig. 6-1) controls the cycling rate of the camera and the forward motion compensation, as well as the exposure since the width of the exposure slit is dependent upon the scanning rate of the lens. The sensor operates in the range from 45 to 80 miles altitude. An override switch in the spacecraft provides the capability for locking out the sensor and substituting preset voltages which correspond to rates for the 55- and 60-mile altitudes.

In accordance with the flight plan, the velocity/altitude sensor was not used during the first panoramic camera operating period; instead, the override switch was used to substitute a preselected velocity/altitude value and thereby achieve the desired forward motion compensation. The sensor was used in the normal mode during the second camera operating period, but due to an indication that the normal mode was operating erratically, the override capability was used for the remainder of the mission.

Data analysis indicates that the erratic operation may have resulted from a downward shift in the scaling of the sensor output signal. If so, the shift was most likely caused by a component failure within the sensor circuitry. Because this was the last mission for the panoramic camera, no further investigation is required.

This anomaly is closed.

6.2 MAPPING CAMERA EXPOSURE PULSE ABSENT AT LOW LIGHT LEVELS

One of the mapping camera telemetry channels incorporates a pulse whose presence each time the film is exposed confirms that light has been transmitted through the metric lens and shutter to the film. This exposure pulse failed to appear at the lower light levels.

The pulse is generated by a light sensor and associated amplifier and a one-shot multivibrator (fig. 6-2). The light sensor consists of four photo diodes, with one near each edge of the 4-1/2 by 4-1/2 inch picture format (fig. 6-3). All four diodes are connected in series.

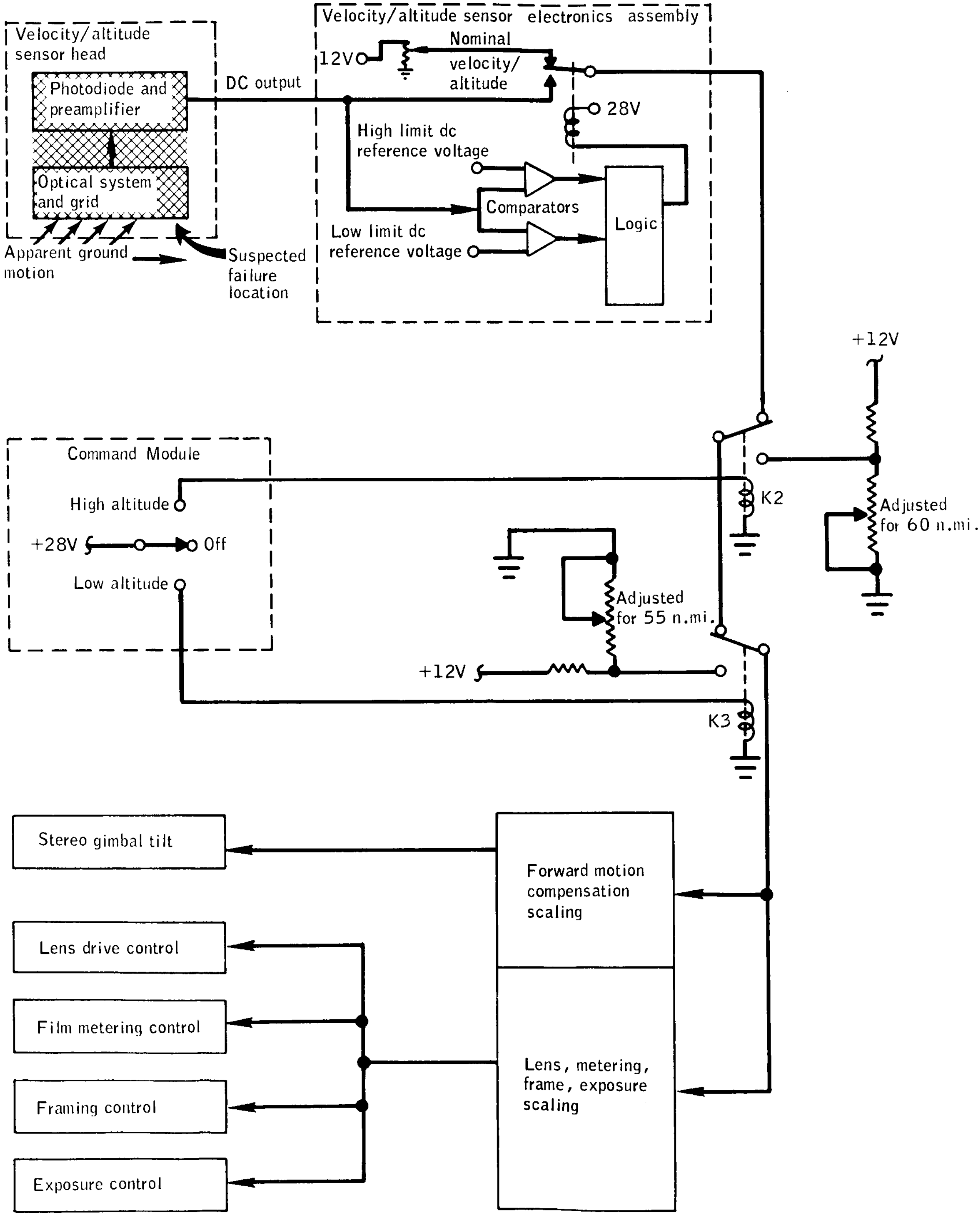


Figure 6-1.- Velocity/altitude output circuitry.

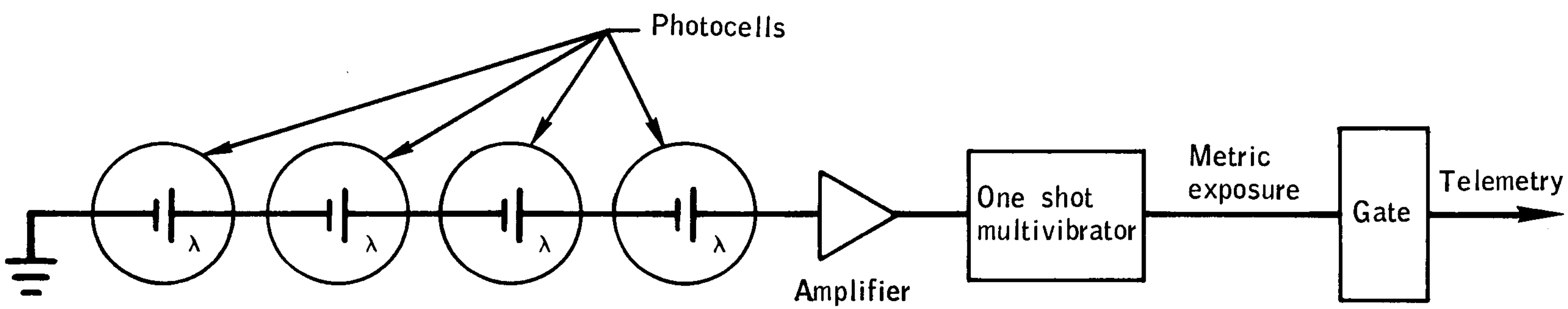


Figure 6-2.- Light sensor circuitry.

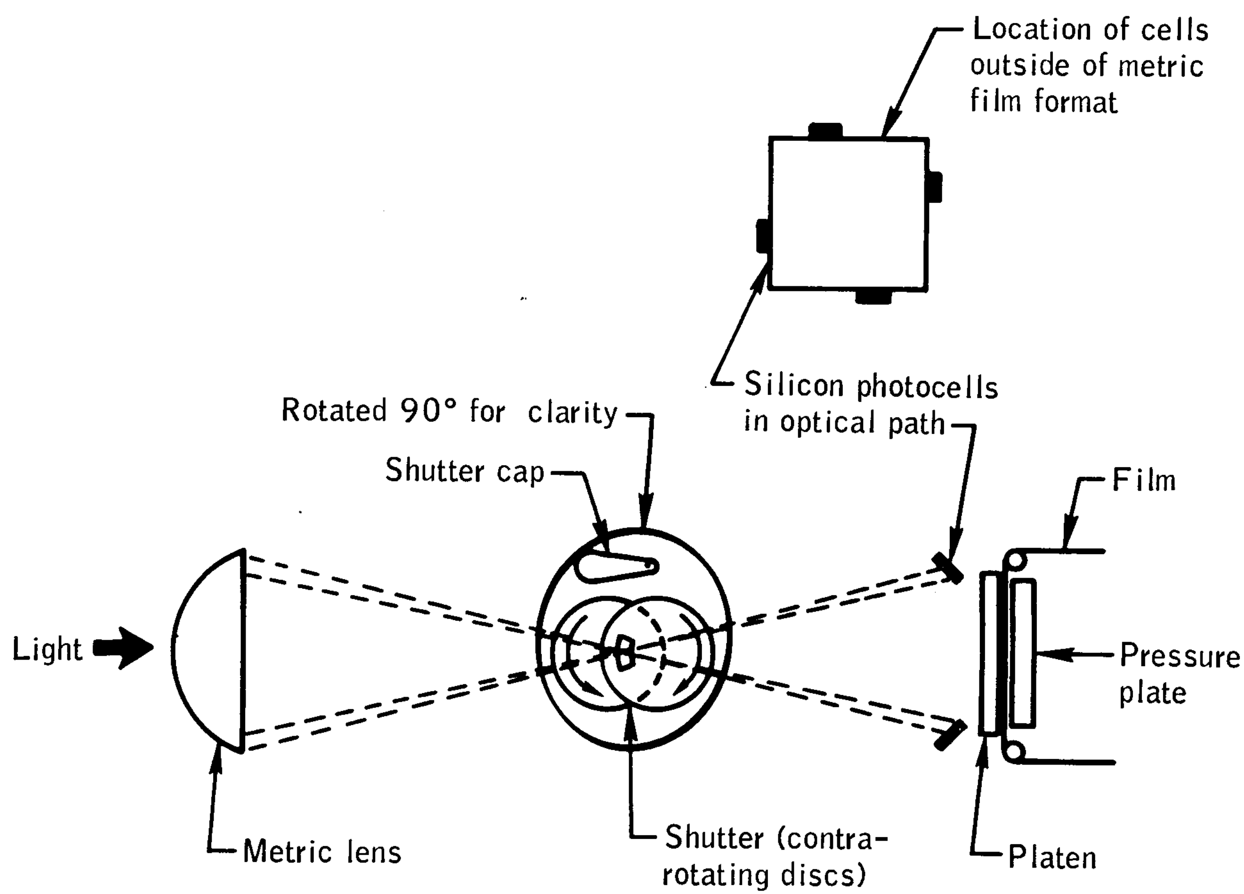


Figure 6-3.- Light energy path to photocells.

During Apollo 15 and 16, this pulse was absent only at the very low light levels, thereby indicating that the Apollo 17 discrepancy may have been due to a threshold shift in the light sensor circuitry. A 50-foot strip of metric photography from revolution 62 was processed in order to establish whether this was the case or some other problem was actually reducing the light being transmitted to the film.

The test strip indicated that the film had been properly exposed, thus indicating that the light sensor circuitry had indeed experienced a threshold shift. This shift could have been the result of a photo diode failure or a change in the performance of the amplifier, the one-shot multivibrator, or the circuitry between these two elements.

Since this was the last mission for this camera, no further analysis will be accomplished.

This anomaly is closed.

6.3 PANORAMIC CAMERA GIMBAL DRIVE FAILURE

The panoramic camera lost its stereo capability 8 minutes prior to completion of its final photographic pass in lunar orbit.

Stereo photography is achieved by gimbaling the lens assembly fore and aft between exposures so that one picture of a stereo pair is taken with the lens viewing ahead of the nadir and the other picture is taken with the lens pointing behind the nadir. Two independent telemetry points indicated that the lens assembly had ceased to gimbal (fig. 6-4). These were the forward motion compensation tachometer voltage and the automatic exposure command voltage. Monographic photography continued, but it was degraded somewhat by the associated loss of forward motion compensation that is achieved by slowly gimbaling the lens during film exposure.

This inability to gimbal the lens system was apparently the result of a failure in either the gimbal drive motor or the electrical circuitry that provides power to the motor. It is most likely that the motor failed, since its brushes are limited life items.

Since this was the last mission for this camera, no further analysis will be performed.

This anomaly is closed.

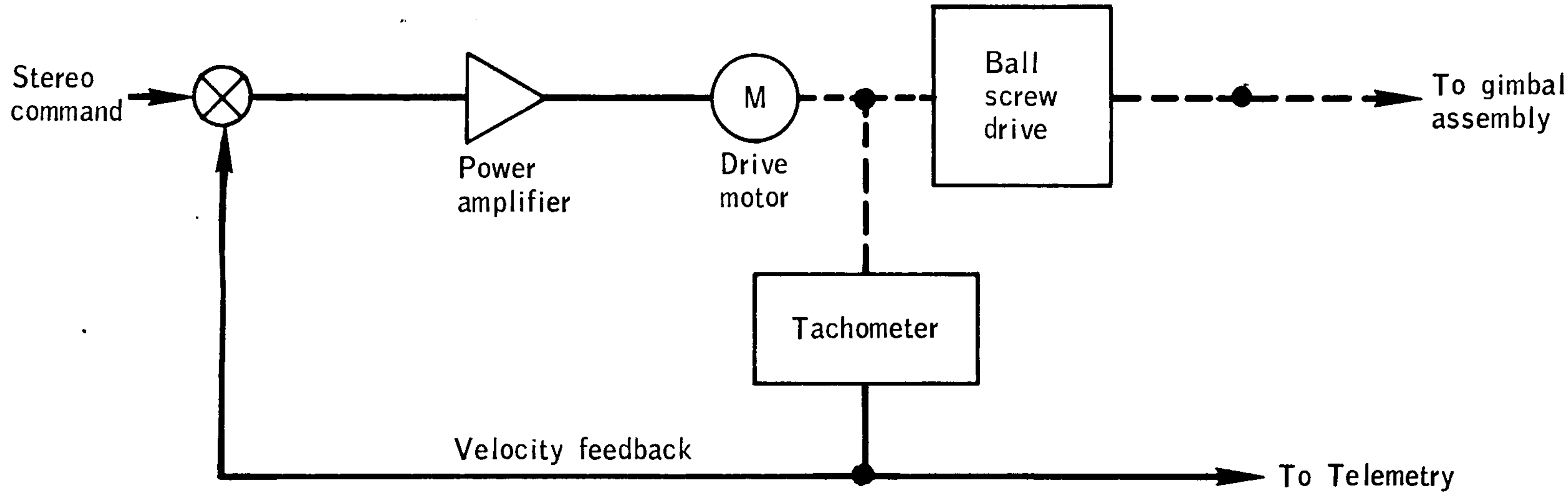


Figure 6-4.- Panoramic camera gimbal drive system.

6.4 ULTRAVIOLET SPECTROMETER TEMPERATURE MEASUREMENT FAILURES

Both ultraviolet spectrometer internal temperature measurements (electronics and motor) failed simultaneously near the end of the mission at approximately 282:20. At the same time, the input current to the spectrometer increased about 10 milliamps (approximately 4 percent). Since these temperatures were for housekeeping purposes and their circuitry is independent of the scientific data circuitry, their failure did not affect the performance of the ultraviolet spectrometer science mission. An external temperature measurement attached to the instrument case continued to provide thermal status after the loss of the internal measurements.

A block diagram of the temperature sensing circuits is shown in figure 6-5. Each thermistor temperature sensor is connected to its own bridge network which in turn drives a d-c operational amplifier whose 0- to 5-volt output is then telemetered. Both temperature circuits are identical and independent except that: (1) they share common returns, (2) they share common ±15 volt power supplies, and (3) each bridge network is biased with a common plus 1-volt precision stable reference. The plus 1-volt reference is derived via a temperature-stabilized zener diode and an inverting d-c amplifier powered from the minus 15-volt supply.

At the time of failure, the temperature indications changed dramatically in a 1-second interval. Such a change was not consistent with the thermal characteristics of the ultraviolet spectrometer. Since the primary indications were the failed temperature channels coupled with the slight increase in input current, it is most likely that the failure occurred in one of the circuits common to the temperature signal conditioners.

Further analyses and testing with the prototype ultraviolet spectrometer indicate that the anomaly was apparently the result of a failure of a component or a short in the circuit wiring in the 1-volt reference voltage or the minus 15-volt supply voltage.

Since this was the only mission for this instrument, no further analysis will be accomplished.

This anomaly is closed.

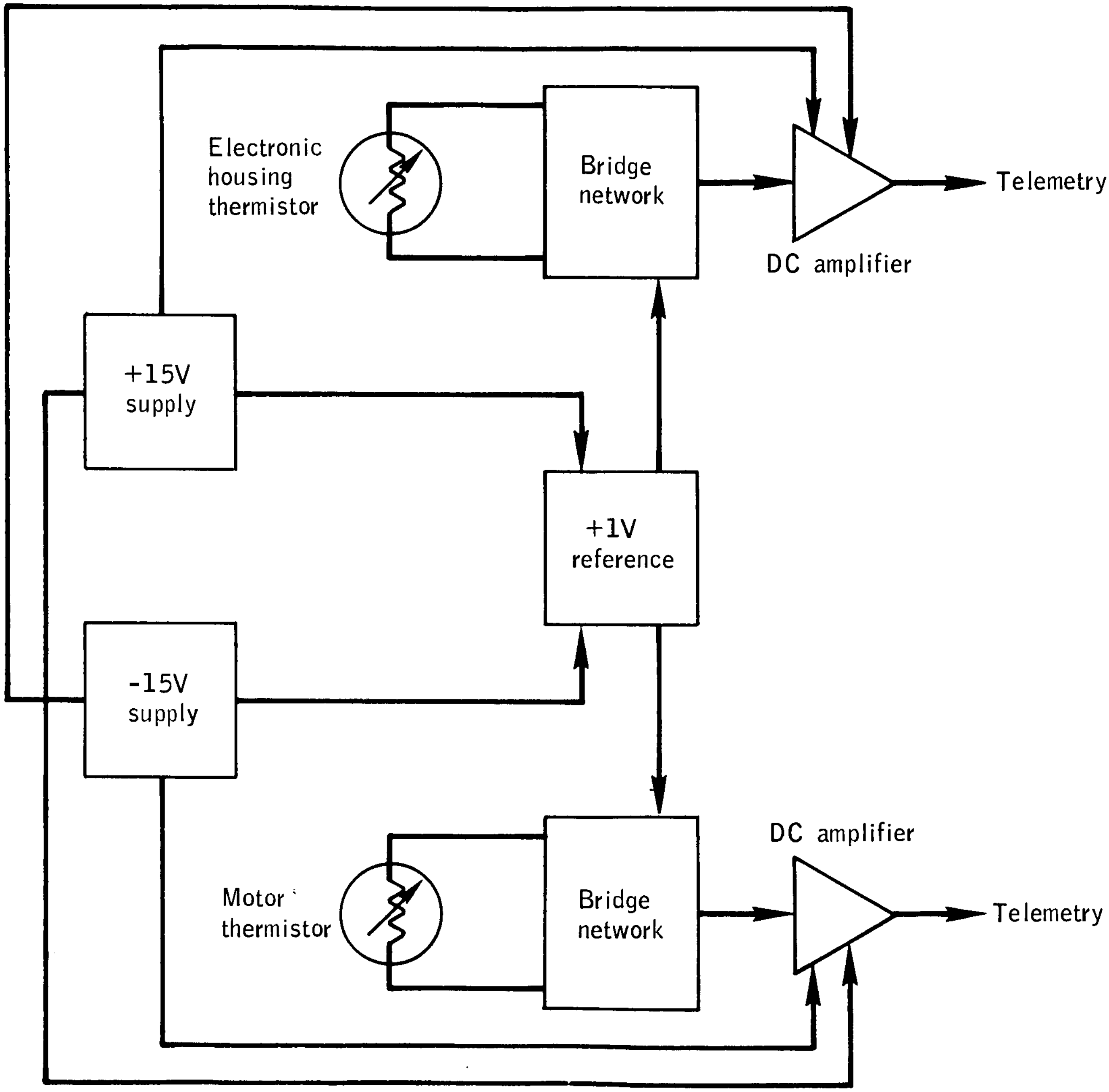


Figure 6-5.- Block diagram of ultraviolet spectrometer temperature sensing circuits.

6.5 MAPPING CAMERA DEPLOY/RETRACT TIMES WERE EXCESSIVE

The first and third extensions of the mapping camera were nominal, but all other deploy and retract times were longer than expected. The behavior was quite similar to that during the Apollo 15 and 16 missions.

The cause of the Apollo 15 and 16 anomalies has not been identified, but as a result of extensive investigations, several precautionary fixes had been implemented, such as removal of the no-back device, improved contamination covers, and a change in the lubricant on the drive screw — all apparently to no avail.

Dynamic testing in support of the Apollo 15 and 16 investigations included thermal-vacuum and simulated zero-g tests. These tests provided no clues to explain the sluggish behavior of the deployment mechanism. Either these tests were not capable of sufficiently simulating the scientific instrument module bay environment or another, as yet unknown, factor was involved.

Other anomalies have occurred with scientific instrument module bay equipments, thus suggesting a common factor. The mapping camera reaction control system plume shield did not properly close on Apollo 15 and 17, and the mapping camera stellar glare shade failed to retract on Apollo 16. The lunar sounder high frequency antenna exhibited sluggish deployment on Apollo 17. In all cases, some degree of sliding between metal surfaces was required. It is, therefore, conceivable that the friction between those surfaces may have been significantly increased by the effects of a hard vacuum that is unobtainable in ground testing.

Since this was the last mission for this device. no further analysis will be performed.

This anomaly is closed.

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