Internal
Memorandum

Bendix Aerospace Systems Division

Date 18 March 1971 Letter No. 9753-78 Ann Arbor, Michigan

To Distribution

From R. Miley

Subject ALSEP-MT-03, Flight System Familiarization Manual, Revision B, Change 1

1. Enclosed is a copy of Change 1 to Revision B of the subject document.

2. Questions or comments concerning this document are solicited and should be directed to R. Miley, TDX, Building 399, telephone 483-5067.

R. Miley

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ALSEP-MT-03

APOLLO LUNAR SURFACE
EXPERIMENTS PACKAGE
(ALSEP)

FLIGHT SYSTEM FAMILIARIZATION MANUAL

(REVISION B, CHANGE 1)

APPROVED BY NASA

LUNAR SURFACE PROJECT OFFICE

MANNED SPACECRAFT CENTER

THE BENDIX CORPORATION
AEROSPACE SYSTEMS DIVISION

CONTRACT NUMBER
NAS 9-5829

15 APRIL 1969
Changed 15 December 1970

CHANGE INSTRUCTION SHEET

TO: Holders of ALSEP-MT-03, Flight System Familiarization Manual

SUBJECT: ALSEP-MT-03 Change 1 dated 15 December 1970

INSTRUCTIONS: Replace pages of ALSEP-MT-03, Revision B, Dated 15 April 1969, with the pages provided in the subject change package as specified in the following table.

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INTRODUCTION

The Apollo Lunar Surface Experiments Package (ALSEP) will be used to obtain long-term scientific measurements of various physical and environmental properties of the Moon consistent with the scientific objectives of the Apollo Program. The ALSEP comprises scientific experiment packages with supporting subsystems. ALSEP will be transported to the lunar surface aboard the Apollo Lunar Module (LM). The ALSEP will remain on the lunar surface after the return of the astronauts and will transmit scientific and engineering data to the Manned Space Flight Network (MSFN).

The purpose of the ALSEP Flight System Familiarization Manual is to familiarize the reader with the scientific objectives of ALSEP, equipment make-up, system deployment, and operation. This manual describes the ALSEP mission and system in Section I, subsystems in Section II, maintenance in Section III, and operations in Section IV. Supplementary command and measurement data are provided in the Appendices. ALSEP Flight 2 subpackages have been used in the Early Apollo Scientific Experiments Package (EASEP) Program. Consequently, any reference to Flight 2 in this manual is no longer applicable.

The information contained in this change of the ALSEP Flight System Familiarization Manual includes formalized data released and available prior to the publication date, 15 December 1970.

1-3. ALSEP MISSION OBJECTIVES

Major objectives of lunar exploration include determination of:

a. The structure and state of the lunar interior

b. The composition and structure of the lunar surface and modifying processes.

c. The evolutionary sequence of events leading to the present lunar configuration.

To initiate partial attainment of these objectives the ALSEP includes eight experiments in varying combinations to measure a number of geophysical characteristics. The various physical and environmental properties to be measured, applicable experiment, and method of measurement are listed in Table 1-1.

1-4. ALSEP SYSTEM DESCRIPTION

The ALSEP is a self-contained package of scientific instruments and supporting subsystems designed to acquire lunar physical and environmental data and transmit the information to Earth. The ALSEP is deployed on the lunar surface by the Apollo crewmen as described in Section IV of this manual. Different configurations of the ALSEP will be used on the different Apollo flights as specified in Table 1-2.

1-5. ALSEP PHYSICAL DESCRIPTION

The ALSEP consists of the following subsystems:

a. Structure/thermal subsystem

b. Electrical power subsystem

c. Data subsystem

d. Apollo lunar hand tools

e. Eight experiment subsystems in varying combinations for each of the flights as presented in Table 1-2.

The experiment and support subsystems of the ALSEP system are mounted in two subpackages as shown in Figure 1-1 for storage and transportation in the LM. The fuel cask (part of the electrical power subsystem) is attached to the LM.

Subpackage No. 1 for Flight 1 and Array A-2 consists of the central station (data subsystem, power conditioning unit, and experiment electronics), the antenna, the passive seismic (PSE), magnetometer (ME), and solar wind (SWE) experiments as shown in Figure 1-2. Subpackage No. 2 for Flights 1 and 4 consists of the radioisotope thermoelectric generator (RTG), suprathermal ion detector experiment (SIDE), Apollo lunar hand tools (ALHT), handling tools, and the antenna mast as shown in Figure 1-3. Similar configurations of the subpackages incorporating different combinations of experiments as shown in Figure 1-4, 1-5, 1-6, and 1-6A will be employed in Flights 3 and 4, and Array A2. The ALSEP Array A2 packages, including fuel capsule and cask, weigh approximately 283.8 pounds and, excluding the fuel capsule and cask, occupy approximately 15 cubic feet.

Table 1-1. ALSEP Scientific Objectives

Measurement Objective	Experiment/ Measurement Method
Natural seismology (meteoroid impacts and moonquakes). Properties of lunar interior (existence of core, mantle)	Passive Seismic Experiment - Uses three long period sensors in an orthogonal arrangement and one vertical short period sensor.
Magnetic field and its temporal variations at the lunar surface.	Magnetometer Experiment - Uses tri-axis flux-gate magnetometer instrument. Three booms, each with flux-gate sensors, are separated to form a rectangular coordinate system and gimballed to allow alignment in parallel or orthogonal configurations.
Interaction of solar wind and Moon (temporal, spectral, and directional characteristics).	Solar Wind Experiment - Detects and monitors particles using exposed collection cups (sensors).
Lunar ionosphere positive ion detection, (flux, energy, and velocity of positive ions). Also pressure of lunar atmosphere and rate loss of contaminants left by astronauts and the LM.	Suprathermal Ion Detector Experiment- Detects positive ions in lunar ionosphere and thermalized solar wind using a curved plate analyzer as detector device. Velocity selector analyzer used to determine particle velocities and energies. Cold cathode ion gauge is used to determine density of lunar atmosphere.
Physical properties of lunar materials at shallow depths (elastic properties of lunar near-surface materials).	Active Seismic Experiment - Uses artificial seismic energy sources (grenade launcher assembly and thumper device) and detection equipment (geophones and amplifiers).
Rate of heat flow through lunar surface that, together with information from other sources, will refine hypotheses concerning: a. the physical and chemical composition of the lunar surface, b. the thermal distribution of the Moon. c. the radioactivity of material at various lunar depths, and d. the thermal history of the Moon.	Heat Flow Experiment - Uses two heat flow probe assemblies, emplaced in lunar crust. Probes contain temperature sensors and heating elements.

Table 1-1. ALSEP Scientific Objectives (cont)

Measurement Objective	Experiment/Measurement Method
Composition of lunar atmosphere (electron/proton energies)	Charged-Particle Lunar Environment Experiment - Detects and monitors particle energy levels using two sensor assemblies (analyzers).
Pressure of ambient lunar atmosphere including temporal variations either random or associated with lunar local time or solar activity.	Cold Cathode Gauge Experiment - Senses lunar atmospheric density variations using a transducer to effect conversion of particle quantity to direct current.

Table 1-2. ALSEP Experiment Subsystem Flight Assignments

Experiment	Flight 1	Flight 3	Flight 4	Array A-2
Passive seismic	X	X	X	X
Magnetometer	X			X
Solar wind	X			X
Suprathermal ion detector	X		X	X
Active seismic			X	
Heat flow		X		X
Charged particle lunar environment		X	X	
Cold cathode gauge		X		

1-6. ALSEP FUNCTIONAL DESCRIPTION

The ALSEP objective of obtaining lunar physical and environmental data is accomplished through employment of the various experiment combinations, the supporting subsystems, and the manned space flight network (MSFN).

The MSFN stations, such as those at Goldstone California, Carnarvon and Canberra Australia, Ascension Island, Hawaii, Guam, Madrid Spain, and KSC Florida, are the Earth terminals for ALSEP communications. Mission Control Center (MCC) participates in the network for activation of the experiments, initial calibration sequences, and for the duration of the mission. Communications consist of an uplink (Earth-Moon) for command transmissions to control the ALSEP functions, and a downlink (Moon-Earth) for transmission of scientific experiment and engineering housekeeping data. The MSFN stations will record the downlink data.

As many as three separate ALSEP systems may be operating on the Moon simultaneously. The downlink telemetry of each of these will operate at a different frequency (2278.5 MHz, 2276.5 MHz, 2275.5 MHz, or 2279.5 MHz). The uplink frequency for all systems is 2119 MHz. The command format addresses each ALSEP specifically, precluding inadvertent activation of the other systems.

The functional operation of ALSEP is illustrated in Figure 1-7. The following paragraphs describe the function, on a system level, of the ALSEP subsystems.

1-7. Structure/Thermal Subsystem. The structure/thermal subsystem provides structural integrity and thermal protection of the ALSEP equipment and LM in transport and in the lunar environment ($-300^{\circ}F$ to $+250^{\circ}F$). This includes packaging, structural support, and isolation from heat, cold, shock, and vibration. A dust detector monitors accumulation of lunar dust.

1-8. Electrical Power Subsystem. The electrical power subsystem generates 63 to 74 watts of electrical power for operation of the ALSEP system. The power is developed by a thermopile system which is heated by a radioisotope fuel capsule. The power is regulated, converted to the required voltage levels, and supplied to the data subsystem for distribution to the support and experiment subsystems. Analog housekeeping data from the electrical power system is supplied to the data subsystem for downlink telemetry.

1-9. Data Subsystem. The data subsystem receives, decodes, and applies discrete logic commands from the MSFN to the deployed units of ALSEP. These commands are used to perform power switching, thermal control, operating mode changes and experiment control. The data subsystem accepts and processes scientific data from the experiments, engineering status data from itself and all the subsystems, and transmits the data to the MSFN receiving stations. The data subsystem also performs the function of switching and distributing operating power to the experiment and support subsystems.

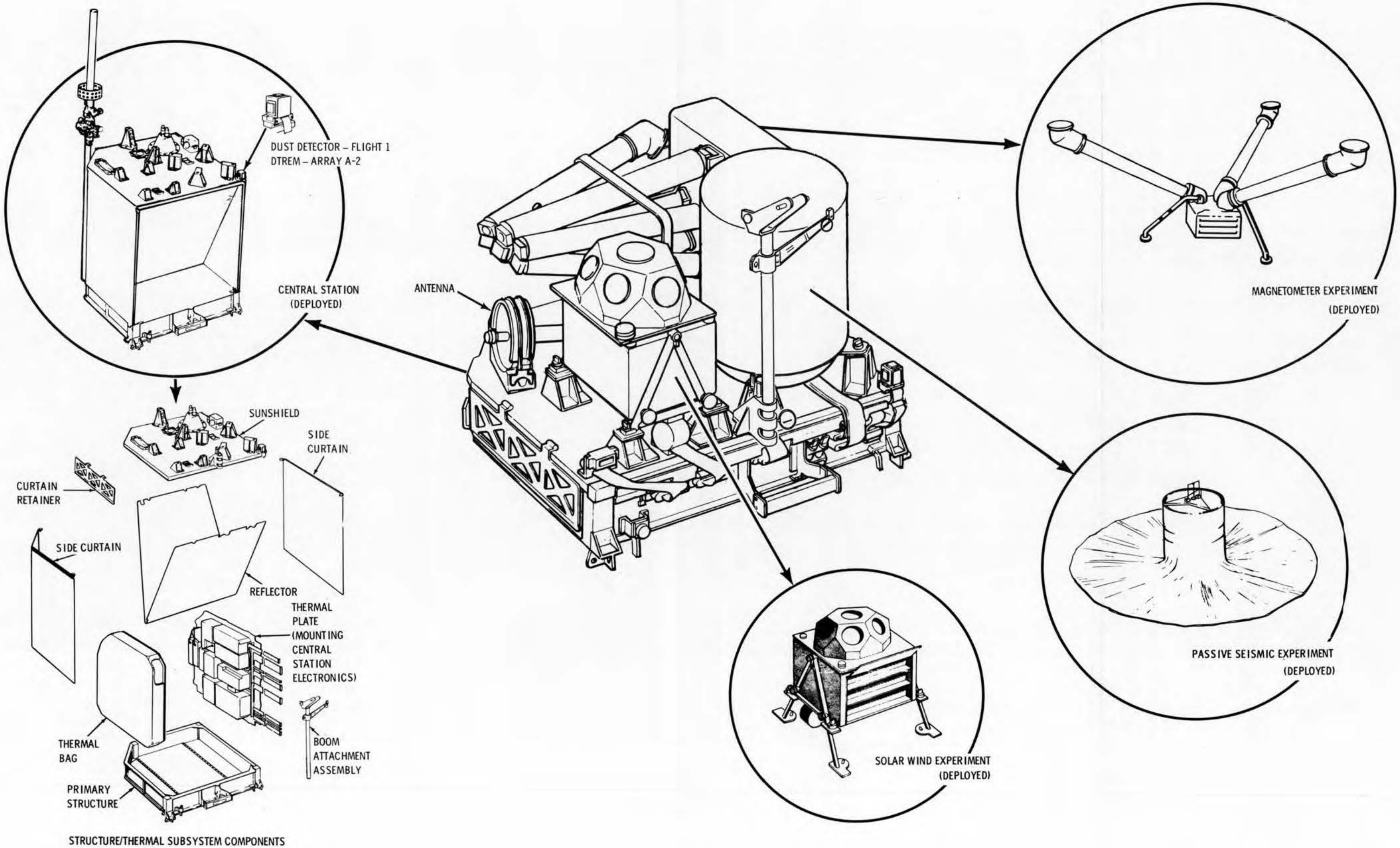


Figure 1-2. ALSEP Subpackage No. 1
(Flight 1 and Array A-2)

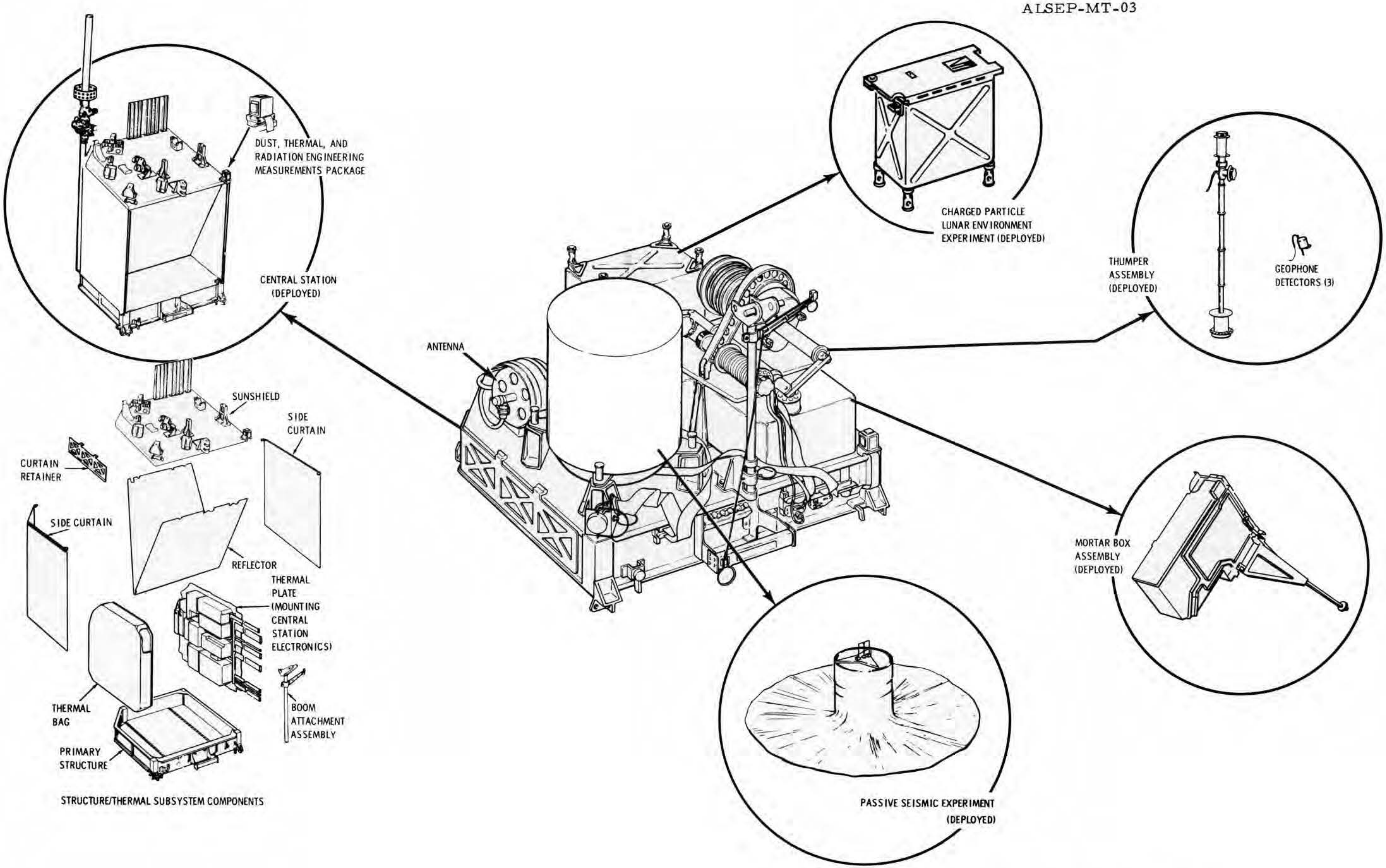


Figure 1-6. ALSEP Subpackage No. 1 (Flight 4)

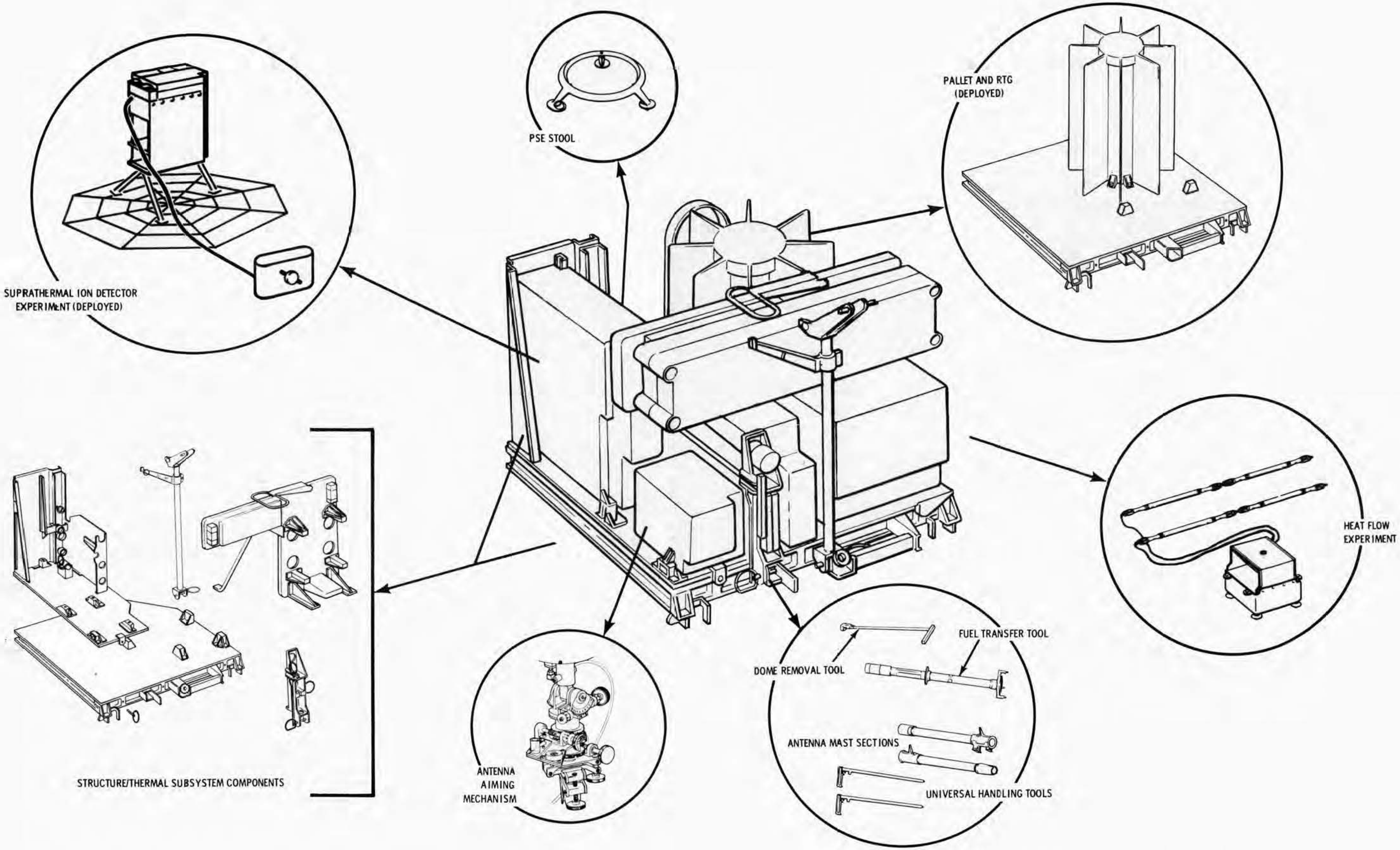


Figure 1-6A. ALSEP Subpackage No. 2 (Array A-2)

Table 1-3. ALSEP Principal Investigators (cont)

Experiment	GFE or CFE	Principal Investigator and Co-Investigators
Charged particle lunar environment	CFE	Dr. Brian J. O'Brien - Rice University
Cold cathode gauge	GFE	Dr. Francis Johnson - University of Texas, Dallas Mr. Dallas Evans - NASA-Manned Spacecraft Center

1-21. OPERATIONAL EXPERIENCE

The crew of Apollo 11 put the Early Apollo Scientific Experiments Package (EASEP), described in EASEP-MT-01, into operation at Tranquillity Base in Mare Tranquillitatis on 21 July 1969. The ALSEP Flight 1 system (ALSEP 1) was deployed by the crew of Apollo 12, and began operating on 19 November 1969 from the site of Surveyor 3 in Oceanus Procellarum.

The receipt of live data from moon-based science equipment is now a routine reality. For more than a year there has been a continuous flow of measurements transmitted to Earth from these lunar laboratories. During this period the Manned Space Flight Network has recorded the data transmissions and the Mission Control Center of NASA has monitored and controlled the performance of the equipment.

These paragraphs summarize the operational experience accumulated with these lunar-based systems. The following documents contain comprehensive descriptions of EASEP and ALSEP 1 operating experiences:

a. Apollo 11 Preliminary Science Report, NASA SP-214
b. Science, Vol. 167, No. 3918 (30 January 1970)
c. Apollo 12 Preliminary Science Report, NASA SP-235

1-22. EASEP OPERATIONAL EXPERIENCE

EASEP is a modified version of ALSEP which was prepared for the Apollo 11 mission. The operating lifetime and scientific scope were reduced to obtain a minimum deployment time. The two subpackages of ALSEP were modified to each carry an experiment. Subpackage 1, the Passive Seismic Experiment Package (PSEP), comprised a passive seismic sensor and a solar-powered central station.

Subpackage 2 comprised a Laser Ranging Retro-Reflector (LRRR) which is electrically passive. Both packages met their operational requirements as shown in Table 1-4.

1-23. PSEP Operation. The Passive Seismic Experiment Package was deployed 70 feet from the LM as shown in Figure 1-8. Immediately after the solar panels were unfolded the system was electrically activated and a downlink signal was detected by the MSFN. During the next five lunations, PSEP transmitted data to Earth when the sun was shining on the panels. The solar panels provided the equipment with almost exactly the design values of electrical power throughout the operating periods. These values were well above the minimum power required for normal operation of the equipment.

An abnormally high rate of rise of central station temperature was detected shortly after LM lift-off, and it became evident that the equipment would be subjected to very high temperatures during lunar noon operation. The electronic units operated at temperatures up to 50°F above the design limit value.

All functions performed normally throughout the first lunar day. The system was commanded off at sunset, and was dormant throughout the lunar night. When reactivated at lunar dawn, the system provided full performance until noon of that lunar day when the command decoder failed to respond to uplink command. The net result of the loss of the command link was (1) inability to level the seismometer or to re-activate it when placed in STANDBY mode by the "ripple" circuit during a power dip, (2) inability to re-activate DTREM I which was turned off when the sun went down on the second lunar day, and (3) inability to exercise thermal control through use of the power dump resistors.

TABLE 1-4. EASEP Operating Experience

	Deployment Time		Operating Time	
	Req'd	Actual	Req'd	Actual
LRRR	5 minutes	3 minutes	1 year	still functioning
PSEP	5 minutes	4 minutes	first lunar daytime	thru noon 2nd lunar day*

* Complete engineering data thru dawn on 6th lunar day

Temperature, voltage, current, and calibration status data was transmitted throughout the next five lunar daytime periods from all sensors except those associated with the seismometer and the DTREM I. This data has been used to evaluate the operation of the equipment in the harsh extremes of the lunar environment.

The PSEP system executed 916 commands during the first lunar day operation. Another 615 commands were implemented on the second day before loss of uplink capability. All redundant facilities (data processors, power converters, transmitters, and command decoders) built into the central station were exercised successfully. Over 800 more commands were directed at PSEP throughout the remaining operational period to determine if the uplink had recovered.

At 10:14 CST on 14 December 1970 (90 minutes after sunrise on the 6th lunar day) the downlink signal from PSEP was lost and has not been detected since.

1-24. LRRR Operation. The LRRR was deployed 55 feet from the LM as shown in Figure 1-8. It was aligned with the sun and leveled with precision sufficient to provide overall pointing of the array to within one degree of the center of the Earth libration pattern.

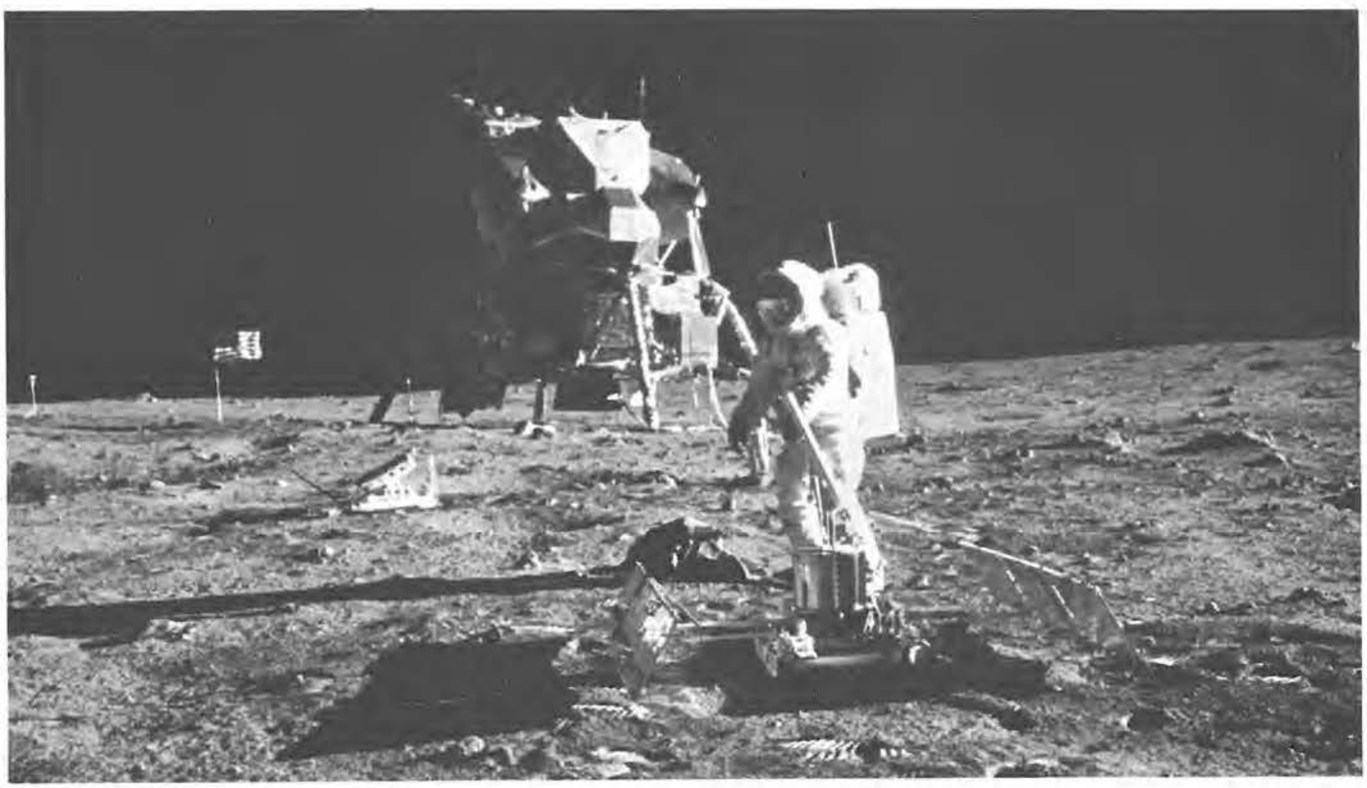


Figure 1-8. EASEP Deployed on Lunar Surface

Reflected signals from the LRRR were first acquired with the 120-inch telescope of the Lick Observatory at Mount Hamilton, California on 1 August 1969. Initial acquisition with the 107-inch telescope of the McDonald Observatory at Mount Locke, Texas was on 20 August 1969.

These, and subsequent observations demonstrated that the LRRR did not suffer major degradation from debris generated during lift-off of the LM. Continued observations at the McDonald Observatory have demonstrated the successful performance of the LRRR at several sun illumination angles, as well as during and after lunar night.

1-25. ALSEP OPERATIONAL EXPERIENCE

ALSEP 1 was carried approximately 600 feet from the Apollo 12 LM and deployed on the lunar surface as shown in Figure 1-9. The deployment operation required 90 minutes from opening the LM SEQ bay until data was being received by the MSFN on Earth. This was 13 minutes longer than nominal, but did not exceed the 18-minute buffer period scheduled into the timeline for deployment uncertainties. Some difficulty was encountered with releasing the fuel capsule from the cask assembly, and with the deployment of the CCIG and the PSE shroud. Also, the lunar dust posed some problems during the deployment operation. Design changes have been incorporated in subsequent systems as a result of these experiences.

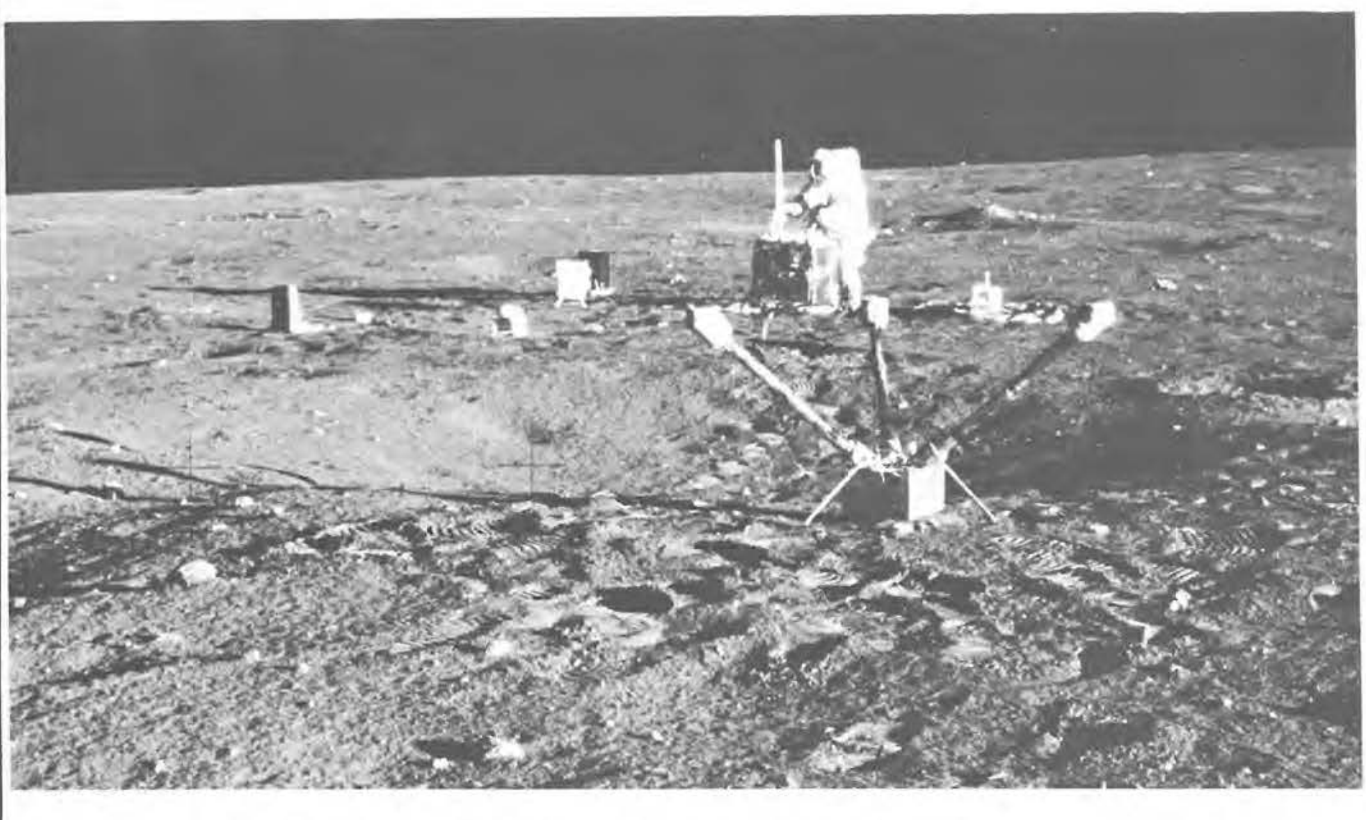


Figure 1-9. ALSEP 1 Deployed on Lunar Surface

1-26. System Operation. During the first full year of operation of the ALSEP I lunar laboratory, over 3 billion measurements from the moon were recorded on magnetic tape as they were received at each station of the MSFN. These measurements were made during 12 complete traverses of the moon through the geomagnetic tail of the earth (Figure 1-10), 12 complete day-night cycles of the thermal environment of the moon, and the seasonal thermal variations caused by the change in distance from the Sun throughout the year. The measurements provided a detailed record of the solar change and thermal transients at the lunar surface during two solar eclipses.

The only breaks in the continuous flow of this data occurred during the two solar eclipses which were viewed from Earth on 7 March and 31 August 1970. During these solar eclipses the MSFN antennas pointed at ALSEP looked into the sun which is a strong source of noise. During these periods (about 3 hours) the network receivers were unable to discriminate the ALSEP signal from the solar noise and the measurement data were lost.

The MSFN stations have consistently reported the downlink signal strength to be -139 (± 1) dbm. Downlink signal strength variations attributable to lunar librations have not been detected.

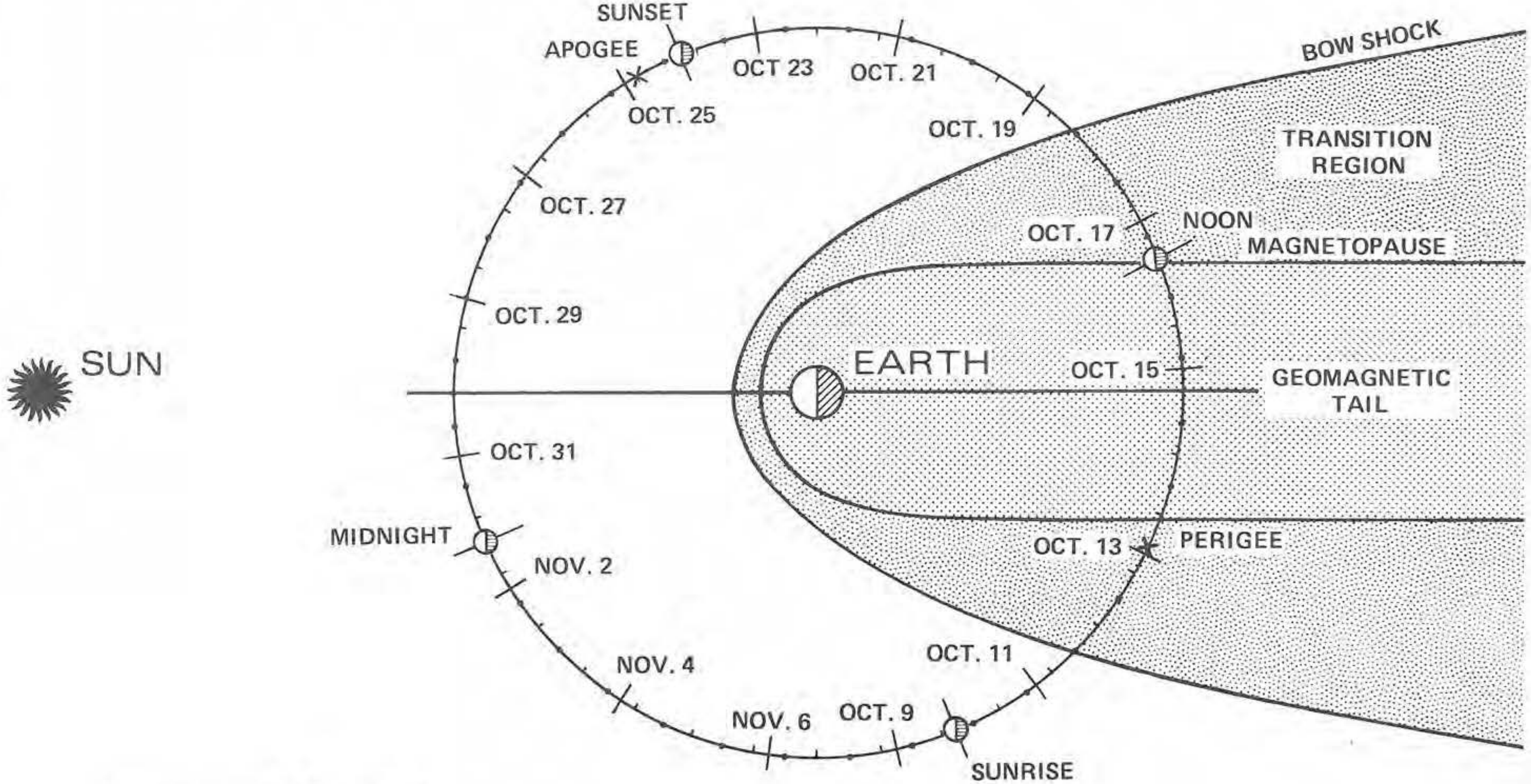
During the year, over 6, 500 functional changes were initiated by command from the mission control center at Houston as part of the operation and calibration of the laboratory. Over 97% of these functional changes were made in the performance of the scientific experiments. The remainder were made in the process of normal laboratory housekeeping.

The facilities of the mission control center were mobilized continuously during the first 45 days of operation to monitor the data in "real" time as it was received from the Moon, and to control the operation of the instruments. After the first 45 days the mission control center was mobilized for a minimum of 2 hours per day during lunar daytime periods, 1 hour every other day during lunar nighttime periods, and for 24 hours during terminator crossings. Support was also provided during periods of special interest such as lunar noon and solar eclipse.

The central station timer failed after 2200 hours of operation. This required ground commands to perform functions normally initiated by the 12-hour pulse. System operation was otherwise uneffected except that the end-of-mission signal will not occur.

The electrical performance of the RTG has been remarkably stable in spite of the severe temperature excursions of the lunar surface. The day-night power output variations were less than 0. 5 watt. The output dropped only 2 watts, from 74 to 72 watts, during the first year (8, 780 hours) of operation.

MOON POSITIONS RELATIVE TO EARTH-SUN LINE



POSITION AT O^h G. M. T.
ON DATES INDICATED

Figure 1-10. ALSEP 1 Lunar Day No. 12

The thermal control of the ALSEP 1 equipment was generally acceptable during the year. The central station electronics units were designed to operate at temperatures between 0°F and 125°F. Their average temperature has been maintained between 20°F and 100°F. The PSE sensor temperatures have been higher than expected around lunar noon, and required heater augmentation to maintain the nighttime minimum temperature. The temperature excursions of the experiments are shown in Table 1-5.

The Dust Detector has not as yet provided evidence of appreciable dust accretion. It has provided a sensitive indication of lunar sunrise and sunset as an on-site measurement. These events are significant in the functional and operational control of ALSEP and serve to permit accurate correlation from lunation to lunation of data which are sun-angle dependent.

1-27. PSE Operation. The PSE operation during the first year was nominal except for low sensitivity of the short period seismometer, and above normal sensor temperatures during high sun-angle periods (145°F, rather than the desirable 126°F). This has had no impact on instrument functioning, but has made the interpretation of the tidal information more difficult. The Z axis sensor leveling motor has been used as an additional heat source during lunar night to maintain the sensor temperature at 126°F.

Data from the PSE has revealed that the Moon is an extremely quiet and stable body as compared to the Earth. The data indicates that the Moon is not stratified like the Earth, but is a rubble of rock clumps which have not congealed.

Table 1-5. ALSEP 1 Experiment Temperature Extremes

Equipment	Nighttime Minimum (°F)	Daytime Maximum (°F)
Magnetometer Electronics	-20	+165
Solar Wind Spectrometer Electronics	5	140
SIDE Electronics	50	130
PSE Sensor Assembly	126	145

The two major seismic events recorded by the PSE were the impacts of the Apollo 12 LM and the Apollo 13 S-IVB stage. The S-IVB impact signal was the largest event recorded. It continued for approximately four hours. Many meteroid impacts were recorded during the year. Analysis of this data eventually will lead to a quantitative estimate of numbers and masses of such pieces of rock material in near lunar space.

Analysis of the data has identified nine types of seismic events which occur every month at or near the time the Moon comes nearest the Earth in its monthly orbital cycle. These events are believed to be moonquakes triggered by tidal strain. All events within a type are identical in every aspect throughout the length of the record. This indicates that each type of event originates at a specific point on the lunar surface.

1-28. SWE Operation. The SWE operation was normal throughout the year, with no indication of degradation. The SWE detected solar wind plasma striking the Moon during all the times that it would be expected to do so. (See Figure 1-10.) The plasma density is very small, with measurements ranging from 1 to 25 particles per cubic centimeter. The solar wind is seldom the same for more than a few minutes at a time.

The Moon does not appear to have a major effect on the solar wind. The plasma sweeps in, impacts the Moon, and is absorbed by the surface.

The SWE detected a complicated gas flow pattern resulting from the impact of the Apollo 13 S-IVB stage. Particle energies of about 35 to 50 electron volts were measured.

1-29. ME Operation. The ME operated normally during lunar daytime periods, returning 2 million bits of data during the first year. This data is analyzed in reference to data from Explorer 35 which was in lunar orbit. The ME has stopped processing data following each lunar sunset when the internal temperature of the instrument drops. Operation returns to normal when the internal temperature rises after lunar sunrise. The ME remains fully operational throughout the periods of maximum solar wind activity.

The sensors detected magnetic field intensities in the 100 gamma and the 200 gamma sensitivity ranges. No field intensities were detected in the 400 gamma range.

The ME detected a steady magnetic field of about 35 gammas immediately after deployment. The data indicates that this is a localized, probably fossil, field located from 0.2 to 200 kilometers from the ME.

The solar wind magnetic field measurement data from the ME has provided evidence that solar wind harmonic wave spectrum is amplified by as much as a factor of five at the lunar surface, and that the lunar electrical conductivity is variable dependent upon the material temperature and chemical composition. The conductivity increases by a factor of one million in going from the surface to a depth of about 200 kilometers. The heat flux of the moon is in the range of two-tenths to three-tenths of a microcalorie per square centimeter per second. The interior temperature of the moon is approximately 800 to 1,000 degrees centigrade.

1-30. <u>SIDE Operation.</u> The SIDE has operated normally, except for a temperature-dependent mode change characteristic, with no indication of degradation of performance or of thermal control capabilities. The mode changes are typical of high voltage arcing effects, and occurred when the instrument internal temperature reached approximately $55^{o}C$. The mode changes have been corrected by command after each occurrance. The SIDE operates throughout the lunar night, and during lunar daytime for periods of two hours followed by periods of power off to allow for cooling.

Mass spectra of 50 ev ions were detected soon after deployment. These showed concentrations of ions in the 18 to 50 amu/q mass-per-charge range. Clouds of 10 to 250 ev ions have been detected, as well as other events, which suggest the operation of a general acceleration mechanism. Solar wind energy ions are detected several days before sunrise at the ALSEP site. Ions of 250 to 3,000 ev, presumed to be protons which escaped from the bow shock, are observed in the time period between lunar sunset and midnight. The SIDE detected ions of 250 to 500 ev from the impact of the Apollo 12 LM. It detected ions of 50 to 70 ev with a large number of ions of mass about 10 to 80 amu/q resulting from the impact of the Apollo 13 S-IVB.

The CCIG operated for approximately 14 hours after it was deployed on the lunar surface. It was shut off by apparent arcing in its 4500 volt power supply due to outgassing in the electronics as it became heated in the hot vacuum environment of the lunar day. During its operation, the CCIG detected a natural lunar atmospheric pressure of 9×10^{-9} torr. Measurements indicated that contaminant gases from the landing operation did not raise the local atmospheric pressure above 9×10^{-9} torr. The gas cloud around an astronaut exceeded the upper range of the gage (approximately 10^{-6} torr) as far as several yards from the astronaut. No perceptible residual contamination at the 10^{-8} torr level remained around the gage for longer than a few minutes after astronaut departure.

SECTION II

ALSEP SUBSYSTEM DESCRIPTION

2-1. ALSEP SUBSYSTEM INTRODUCTION

This section describes the thirteen (eight experiment and five support) subsystems which comprise the total ALSEP system. A listing of the subsystems follows:

a. Structure/thermal subsystem
b. Electrical power subsystem (EPS)
c. Data subsystem (DS/S)
d. Passive seismic experiment subsystem (PSE)
e. Magnetometer experiment subsystem (ME)
f. Solar wind experiment subsystem (SWE)
g. Suprathermal ion detector experiment subsystem (SIDE)
h. Active seismic experiment subsystem (ASE)
i. Heat flow experiment subsystem (HFE)
j. Charged particle lunar environment experiment subsystem (CPLEE)
k. Cold cathode gauge experiment subsystem (CCGE)
l. Apollo lunar hand tools subsystem (ALHT)
m. Apollo lunar surface drill (ALSD)

All subsystems are described in terms of their physical characteristics, functional operation, and system interfaces.

2-2. STRUCTURE/THERMAL SUBSYSTEM

The structure/thermal subsystem provides the structural integrity and passive thermal protection required by the ALSEP experiment and support subsystems to withstand the environments encountered in storage, transportation and handling, testing, loading on LM, space flight, and lunar deployment. During operation on the Moon, the structure/thermal subsystem will continue to provide structural support and thermal protection to the data subsystem in the central station and to the electrical power subsystem.

2-3. STRUCTURE/THERMAL SUBSYSTEM PHYSICAL DESCRIPTION

The structure/thermal subsystem includes the basic structural assembly of the ALSEP system subpackages, the fuel cask structure assembly, handling tools, antenna mast, and a dust detector. Structure/thermal subsystem leading particulars are provided in Table 2-1.

Table 2-1. Structure/Thermal Subsystem Leading Particulars

Component	Characteristic	Value
Subpackage No. 1 Structure	Size (inches)	L 26.75 W 27.37 H 6.87
	Weight (pounds)	24.86
Subpackage No. 2 Structure	Size (inches)	L 25.87 W 27.14 H 3.37
	Weight (pounds)	25.15
Fuel Cask Support	Size (inches)	H 28.86 D 12.25
	Weight (pounds)	19.60
FTT	Length (inches)	24.12
	Weight (pounds)	1.51
UHT	Length (inches)	26.50
	Weight (pounds)	0.82
DRT	Length (inches)	23.67
	Weight (pounds)	0.65
Antenna Mast (two sections)	Section length (inches)	20.75
	Basic diameter (inches)	1.75
	Weight (pounds)	1.30
Dust Detector	Power Requirements	
	On mode	540 mw maximum, + and -12 vdc.
	Off mode	70 mw maximum, + and -12 vdc.
	Analog Outputs	0 to +5 vdc.
Sensor Package	Size (inches	1.75 x 1.75 x 1.75
	Weight (pounds)	0.35
Circuit Board	Size (inches	3.3 x 6.1
	Weight (pounds)	0.26
Dust, Thermal, and Radiation Engineering Measurements Package	Power Requirements	
	On Mode	245 mw maximum, + and -12 vdc.
	Off Mode	45 mw maximum, + and -12 vdc.
	Analog Outputs	0 to +5 vdc.

2-4. STRUCTURE/THERMAL SUBSYSTEM FUNCTIONAL DESCRIPTION

2-5. Subpackage No. 1 Structure/Thermal. The structure/thermal portion of subpackage No. 1 consists of a primary structure, boom attachment assembly, thermal plate, sunshield, side curtains, reflector, and thermal bag as shown in Figure 2-1. The primary structure provides tie points for securing the subpackage in the SEQ bay of the LM. It is recessed to receive the central station electronics which are mounted on the thermal plate. The sunshield provides tie points for mounting the boom attachment assembly, experiment subsystems, and associated equipment. The sunshield, side curtains, and reflector are raised during deployment to provide thermal protection for the central station electronics.

Thermistor temperature detectors monitor thermal bag, primary structure, and sunshield temperatures during operation. These temperature signals are supplied to the data subsystem for insertion into the ALSEP telemetry data.

2-6. Subpackage No. 2 Structure/Thermal. The structure/thermal portion of subpackage No. 2 consists of boom attachment assembly, pallet, and subpallet as shown in Figures 2-2, 2-2A, and 2-2B. It provides tie points to mount experiment and support subsystems, and to secure the subpackage in the SEQ bay of the LM. The pallet assembly protects the astronaut from the electrical power subsystem components during deployment, and serves as a base for that subsystem during operation.

2-6A. Dust Covers. Dust covers have been added to the Flight 4 and Array A-2 systems to protect mechanisms and thermal coatings from lunar dust during the deployment operations. The dust covers (Figure 2-2C) are installed during the preparation for flight operations at KSC. They are removed by the astronauts during the lunar deployment operations.

2-7. Fuel Cask Structure Assembly. The fuel cask structure assembly consists of the structure, thermal shield, cask bands, and cask guard as shown in Figure 2-3. The structure provides tie points for attachment of the fuel cask to the exterior of the LM, and provides the thermal shield to reflect fuel capsule thermal radiation away from the LM. The cask bands are clamped onto the cask, and provide tie points for attachment to the structure. The lower band includes a mechanism to tilt the fuel cask for access to the fuel capsule. The guard is provided to prevent astronaut contact with the cask during deployment.

Two temperature transducers monitor thermal shield temperature. The temperature measurements are included in the Apollo telemetry data.

2-8. Handling Tools. The handling tools consist of a dome removal tool (DRT), two universal handling tools (UHT), and a fuel transfer tool (FTT) as shown in Figure 2-4. These tools are used by the astronaut to deploy the ALSEP system on the lunar surface.

The DRT is used to remove and handle the dome of the fuel cask. The tool engages, locks in, and unlocks a nut on the dome. Rotation of the nut releases the dome.

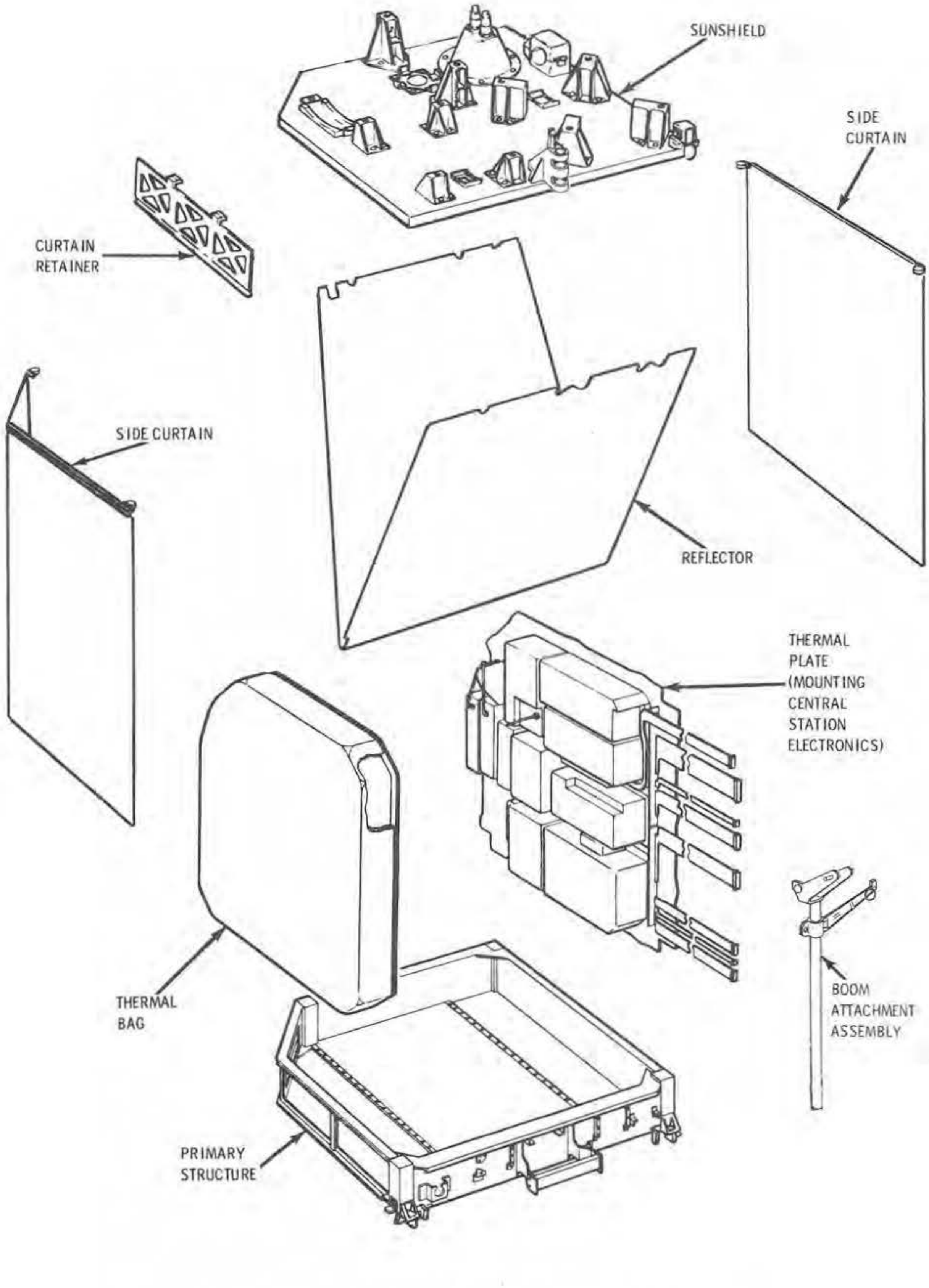


Figure 2-1. Structure, Subpackage No. 1 (Typical)

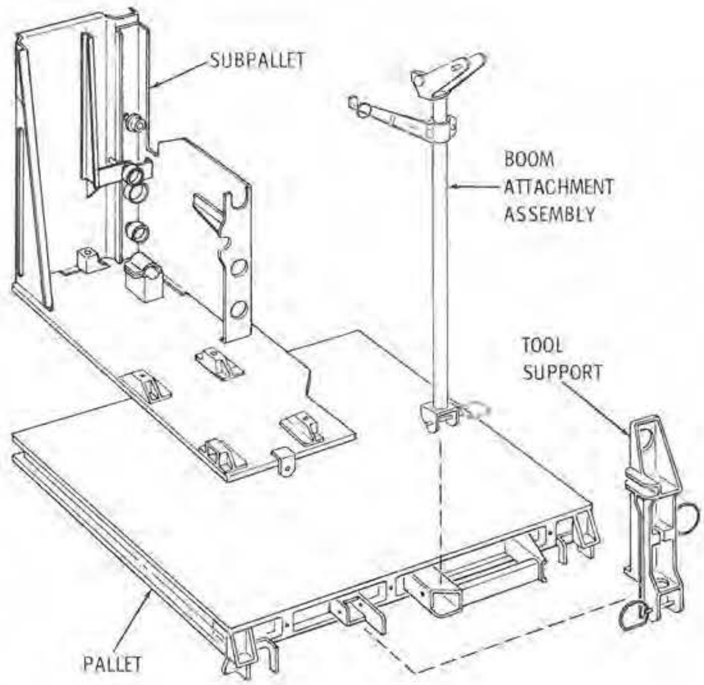


Figure 2-2. Structure, Subpackage No. 2 (Flights 1, 2, and 4)

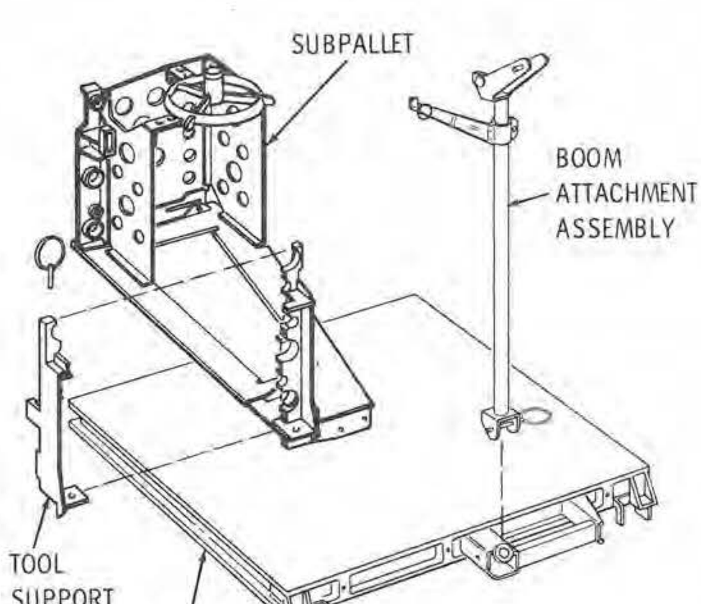


Figure 2-2A. Structure, Subpackage No. 2 (Flight 3)

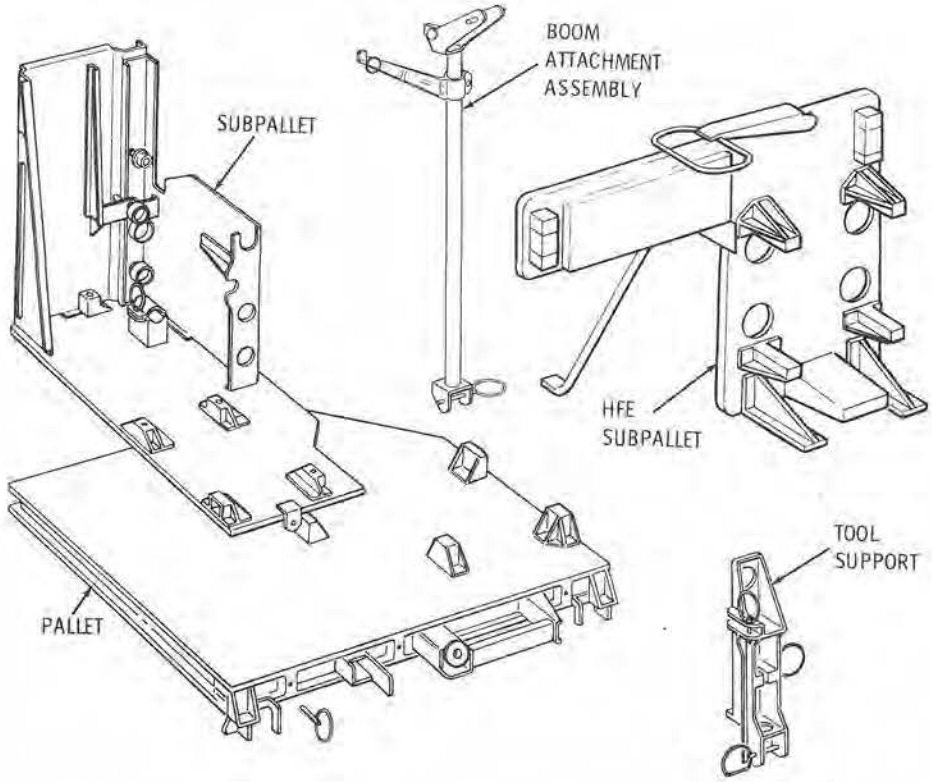
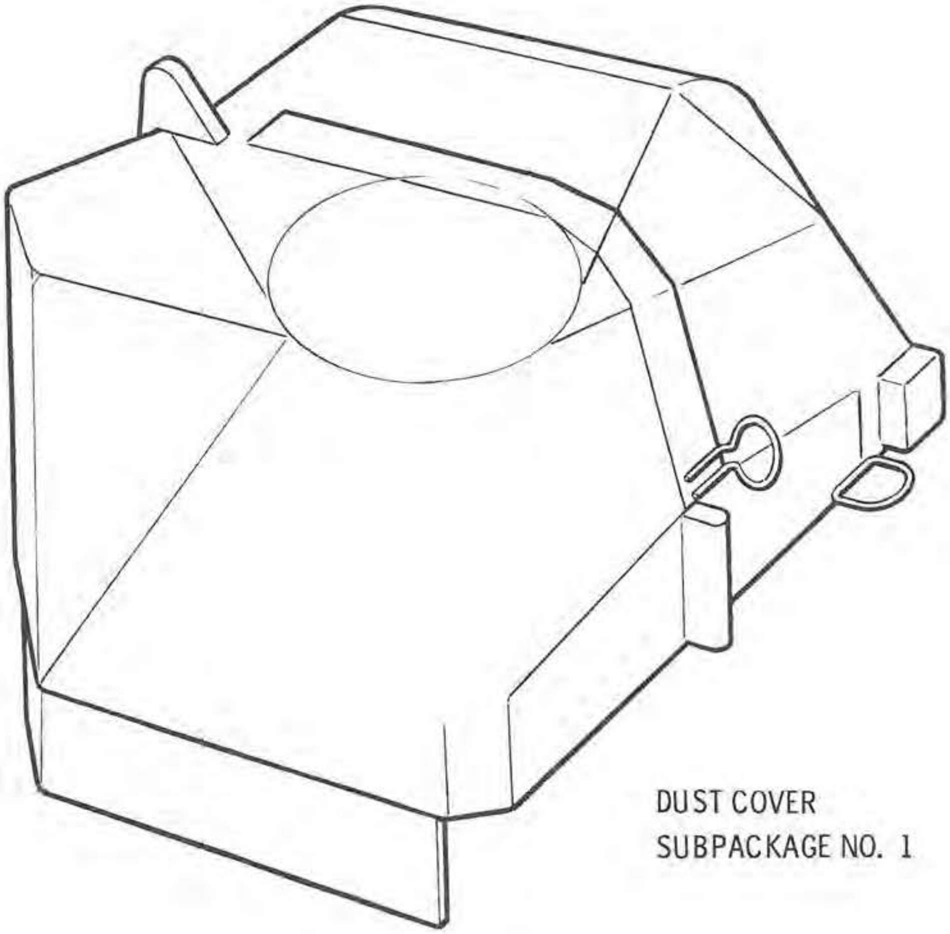
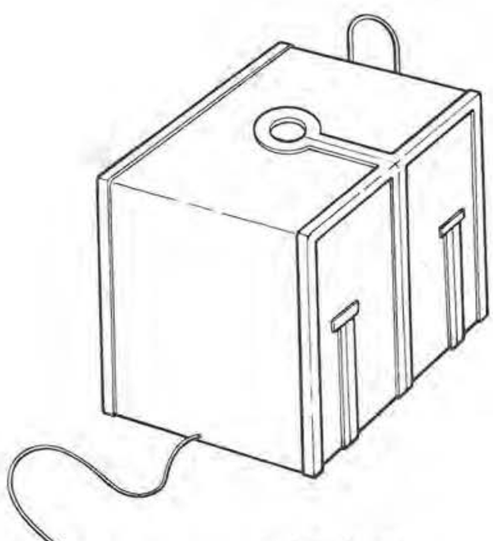


Figure 2-2B. Structure, Subpackage No. 2 (Array A-2)





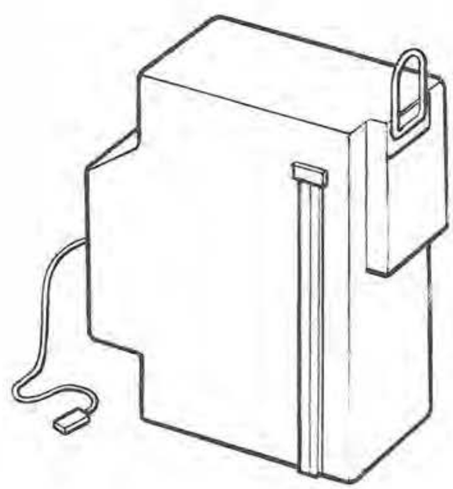


Figure 2-2C Dust Covers

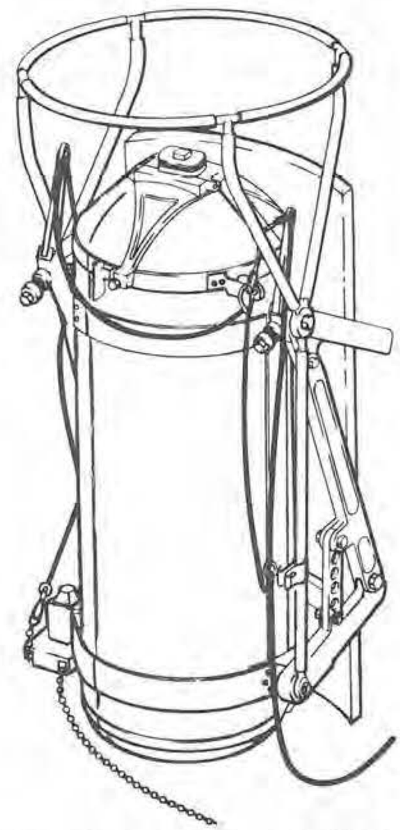


Figure 2-3 Fuel Cask Structure Assembly

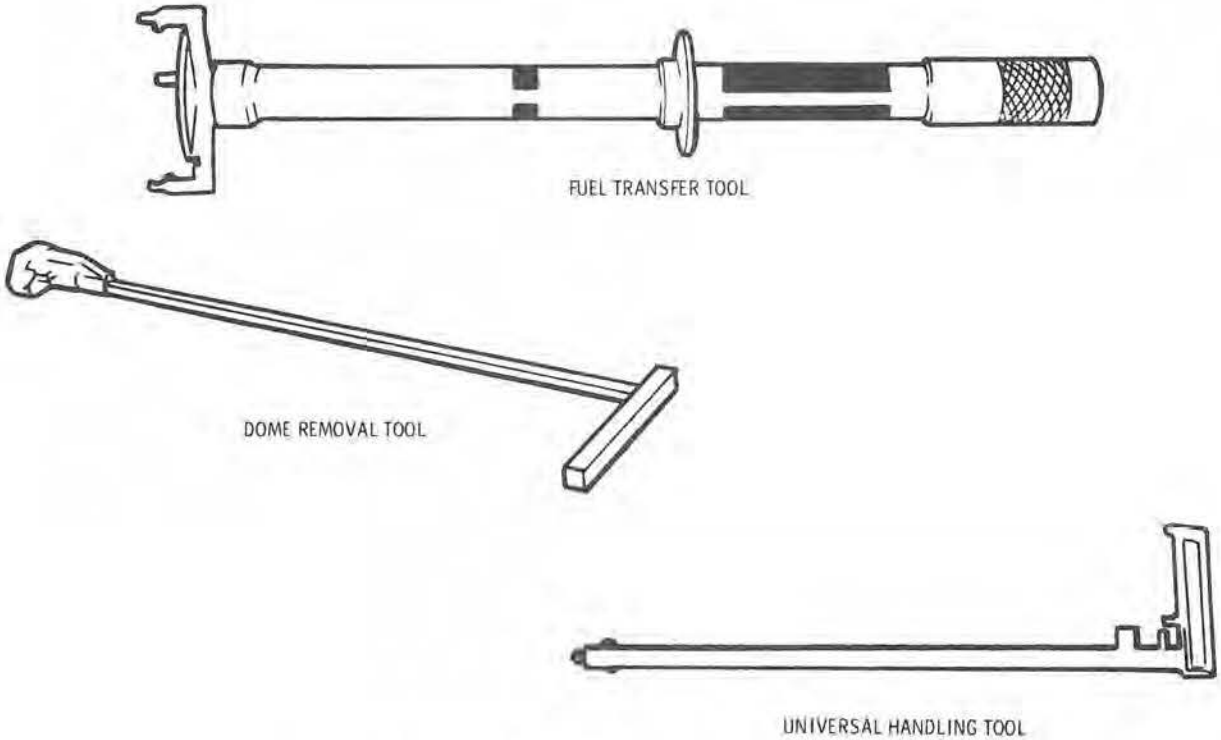


Figure 2-4 Handling Tools

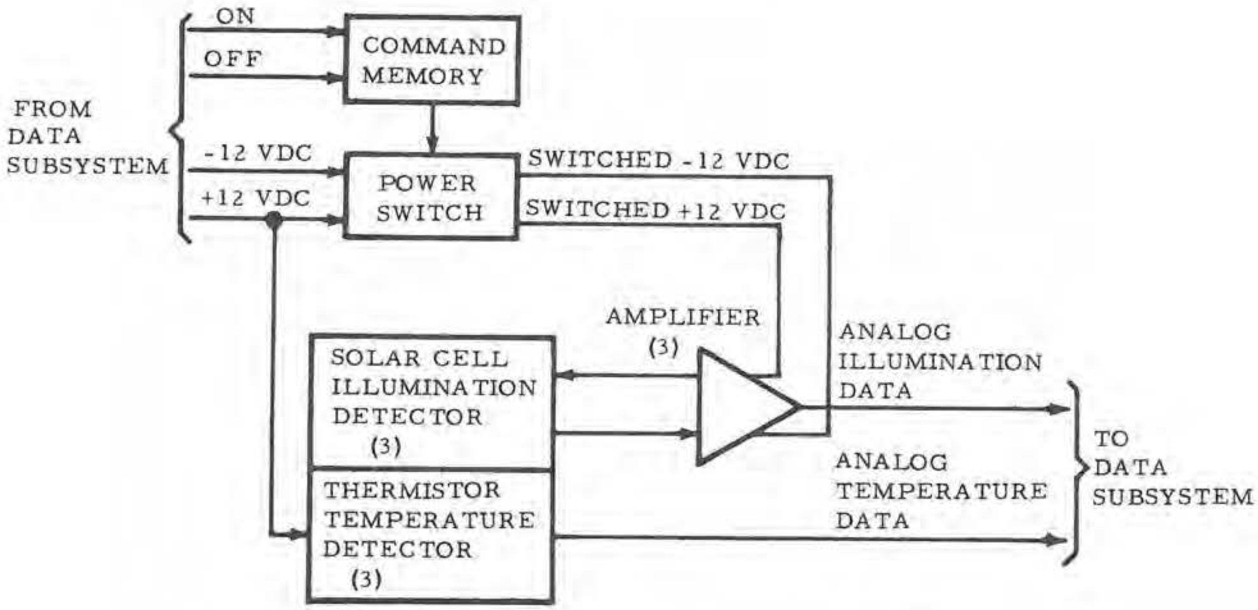


Figure 2-7. Dust Detector, Simplified Block Diagram

2-12A. DUST, THERMAL, AND RADIATION ENGINEERING MEASUREMENTS PACKAGE DESCRIPTION

The modified dust, thermal, and radiation engineering measurement package (DTREM II), part no. 2341440, will be used on ALSEP Flight 4 and Array A-2 to obtain data for assessment of dust accretion, the lunar radiation environment, and the lunar surface brightness temperature.

2-12B. DTREM II Physical Description. The DTREM II has two components: a sensor package (Figure 2-7A), and a printed circuit board. The sensor package is mounted on the subpackage no. 1 sunshield. It has three 1-cm by 2-cm solar cells located on the top horizontal surface. Two cells are protected by a 6-mil fused silica filter cover glass, and one cell is bare. The sensor package has three temperature sensors; one is attached to the underside of the center solar cell, one is attached to the inside surface, and one to the outside surface of the side (surface 3) of the package. The sensor package is connected through an H-film cable to the printed circuit board which is located in the power distribution unit of the data subsystem.

2-12C. DTREM II Functional Description. Dust accretion on the solar cells will reduce the intensity of solar radiation reaching the three cells. This can be measured by an equal reduction in output from the cells as a function of the amount of dust.

The radiation environment will be measured by comparing the reduction of the solar cell output voltages due to radiation degradation of the cells. Cover glass radiation shields on two of the cells reduce the amount of radiation reaching the cells. The third cell has no radiation protection. One of the protected cells has been irradiated to reduce its sensitivity to the radiation environment. Its output will be used as a base in measurement analysis. The different degrees of sensitivity and protection of the three cells enable them to form a simple spectrometer which measures proton dose in two energy intervals. The thermistor attached to the underside of the center solar cell provides a measure of the solar cell temperature.

The resistive temperature sensor on the outside of surface 3 is insulated from the DTREM II structure so that its temperature is determined mainly by the thermal radiative exchange with the lunar surface and deep space. The resistive temperature sensor on the inside of surface 3 provides the DTREM II structure temperature data needed to quantitatively define the heat leaks to the outside temperature sensor. The lunar surface brightness temperature will be derived from these measurements in conjunction with the data derived from the ALSEP sunshield, thermal plate, and electronics temperature measurements.

The outputs of the solar cells are applied to three amplifiers which condition the signals and apply them to three subcommutated analog data channels of the data subsystem. (See Figure 2-7B.) The temperature sensor outputs are also applied to three subcommutated analog data channels of the data subsystem.

DTREM II solar cell measurements are controlled by on and off commands from Earth. These commands are applied to the command memory through the data subsystem. The command memory stores the command and controls the operation of the power switches in accordance with the command. The two solid state switches control the application of +12 VDC and -12 VDC operating power from the data subsystem. Individual fusing protection is provided on each of the two voltages.

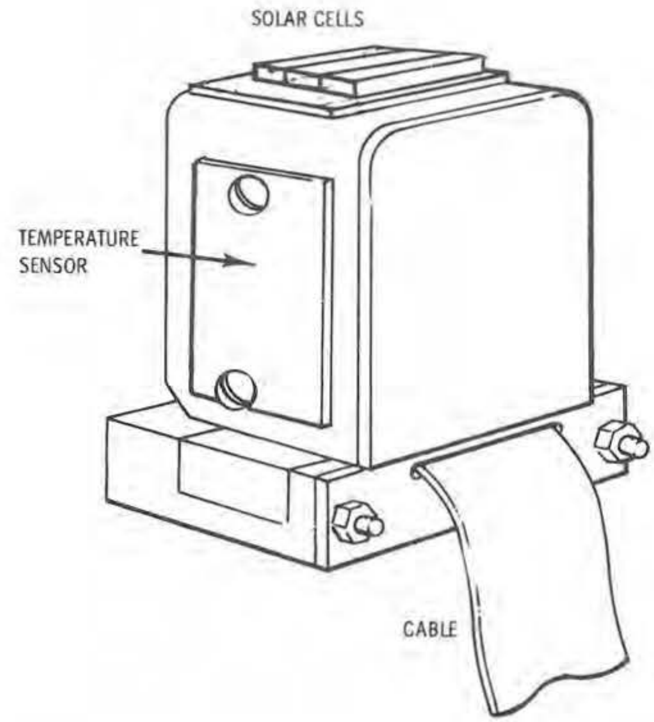


Figure 2-7A. Dust, Thermal, and Radiation Engineering Measurements Package

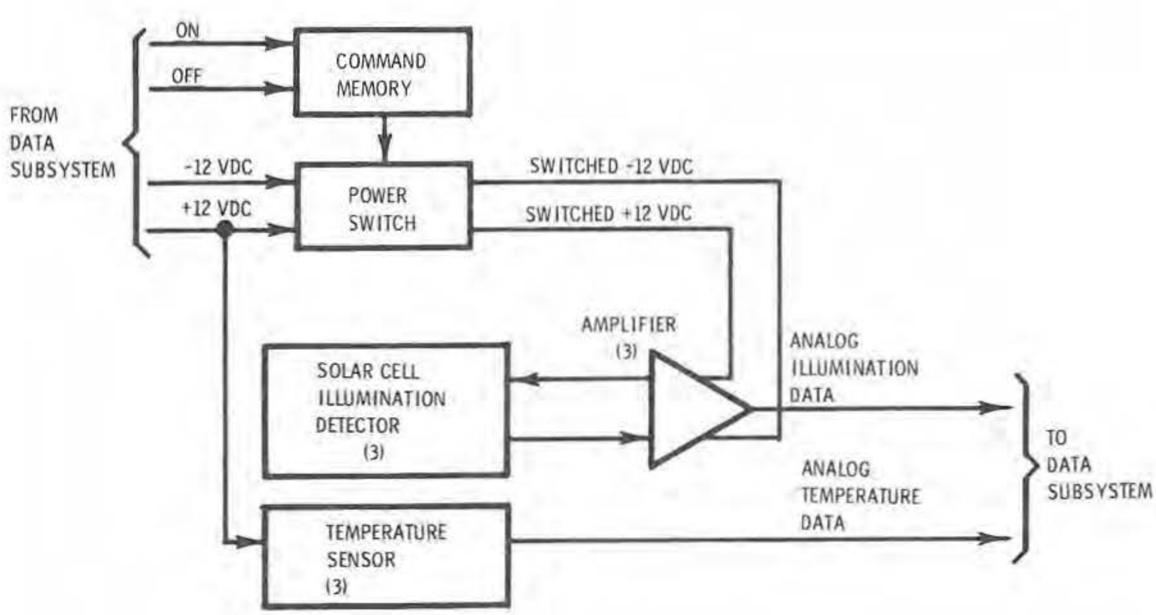


Figure 2-7B. Dust, Thermal, and Radiation Engineering Measurements Package, Simplified Block Diagram

Table 2-2. Electrical Power Subsystem Leading Particulars

Component	Characteristic	Value
Radioisotope Thermoelectric Generator	Output power	63 to 74 watts
	Output voltage	16.1 ± 0.5 vdc
	Hot junction temperature, lunar day	900 to 1100 deg. F
	Cold junction temperature, lunar day	350 to 550 deg. F
	Length	18.12 inches
	Diameter	16 inches
	Weight	28 pounds maximum
Fuel Capsule	Length	16.92 inches
	Diameter	2.6 inches (except end plate)
	Weight	15.46 pounds maximum
	Thermal output	1430 to 1520 watts
Power Conditioning Unit	Nominal outputs	+29 vdc at 1.19 amps +15 vdc at 0.08 amp +12 vdc at 0.30 amp +5 vdc at 0.90 amp -6 vdc at 0.05 amp -12 vdc at 0.15 amp
	Output voltage regulation	±1 percent
	Length	8.36 inches
	Width	4.14 inches
	Height	2.94 inches
	Weight	4.5 pounds
Fuel Cask	Length	23 inches
	Diameter	8.0 inches
	Weight	25.0 pounds nominal

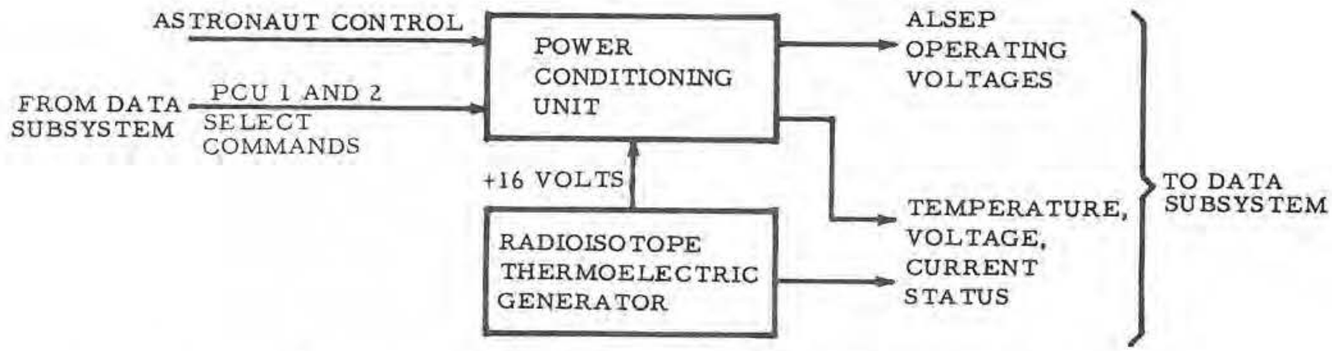


Figure 2-9. Electrical Power Subsystem, Functional Block Diagram

A manual control switch is provided as a back-up signal to allow the astronaut to start the PCU. PCU #1 and PCU #2 select commands from the data subsystem activate control circuits that switch the redundant circuits of the PCU.

Analog voltages from the RTG and PCU provide temperature, voltage, and current status to the data subsystem.

2-21. EPS DETAILED FUNCTIONAL DESCRIPTION

2-22. EPS Radioisotope Thermoelectric Generator. The operation of the RTG is illustrated in the block diagram of Figure 2-10. A radioisotope source (fuel capsule) develops thermal energy that is applied to the hot frame (inner case). The difference in temperature between the hot frame and the cold frame causes the thermoelectric couple assembly (thermopile) to develop electrical energy through thermoelectric action. The electrical energy produced by the thermopile provides a minimum of 63 watts at 16 volts to the power conditioning unit.

Excess heat from the thermopile is conducted through a cold frame (outer case) to a thermal radiator (heat rejection fins) for dissipation into the lunar environment. This maintains the cold frame at a lower temperature than the hot frame so that thermoelectric action is maintained.

Temperatures are monitored at three cold frame and at three hot frame locations to provide six temperature signals to the data subsystem.

2-23. EPS Power Conditioning Unit. The power conditioning unit performs three major functions:

a. Voltage conversion
b. Voltage regulation
c. RTG protection.

The PCU contains redundant power conditioners. As shown in Figure 2-11, each power conditioner consists of a dc-to-dc power converter (inverter and rectifiers), which converts the RTG 16-volt input to the six operating voltages, and a shunt voltage regulator to maintain the output voltages within approximately ± 1%. The input voltage is also regulated by this action because of the fixed ratio converter. It is necessary to keep a constant load on the generator to prevent generator overheating.

2-24. DATA SUBSYSTEM

The data subsystem is the focal point for control of ALSEP experiments and the collection, processing, and transmission of scientific data and engineering status data to the Manned Space Flight Network (MSFN). To accomplish the basic functions of (a) reception and decoding of uplink (Earth-to-Moon) commands (b) timing and control of experiment subsystems, and (c) the collection and transmission of downlink (Moon-to-Earth) scientific and engineering data, the data subsystem consists of an integration of units interconnected as shown in Figure 2-12. The uplink shown in Figure 2-12 requires the antenna, diplexer, command receiver, and command decoder components of the data subsystem. The downlink requires the data processor, transmitter, diplexer and antenna components. The major components of the data subsystem and associated functions are listed in Table 2-3.

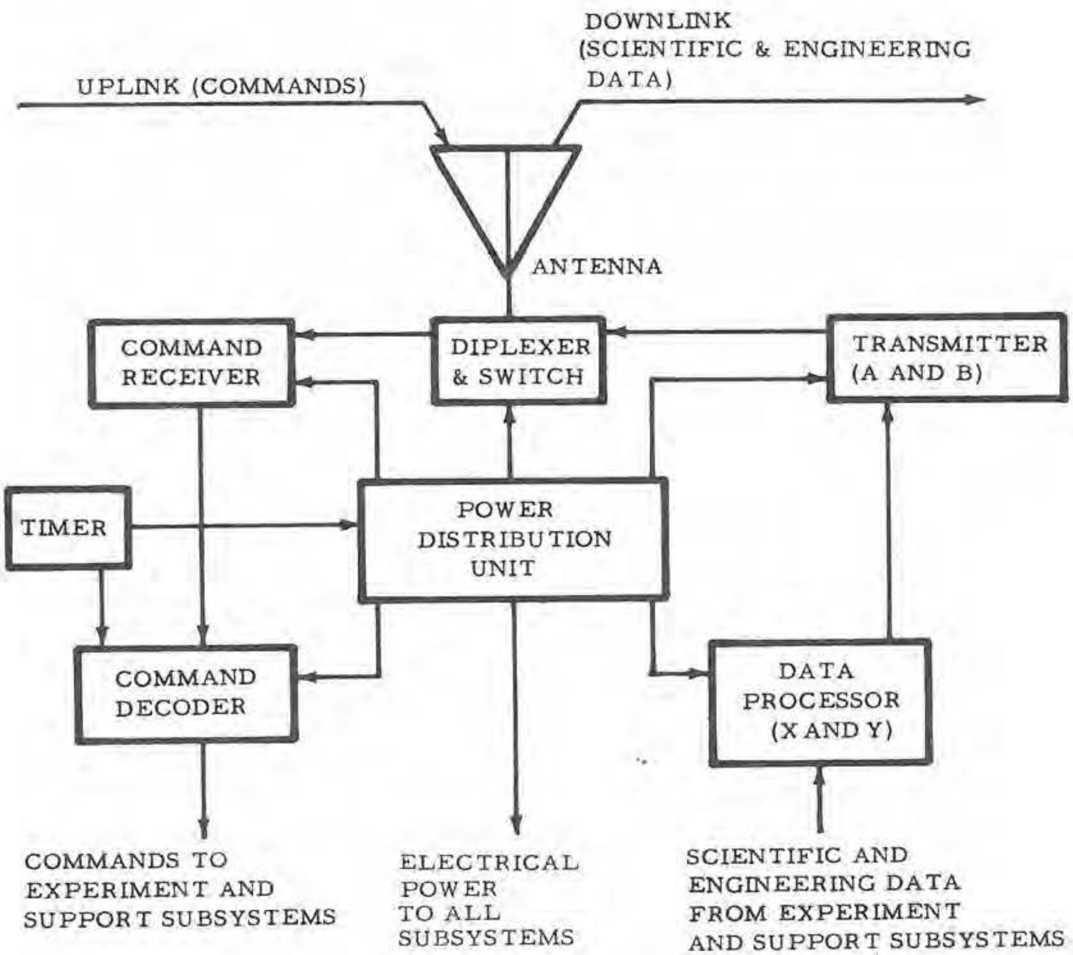


Figure 2-12. Data Subsystem, Simplified Block Diagram

Table 2-3. Data Subsystem Component Functions

Component	Function
Antenna	Provides simultaneous uplink reception and downlink transmission of ALSEP signals.
Diplexer switch	Connects either transmitter to the antenna.
Diplexer filter	Connects receiver input and transmitter output to the antenna.
Transmitter	Transmits Moon-to-Earth downlink signals.
Command receiver	Accepts Earth-to-Moon uplink signal.
Command decoder	Decodes received command signals and issues commands to the system.
Central station timer	Provides timing signals used to initiate periodic automatic functions, and switch off transmitter after 720 (±30) days.
Resettable solid state timer 2338511	Provides timing signals to initiate periodic automatic functions, and switch off transmitter after 97 (±5) days. Reset by command.
Data processor	Collects and formats scientific data inputs from the experiments. Collects and converts analog housekeeping data into binary form.
Power distribution	Controls power switching and conditions engineering status data.

2-25. DATA SUBSYSTEM PHYSICAL DESCRIPTION

The data subsystem components are mounted on a 23.25-inch by 20-inch section of the central station thermal plate. Figure 2-13 shows data subsystem component location within the central station. A pre-formed harness electrically connects the components. The harness is attached to each component with a multi-pin connector. Power for each unit and electrical signals are conducted to and from each component via the harness. Coaxial cables connect the command receiver and transmitters to the diplexer switch and thence to the antenna.

Other items installed within the central station include central station temperature sensors, manual control switches, transmitter and receiver heaters, central station backup heaters, and a central station thermostat. Five thermal plate sensors are placed throughout the central station to monitor engineering temperature status data. Manual control switches are provided as a backup to permit the astronaut to start system operation in the event of uplink failure.

The overall weight of the data subsystem is approximately 25 pounds and the power consumption is approximately 20 watts.

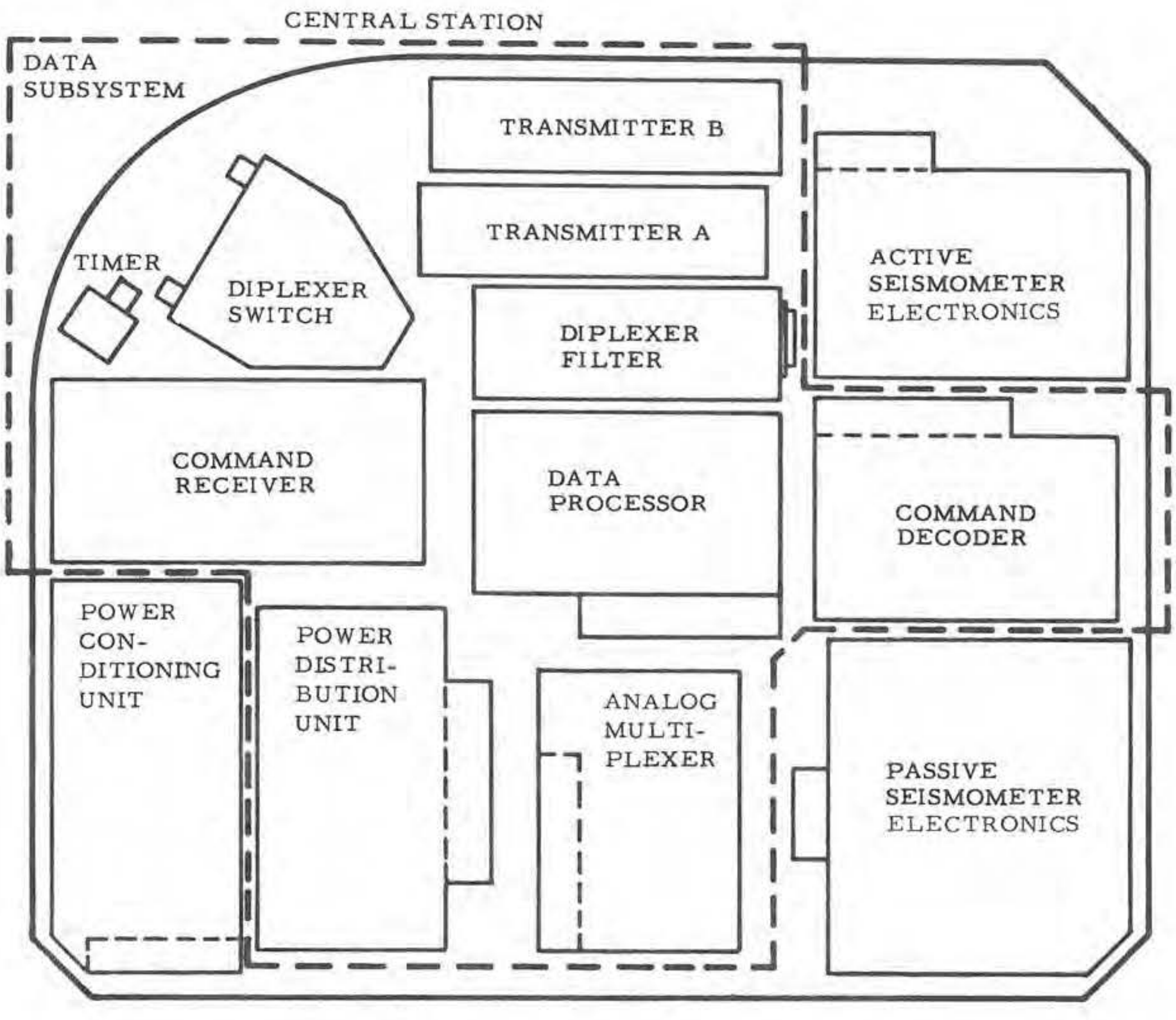


Figure 2-13. Data Subsystem Component Location

2-26. DATA SUBSYSTEM FUNCTIONAL DESCRIPTION

Uplink command data transmitted from the MSFN is received by the data subsystem antenna, routed through the diplexer, demodulated by the command receiver, decoded by the command decoder, and applied to the experiment and support subsystems as discrete commands. The discrete commands control experiment and support subsystem operations and initiate command verification functions. Table 2-4 lists the uplink commands by subsystem termination.

Table 2-4. ALSEP Commands

Command Usage	Number
Active seismic experiment	7
Passive seismic experiment	15
Heat flow experiment	10
Magnetometer experiment	8
Charged particle experiment	8
Suprathermal ion detector experiment	5
Solar wind experiment	1
Command decoder	2
Data Processor	5
Power distribution unit	29
Power conditioning unit	2
Timer (Array A-2 only)	1

Downlink data consists of analog and digital data inputs to the data processor from the experiment and support subsystems in response to periodic demands from the data processor. Scientific inputs to the data processor from the experiment subsystem are primarily in digital form. Engineering data is usually analog and consists of status and housekeeping data such as temperatures and voltages which reflect operational status and environmental parameters. The data processor accepts binary and analog data from the experiment and support subsystems. It generates timing and synchronization signals, converts analog data to digital form, formats digital data, and provides data in the form of a split-phase modulated signal to the transmitter. The transmitter generates the downlink transmission carrier and phase modulates that carrier with the signal from the data processor. The transmitter signal is selected by the diplexer switch and routed to the antenna for downlink transmission to the MSFN.

Figure 2-14 shows a functional diagram of the data subsystem and its interfaces with other ALSEP subsystems for Flight 1. Figures 2-15, 2-16, and 2-16A show functional block diagrams of the Flight 3, Flight 4, and Array A-2 ALSEP systems. The later flight configurations are similar to the Flight 1 configuration except for the selection of experiments. Redundant channels are provided for the transmitter and portions of the command decoder and data processor to improve system reliability.

The uplink transmission from MSFN is a 2119 MHz RF carrier with a 2 KHz data subcarrier modulated to a 1 KHz synchronizing subcarrier. The command receiver demodulates the carrier and provides the composite 2 KHz and 1 KHz subcarrier to the command decoder. The command decoder demodulator section detects the 2 KHz command data subcarrier and 1 KHz timing signal and applies both to the redundant digital decoder sections (A and B) of the command decoder. The digital decoder sections identify correct address codes, decode the digital

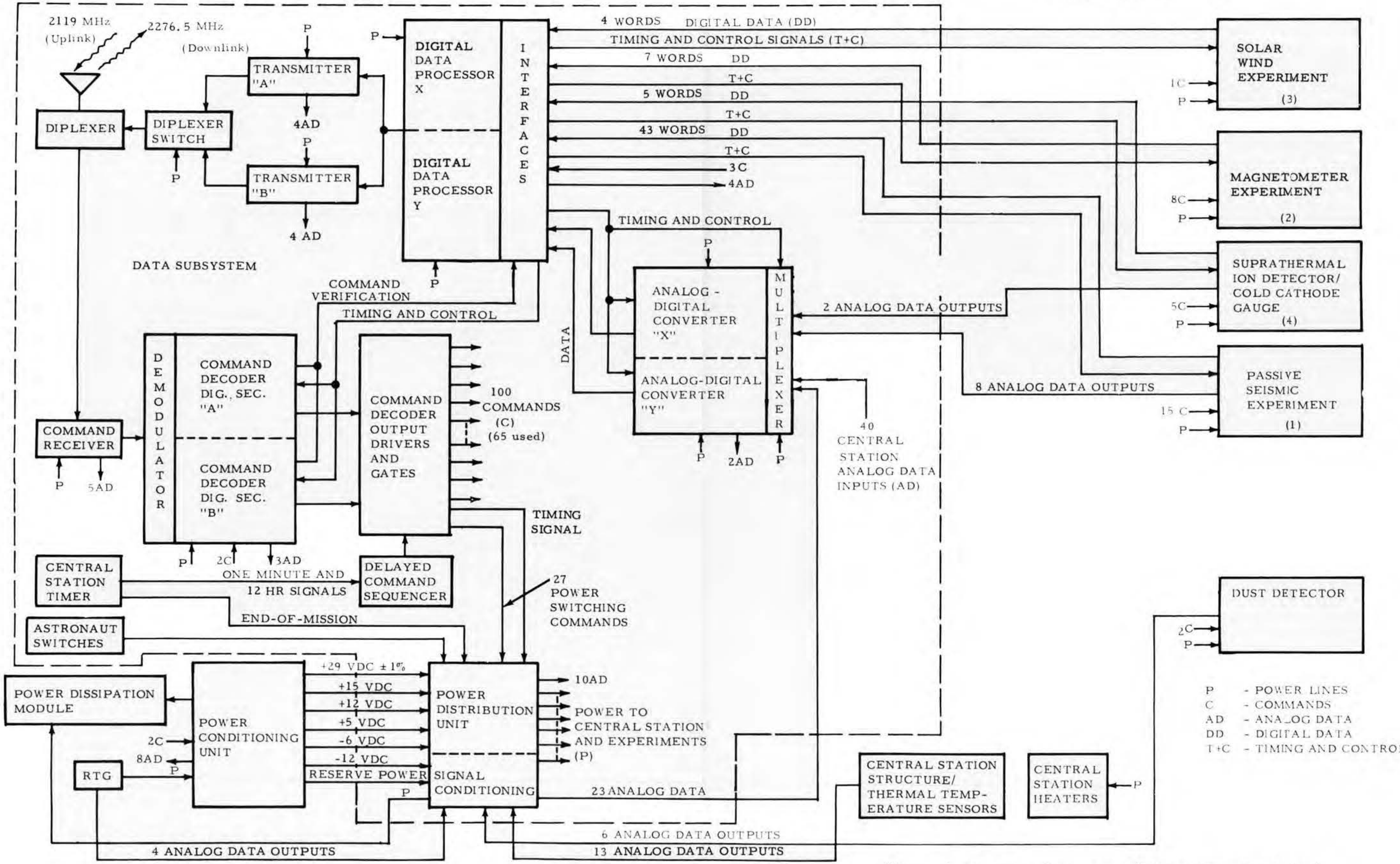


Figure 2-14. Data Subsystem (Flight 1 Configuration) Functional Block Diagram

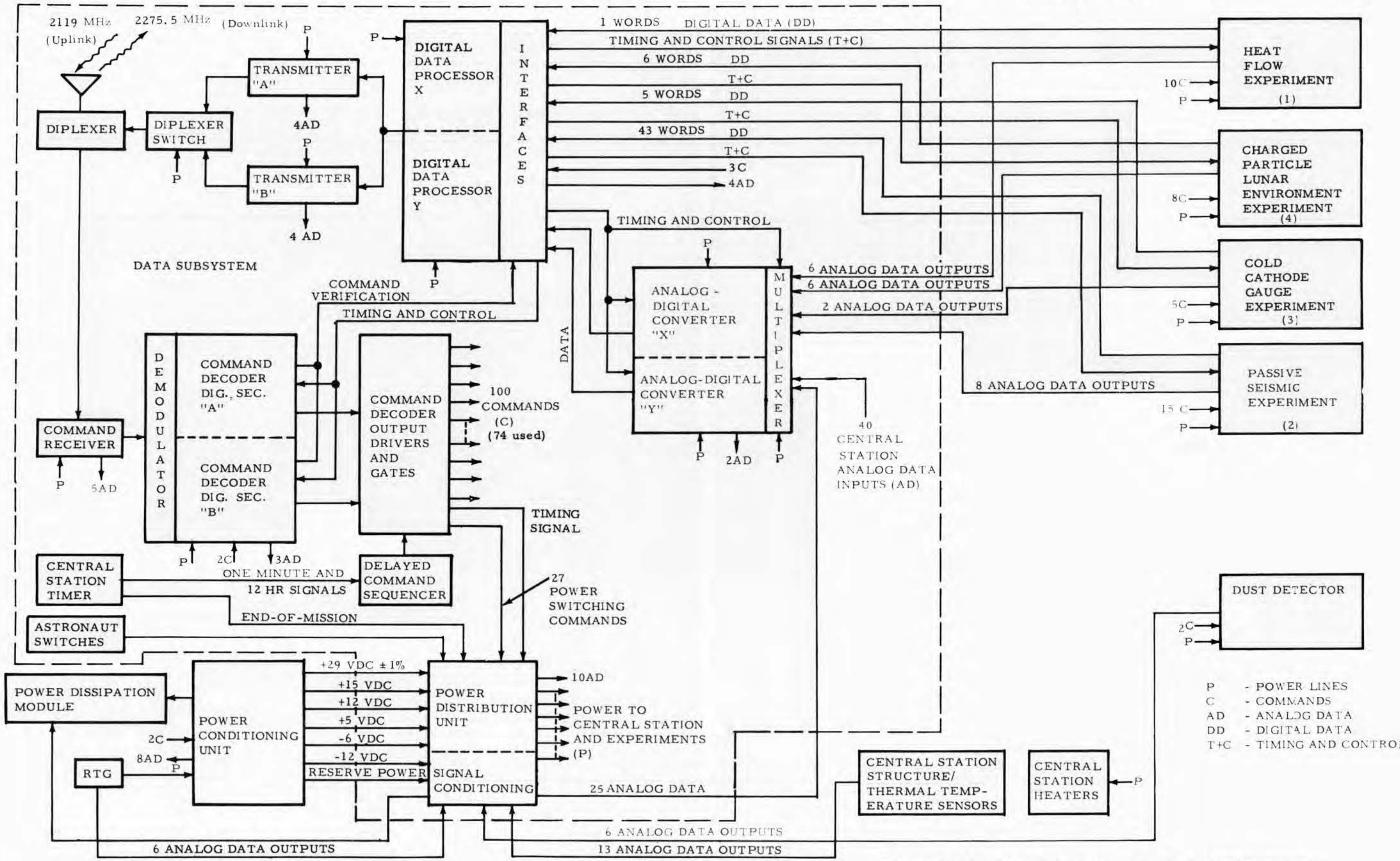


Figure 2-15. Data Subsystem (Flight 3 Configuration), Functional Block Diagram

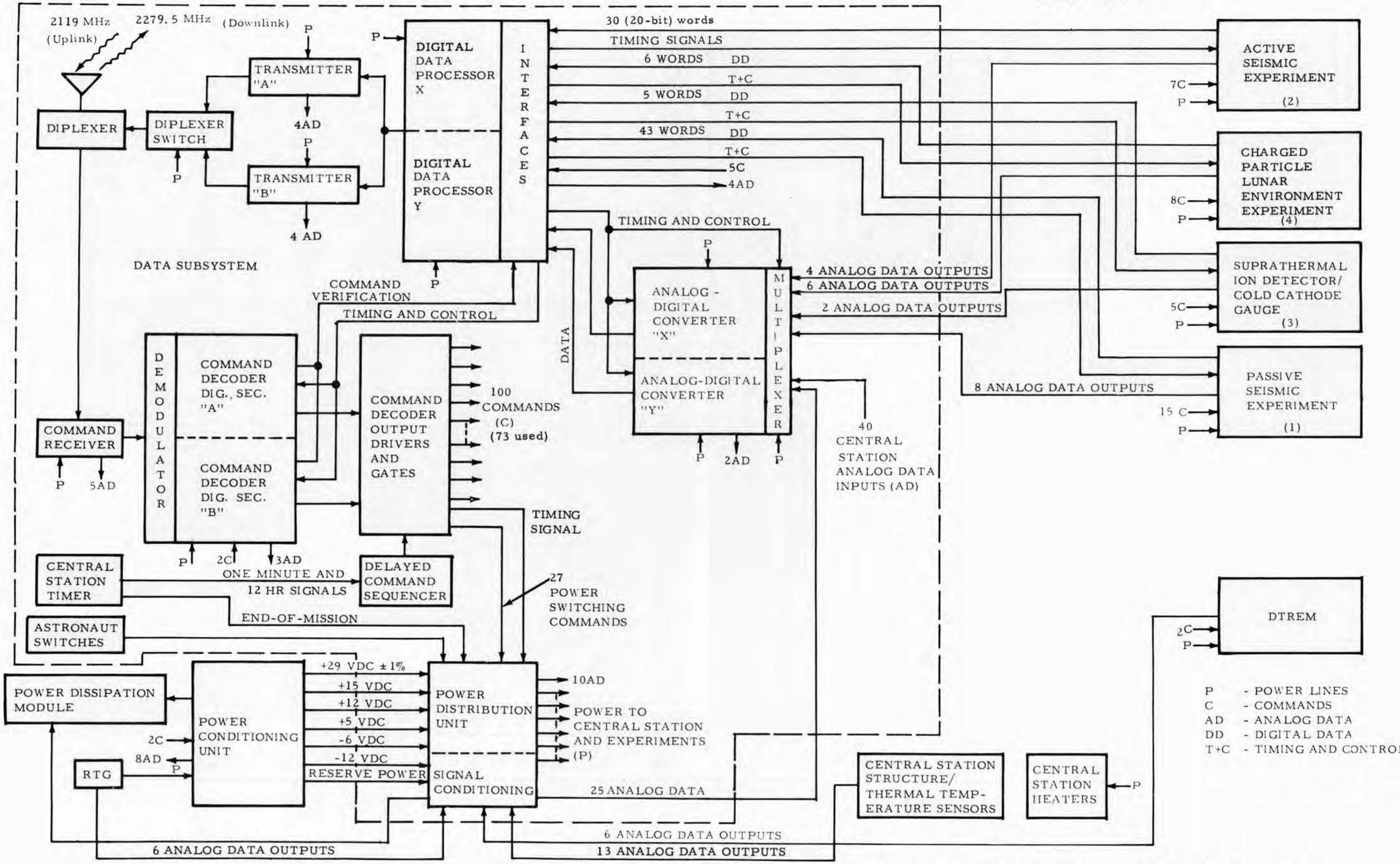


Figure 2-16. Data Subsystem (Flight 4 Configuration), Functional Block Diagram

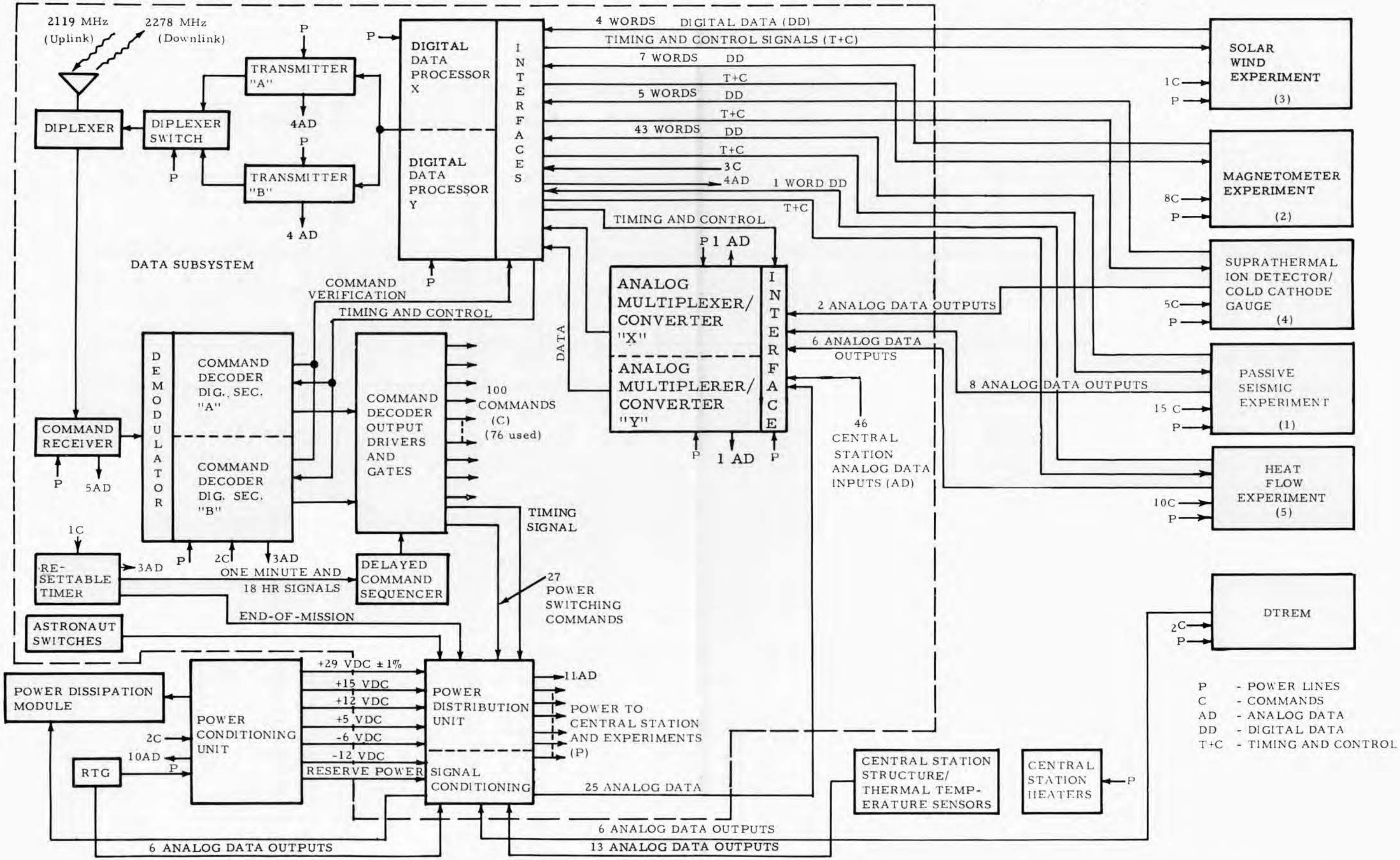


Figure 2-16A. Data Subsystem (Array A-2), Functional Block Diagram

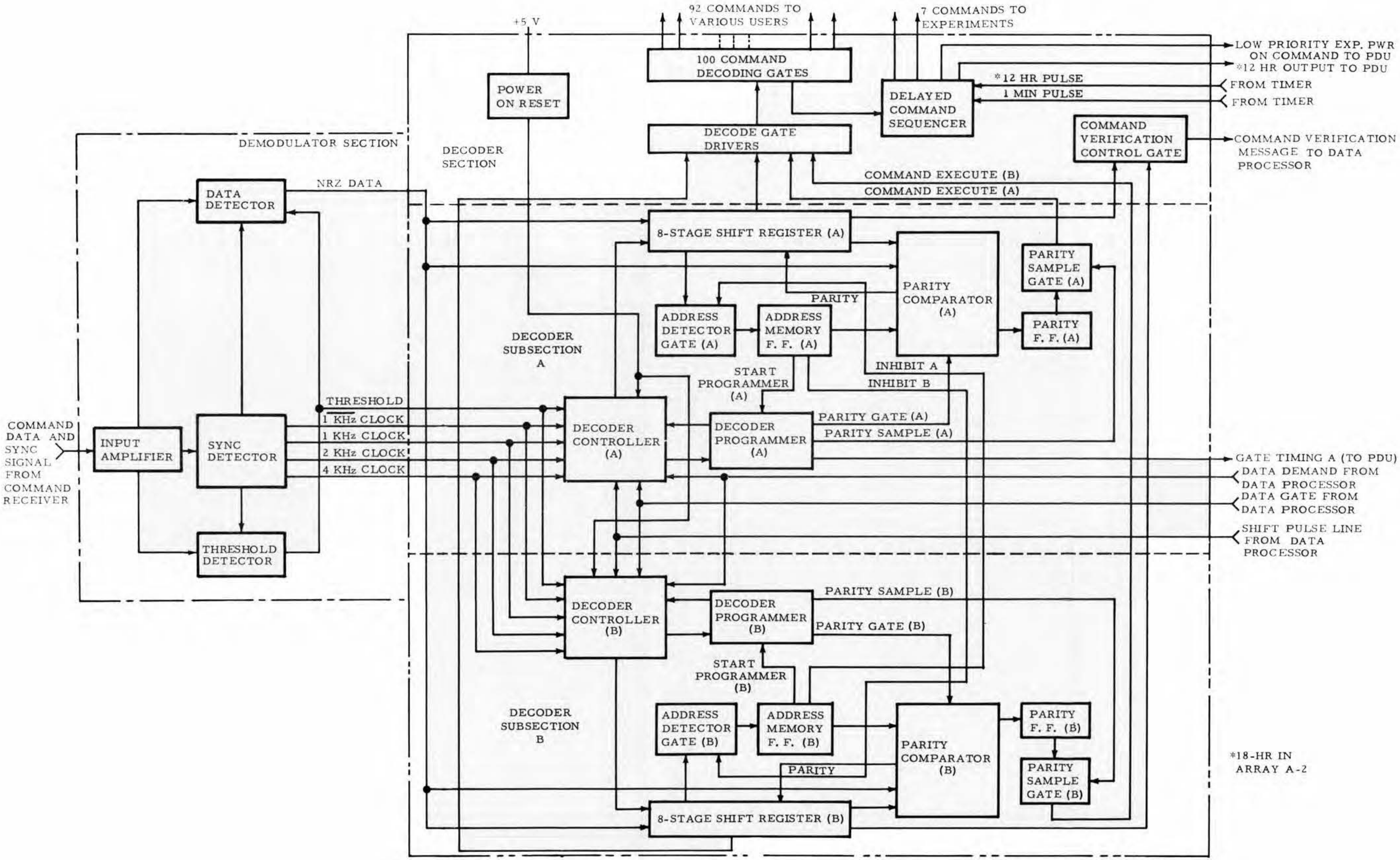


Figure 2-25. Data Subsystem Command Decoder, Functional Block Diagram

Normally at this time, shift register A contains the seven bit command and the parity information. This information, named the command verification message, stays in the register until the data processor requests transfer (data demand) of this data. As soon as the transfer takes place, a master reset signal returns the command decoder to the search mode. Likewise, the command verification message is inhibited if the data demand is not activated during the following two-second timing interval.

In contrast to the normal mode of operation, the active seismic mode inhibits the command verification message from reaching the data processor. The command decoder receives an active seismic ON command to operate in this mode and an active seismic OFF command to operate in the normal mode. The foregoing description applies equally to subsection B whenever address gate B detects its own address.

2-40. Data Commands - Commands are transmitted as a 61-bit message with the following format:

a.	Preamble	20 bit minimum (all zeros or all ones for synchronization)
b.	Decoder address	7 bits (selects decoder subsection)
c.	Command complement	7 bits (for parity check)
d.	Command	7 bits
e.	Timing	20 bits (all zeros or all ones - command execution interval)

The demodulator section achieves phase and bit synchronization during the first eighteen timing bits of the preamble and maintains synchronization during the entire command timing interval.

The 64, 32, 16, 8, 4, 2, 1 binary weighted code is used to decode the seven-bit decoder address group, the seven-bit command complement group, and the seven-bit command group.

Seven address bits are used to uniquely command the ALSEP systems. Each command decoder shall respond to two address codes; one for section A and another for section B. Address codes have been selected as follows:

ALSEP No.	Address Code No.	Binary Weighted Code Pattern	Command Decoder No.
1	88	1011000	1A
1	24	0011000	1B
A-2	78	1001110	A-2A
A-2	14	0001110	A-2B

ALSEP No.	Address Code No.	Binary Weighted Code Pattern	Command Decoder No.
3	105	1101001	3A
3	41	0101001	3B
4	21	0010101	4A
4	53	0110101	4B

The seven-bit command complement group is transmitted after the address and is followed with the seven-bit command group. The command decoder performs a bit-by-bit parity check over the command complement and command bits. A decoder command is executed if parity is correct and is rejected if incorrect.

Twenty timing bits are transmitted to allow for a 20 millisecond command execution timing interval.

The command decoder is capable of accepting 128 different command messages and is designed to provide 100 commands to ALSEP users. All command code numbers except the following are available to the users: 0, 1, 2, 4, 8, 14, 16, 22, 24, 32, 39, 41, 49, 63, 64, 78, 86, 88, 95, 103, 105, 111, 113, 119, 123, 125, 126, 127.

Provisions have been incorporated in the command decoder to accommodate a maximum of 114 discrete commands which have been allotted as follows:

a.	Experiments	62
b.	Power distribution	29
c.	Power conditioning unit	2
d.	Data processor	5
e.	Command decoder	2
f.	Available for test purposes	14
g.	Timer	1

The command decoder stores an eight-bit command verification message which consists of seven command bits and a parity bit. The command verification message is sampled by, and shifted to, the data processor once every frame time, if a command has been received.

The command word rate is limited to approximately one message per second during a data processor normal mode of operation and to approximately one message per two seconds during the data processor slow mode of operation.

No special requirements exist for intercommand operation. Loss of synchronization between commands does not affect the operation of the command decoder.

A list of the discrete commands issued by the command decoder is presented in the Appendix.

The command decoder automatically generates seven one-time commands after a 96-hour delay. The delayed command functions and time of execution are listed in Table 2-10. A flow chart of delayed command sequences is shown in Figure 2-27. (A 144-hour delay is used in Array A-2).

Monitoring circuits provide telemetry data to the data processor on the status of command decoder internal, base and demodulator oscillator temperatures.

Table 2-10. Data Subsystem Delayed Command Functions (Flights 1, 3, and 4)

Command	Function	Time of Execution
75	Blow CPLEE dust cover	96 hours + 2 minutes
69	Set CCIG seal break	"
59	Uncage PSE	"
72	Execute CCIG seal break	96 hours + 3 minutes
82	Blow SWE dust cover	96 hours + 4 minutes
71	Set SIDE blow dust cover	"
72	Execute SIDE blow dust cover	96 hours + 5 minutes
89	Magnetometer flip calibrate	108 hours + 1 minute, then every 12 hours
42	Restore power to lowest priority experiment	108 hours + 7 minutes, then every 12 hours

Table 2-10A. Data Subsystem Delayed Command Functions (Array A-2)

Command	Function	Time of Execution
59	Uncage PSE	144 hours + 2 minutes
69	Set CCIG seal break	"
72	Execute CCIG seal break	144 hours + 3 minutes
82	Blow SWE dust cover	144 hours + 4 minutes
71	Set SIDE blow dust cover	"
72	Execute SIDE blow dust cover	144 hours + 5 minutes
89	Magnetometer flip calibrate	162 hours + 1 minute, then every 18 hours
42	Restore power to lowest priority experiment	162 hours + 7 minutes, then every 18 hours

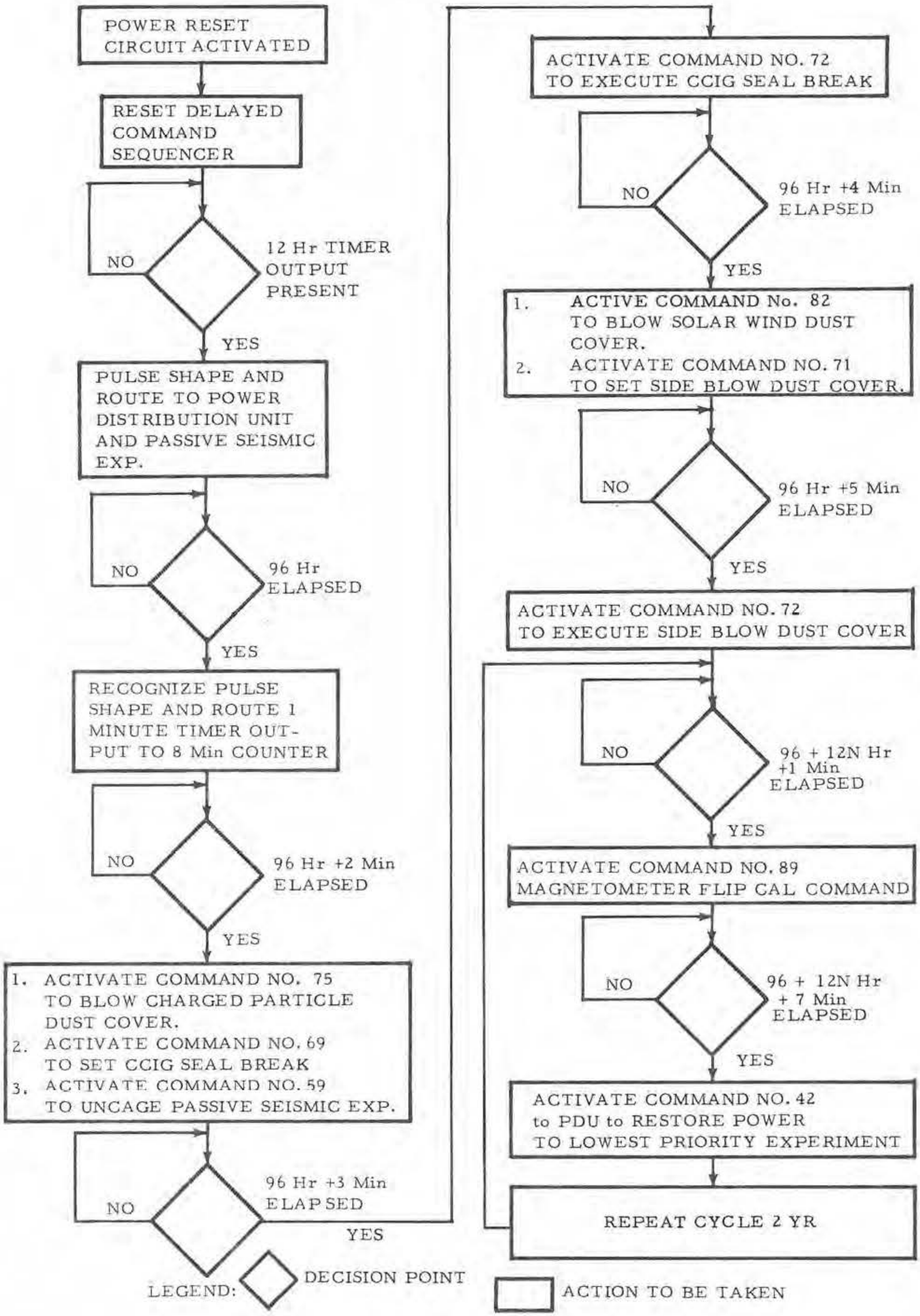


Figure 2-27. Data Subsystem Delayed Command Sequence, Functional Flow Chart

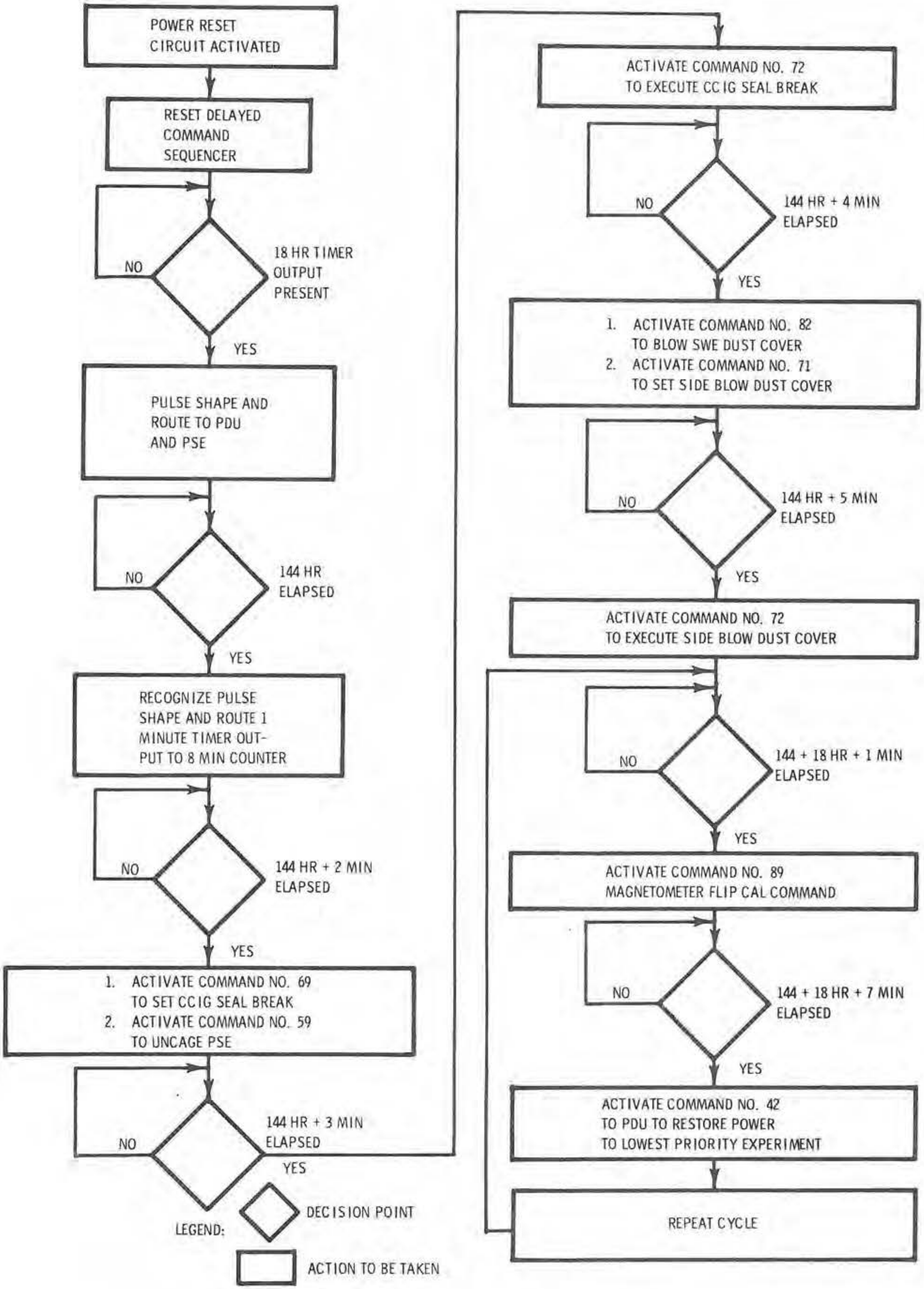


Figure 2-27A. Data Subsystem Delayed Command Sequence, Functional Flow Chart (Array A-2)

2-41. DATA SUBSYSTEM CENTRAL STATION TIMER

The central station timer provides predetermined switch closures used to initiate specific functions within the data subsystem of ALSEP Flight 1, 3, and 4 systems.

2-42. Data Subsystem Central Station Timer Physical Description. The central station timer consists of a Bulova model TE-12 Accutron clock and a long life mercury cell battery.

The timer is housed in a black anodized aluminum case approximately 2.6 inches long and 1.3 inches in diameter. Weight of the unit is slightly more than 0.25 pounds. Solder terminals provide electrical connection. Figure 2-28 shows the central station timer.

2-43. Data Subsystem Central Station Timer Functional Description. Figure 2-29 shows a block diagram of the timer. The central station timer starts to provide back-up timing pulses when the IPU cable is mated to the central station. A tuning fork controls the frequency of a transistorized 360 Hz oscillator which provides the basic timing frequency. This timing frequency drives the electromechanical arrangement used to provide three back-up timing switch closures. The switch closures are at one minute, 12-hour, and 720-day intervals. The one-minute and 12-hour closures are continuously repetitive and are applied to the delayed command sequencer in the command decoder. The 720-day closure occurs only once and initiates a permanent off command to the ALSEP transmitter. The commands activated by the command decoder delayed command sequencer are listed in Table 2-10.

Figure 2-28. Data Subsystem Central Station Timer

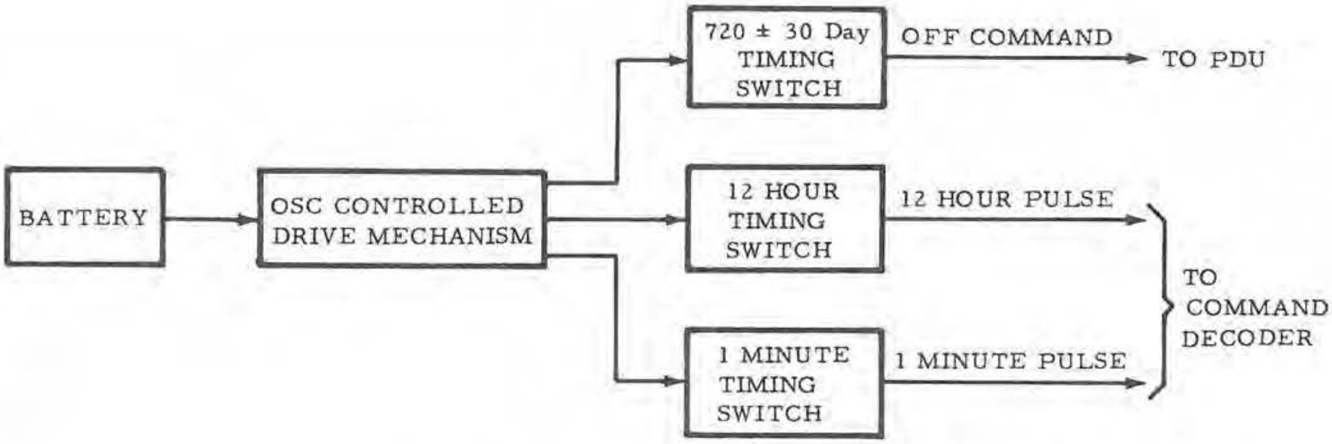


Figure 2-29. Data Subsystem Central Station Timer, Block Diagram

2-43A. DATA SUBSYSTEM RESETTABLE SOLID STATE TIMER

The resettable solid state timer is used in the ALSEP Flight System Array A-2 to provide timing signals to the command decoder, and to terminate ALSEP transmission.

The timer generates its own reset signal upon initial application of +12 vdc power from the PCU so that it will begin its count at zero. It will retain its count during approximately 30 seconds of power loss. Its outputs are 1-minute, 18-hour, and 1.5-month timing and telemetry signals, and a 97 (±5) day transmitter off signal. A timer reset command from Earth will reset the timer to initiate an additional 97 (±5) day ALSEP transmission period.

2-43B. Resettable Solid State Timer Physical Description. The resettable solid state timer (Figure 2-29A) consists of three circuit boards housed in an aluminum case approximately 2.8 inches high, 1.4 inches wide, and 2.2 inches long. Electrical connections are made through a 37-pin connector. Maximum weight of the unit is 7.3 ounces.

2-43C. Resettable Solid State Timer Functional Description. Figure 2-29B is a functional block diagram of the resettable solid state timer. An oscillator generated 16,384 Hz (±5%) clock is divided down to drive two parallel 28-bit ripple counter divider chains at a 1-second rate. The count of divider chain no. 1 is decoded to generate the 1-minute and the 18-hour timing signals which are applied to the delayed command sequencer of the command decoder.

Figure 2-29A. Resettable Solid State Timer

The three-month output (bit 24) of each of the divider chains is used to drive the transmitter turn-off relay, while ensuring that a premature turn-off does not occur. Operation of the relay applies a transmitter-off signal to the transmitter on/off relay in the PDU. Application of the timer reset command at any time prior to relay operation will reset the counters to extend transmitter operation for a three month period.

The 1.5 month count (bit 23) of each of the divider chains, and the 18 hour count are applied to the data processor analog multiplexer for downlink telemetry.

2-44. DATA SUBSYSTEM DATA PROCESSOR

The data processor generates ALSEP timing and control signals, collects and formats both analog and digital data, and provides split-phase modulated data used for phase modulation of the downlink RF carrier.

2-45. Data Subsystem Data Processor Physical Description. The data processor consists of two physical components: (a) digital data processor, (b) analog multiplexer/converter. ALSEP flight 1, 3, and 4 systems use analog multiplexer/converter P/N 2330524, and ALSEP Array A-2 uses dual analog multiplexer/converter P/N 2338900. Figures 2-30 and 2-31 show the digital processor and the analog multiplexer/converter. Multilayer printed circuit boards are used

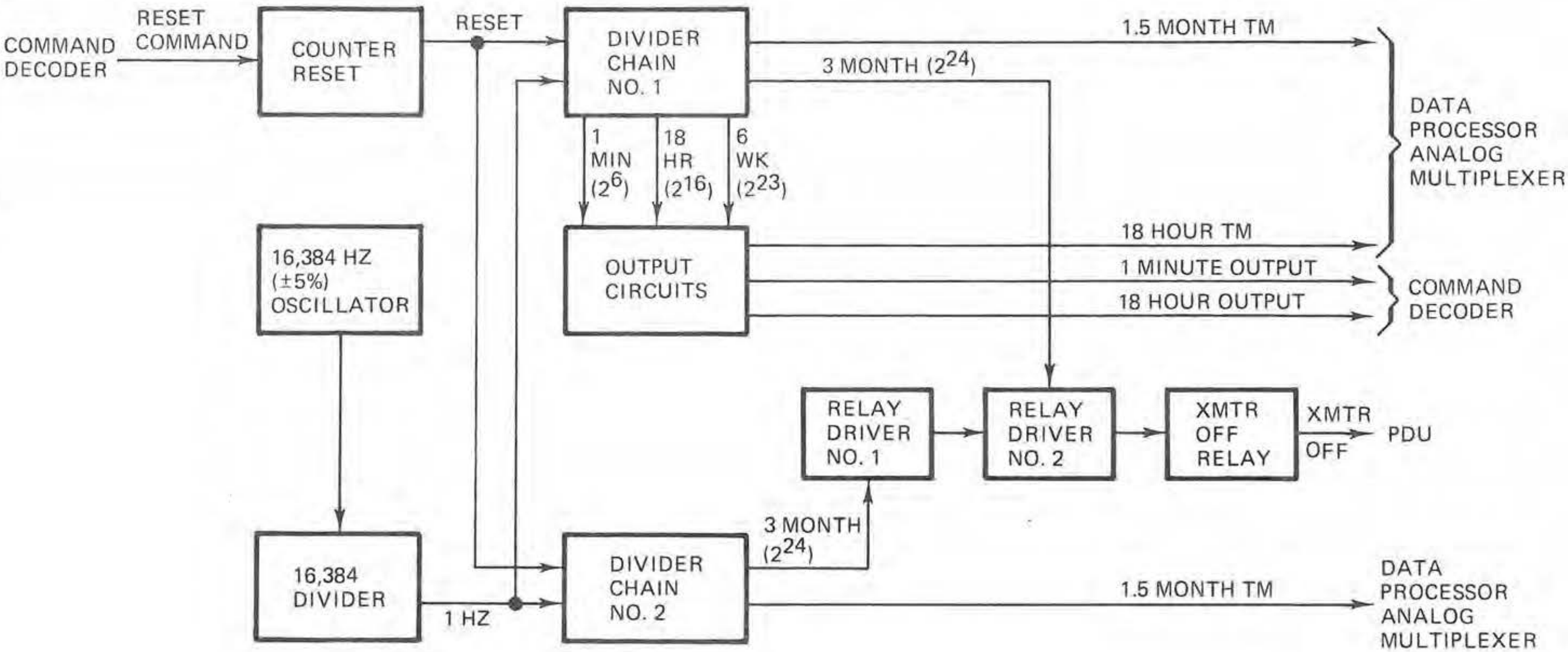


Figure 2-29B. Resettable Solid State Timer, Block Diagram throughout the digital data processor and analog multiplexer/converter. The analog multiplexer/converter 2330524 uses 15 two-layer boards, and analog multiplexer/converter 2338900 uses 11 two-layer boards. The digital data processor uses seven twelve-layer boards, one six-layer board and one three-layer discrete component board. Leading particulars are listed in Table 2-11.

2-46. Data Subsystem Data Processor Functional Description. Functionally, there are two redundant data processing channels (data processor X and data processor Y) which process both analog and digital data. Either processor channel may be selected to perform the data processing function. Figure 2-32 is a block diagram of the data processor showing redundant data processor channels X and Y. Digital data is applied directly to the processor channels. Analog engineering (housekeeping) data is applied to the 90-channel analog multiplexer.

Figure 2-33 is a block diagram of the analog multiplexer of 2330524. Multiplexer channels 1 through 15 are considered high reliability channels because of the redundant gating provided. Channels 16 through 90 are normal channels without redundant gating. Figure 2-33A is a block diagram of the dual analog multiplexer of 2338900. The 90 analog inputs are applied to two totally redundant multiplexer circuits. Operation of the two multiplexer units is otherwise identical.

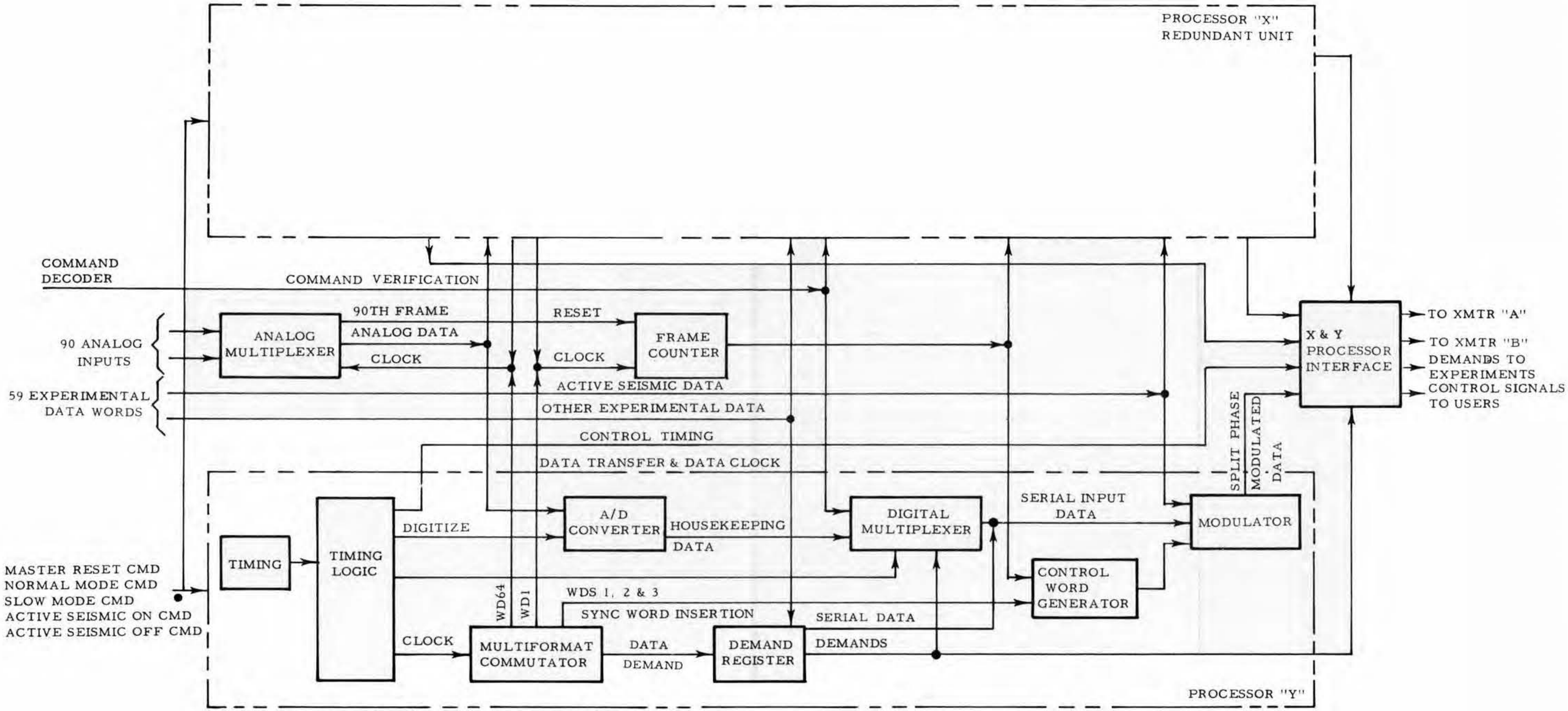
An advance pulse from the timing and control circuits of the X and Y processor channels is applied to the multiplexer sequencer logic. The sequencer logic applies timing signals to the multiplexing circuitry, and an end-of-frame signal to the frame counter when the frame advance reaches ninety. Multiplexed analog outputs from the multiplexing circuitry are applied through two parallel buffer stages to the analog-to-digital converters in data processors X and Y. The channel assignments of the analog multiplexer/converter are listed in the Appendix.

Analog data inputs from the analog multiplexer are received by the analog-to-digital converter. (See Figure 2-32.) The analog-to-digital converter digitizes the PAM output signal from the analog multiplexer. The analog-to-digital converters use a ramp generation technique to encode the analog signal into an eight-bit digital word. A single eight-bit conversion is made every telemetry frame. Processor timing and control circuits provide signals which assure that the conversions are made at the appropriate time. The digitized output data is applied to the digital multiplexer in parallel data form.

The digital multiplexer consists of a ten-bit shift register which accepts eight parallel bits from the analog-to-digital converter or eight serial bits from the command decoder and serially shifts them as a ten-bit word with zeros inserted in the two most significant figures. The bits are shifted high order first. Gates

Figure 2-30. Data Subsystem Digital Data Processor

Figure 2-31. Data Subsystem Analog Data Multiplexer/Converter



NOTE: 1 POWER DISTRIBUTION UNIT SUPPLIES:
+5 VDC
+15 VDC
-12 VDC
2 CONTROL SIGNALS:
EVEN FRAME MARK
FRAME MARK
SHIFT PULSE LINE
DEMAND LINE
DATA GATE
90TH FRAME MARK

Figure 2-32. Data Subsystem Data Processor, Functional Block Diagram

Table 2-11. Data Subsystem Data Processor Leading Particulars

Characteristic	Value
Digital Data Processor	
Height	2.8 inches
Width	3.94 inches
Length	6.25 inches
Weight	2.60 pounds
Power consumption	Less than 0.5 watts
Analog Multiplexer/Converter	
Height	2.62 inches
Width	4.2 inches
Length	5.9 inches
Weight	1.86 pounds (2330524) 1.83 pounds (2338900)
Power consumption	Approx. 1.44 watts

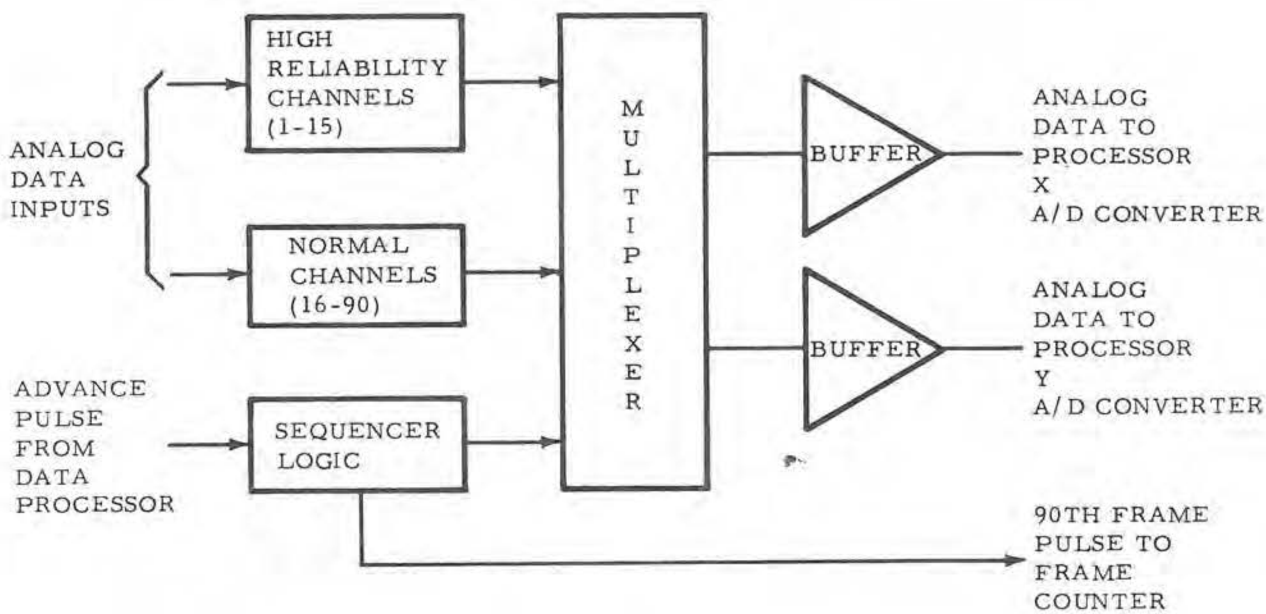


Figure 2-33. Data Subsystem Analog Multiplexer
(of 2330524), Block Diagram

are included in the digital multiplexer circuitry which gate serial input data directly from the experiments. The gate outputs and the ten-bit shift register outputs are "OR'd" and presented to a two-bit shift register which accepts either serial data from experiments or parallel control word coding.

The two-bit shift register presents the experiment and control word data in serial form to the PCM format converter. A PCM "0" is represented by a "01" and a PCM "1" is represented by a "10". The split phase signal phase modulates the transmitter so that a PCM "0" causes a positive phase transition and a PCM "1" causes a negative phase transition.

Table 2-12 lists the characteristics of ALSEP timing and control signals.

Table 2-12. Data Subsystem Timing and Control Pulse Characteristics in Normal ALSEP Data Mode

Pulse Type	Duration* (μsec)	Repetition Rate*	Timing Relative to Frame Mark
Frame mark	118	once per ALSEP frame	occurs at start of word 1 of each frame
Even frame mark	118	once every other frame	in coincidence with frame mark
90th frame mark	118	once every 90th frame	in coincidence with frame mark
Data gate (word mark)	118	64, once per each ten-bit word in frame	data gate of word 1 is in coincidence with frame mark
Data demand	9434	once per experiment word in ALSEP frame	occurs asymmetrically as defined in Figure 2-34
Shift pulse	47	640 pulses per frame 1060 pulses per second	a continuous 1060 pulses per second symmetrical square wave

Amplitude: High or logic "1"— +2.5 to 5.0 volts
Low or logic "0" — 0 to +0.4 volts
Rise and Fall Times: 2 to 10 μsec 10% to 90% points and 90% to 10% points

*In slow ALSEP data mode, duration is twice the normal mode and repetition rate is one-half normal mode.

2-47. Operating Modes - The data processor operates in three modes:

a. Normal mode (1060 bps)
b. Slow mode (530 bps)
c. Active Seismic mode (10600 bps).

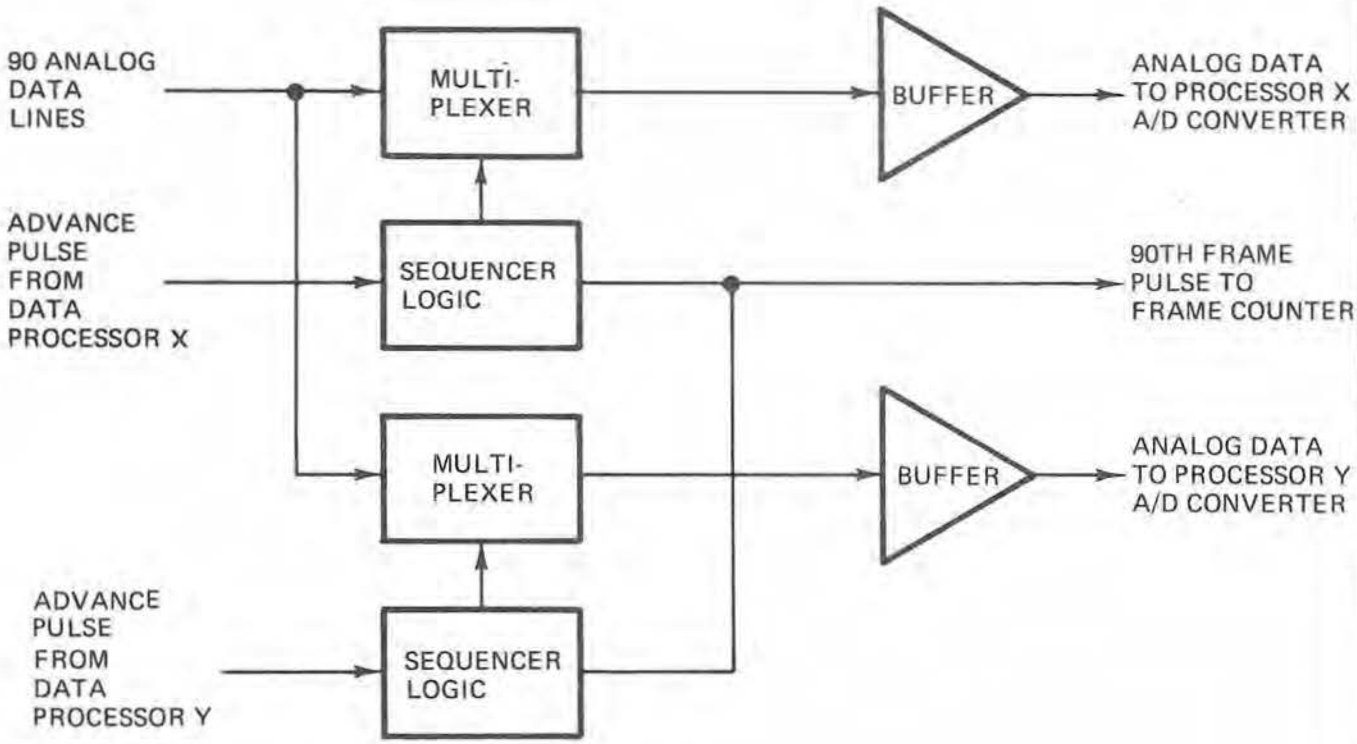


Figure 2-33A. Data Subsystem Dual Analog Multiplexer (of 2338900), Block Diagram.

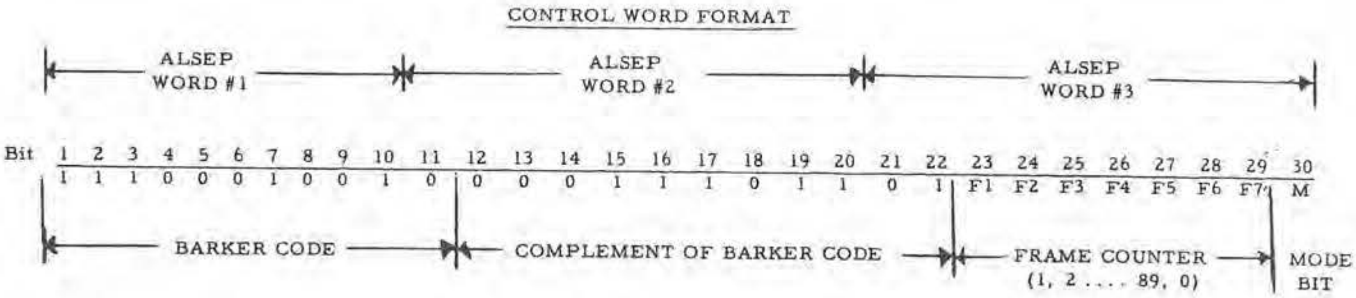
ARRAY A2

1 x	2 x	3 x	4 X	5 o	6 X	7 S	8 X
9 -	10 X	11 -	12 X	13 -	14 X	15 I	16 X
17 o	18 X	19 o	20 X	21 o	22 X	23 S	24 HF
25 -	26 X	27 -	28 X	29 -	30 X	31 I	32 X
33 H	34 X	35 •	36 X	37 •	38 X	39 S	40 X
41 -	42 X	43 -	44 X	45 -	46 CV	47 I	48 X
49 o	50 X	51 o	52 X	53 o	54 X	55 S	56 I
57 -	58 X	59 -	60 X	61 -	62 X	63 I	64 X

WORD TOTALS	LEGEND	
3	x	= Control
28	X	= Passive Seismic - Short Period
12	-	= Passive Seismic - Long Period
2	•	= Passive Seismic - Long Period Tidal and one Temperature
7	o	= Magnetometer
4	S	= Solar Wind
5	I	= Suprathermal Ion Detector
1	CV	= Command Verification
1	H	= Housekeeping
1	HF	= Heat Flow

Each box contains one ten-bit word
Total bits per frame = 10 x 64 = 640 bits

Figure 2-34A. ALSEP Telemetry Frame Format



Symbol	Name	ALSEP Words	Range	Bits/ Sample	Samples/ Second
DA-1	Barker Code and Complement	1, 2, and bits 1 and 2 of word 3	NA	22	1.67
DA-2	Frame Count	Bits 3 to 9 inclusive of word 3	1-90	7	1.67
DA-3	Mode Bit	Bit 10 of word 3			1.67
		Frame / Mode Bit	Meaning		
		1 / 1	Normal data rate		
		2 / 1	Slow data rate		
DA-4	ALSEP ID	Bit 10 of word 3		3	1/54
		Frame / Mode Bit			
		3 / X (MSB)	Data processor Serial number		
		4 / X			
		5 / X			

Figure 2-35. ALSEP Telemetry Control Word Bit Assignments

counter to obtain the 10.6 KHz signal used in the active seismic mode. This counter is gated to produce the 42.4 KHz signal used in the slow data mode of 530 bps.

The 84.8 KHz, or the 42.4 KHz signal also drives a divide-by-ten counter. The outputs from this counter are used to drive the sub-bit counter and the timing logic. The sub-bit counter is a divide-by-eight counter with output frequencies of 1060 Hz, or 530 Hz, depending upon the operational mode. This output establishes the bit rate, drives a bit time counter, and provides timing signals for the timing logic.

The bit time counter is a divide-by-ten counter with an output frequency of 106 Hz, or 53 Hz, which establishes the word rate. Outputs of this counter are used in generating the control words and signal timing throughout the processor.

The multiformat commutator determines the specific assignments of each word within the 64 word telemetry format. The commutator provides signals (demand pulses) of one word length and multiples of one word length in duration so that data may be gated from the experiments and command decoder through the split-phase modulator and into the transmitter in a predetermined sequence. The output of the multiformat commutator is applied to the demand register and the control word generator.

The demand register performs the following functions:

a. Provides memory for the demand signal while the commutator is being switched.

b. Acts as a master switch turning off all demands while allowing the format generator and all control signals to function normally while in active seismic mode.

c. Acts as a buffer between the demand decoder assembly eliminating any gating transients from the demand lines.

The control word generator generates the synchronization code and provides the information to the output register during the proper bit times of the control word. Mode, frame, and data processor serial number information is provided to the output register at the appropriate bit times.

The frame counter generates the frame bits. The frame counter is essentially a ripple-through counter which is advanced one step whenever the first word of each frame occurs. Reset is accomplished by means of the 90th frame end-of-frame signal generated by the analog multiplexer.

A flow chart of the data processor is presented in Figure 2-36.

2-49. DATA SUBSYSTEM TRANSMITTER 2330527

The data subsystem transmitter 2330527 is used in the ALSEP Flight 1 through 4 systems to generate an S-band carrier frequency between 2275 and 2280 MHz which is phase modulated by the split-phase serial bit stream from the data processor.

2-50. Data Subsystem Transmitter Physical Description. Two identical transmitters are used in each data subsystem to provide standby redundant operation. Either transmitter can be selected to transmit downlink data. A transmitter is shown in Figure 2-37. Most circuit modules are mounted on a milled out magnesium base plate. Some modules and other components are located inside the base plate. Transmitter leading particulars are listed in Table 2-13.

2-51. Data Subsystem Transmitter Functional Description. Figure 2-38 shows a block diagram of the transmitter circuit. Transmitter output frequency is a function of the oscillator crystal and tuning. Transmitter frequencies will vary between individual ALSEP systems. An oscillator frequency of 142 MHz is used as an example in this discussion. The crystal-controlled oscillator in the oscillator-buffer-phase modulator generates a 142 MHz frequency which is phase modulated by the binary data from the data processor. A buffer amplifier between

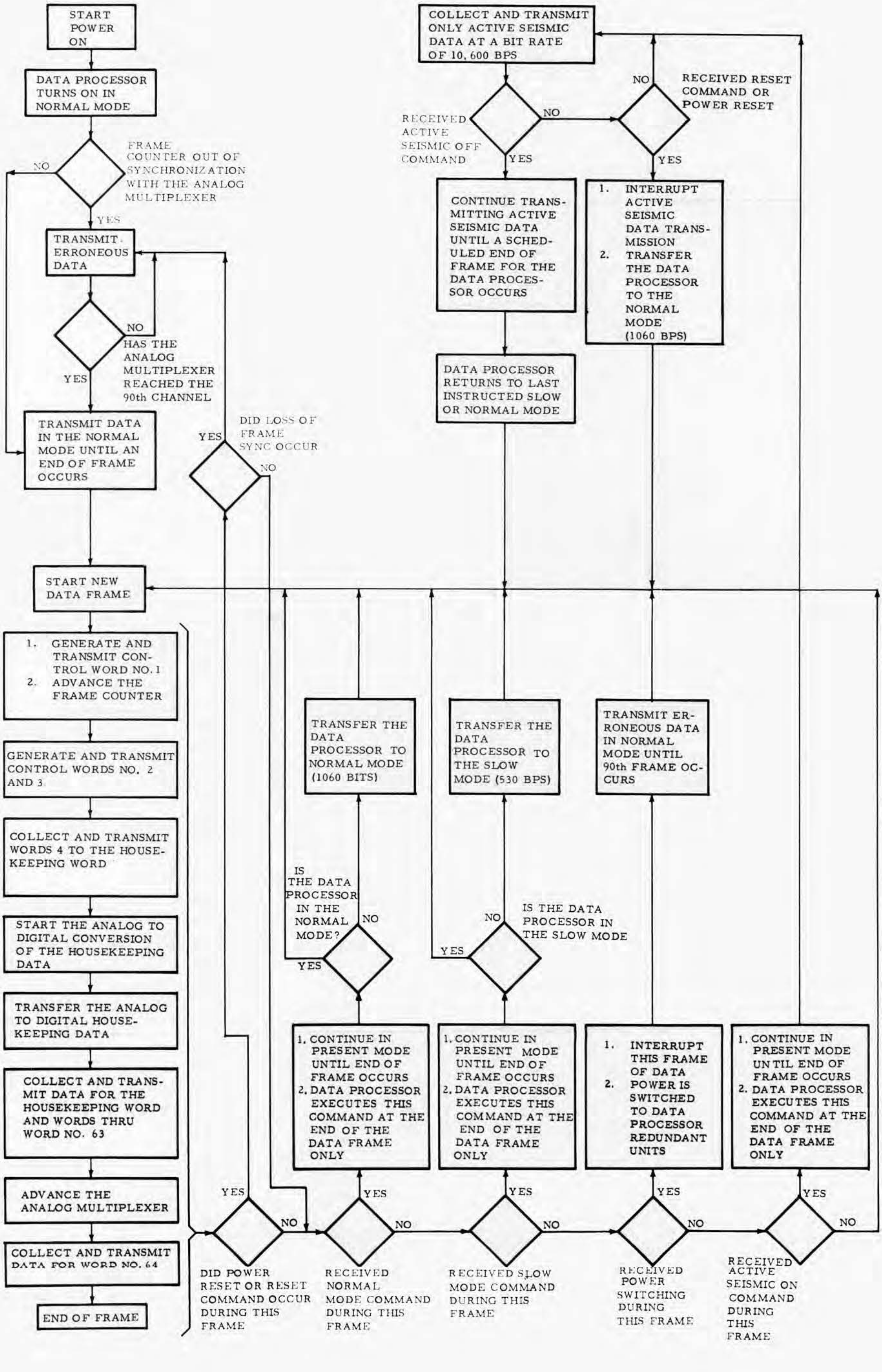


Figure 2-36. Data Subsystem Data Processor Flow Chart

Figure 2-37. Data Subsystem Transmitter 2330527

Table 2-13. Data Subsystem Transmitter 2330527 Leading Particulars

Characteristic	Value
Output frequency	Channel 1 = 2276.5 MHz Channel 2 = 2278.5 MHz Channel 3 = 2275.5 MHz
Frequency stability	(a) ±.0025%/year (long term) (b) 2.2 x 10^{-10} parts/second (short term)
Output power	1 watt minimum into 50 ohm load with maximum VSWR of 1.3:1
Output spurious	(a) Harmonically related: 0 dbm, 2-7 GHz (b) Other: -50 dbm above 2-GHz - 10 dbm, 7-10 GHz (c) All: 0 dbm below 2 GHz
Incidental AM	Less than 3% (0.25 db power ratio)
Phase noise	Less than 4.5° rms as measured with a phase coherent receiver having a loop bandwidth $2 B_L = 50$ cps
Carrier deviation	Fixed at ±1.25 radians ±5%
Modulation drive	+2.5 to +5.5 volt peak-to-peak (binary voltage only)

Table 2-13. Data Subsystem Transmitter Leading Particulars (cont)

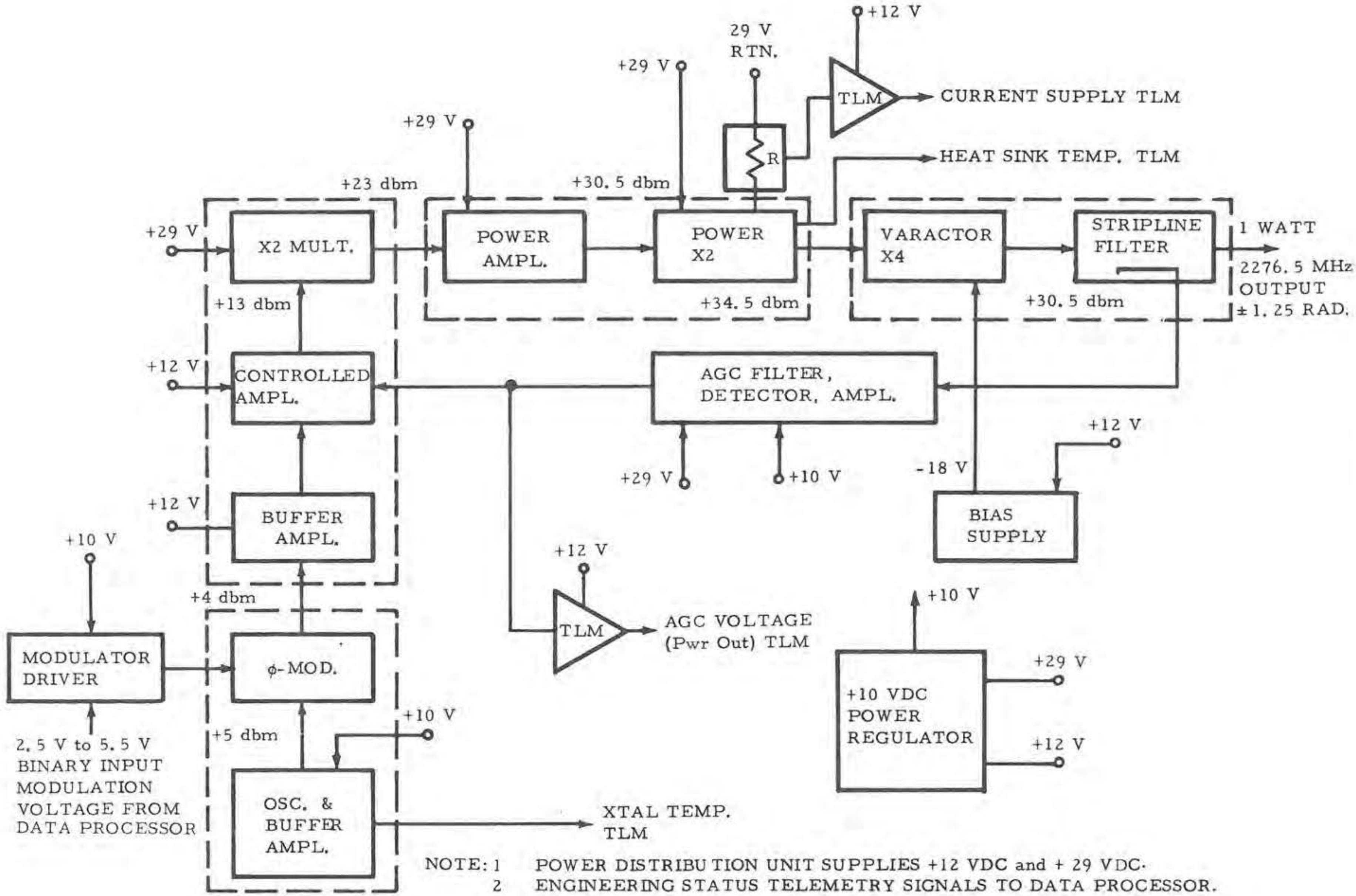
Characteristic	Value
Modulation polarity	+ phase shift for + modulation voltage
Modulation frequency	200 Hz to 12 KHz/binary voltage
Modulation input impedance	22K ohm minimum shunted by less than 100 pf (ac coupled)
Supply voltages	+29 vdc ±1% +12 vdc ±1%
Supply power	9.5 watts maximum (9.2 watts nominal = 8.7 w @ +29 v + 0.5 watts @ +12v)
Telemetry outputs	(a) Oscillator crystal temperature (b) Heat sink temperature at highest power stage (c) RF level at output (AGC voltage) (d) Supply current to power doubler
Weight	1.13 pounds
Form factor	7.5 x 2.0 inches mounting surface x 1.50 inches in height exclusive of connectors

the 142 MHz oscillator and the phase modulator provides impedance matching and circuit isolation which enhance modulator stability. The analog phase modulator contains a pair of back-to-back varactor diodes which vary the capacitance of a parallel resonant tank circuit by varying the diode back bias at the modulating frequency. A modulator driver maintains the proper diode bias voltages for binary modulation voltage variations from 2.5 volts to 5.5 volts peak-to-peak.

The output of the phase modulator is applied to buffer amplifier, AGC-controlled amplifier, and frequency doubler stages. The buffer amplifier stage between the phase modulator output and the AGC-controlled amplifier inputs prevents modulator tank circuit detuning which would be caused by amplifier input impedance changes resulting from temperature and aging. The times two frequency multiplier stage increases the carrier frequency to 284 MHz.

The 284 MHz output from the frequency multiplier is amplified by the power amplifier, and doubled in frequency by the power doubler. A times four varactor frequency multiplier then quadruples the carrier frequency. The output frequency is between 2275 and 2280 MHz, depending on the selection of the crystal-controlled oscillator. A stripline filter reduces spurious harmonics of the output signal to 30 db below the carrier. Additional spurious rejection is provided by the interfacing diplexer. A directional coupler built into the filter provides an RF output to the AGC circuit.

Monitor circuits provide analog signals to the data processor indicating the status of current supply, AGC voltage and the temperatures at the oscillator crystal and the power heat sink.



NOTE: 1 POWER DISTRIBUTION UNIT SUPPLIES +12 VDC and + 29 VDC.
2 ENGINEERING STATUS TELEMETRY SIGNALS TO DATA PROCESSOR.

Figure 2-38. Data Subsystem Transmitter (2330527) Block Diagram

2-51A. DATA SUBSYSTEM TRANSMITTER 2345250

The data subsystem transmitter 2345250 is used in the ALSEP flight system Array A-2 to generate a specific S-band carrier frequency within the range of 2275 to 2280 MHz. The signal is phase modulated by the split-phase serial bit stream from the data processor. Two identical transmitters are used in the data subsystem to provide standby redundant operation. Either transmitter can be selected to transmit downlink data.

2-51B. Data Subsystem Transmitter Physical Description. The transmitter is comprised of six circuit modules. The X6 multiplier module is superimposed on the power amplifier module to form an integral structural unit with an aluminum base plate. The other four modules are printed circuit boards which are mounted in cavities in the side of the power amplifier module. The operating power and data signal input and telemetry output interface is through a 14-pin connector. The RF carrier output interface is through a coaxial connector. Figure 2-38A shows the structural configuration of the transmitter. Transmitter leading particulars are listed in Table 2-13A.

2-51C. Data Subsystem Transmitter Functional Description. Figure 2-38B shows a block diagram of the transmitter circuit. Transmitter output frequency is determined by the selection of the oscillator crystal. An oscillator frequency of 38 MHz is used in this discussion.

The crystal-controlled oscillator in the oscillator, buffer, modulator module, A3, generates a 38 MHz signal. The power level of the signal is increased by a buffer amplifier, and applied to a X5 multiplier which consists of a step recovery diode for harmonic generation, and a tuned circuit which passes the fifth harmonic, 190 MHz. A cascode amplifier acts as a buffer between the multiplier and the phase modulator.

The phase modulator module, A4, consists of a modulator and a modulator driver. The modulator receives the 190 MHz carrier signal. Modulation of the signal takes place in a series capacitor and resistor network in which the capacitance is provided by two parallel varactor diodes. The modulator driver receives the 2.5 to 5.5 volt, 265 Hz to 10,600 KHz split-phase modulated binary data signal from the data processor, and develops a back bias across the modulator varactors. The back bias is varied at the data signal frequency to alter the capacitance of the varactors and thus cause a phase shift of the 190 MHz carrier signal. The resultant phase modulated 190 MHz carrier signal is applied through a resistive T-network to the preamplifier.

The preamplifier module, A5, is a three-stage limiting preamplifier which provides a constant drive level over a wide range of temperatures. The output is applied through a resistive T-network which is selected through test to attenuate the phase modulated carrier signal to the correct drive level for the power amplifier.

The power amplifier module, A2, provides a stage of amplification, a X2 multiplier, and two more stages of amplification. The X2 multiplier is a common-base doubler which raises the 190 MHz phase modulated carrier frequency to 380 MHz. The amplifiers raise the power of the phase modulated carrier to three watts. This module also performs 29VDC power filtering for all modules.

The X6 multiplier module, A1, increases the frequency of the phase modulated carrier to 2280 MHz in two stages. A coaxial cavity is tuned to the 380 MHz phase modulated carrier input from the power amplifier, and applies it to a varactor multiplier which produces many harmonics. The third harmonic, 1140 MHz, is selected by a tuned coaxial cavity and applied to a second varactor multiplier to produce harmonics. The second harmonic, 2280 MHz, is selected by a tuned coaxial cavity and fed through another tuned coaxial cavity to filter spurious harmonics. The 1-watt, 2280 MHz, split-phase modulated output is applied to the diplexer switch for downlink transmission.

The current, temperature, and RF power telemetry module, A6, circuits provide signals representative of monitored transmitter operational parameters to the analog multiplexer of the data processor for downlink telemetry. The 29VDC operating current, the output signal power at A1, and the temperature of the crystal in A3 and the output transistor heat sink in A2 are monitored.

Figure 2-38A. Data Subsystem Transmitter 2345250

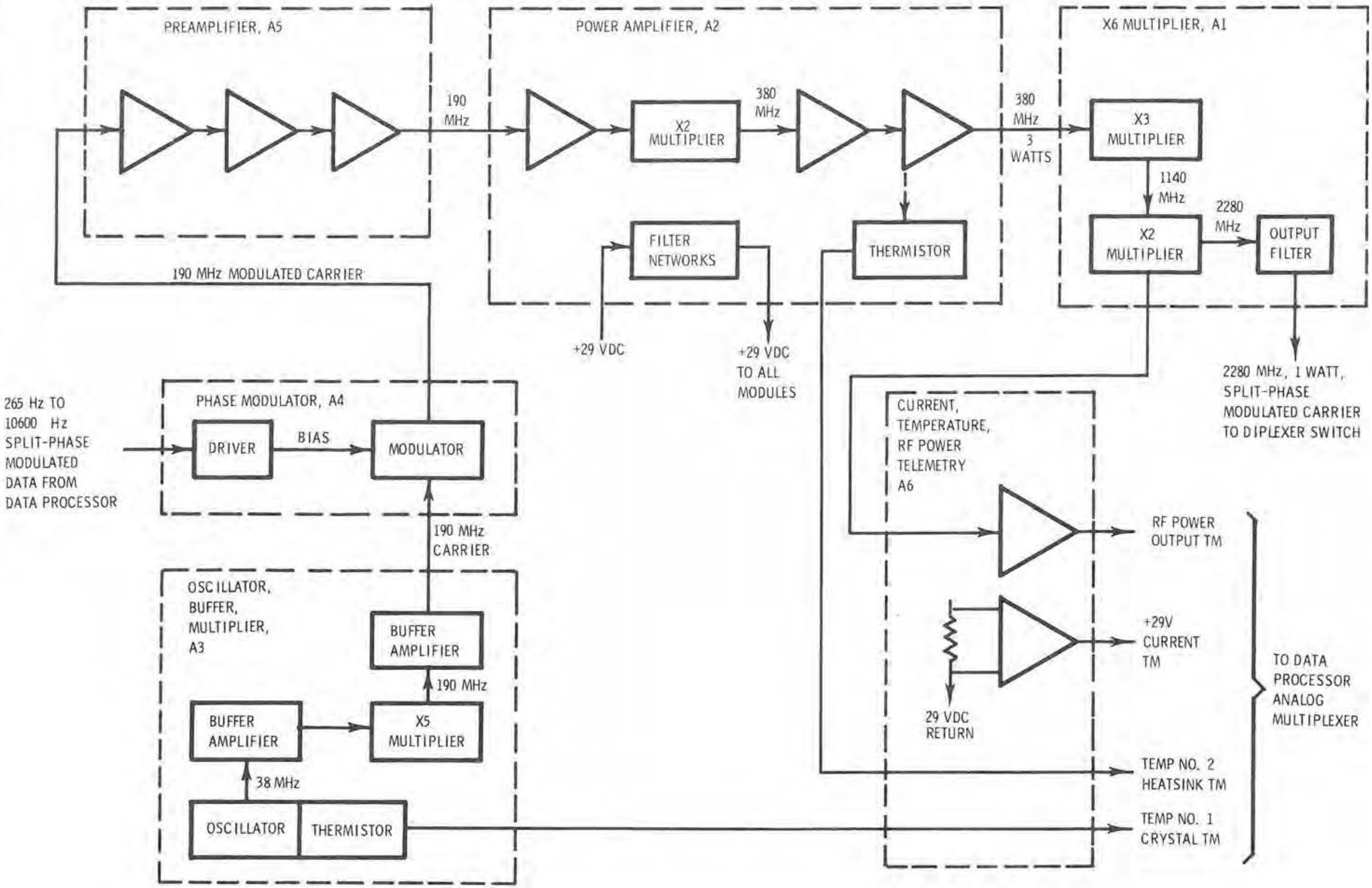


Figure 2-38B. Data Subsystem Transmitter 2345250, Block Diagram

Table 2-13A. Data Subsystem Transmitter 2345250 Leading Particulars

Characteristic	Value
Output Frequency	2275 to 2280 MHz fixed by selected oscillator crystal.
Frequency Stability	± 0.0025% per year.
Output Power	1 watt min. into 50 ohms at a maximum VSWR of 1.3:1
Output Spurious	Frequency: 0 to 2 GHz -30 db below unmodulated carrier 2 to 2.45 GHz -80 db 2.45 to 4.60 GHz -20 db 4.60 to 10.0 GHz -40 db
Spurious A.M.	Less than 3%
Phase Noise	Less than 0.1 rad. RMS measured with a phase coherent receiver with a loop bandwidth $2 B_L = 50$ Hz.
Carrier Deviation	± 1.25 radians ± 5%.
Modulation Drive	Binary signal +2.5 to +5.5 volt p-p.
Modulation Frequencey	265 Hz to 10.6 KHz binary signal.
Modulator Input Impedance	Greater than 10K ohms shunted by less than 100 pf (ac coupled)
Supply Voltage	29 volts ± 2%
Supply Current	Less than 418 ma.
Telemetry Outputs	a) Oscillator crystal temperature (-30 to +70°C) b) Heat sink temperature of power output stage (-30 to +70°C) c) R.F. level at power amplifier output (0.63 to 1.58 watts) d) Supply current (250 to 475 ma).
Weight	Less than 2.1 lb..
Form Factor	7.5 x 2.0 inches mounting surface x 2.8 inches high.

2-52. DATA SUBSYSTEM POWER DISTRIBUTION UNIT

The power distribution unit (PDU) distributes power to experiment and central station components and provides circuit overload protection and power switching of selected circuits. The PDU also provides signal conditioning of selected central station and RTG telemetry monitor signals prior to input to the analog multiplexer for analog-to-digital conversion and subsequent data transmission to earth.

2-53. Data Subsystem Power Distribution Unit Physical Description. A PDU is shown in Figure 2-39. The power distribution unit is comprised of five printed circuit cards, a mother board to provide interconnection between the individual boards, the component connector, a case, and a cover. All electrical inputs are made through a rectangular, screw-lock, 244-pin connector.

Figure 2-39. Data Subsystem Power Distribution Unit

The amplifier board mounts the RTG temperature sensing bridges and amplifiers, the power reserve sequencer comparator, and one experiment power control circuit.

The experiment drive card contains the relay driver, relays, fuses, and associated circuit components for the power control of four experiments.

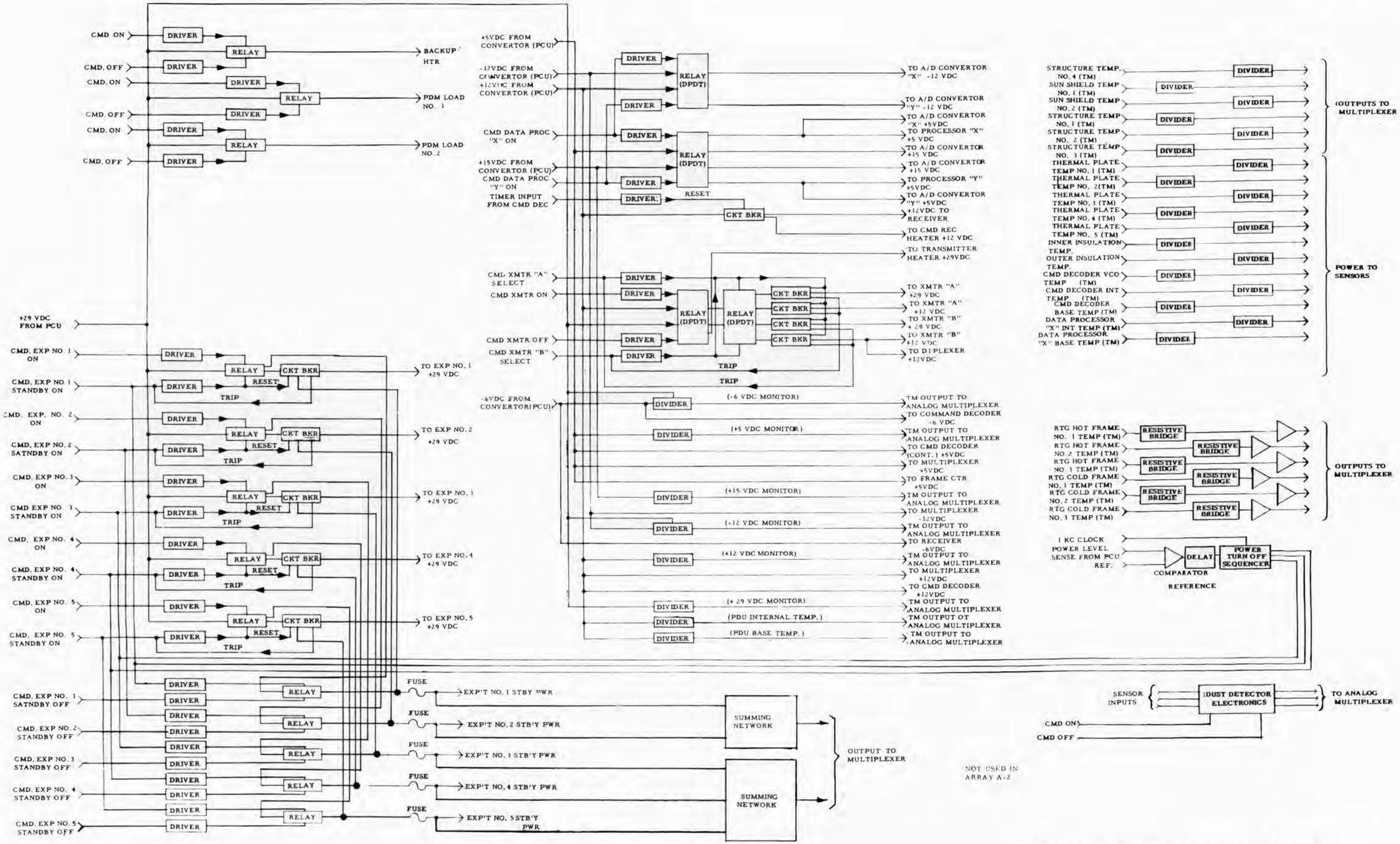


Figure 2-40. Data Subsystem Power Distribution Unit, Block Diagram

resetting its contacts to permit normal standby-on command inputs. Provisions have been made to shunt each current sensing coil to provide a 0.5 amp capability to all experiments.

A high conductance diode is paralleled (in a forward biased condition) with the current sensing coil of the overload sensing relay. This diode permits an extension of the dynamic range of the overload sensor to high transient overloads. Two resistive summing networks provide a telemetry output to indicate the presence or absence of standby power for all experiment power switching circuits.

Transmitter power control and overload protection as shown in Figure 2-41 uses two power control relays, four overload sensing relays, and associated relay drivers. Four commands are required:

a. Transmitter on
b. Transmitter off
c. Transmitter A select
d. Transmitter B select.

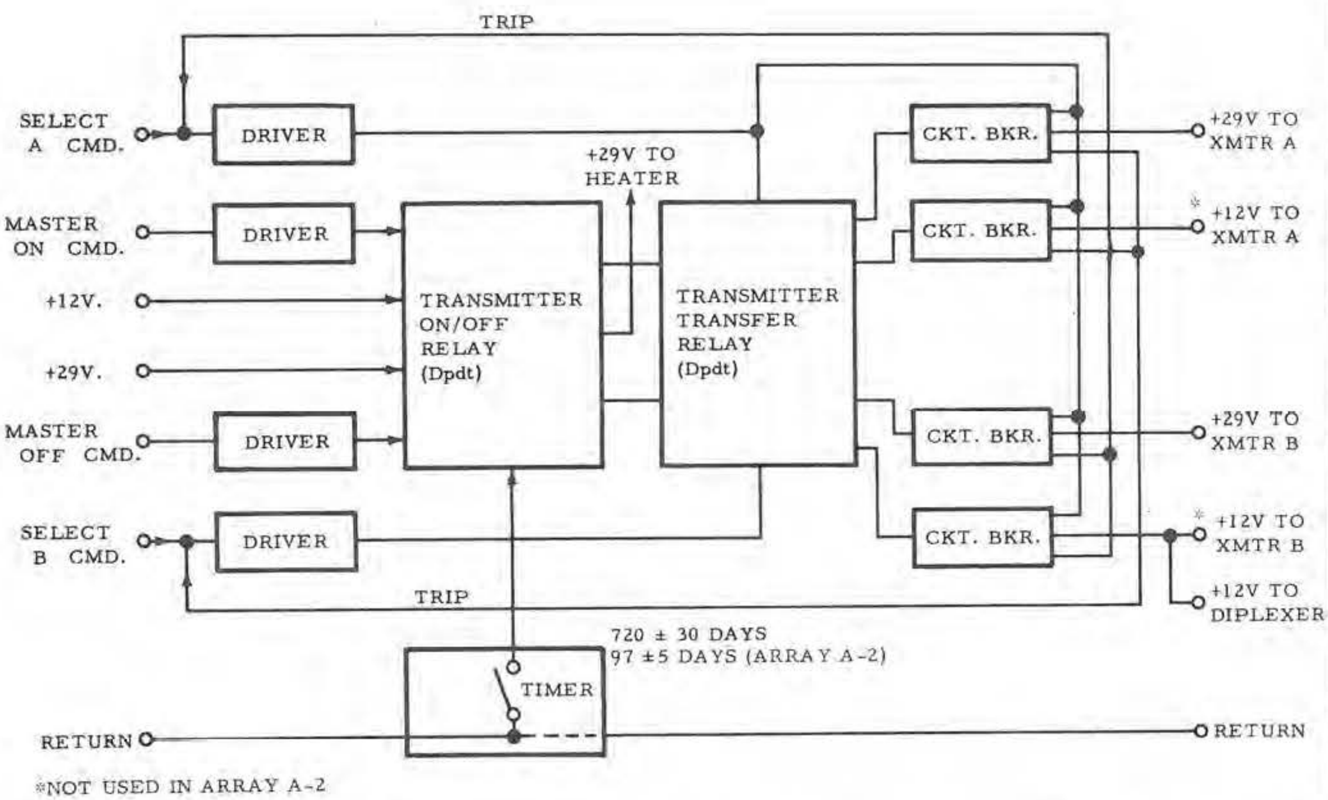


Figure 2-41. Data Subsystem Transmitter Power Control

The transmitter on and off commands operate the double-pole, double-throw relay which switches both 12 vdc and 29 vdc to the transmitter transfer relay. When the transmitter control relay is off, nominal transmitter operating power is applied to the transmitter heater which maintains thermal balance within the central station. Two power lines to either of two transmitters are selectable via transmitter A or transmitter B select commands as appropriate. If either power line to either transmitter is overloaded, the contacts of the overload sensing relay transfers the transmitter select relay to supply power to the alternate transmitter. When power is transferred to the alternate transmitter, the circuit overload sensing relays are both reset and the normal command link inputs are restored. Diplexer switching power, required only when transmitter B is selected, is obtained directly from the 12 vdc transmitter power line.

A transmitter turn-on capability is provided by a manually operated backup switch which is used if an uplink cannot be established following deployment of ALSEP on the lunar surface.

The command receiver requires both 12 vdc and -6 vdc for operation (Figure 2-41). The -6 vdc line is not provided with circuit protection because of the high reliability of the -6 volt line load. The 12 vdc line is provided with overload protection which uses a magnetic latching circuit breaker relay. The sensing coil of this device will interrupt the 12 vdc of the receiver when current is excessive. Since no redundancy of receivers exists, a 12-hour reset pulse is supplied to the breaker every 12 hours. If the receiver is tripped off, a receiver heater load is energized by the transfer of the circuit breaker contacts to maintain thermal balance. (An 18-hour reset pulse is used in Array A-2.)

For data processor power control (Figure 2-42), redundant electronics are switched using standard magnetic latching relays. These relays are controlled by standard commands. Overload protection is not provided.

Power dissipation module 1, power dissipation module 2, and the central station backup heaters are switched off and on by ground command only.

Electronics for the dust detector are mounted on a printed circuit card in the PDU and consist of the following three functional areas:

a. Power switching
b. Operational amplifiers
c. Temperature measurement.

The power switching function switches 12 vdc and -12 vdc power to the amplifiers upon receiving a ground command. Power protection for the card is provided by individual fuses on each of the two voltages.

The operational amplifier consists of an integrated circuit differential amplifier with added circuitry to establish a closed loop fixed gain configuration. Its functional purpose is to condition the output of the photocell detectors, which act as variable current sources of a 0 to +5 vdc varying dc level for telemetry information. Temperature measurement is accomplished with a thermistor attached to the photocell and a series resistor, located on the card to optimize thermistor sensitivity and provide a 0 to +5 vdc telemetry signal.

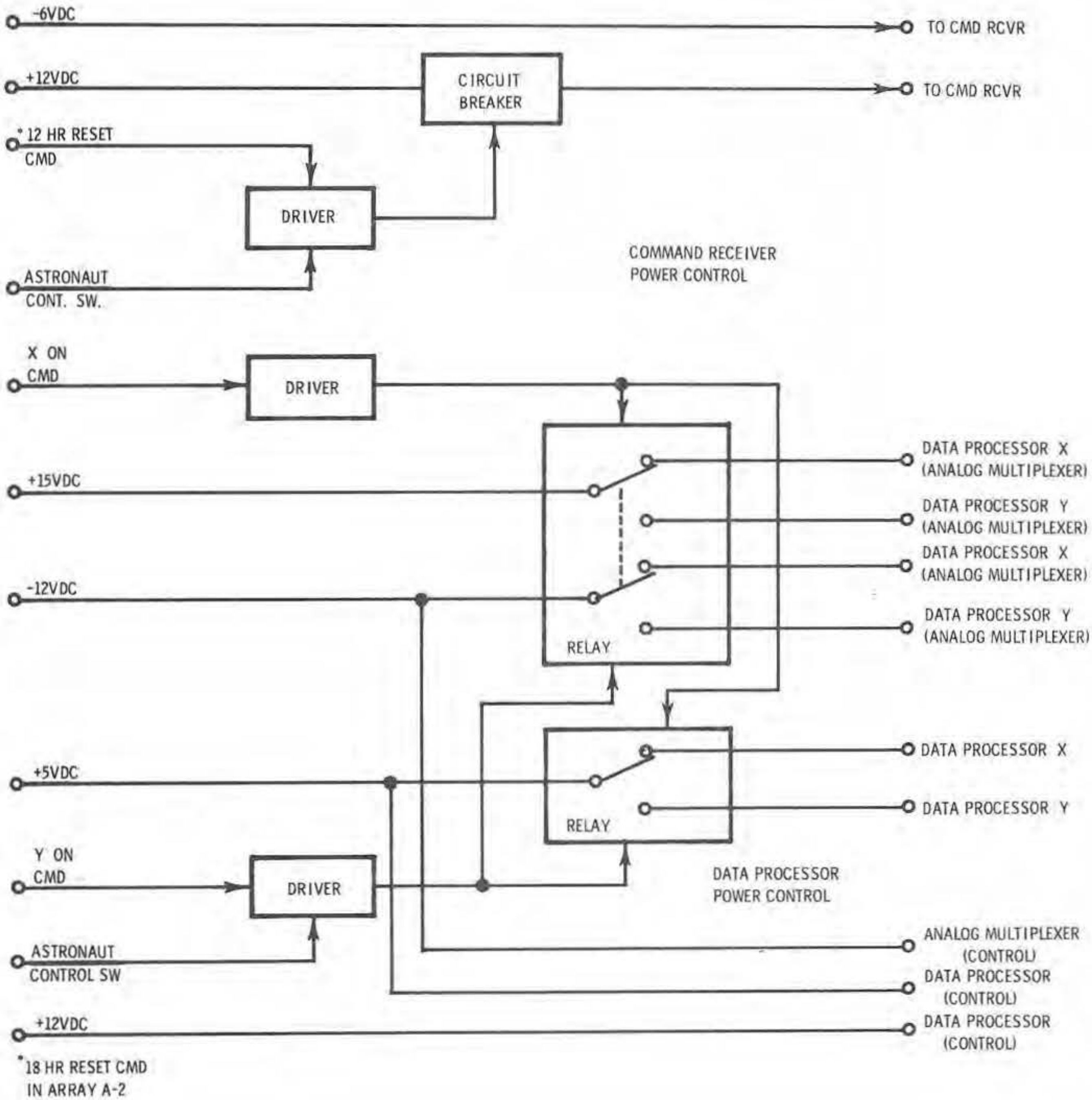


Figure 2-42. Command Receiver and Data Processor Power Control

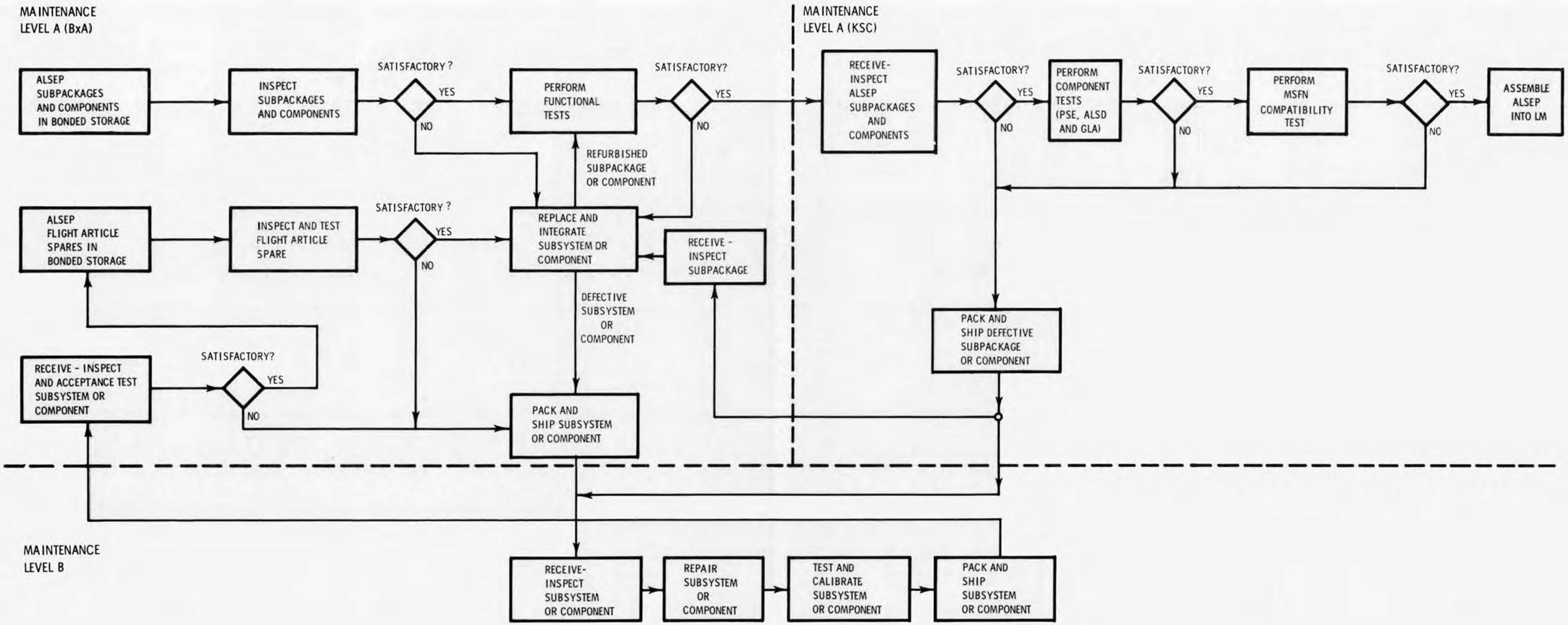


Figure 3-1. ALSEP Flight System Maintenance Flow Diagram

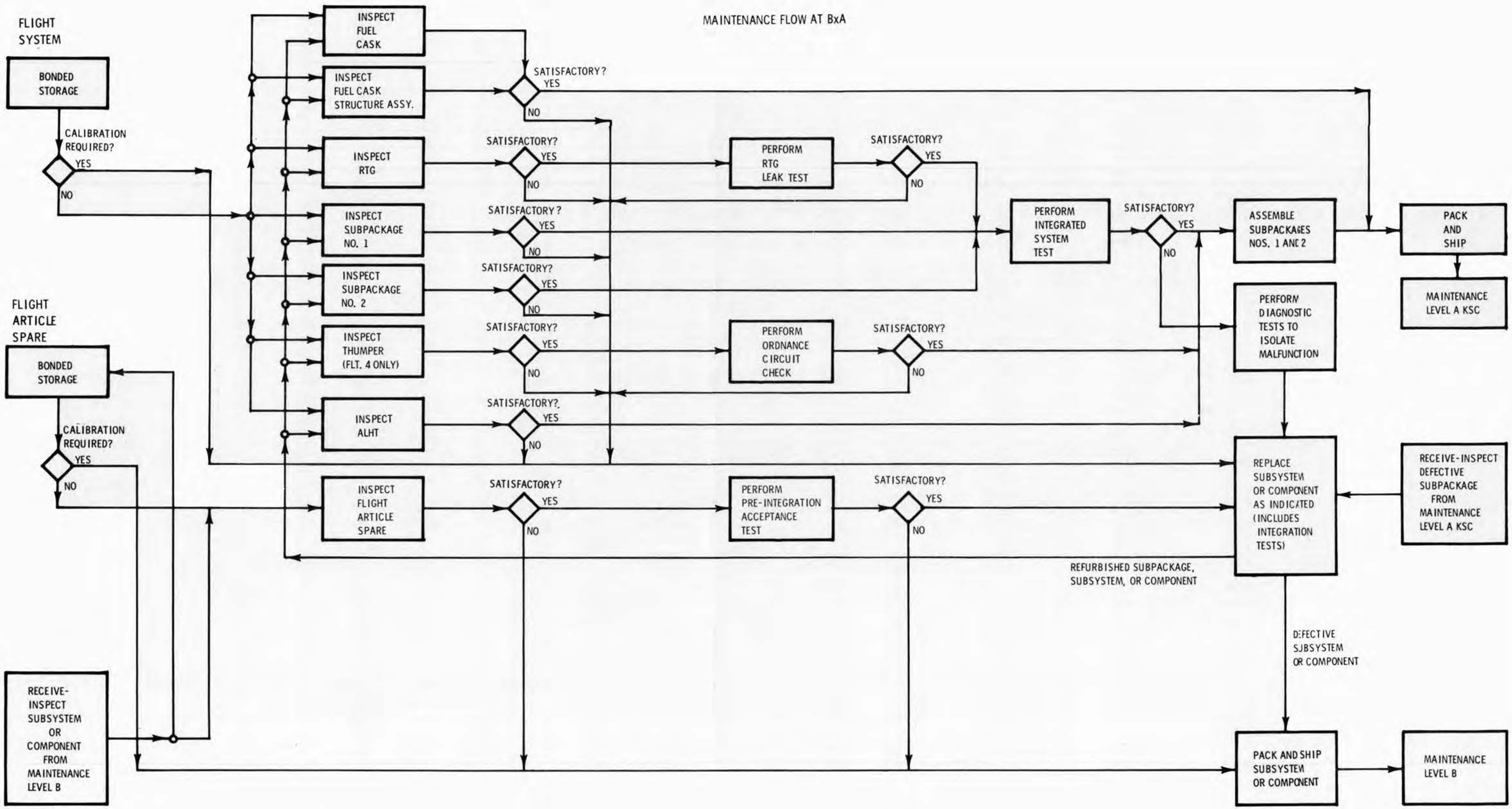


Figure 3-2. Level A Maintenance Flow Diagram (Sheet 1 of 2)

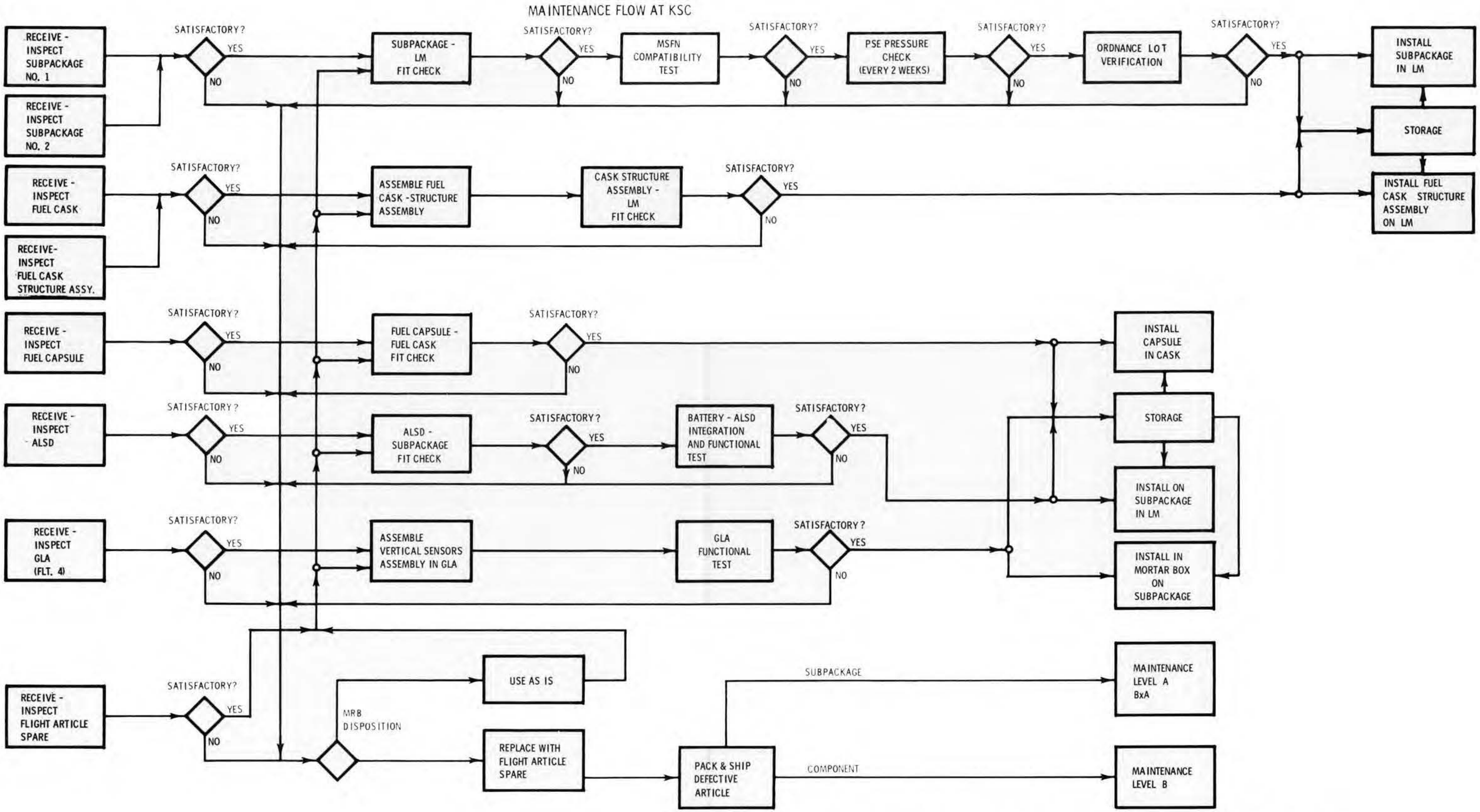


Figure 3-2. Level A Maintenance Flow Diagram (Sheet 2 of 2)

ALSEP 3-2. ALSEP Flight Article Spares

Nomenclature	Quantity	Part Number	Note
Passive seismic experiment	1	2330659	
Heat flow experiment	2	2330661	
Charged particle lunar environment experiment	1	2330662	
Active seismic experiment electronics	1	2334468	
Grenade launch assembly	2	2338507-2	KSC
Mortar box assembly	2	2334499-4	
Thumper and geophone assembly	2	2334772-4	
Magnetometer experiment	0	2330657	GFE
Solar wind experiment	1	2330658	GFE
Suprathermal ion detector experiment	2	2330660	GFE
Dust detector package	0	2330370-2	
Dust detector package	0	2341440	
Radioisotope thermoelectric generator	1	47E300779	GFE
Apollo lunar surface drill	1	467A805000	GFE
Apollo lunar hand tools	0	SGB39101165	GFE
Fuel cask	0	47E301134	GFE
Fuel capsule	0	47D300400	GFE
Universal handling tool	1	2338102	
Dome removal tool	1	2337954	
Helical antenna	0	2330307	
Antenna cable assembly	1	2334522	
Antenna aiming mechanism	1	2330309	
Diplexer switch	1	2330526	
Diplexer filter	1	2330525	
Command receiver	1	2330523	
Command decoder	1	2330509	
Analog to digital converter-multiplexer	0	2330524	
Analog to digital converter-multiplexer	1	2338900	
Data processor	1	2330521-A4	
Data processor	1	2330521-B7	
Transmitter (2276.5 mc)	1	2330527	
Transmitter (2278.5 mc)	1	2330527	
Transmitter A & B	2	2345250	
Power distribution unit	1	2330450-2	
Timer	1	2330626	
Timer battery	2	2334476	
Timer	1	2338511	
Power conditioning unit	1	2330000-3	
RF cable assembly	2	2330528-4	
RF cable assembly	2	2330528-5	
RF cable assembly	2	2330528-6	
RF cable assembly	2	2330670-3	
RF cable assembly	2	2330670-4	

Table 3-2. ALSEP Flight Article Spares (cont)

Nomenclature	Quantity	Part Number	Note
RF cable assembly	2	2330671-2	
RF cable assembly	2	2330671-3	
RF cable assembly	2	2344607	
Diplexer switch cable assembly	2	2344698-1	
Diplexer switch cable assembly	2	2344698-2	
Ammeter shorting plug	2	2338017	
PSE stool quick release pin	1	2335565	
SIDE connector quick release pin	1	2335574	
Fuel cask mounting assembly	1	2338660	
Lever and wire assembly	2	2338681-1	
Lever and wire assembly	1	2338681-2	
Body release mechanism	1	2338687-1	
Body release mechanism	1	2338687-2	
Shear pin stop bracket (left hand)	1	2338685	
Shear pin stop bracket (right hand)	1	2338686	
Tab lock	2	2338689	
Special washer	2	2338693	
Shear pin	2	2338668	
Tension stud	2	2338692	
Square shear pin cutter	4	2338671-3	
Self-locking nut	4	MS21043-4	
Belleville washer	8	BO500-025	
Shear wire	13	2338043	
Shear wire	14	2338054	
Setscrew	2	2338665	
Screw 4-40 x .25 inch	4	MS35275-213	
Lanyard assembly	1	2338128	
Tool support quick release pin	1	2335575	
RTG cable spring clip	4	2335516	
Boom quick release pin	1	2335262	
Outboard support pin	2	2335126	
Outboard quick release pin	2	2334525-3	
Guide fastener	20	2335931-1	
Guide fastener	2	2335931-2	
Guide fastener	2	2335931-4	
Guide fastener	3	2335931-5	
Guide fastener	2	2335931-6	
Guide fastener	2	2335931-7	
Guide fastener	2	2344998	
Guide fastener cap	100	2334675-1	
Guide fastener cap	16	2334675-2	
Guide fastener cap	10	2334675-3	
Guide fastener cap	4	2334675-4	
Dust cover	2	2344999	
Quick release pin	1	2335577-5	
Quick release pin	1	2335577-4	

Table 3-2. ALSEP Flight Article Spares (cont)

Nomenclature	Quantity	Part Number	Note
Quick release pin	1	2335577-1	
Dust cover connector	1	2334528-2	
Dust cover connector	1	2334528-6	
Dust cover connector	1	2334528-8	
Bolt, special	6	2335067	
Bolt, special	4	2338041	
Boyd bolt	4	CA2773-2-1	
Boyd bolt	4	CA2773-4-1	
Boyd bolt	4	CA2773-6-1	
Boyd bolt	2	CA2773-8-1	
Boyd bolt	4	CA2773-10-1	
Boyd bolt	8	CA2773-14-1	
Boyd bolt	4	CA2773-18-1	
Boyd bolt	4	CA2773-20-1	
Boyd bolt	4	CA2773-24-1	
Boyd bolt spring	25	CS1014	
Boyd bolt nut	25	SP1015	
Accordion rivet	50	PC47290	
Accordion rivet	50	PC47289	
Boom release assembly cable	3	2335501-1	
Boom release assembly cable	3	2335501-2	
Boom release assembly cable	1	2335501-3	

3-4. Level A Maintenance at KSC. Level A maintenance at KSC consists of those actions required to receive the flight system from BxA, and install it in the LM. It includes receiving-inspection, fit checks, and functional checks in the sequence illustrated in Figure 3-2. Any discrepancy requires a Material Review Board disposition. If an article cannot be used as is, it is replaced with a flight article spare which is requested from Level A BxA.

3-5. MAINTENANCE LEVEL B (SPECIALIZED)

Maintenance level B consists of factory repair and overhaul of ALSEP flight equipment. It will consist of detailed repair, overhaul, and component/part removal and replacement as well as required adjustments and calibration necessary to achieve the high level of ALSEP performance.

3-6. GROUND SUPPORT EQUIPMENT (GSE)

ALSEP GSE includes test sets, exciters, simulators, handling equipment, and selected standard tools and test equipment. Corrective maintenance for the STS includes self-test diagnostic programs (in conjunction with the "ALSEP System Test Equipment Maintenance Manual") to fault-isolate to the black box, panel, component, part, or to a functional circuit group of logic cards in the programmer/processor.

Maintenance beyond the level A capability will be accomplished at specialized repair (level B maintenance) levels, or by vendor services. ALSEP peculiar deliverable GSE will be directed to Bendix (or Bendix subcontractor), for repair as required.

3-7. GSE ELECTRICAL

Electrical GSE used in level A maintenance for testing of the ALSEP system is listed in Table 3-3. The system test set is the prime ALSEP maintenance tool and all other equipment listed in Table 3-3 is considered peripheral test equipment that complements the system test set. Figures 3-3 through 3-17 illustrate these equipments.

3-8. GSE MECHANICAL

Mechanical GSE used in handling, test, installation, and maintenance of the ALSEP system is listed in Tables 3-4 through 3-6, and illustrated in Figures 3-18 through 3-22.

3-9. TOOLS AND TEST EQUIPMENT

Standard tools and test equipment, facilities, and supplies required for maintenance are listed in Table 3-7.

Table 3-3. Electrical Ground Support Equipment

Figure No.	Nomenclature	Part Number	CFE or GFE
3-3	ALSEP system test set	2331700	CFE
3-4	Magnetometer flux tank assembly	WDL-29-173299 (Philco)	GFE
3-5	Gamma control console	WDL-99-173301 (Philco)	GFE
3-6	Integrated power unit test set	47E300467G1 (GE-MSD)	GFE
3-7	Environmental test chamber	PD452971 (3M)	GFE
3-8	IPU breakout box	BSX 7482	CFE
3-9	RTG simulator	BSX 6997	CFE
3-10	Grenade launch assembly test set	2331657	CFE
3-11	Active seismic sensor simulator	2331601	CFE
3-12	Passive seismic sensor exciter	CBE 2250 (Teledyne)	CFE
3-13	Heat flow sensor simulator	2332375	CFE
3-14	ALSD pressurization unit	467A8090000 (Martin-Marietta)	GFE
3-15	ALSD battery charging unit	467A808000 (Martin-Marietta)	GFE
3-16	Electric fuel capsule simulator	47D300261 (GE-MSD)	GFE
3-17	Antenna cap fixture	2333830	CFE
-	Thumper — AIRME adapter	2345477	CFE

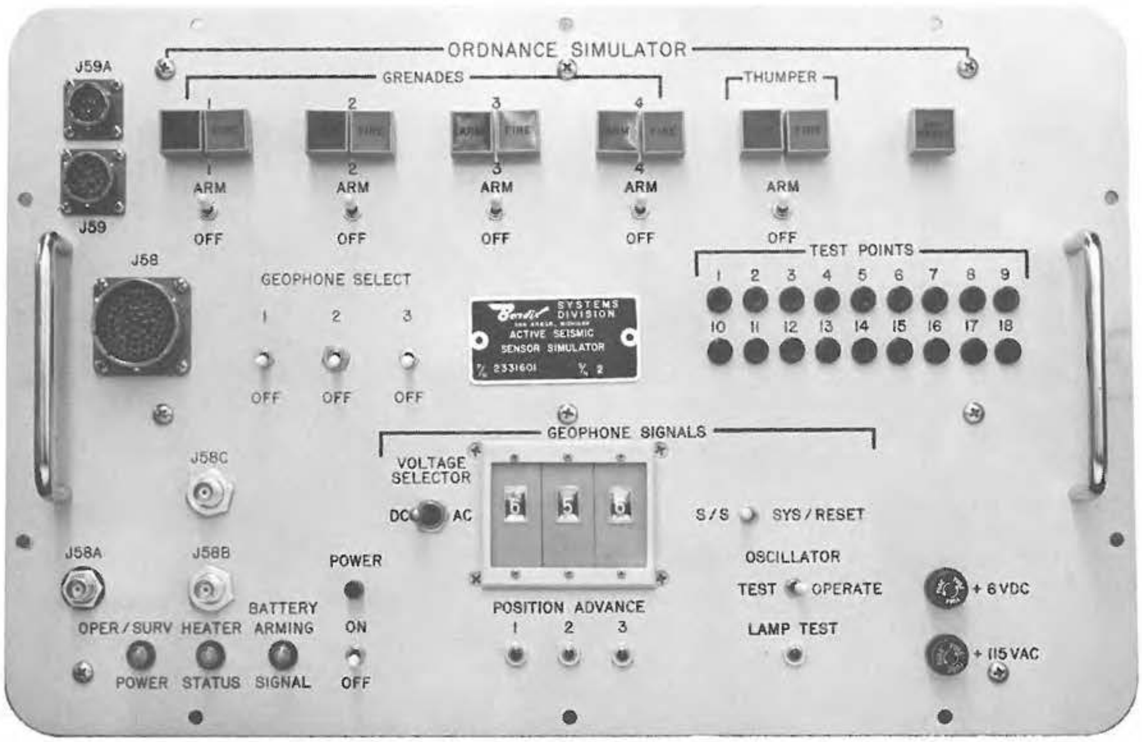


Figure 3-11. Active Seismic Sensor Simulator

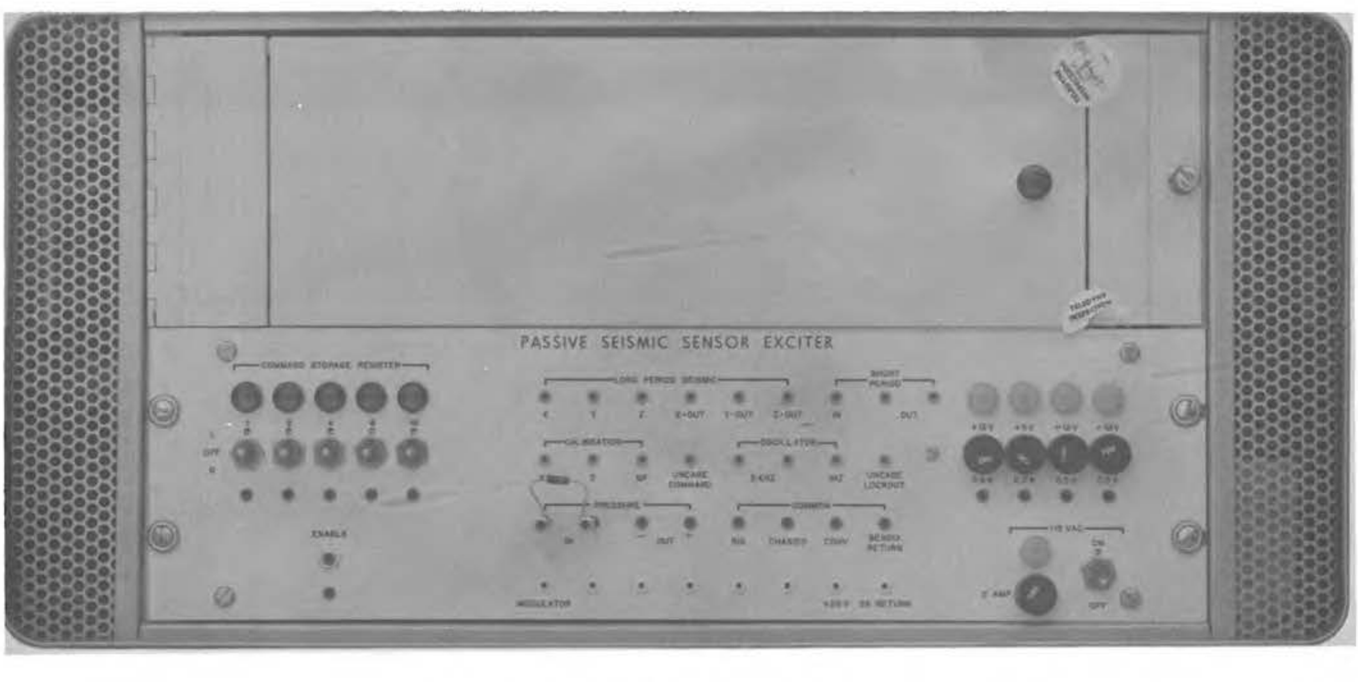


Figure 3-12. Passive Seismic Sensor Exciter

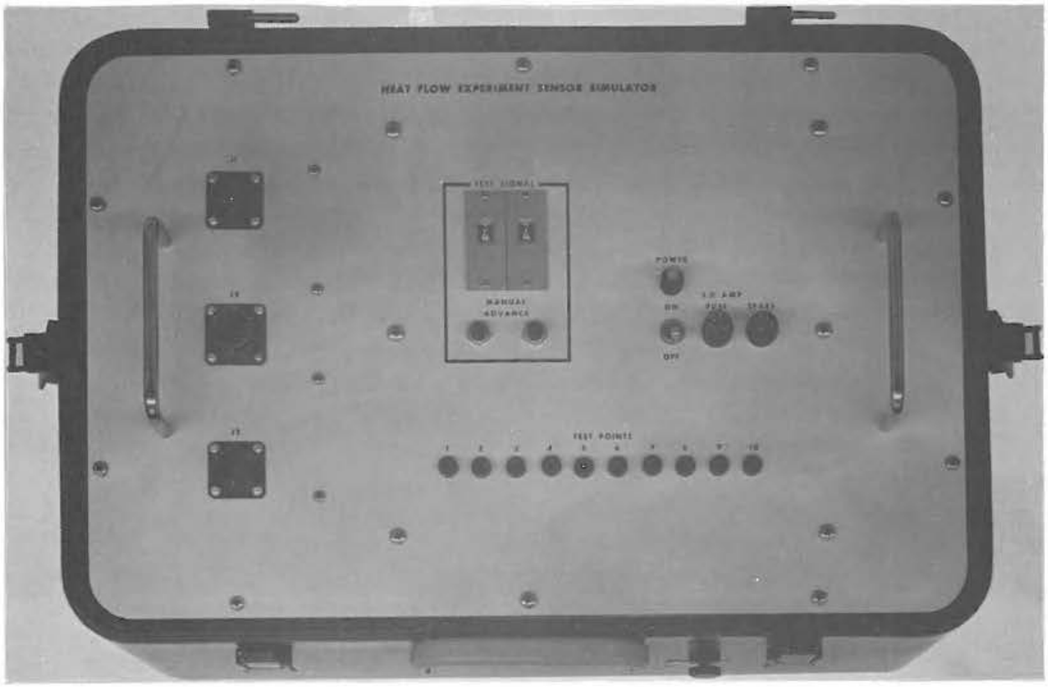


Figure 3-13. Heat Flow Sensor Simulator

Figure 3-14. ALSD Pressurization Unit

Table 3-4. Mechanical Ground Support Equipment (cont)

Nomenclature	Function	Part Number
Handling Device, Subpackage No. 2	Attaches to base of subpackage No. 2 for subpackage transfer to various test fixtures.	2335313
Handling Cart	Provides mounting tie-down for ALSEP subpackages during handling and transportation during maintenance.	2332899
Hoisting Device	Attaches to ALSEP holding fixture or handling device for subpackage hoisting operations.	2335310
Boyd Bolt Installation Tool	Attaches to Boyd bolt for insertion into ALSEP structure.	2338343
Boyd Bolt Torque Tool (Long)	Used to tighten Boyd bolt to required tension.	2338212
Boyd Bolt Torque Tool (short)	Used to tighten Boyd bolt to required tension.	2338215
Boyd Bolt Spindle Force Measuring Tool	Used to measure force required to depress Boyd bolt spindle.	2338213
Boyd Bolt Spindle Position Measuring Tool (long & short)	Used to measure position of spindle relative to Boyd bolt body.	2338651-1 2338651-2
Boyd Bolt Release Tool	Used to release Boyd bolt.	2335910
GLA Test Fixture	GLA alignment sensor checkout.	2331455
Cask Assembly Protective Cover	Protects fuel cask assembly on LM in SLA until fuel capsule loading	2345612
Central Station Handling Cart	Provides mounting tie-down for central station during handling and transportation.	2333431
Center of Gravity Fixture	Provides mounting tie-down during subpackage No. 1 or No. 2 center of gravity testing.	2335309
Pressure Regulator Assembly	Lowers pressure of gas from gas cylinders to purge or pressurize containers.	2338476

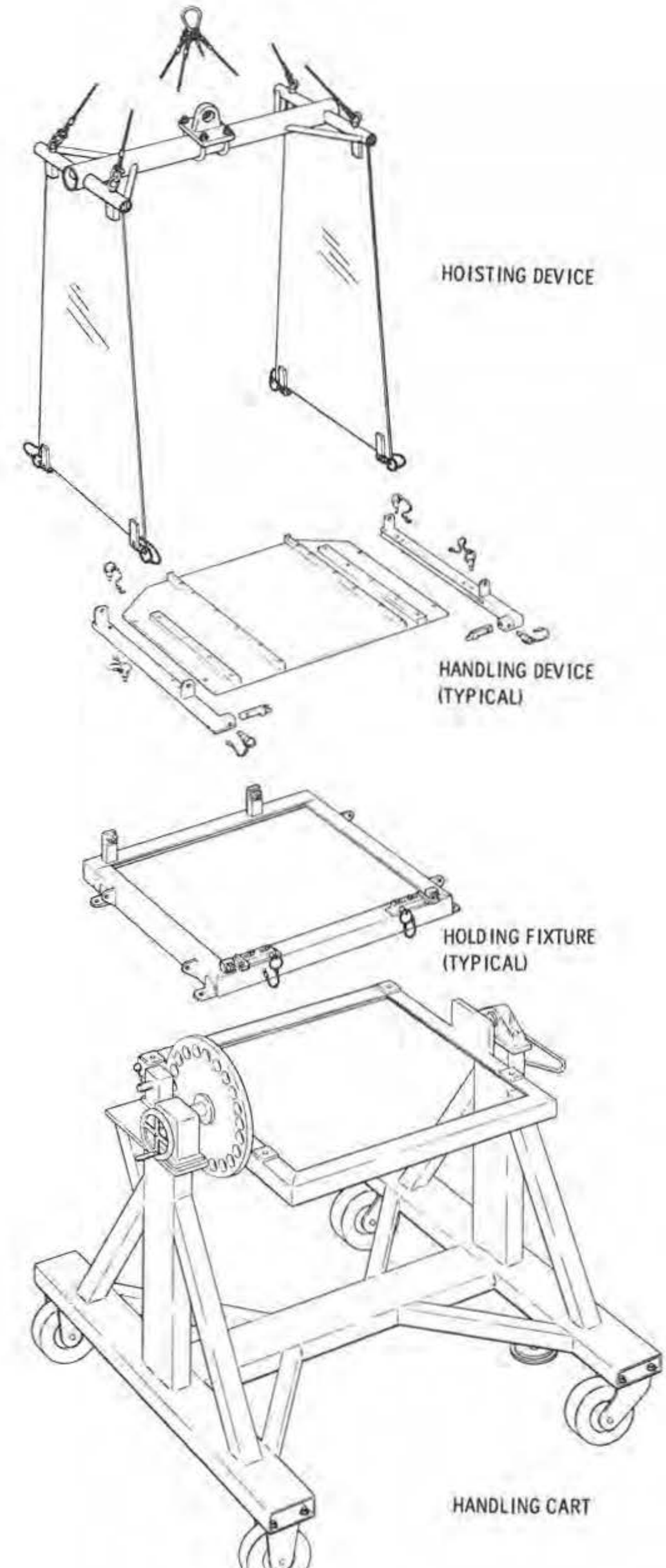


Figure 3-18. Subpackage Handling GSE

Figure 3-19. Boyd Bolt Tools

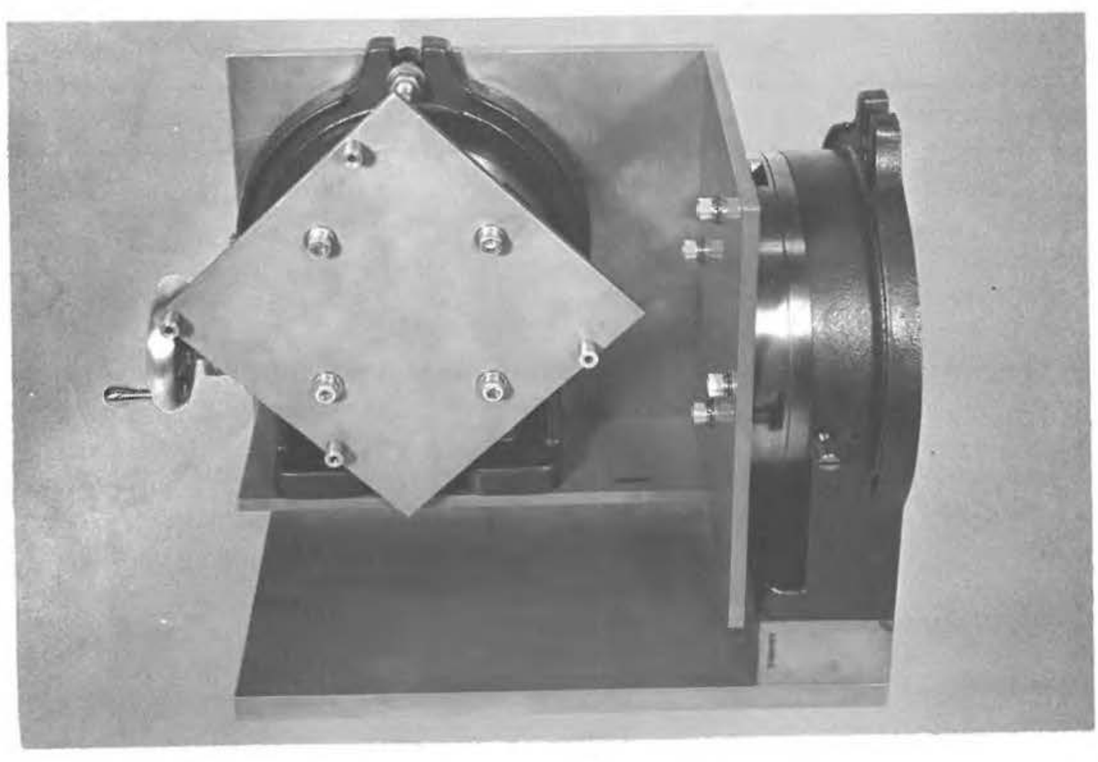


Figure 3-20. GLA Test Fixture

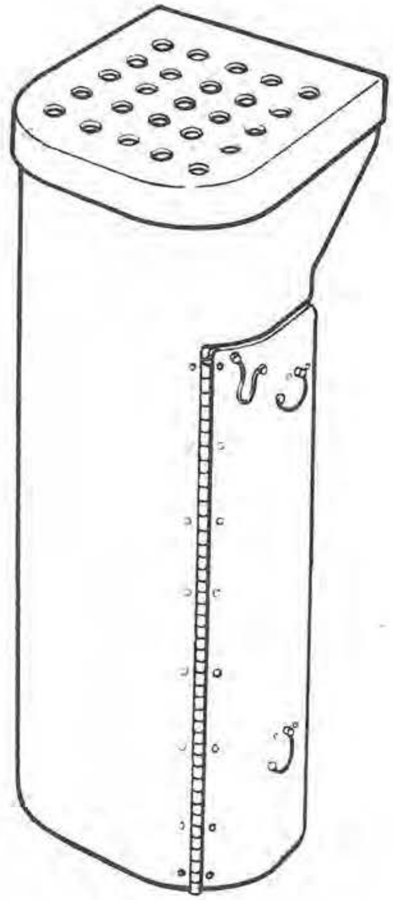


Figure 3-20A. Cask Assembly Protective Cover

Table 3-4A. SLA Installation Ground Support Equipment

Nomenclature	Function	Part Number
Lifting Frame Assembly	Attaches to base of subpackage No. 1 or No.2 for SLA installation handling operations. Mounts in transit container for transportation operations.	2345480
Transit Container Assembly	Provides environmental protection for subpackage No. 1 or No. 2 during SLA installation transportation operations.	2345410
Sling Assembly	Attaches to lifting frame assembly for SLA installation hoisting operations.	2340585
Safety Hook Assembly	Provides attachment of sling assembly to hositing device in SLA.	2345600

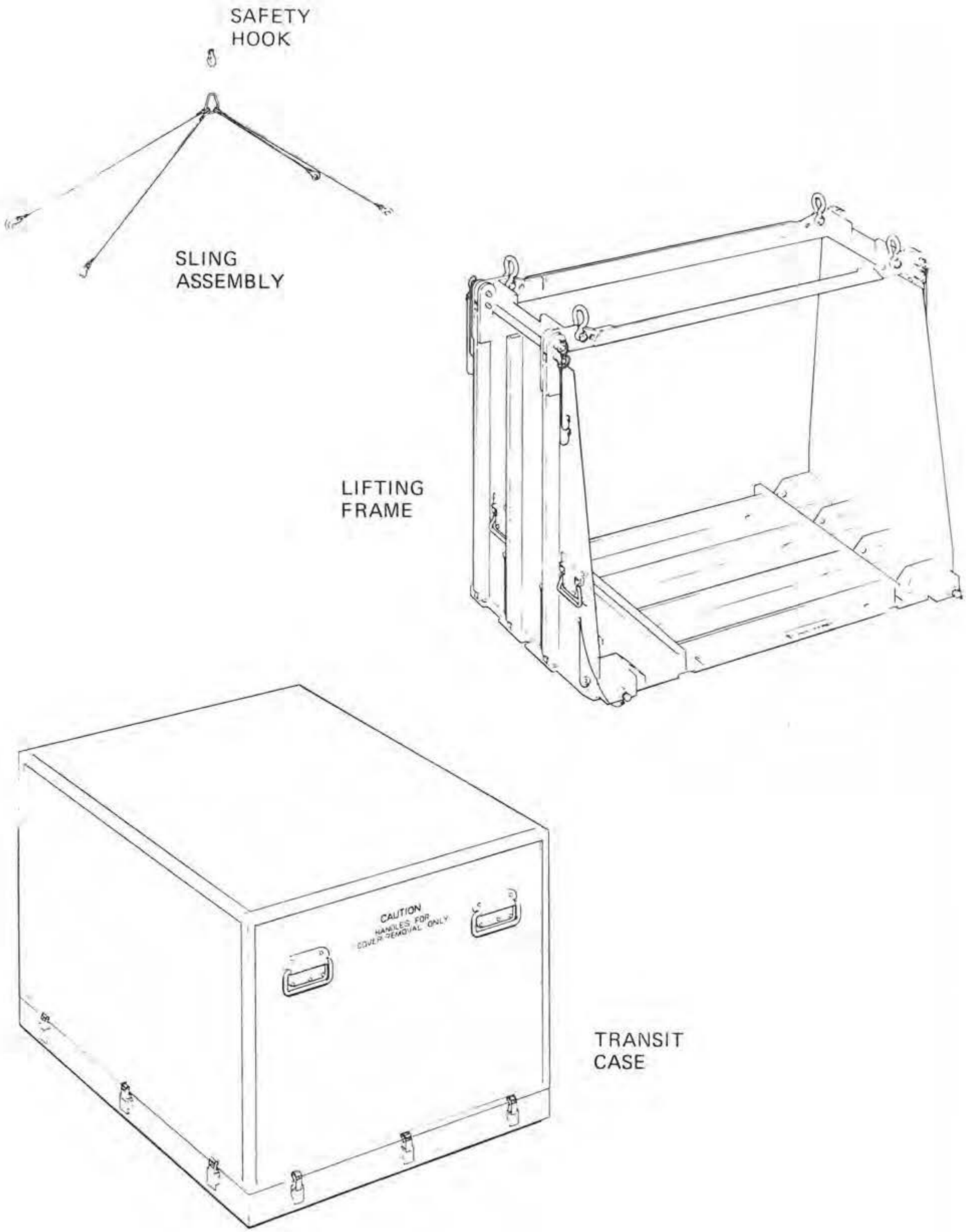


Figure 3-20B. SLA Installation GSE

Table 3-5. Fuel Cask/Structure Assembly Handling Equipment

Nomenclature	Function	Part Number
Cask/Structure Handling Device	Fuel cask structure assembly handling during fuel cask fit checks and LM fit checks.	2335319
Fuel Cask/Band Assembly Handling Device	Fuel cask/band assembly handling during fit checks to fuel cask structure assembly and installation on LM.	2335318
Trunnion Alignment/ Band Calibration Fixture	Fixture for cask/band assembly trunnion alignment and band tensioning procedures.	2335316
Dome Handling Tool	Fuel cask dome removal and handling during fuel capsule insertion/removal operations.	2335908
Strain Gage Readout Device	Provides tensioning readout during cask band tensioning procedures.	2332320
Fuel Cask Handling Cart	Provides transportation accommodations for fuel cask movement.	2335315
Dome Removal Tool	Remove dome from fuel cask during buildup.	2335317
Band Tensioning Tool	Used to tighten or loosen cask bands.	2338044
Dome/Tool Receptacle	Provides storage for fuel cask dome with dome handling tool attached.	2337950
CG Determination Fixture	Holding, CG, and fit check fixture for fuel cask and structure assembly.	2335314

Table 3-6. Fuel Capsule Handling Equipment

Nomenclature	Function	Part Number
Capsule SLA handling tool	Used at the launch area for insertion and removal of the fuel capsule assembly.	(GFE)
Capsule transfer cask	Used to transport fuel capsule assembly from a van on the launch pad to the SLA platform area of the Apollo spacecraft.	(GFE)
Capsule port entry trough	Used to transfer the fuel capsule assembly, with the SLA handling tool attached through a ten-inch access port in the spacecraft structure at the level of LM/ fuel cask attachment.	(GFE)
Capsule inspection tool	Used to verify proper engagement of fuel capsule assembly in the LM fuel cask.	(GFE)

Table 3-7. Standard Tools, Test Equipment, Facilities, and Supplies

Part Number	Nomenclature	Function
Tektronix 546	Oscilloscope (2)	
Tektronix CA	Vertical plug-in unit (2)	
HP 805 C	Slotted line (1)	
HP 415 B	VSWR meter (1)	
HP 211 A	Square wave generator (1)	
HP 616 B	Signal generator (1)	
HP 851-8551	Spectrum analyzer (1)	
Empire AT30-10	Attenuator pad (2)	
BPD-SPS2000 (or equivalent)	Stored program simulator (1)	
HP 410 B	VTVM (2)	
Simpson 206-5M	VOM (2)	
HP 721 A	Power Supply (1)	
HP 405	Digital Voltmeter (1)	
	Set miscellaneous cables	
(GFE)	Apollo Initiator Resistance Measuring Equipment (AIRME)	Thumper assembly and GLA circuit checks.
(GFE)	ALINCO squib tester	CPLEE ordnance circuit checks.
	Vacuum enclosure	RTG leak test.
	Vacuum pump	RTG leak test.
(GFE)	Spectrometer type leak detector	RTG leak test.
	Gaseous nitrogen supply (regulated at 150 psig (max.)	Calibration and checkout of ALSD.
	Gaseous argon supply	Repressurizing RTG container.
11310 Yardney Elect. Co.	ALSD battery filling kit	ALSD battery activation

3-10. TRANSPORTATION EQUIPMENT

Transportation equipment consists of ALSEP containers that provide protection for the flight article subsystems and components during delivery to KSC and movement between facilities at KSC during maintenance activities. Transportation equipment for the ground support equipment consists of commercial packages that provide protection for the GSE components during shipment to KSC.

The shipping containers used for transportation of the ALSEP flight article and associated GSE include two types, ALSEP containers and commercial packages. The following paragraphs briefly describe each type of container.

3-11. ALSEP Containers. Special containers are provided for each ALSEP subpackage assembly, and separately shipped subsystem component. Figure 3-23 illustrates typical ALSEP containers.

The ALSEP containers are constructed for an outer metal housing specifically shaped to enclose the associated assembly which is mounted on a shock isolation plate. The containers are instrumented to provide a real-time history of shock on three axes, and temperature for at least seven days. A humidity indicator, visible from outside the container, provides an indication of the humidity within the container. The container for subpackage No. 1, Flight 1 and Array A-2, incorporates a GFE flux recorder for checking magnetic field exposure during shipment.

3-12. Commercial Packages. Commercial packaging is primarily used for shipment of GSE. The packages consist of components wrapped or packaged in a carton, box, bag, or similar container that conforms to commercial shipping practice. Commercial packaging methods are as follows:

a. Component mounted on a pallet, wrapped in plastic, and metal-banded to pallet.

b. Component mounted in a plywood box on mating hardpoints and box packed with dunnage.

c. Component wrapped in plastic, placed in a plywood box, and packed with dunnage.

d. Component sealed in plastic, wrapped in cellulose or aircap, and placed in corrugated paper box.

e. Component packed in foam, molded to fit component contour, and packed in wood, metal, or plastic box.

3-13. ALSEP SUPPORT MANUALS

There are six ALSEP support manuals used as an integrated documentation system to support the ALSEP hardware system. These manuals are listed in Table 3-8.

Table 3-8. ALSEP Support Manuals

Title	Document Number
ALSEP General Familiarization Manual	ALSEP-MA-24
ALSEP Flight System Familiarization Manual	ALSEP-MT-03
ALSEP Flight System Maintenance Manual	ALSEP-LS-04
ALSEP System Test Equipment Maintenance Manual	ALSEP-LS-06
ALSEP Transportation and Handling Manual	ALSEP-LS-03
Grenade Launch Assembly Test Set Instructions Manual	ALSEP-LS-07

SECTION IV

OPERATIONS

4-1. OPERATIONS, GENERAL

This section presents a description of the operational ALSEP flight hardware operations. The description encompasses events occurring between equipment receipt at Kennedy Space Center (KSC) and the programmed shutdown of ALSEP lunar operation. Table 4-1 contains a location index of ALSEP operations.

Table 4-1. ALSEP Operations Locations

KSC	Lunar Surface	Postdeployment
ALSEP inspection	In-flight configuration	MSFN operation
	Post-landing operations	MCC operation
Fit checks	Carry mode	PI activities
Ordnance verification		
ALSD activation	Deployment: (a) Support subsystems (b) Experiment subsystems	
ALSEP installation		
ALSD installation		
Grenade and thumper installation		

4-2. KSC PRELAUNCH CHECKOUT AND INSTALLATION

Activity at KSC includes inspection, fit checks, ordnance verification, assembly, test, and ALSEP installation. Figure 3-2, Sheet 2 shows the sequence of events necessary to receive, check out, and install ALSEP equipment in the LM. Note that Class A ordnance and radioactive items are received and checked in a location separate from the rest of the ALSEP equipment. KSC ALSEP facilities consist of:

a. Bunker facility - used for checkout of the GLA

b. Ordnance laboratory building, M7-1417 - Used in conjunction with the bunker facility to test the GLA, thumper, and ordnance

c. ALSEP launch preparation site (ALPS) - Used for receipt, inspection, assembly, and bonded stores operations.
d. AEC fuel capsule storage.

4-3. KSC INSPECTION AND CHECKOUT

ALSEP activities are centered in the ALPS (Hangar S, Cape Kennedy Air Force Station). All ALSEP subsystems except the GLA and thumper are received and tested here.

Ordnance items are stored in the ordnance test storage facility (LC-39) where ordnance circuit tests, lot verification and installation are accomplished. Ordnance items include the following:

a. Squib devices - used to actuate CCIG and CPLEE dust covers and uncage the PSE after experiment deployment.
b. Thumper initiators - used in thumper firing operations.
c. Four rocket grenades - used in the active seismic experiment. (Class A ordnance)

4-4. KSC Inspection. Ordnance items, as noted in paragraph 4-3, will be received, inspected, and stored at the KSC ordnance test storage facility. The remaining ALSEP equipment will be received, inspected, and stored at the ALPS.

The ALSEP equipment listed in Table 4-2 will be inspected upon receipt for possible shipping damage that may have occurred in transit. Temperature, humidity, magnetic flux and shock recorders will be monitored for maximum excursions, if applicable. Excursions will be recorded on the logistic traveler or the quality assurance inspection report (QAIR).

4-5. KSC Equipment Calibration. Equipment calibration conducted at KSC is listed in Table 4-3 with an explanation of the task to be performed. All calibration data will be entered in the GSE calibration log.

4-6. KSC Equipment Checkout. Table 4-4 lists the ALSEP equipment and ALSEP GSE requiring checkout. Appropriate checks for each item are referenced.

4-7. KSC Fit Checks. Fit checks of ALSEP hardware, tools, packages, and the LM are required to verify tolerances and effective operation and installation. Table 4-5 lists the fit checks required.

4-8. KSC ALSEP INSTALLATION

4-9. KSC Ordnance Installation. The ALSEP system is delivered to the ordnance laboratory after all ordnance tests are complete. The ALSEP system is stored in the ordnance laboratory storage facility between ordnance installation activities. Ordnance items are installed as follows:

Table 4-2. KSC Inspection

Item	Sub-item (if applicable)
GLA Test Set (GLATS)	(Received at ordnance facility and transferred to Building M7-1210 for inspection)
CPLEE CCIG, PSE Ordnance	Lot verification ordnance
Thumper Geophone Cable Assembly	Thumper 21 Apollo Standard Initiators (ASI) Three geophones and cables
Grenade Launcher Assembly (GLA)	Launcher assembly Four rocket grenades
ALSEP Subpackage No. 1	Experiment subsystems Data subsystem
ALSEP Subpackage No. 2	Experiment subsystems Radioisotope Thermoelectric Generator Handling tools
Apollo Lunar Hand Tools	
Apollo Lunar Surface Drill (ALSD)	Battery pack Power head Casing
ALSD GSE	Transport/storage case Battery charger Pressurization unit
Flight Fuel Cask	
Fuel Cask Structure Assembly	
RTG Fuel Capsule	(The fuel capsule will not be removed from the shipping cask for inspection and will be stored in the AEC storage facility)
Fuel Capsule Handling Tools	Capsule ground handling tool Capsule spacecraft LM adapter (SLA) handling tool Capsule transfer cask Capsule port transfer trough
ALSEP/LM Installation and Handling Equipment	Sub-package hoist equipment ALSEP/LM Insertion handling fixtures Handling equipment support platform

a. Dust cover squibs are installed on particle experiments and the connections are soldered.

b. The thumper assembly is installed on subpackage no. 2.

c. The GLA is installed in the mortar box to make up the mortar package assembly which is mounted on subpackage No. 1.

Table 4-3. KSC GSE Calibration

Item	Task
GLA Test Set	Calibrate in accordance with "GLA Test Set Instructions Manual."
ALSD (GSE)	Check the battery charger for rate, voltage, and charge termination using spare set of silver oxide zinc cells. Calibrate low and high pressure relief valve settings.
Trunnion Alignment/Band Calibration Fixture	Adjust per top assembly drawing.

4-10. KSC ALSEP Installation in LM. The ALSEP subpackages prior to flight 4 are installed in the SEQ bay while the LM is in the landing gear fixture just prior to mating with the spacecraft LM adapter (SLA). A special platform is erected to the SEQ bay level to facilitate ALSEP installation.

Table 4-4. KSC ALSEP Equipment Checkout

Item	Checks
GLA test set	Check satisfactory operation in accordance with "GLA Test Set Instructions Manual."
Thumper assembly circuit check	Verify circuit continuity of Apollo standard initiators installed in thumper using squib tester at ordnance test facility.
GLA	Verify circuit continuity of squibs and cable using AIRME squib tester and ordnance voltmeter (Simpson 260 with batteries removed).
ALSD	Verify the ALSD battery and power head have correct internal pressure settings on the relief valve and that the power head functions satisfactorily.
ALSD GSE	Verify correct operation of ALSD battery charger and pressurization unit by verifying the output of the battery charger and leak testing the pressurization unit.

The ALSEP subpackages of flight 4 and subsequent are installed in the SEQ bay of the LM in the SLA at Complex 39. The special GSE listed in Table 3-4A is used to facilitate this operation.

4-11. KSC ALSD Installation. Included in the ALSD installation are battery activation, pressure checks, and functional tests, which are performed as follows:

a. The ALSD battery is activated and charged prior to installation in the ALSD. If rescheduling at this point delays the activity by more than 6 days, the batteries are replaced.

b. The pressurization unit is connected to a supply of regulated nitrogen. The pressure required to actuate the relief valve is checked. A soak test is conducted to check for leaks from the battery box. A check is then made of the battery power switch operation and the off load voltage at the output connector.

c. The ALSD power head and battery pack are assembled and locked together. The power head is operated for ten seconds to verify proper operation.

d. The ALSD is transported to the SLA at Complex 39 where it is mounted on ALSEP subpackage No. 2 which is already installed in the SEQ bay. After completion of the ALSD installation, the SEQ bay door is closed and secured. In Array A-2, the ALSD is mounted elsewhere on the LM.

Table 4-5. KSC Fit Checks

Item	Fit Checked with:
ALSD	Subpackage No. 2
Fuel Capsule	SLA handling tool (from cask to port entry trough and back to cask)
	Fuel Transfer tool
	Fuel cask
	RTG
Fuel Cask	Fuel cask structure assembly
Fuel Cask structure assy	LM
ALHT	Subpackage No. 2
ALSEP (Subpackages and ALSD)	LM

4-12. KSC Fuel Cask and Fuel Capsule Installation. The fuel cask and mounting structure assembly is transported to the work platform at SLA and is mounted on the LM structure after the LM has been fueled.

The radioactive and hot (1200°F) fuel capsule is transported to the SLA work platform, inserted into the fuel cask in the upright position, and locked in place using the SLA handling tool.

4-13. LUNAR SURFACE OPERATIONS

The following paragraphs describe the events that take place from the time the LM lands on the lunar surface until all ALSEP experiments have been deployed. Included in the discussion are:

a. Flight mode - The in-flight configuration of ALSEP equipment.

b. Post-landing operations - The events that occur between lunar landing and the beginning of ALSEP deployment procedures.

c. Carry mode - The activity performed by the crewmen in removing the ALSEP equipment from the LM and transporting it to the emplacement area.
d. Deployment and activation - The events performed by the crewmen in emplacing and activating the experiments.

4-14. FLIGHT MODE

During flight, the ALSEP system is inert except for the structure/thermal subsystem function of providing thermal protection to the LM. The location of the fuel cask assembly, external to the LM, provides a heat rejection system for the fuel capsule and for crew safety during deployment. The cask support structure incorporates a thermal shield to reflect cask thermal radiation away from the LM. In addition, insulators are incorporated in the structure to reduce conductive heat transfer to the LM.

ALSEP subsystems and experiments are mounted on subpackage pallets which are secured in the LM SEQ bay. The SEQ bay is located in LM descent stage behind a thermal door. The subpackages occupy a volume of approximately 15 cubic feet and are locked in place by retaining pins. Contents of the two subpackages for Flight 1 are listed in Table 4-6. On Flight 3 the magnetometer and solar wind experiments are replaced by charged particle, cold cathode gauge, and heat flow experiments on subpackage No. 1 and the Apollo lunar surface drill replaces the suprathermal ion detector experiment on subpackage No. 2. On Flight 4 subpackage No. 2 is identical with subpackage No. 2 of Flight 1. Flight 4 subpackage No. 1 will mount the passive seismic and charged particle experiments, the mortar box assembly and the thumper of the active seismic experiment. In addition, the active seismic electronics package will be incorporated in the central station. The Array A-2 subpackage No. 1 mounts the same experiments as the Flight 1 subpackage No. 1. The Array A-2 subpackage No. 2 is the same as the Flight 1 subpackage No. 2 except the Apollo lunar hand tools are replaced by the heat flow experiment. The Apollo lunar surface drill and the Apollo lunar hand tools are mounted elsewhere on the LM.

Table 4-6. Subpackage Configuration, Flight 1

Subpackage No. 1 (SEQ Compartment No. 1)	Subpackage No. 2 (SEQ Compartment No. 2)
Magnetometer experiment Passive seismic experiment Solar wind experiment Dust detector* Data subsystem antenna* Data subsystem* Power conditioning unit* *Part of central station	Suprathermal ion detector experiment Radioisotope thermoelectric generator Passive seismic stool Apollo lunar hand tools Fuel transfer tool Universal handling tool (2) Dome removal tool Antenna aiming mechanism Antenna mast/carry bar sections (2)

rotate the cask to a proper unloading angle. Using the dome removal tool, the crewman removes the cask dome and discards the cask dome and the DRT.

The crewman removes the fuel capsule from the fuel cask by inserting the FTT into the fuel capsule head, rotating the tool handle to achieve engagement and capsule release, and withdrawing the tool and capsule from the cask. The crewman then moves with the tool and attached fuel capsule to the RTG and lowers the capsule into the generator cavity. Once the fuel capsule has been placed in the RTG, release is accomplished by reversing the rotation of the tool handle. Releasing the tool from the fuel capsule head automatically locks the fuel capsule in the RTG. The tool provides positive connection with the fuel capsule, separation from the hot element, and control of the transfer by the crewman. The FTT is discarded.

4-21. Transport ALSEP to Emplacement Area. The crewman places the subpackages in the carrying position and connects the antenna mast between the subpackages. The connectors are simple keyhole slip-fit. The crewman lifts the subpackages to the carrying position in "barbell" fashion as shown in Figure 4-1, and carries them approximately 300 feet from the LM on the Z axis. The representative direction of the Z axis is affected by the suitability of the surrounding terrain. For purposes of this description, it is assumed that a southwesterly direction from LM is satisfactory for the emplacement of the ALSEP. While carrying the subpackages, lateral balance is shifted by changing the hand position on the carry bar.

The 300-foot (approximate) distance to the emplacement area is the result of a trade-off in comparing the necessity of ALSEP deployment out of the LM ascent blast area with the constraints of keeping the crewman within the time and distance limitations dictated by the mission. The walk to the deployment area is timed to prevent excess RTG warmup and thereby avoid potential thermal problems for the crewman.

4-22. DEPLOYMENT

To aid the astronaut in proper deployment of the experiments, decals, similar to those shown in Figure 4-1A, are attached to the subpackages and experiments. The deployment alignment and level indicating devices of the central station and experiments are illustrated in Figure 4-1B.

The following paragraphs describe the events that occur from the time the crewman arrives at the ALSEP emplacement area until he has deployed all ALSEP equipment. It is assumed that the ALHT was removed from the ALSEP No. 2 subpackage on the initial excursion. Deployment activities are discussed in the procedural sequence performed by the crewman. Figures 4-2 through 4-4A illustrate the layout of the ALSEP equipment and experiments after deployment.

Each of the ALSEP systems will carry different combinations of experiments. Deployment steps applicable to the experiments carried on Flights 1 and 2 are discussed in paragraph 4-23. Deployment steps applicable to the experiments carried on Flights 3 and 4 and Array A-2, which were not discussed in paragraph 4-23, are provided in paragraphs 4-24 through 4-25A.

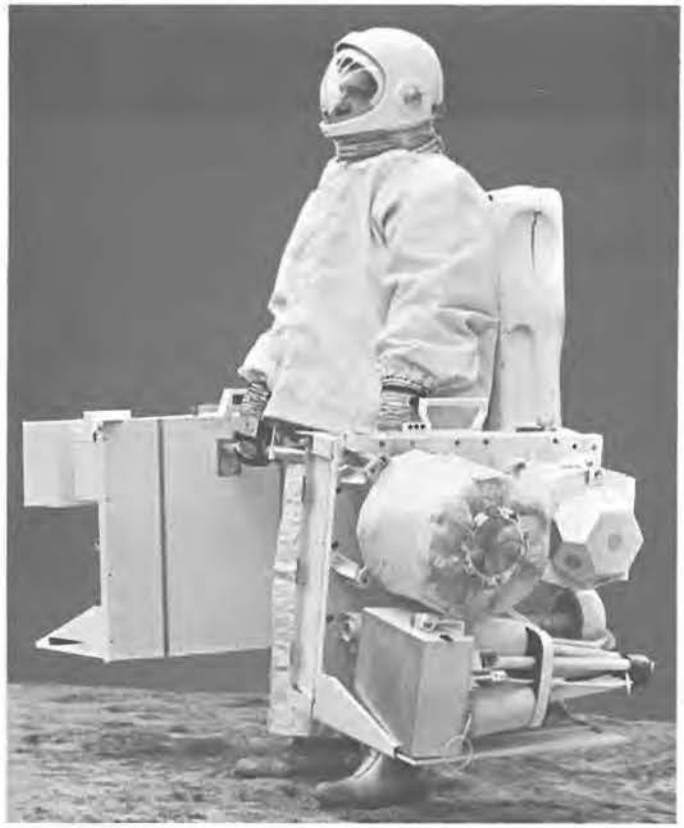


Figure 4-1. Barbell Carry Mode

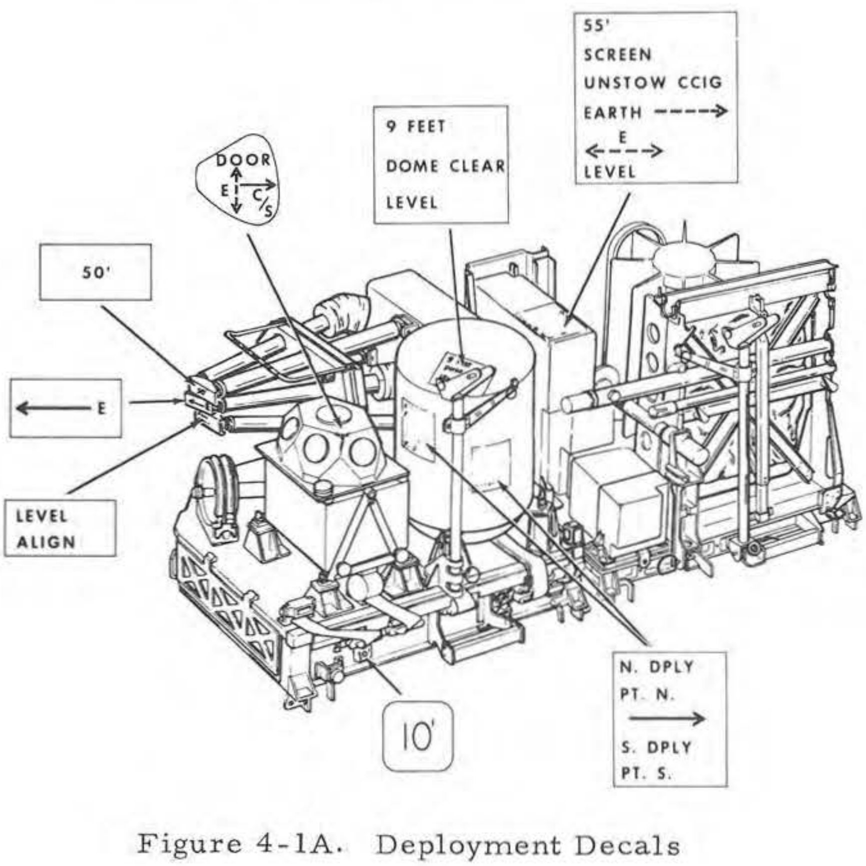


Figure 4-1A. Deployment Decals

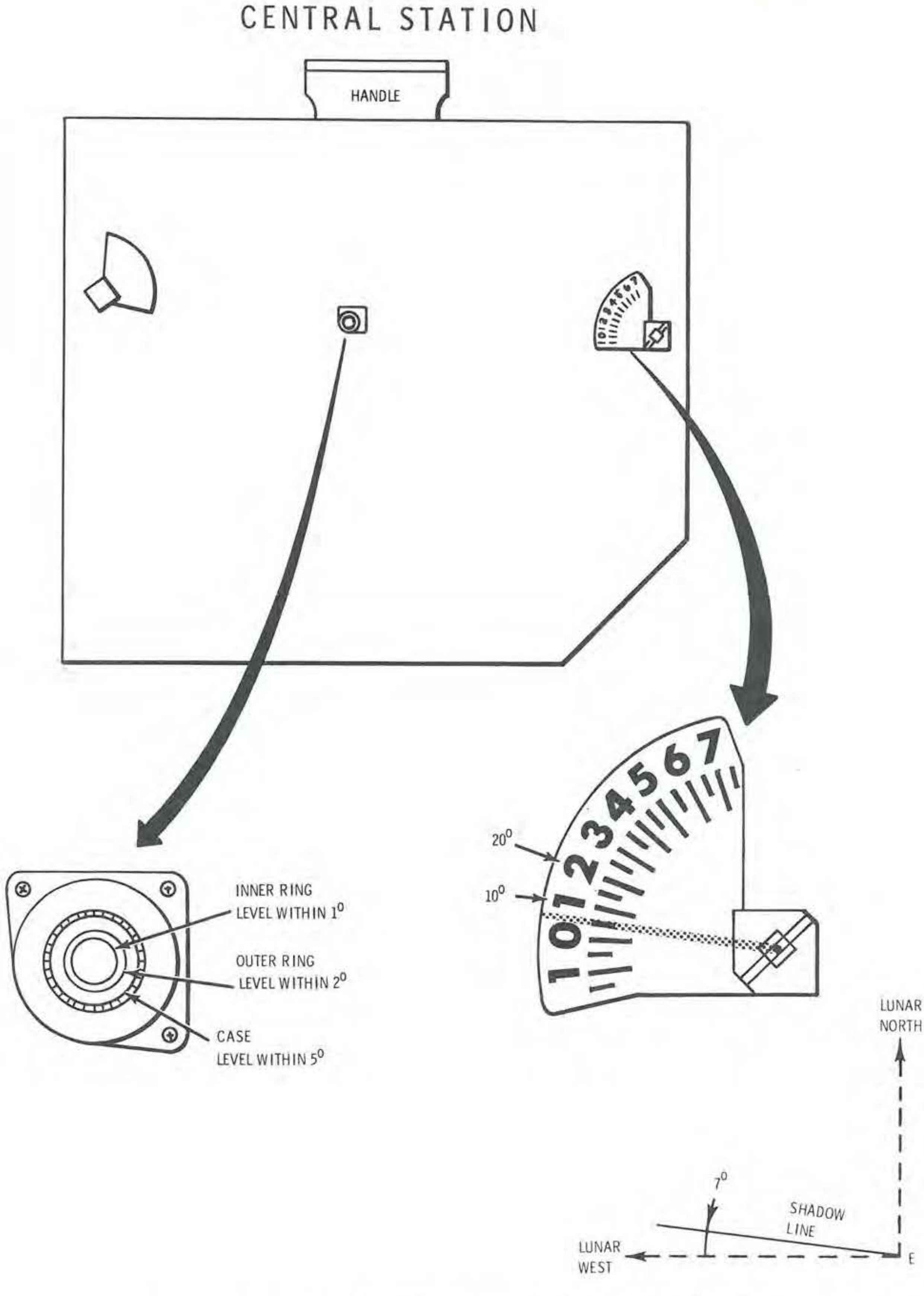


Figure 4-1B. ALSEP Array A-2 Alignment and Leveling Devices (Sheet 1 of 7)

CENTRAL STATION ANTENNA

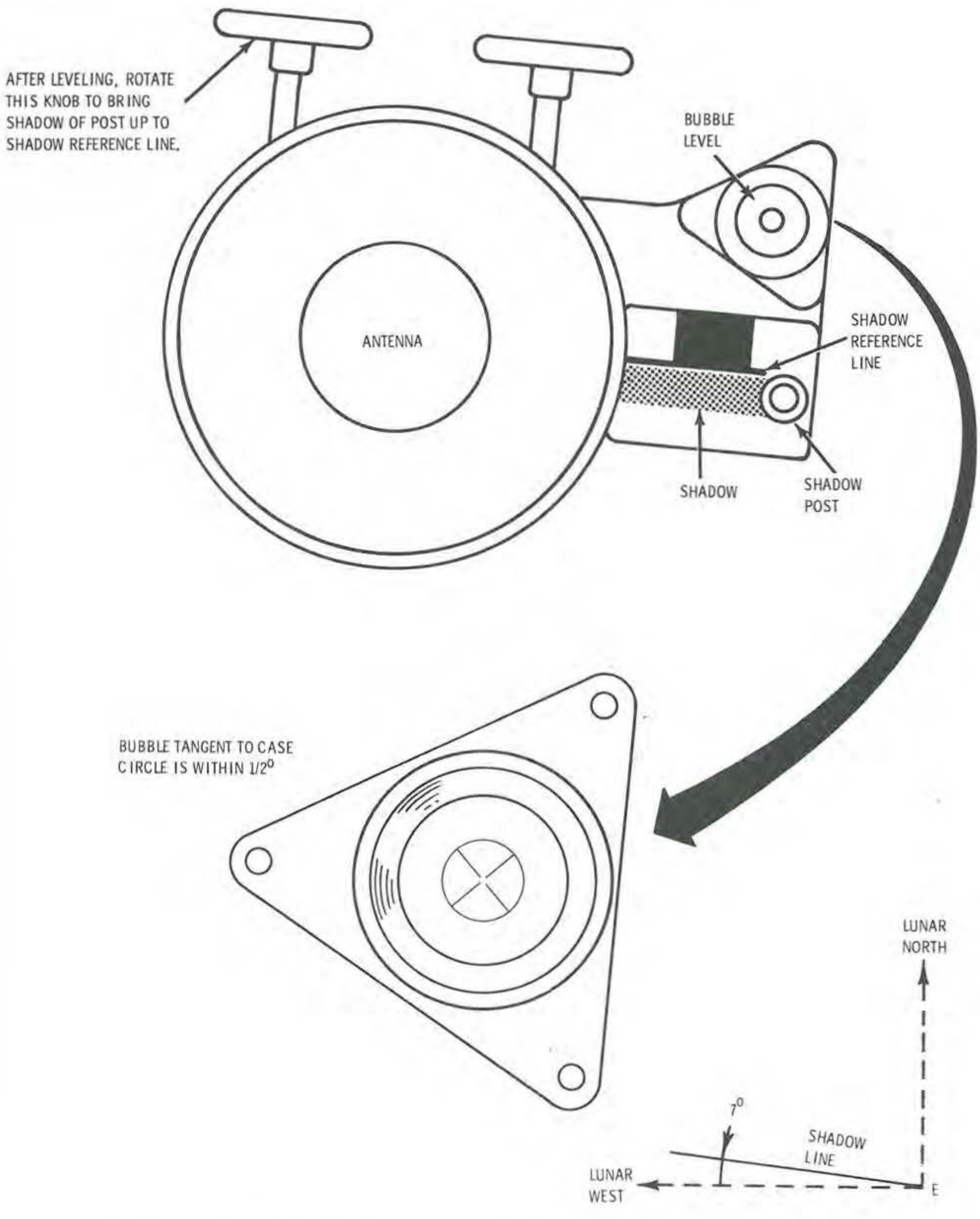


Figure 4-1B. ALSEP Array A-2 Alignment and Leveling Devices (Sheet 2 of 7)

PSE

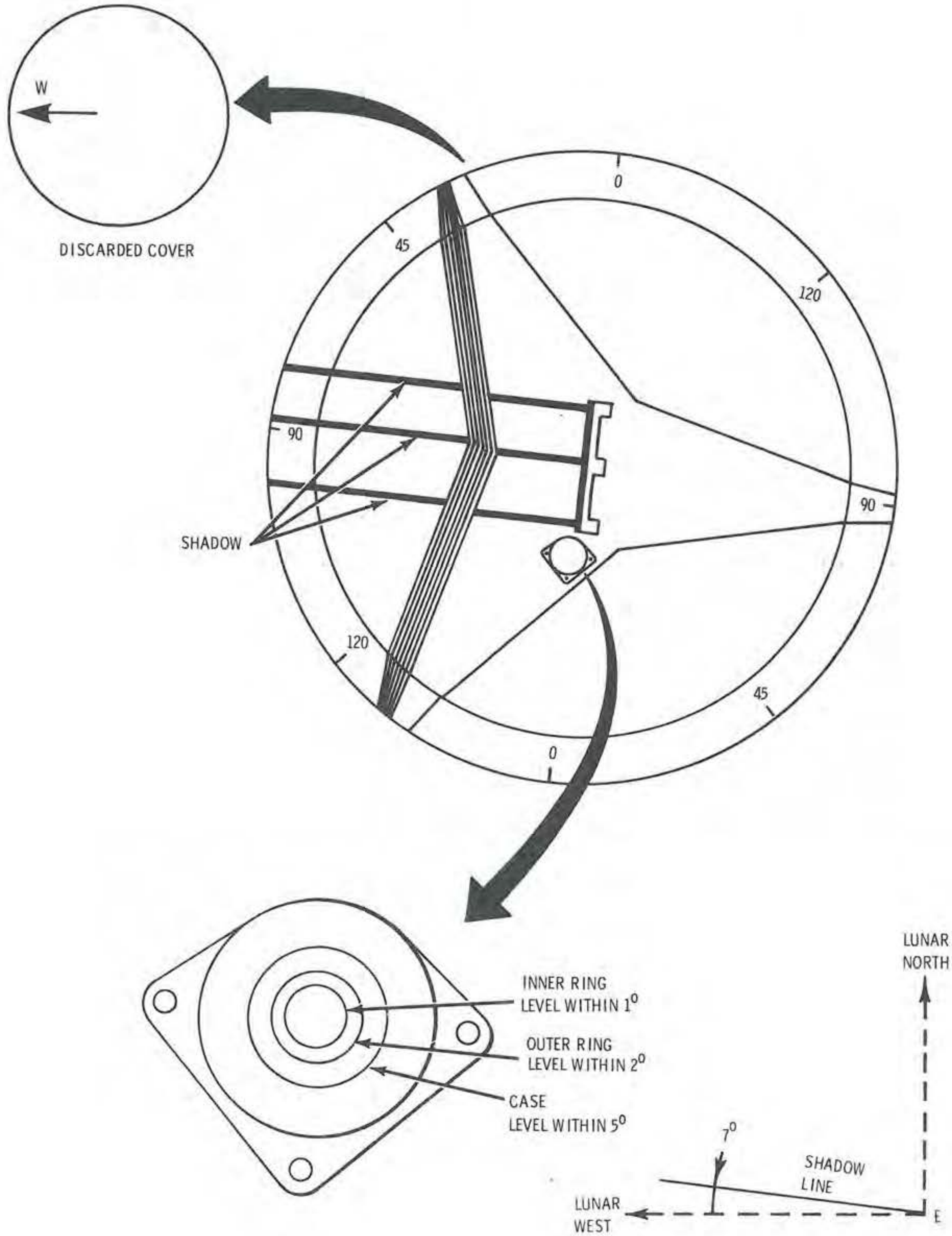


Figure 4-1B. ALSEP Array A-2 Alignment and Leveling Devices (Sheet 3 of 7)

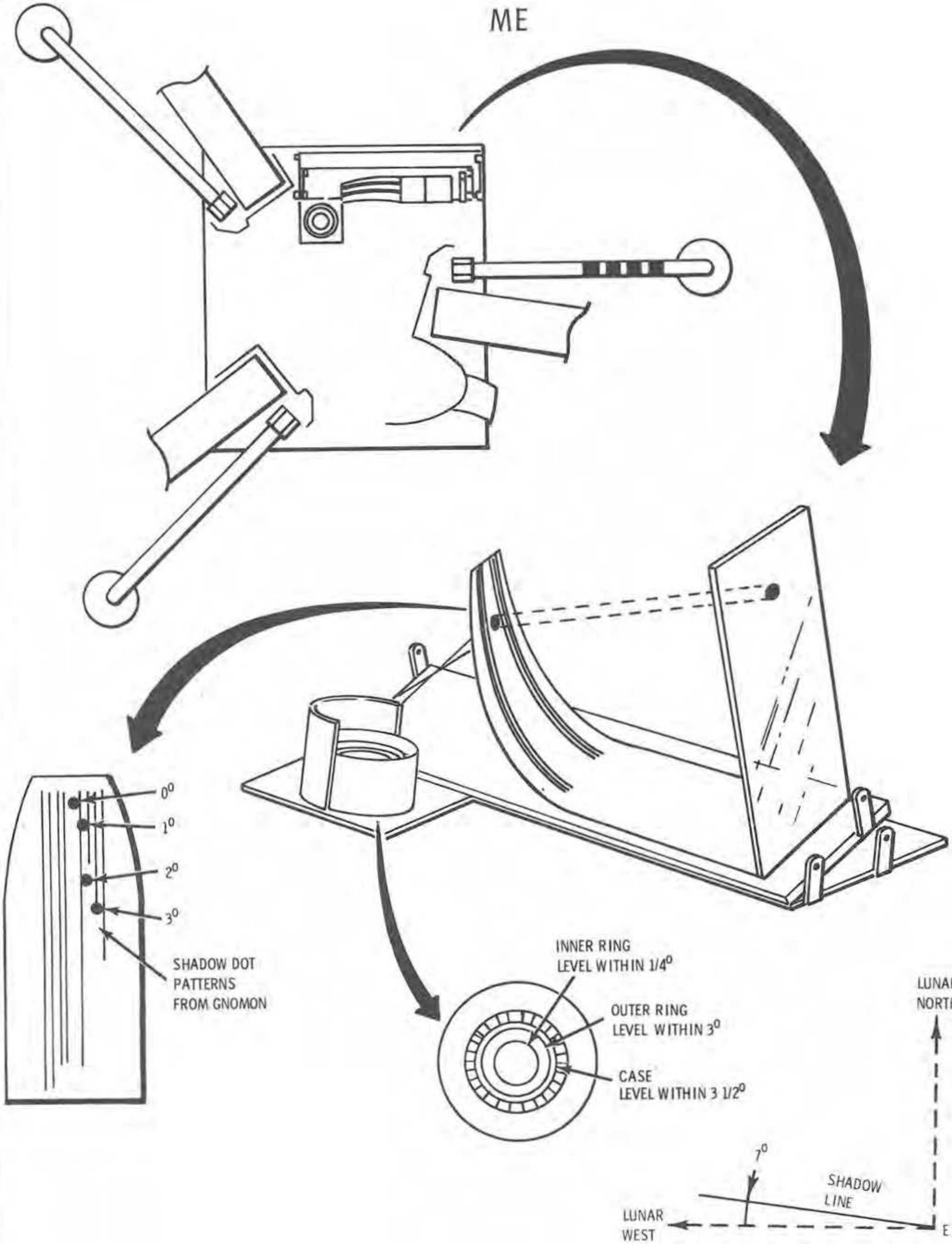


Figure 4-1B. ALSEP Array A-2 Alignment and Leveling Devices (Sheet 4 of 7)

SWE

NOTE: SWE TO BE POSITIONED SO AS TO ASSURE FREE N-S PENDULOUS ACTION AND ALIGNED SO THAT SHADOW CAST BY GNOMON IS PARALLEL WITH E-W EDGE OF SUNSHIELD

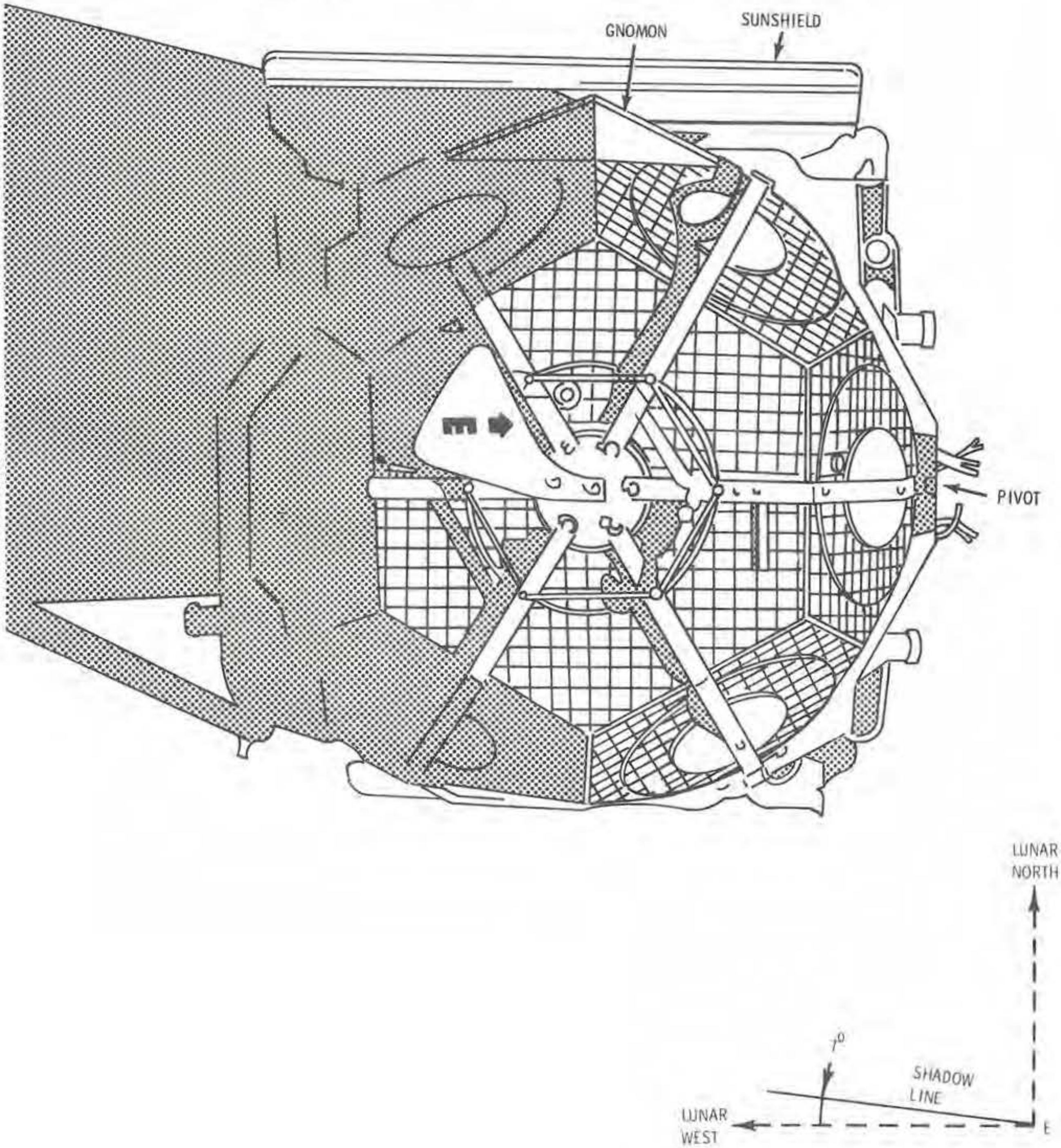


Figure 4-1B. ALSEP Array A-2 Alignment and Leveling Devices (Sheet 5 of 7)

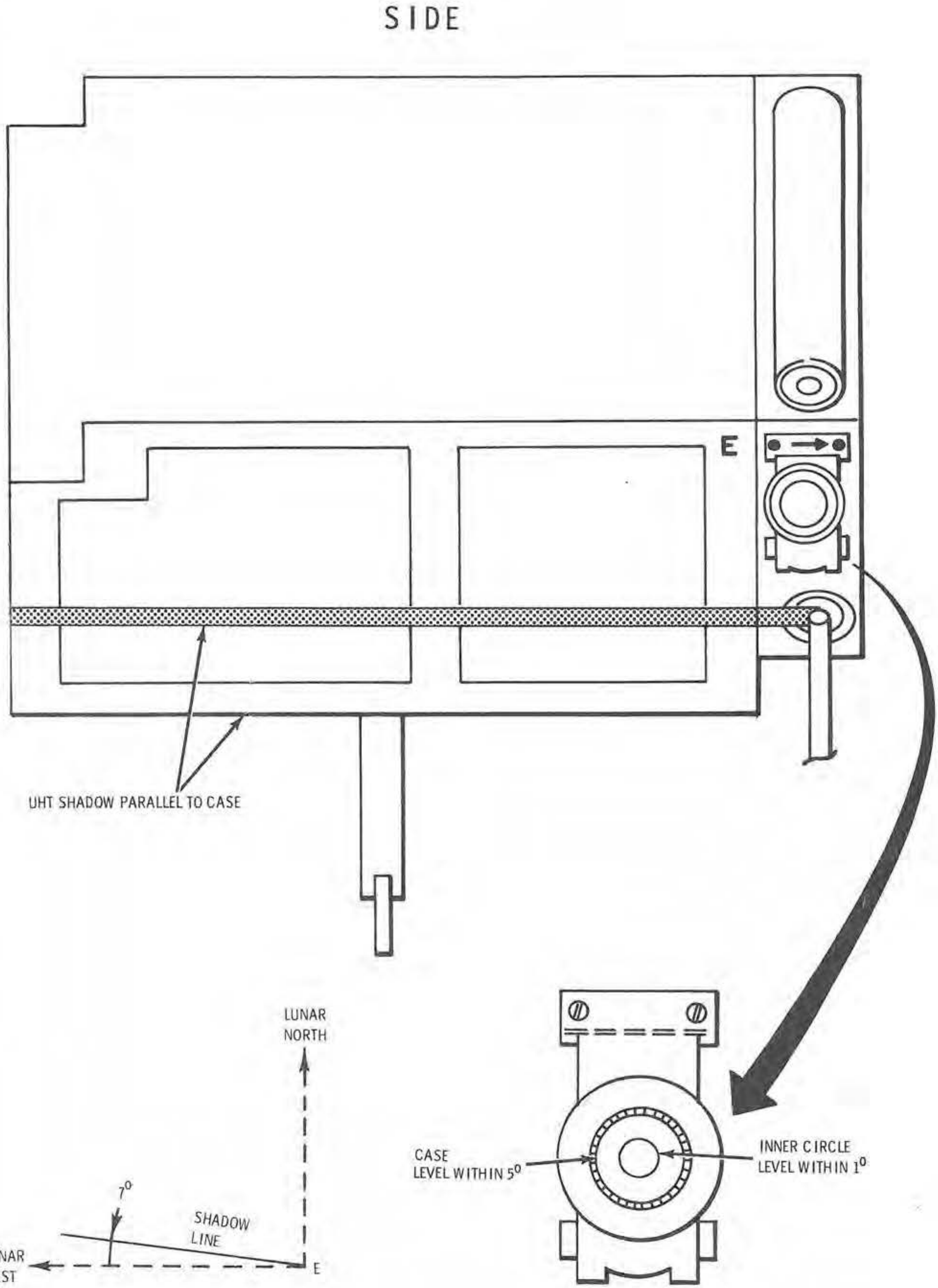


Figure 4-1B. ALSEP Array A-2 Alignment and Leveling Devices (Sheet 6 of 7)

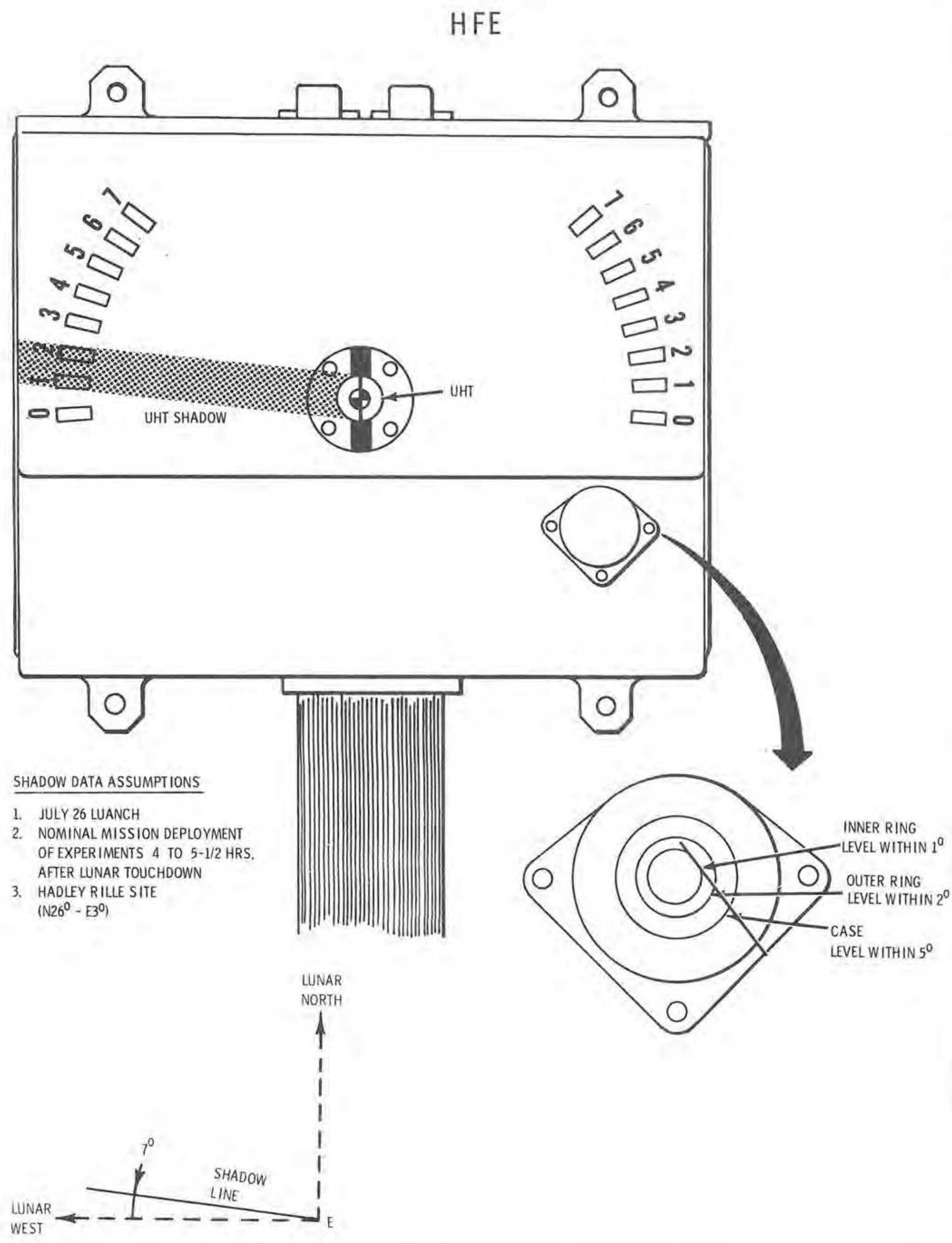


Figure 4-1B. ALSEP Array A-2 Alignment and Leveling Devices (Sheet 7 of 7)

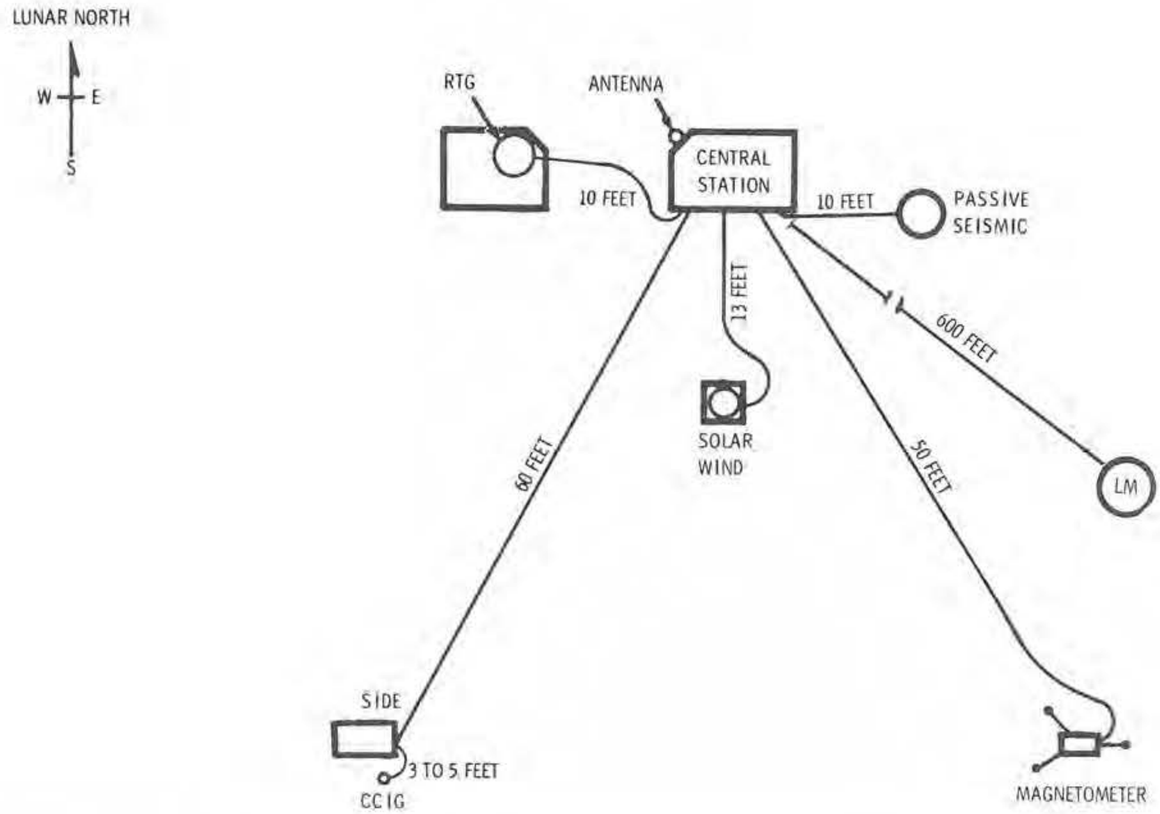


Figure 4-2. Deployment Arrangement Flight 1 (Actual)

4-23. Flights 1 and 2 Deployment. Flights 1 and 2 systems include the passive seismic experiment (PSE), magnetometer experiment (ME), solar wind experiment (SWE), and the suprathermal ion detector experiment (SIDE). Deployment of these experiments is covered in the following steps.

Step	Event
1	Emplace ALSEP on lunar surface on a N/S axis with subpackage No. 1 on the South side.
2	Remove subpackage No. 1 and carry to emplacement site 10 feet East of subpackage No. 2.
3	Return to subpackage No. 2, rotate it upright and align subpackage on E/W axis with RTG on East side. Remove subpallet and carry to subpackage No. 1.
4	Return to subpackage No. 2, remove cable reel, and return to subpackage No. 1 deploying cable enroute. Make power connection to subpackage No. 1.
5	Remove SIDE from subpallet, unfold legs, place SIDE on lunar surface approximately 5 feet South of subpackage No. 1, and complete cable connection.

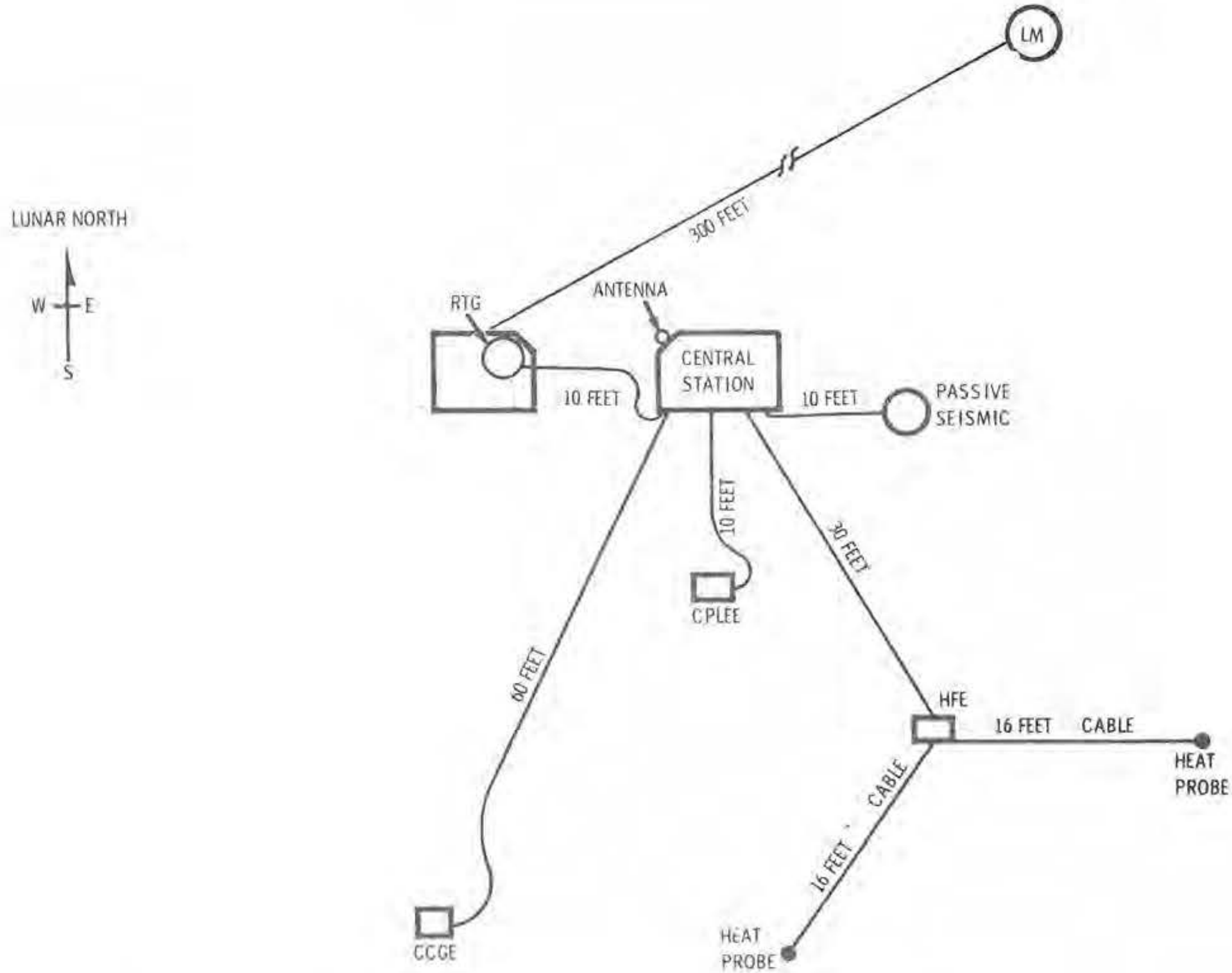


Figure 4-3. Deployment Arrangement Flight 3, Typical

Step	Event
6	Return to subpackage No. 1, remove carry bar and install on subpallet taper fitting.
7	Using handle of UHT, release PSE leveling stool pull pin, and remove stool from subpallet, carry stool to a point 10 feet East of subpackage No. 1 and emplace. Return to subpackage No. 1.
8	Set subpackage upright and align on E/W axis.
9	Release SWE, remove SWE from central station, carry 13 feet South, and emplace on lunar surface. Align by observing shadow cast by sensor head.
10	Release PSE, remove PSE from subpackage No. 1, carry with UHT to emplacement site, release thermal shroud restraint, emplace and align PSE, deploy thermal shroud, and level PSE. (See Figure 4-5.)
11	Release ME sensor arm fasteners, remove horse collar/brace assembly, release ME from subpackage No. 1, and place ME on lunar surface about 5 feet from subpackage No. 1 in the direction of deployment.

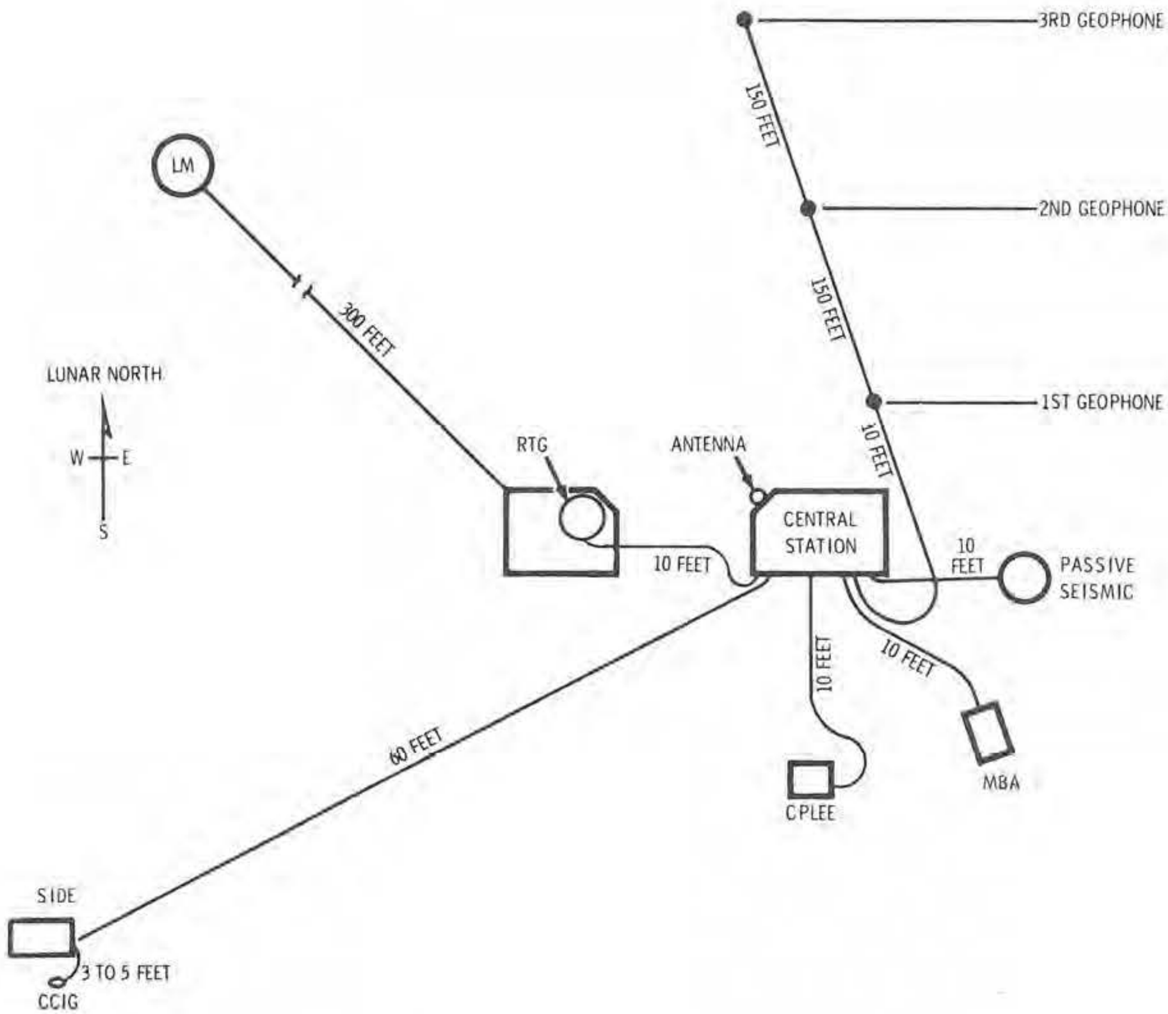


Figure 4-4. Deployment Arrangement Flight 4, Typical

Step	Event
12	Return to central station, release SIDE connector, release and deploy RF cable, release antenna tie-downs, release and raise sunshield, remove antenna mast and antenna aiming mechanism housing from sub-pallet, assemble to central station, retrieve antenna and install on aiming mechanism. (See Figure 4-6.)
13	Align central station antenna by: entering azimuth and elevation offsets, leveling and aligning the antenna subsystem. (See Figure 4-7.)
14	Walk to ME, grasp carry handle, carry ME in predetermined direction 50 feet, deploy legs, align ME and place on lunar surface, extend sensors, deploy parabolic reflector assemblies, level and align ME. (See Figure 4-8.)

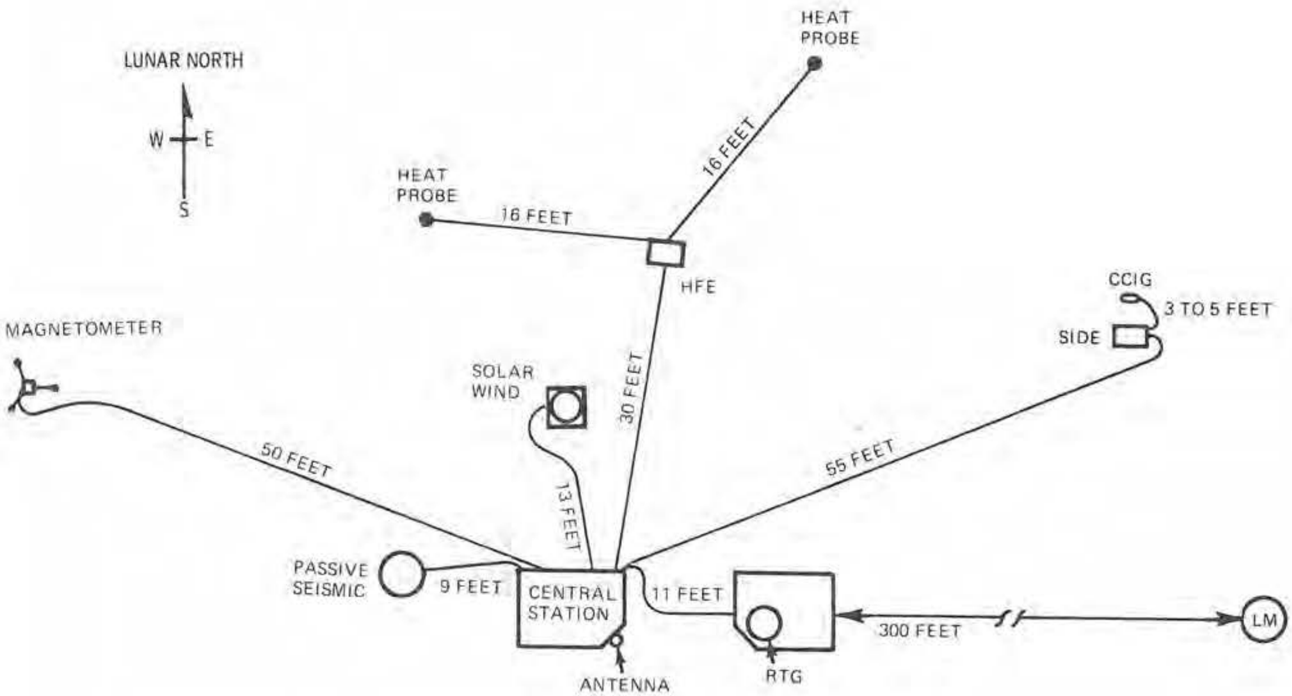


Figure 4-4A. Deployment Arrangement Array A-2, Typical

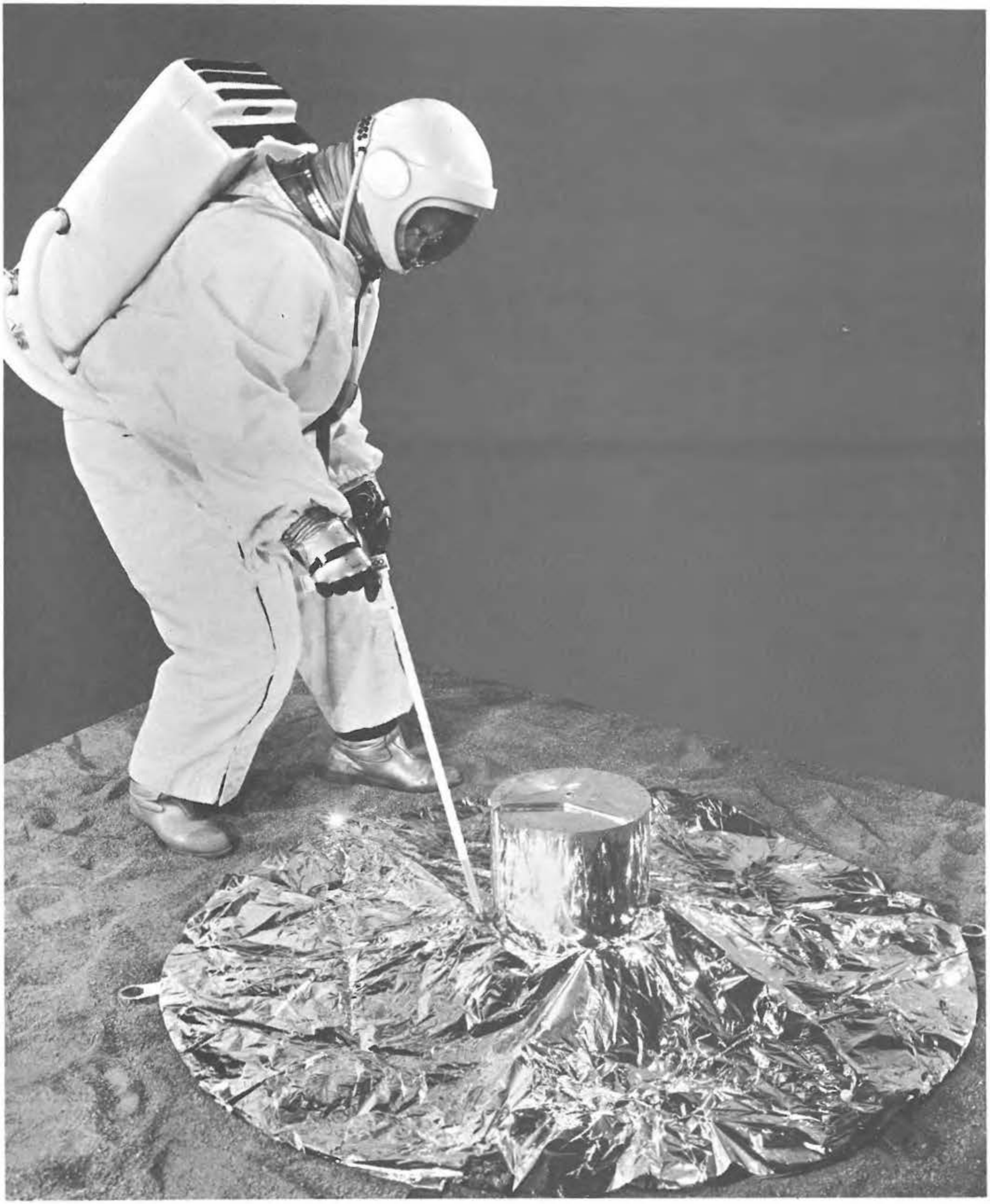


Figure 4-5. PSE Shroud Deployment and Experiment Leveling

Figure 4-8. ME Deployment

Step	Event
15	Walk to SIDE, insert UHT, carry SIDE 55 ± 5 feet in predetermined direction deploying cable, emplace SIDE on lunar surface, deploy ground screen on level surface, lift SIDE, remove CCIG and hold, emplace SIDE on ground screen, emplace CCIG maximum distance from SIDE with seal side of CCIG away from SIDE, central station, and LM, and level and align SIDE.
16	Return to central station, turn on Astronaut switch No. 1 using UHT, request transmitter turn-on, check antenna orientation, receive confirmation of receipt of RF signal and useful data.

4-24. Flight Three. Flight three will carry the heat flow experiment (HFE), the passive seismic experiment (PSE), the charged particle lunar environment experiment (CPLEE), and the cold cathode gauge experiment (CCGE). Deployment of the PSE has been discussed in paragraph 4-23, and therefore, the following steps cover deployment of the CPLEE, CCGE, and HFE only (Figure 4-3).

Step	Event
1	Remove CCGE from subpackage No. 1 and place CCGE on lunar surface approximately 5 feet South of subpackage No. 1.
2	Remove HFE electronic package, with probe box attached, from subpackage No. 1 and place on lunar surface approximately 5 feet South of subpackage No. 1.
3	Remove and carry the CPLEE, deploying the cable, to approximately 10 feet South of the central station.
4	Emplace the CPLEE parallel to the central station. Level and align the CPLEE and return to the central station.
5	Insert UHT and carry CCGE 55 ±5 feet in predetermined direction, deploying cable. Emplace CCGE on lunar surface, level and align. Return to central station.
6	Insert UHT and carry HFE assembly 30 feet South, deposit package, and return to package No. 2 for ALHT and ALSD. After retrieving ALHT and ALSD and returning to HFE assembly, walk an additional 16 feet to site for probe No. 1 emplacement.
7	Drill probe hole (Figure 4-9) and insert sheathing.
8	Return to electronics package, detach probe box and separate two halves of probe box; carry half probe box with attached emplacement tool to probe emplacement site deploying cable enroute. Insert HFE probe (Figure 4-10) and proceed to second emplacement area with ALHT, ALSD, and emplacement tool.
9	Return to electronics package, pick up remaining half of probe box, return to second probe emplacement site and emplace probe as in steps 7 and 8. Return to and align the HFE electronics package.

4-25. Flight Four. Flight four will carry the suprathermal ion detector experiment (SIDE), the PSE, the CPLEE, and the active seismic experiment (ASE). All but the ASE deployment have been discussed in previous paragraphs; therefore the following steps cover deployment of the ASE only. (Figure 4-4).

Step	Event
1	Remove thumper-geophone assembly and mortar package from experiment package, assemble thumper, and partially deploy mortar package.
2	Using UHT turn central station ASE safe/enable switch to enable.
3	Emplace geophones at 10, 160, and 310 foot points along a Northwest line, deploying geophone and thumper cables enroute.
4	Return along the geophone cables activating the thumper at the marked intervals; approximately every 15 feet. Return to central station after final thumper activation.
5	Using UHT turn central station ASE safe/enable switch to safe.
6	Remove safety rods from mortar package, turn on mortar package safe/arm switches, return to the central station and enable the ASE.

The mortar package and grenades will be activated by commands from MSFN on Earth some time (approximately on year) after the astronauts and LM have left the Moon.

4-25A. Array A-2. The Array A-2 system includes the passive seismic experiment (PSE), magnetometer experiment (ME), solar wind experiment (SWE), suprathermal ion detector experiment (SIDE), and the heat flow experiment (HFE). Deployment of these experiments was discussed in paragraphs 4-23 and 4-24.

4-26. Antenna Aiming. The final step in all deployment sequences before returning to the LM is to verify, and correct if necessary, the alignment and leveling of the central station antenna. The following operations, performed in the sequence shown, effect antenna aiming:

a. Set the antenna in elevation.
b. Set the antenna in azimuth.
c. Level the mechanism.
d. Align the shadow with the marked null line.

On completion of antenna aiming, all four settings are checked and readjusted as necessary. Any readjustment in leveling may require further adjustment of the shadow null setting. Refer to Figure 4-11 for location of adjustments and position readouts.

The ALSEP antenna is pointed to the mean position of Earth by means of the elevation, azimuth, and shadow adjustments. The three gimbal mechanisms provide null and angular adjustments through worm and wheel gears at a 72:1 ratio. Correction range for each adjustment is as follows:

a. Sun shadow null ± 15 degrees
b. Azimuth angle ± 15 degrees
c. Elevation angle ± 50 degrees

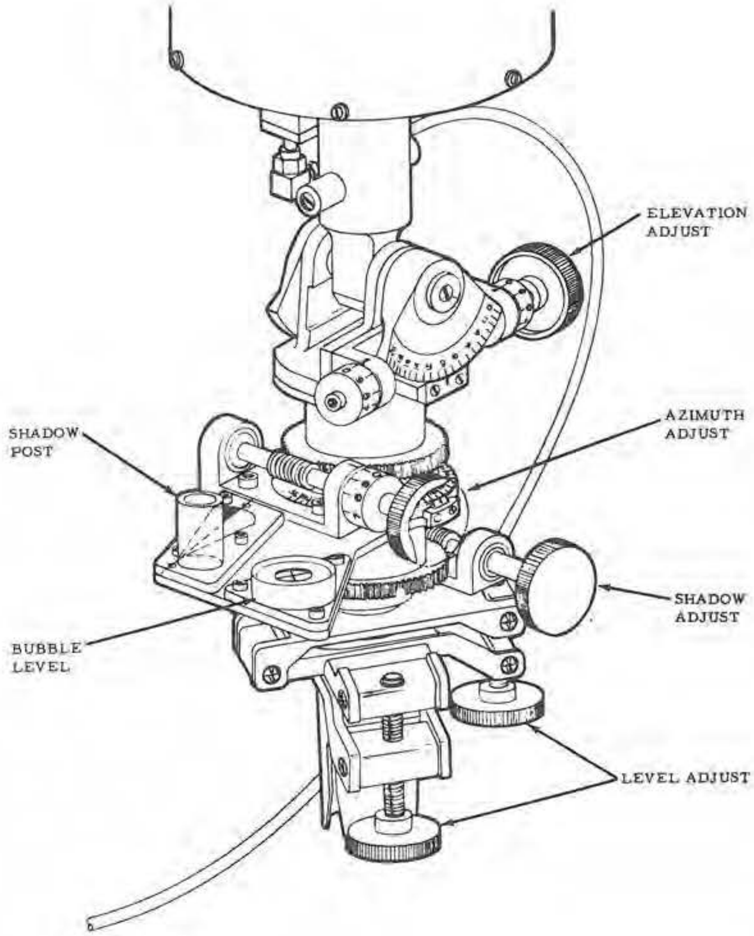


Figure 4-11. Antenna Aiming Mechanism

Elevation and azimuth adjustments are made by rotating the applicable knobs. The elevation and azimuth angles will each be measured by two scales, a coarse scale measuring increments of 5 degrees and set on the respective elevation and azimuth axis, and a fine scale measuring increments of 1/20 of each 5 degree resolution and set on the respective worm drive axis. Data for these settings are derived from aiming tables (Figure 4-12) and relayed via the voice link between astronaut and MCC.

From these two fixed data the mechanism sets the antenna at a predetermined angle in elevation and in azimuth. The azimuth and sunshadow null adjustments are on a common axis. Therefore, the azimuth adjustment is relative to the shadow null position. The elevation angle is measured relative to the local vertical set of the bubble level.

The antenna is leveled to ±0.5 degrees by adjusting the two knobs located on the lower side of the aiming mechanism. Sensitivity of the leveling adjustments is 1 degree per revolution of the knob. The adjustment mechanism will correct up to ±6 degrees from the horizontal plane. As the knobs are rotated observe the bubble level to determine when leveling is accomplished.

Upon satisfying the leveling requirements, the shadow knob is rotated (which rotates the mechanism in azimuth) until a specified (null) setting is positioned directly under the shadow from the antenna mounted sun compass. With this accomplished, the antenna is pointed toward the mean position of Earth within ±0.7 degrees, and provides a reference direction between LM and a subsolar point from which fine antenna aiming is made.

To check all adjustments after the mechanism has been set, the bubble level is positioned 3-1/2 inches out from the center of the mechanism and the elevation coarse and fine scales are set at each end of their respective axis.

4-27. POST-DEPLOYMENT OPERATIONS

Communication between MCC and ALSEP is established with the activation of central station during deployment operations. For 45 days ALSEP operation is monitored continuously. Commands which initiate specific actions required for normal operation are sent to ALSEP during this period. Commands are also sent to change or request status of ALSEP subsystems or experiments.

After the initial 45-day period, MCC monitors and controls ALSEP at least two hours out of each 24-hour day and 48 to 60 hours during lunar sunrise and sunset. For the active seismic experiment, high data rate is used either 15 minutes once a week or 30 minutes every two weeks.

ALSEP transmission (downlink) is received by remote sites on Earth and relayed to MCC via tie line cables. Commands initiated by MCC are routed through another tie line cable to the remote site and are transmitted to ALSEP. This communication system is referred to as the manned space flight network (MSFN).

Because of the Earth's rotation, it is necessary to schedule remote sites around the Earth. The following MSFN remote sites are typical of those which may be scheduled for ALSEP operations:

a. Goldstone, California (85-foot antenna)
b. Carnarvon, Australia (30-foot antenna)
c. Ascension Island (30-foot antenna)
d. Hawaii (30-foot antenna)
e. Guam (30-foot antenna)
f. Madrid, Spain (85-foot antenna)
g. Canberra, Australia (85-foot antenna).

The stations selected will provide transmitters/receivers in latitude about the equator ranging from approximately 34 degrees north to 37 degrees south.

The 30-foot dish antennas can be used for normal operations, but the 85-foot dish antennas will be used when ALSEP is in the active seismic mode. ALSEP will be in the active seismic mode approximately one hour during deployment when the astronaut activates the thumper, and another hour at the time that the grenades are launched (this is in addition to intermittent monitoring periods).

Longitude 22° 12'

Latitude	Upper Gimbal +East -West	N.E. Quad	Sun Compass S.E. Quad	S.W. Quad	N.W. Quad
0°0'	22.0	0.0	0.0	0.0	0.0
0°4'	22.0	0.3	-0.4	0.1	-0.2
0°8'	22.0	0.6	-0.8	0.2	-0.3
0°12'	22.0	0.9	-0.2	0.3	-0.5
'	'	'	'	'	'
'	'	'	'	'	'
'	'	'	'	'	'
4°48'	22.5	16.4	-1.82	6.6	-9.4
4°52'	22.5	16.7	-18.6	6.7	-9.5
4°56'	22.5	17.0	-19.0	6.9	-9.7
5°0'	22.5	17.2	-19.4	7.0	-9.8

(Main Table)

Latitude 4°40'

Sun Elevation	
0°	-1.5
5°	-1.1
10°	-0.8
15°	-0.4
20°	-0.1
25°	+0.3
30°	+0.7
35°	+1.0
40°	+1.2
45°	+1.6

(Correction Table)

NOTE: Table entries are not correct and are given for illustration only.

Figure 4-12. Antenna Aiming Table (Sample)

GLOSSARY

Abbreviation	Definition
A/D	Analog to Digital
ALHT	Apollo Lunar Hand Tools
ALSD	Apollo Lunar Surface Drill
ALSEP	Apollo Lunar Surface Experiments Package
AMU	Atomic Mass Unit
ASE	Active Seismic Experiment
ASI	Apollo Standard Initiator
BxA	Bendix Aerospace Systems Division
CCGE	Cold Cathode Gauge Experiment
CCIG	Cold Cathode Ion Gauge
CFE	Contractor Furnished Equipment
CM	Command Module
CPA	Curved Plate Analyzer
CPLEE	Charged Particle Lunar Environment Experiment
CS	Central Station
DRT	Dome Removal Tool
DS/S	Data Subsystem
DTREM	Dust, Thermal, and Radiation Engineering Measurements Package
EASEP	Early Apollo Scientific Experiment Package
EGFU	Electronics/Gimbal-Flip Unit
EMU	Extravehicular Mobility Unit
EPS	Electrical Power Subsystem
FCA	Fuel Capsule Assembly
FET	Field Effect Transistor
FTT	Fuel Transfer Tool
GFE	Government Furnished Equipment
GHz	Gigahertz
GLA	Grenade Launch Assembly
GSE	Ground Support Equipment
HFE	Heat Flow Experiment

GLOSSARY (cont)

Abbreviation	Definition
Hz	Hertz; Cycles per Second
IPU	Integrated Power Unit
IST	Integrated Systems Test
KHz	Kilohertz
KSC	Kennedy Space Center
LM	Lunar Module
LP	Long Period
LRL	Lunar Receiving Laboratory
LRRR	Laser Ranging Retro-Reflector
LTA	Launch Tube Assembly
MCC-H	Mission Control Center-Houston
ME	Magnetometer Experiment
MSC	Manned Spacecraft Center
MSFN	Manned Space Flight Network
MSOB	Manned Spacecraft Operation Building
NASA	National Aeronautics and Space Administration
NRZ	Non Return to Zero
PAM	Pulse Amplitude Modulation
PCM	Pulse Coded Modulation
PCU	Power Conditioning Unit
PDU	Power Distribution Unit
PI	Principle Investigator
PSE	Passive Seismic Experiment
PSEP	Passive Seismic Experiment Package
RF	Radio Frequency
RFI	Radio Frequency Interference
RTG	Radioisotope Thermoelectric Generator
SBASI	Single Bridgewire Apollo Standard Initiator
SEQ	Scientific Equipment Bay in LM
SIDE	Suprathermal Ion Detector Experiment
SIDE/CCIG	Suprathermal Ion Detector Experiment with Cold Cathode Ion Gauge

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INTRODUCTION

This document tabulates the commands used in the ALSEP flight systems. Table 1 lists the commands by symbol, nomenclature, number, and termination point. Table 2 provides a summary of command allocation. Table 3 cross-references command numbers and command functions. Table 4 cross-references array and experiment number assignments.

Flight 1 - Array A
Flight 2 - Array A (deleted)
Flight 3 - Array B
Flight 4 - Array C
- Array A-2

TABLE I

Symbol	Command Nomenclature	Octal Command	Decimal Command	Termination Point
CD-31	ASE High Bit Rate ON[3]	003	3	Data Processor
CD-32	ASE High Bit OFF[1]	005	5	" "
CD-33	Normal Bit Rate[1, 3]	006	6	" "
CD-34	Slow Bit Rate[3]	007	7	" "
CD-35	Normal Bit Rate Reset[4]	011	9	" "
CD-1	Transmitter "A" Select[2]	012	10	Power Dist. Unit
CD-2	Transmitter ON[2]	013	11	" " "
CD-3	Transmitter OFF	014	12	" " "
CD-4	Transmitter "B" Select	015	13	" " "
CD-5	DSS HTR 1 ON (5 watts)	017	15	" " "
CD-6	DSS HTR 1 OFF[2]	021	17	" " "
CD-7	PDR #2 ON	022	18	" " "
CD-8	PDR #2 OFF[2]	023	19	" " "
CD-9	DSS HTR 2 ON (10 watts)	024	20	" " "
CD-10	DSS HTR 2 OFF[2]	025	21	" " "
CX-1	Dust Detector - ON	027	23	" " "
CX-2	Dust Detector - OFF	031	25	" " "
CD-36	Timer Output Accept[1]	032	26	Command Decoder
CD-37	Timer Output Inhibit	033	27	" "
CD-11	Data Processor "X" Select[2]	034	28	Power Dist. Unit
CD-12	Data Processor "Y" Select	035	29	" " "
CD-13	Experiment 1 Operational Power ON[5]	036	30	" " "
CD-14	Experiment 1 Standby Power[2]	037	31	" " "
CD-15	Experiment 1 Standby OFF	041	33	" " "
CD-16	Experiment 2 Operational Power ON	042	34	" " "
CD-17	Experiment 2 Standby Power[2]	043	35	" " "

TABLE 1 (CON'T)

Symbol	Command Nomenclature	Octal Command	Decimal Command	Termination Point
CD-18	Experiment 2 Standby OFF	044	36	Power Dist. Unit
CD-19	Experiment 3 Operational Power ON	045	37	" " "
CD-20	Experiment 3 Standby Power[2]	046	38	" " "
CD-21	Experiment 3 Standby OFF	050	40	" " "
CD-22	Experiment 4 Operational Power ON	153	107	" " "
CD-23	Experiment 4 Standby Power[2]	053	43	" " "
CD-24	Experiment Standby OFF	054	44	" " "
CD-25	Experiment 5 Operational Power ON	055	45	" " "
CD-26	Experiment 5 Standby Power[2]	056	46	" " "
CD-27	Experiment 5 Standby OFF	057	47	" " "
CU-1	PCU #1 Select[2]	060	48	Power Cond. Unit
CU-2	PCU #2 Select	062	50	" " "
CL-1	Gain Change LPX, LPY	063	51	Passive Seismic Exp.
	(Steps through following sequence one step per command)			
	-30db[1]			
	0db			
	-10db			
	-20db			
CL-2	Gain Change LPZ	064	52	" " "
	(Steps through same sequence as CL-1)			
CL-3	Calibration SP ON/OFF[1,6]	065	53	" " "
CL-4	Calibration LP ON/OFF[1]	066	54	" " "
CL-5	Gain Change SPZ	067	55	" " "
	(Steps through same sequence as CL-1)			
CL-6	Leveling Power X Motor[8] ON/OFF[1]	070	56	" " "
CL-7	Leveling Power Y Motor[8] ON/OFF[1]	071	57	" " "
CL-8	Leveling Power Z Motor[8] ON/OFF[1]	072	58	" " "

TABLE I (CON'T)

Symbol	Command Nomenclature		Octal Command	Decimal Command	Termination Point
CL-9	Uncage[7, 6]	Arm/Fire	073	59	Passive Seismic Exp.
CL-10	Leveling Direction[8]	Plus[1]/Minus	074	60	" " "
CL-11	Leveling Speed[8]	Low[1]/High	075	61	" " "
CL-12	Thermal Control Mode	Auto[1]/Manual[9]	076	62	" " "
CL-13	Feedback Filter	IN/OUT[1]	101	65	" " "
CL-14	Coarse Level Sensor	IN/OUT[1]	102	66	" " "
CL-15	Leveling Mode[8]	Auto[1]/Manual	103	67	" " "
CT-1	SIDE Load Cmd #1	Command	104	68	Suprathermal Ion Det.
CT-2	SIDE Load Cmd #2	Functions	105	69	" " "
CT-3	SIDE Load Cmd #3	As shown	106	70	" " "
CT-4	SIDE Load Cmd #4	in Note 15	107	71	" " "
CT-5	SIDE Execute Command		110	72	" " "
CG-1	Cal Mode Set		104	68	Cold Cathode Gauge Expt.
CG-2	Uprange[17]		105	69	" " " "
CG-3	Manual Ranging Mode (Steps through seven ranges)		106	70	" " " "
CG-4	Downrange[17, 18]		107	71	" " " "
CG-5	Automatic Ranging Mode[1]		110	72	" " " "
CC-1	CPLEE Operational Heater ON[1, 20]		111	73	Charged Particle Exp.
CC-2	CPLEE Operational Heater OFF		112	74	" " "
CC-3	CPLEE Dust Cover Removal		113	75	" " "
CC-4	CPLEE Automatic Voltage Sequence ON[1]		114	76	" " "

TABLE I (CON'T)

Symbol	Command Nomenclature	Octal Command	Decimal Command	Termination Point
CC-5	CPLEE Step Voltage Level [19] (Steps voltage through following steps one step per command) 3500, 350, 35, 0, -35, -350, -3500, 0 and repeat	115	77	Charged Particle Exp.
CC-6	CPLEE Automatic Voltage Sequence - OFF[21]	117	79	" " "
CC-7	CPLEE Channeltron Voltage Increase - ON (One step increase in voltage)	120	80	" " "
CC-8	CPLEE Channeltron Voltage Increase - OFF[1]	121	81	" " "
CW-1	SWS Dust Cover Removal[13]	122	82	Solar Wind Experiment
CM-1	LSM Range Select (Steps through three ranges, one step per command) 200 gammas full scale[1], 50 " " ", 100 " " ", repeat	123	83	LSM Experiment

TABLE 1 (CON'T)

Symbol	Command Nomenclature	Octal Command	Decimal Command	Termination Point
CM-2	Steady Field Offset[12] (Step through seven values, one step per command) 0 percent of full scale[1], +25 percent of full scale, +50 percent of full scale, +75 percent of full scale, -75 percent of full scale, -50 percent of full scale, -25 percent of full scale [10], 0 percent of full scale and repeat	124	84	LSM Experiment
CM-3	Steady Field Address (Steps through following step X-axis to Y-axis to Z-axis to neutral[1])	125	85	" "
CM-4	Flip/Cal Inhibit In[1]/Out	127	87	" "
CM-5	Flip/Cal Initiate (Returns to Science mode after Flip/Cal sequence[11])	131	89	" "
CM-6	LSM Filter (In[1]/Out)	132	90	" "
CM-7	Site Survey[14]	133	91	" "
CM-8	Temperature Control x[1]/y/OFF Repeat (Changes from X-axis sensor[1] to Y-axis sensor to OFF)	134	92	" "
CH-1	Normal (Gradient) Mode Select[1]	135	93	Heat Flow Experiment
CH-2	Low Conductivity Mode Select (Ring Source)	136	94	" " "

TABLE 1 (CON'T)

Symbol	Command Nomenclature	Octal Command	Decimal Command	Termination Point
CH-3	High Conductivity Mode Select (Heat Pulse)	140	96	Heat Flow Experiment
CH-4	HF Full Sequence Select[1]	141	97	" " "
CH-5	HF Probe #1 Sequence Select	142	98	" " "
CH-6	HF Probe #2 Sequence Select	143	99	" " "
CH-7	HF Subsequence #1 } Command Func-	144	100	" " "
CH-8	HF Subsequence #2 } tions as shown in	145	101	" " "
CH-9	HF Subsequence #3 } Note 16	146	102	" " "
CH-10	HF Heater Advance (Steps through following 16-step sequence one step per command) All heaters off Probe #1 heater #2 ON All heaters off Probe #1 heater #4 ON All heaters off Probe #1 heater #1 ON All heaters off Probe #1 heater #3 ON All heaters off Probe #2 heater #2 ON All heaters off Probe #2 heater #4 ON All heaters off Probe #2 heater #1 ON All heaters off Probe #2 heater #3 ON repeat	152	106	" " "
CR-1	Timer Reset	150	104	Timer

TABLE 1 (CON'T)

Symbol	Command Nomenclature	Octal Command	Decimal Command	Termination Point
CS-1	Geophone Calibrate	156	110	Active Seismic Exp.
CS-3	ASE Grenade Sequential Single Fire (Fires single grenades in sequence 2, 4, 3, 1. Previous grenade must fire before next grenade will fire. Four executions required.)	162	114	" " "
CS-4	ASE Grenade #1 Fire	163	115	" " "
CS-5	ASE Grenade #2 Fire	164	116	" " "
CS-6	ASE Grenade #3 Fire	165	117	" " "
CS-7	ASE Grenade #4 Fire	166	118	" " "
CS-8	Arm Grenades	170	120	" " "

TABLE 1 (NOTES)

[1] Preset turn-on operating mode.

[2] Lunar surface initial conditions programmed in during final system checkout.

[3] Changes bit rate at end of ALSEP frame during which command executed.

[4] Changes bit rate upon command execution.

[5] Experiment numbers are noted in Table 4.

[6] Short period calibration and uncage commands are initiated automatically at 12 hour (18 hour*) intervals by the timer unless this feature has been inhibited by execution of CD-37.

[7] Uncage command is executed automatically by the delayed command sequencer at 96 hours + 2 minutes (144 hours + 2 minutes*), although uncaging may have been previously accomplished by ground command or as outlined in Note 6 above.

[8] Manual leveling sequence is as follows: Send CL-15 to change from auto to manual leveling mode, change direction, and speed by CL-10 and CL-11 as necessary, and then execute leveling operation by sending appropriate leveling motor commands, CL-6, CL-7, or CL-8. Leveling operation is terminated by retransmission of CL-6, CL-7, or CL-8.

[9] Sequence of command is auto on[1]/auto off/manual on/manual off.

[10] For 0^{o} flip position; reverse sign for 180^{o} flip position.

[11] Also activated every 12 hours (18 hours*) after and including hour 108 + 1 minute (162 + 1 minute*) by delayed command sequence.

[12] Field offset sequence is as follows: select proper axis with CM-3, then execute CM-2 the proper number of times to step from present value to desired value.

[13] Also executed at hour 96 + 4 minutes (144 + 4 minutes*) by delayed command sequence. Repetition of CW-1 three times within ten seconds results in High Voltage Gain Change.

[14] First execution of CM-7 performs X-axis survey, second execution Y-axis survey and third execution Z-axis survey.

* Array A-2

TABLE 1 (NOTES) (CON'T)

[15] Suprathermal Ion Detector Command Structure

All commands are pulses. The SIDE uses these pulsed commands by encoding. Two encoded commands are used for one time only operations as well as routine operation. Four of the five incoming command lines are encoded in a four bit command buffer which is then strobed into a second (mode) buffer where it is held for decoding and execution. This latter buffer might be thought of as an execute buffer. The commands are as follows:

Group	SYMBOL	FUNCTION	OCTAL COMMAND SEQUENCE				
			104	105	106	107	110
One Time Commands	CI-1	Break CCIG Seal[2]		X			X
	CI-2	Blow Dust Cover[2]				X	X
	CI-5	Not Used					X
Operational Commands	CI-6	Ground Plane Step Programmer ON[1]/OFF	X				X
	CI-7	Reset SIDE Frame Counter at 10		X			X
	CI-8	Reset SIDE Frame Counter at 39	X	X			X
	CI-9	Reset Velocity Filter at 9			X		X
	CI-10	Reset SIDE Frame Counter at 79	X		X		X
	CI-11	Reset SIDE Frame Counter at 79 and Velocity Filter Counter at 9		X	X		X
	CI-12	X 10 accumulation interval ON/OFF[1]	X	X	X		X
	CI-13	Master Reset				X	X
	CI-14	Velocity Filter Voltage ON[1]/OFF	X			X	X
	CI-15	Low Energy CPA high voltage ON[1]/OFF		X		X	X
	CI-16	High Energy CPA high voltage ON[1]/OFF	X	X		X	X
	CI-17	Force Continuous Calibration (Reset to 120)			X	X	X
	CI-18	Cold Cathode Ion Gauge HiV ON[1]/OFF	X		X	X	X
	CI-19	Channeltron high voltage ON[1]/OFF		X	X	X	X
	CI-20	Reset Command Register	X	X	X	X	X

Commands CI-1 and CI-2 have been incorporated into the design of the SIDE as one time CCIG Seal Break and one time Dust Cover Blow. These are identical to CI-7 and CI-13 respectively, thus the first time CI-7 is executed, so is CI-1 but not thereafter. A similar statement holds for CI-13 and CI-2.

[1] Preset turn-on operating mode.

[2] Also activated at hour 96 + 3 minutes (144 + 3 minutes)* by delayed command sequence.

*Array A-2

TABLE 1 (NOTES) (CON'T)

[16] Heat Flow Command Structure

Octal commands 144 through 146 are used to select subsets of the full heat flow measurement sequence as follows:

> Command 144 selects a subset consisting of the four high sensitivity gradient measurements only.
>
> Command 144 followed by command 145 selects a subset consisting of the four low sensitivity gradient measurements only.
>
> Command 144 followed by command 146 selects a subset consisting of probe ambient temperature measurements only.
>
> Command 145 followed by command 146 selects a subset consisting of thermocouple measurements only.

[17] Command sequence for manually changing range is CG-3 after either CG-2 or CG-4 to set up or downrange respectively.

[18] Command CG-4 breaks CCGE seal on first execution, may require prior execution of CG-2 to set.

[19] Command sequence is to send CC-6 and then send CC-5 to step voltage levels. CPLEE stops at level it is on at time of command execution.

[20] There are three CPLEE heater modes. On initial turn on the CPLEE thermostat controls the heaters. CC-1 over rides thermostat and turns heaters on, CC-2 turns heaters off. CPLEE is placed back on thermostat by experiment power turn off and back on.

[21] CPLEE remains in voltage level activated at time of CC-6 command execution and then can be stepped to the next step in sequence by CC-5 or returned to automatic mode by CC-4.

TABLE 2

COMMAND SUMMARY

Termination Point	Number of Commands Array A	Array B	Array C	Array A2
Data Processor	3	3	5	3
Power Distribution Unit (Power Switching)	29	29	29	29
Power Conditioning Unit	2	2	2	2
Command Decoder	2	2	2	2
Timer	0	0	0	1
Passive Seismic	15	15	15	15
Suprathermal Ion Detector/CCGE	5	0	5	5
Charged Particle	0	8	8	0
Solar Wind	1	0	0	1
Magnetomer	8	0	0	8
Heat Flow	0	10	0	10
Active Seismic	0	0	7	0
CCGE (MSC)	0	5	0	0
Total	65	74	73	76

Function	Octal Code	Number
Test Commands	1, 2, 4, 10, 20, 40, 100, 77, 137, 157, 167, 173, 175, 176	14
Address	130^1/30, 116^2/16, 151^3/51, 25^4/65	8
Address Complement	47^1/147, 61^2/161, 26^3/126, 152^4/112	8
No Command	0, 177	2
Commands Assigned to Arrays A, B, C, A2		94
Commands Not Presently Assigned (154, 155, 160, 171, 172, 174)		6
		132
Commands Assigned with same code as either Address or Address Complement (25, 33, 62, 65, 112, 152)		-4
		128 Total Commands

Notes: 1. Array A 2. Array A2 3. Array B 4. Array C

TABLE 3

CROSS REFERENCE OF COMMAND NUMBER TO COMMAND FUNCTION

Decimal Command	Octal Command	Command Symbol	Array Usage A	Array Usage B	Array Usage C	Array Usage A-2	Test Cmds.	Address	Address Complement	No Command	Not Presently Assigned
1	1						X				
2	2						X				
3	3	CD-31			X						
4	4						X				
5	5	CD-32			X						
6	6	CD-33	X	X	X	X					
7	7	CD-34	X	X	X	X					
8	10						X				
9	11	CD-35	X	X	X	X					
10	12	CD-1	X	X	X	X					
11	13	CD-2	X	X	X	X					
12	14	CD-3	X	X	X	X					
13	15	CD-4	X	X	X	X					
14	16							X			
15	17	CD-5	X	X	X	X					
16	20						X				
17	21	CD-6	X	X	X	X					
18	22	CD-7	X	X	X	X					
19	23	CD-8	X	X	X	X					
20	24	CD-9	X	X	X	X					

TABLE 3 (CON'T)

Decimal Command	Octal Command	Command Symbol	Array Usage A	B	C	A-2	Test Cmds.	Address	Address Complement	No Command	Not Presently Assigned
21	25	CD-10	X	X	X*	X		X*			
22	26								X		
23	27	CX-1	X	X	X	X					
24	30							X			
25	31	CX-2	X	X	X	X					
26	32	CD-32	X	X	X	X					
27	33	CD-37	X	X	X	X					
28	34	CD-11	X	X	X	X					
29	35	CD-12	X	X	X	X					
30	36	CD-13	X	X	X	X					
31	37	CD-14	X	X	X	X					
32	40						X				
33	41	CD-15	X	X	X	X					
34	42	CD-16	X	X	X	X					
35	43	CD-17	X	X	X	X					
36	44	CD-18	X	X	X	X					
37	45	CD-19	X	X	X	X					
38	46	CD-20	X	X	X	X					
39	47								X		
40	50	CD-21	X	X	X	X					
41	51							X			

*Cmds with same code as their Array Address or Address Complement.

TABLE 3 (CON'T)

Decimal Command	Octal Command	Command Symbol	Array Usage A	Array Usage B	Array Usage C	Array Usage A-2	Test Cmds.	Address	Address Complement	No Command	Not Presently Assigned
42	52	CD-22	X	X	X						
43	53	CD-23	X	X	X	X					
44	54	CD-24	X	X	X	X					
45	55	CD-25	X	X	X	X					
46	56	CD-26	X	X	X	X					
47	57	CD-27	X	X	X	X					
48	60	CU-1	X	X	X	X					
49	61								X		
50	62	CU-2	X	X	X	X					
51	63	CL-1	X	X	X	X					
52	64	CL-2	X	X	X	X					
53	65	CL-3	X	X	X*	X		X*			
54	66	CL-4	X	X	X	X					
55	67	CL-5	X	X	X	X					
56	70	CL-6	X	X	X	X					
57	71	CL-7	X	X	X	X					
58	72	CL-8	X	X	X	X					
59	73	CL-9	X	X	X	X					
60	74	CL-10	X	X	X	X					
61	75	CL-11	X	X	X	X					
62	76	CL-12	X	X	X	X					

TABLE 3 (CON'T)

Decimal Command	Octal Command	Command Symbol	Array Usage A	Array Usage B	Array Usage C	Array Usage A-2	Test Cmds.	Address	Address Complement	No Command	Not Presently Assigned
63	77						X				
64	100						X				
65	101	CL-13	X	X	X	X					
66	102	CL-14	X	X	X	X					
67	103	CL-15	X	X	X	X					
68	104	CG-1^{+}/CT-1	X	X^{+}	X	X					
69	105	CG-2^{+}/CT-2	X	X^{+}	X	X					
70	106	CG-3^{+}/CT-3	X	X^{+}	X	X					
71	107	CG-4^{+}/CT-4	X	X^{+}	X	X					
72	110	CG-5^{+}/CT-5	X	X^{+}	X	X					
73	111	CC-1		X	X						
74	112	CC-2		X	X*				X*		
75	113	CC-3		X	X						
76	114	CC-4		X	X						
77	115	CC-5		X	X						
78	116							X			
79	117	CC-6		X	X						
80	120	CC-7		X	X						
81	121	CC-8		X	X						
82	122	CW-1	X			X					
83	123	CM-1	X			X					

TABLE 3 (CON'T)

Decimal Command	Octal Command	Command Symbol	Array Usage A	Array Usage B	Array Usage C	Array Usage A-2	Test Cmds.	Address	Address Complement	No Command	Not Presently Assigned
84	124	CM-2	X			X					
85	125	CM-3	X			X					
86	126								X		
87	127	CM-4	X			X					
88	130							X			
89	131	CM-5	X			X					
90	132	CM-6	X			X					
91	133	CM-7	X			X					
92	134	CM-8	X			X					
93	135	CH-1		X		X					
94	136	CH-2		X		X					
95	137						X				
96	140	CH-3		X		X					
97	141	CH-4		X		X					
98	142	CH-5		X		X					
99	143	CH-6		X		X					
100	144	CH-7		X		X					
101	145	CH-8		X		X					
102	146	CH-9		X		X					
103	147								X		
104	150	CR-1				X					
105	151							X			
106	152	CH-10		X		X			X		

TABLE 3 (CON'T)

Decimal Command	Octal Command	Command Symbol	Array Usage A	Array Usage B	Array Usage C	Array Usage A-2	Test Cmds.	Address	Address Complement	No Command	Not Presently Assigned
107	153	CD-22				X					
108	154										X
109	155										X
110	156	CS-1			X						
111	157						X				
112	160										X
113	161								X		
114	162	CS-3			X						
115	163	CS-4			X						
116	164	CS-5			X						
117	165	CS-6			X						
118	166	CS-7			X						
119	167						X				
120	170	CS-8			X						
121	171										X
122	172										X
123	173						X				
124	174										X
125	175						X				
126	176						X				
127	177									X	
0	000									X	
		TOTALS	65	74	73	76	14	8	8	2	6

TABLE 4

Array Experiment Numbers

Expt No \ Array	A	B	C	A-2
1	PSE	HFE	PSE	PSE
2	LSM	PSE	ASE	LSM
3	SWS	CCGE	SIDE	SWS
4	SIDE	CPLEE	CPLEE	SIDE
5	—	—	—	HFE

INTRODUCTION

This document tabulates the measurements to be telemetered from the ALSEP system. The included tables indicate the functions measured, the designation symbol, the assigned channel, accuracy, range, number of bits per sample, and sample rate provided via the PCM telemetry link.

Operational data is defined as that data required to indicate the readiness of the equipment to perform its intended function. In keeping with this definition, all of the data transmitted on analog housekeeping channels are designated as operational.

The A/D converter provided in the data subsystem is capable of encoding analog housekeeping and science signals to 8-bit accuracy. The encoded word occupies 10 bit positions to fill word 33 in the ALSEP format. Each housekeeping signal is read out once in 90 frames of the PCM format. The analog multiplexer advances one position each frame. Digital data derived from the experiments has an output consistent with the frame format section of the ALSEP Data Subsystem. The high data rate required by the Active Seismic Experiment (ASE) necessitates inhibiting other signals for the operation period of the ASE, except for selected critical items which are incorporated in the ASE format.

The following tables categorize the telemetered measurements:

Table 1 (a)	-	Channel Assignments for the Analog Multiplexer (ALSEP Word 33)
Table 1 (b)	-	Analog Housekeeping Channel Usage
Table 1 (c)	-	Summary of Analog Channel Usage, Flights 1 to 4 and Array A-2
Table 2	-	Passive Seismic Experiment
Tables 3, 4, 5	-	Magnetometer Experiment
Table 6	-	Suprathermal Ion Detector and Cold Cathode Gauge Experiment

Table 7	- Active Seismic Experiment
Table 8	- Charged Particle Experiment
Tables 9-12	- Heat Flow Experiment
Table 13	- Solar Wind Experiment
Table 14	- Cold Cathode Gauge Experiment (MSC)

Flights 1 & 2	Array A
Flight 3	Array B
Flight 4	Array C

Flight Systems 1 & 2

1 x	2 x	3 x	4 X	5 O	6 X	7 S	8 X
9 -	10 X	11 -	12 X	13 -	14 X	15 I	16 X
17 O	18 X	19 O	20 X	21 O	22 X	23 S	24 X
25 -	26 X	27 -	28 X	29 -	30 X	31 I	32 X
33 H	34 X	35 ●	36 X	37 ●	38 X	39 S	40 X
41 -	42 X	43 -	44 X	45 -	46 CV	47 I	48 X
49 O	50 X	51 O	52 X	53 O	54 X	55 S	56 I
57 -	58 X	59 -	60 X	61 -	62 X	63 I	64 X

Legend

Symbol		Description	Number of Words Per Frame	
x	-	Control	3	
X	-	Passive Seismic - Short Period	29	43
-	-	Passive Seismic - Long Period Seismic	12	
●	-	Passive Seismic - Long Period Tidal and One Temperature	2	
O	-	Magnetometer	7	
S	-	Solar Wind	4	
I	-	Suprathermal Ion Detector	5	
CV	-	Command Verification (upon command, otherwise all zeros)	1	
H	-	Housekeeping	1	
		TOTAL	64	

Each box contains one 10-bit word
Total bits per frame - 10 x 64 = 640 bits

12

Figure 1. ALSEP Channel Assignment for Array A

Flight System 3

1 x	2 x	3 x	4 X	5 CV	6 X	7 CP	8 X
9 -	10 X	11 -	12 X	13 -	14 X	15 CG	16 X
17 CP	18 X	19 CP	20 X	21 HF	22 X	23 CP	24 X
25 -	26 X	27 -	28 X	29 -	30 X	31 CG	32 X
33 H	34 X	35 ●	36 X	37 ●	38 X	39 CP	40 X
41 -	42 X	43 -	44 X	45 -	46 X	47 CG	48 X
49 NA	50 X	51 NA	52 X	53 NA	54 X	55 CP	56 CG
57 -	58 X	59 -	60 X	61 -	62 X	63 CG	64 X

Legend		Number of Words Per Frame	
x	- Control	3	
X	- Passive Seismic - Short Period	30	44
-	- Passive Seismic - Long Period Seismic	12	
●	- Passive Seismic - Long Period Tidal and One Temperature	2	
HF	- Heat Flow	1	
CP	- Charged Particle	6	
CV	- Command Verification (upon command, otherwise all zeros)	1	
H	- Housekeeping	1	
NA	- Not Assigned (all zeros shall be transmitted)	3	
CG	- Cold Cathode Gauge Experiment (MSC)	5	
	TOTAL	64	

Each box contains one 10-bit word. Total bits per frame - 10 x 64 = 640 bits.

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Figure 2 ALSEP Channel Assignment for Array B

Flight System 4

1 x	2 x	3 x	4 X	5 CV	6 X	7 CP	8 X
9 -	10 X	11 -	12 X	13 -	14 X	15 I	16 X
17 CP	18 X	19 CP	20 X	21 NA	22 X	23 CP	24 X
25 -	26 X	27 -	28 X	29 -	30 X	31 I	32 X
33 H	34 X	35 ●	36 X	37 ●	38 X	39 CP	40 X
41 -	42 X	43 -	44 X	45 -	46 X	47 I	48 X
49 NA	50 X	51 NA	52 X	53 NA	54 X	55 CP	56 I
57 -	58 X	59 -	60 X	61 -	62 X	63 I	64 X

Legend		Number of Words Per Frame	
x	- Control	3	
X	- Passive Seismic - Short Period	30	44
-	- Passive Seismic - Long Period Seismic	12	
●	- Passive Seismic - Long Period Tidal and One Temperature	2	
I	- Suprathermal Ion Detector/CCGE	5	
CP	- Charged Particle	6	
CV	- Command Verification (upon command, otherwise all zeros)	1	
H	- Housekeeping	1	
NA	- Not Assigned (all zeros shall be transmitted)	4	
	TOTAL	64	

Each box contains one 10-bit word. Total bits per frame - 10 x 64 = 640 bits.

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Figure 3. ALSEP Channel Assignment for Array C

1 x	2 x	3 x	4 X	5 O	6 X	7 S	8 X
9 -	10 X	11 -	12 X	13 -	14 X	15 I	16 X
17 O	18 X	19 O	20 X	21 O	22 X	23 S	24 HF
25 -	26 X	27 -	28 X	29 -	30 X	31 I	32 X
33 H	34 X	35 •	36 X	37 •	38 X	39 S	40 X
41 -	42 X	43 -	44 X	45 -	46 CV	47 I	48 X
49 O	50 X	51 O	52 X	53 O	54 X	55 S	56 I
57 -	58 X	59 -	60 X	61 -	62 X	63 I	64 X

Legend		Number of Words Per Frame	
HF	- Heat Flow	1	
x	- Control	3	
X	- Passive Seismic - Short Period	28	42
-	- Passive Seismic - Long Period Seismic	12	
•	- Passive Seismic - Long Period Tidal and One Temperature	2	
O	- Magnetometer	7	
S	- Solar Wind	4	
I	- Suprathermal Ion Detector	5	
CV	- Command Verification (upon command, otherwise all zeros)	1	
H	- Housekeeping	1	
	TOTAL	64	

Each box contains one 10-bit word
Total bits per frame - 10 x 64 = 640 bits

Figure 3A. ALSEP Channel Assignment for Array A-2

CONTROL WORD FORMAT

	ALSEP WORD #1										ALSEP WORD #2										ALSEP WORD #3									
Bit	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	1	1	1	0	0	0	1	0	0	1	0	0	0	0	1	1	1	0	1	1	0	1	F1	F2	F3	F4	F5	F6	F7	M

BARKER CODE (bits 1–11) — COMPLEMENT OF BARKER CODE (bits 12–22) — FRAME COUNTER (1, 2 .... 89, 0) (bits 23–29) — MODE BIT (bit 30)

Symbol	Name	ALSEP Words	Range	Bits/ Sample	Samples/Second (at Normal Data Rate)
DA-1	Barker Code and Complement	1, 2, and bits 1 and 2 of word 3	NA	22	1.67
DA-2	Frame Count	Bits 3 to 9 inclusive of word 3	0-89	7	1.67
DA-3	Bit Rate ID	Bit 10 of word 3		1	1/54
		Frame / Mode Bit	Meaning		
		1 / 1	Normal data rate		
		2 / 1	Slow data rate		
DA-4	ALSEP ID	Bit 10 of word 3		3	1/54
		Frame / Mode Bit			
		3 / X (MSB)	Data processor number		
		4 / X			
		5 / X			
DA-5***	**Received Command Message**	**Bits 3 to 9 inclusive of word 46 or 5***	**0-127**	**7**	******
DA-6	**Command MAP** ****	**Bit 10 of word 46 or 5***	**"0" no parity "1" parity**	**1**	******
DA-7	**Filler Bits**	**Bits 1 and 2 of word 46 or 5***	**All zeros**	**2**	******
		Bits 1 and 2 of word 33	**All zeros**	**2**	**1.67**

****One word sample is sent for each command received, other samples are all zeros. Maximum sampling rate is about once per second.**

*** Command verification** word is 46 on Array A and A2 and word 5 on Array C

***** Verifies reception and decoding of commands by retransmission of command message.**

**** Message Acceptance Pulse

Figure 4. Control and Command Verification Words Format

TABLE 1 (a)

CHANNEL ASSIGNMENTS FOR ANALOG MULTIPLEXER (ALSEP WORD 33)

FLIGHT SYSTEMS 1, 2, 3, 4 and A-2

Channel Number	Flight Systems 1 and 2	Flight System 3	Flight System 4	Array A-2
1.	AE-3			
2.	AE-1			
3.	AE-2			
4.	AT-3			
5.	AE-4	Same on all Flight Systems		
6.	AR-1			
7.	AR-4			
8.	AE-5			
9.	AB-1			
10.	BLANK	AC-4	AC-4	AZ-1
11.	BLANK	AC-5	AC-5	AZ-2
12.	AB-4			
13.	AE-6			
14.	AB-5			
15.	AT-10			
16.	AT-21			
17.	AT-22	Same on all Flight Systems		
18.	AT-23			
19.	AT-24			
20.	AE-7			
21.	AE-13			
22.	AE-18			
23.	AL-1			
24.	AL-5			
25.	BLANK	AC-1	AC-1	AB-6
26.	AX-5			
27.	AT-1	Same on all Flight Systems		
28.	AT-4			
29.	BLANK	AH-1	AS-1	AH-1
30.	AX-2			
31.	AT-25			
32.	AT-26			
33.	AT-27			
34.	AT-28			
35.	AE-8	Same on all Flight Systems		
36.	AE-14			
37.	AR-2			
38.	AL-2			
39.	AL-6			
40.	BLANK	AC-3	AC-3	AE-6
41.	AX-6			
42.	AT-2	Same on all Flight Systems		
43.	AT-5			

NOTE: Channels 1-15 are "High Reliability" channels.

TABLE 1 (a) (CONT.)
CHANNEL ASSIGNMENTS FOR ANALOG MULTIPLEXER
(ALSEP WORD 33)

Channel Number	Flight Systems 1 and 2	Flight System 3	Flight System 4	Array A-2
44.	BLANK	BLANK	AS-2	AE-5
45.	BLANK	AH-2	BLANK	AH-2
46.	AT-29			
47.	AT-30			
48.	AT-31			
49.	AT-32	Same on all Flight Systems		
50.	AE-9			
51.	AE-15			
52.	AR-3			
53.	AL-3			
54.	AL-7			
55.	BLANK	AH-3	AS-3	AH-3
56.	AX-[illegible]	AX-3	AX-3	AX-3
57.	BLANK	AH-6	BLANK	AH-6
58.	AT-6			
59.	AT-8			
60.	AT-12			
61.	AT-33			
62.	AT-34			
63.	AT-35	Same on all Flight Systems		
64.	AT-36			
65.	AE-10			
66.	AE-16			
67.	AR-5			
68.	AL-4			
69.	AL-8			
70.	AI-1	AG-1	AI-1	AI-1
71.	AT-7	Same on all Flight Systems		
72.	AT-13	Same on all Flight Systems		
73.	BLANK	BLANK	AS-4	BLANK
74.	BLANK	AH-4	BLANK	AH-4
75.	BLANK	AH-7	BLANK	AH-7
76.	AT-37			
77.	AT-38			
78.	AT-39			
79.	AE-11			
80.	AE-12	Same on all Flight Systems		
81.	AE-17			
82.	AR-6			
83.	AX-1			
84.	AX-4			
85.	AI-2	AG-2	AI-2	AI-2
86.	BLANK	BLANK	BLANK	AZ-3
87.	AT-9	Same on all Flight Systems		
88.	AT-11	Same on all Flight Systems		
89.	BLANK	AC-2	AC-2	BLANK
90.	BLANK	AC-6	AC-6	BLANK

TABLE 1 (b)
ANALOG HOUSEKEEPING CHANNEL USAGE

Symbol	Location/Name	Flight	Channel	Range	Sensor Accuracy
	Structural/Thermal Temperatures				
AT-1	Sunshield #1	All	27	-300°F to +300°F	±15°F
AT-2	" #2	"	42	" "	"
AT-3	Thermal Plate #1	"	4	-50°F to +200°F	±10°F
AT-4	" " #2	"	28	" "	"
AT-5	" " #3	"	43	" "	"
AT-6	" " #4	"	58	" "	"
AT-7	" " #5	"	71	" "	"
AT-8	Left Side Structure #1	"	59	-300°F to +300°F	±15°F
AT-9	Right Side Structure #2	"	87	" "	"
AT-10	Bottom Structure #3	"	15	" "	"
AT-11	Power Dump Module	"	88	" "	"
AT-12	Inner Multilayer Insulation	"	60	-50°F to +200°F	±10°F
AT-13	Outer Multilayer Insulation	"	72	-300°F to +300°F	±15°F
	Electronic Temperatures				
AT-21	Local OSC. Crystal A	"	16	-10°F to +140°F	±10°F
AT-22	Local OSC. Crystal B	"	17	" "	"
AT-23	Transmitter A Crystal	"	18	" *	"
AT-24	Transmitter A Heat Sink	"	19	" *	"
AT-25	Transmitter B Crystal	"	31	" *	"
AT-26	Transmitter B Heat Sink	"	32	" *	"
AT-27	Analog Data Processor, Base	"	33	-50°F to +200°F	"
AT-28	Analog Data Processor, Internal	"	34	" "	"
AT-29	Digital Data Processor, Base	"	46	" "	"
AT-30	Digital Data Processor, Internal	"	47	" "	"
AT-31	Command Decoder, Base	"	48	" "	"
AT-32	Command Decoder, Internal	"	49	" "	"
AT-33	Command Demodulator VCO	"	61	" "	"
AT-34	PDU, Base	"	62	" "	"
AT-35	PDU, Internal	"	63	" "	"
AT-36	PCU, Power OSC #1	"	64	" "	"
AT-37	PCU, Power OSC #2	"	76	" "	"
AT-38	PCU, Regulator #1	"	77	" +210°F	"
AT-39	PCU, Regulator #2	"	78	" "	"

Total of 32 Central Station Temperatures

* Calibration Range for Flights A, B and C shown.
Calibration Range for A2 Transmitter is -220°F to +150°F.

TABLE 1 (b) (CONT.)

ANALOG HOUSEKEEPING CHANNEL USAGE

Symbol	Location/Name	Array	Channel	Range	Sensor Accuracy
	Central Station Electrical				
AE-1	ADC Calibration 0.25V	All	2	Octal Count 015 ± 1	0.5%
AE-2	ADC Calibration 4.75V	"	3	Octal Count 361 ± 1	"
AE-3	Converter Input Voltage	"	1	0 to 20 VDC	±2%
AE-4	Converter Input Current	"	5	0 to 5 ADC	"
AE-5	Shunt Reg #1 Current	"	8 **	0 to 3.5 ADC	"
AE-6	Shunt Reg #2 Current	"	13 **	0 to 3.5 ADC	"
AE-7	PCU Output Voltage #1 (29V)	"	20	0 to 35 VDC	"
AE-8	PCU Output Voltage #2 (15V)	"	35	0 to 18 VDC	"
AE-9	PCU Output Voltage #3 (12V)	"	50	0 to 15 VDC	"
AE-10	PCU Output Voltage #4 (5V)	"	65	0 to 6 VDC	"
AE-11	PCU Output Voltage #5 (-12V)	"	79	0 to -15 VDC	"
AE-12	PCU Output Voltage #6 (-6)	"	80	0 to -7.5 VDC	"
AE-13	RCVR., Pre-Limiting Level	"	21	-101 to -61 dBm	±1 dBm
AE-14	RCVR., Local OSC Level	"	36	0 to 10 dBm	±0.5 dB
AE-15	Trans. A, AGC Voltage	A, and C	51	0 to 5 V	±5%
AE-16	Trans. B, AGC Voltage	"	66	0 to 5 V	"
AE-17	Trans. A, DC, Power Doubler	"	81	100 to 220 ma	"
AE-18	Trans. B, DC, Power Doubler	"	22	100 to 220 ma	"
AE-15	Trans. A, RF Power	A2	51	27 to 32 dBm	0.1 dB
AE-16	Trans. B, RF Power	A2	66	27 to 32 dBm	0.1 dB
AE-17	Trans. A, Current	A2	81	0 to 500 ma	±5 ma
AE-18	Trans. B, Current	A2	22	0 to 500 ma	±5 ma

Central Station Bistatic

Symbol	Location/Name	Array	Channel	Range			
AB-1	Receiver, 1 KHz Subcarrier Present	All	9				
				Exper. #1	Exper. #2	Octal Count	
AB-4*	Power Distribution, Experiments #1 and #2.	"	12 **	—	—	000-002	
				Standby	—	076-122	
				—	Standby	171-215	
				Standby	Standby	264-314	
AB-5*	Power Distribution, Experiments 3, 4, and 5.	"	14	Exper. #3	Exper. #4	Exper. #5	Octal Cnt
				—	—	—	000-002
				—	—	Standby	031-055
				—	Standby	—	073-117
				—	Standby	Standby	132-156
				Standby	—	—	171-215
				Standby	—	Standby	226-252
				Standby	Standby	—	262-306
				Standby	Standby	Standby	314-340
AB-6	Data Processor X On/Off	A2	25	Octal 0 to 2 OFF/ 160 to 220 ON			

*Experiments numbered as shown below:

Exp. No.	A		C	A2
1	PSE		PSE	PSE
2	LSM		ASE	LSM
3	SWS		SIDE/ CCGE	SWS
4	SIDE/CCGE		CPLEE	SIDE/CCGE
5	[DSS	Heaters	1 & 2]	HFE

**For Array A2 only

AE-5 8, 44

AE-6 13, 40

**For Arrays A, C.

Exp. 5 Power On;DSS Heater 1 ON

Exp. 5 Standby Power;DSS Heater 2 ON

Exp. 5 Standby OFF;DSS Heater 1 and 2 OFF.

TABLE 1 (b) (CONT.)
ANALOG HOUSEKEEPING CHANNEL USAGE

Symbol	Location/Name	G.E. No.	Array	Channel	Range	Sensor Accuracy	Bits/Sample	Samples/Sec.
	RTG Temperatures							
AR-1	Hot Frame #1	(R1-1)	All	6	950°F to 1150°F	±5°F	8	.0185
AR-2	Hot Frame #2	(R1-2)	"	37	*950°F to 1150°F	"	"	"
AR-3	Hot Frame #3	(R1-3)	"	52	950°F to 1150°F	"	"	"
AR-4	Cold Frame #1	(R3-1)	"	7	400°F to 600°F	"	"	"
AR-5	Cold Frame #2	(R3-2)	"	67	400°F to 600°F	"	"	"
AR-6	Cold Frame #3	(R3-3)	"	82	*400°F to 600°F	"	"	"
	Dust Accretion							
AX-1	#1 Cell Temperature		A & B	83	+27°C to +160°C	±8°C	8	.0185
AX-2	#2 Cell Temperature		"	30	+27°C to +160°C	"	"	"
AX-3	#3 Cell Temperature		"	56	+27°C to +160°C	"	"	"
AX-4	#1 Cell Output		"	84	0-150 mV	±1%	"	"
AX-5	#2 Cell Output		"	26	0-150 mV	"	"	"
AX-6	#3 Cell Output		"	41	0-150 mV	"	"	"
	D.T.R.E.M.							
AX-1	Inner Temperature		C & A2	83	-160°C to +120°C	±2°C	8	.0185
AX-2	Cell Temperature		"	30	+27°C to +160°C	±5°C	"	"
AX-3	Outer Temperature		"	56	-160°C to +120°C	±2°C	"	"
AX-4	#1 Cell Output (Bare)		"	84	0-150 mV	±1%	"	"
AX-5	#2 Cell Output (Irradiated Filter)		"	26	0-150 mV	"	"	"
AX-6	#3 Cell Output (Filter)		"	41	0-150 mV	"	"	"
	Passive Seismic							
AL-1	L. P. Ampl. Gain (X & Y)		All	23	Discrete		8	.0185
AL-2	L. P. Ampl. Gain (Z)		"	38	"		"	"
AL-3	Level Direction and Speed		"	53	"		"	"
AL-4	S. P. Ampl. Gain (Z)		"	68	"		"	"
AL-5	Leveling Mode & Coarse Sensor Mode		"	24	" See Table 2		"	"
AL-6	Thermal Control Status		"	39	"		"	"
AL-7	Calibration Status L. P. & S. P.		"	54	"		"	"
AL-8	Uncage Status		"	69	"		"	"
	Active Seismic							
AS-1	Central Station Package Temp.		C	29	-40°C to +100°C	±3°C	8	.0185
AS-2	Mortar Box Temperature		C	44	-75°C to +100°C	"	"	"
AS-3	Grenade Launcher Assembly Temp.		C	55	-75°C to +100°C	"	"	"
AS-4	Geophone Temperature		C	73	-200°C to +130°C	"	"	"
	Heat Flow							
AH-1	Supply Voltage #1		B & A2	29	0 to +5 volts	5% full scale	8	.0185
AH-2	Supply Voltage #2		B & A2	49	0 to -5 volts	"	"	"
AH-3	Supply Voltage #3		B & A2	55	0 to +15 volts	"	"	"
AH-4	Supply Voltage #4		B & A2	74	0 to -15 volts	"	"	"
AH-5	Not Assigned							
AH-6	Supply Voltage #6		B & A2	57	Discrete	"	"	"
AH-7	Supply Voltage #7		B & A2	75	"	"	"	"

*In Array A, these channels monitor fixed resistors, giving, typically, octal readings of 151-171 for channel 37 and 215-223 for channel 82.

TABLE 1 (b) (CONT.)

ANALOG HOUSEKEEPING CHANNEL USAGE

Symbol	Location/Name	Flight	Channel	Range	Sensor Accuracy	Bits/ Sample	Samples/ Sec.
	Charged Particle						
AC-1	Switchable P. S. Voltage	3, 4	25	0-4.5V	±5%	8	.0185
AC-2	Channeltron P. S. #1	"	89	0-4.5V	"	"	"
AC-3	Channeltron P. S. #2	"	40	0-4.5V	"	"	"
AC-4	DC-DC Converter Voltage	"	10	0-4.5V	"	"	"
AC-5	Temperature of Physical Analyzer	"	11	-30° to +80°C	"	"	"
AC-6	Temperature of Switchable P. S.	"	90	-39° to +80°C	"	"	"
	SIDE/CCGE						
AI-1	Low Energy Detector Count Rate	1, 2, 4	70	$10-10^6$ counts/sec	±10%	8	.0185
AI-2	High Energy Detector Count Rate	1, 2, 4	85	$10-10^6$ counts/sec	"	"	"
	CCGE						
AG-1	Gauge Output	3	70	0-5.0V		8	.0185
AG-2	Gauge Range	"	85	0-5.0V		"	"
	TIMER						
AZ-1	Timer 18 Hour Bistatic	A2	10	Alternately HI-LO*			
AZ-2	Timer 1 1/2 Month #1	A2	11	HI after 1 1/2 months*			
AZ-3	Timer 1 1/2 Month #2	A2	86	HI after 1 1/2 months*			

*for these channels HI = $>200_8$ LO = $<40_8$; Initial and reset condition is LO for AZ-2 and AZ-3, random for AZ-1.

TABLE 3

MAGNETOMETER MEASUREMENTS

Scientific Measurements

Symbol	Location/Measurement	ALSEP Word	Frame	Range	Sensor Accuracy	Frequency Response	Bits/ Sample	Sample/ Sec.	Sample/ Frame
**** DM-25	X-Axis Field	17, 49	Every	±100, ±200, ±400 gamma	*	~1.5 cycle/sec.	10	3.3	2
**** DM-26	Y-Axis Field	19, 51	"	" " " "	*	~ " " "	"	"	"
**** DM-27	Z-Axis Field	21, 53	"	" " " "	*	~ " " "	"	"	"

These data are in Words 17, 19, 21, 49, 51, 53 and have the following format:

2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Polarity** Bit	Science Data ***								

* Resolution - 0.2% Full Scale
Accuracy - 0.5% Full Scale

** 0 = Plus, 1 = Minus

***Calibrate levels of Science Data are 1/4, 1/2 and 3/4 of saturation level, or PCM counts of 128, 256 and 384.

**** ±50, ±100 and ±200 gamma for A-2.

Engineering Measurements

Housekeeping is located in ALSEP Word 5 which is sub- commutated over 16 frames as follows:

Bit in Word 5	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Meaning	F	A1	A2	A3	A4	A5	A6	A7	B1	B2
		Engineering Data								

Where B1, B2 are bistable status data
A1, ..., A7 are bits derived from analog measurements
F locates the subcommutation start, F = 1 is frame 1 of the subcommutation and F = 0 elsewhere.

TABLE 3 (CONT.)
MAGNETOMETER MEASUREMENTS

Engineering Measurements (Cont.)

Symbol	Location/Measurement	ALSEP Word	Frame	Range	Sensor Accuracy	Bits/ Sample	Sample/ Sec	Sample/ Frame
DM-1	Temperature #1 (X Sensor)	5	1, 9,	$-30^{\circ}C$ to $+65^{\circ}C$	$\pm3\%$	7	.207	1/8
DM-2	Temperature #2 (Y Sensor)	"	2, 10,	" "	"	"	"	"
DM-3	Temperature #3 (Z Sensor)	"	3, 11,	" "	"	"	"	"
DM-4	Temperature #4 (Base)	"	4, 12,	" "	"	"	"	"
DM-5	Temperature #5 (Internal)	"	5, 13,	" "	"	"	"	"
DM-6	Level Sensor #1	"	6, 14,	-15° to $+15^{\circ}$		"	"	"
DM-7	Level Sensor #2	"	7, 15,	" "		"	"	"
DM-8	Supply Voltage	"	8, 16,	0 to +6.25V	$\pm0.1\%$	"	"	"
DM-9	X Flip Position	"	1	Discrete		2 status bits	.104	1/16
DM-10	Y Flip Position	"	2	"		2 " "	"	"
DM-11	Z Flip Position	"	3	"		2 " "	"	"
DM-12	X Gimbal Position	"	4	"		1 " "	"	"
DM-13	Y Gimbal Position	"	4	"		1 " "	"	"
DM-14	Z Gimbal Position	"	5	"		1 " "	"	"
DM-15	Temperature Control Select	"	5	"		1 " "	"	"
DM-16	Measurement Range	"	7	"		2 " "	"	"
DM-17	X Offset Field	"	See Table 4	"		3 " "	"	"
DM-18	Y Offset Field	"	See Table 4	"	See Table 5	3 " "	"	"
DM-19	Z Offset Field	"	See Table 4	"		3 " "	"	"
DM-20	Mode State	"	13	"		1 " "	"	"
DM-21	Offset Address	"	14	"		2 " "	"	"
DM-22	Filter In/Out	"	15	"		1 " "	"	"
DM-23	Flip/Cal Inhibit Status	"	15	"		1 " "	"	"
DM-24	Filler Bits	"	16	"		2 " "	"	"
DM-28	Heater Power Status	"	6	"		2 " "	"	"
DM-29	Filler Bits	"	6, 8	"		2 " "	"	"
DM-30	LSM Frame ID	"	(Derived from F in Frame #1)					

Detail of the status-bit usage is shown in Table 4 and the status bit structure is shown in Table 5.

TABLE 1 (c)

SUMMARY OF ANALOG CHANNEL USAGE FLIGHTS 1 TO 4, A-2

	Flights 1 & 2	Flight 3	Flight 4	Array A-2
Central Station				
Data and Power Subsystems (including timer)	38	38	38	44
Experiment On-Off Status	2	2	2	2
Structural/Thermal	13	13	13	13
RTG Temperatures	4	6	6	6
TOTAL	57	59	59	65
Experiments				
Passive Seismic	8	8	8	8
Solar Wind	—	—	—	—
Magnetometer	—	—	—	—
SIDE	2	—	2	2
Heat Flow	—	6	—	6
CPLEE	—	6	6	—
Active Seismic	—	—	4	—
CCGE (MSC)	—	2	—	—
Dust Detector	6	6	6	6
TOTAL	16	28	26	22
Not Assigned	17	3	5	3
TOTAL	90	90	90	90

TABLE 2

PASSIVE SEISMIC MEASUREMENT, FLIGHT 1, 2, 3, 4 AND A2

Scientific Measurements:

Symbol	Location/Measurement	ALSEP Word	Frame	(Dynamic) Range	Sensor Accuracy	Bits/ Sample	Sample/ Sec	Sample/ Frame
DL-1	L. P. Seismic X	9, 25, 41, 57	Every	1 mμ to 10 μ	5% of reading	10	6.625	4
DL-2	L. P. Seismic Y	11, 27, 43, 59	"	1 mμ to 10 μ	" "	"	"	"
DL-3	L. P. Seismic Z	13, 29, 45, 61	"	1 mμ to 10 μ	" "	"	"	"
DL-4	Tidal: X	35	Even	.01 to 10" (arc)	" "	"	0.85	0.5
DL-5	Tidal: Y	37	Even	.01 to 10" (arc)	" "	"	0.85	0.5
DL-6	Tidal: Z	35	Odd	8 μgal to 8 mgal	" "	"	"	"
DL-7	Sensor Unit Temp.	37	Odd	107-143°F	+1% of reading***	"	"	"
DL-8	Short Period Seismic: Z	Every Even Word Except 2, 46, 56, 24*	Every	1 mμ to 10 μ	5% of reading	"	48.0	**

Housekeeping Measurements

8 channels of Engineering Measurements included in ALSEP Word 33, all 0-5 VDC.

Symbol	Location/Measurement	Channel	Range		Octal Count	Bits/ Sample	Sample/ Sec
AL-1	L. P. Amp. Gain X, Y	23	0db -10db -20db -30db	0-0.4V 0.6-1.4 1.6-2.4 2.6-4.0	0 to 25 37 to 110 122 to 172 205 to 314	8	.0185
AL-2	L. P. Amp. Gain Z	38	0db -10db -20db -30db	0-0.4V 0.6-1.4 1.6-2.4 2.6-4.0	0 to 25 37 to 110 122 to 172 205 to 314	8	.0185
AL-3	Level Direction and Speed	53	+low -low +high -high	0-0.4V 0.6-1.4 1.6-2.4 2.6-4.0	0 to 25 37 to 110 122 to 172 205 to 314	8	.0185
AL-4	S. P. Amp. Gain Z	68	0db -10db -20db -30db	0-0.4V 0.6-1.4 1.6-2.4 2.6-4.0	0 to 25 37 to 110 122 to 172 205 to 314	8	.0185
AL-5	Leveling Mode and Coarse Sensor Mode	24	Automatic, coarse level out Manual, coarse level out Automatic, coarse level in Manual, coarse level in	0-0.4V 0.6-1.4 1.6-2.4 2.6-4.0	0 to 25 37 to 110 122 to 172 205 to 314	8	.0185
AL-6	Thermal Control Status	39	Automatic Mode ON Automatic Mode OFF Manual Mode ON Manual Mode OFF	0-0.4V 0.6-1.4 1.6-2.4 2.6-4.0	0 to 25 37 to 110 122 to 172 205 to 314	8	.0185
AL-7	Calibration Status LP & SP	54	Both ON LP-ON SP-OFF LP-OFF SP-ON Both OFF	0-0.4V 0.6-1.4 1.6-2.4 2.6-4.0	0 to 25 37 to 110 122 to 172 205 to 314	8	.0185
AL-8	Uncage Status****	69	Caged Arm Uncage	0-0.4V 0.6-1.4 1.6-2.4	0 to 25 37 to 110 122 to 172	8	.0185

* The exception of four ALSEP words occurs in Flight System A2. In Flight Systems B & C, word 46 & 24 are used for Short Period. In Flight System A, word 24 is used for Short Period Z.

** 29 in Flight System A, 30 in Flight Systems B & C, 28 in A2

*** +0.05°C resolution.

**** Uncage locked-out on all ground tests.

TABLE 4

MAGNETOMETER 16 POINT ENGINEERING SUBCOMMUTATION FORMAT

Magnetometer Subcommutation Frame	Frame Mark Bit	Data	Status Bits (bits 9 and 10 in word 5)
1	1	Temp #1	X-axis Flip Position - B_1 B_2
2	0	Temp #2	Y-axis Flip Position - B_1 B_2
3	0	Temp #3	Z-axis Flip Position - B_1 B_2
4	0	Temp #4	{X-axis Gimbal Position - B_1 Y-axis Gimbal Position - B_2}
5	0	Temp #5	{Z-axis Gimbal Position - B_1 Thermal Control Select - B_2}
6	0	Level #1	Spare Bit - B_1 Heater Power Status - B_2
7	0	Level #2	Measurement Range - B_1 B_2
8	0	Voltage #1	Filler Bits - B_1 B_2
9	0	Temp #1	X-axis Field Offset - B_1 B_2 } 3 bit word (with frame 10 B_1)
10	0	Temp #2	{X-axis Field Offset - B_1 Y-axis Field Offset - B_2}
11	0	Temp #3	Y-axis Field Offset - B_1 B_2 } 3 bit word (with frame 10 B_2)
12	0	Temp #4	Z-axis Field Offset - B_1 B_2 } 3 bit word (with frame 13 B_1)
13	0	Temp #5	{Z-axis Field Offset - B_1 Mode State - B_2}
14	0	Level #1	Offset Address State -B_1 B_2
15	0	Level #2	{Filter Status - B_1 Flip/Cal inhibit status - B_2}
16	0	Voltage #1	Filler bits - B_1 B_2

TABLE 5

MAGNETOMETER ENGINEERING STATUS BIT STRUCTURE

Status Flag	Commutator Point	B_1	B_2	Status
X-axis Flip Position	1	0	0	Not at 0°, 90°, or 180° position
" " "	1	0	1	0° position
" " "	1	1	0	90° position
" " "	1	1	1	180° position
Y-axis Flip Position	2	0	0	Not at 0°, 90°, or 180° position
" " "	2	0	1	0° position
" " "	2	1	0	90° position
" " "	2	1	1	180° position
Z-axis Flip Position	3	0	0	Not at 0°, 90°, or 180° position
" " "	3	0	1	0° position
" " "	3	1	0	90° position
" " "	3	1	1	180° position
X-axis Gimbal Position	4	1		Pre Site Survey Position
" " "	4	0		Post Site Survey Position
Y-axis Gimbal Position	4		1	Pre Site Survey Position
" " "	4		0	Post Site Survey Position
Z-axis Gimbal Position	5	1		Pre Site Survey Position
" " "	5	0		Post Site Survey Position
Temp Control State	5		1	X-axis Control
" " "	5		0	Y-axis Control/Off
Heater Power Status	6, 6		1	Heater ON/Heater OFF
Filler bits	6	1	0	Not Used
Measurement Range	7	0	0	100γ Range *
" " "	7	1	0	200γ Range *
" " "	7	1	1	400γ Range *
" " "	7	0	1	Error
Filler Bits	8	1	1	Not used
X-axis Field Offset	9	0	1	0% offset
" " "	10	1		0% offset
" " "	9	1	0	-25% offset
" " "	10	0		-25% offset
" " "	9	1	0	-50% offset
" " "	10	1		-50% offset
" " "	9	1	1	-75% offset
" " "	10	0		-75% offset
" " "	9	0	0	+75% offset
" " "	10	0		+75% offset
" " "	9	0	0	+50% offset
" " "	10	1		+50% offset
" " "	9	0	1	+25% offset
" " "	10	0		+25% offset
Y-axis Field Offset	10		0	0% offset
" " "	11	1	1	0% offset
" " "	10		1	-25% offset
" " "	11	0	0	-25% offset
" " "	10		1	-50% offset
" " "	11	0	1	-50% offset
" " "	10		1	-75% offset
" " "	11	1	0	-75% offset
" " "	10		0	+75% offset
" " "	11	0	0	+75% offset
" " "	10		0	+50% offset
" " "	11	0	1	+50% offset
" " "	10		0	+25% offset
" " "	11	1	0	+25% offset
Z-axis Field Offset	12	1	1	0% offset
" " "	13	1		0% offset
" " "	12	1	0	- 25% offset
" " "	13	0		- 25% offset
" " "	12	1	0	- 50% offset
" " "	13	1		- 50% offset
" " "	12	1	1	- 75% offset
" " "	13	0		- 75% offset
" " "	12	0	0	+ 75% offset
" " "	13	0		+ 75% offset
" " "	12	0	0	+ 50% offset
" " "	13	1		+ 50% offset
" " "	12	0	1	+ 25% offset
" " "	13	0		+ 25% offset
Mode State	13		0	Calibrate ON
" "	13		1	Calibrate OFF (Science)
Offset Address State	14	0	0	Not at X, Y, or Z
" " "	14	1	0	X-axis position
" " "	14	0	1	Y-axis position
" " "	14	1	1	Z-axis position
Filter Status	15	1		Filter bypassed
" " "	15	0		Filter not bypassed
Flip/Cal. Inhibit Status	15		1	Calibration Inhibited
" " "	15		0	Calibration not inhibited
Filler bits	16	0	0	Not used

* ±50, ±100, ±200 range for A-2

TABLE 6
SUPRATHERMAL ION DETECTOR AND COLD CATHODE GAUGE EXPERIMENT MEASUREMENTS

(SIDE)

Symbol	Location/Name	SIDE Frame	Range**	Accuracy	Bit/ Sample	Sample/ Sec.
Following measurements carried in ALSEP Word 15 even, SIDE Word 1 and in indicated SIDE Frames.						
DI-1	*SIDE Frame Number	All	0-127	NA	7 bit 4 to 10* inclusive	
Following measurements carried in ALSEP Word 31 even, SIDE Word 2 and in indicated SIDE Frames.						
DI-2	+5 volts analog	0, 32, 64, 96	5V ±0.15V		8	
DI-3	CCGE Output	1, 3, 5, 7, 9, 41, 73, 105, 121-127	****		"	
DI-4	Temp. #1	2, 34, 66, 98	100 to 400°K	± 10°K	"	
DI-5	Temp. #2	4, 36, 68, 100	-90 to +125°C	±5°C	"	
DI-6	Temp. #3	6, 38, 70, 102	-90 to +125°C	±5°C	"	
DI-7	4.5 KV	8, 40, 72, 104	3.72 to 5.45KV		"	
DI-8	CCGE Range	10, 24, 42, 56, 74, 88, 106, 120	Range #1 6.9 to 9.0V Range #2 4.2 to 5.7V Range #3 2.2 to 3.2V		" " "	
DI-9	Temp. #4	11, 43, 75, 107	-50 to +90°C		"	
DI-10	Temp. #5	12, 44, 76, 108	-50 to +90°C		"	
DI-11	GND Plane Voltage	13, 15, 29, 31, 45, 47, 61, 63, 69 77, 79, 93, 95, 109, 111			" "	
DI-12	Solar Cell	14, 78	15 mV to 600 mV	±3%	"	
DI-13	+60 volts	16, 48, 80, 112	.15 to 150V		"	
DI-14	+30 volts	17, 49, 81, 113	.15 to 150V		"	
DI-15	+5 volts digital	18, 50, 82, 114	15 mV to 15V		"	
DI-16	Ground	19, 51, 83, 115	0 to 18 mV		"	
DI-17	-5 volts	20, 52, 84, 116	-15 mV to -15V		"	
DI-18	-30 volts	21, 53, 85, 117	-.15 to -150V		"	
DI-19	Temp. #6	22, 54, 86, 118	-50 to +90°C		"	
DI-20	-3.5 KV	23, 55, 87, 119	-2.9 to -4.25 KV		"	
DI-21	+1.0 volt cal.	27, 59, 91	153 - 157 Count		"	
DI-22	+30 mV cal.	25, 57, 89	20 - 34 Count		"	
DI-23	+ A/D Ref. voltage	26, 58, 90	15 mV to 15V		"	
DI-24	Dust Cover and Seal	67, 71	Preset 3.125 to 5.5V Seal only 1.875 to 3.125V Dust cover only .625 to 1.875V Cover and seal 0 to .625V		" " " " "	
DI-25	-A/D Ref. volt	30, 62, 94	-15 mV to -15V		"	
DI-26	-1.0 volt cal.	37, 101	153 - 157 Count		"	
DI-27	-12 volt cal.	39, 103	244 - 248 Count		"	
DI-28	+12 volt cal.	28, 60, 92	244 - 248 Count		"	
DI-29	Pre Reg Duty Fact.	65	68% to 100%		"	
DI-30	-30 mV cal.	46, 110	12 - 34 Count		"	

*See note on Page 21 for measurement content.

**Range of sensor output

*** With HV (4.5 KV) OFF, cal. counts as follows:

TABLE 6 (CONT.)

SUPRATHERMAL ION DETECTOR AND COLD CATHODE GAUGE EXPERIMENT MEASUREMENTS

SIDE

Symbol	Location/Name	SIDE Frame	Nominal Value	Tolerance	Bit/ Sample	Sample/ Sec.
DF-29	One Time Command Register Status	33, 35, 97, 99	Preset 0 to .625V		8	
			Seal only .625 to 1.875V		"	
			Dust cover 1.875 to 3.125V		"	
			Dust cover and Seal 3.125 to 5.5V		"	

Following measurements carried in ALSEP Word 47 even, SIDE Word 3 and in indicated SIDE Frames.

Symbol	Location/Name	SIDE Frame	Energy Filter Voltage	Tolerance	Bit/ Sample	Sample/ Sec.
DI-40	HECPA Stepper Voltage	1, 21, 41, 61, 81, 101	+437.5V		8	
DI-41	"	2, 22, 42, 62, 82, 102	406.25V		"	
DI-42	"	3, 23, 43, 63, 83, 103	375.0V		"	
DI-43	"	4, 24, 44, 64, 84, 104	343.75V		"	
DI-44	"	5, 25, 45, 65, 85, 105	312.5V		"	
DI-45	"	6, 26, 46, 66, 86, 106	281.25V		"	
DI-46	"	7, 27, 47, 67, 87, 107	250.0V		"	
DI-47	"	8, 28, 48, 68, 88, 108	218.75V		"	
DI-48	"	9, 29, 49, 69, 89, 109	187.5V		"	
DI-49	"	10, 30, 50, 70, 90, 110	156.25V		"	
DI-50	"	11, 31, 51, 71, 91, 111	93.75V		"	
DI-51	"	12, 32, 52, 72, 92, 112	93.75V		"	
DI-52	"	13, 33, 53, 73, 93, 113	62.5V		"	
DI-53	"	14, 34, 54, 74, 94, 114	31.25V		"	
DI-54	"	15, 35, 55, 75, 95, 115	12.5V		"	
DI-55	"	16, 36, 56, 76, 96, 116	8.75V		"	
DI-56	"	17, 37, 57, 77, 97, 117	6.25V		"	
DI-57	"	18, 38, 58, 78, 98, 118	3.75V		"	
DI-58	"	19, 39, 59, 79, 99, 119	2.5V		"	
DI-59	"	20, 40, 60, 80, 100, 120	1.25V		"	
DI-60	"	0, 121, 122, 123, 124, 125 126, 127	0V		" "	

Following measurements carried in ALSEP Word 56 even, SIDE Word 4 and in indicated SIDE Frames.

Symbol	Location/Name	SIDE Frame	Nominal Value	Tolerance	Bit/ Sample	Sample/ Sec.
DI-61***	HE Data - MSD*	All	0 to 999 decimal		10	

Following measurements carried in ALSEP Word 63 even, SIDE Word 5 and in indicated SIDE Frames.

Symbol	Location/Name	SIDE Frame	Nominal Value	Tolerance	Bit/ Sample	Sample/ Sec.
DI-62***	HE Data - LSD**	All	0 to 999 decimal		10	

*MSD - Most significant data

**LSD - Least significant data

*** For Calibration values, see end of table.

TABLE 6 (CONT.)

SUPRATHERMAL ION DETECTOR AND COLD CATHODE GAUGE EXPERIMENT MEASUREMENTS

SIDE

Symbol	Location/Name	SIDE Frame Normal Mode	SIDE Frame Reset @ 9	Nominal Value Voltage	Tolerance	Bits/ Sample	Samples/ Sec.
DJ-92	Velocity Filter Voltage	120	120	29.0		8	
DJ-93	" " "	121	121	26.3		"	
DJ-94	" " "	122	122	23.8		"	
DJ-95	" " "	123	123	21.4		"	
DJ-96	" " "	124	124	19.2		"	
DJ-97	" " "	125, 126, 127	125, 126, 127	>29.0		"	

Following measurements carried in ALSEP Word 47 odd, SIDE Word 8 and in indicated SIDE Frames.

Symbol	Location/Name	Normal Mode	Reset Vel. Filter @ 9	Energy Filter Voltage	Tolerance	Bits/ Sample	Samples/ Sec.
DJ-98	LECPA Stepper Voltage	0-19	0-9, 60-69	12.15V		8	
DJ-99	"	20-39	10-19, 70-79	4.050		"	
DF-0	"	40-59	20-29, 80-89	1.35		"	
DF-1	"	60-79	30-39, 90-99	.450		"	
DF-2	"	80-99	40-49, 100-109	.150		"	
DF-3	"	100-119	50-59, 110-119	.050		"	
DF-4	"	120-127	120-127	0V		"	

Symbol	Location/Name	SIDE Frame	Range	Accuracy	Bits/ Sample	Sample/ Sec.
Following measurements carried in ALSEP Word 56 odd, SIDE Word 9 and in indicated SIDE Frames.						
DF-5	LE Data - MSD	All	0 to 999 decimal		10	
Following measurements carried in ALSEP Word 63 odd, SIDE Word 10and in indicated SIDE Frames.						
DF-6	LE Data - LSD	All	0 to 999 decimal		10	
Two SIDE measurements are included in ALSEP Housekeeping Word 33 (Table 1)						
AI-1	Low Energy Detector Count Rate	70	10 - 10^6 counts/sec		8	.0185
AI-2	High Energy Detector Count Rate	85	10 - 10^6 counts/sec		8	.0185

SCIENCE CAL. DATA (NORMAL MODE)

Symbol	Location/Name	SIDE Frame	PCM Count Range
DI-61, 62	HE Data	0, 124	618,800 to 646,800
		121, 125	0 to 4
		122, 126	150 to 158
		123, 127	19,375 to 20,175
DF-5, 6	LE Data	120, 124	0 to 4
		121, 125	150 to 158
		122, 126	19,375 to 20,175
		123, 127	618,800 to 646,800

TABLE 7

ACTIVE SEISMIC MEASUREMENTS

Symbol	Location/Name	Channel		Range	Sensor Accuracy	Bits/Sample	Samples/Sec.
	When the Active Seismic is not operating, the following measurements are provided through the 90-channel multiplexer of the Data S/S.						
	Active Seismic Temperatures (From Table 1)						
AS-1	Central Station Package Temp.	29		$-40^{\circ}C$ to $+100^{\circ}C$	$\pm 3^{\circ}C$		
AS-2	Mortar Box Temp.	44		$-75^{\circ}C$ to $+100^{\circ}C$	$\pm 3^{\circ}C$		
AS-3	Grenade Launcher Assembly Temp	55		$-75^{\circ}C$ to $+100^{\circ}C$	$\pm 3^{\circ}C$		
AS-4	Geophone Temp.	73		$-200^{\circ}C$ to $-130^{\circ}C$	$\pm 3^{\circ}C$		
	Active Seismic Measurements						
		A/S Word	Subword				
(6) DS-17	Frame Sync	(1) 1	1, 2	N/A	N/A	10	16.56
DS-2	Geophone #2 Data	All	3 (7)		± 10 mμ referred to	5	530
DS-3	Geophone #3 Data	All	4 (7)		" input	5	530
DS-1	Geophone #1 Data	2	1 (7)		"	5	530
		2 through 32	2 (7)		"	5	530
AR-4	RTG Cold Frame Temp #1	(2) 3, 4	1	$400^{\circ}F$ to $600^{\circ}F$	$\pm 5^{\circ}F$	8	16.56
DS-7	Pitch Angle	5, [illegible]	1	$\pm 10^{\circ}$	$\pm 20'$	8	16.56
DS-5	Mortar Box Ground Monitor	7, 8	1	0 to 400 mV	± 16.5 mV	8	16.56
DS-6	Roll Angle	9, 10	1	$\pm 10^{\circ}$	$\pm 20'$	8	16.56
—	Not Used	11, 12	1			8	16.56
AS-3	Grenade Launcher Assy. Temp.	13, 14	1	$-75^{\circ}C$ to $+100^{\circ}C$	$\pm 3^{\circ}C$	8	16.56
DS-8	Geophone Calibrate Pulse	15, 16	1	0 to +5V	$\pm 1\%$	5	16.56
DS-11	A/D Calibration 3.75V	17, 18	1	272 to 316 (Octal)	$\pm 0.5\%$	8	16.56
DS-10	A/D Calibration 1.25V	19, 20	1	76 to 104 (Octal)	$\pm 0.5\%$	8	16.56
AS-1	Central Station Package Temp.	21, 22	1	$-40^{\circ}C$ to $+100^{\circ}C$	$\pm 3^{\circ}C$	8	16.56
AE-3	Converter Input Voltage	23, 24	1	0 to 20 VDC	$\pm 2\%$	[illegible]	16.56
AE-4	Input Current	25, 26	1	0 to 5 A DC	$\pm 2\%$	[illegible]	16.56
AR-1	RTG Hot Frame Temp #1	(2) 27, 28	1	$950^{\circ}F$ to $1150^{\circ}F$	$\pm 5^{\circ}F$	[illegible]	16.56
DS-18	Mark Event	(3) 29	1	N/A	N/A	[illegible]	N/A
DS-19	Word Count	(4) 30	1	N/A	N/A	5	N/A
DS-20	Event Bit Count	(5) 31	1	N/A	N/A	5	N/A
DS-13	Mode ID	(6) 32	1	N/A	N/A	3	16.56

(1) In the first 10 bits of the word.

(2) The first four bits of the measurement are carried in the first four bits of the odd word. The last four bits of the measurement are carried in the first four bits of the even word. In each case the last (or fifth) bit of each subword is spare.

(3) Mark code when Real Time Event occurs during prior frame (frame = 32 word sequence); mark code is 00100 (all zeroes if no event).

(4) Measures word in prior frame during which Real Time Event occurred.

(5) Measures bit during which Real Time Event occurred in above word in prior frame.

(6) In the first 3 bits of the subword - other 2 bits are filler 1's; code as follows:

Seismic 000
Arm Grenade 001
Arm Thumper 010
Geophone Calibrate 100

(7) Calibrated data in milli microns of ground motion (log compressed, 80 dB dynamic range).

TABLE 8 (CONT.)

CHARGED PARTICLE EXPERIMENT SCIENTIFIC MEASUREMENTS

Symbol	Measurement	ALSEP Words	*CPLEE Frame	Range (Counts)	Accuracy	T/M Bits Per Sample	Samples Per Second	Samples Per Frame
DC-61	DET. 1-A -350	7, 17	21	0-524, 287	**	19	1/19.3	1/32
DC-62	DET. 2-A -350	19, 23	21	"	"	19	"	"
DC-63	DET. 3-A -350	39, 55	21	"	"	19	"	"
DC-64	DET. 4-A -350	7, 17	22	"	"	19	"	"
DC-65	DET. 5-A -350	19, 23	22	0-1048, 575	"	20	"	"
DC-66	DET. 6-A -350	39, 55	22	"	"	20	"	"
DC-67	DET. 1-B -350	7, 17	23	0-524, 287	"	19	"	"
DC-68	DET. 2-B -350	19, 23	23	"	"	19	"	"
DC-69	DET. 3-B -350	39, 55	23	"	"	19	"	"
DC-70	DET. 4-B--350	7, 17	24	"	"	19	"	"
DC-71	DET. 5-B -350	19, 23	24	0-1048, 575	"	20	"	"
DC-72	DET. 6-B -350	39, 55	24	"	"	20	"	"
DC-73	DET. 1-A -35	7, 17	25	0-524, 287	"	19	"	"
DC-74	DET. 2-A -35	19, 23	25	"	"	19	"	"
DC-75	DET. 3-A -35	39, 55	25	"	"	19	"	"
DC-76	DET. 4-A -35	7, 17	26	"	"	19	"	"
DC-77	DET. 5-A -35	19, 23	26	0-1048, 575	"	20	"	"
DC-78	DET. 6-A -35	39, 55	26	"	"	20	"	"
DC-79	DET. 1-B -35	7, 17	27	0-524, 287	"	19	"	"
DC-80	DET. 2-B -35	19, 23	27	"	"	19	"	"
DC-81	DET. 3-B -35	39, 55	27	"	"	19	"	"
DC-82	DET. 4-B -35	7, 17	28	"	"	19	"	"
DC-83	DET. 5-B -35	19, 23	28	0-1048, 575	"	20	"	"
DC-84	DET. 6-B -35	39, 55	28	"	"	20	"	"
DC-85	DET. 1-A-0	7, 17	29	420, 000±10%	10 counts	19	"	"
DC-86	DET. 2-A-0	19, 23	29	"	"	19	"	"
DC-87	DET. 3-A-0	39, 55	29	"	"	19	"	"
DC-88	DET. 4-A-0	7, 17	30	"	"	19	"	"
DC-89	DET. 5-A-0	19, 23	30	"	"	20	"	"
DC-90	DET. 6-A-0	39, 55	30	"	"	20	"	"

*CPLEE sampling may initialize at any step voltage but always starts with analyzer A, Detector 1 on an even ALSEP frame. "CPLEE Frame Numbers" are arbitrarily assigned to designate a position in the sequence.

** Error is stochastically related to count magnitude.

TABLE 8 (CONT.)

CHARGED PARTICLE EXPERIMENT SCIENTIFIC MEASUREMENTS

Symbol	Measurement	ALSEP Words	*CPLEE Frame	Range (Counts)	Accuracy	T/M Bits Per Sample	Samples Per Second	Samples Per Frame
DC-91	DET. 1-B-0	7, 17	31	420,000 ±10%	10 counts	19	1/19.3	1/32
DC-92	DET. 2-B-0	19, 23	31	"	"	19	"	"
DC-93	DET. 3-B-0	39, 55	31	"	"	19	"	"
DC-94	DET. 4-B-0	7, 17	32	"	"	19	"	"
DC-95	DET. 5-B-0	19, 23	32	"	"	20	"	"
DC-96	DET. 6-B-0	39, 55	32	"	"	20	"	"
DC-97	Physical Analyzer ID	7	1. *	N. A.	N. A.	1	1/1.208	1/2
DC-98	Polarity of Deflection Voltage ID	19	1. *	N. A.	N. A.	1	"	"
DC-99	Deflection Voltage Level ID	{39	1. *	N. A.	N. A.	1	"	"
		{7	2. *	N. A.	N. A.	1	"	"

*Measurement DC-97 is the first bit of word 7, even ALSEP frames; one bit of DC-99 is the first bit of word 7, odd ALSEP frames. DC-98 is the first bit of word 19, even frames. The remaining bit of DC-99 is the first bit of word 39, even frames.

CPLEE ANALOG HOUSEKEEPING DATA

(ALSEP Word 33)

Symbol	Housekeeping Parameter	Channel	Range	Accuracy
AC-1	Switchable P. S. Voltage	25	0-4.5V	±5%
AC-2	Channeltron P. S. #1	89	0-4.5V	"
AC-3	Channeltron P. S. #2	40	0-4.5V	"
AC-4	DC-DC Converter Voltage	10	0-4.5V	"
AC-5	Temperature of Physical Analyzer	11	-30° to +80°C	"
AC-6	Temperature of Switchable P. S.	90	-30° to +80°C	"

TABLE 9 (a)

WORD FORMAT FOR HEAT FLOW EXPERIMENT

Each Heat Flow data point employs eight 10-bit words (ALSEP Word 21 (B) or 24 (A-2) in eight consecutive frames), arranged as follows:

Heat Flow Word	Bit Position									
	1	2	3	4	5	6	7	8	9	10
0	R_2 2^9	R_1 2^8	0 2^7	P_4 2^6	P_3 2^5	P_2 2^4	P_1 2^3	2^{12} 2^2	2^{11} 2^1	2^{10} 2^0
1	R_2 2^9	R_1 2^8	M_1 2^7	M_2 2^6	M_3 2^5	0 2^4	0 2^3	2^{12} 2^2	2^{11} 2^1	2^{10} 2^0
2	R_2 2^9	R_1 2^8	H_4 2^7	H_3 2^6	H_2 2^5	H_1 2^4	0 2^3	2^{12} 2^2	2^{11} 2^1	2^{10} 2^0
3	R_2 2^9	R_1 2^8	0 2^7	0 2^6	0 2^5	0 2^4	0 2^3	2^{12} 2^2	2^{11} 2^1	2^{10} 2^0

Where:

DH-90 M_1, M_2, M_3 are mode registers, (100) Gradient Mode, (010) Low Conductivity Mode, and (001) High Conductivity Mode, respectively.

DH-91 P_4, P_3, P_2, P_1 are measurement identification as described in Table 9(b).

DH-92 R_2, R_1 are binary equivalent of Heat Flow Word.

DH-93 H_4, H_3, H_2, H_1 are conductivity heater registers (8 heaters).

DH-94 HFE filler bits (shown as zeros in above chart).

TABLE 9(b)

HEAT FLOW P-BIT MEASUREMENT DESIGNATIONS

P Identification Bits				Measurement	P Identification Bits				Measurement
P_4	P_3	P_2	P_1		P_4	P_3	P_2	P_1	
0	0	0	0	$\Delta T_{11}H$	1	0	0	0	T_{11}
0	0	0	1	$\Delta T_{12}H$	1	0	0	1	T_{12}
0	0	1	0	$\Delta T_{21}H$	1	0	1	0	T_{21}
0	0	1	1	$\Delta T_{22}H$	1	0	1	1	T_{22}
0	1	0	0	$\Delta T_{11}L$	1	1	0	0	T_{ref}
0	1	0	1	$\Delta T_{12}L$	1	1	0	1	TC group, Probe 1
0	1	1	0	$\Delta T_{21}L$	1	1	1	0	T_{ref}
0	1	1	1	$\Delta T_{22}L$	1	1	1	1	TC group, Probe 2

Key to Measurement Name

The first subscript refers to the probe (probe 1 or probe 2), the second refers to the probe section (upper or lower, respectively)

$\Delta T_{ij}H$ = Bridge measurement of probe temperature gradient, high sensitivity.

$\Delta T_{ij}L$ = Bridge measurement of probe temperature gradient, low sensitivity.

T_{ij} = Total bridge resistance measurement of ambient temperature.

TC group = Thermocouple measurements of probe cable ambient temperature, 4 measurements per probe.

T ref = Bridge measurement of the temperature of the thermocouple reference junction.

TABLE 12

HFE ANALOG (ENGINEERING) MEASUREMENTS
(ALSEP Word 33)

Symbol	Data	Frame	Range	Accuracy	Bits/ Sample	Samples/ Sec
AH-1	Supply Voltage #1	29	0-160 (octal)	5% full scale	8	.0185
AH-2	Supply Voltage #2	45	0-160 (octal)	5% full scale	8	.0185
AH-3	Supply Voltage #3	55	0-160 (octal)	5% full scale	8	.0185
AH-4	Supply Voltage #4	74	0-160 (octal)	5% full scale	8	.0185
AH-5	Spare				8	.0185
AH-6	Low Conductivity Heater Power Status	57	2.0-2.5 volts ON Otherwise OFF		8	.0185
AH-7	High Conductivity Heater Power Status	75	2.0-2.5 volts ON Otherwise OFF		8	.0185

TABLE 13

SOLAR WIND SPECTROMETER (SWS) MEASUREMENTS

Note: The SWS uses ALSEP Words 7, 23, 39 and 55 (in that order) to convey experiment data. The data is organized into 16 sequences of 186 words per sequence. Since the position of any element of data (Word) is indeterminate with respect to ALSEP Frames and Words, the channel designation is determined internally from information carried in the data. Therefore, in the following data, channel designation is not used but the data is identified by the SWS Word and by the first two bits (FB) which have been provided for Word identification within the sequence; and the sequence is identified by the Least Significant Bits (LSB) of Word 184 lying in the sequence being identified.

<u>Basic Sequence</u>, Repeated 16 times per cycle