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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CSM/LM SPACECRAFT OPERATIONAL DATA BOOK

VOLUME V

ALSEP DATA BOOK

APPENDIX F

APOLLO 17 ALSEP ARRAY E AND LUNAR SURFACE EXPERIMENTS

OCTOBER 1972

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

DATA CHANGE NOTIFICATION FORM
CSM/LM SPACECRAFT OPERATIONAL DATA BOOK

SNA-8-D-027

VOLUME V PART ____

DATE October 17, 1972

PAGE 1 OF 262

AMENDMENT 13

SHORT TITLE OF CHANGE Add APPENDIX F containing data pertaining to the Apollo 17 Lunar Surface experiments.

CHANGE DESCRIPTION

Complete new Appendix F for the following lunar surface experiments:

Apollo 17 ALSEP Array E:

a. Heat Flow
b. Lunar Surface Gravimeter
c. Lunar Seismic Profiling
d. Lunar Atmospheric Composition
e. Lunar Ejecta and Meteorite

Non-ALSEP:

a. Surface Electrical Properties
b. Traverse Gravimeter
c. Lunar Neutron Probe
d. Cosmic Ray Detector

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APPROVAL

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Lunar Experiments Project Office
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DATE 10/18/72

VOLUME V

REVISIONS

REV.	AMEND. NO.	DESCRIPTION	DATE	APPROVAL
	1	Insert revised pages 3-11, 3-12, 3-13, 3-14, 3-16, 3-22, 3-24, 3-30, 3-34, 3-37, 3-46, 3-47, 3-48, 3-49, 3-54, 3-55, 3-56 4-4, 4-6, 4-8, 4-10, 4-11, 4-13, 4-17, 4-19, 4-21, 5-3, 5-4, 5-8, 5-9, 5-10, 5-13	10/1/69	SED
	2	Insert revised pages 3-7, 3-28 and 4-8	11/7/69	SED
	3	Insert complete, new Appendix B for ALSEP Array "B". 96 Pages plus tabs.	1/15/70	SED
	4	Insert revised pages B-3-34, B-3-35 and B-3-43. Insert newly added Apollo Lunar Surface Drill pages B-3-40.1 through B-3-40.6 and B-4-16.1	3/20/70	SED
	5	Add Appendix C for ALSEP Array "C"	11/13/70	MOB
	6	Insert revised pages C-i, C-ii, C-3-2, C-3-5, C-3-6, C-3-7, C-3-21, C-3-22, C-3-23, C-3-33, C-4-4.1, C-4-5.1, C-4-12, C-4-14.1, C-4-16.1, C-4-18.1, C-4-20.1, C-4-22.1, C-4-24.1, C-5-11	1/15/71	MOB

VOLUME V

REVISIONS

REV.	AMEND. NO.	DESCRIPTION	DATE	APPROVAL
	7	Insert revised pages C-3-41, C-3-52, C-4-19, C-4-20, C-5-11, C-5-12, C-5-13	1/25/71	MOB
	8	Add Appendix D for Apollo 15 ALSEP, Array A-2	6/1/71	OAB
	9	Insert new or revised pages D-2-4, D-2-15, D-3-24, D-3-26, D-3-28, D-3-29, D-3-30, D-3-31 D-3-32, D-3-33, D-3-34, D-3-34.1, D-3-35, D-3-36, D-3-37, D-3-74, D-3-77, D-3-78, D-3-82, D-3-83, D-3-84, D-3-84.1, D-3-86.1, D-3-86.2, D-4-1, D-4-3, D-4-3.1, D-4-13, D-5-8, D-5-22, and D-5-24.	7/21/71	OAB
	10	Add Appendix E for Apollo 16 ALSEP Array D	3/8/72	OAB
	11	Insert revised pages E-2-10, E-3-16, E-3-17; add new page E-4-17.1	3/24/72	OAB
	12	Insert revised page E-3-21.2	4/1/72	OAB
	13	Add APPENDIX F for Apollo 17 Lunar Surface Experiments	10/17/72	OAB

CSM/LM SPACECRAFT OPERATIONAL DATA BOOK

VOLUME V

ALSEP DATA BOOK

APPENDIX F

APOLLO 17 LUNAR SURFACE EXPERIMENTS

INCLUDING

APOLLO 17 ALSEP ARRAY E

Prepared by
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Manned Spacecraft Center
Houston, Texas

APOLLO 17 LUNAR SURFACE EXPERIMENTS

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TABLES

TABLES (Concluded)

SECTION 1

INTRODUCTION

1.1 PURPOSE

The Apollo Lunar Surface Experiments Package (ALSEP) Data Book Appendix F presents parametric data defining the operational capabilities and limitations of the Apollo 17 lunar surface experiments, including Apollo 17 ALSEP Array E and its constituent subsystems. The information is intended for use in mission planning, support studies and real-time missions operations. It is planned that these lunar surface experiments will be deployed on Apollo Mission 17.

1.2 CONTENT

The complete CSM/LM Spacecraft Operational Data Book consists of seven separate volumes, defined as follows:

Volume I	CSM Data Book
Volume II	LM Data Book
Volume III	Mass Properties Data Book
Volume IV	EMU Data Book
Volume V	Lunar Surface Experiments Data Book
Volume VI	CSM Experiments Data Book
Volume VII	LCRU/GCTA Data Book

This Appendix F to Volume V is divided into sections pertaining to Apollo 17 ALSEP Array E and the other lunar surface experiments to be deployed on the lunar surface at the Taurus-Littrow site.

1.3 ABBREVIATIONS AND ACRONYMS

ALHT	Apollo Lunar Hand Tools
ALSD	Apollo Lunar Surface Drill
ALSEP	Apollo Lunar Surface Experiments Package
APM	Automatic Power Management
CMD	Octal Command Number
CS	Central Station
EP	Explosive Package
EVA	Extravehicular Activity
HFE	Heat Flow Experiment
LACE	Lunar Atmospheric Composition Experiment (see LMS)
LEAM	Lunar Ejecta and Meteorite Experiment
LM	Lunar Module
LMS	Lunar Mass Spectrometer (see LACE)
LNPE	Lunar Neutron Probe Experiment
LRL	Lunar Receiving Laboratory
LRV	Lunar Roving Vehicle
LSG	Lunar Surface Gravimeter
LSPE	Lunar Seismic Profiling Experiment
MCC	Mission Control Center
MESA	Modularized Equipment Stowage Assembly
MSFN	Manned Space Flight Network
MUX	Multiplexer
PCU	Power Conditioning Unit
PDR	Power Dissipation Resistor
PDU	Power Distribution Unit
PI	Principal Investigator
PLSS	Portable Life Support System
RTG	Radioisotope Thermoelectric Generator
SEQ	Scientific Equipment Bay in LM
SEP	Surface Electrical Properties
STDN	Spacecraft Tracking and Data Network
TGE	Traverse Gravimeter Experiment
TM	Telemetry
UHT	Universal Handling Tool

NOTE: The terms Lunar Atmospheric Composition Experiment (LACE) and Lunar Mass Spectrometer (LMS) are used interchangeably to define NASA Exp. No. S-205.

SECTION 2

EXPERIMENTS SUMMARY

2.1 EQUIPMENT COMPOSITION

The Apollo 17 lunar surface experiments include the five Apollo 17 ALSEP Array E experiments plus four non-ALSEP experiments. The ALSEP Array E includes a Central Station and a Radioisotope Thermoelectric Generator (RTG). Because of extensive design changes, the Array E Central Station is considerably different from the design used in previous ALSEP arrays. Each experiment and Principal Investigator is listed in Table 2-1.

The identification numbers of the major ALSEP experiment components are provided in Table 2-2, and the physical characteristics of the ALSEP Array E system are given in Table 2-3.

TABLE 2-1. APOLLO 17 LUNAR SURFACE SCIENCE EXPERIMENTS

ALSEP EXPERIMENTS	PRINCIPAL INVESTIGATOR
Heat Flow Experiment (HFE) NASA Exp. No. S-037	Dr. Marcus G. Langseth Lamont-Doherty Geological Observatory
Lunar Surface Gravimeter (LSG) NASA Exp. No. S-207	Dr. Joseph Weber University of Maryland
Lunar Seismic Profiling Exp. (LSPE) NASA Exp. No. S-203	Dr. Robert L. Kovach Stanford University
Lunar Atmospheric Composition Experiment (LACE) NASA Exp. No. S-205	Dr. John H. Hoffman University of Texas at Dallas
Lunar Ejecta and Meteorite Experiment (LEAM) NASA Exp. No. S-202	Mr. Otto E. Berg Goddard Space Flight Center
NON-ALSEP EXPERIMENTS	**PRINCIPAL INVESTIGATOR**
Surface Electrical Properties (SEP) NASA Exp. No. S-204	Dr. M. Gene Simmons Massachusetts Institute of Technology
Traverse Gravimeter Experiment (TGE) NASA Exp. No. S-199	Dr. Manik Talwani Lamont-Doherty Geological Observatory
Lunar Neutron Probe Experiment (LNPE) NASA Exp. No. S-229	Dr. Donald R. Burnett California Institute of Technology
Cosmic Ray Detector Experiment NASA Exp. No. S-152	Dr. Robert M. Walker Washington University St. Louis, Missouri

TABLE 2-2. MAJOR COMPONENTS OF APOLLO 17 ALSEP ARRAY E

MAJOR COMPONENTS	PART NO.	SERIAL NO.
Lunar Mass Spectrometer	2347400	7
Lunar Ejecta and Meteorites	2347700	3
Heat Flow Experiment	2345430-102	7
Lunar Surface Gravimeter	2345856	3
Lunar Seismic Profiling		
- Expl. Packages	2348550	-
- Geophones	2348321	3
Fuel Capsule	47D300400GI	6330008
Fuel Cask	47E301134	6406007
Fuel Cask Mounting	2338660	11
Radioisotope Thermoelectric Generator	47E300779	6320014
Central Station		
- LSP Electronics	2347800	3
- Central Electronics	2362900	11
- Antenna	2330307	15
- Antenna Aiming Mechanism	2367400	13

TABLE 2-3. ALSEP ARRAY E PHYSICAL CHARACTERISTICS

SUBPACKAGE NO. 1	
Dimensions:	25.2" x 27.1" x 21.6"
Weight:	137.11 pounds
SUBPACKAGE NO. 2	
Dimensions:	25.2" x 27.2" x 21.6"
Weight:	99.83 pounds
LSPE EXPLOSIVE PACKAGES ON TWO TRANSPORT MODULES	41.24 pounds
EQUIPMENT EXTERNAL TO LM	
RTG Fuel Capsule, Cask and Mounting - Weight:	54.28 pounds
TOTAL ALSEP WEIGHT LESS LSPE EXPLOSIVE PACKAGE TRANSPORT MODULE	291.22 pounds
TOTAL WEIGHT	332.46 pounds

2.2 LUNAR SURFACE EXPERIMENTS STOWAGE

The lunar surface experiments are carried to the moon stowed in the ascent and descent stages of the Lunar Module. The ALSEP is packaged and stowed in the Quad II Scientific Equipment Bay. The radioisotope fuel capsule for the radioisotope thermoelectric generator is stowed in a special fuel cask mounted externally on the LM. The Surface Electrical Properties experiment and the Traverse Gravimeter are stowed in Quad III together with the two transport modules containing the eight explosive packages which are part of the Lunar Seismic Profiling experiment. The Lunar Neutron Probe is stowed in the Modularized Equipment Stowage Assembly in Quad IV. The Cosmic Ray Detector is stowed in the ascent stage of the LM. See Figures 2-1, 2-2, and 2-3.

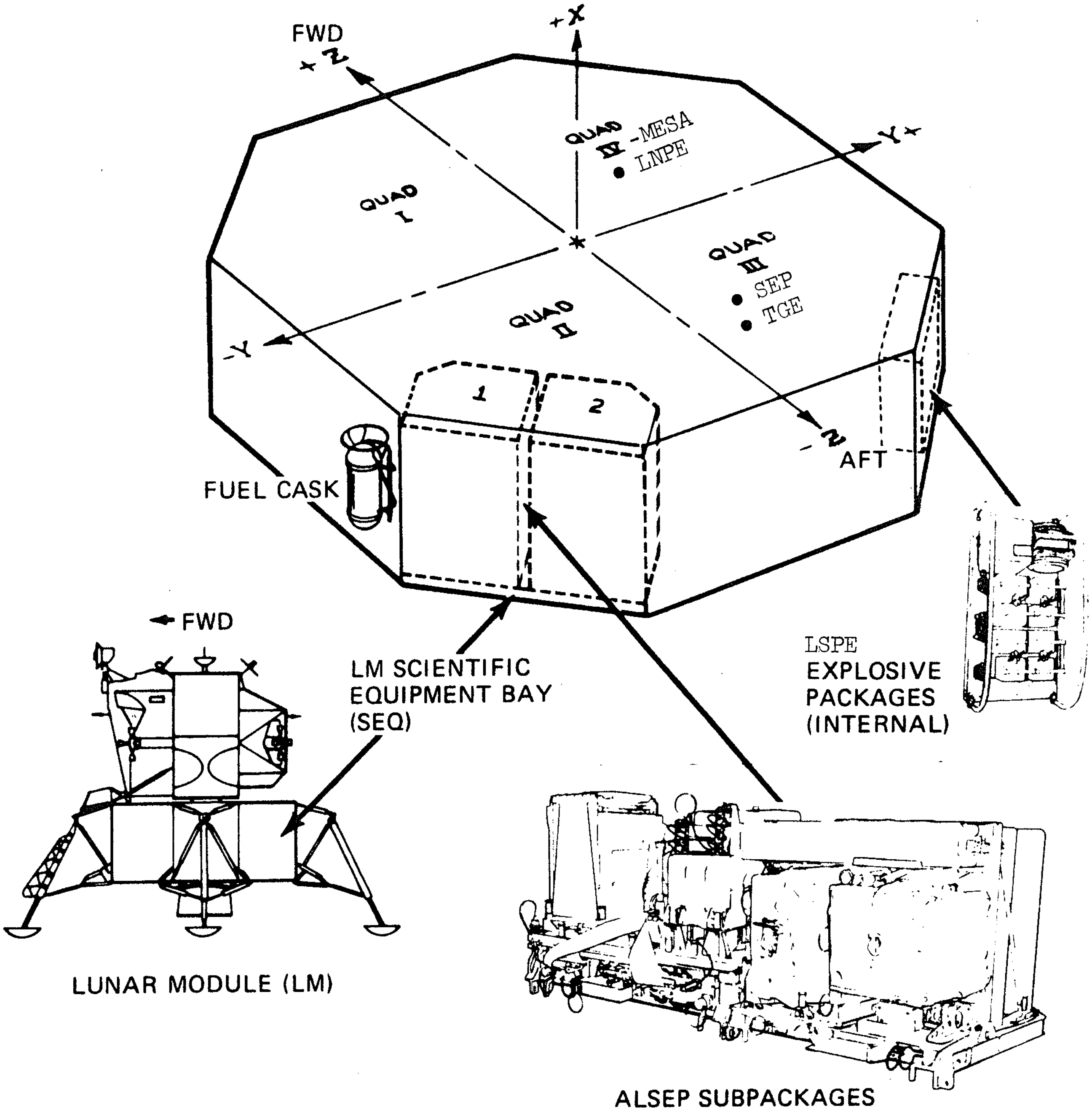


Figure 2-1. ALSEP Array E Stowage in Lunar Module

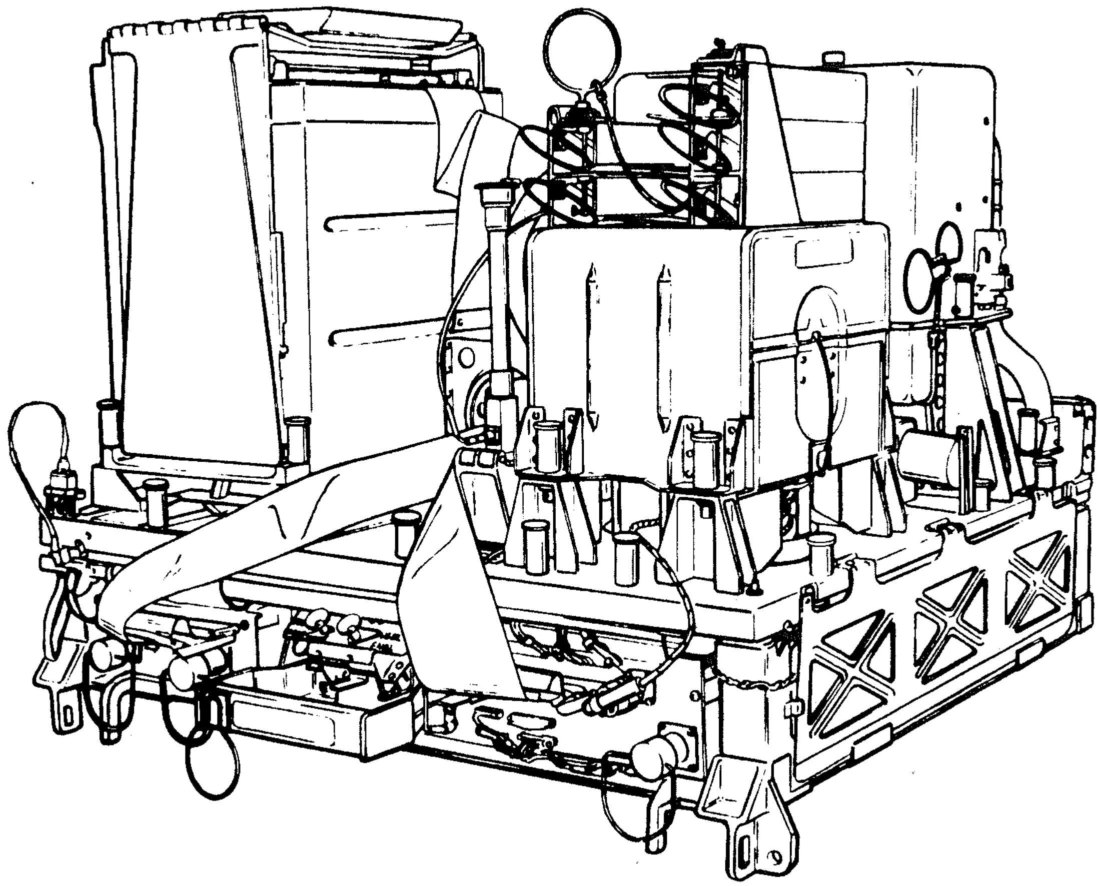


Figure 2-2. ALSEP Array E - Subpackage 1

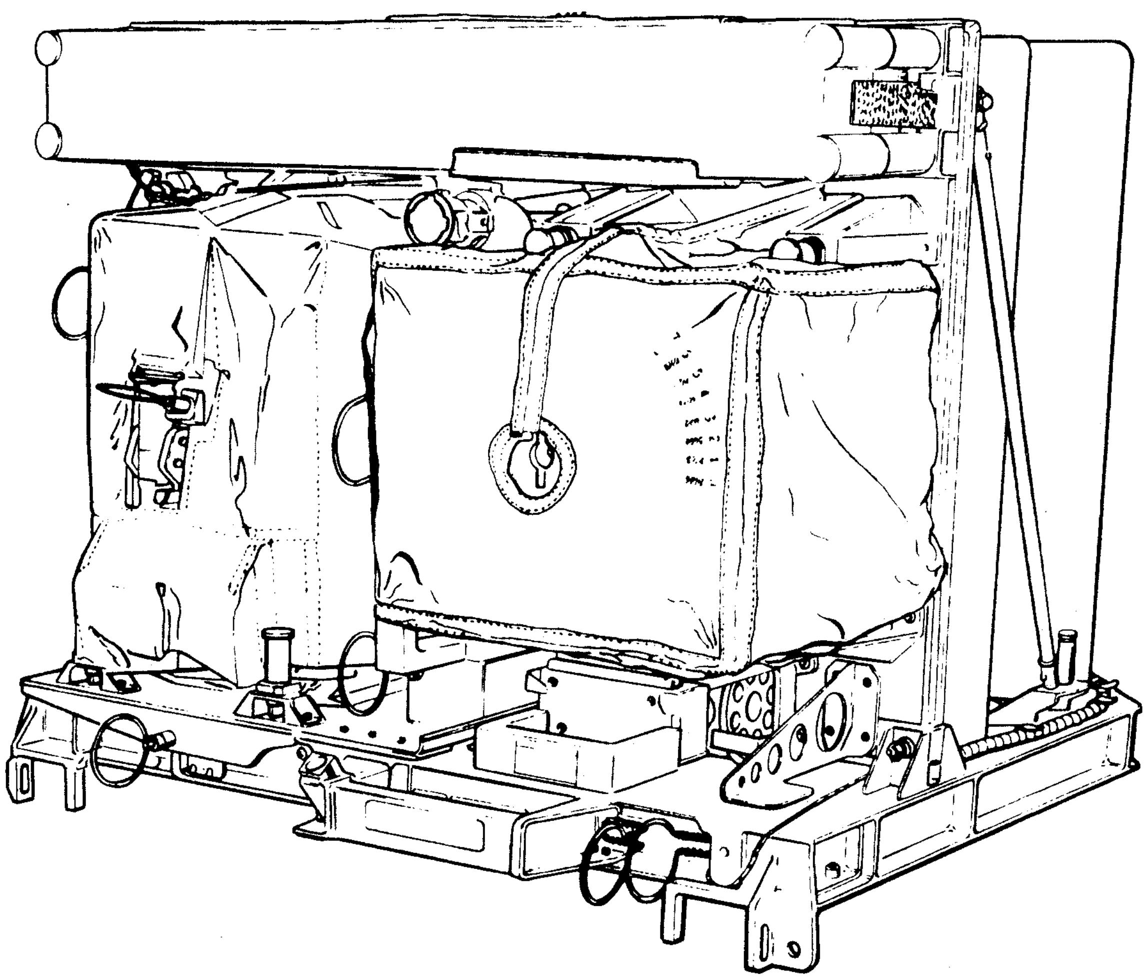


Figure 2-3. ALSEP Array E - Subpackage 2

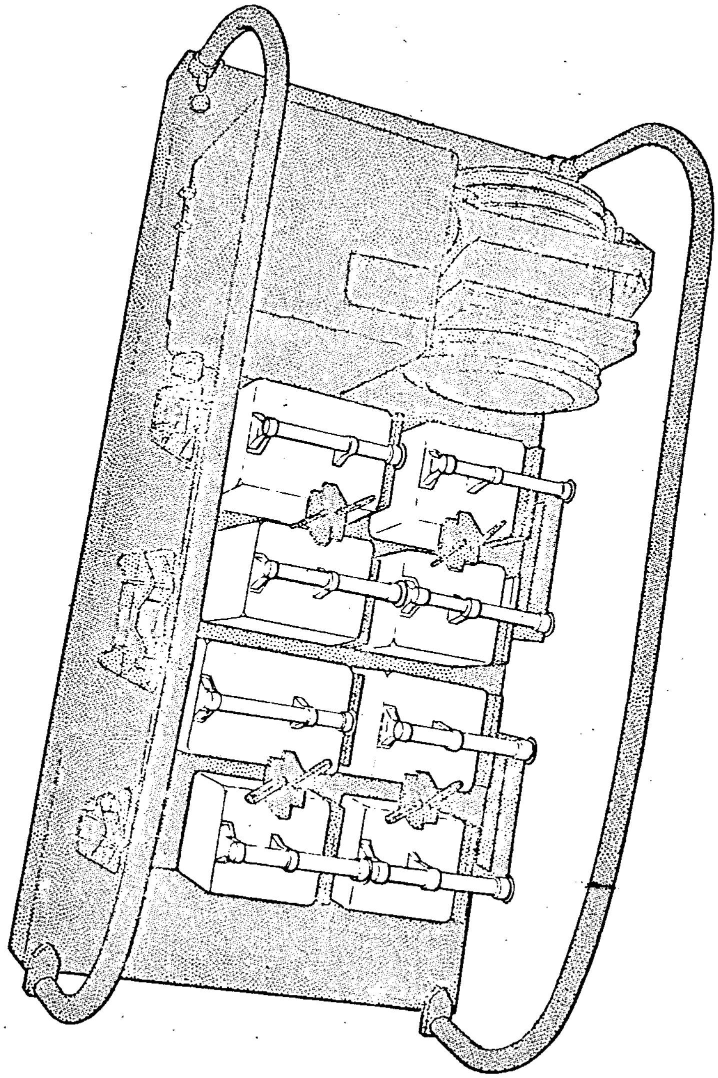


Figure 2-4. LSPE Transport Modules - Stowed Configuration

2.3 LUNAR SURFACE EXPERIMENTS DEPLOYED CONFIGURATION

At the Apollo 17 landing site, Taurus-Littrow, the Commander and LM Pilot will remove the lunar surface experiments from their stowage compartments in the LM and deploy them on the lunar surface. (See Figures 2-4 and 2-5.) Detailed deployment criteria and illustrations are given in the individual sections for each experiment.

Given a normal Apollo 17 mission timeline, the approximate ALSEP deployment time will be December 12, 1972, at 0100 GMT.

The performance of each experiment is strongly dependent on its deployed configuration and location. The following sections identify normal deployment of each major item and the indicators provided to assist the crew in validating proper deployment. This information is contingent upon deployment of the Apollo 17 lunar surface experiments at Taurus-Littrow and is subject to review if another deployment site is used.

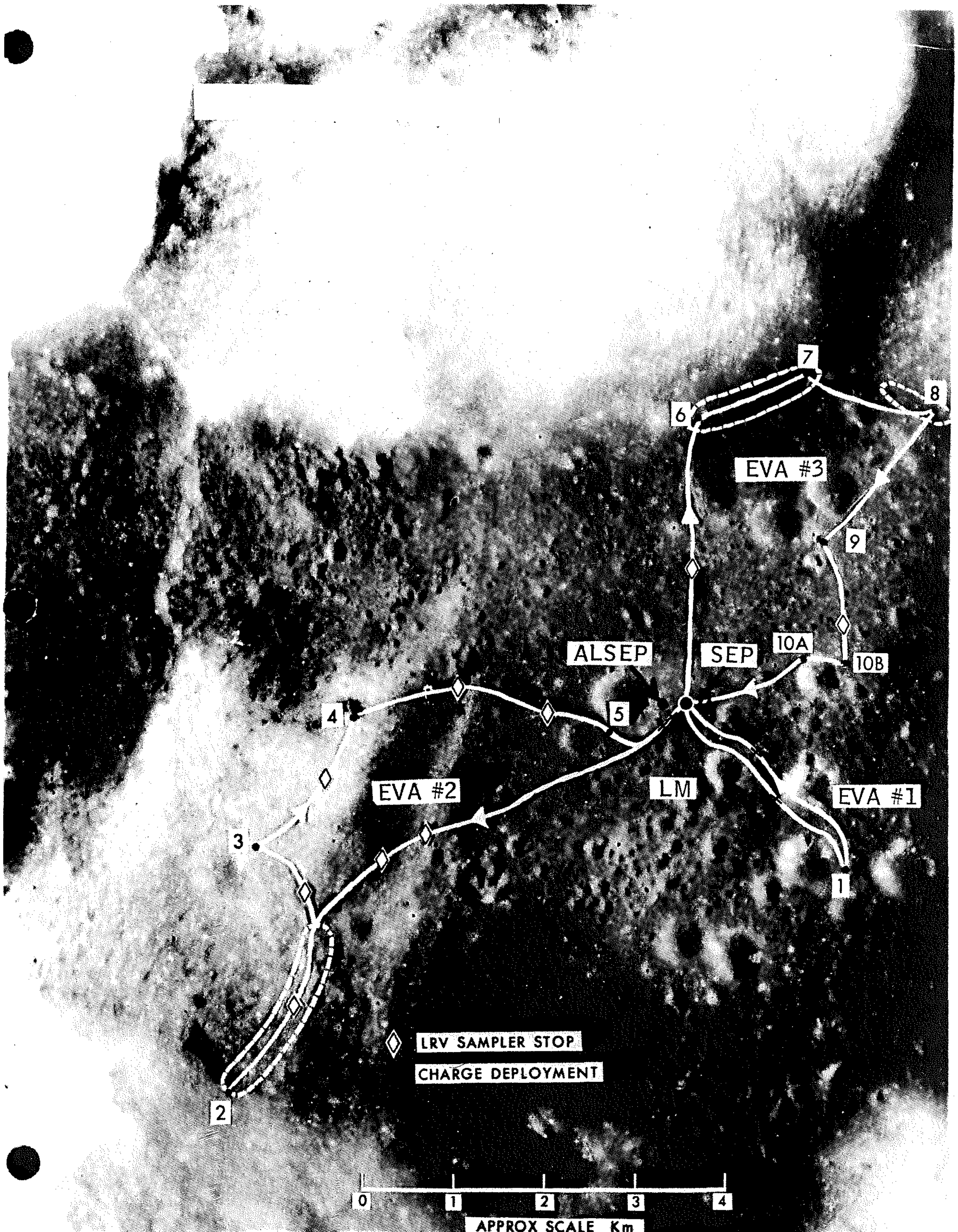


Figure 2-5. Apollo 17 Taurus-Littrow Site Plans

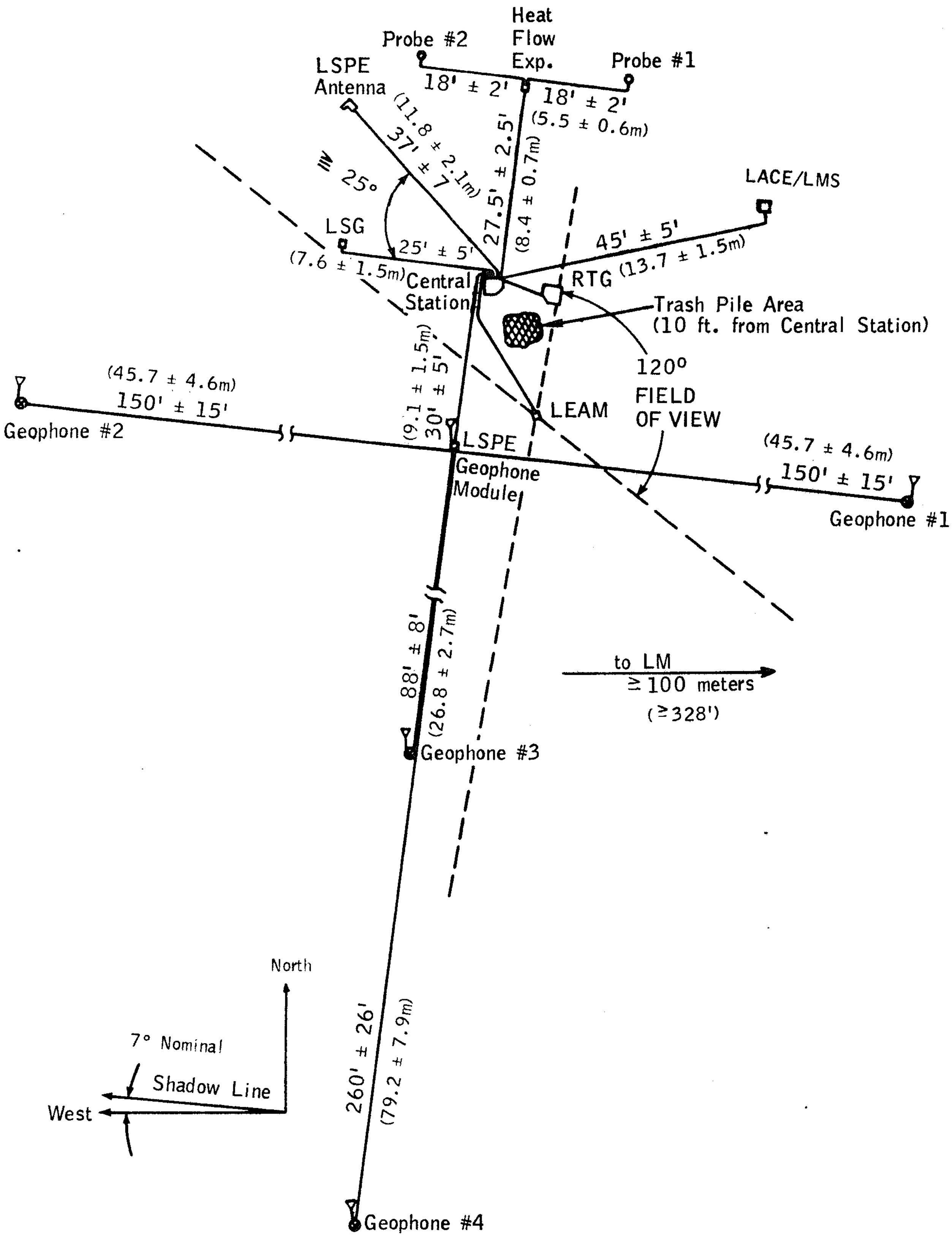


Figure 2-6. Apollo 17 ALSEP Array E Normal Deployment Arrangement

2.4 LUNAR SURFACE EXPERIMENTS OPERATIONAL DATA

In the individual experiment sections of this document is presented information on normal operation and normal ranges of the measured parameters; operational constraints and limitations on the manner in which the experiments can be successfully deployed and operated; and telemetered uplink commands pertaining only to the ALSEP experiments.

SECTION 3.0 APOLLO 17 ALSEP CENTRAL STATION

3.1 CENTRAL STATION DEPLOYMENT CRITERIA

TABLE 3-1. CENTRAL STATION DEPLOYMENT CRITERIA

PARAMETER	CRITERIA
Central Station Site	ALSEP deployment site should be a minimum of 100 meters west of LM with the carry handle side of Central Station facing north. ALSEP deployment area should be in direct sunlight and generally level, free from craters, boulders, and debris which might restrict view of space seen by thermal control surfaces. Central Station radiator requires clear field-of-view for good thermal control. See Figure 3-1. Subpackage #2, which includes the RTG, should be positioned 9 to 12 feet east of Central Station.
Leveling	While sun shield is still down in the stowed position, level unit within 5 degrees. When bubble is within the outer case circle of bubble level, the unit is properly tilted 7 degrees toward the south.
Alignment	Align Central Station within 5 degrees of the shadow line. Use the North partial compass rose. Align gnomon shadow with alignment decal. When aligned, open side of Central Station should face north. Because of the 7-degree tilt to the south, the gnomon shadow should fall on the 4.9-degree mark. Sun elevation angle should be 16 degrees and must be less than 45 degrees for proper use of the sun compass.
Precautions	After Central Station deployment, do not bump or twist the sun shield. Damage to the lifting springs may result. The thermal control of the Central Station electronic elements is contingent upon proper azimuth alignment relative to the sun. This alignment is indicated on the "N" compass rose on the sun shield (Figure 3-2) when the gnomon shadow covers the alignment mark (a decal to be added prior to flight) within 5 degrees. Since shadow line is a function of actual deployment time, the 7° shown on Figure 3-2 is normal for the predicted deployment time.

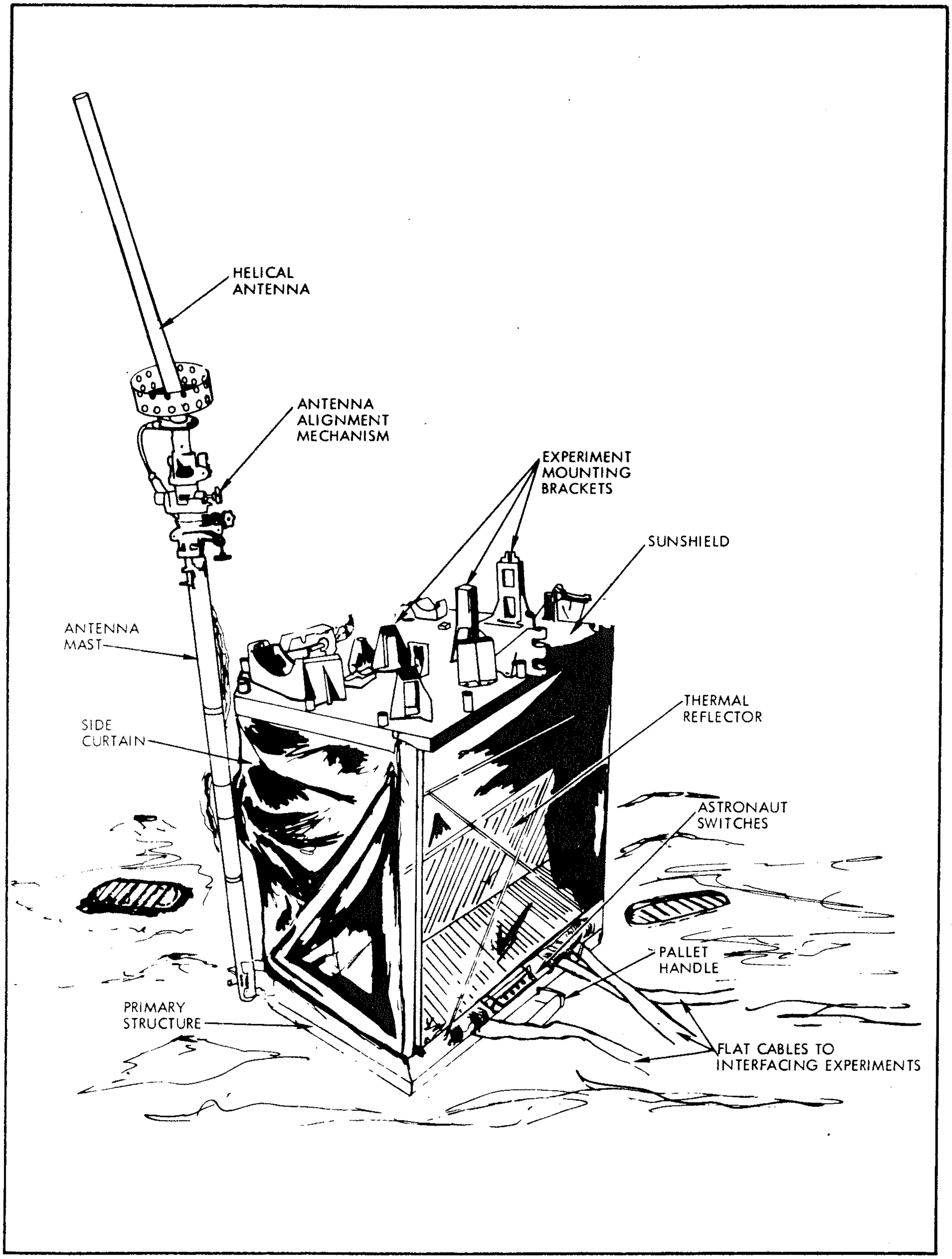
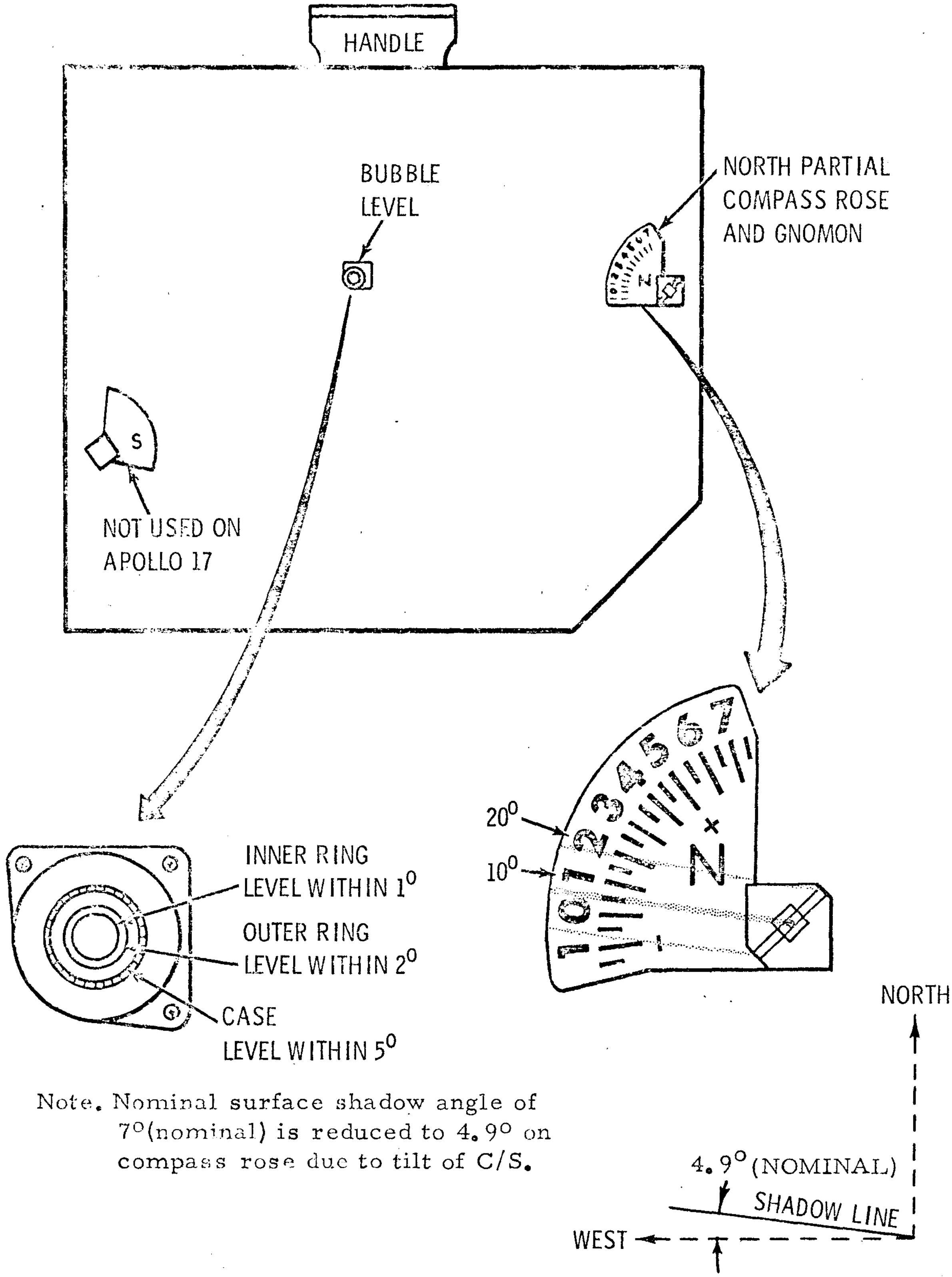


Figure 3-1. Apollo 17 ALSEP Array E Central Station



Note. Nominal surface shadow angle of 7°(nominal) is reduced to 4.9° on compass rose due to tilt of C/S.

Figure 3-2. Central Station Leveling and Alignment

TABLE 3-2. ALSEP CENTRAL STATION ANTENNA DEPLOYMENT CRITERIA

PARAMETER	CRITERIA
Antenna Emplacement	With the antenna mechanism still in stowage container, position the antenna aiming mechanism on the mast with the arrow pointed toward the sun. This will ensure that the latitude adjustment will tilt the antenna toward the equator. Verify that antenna is properly seated in Central Station fixture. See Figure 3-3.
Latitude Setting	The course latitude dial on the antenna aiming mechanism will be indicating approximately 2 when the mechanism is first mounted on the mast. The course dial is marked in increments of 10° while the fine dial is marked in increments of 1°. The crew will turn the latitude-setting knob (Figure 3-3) until, simultaneously (for latitude of 20.2°): (a) the index mark on the course scale reads 2 and (b) the index mark on the fine scale indicates 0.2 (between the marks at 0 and 0.5).
Longitude Setting	The course longitude dial will be indicating approximately 3 when the mechanism is first mounted on the mast. The coarse dial is marked in increments of 10° while the fine dial is marked in increments of 1°. The crew will turn the longitude-setting knob (Figure 3-3) until, simultaneously (for longitude of 30.8°): (a) the index mark on the course scale lies just past 3, and (b) the index mark on the fine scale indicates 0.8 (i.e., between the marks at 0.5 and 1).
Leveling	Level antenna within $\pm \frac{1}{2}$ degree as indicated by tubular bubble levels. Bubbles should be centered between scribe marks to be level within $\frac{1}{2}$ degree. See Figure 3-3.
Alignment	Align antenna with the sun line using the sun dial. When shadow of gnomon covers the shadow reference block, the antenna is aligned within $\pm \frac{1}{2}$ degree and generally pointed toward the earth. NOTE: Landing Site Coordinates for Taurus-Littrow are: Latitude 20.164° North Longitude 30.75° East

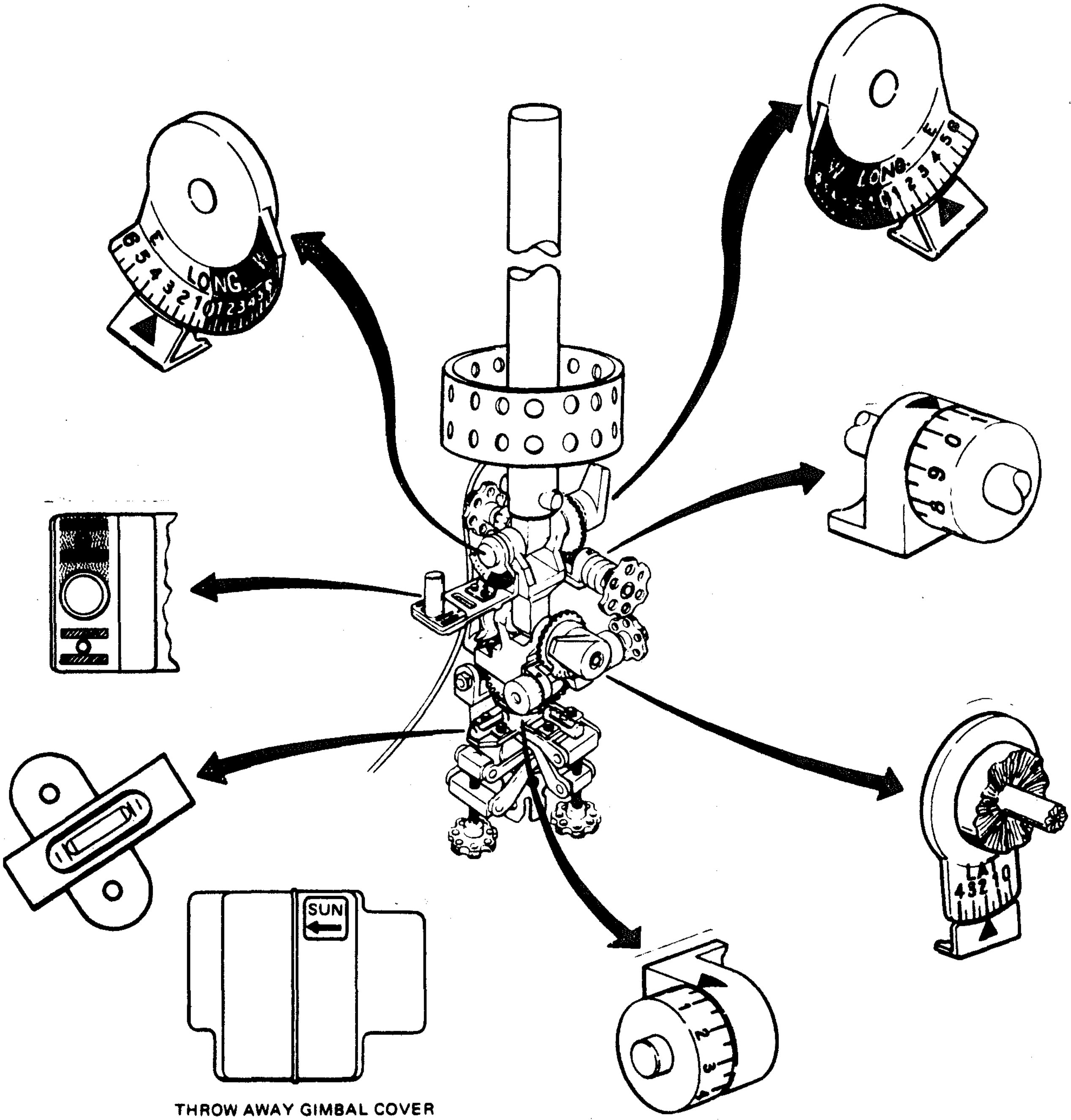
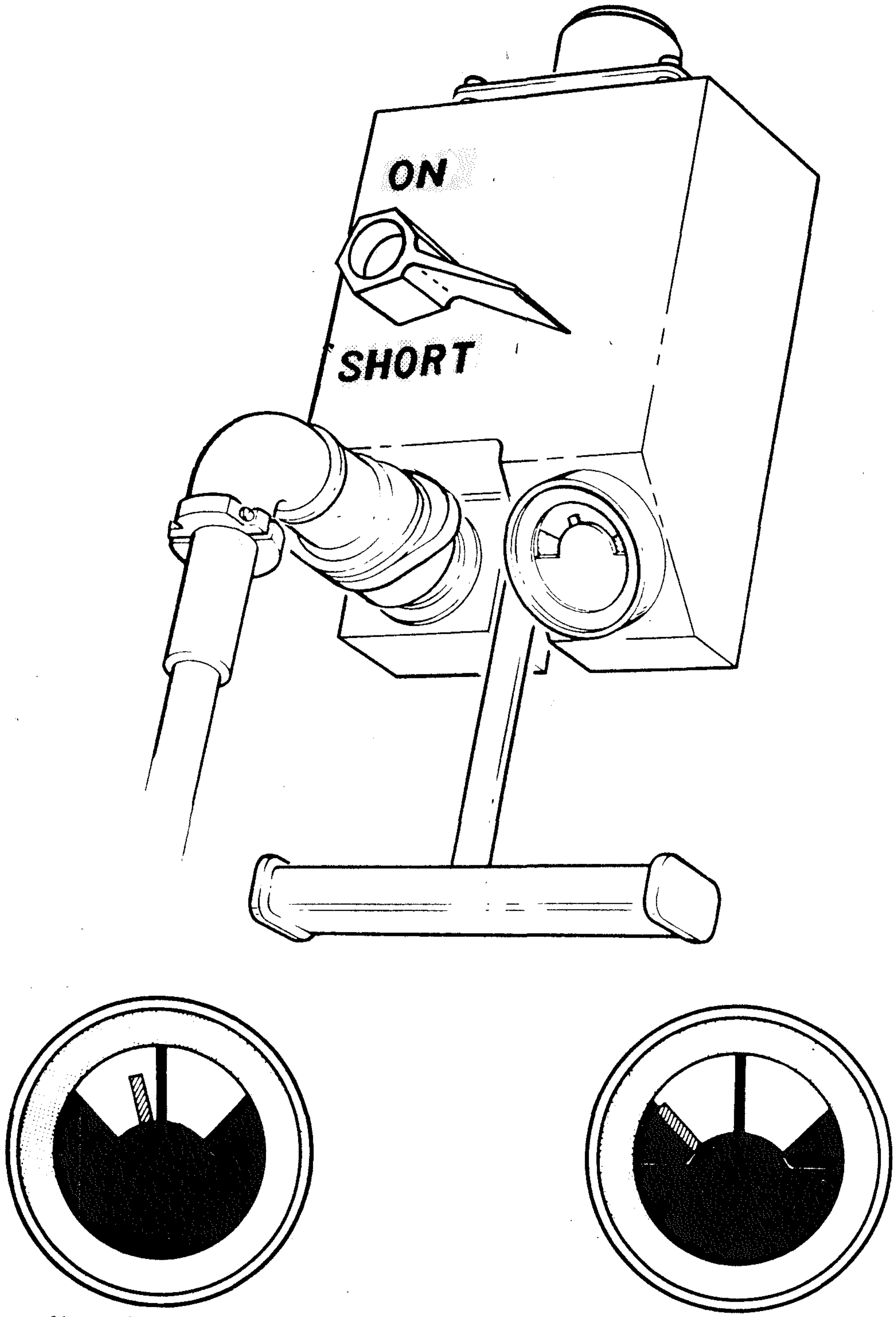


Figure 3-3. Apollo 17 ALSEP Antenna Alignment Settings

TABLE 3-3. RADIOISOTOPE THERMOELECTRIC GENERATOR DEPLOYMENT CRITERIA

PARAMETER	CRITERIA
RTG Emplacement	RTG (Subpackage #2) should be deployed 9 to 12 feet due east of Central Station. Separation is limited by 13-foot cable. Hot RTG should be separated from Central Station as far as possible to provide maximum heat radiation into free space and to provide safety factor for astronauts working around Central Station (Subpackage #1). No part of the RTG shall be within the field-of-view of the open (north) side of the Central Station.
Leveling	RTG pallet should be as level as possible, determined visually by astronaut, since there are no mechanical provisions for leveling. Avoid craters and slopes which would impede heat dissipation from RTG fins.
Alignment	Align Subpackage #2 so that the cable exit from the RTG points toward the Central Station. Use care to avoid damage to RTG fins.
RTG Shorting Switch	Before connecting the shorting switch box to the Central Station the astronaut will read the ammeter (see Figure 3-4) on that box to confirm a value greater than zero. After making this connection to the Central Station, the meter will be checked again for a reading greater than zero. A third reading of this ammeter will be taken later in the deployment after the shorting switch is actuated, to confirm zero meter deflection.



Normal Reading - RTG Short-Circuited

Normal Reading - RTG Short Removed

Figure 3-4. RTG Current Indicator

3.2 CENTRAL STATION OPERATIONAL DATA

3.2.1 Data Transmission Characteristics

The data provided by Array E is transmitted on a carrier having a nominal frequency of 2275.5 MHz. The quantitative values of the various parameters are provided in binary format by modulating the phase of this carrier. The rate at which data is normally provided is given in Table 3-4, together with the corresponding slow data rate (which is to be used only at those times when STDN has difficulty extracting the downlink data at normal data rate).

In the LSPE mode of operations a measurement of the output of each geophone is provided in each 30-bit data word. A complete set of engineering data is provided in each sequence of sixty such data words.

All other Array E measurements are provided in repetitive sequences of sixty-four 10-bit words as illustrated in Figure 3-5. The parameters represented in, or derived from these measurement words can be generally classified as shown in Table 3-5.

3.2.2 Normal Values of Operational Data

When operating in Normal (or Low) Data Rate Mode, sixty-nine engineering sensors provide information on 72 status and performance parameters of the Central Station and the Radioisotope Thermoelectric Generator (RTG). These can be classified as follows:

Central Station

- 10 structure temperatures (see Table 3-6)
- 21 module temperatures (see Table 3-7)
- 19 electrical parameters (see Table 3-9)
- 16 configuration status (see Table 3-10)

Radioisotope Thermoelectric Generator

- 6 temperatures (see Table 3-8)

Not included in the above list of parameters or in the discussion which follows are data on certain downlink characteristics available only on special request from the STDN receiving station, namely:

- received signal strength
- command verification word content
- specific value of downlink carrier frequency

The range of values expected for each Central Station measurement during normal lunar surface operations is given in Tables 3-6 through 3-10. When operating in the LSPE mode, six of these engineering measurements are selected for display. These parameters are listed in Table 3-12.

Normal operation, for purposes of this document, is considered to be that functional condition of a properly deployed system in which optimum data is being provided from each scientific experiment under the prevailing environmental conditions.

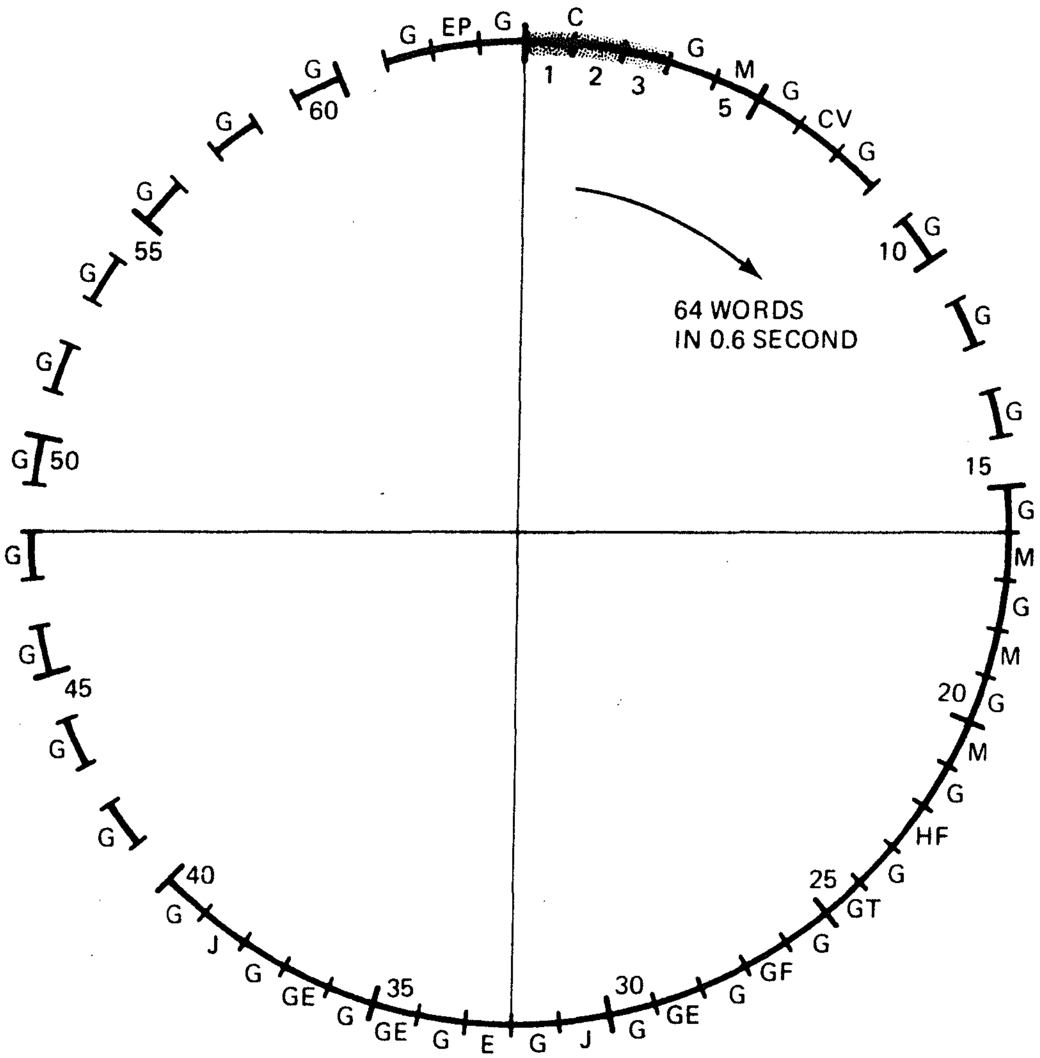
The criteria by which proper deployment is measured are identified in the Deployment Criteria tables. Similarly, a range of normal operation values for each engineering parameter is provided in each experiment section to identify proper performance of the system as seen through the telemetry link. This range of values has been derived by an engineering evaluation of pre-mission test program results and the performance of other experiments presently operating on the moon. Since the value of a science data parameter is, by nature, not predictable, only the measurement ranges of such parameters are listed where it is appropriate to instrument operation.

TABLE 3-4. ARRAY E DATA RATES

Data	Data Rate (Bits Per Second)	
	Normal	Low
LSP	3,533	1,060
ALL OTHER	1,060	530

TABLE 3-5. SUMMARY OF MEASURED PARAMETERS

EQUIPMENT	No. of Parameters Measured: SCIENCE	ENGINEERING	
LSPE OPERATING MODE			
LSPE	4	8	
CENTRAL STATION	-	6	
GENERAL OPERATING MODE		WORD 33	OTHER WORDS
LACE (LMS)	3	16	10
LEAM	29	11	2
HFE	64	6	4
LSG	3	10	10
LSPE	-	1	-
CENTRAL STATION (Incl. RTG)	-	72	5
ARRAY E	103	116	31



C	CONTROL	E	GENERAL ENGINEERING
G	LSG SEISMIC	EP	RESERVE POWER
M	LMS	GT	LSG TIDAL
J	LEAM	GF	LSG FREE MODE
CV	COMM VERIF	GE	LSG ENGINEERING
HF	HFE		

Figure 3-5. Word Assignments in General Mode Data Frame

TABLE 3-6.

STRUCTURAL TEMPERATURE DATA

Meas. No.	Frame	Description	Normal Oper. Range (°F)		Nominal (Fig. No.)	Limits - °F See Note 1	
			Low	High		Low	High
AT.01	27	Sunshield #1 (Top)	-300	+160	3-6	-350 (M)	+304 (M)
AT.02	42	Sunshield #2 (Underside)	-300	+160	3-6	-350 (M)	+304 (M)
AT.08	59	Vertical Structure #1 (Side #1) (East Side)	-225	+210	3-8	-350 (M)	+304 (M)
AT.09	87	Vertical Structure #2 (Side #2) (West Side)	-225	+210	3-8	-350 (M)	+304 (M)
AT.10	15	Bottom Structure	-225	+160	3-9	-350 (M)	+304 (M)
AT.11	88	External Power Module (PDM)	-245	+260	3-10	-350 (M)	+304 (M)
AT.12	60	Thermal Bag (Inner)	- 12	+115	3-7	-350 (M)	+304 (M)
AT.13	72	Thermal Bag (Outer)	-160	+150	3-8	-350 (M)	+304 (M)
AT.14	46	Front Structure (North)	-225	+180	3-9	-350 (M)	+304 (M)
AT.15	47	Rear Structure (South)	-225	+210	3-9	-350 (M)	+304 (M)

Note 1: Limits stated are Measurement limits (See Section 3.3.9) established for the Array E calibration curves as described in ATM 1095.

TABLE 3-7.

ELECTRONICS TEMPERATURE DATA

Meas. No.	Frame	Description	Normal Oper. Range (°F) Low	Normal Oper. Range (°F) High	Nominal (Fig. No.)	Limits - °F See Note 1 Low	Limits - °F See Note 1 High
AT.03	4	No. 1 Thermal Plate Temperatures	- 4	126	3-7	-10 (T) -40 (M)	+140 (T) +205 (M)
AT.04	28	No. 2 Thermal Plate Temperatures	4	129	3-7	-10 (T) -40 (M)	+140 (T) +205 (M)
AT.05	43	No. 3 Thermal Plate Temperatures	- 2	129	3-7	-10 (T) -40 (M)	+140 (T) +205 (M)
AT.06	58	No. 4 Thermal Plate Temperatures	12	140	3-7	-10 (T) -40 (M)	+145 (T) +205 (M)
AT.07	71	No. 5 Thermal Plate Temperatures	7	132	3-7	-10 (T) -40 (M)	+140 (T) +205 (M)
AT.31	48	Demodulator B (Note 2)	0	127	3-7	-10 (T) -40 (M)	+158 (T) +205 (M)
AT.49	49	Demodulator A (Note 2)	0	127	3-7	-10 (T) -40 (M)	+160 (T) +205 (M)

Note 1: Legend - (M) Measurement Limit, (T) Test Limit. See Section 3.3.9.
Note 2: Only the active section of the command decoder's demodulator provides valid measurements.

TABLE 3-7. (Continued)

ELECTRONICS TEMPERATURE DATA

Meas. No.	Frame	Description	Normal Oper. Range (°F)		Nominal (Fig. No.)	Limits - °F See Note 1	
			Low	High		Low	High
AT.23	18	Transmitter A, Power Ampl.(2)	+10	+140	3-7	-10 (T) -50 (M)	+158 (T) +190 (M)
AT.24	19	Transmitter A, Case (2)	+10	+140	3-7	-10 (T) -50 (M)	+158 (T) +190 (M)
AT.25	31	Transmitter B, Power Ampl.(2)	+10	+140	3-7	-10 (T) -50 (M)	+158 (T) +190 (M)
AT.26	32	Transmitter B, Case (2)	+10	+140	3-7	-10 (T) -50 (M)	+158 (T) +190 (M)
AT.27	33	Data Processor Base	0	+130	3-7	-10 (T) -40 (M)	+158 (T) +205 (M)
AT.28	34	Data Processor Internal	0	+150	3-7	-10 (T) -40 (M)	+170 (T) +205 (M)
AP.01	25	Electronics Internal Temperature (LSP)	+ 4	+129	3-7	-10 (T) -40 (M)	+158 (T) +190 (M)

Note 1: Legend - (M) Measurement Limit, (T) Test Limit. See Section 3.3.9.
Note 2: Only the active section provides valid measurements.

TABLE 3-7 (Concluded)

ELECTRONICS TEMPERATURE DATA

Meas. No.	Frame	Description	Normal Oper. Range (°F) Low	Normal Oper. Range (°F) High	Nominal (Fig. No.)	Limits - °F See Note 1 Low	Limits - °F See Note 1 High
AT.34	62	PDU #1	0	+130	3-7	-10 (T)	+158 (T)
						-40 (M)	+205 (M)
AT.35	63	PDU #2	+35	+155	3-7	-10 (T)	+160 (T)
						-40 (M)	+205 (M)
AT.38	77	PCU Regulator #1 (2)	+10	+180	3-7	-10 (T)	+190 (T)
						-40 (M)	+205 (M)
AT.39	78	PCU Regulator #2 (2)	+10	+180	3-7	-10 (T)	+190 (T)
						-40 (M)	+205 (M)
AT.40	16	Receiver Case (Uplink A only)	+ 5	+130	3-7	-10 (T)	+130 (T)
						-40 (M)	+195 (M)
AT.41	61	APM #1 (2)	+39	+109	3-7	-22 (T)	+158 (T)
						-40 (M)	+205 (M)
AT.42	64	APM #2 (2)	+39	+109	3-7	-22 (T)	+150 (T)
						-40 (M)	+205 (M)

Note 1: Legend - (M) Measurement Limit, (T) Test Limit. See Section 3.3.9.
Note 2: Only the active section provides valid measurements.

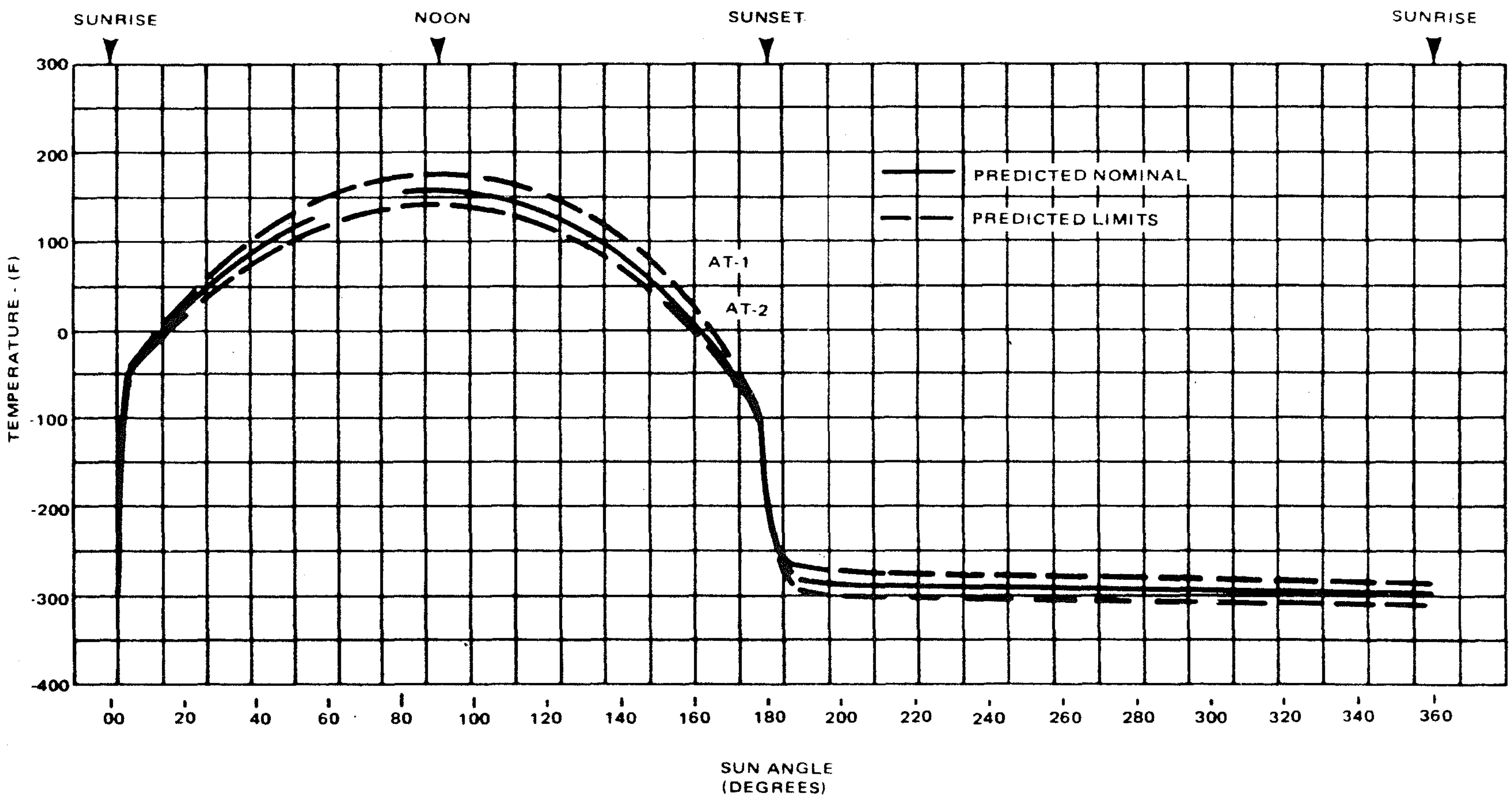


Figure 3-6. Normal Sunshield Temperatures

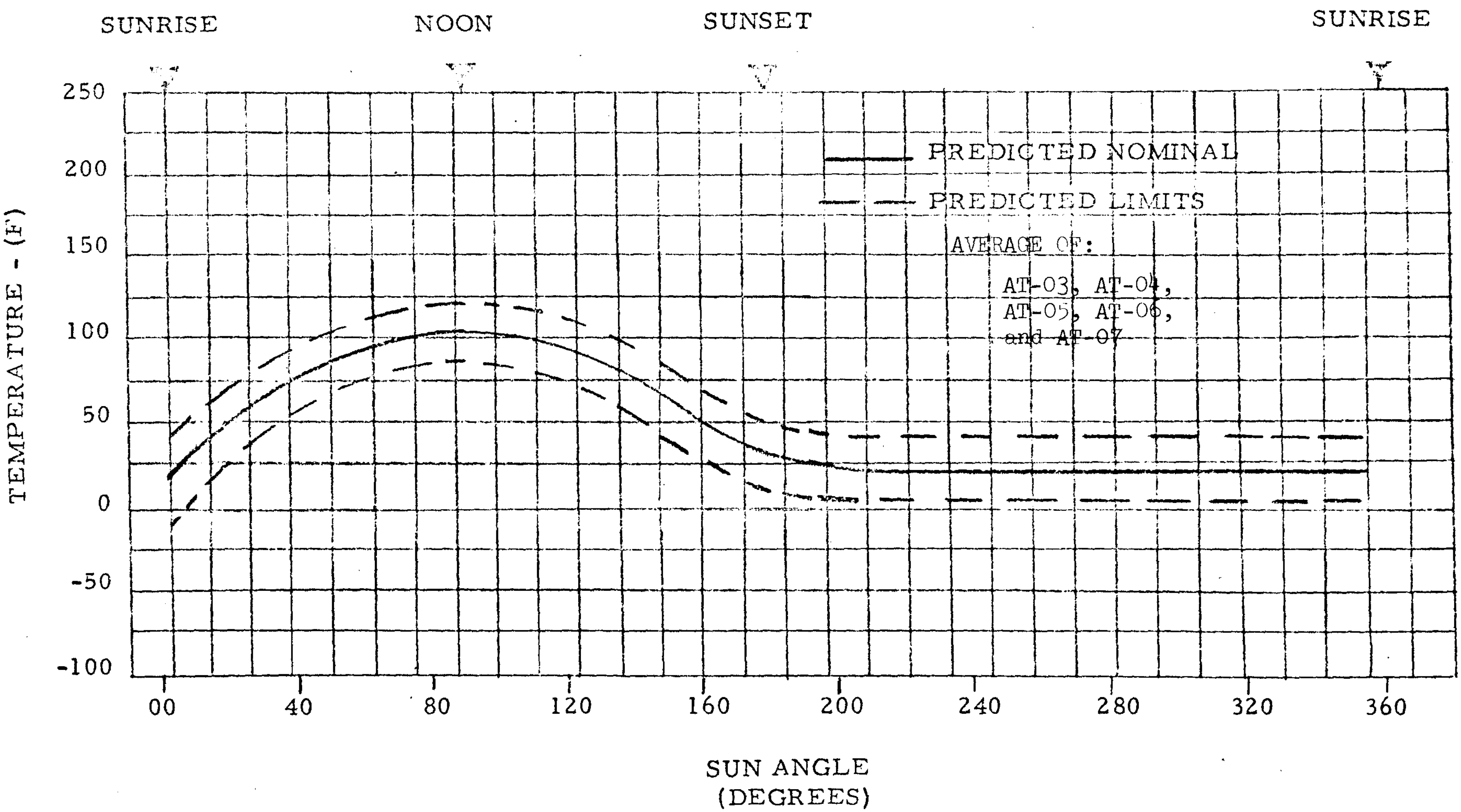


Figure 3-7. Normal Thermal Plate Average Temperatures

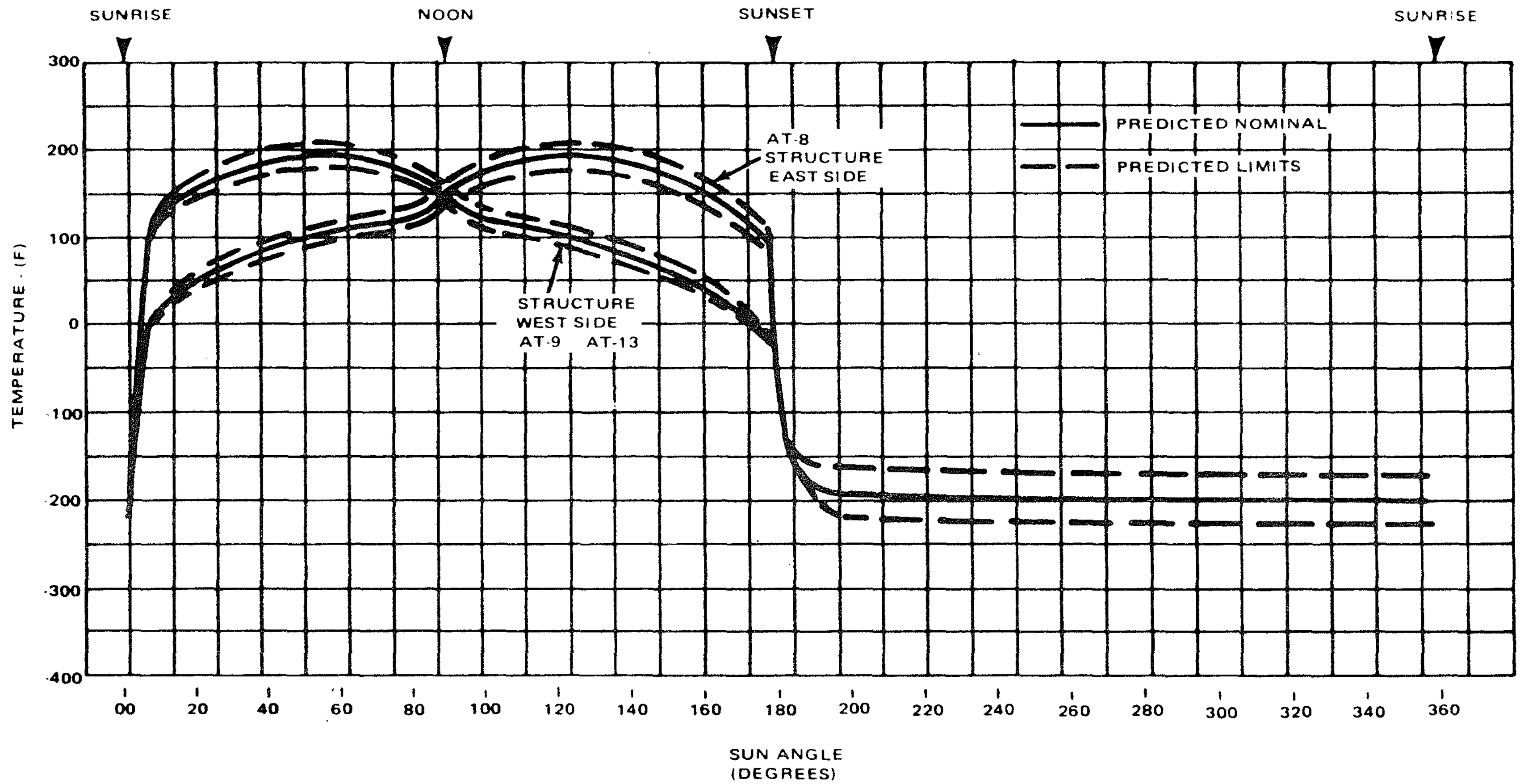


Figure 3-8 Normal Primary Structure Side Temperatures

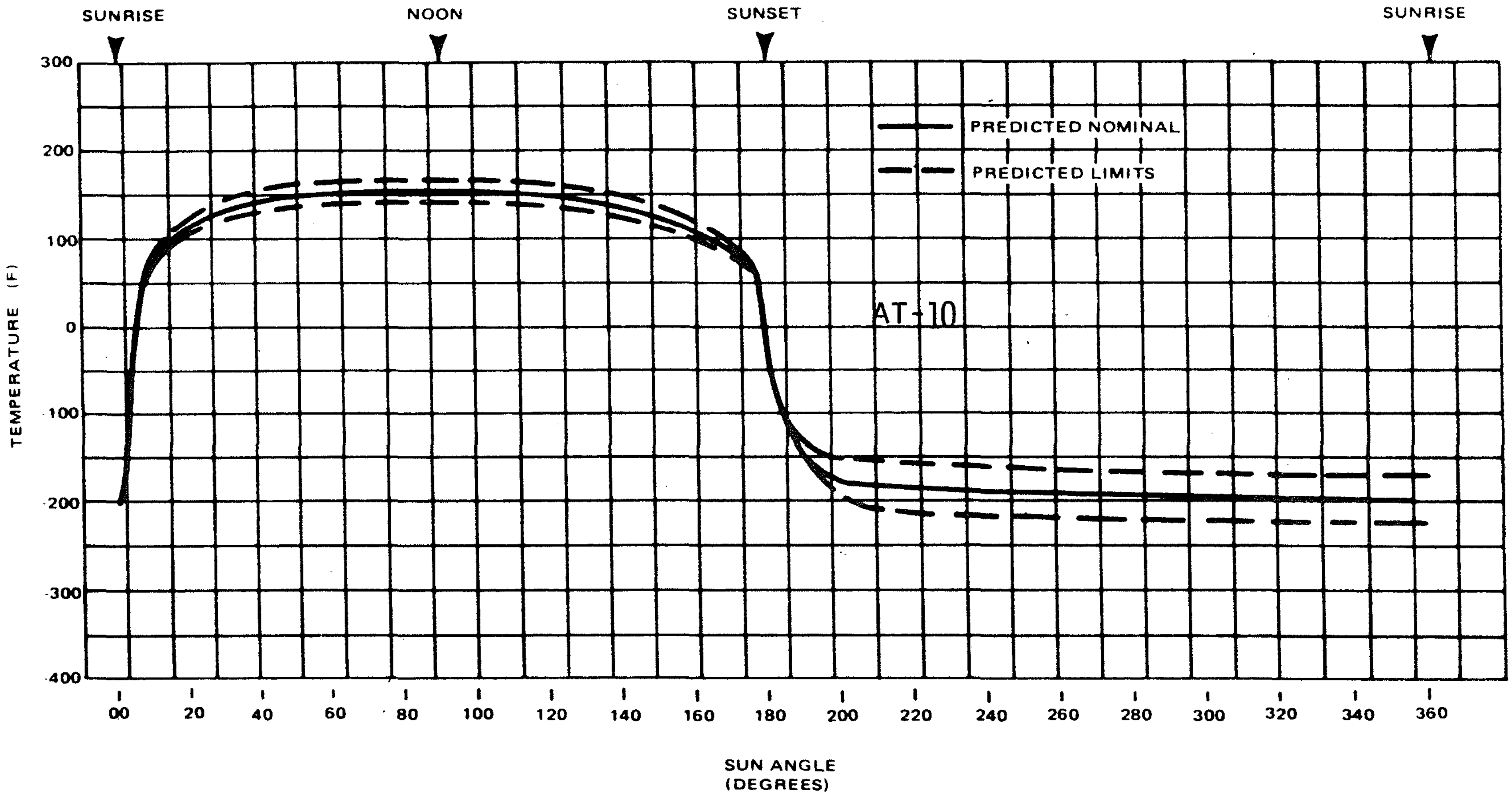


Figure 3-9. Normal Primary Structure Bottom Temperatures

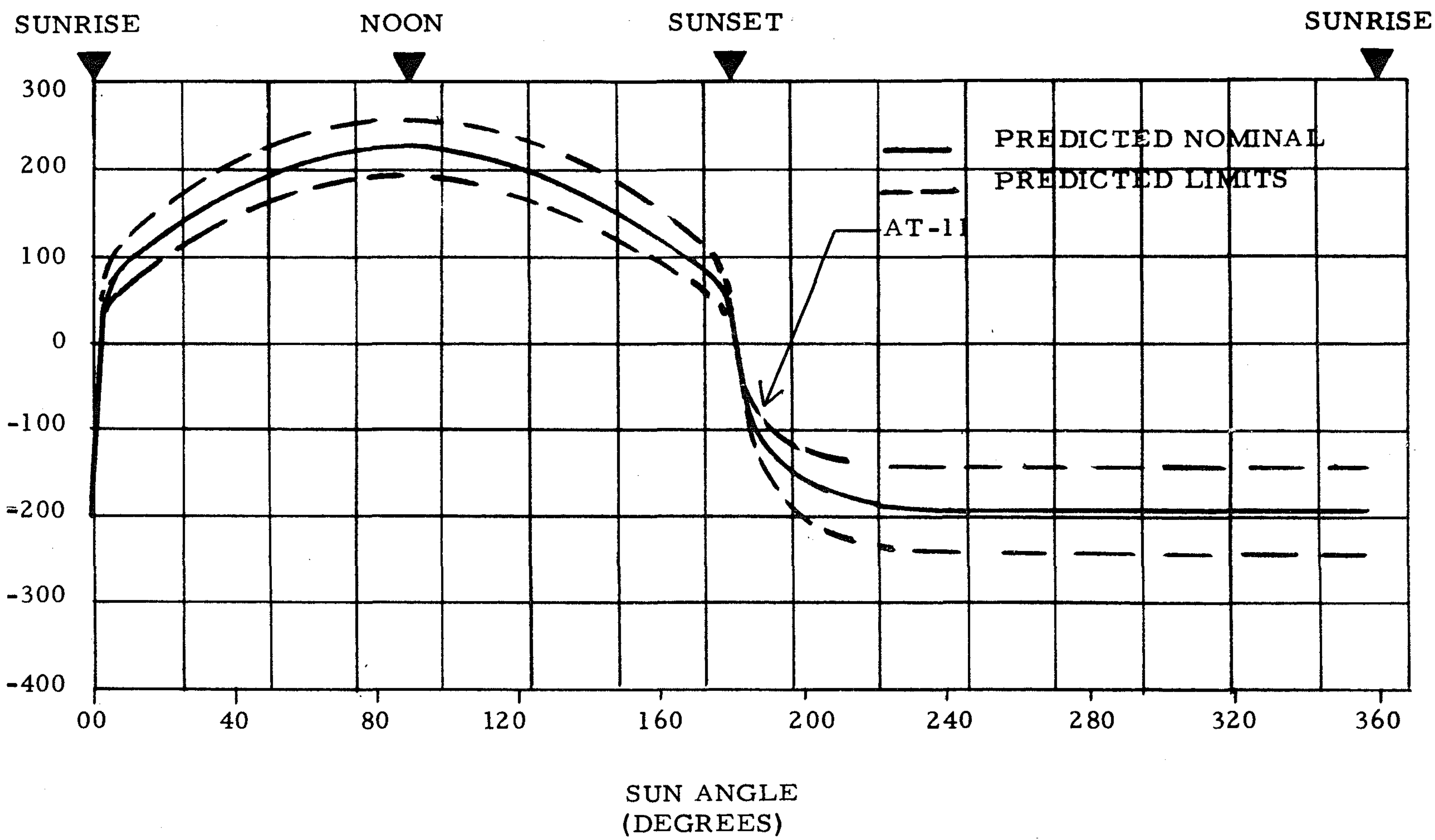


Figure 3-10. Normal PDM Temperatures

TABLE 3-8.

RTG TEMPERATURE DATA

Meas. No.	Frame	Description	Normal Oper. Range (°F)		Nominal (Fig. No.)	Limits - °F See Note 1	
			Low	High		Low	High
AR-01	6	Hot Frame #1, (°F)	1050	1150		958 (M)	1223 (M)
AR-02	37	Hot Frame #2, (°F)	1050	1150		962 (M)	1238 (M)
AR-03	52	Hot Frame #3, (°F)	1050	1150		969 (M)	1241 (M)
AR-04	7	Cold Frame #1, (°F)	-	-		Inoperative	
AR-05	67	Cold Frame #2, (°F)	370	510	(Intermittent)	330 (M)	569 (M)
AR-06	82	Cold Frame #3, (°F)	370	510		334 (M)	573 (M)
CS-43	-	AR.01 - AR.05			(AR-04 - Inoperative)		

Note 1: Limits stated are measurement limits. See Section 3.3.9.

TABLE 3-9.

CENTRAL STATION ELECTRICAL DATA

Meas. No.	Frame	Description	Normal Oper. Range		Nominal	Limits See Note 1	
			Low	High		Low	High
AE.01	2	ADC Lo-Calibration, 0.25 volts	0.23	0.25	0.24	0.04 (M)	5.00 (M)
AE.02	3	ADC Hi-Calibration, 4.75 volts	4.72	4.78	4.76	0.04 (M)	5.00 (M)
AE.07	20	+29	28.5	29.1	29	0.37 (M)	35.26 (M)
AE.09	50	+12 Supply Voltages	11.9	12.1	12	0.15 (M)	15.02 (M)
AE.10	65	+ 5	4.8	5.4	5	0.07 (M)	6.00 (M)
AE.11	79	-12	-11.9	-12.7	-12	-8.77 (M)	-25.52 (M)

Note 1: Legend - (M) Measurement Limit. See Section 3.3.9.

TABLE 3-9. (Continued)

CENTRAL STATION ELECTRICAL DATA

Meas. No.	Frame	Description	Normal Oper. Range		Nominal	Limits See Note 1	
			Low	High		Low	High
AE.03	8(2)	PCU #1 Input Voltage	15.8	16.4		0.14 (M)	16.55 (M)
AE.23	11(2)	PCU #2 Input Voltage	15.8	16.4		0.16 (M)	16.57 (M)
AE.04	5(3)	PCU Input Current (amps)	4.1	4.8		0.93 (T) 0.08 (M)	5.21 (T) 6.17 (M)
AE.24	30	Reserve Current (amps)	0.3	2.7		0.15 (T) 0.00 (M)	3.64 (T) 4.96 (M)
DA.08	-	Reserve Current (amps)	0.3	2.7		0.15 (T) 0.00 (M)	3.64 (T) 4.96 (M)
AE.21	35(2)	APM #1 Current (amps)	0.06	1.8		0.02 (T) 0.02 (M)	1.77 (T) 1.95 (M)
AE.22	56(2)	APM #2 Current (amps)	0.06	1.8		0.02 (T) 0.02 (M)	1.77 (T) 1.95 (M)

Note 1: Legend - (M) Measurement Limit, (T) Test Limit. See Section 3.3.9.
Note 2: Only the active unit provides valid measurements.
Note 3: Multiple - calibration measurement. See Page F-3-26.

TABLE 3-9. (Continued)

CENTRAL STATION ELECTRICAL DATA

Meas. No.	Frame	Description		Normal Oper Range (2) Low	Normal Oper Range (2) High	Nominal	Test & Measurement Limits (1) Low	Test & Measurement Limits (1) High
AE. 15	51	Trans. A	17^{V} Regulator Current (ma.) (See Note 3)			-	1.10 (T) -85. (M)	65.4 (T) 628. (M)
AE. 16	66	Trans. B				-	2.13 (T) -85. (M)	64.7 (T) 639. (M)
AE. 17	81	Trans. A	Regulator Voltage			23	0.36 (T) 0.36 (M)	25.17 (T) 45.82 (M)
AE. 18	22	Trans. B				23	0.36 (T) 0.36 (M)	25.17 (T) 45.82 (M)
AE. 19	21	Rcvr. A	Input Signal Level (dbm) (See Notes 3 & 4)	-92.3	-74.1	-	-100 (T) -110 (M)	-60 (T) -60 (M)
AE. 20	36	Rcvr. B		-92.3	-74.1	-	-100 (T) -110 (M)	-60 (T) -60 (M)

Note 1: Legend - (M) Measurement Limit, (T) Test Limit. See Section 3.3.9.
Note 2: Only the active unit provides valid measurements.
Note 3: Multiple-calibration measurement. See Page F-3-26.
Note 4: Values are valid only when uplink carrier is active.

TABLE 3-9. (Concluded)

CENTRAL STATION ELECTRICAL DATA

(Multiple-Calibration Measurements)

Meas. No.	Measurement Description	Calibration Dependent On: Parameter	Calibration Dependent On: Value	Cal. Curve Indication
AE.04	PCU Input Current		PCU 1	06
AB.06	Uplink A/B & Power Routing Status	Active PCU		
AB.17	ADP X/Y & Power Routing Status		PCU 2	07
AE.15	Trans. A 17-V Regulator Current	AT.24	-10°F	01
AE.16	Trans. B 17-V Regulator Current	AT.26	+10°F +77°F	02 03
AE.19	Revr. A Input Signal Level	AT.40	+100°F	04
AE.20	Revr. B Input Signal Level	AT.04	+140°F	05
AB.04	Pwr. Distr. Status (Exp 1&2)	AB-11	Stby/Off	06
AB.05	Pwr. Distr. Status (Exp 3&4)		ON	07

TABLE 3-10.

CENTRAL STATION CALCULATED PARAMETERS

Meas. No.	Units	Description	Normal Operating Range Low	Normal Operating Range High	Nominal	Red Line Limits - Watts/°F Low	Red Line Limits - Watts/°F High
CS-35	watts	AE.02 x AE.04 (-6) (PCU 1 Input Power)	68 watts	74 watts	NA		
CS-36	watts	AE.23 x AE.04 (-7) (PCU 2 Input Power)	68	74	NA		
CS-60*	watts	AE.03 x DA.08 (PCU 1 Reserve Power)	4	32	NA		
CS-61*	watts	AE.23 x DA.08 (PCU 2 Reserve Power)	4	32	NA		
CS-62*	watts	$8.2 \times (AE.21)^2$ (APM 1 External Reserve Pwr.)	0	28	NA		30 watts
CS-63*	watts	$8.2 \times (AE.22)^2$ (APM 2 External Reserve Pwr.)	0	28	NA		30 watts
CS-37	°F	$\frac{AT.3 + AT.4 + AT.5 \quad AT.6 + AT.7}{5}$ (Avg. Therm. Plate Temp.)	+4°F	+119°F	See Figure 3-7		
CS-43	°F	AR.01 - AR.04		AR-04 is inoperative			

* Only the active unit provides valid data.

TABLE 3-11.

CENTRAL STATION STATUS INDICATORS

Meas. No.	Parameter/Status	Indication
AB-04	Experiment Power Status (All Experiments)	
AB-05	- Standby Power On	STBY
AB-11	- Operational Power On	ON
	- All Power Off	OFF
AB-14	External Power Dissipators (7^W and 14^W)	
	- PDM Energized	ON
	- PDM De-energized	OFF
AE-03 AE-23	Power Conditioning Unit Status	1 or 2
AB-16	PC Autoswitch Status	Auto Select to PC #1 or PC #2
AB-13	APM Status	APM ON or APM OFF
AB-06	Uplink A/B and Power Routing Status	
	- Active Receiver/Decoder	A or B
	- Power Supply Routing	PRI or BKUP
AB-18	Uplink Switch Delay Status (Automatic Uplink Transfer)	READY or DELAY
AB-08	Receiver A, Command Subcarrier Status	
AB-09	Receiver B, Command Subcarrier Status	PRESENT ABSENT
AB-10	DDP X/Y Status	X or Y
AB-17	ADP X/Y and Power Routing Status	
	- Active ADP	X or Y
	- Power Supply Routing	PRI or BKUP

TABLE 3-12.

CENTRAL STATION ENGINEERING DATA DURING LSPE MODE

Meas. No.	Frame	Description	Normal Oper. Range		Nominal	Limits See Note 1	
			Low	High		Low	High
AE.03	-	PCU #1 Input Voltage (Note 2)	15.8	16.4	-	0.14 (M)	16.55 (M)
AE.04	-	PCU Input Current (amps) (Note 3)	4.1	4.8	-	0.08 (M)	6.17 (M)
AE.24	-	Reserve Current (amps)	0.3	2.7	-	0.00 (M)	4.96 (M)
AT.16	-	Thermal Plate #6 Temp. (°F)	+5	+117	See Fig. 3-7	-10(T) -40(M)	+140 (T) +205 (M)
AB.04	-	Power Distribution Status Experiments 1 and 2 (Note 3)	-	-	-	-	-
AB.05	-	Power Distribution Status Experiments 3 and 4 (Note 3)	-	-	-	-	-

Note 1: Legend - (M) Measurement Limit, (T) Test Limit. See Section 3.3.9.
Note 2: Measurement valid only if PCU 1 is active.
Noe 3: Multiple-calibration measurement. See Page F-3-26.

3.3 CENTRAL STATION CONSTRAINTS AND LIMITATIONS

3.3.1 General

Under normal circumstances ALSEP Array E, when properly deployed, will perform as outlined in Section 3. Array E has been designed to permit operation to continue in spite of a number of component failures. Recovery from some of these anomalous conditions is automatically programmed within the system. Recovery from other off-limit conditions can be implemented by ground command. This section contains information on:

(a) certain crucial Central Station deployment constraints,

(b) limitations on the use of the command link to modify the performance of the system,

(c) definitions of the classes of red-line limit data provided in this document,

(d) specific operational constraints associated with the Central Station.

3.3.2 Deployment Constraints

Before ALSEP can be put into operation, it must be removed by the crew from the various stowage areas in the Lunar Module descent stage (Figure 2-1) and each item properly deployed as shown in Figure 2-5. These deployment activities (see Table 3-13) as scheduled, will require 1 hour and 41 minutes to complete and are distributed throughout each of the lunar surface EVA periods.

During transfer of the equipment from the LM landing site to the ALSEP deployment site in the Astronaut-Carry configuration (Figure 3-11) the crew must be aware of the temperatures of equipment stowed near the fueled RTG. These temperatures are indicated by temperature monitors at the locations listed in Table 3-14.

The area selected by the crew for deployment of the equipment items shown in Figure 2-5 shall be located more than 100 meters west of LM. The area shall be generally level and free from craters comparable in size to the instruments especially in those areas where equipment is to be placed. (Note that a level area 25 meters in diameter will accommodate the deployment of all equipment except the geophones and explosive packages.)

The lunar surface in the vicinity of each equipment item shall be free from boulders and debris which might significantly restrict the view of space as seen by the thermal control surfaces.

The performance of each item of Array E equipment is strongly dependent on its deployed configuration and location. The following sections identify normal deployment of each major item and the indicators provided to assist the crew in validating proper deployment. This information is contingent upon deployment of Array E at Taurus-Littrow and is subject to review if another deployment site is used.

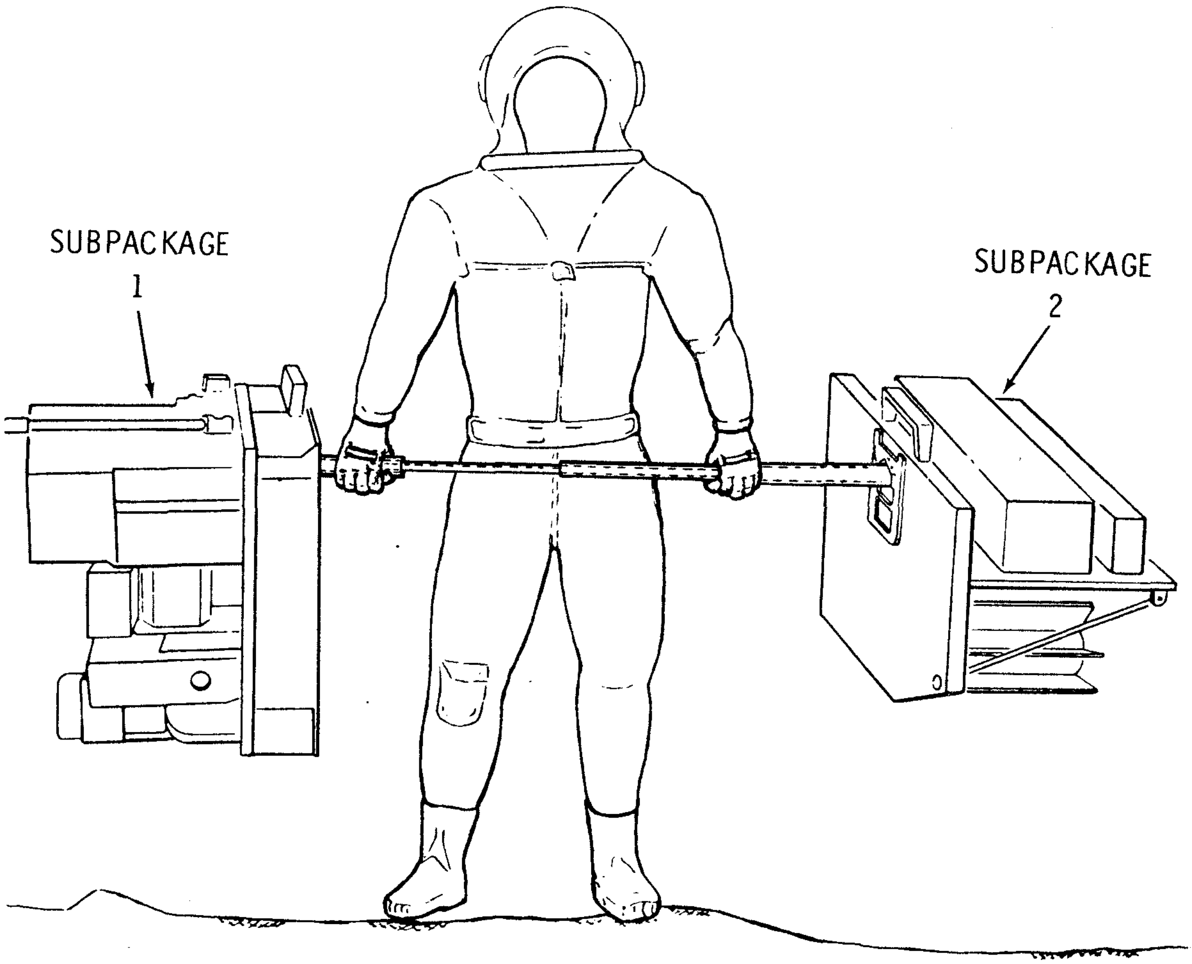


Figure 3-11. Astronaut-Carry Configuration

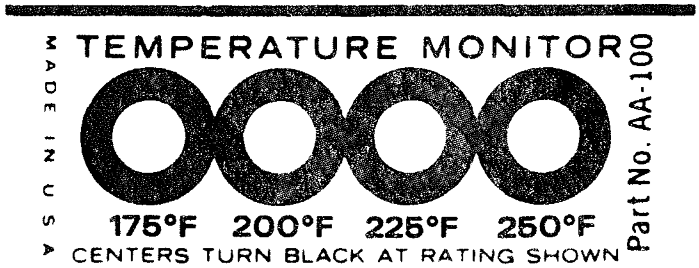
TABLE 3-13.

ALSEP DEPLOYMENT ACTIVITIES BY FLIGHT CREW

Commander Activities	Lunar Module Pilot Activities
Offload ALSEP	
Offload Quad III Pallet	Open SEQ Bay Doors
	Offload ALSEP Packages
	Fuel RTG
Offload LSP Explosive Packages	Configure ALSEP For Traverse
Offload Drill	Close SEQ Bay Doors
ALSEP Traverse	
Drive LRV to ALSEP site	Walk to ALSEP site with ALSEP in barbell configuration
ALSEP System Interconnect	
Connect HFE to Central Station	Connect RTG to Central Station
Deploy HFE	
. Set up Drill	Deploy LSG
. Implant Drill Stem #1	Offload LSP Geophone Module
. Insert Probe #1	Deploy LMS
. Implant Drill Stem #2	
. Insert Probe #2	Erect Central Station
. Align Electronics	Activate Central Station
	Deploy LEAM
	Deploy LSP Antenna
	Deploy LSP Geophones
Deploy LSP Explosive Packages	Deploy LSP Explosive Packages

TABLE 3-14.

ALSEP TEMPERATURE MONITOR LOCATIONS



The "Tempilabel" is a temperature monitor consisting of 4 heat-sensitive indicators sealed under transparent, heat-resistant windows. The center of each indicator circle will turn black at the temperature shown. The change to black is irreversible.

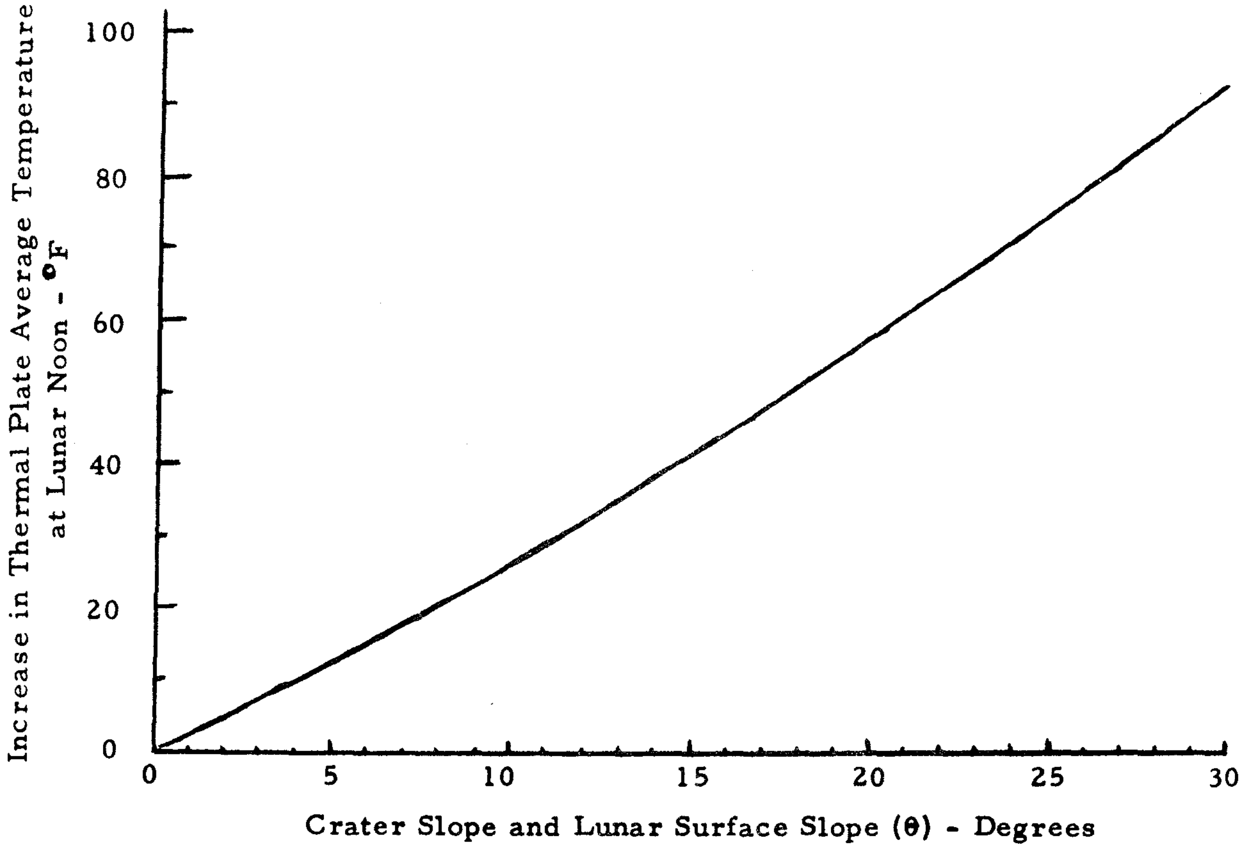
ALSEP Equipment Item	Tempilabel Location
Subpackage #2 Pallet	Bottom
Dome Removal Tool	Center of Handle
Fuel Transfer Tool	Forward of Flange
Carry Bar	Near the hand position of Subpackage Two Section
Universal Handling Tools (2)	One on Each Side of the Handle (2 labels)
RTG Cable Reel	Top
Antenna Gimbal Container	Top
LEAM	Connector
HFE Subpallet	Handle
Heat Flow Experiment	Connector

3.3.3 Thermal Constraints

The performance of ALSEP Array E is dependent on the location and the terrain characteristics of the landing site. As presently constituted, each unit of the system is configured for operation at approximately 20° north latitude in anticipation of deployment at Taurus-Littrow. This offset from the equator means that the sun does not traverse an arc passing through the zenith. Hence the equipment configurations governing thermal control are non-symmetrical (alignment dependent) and some alignment indicators have nominal settings which are valid only at specific times and/or locations. For these reasons, if a site other than Taurus-Littrow is chosen for deployment of Array E, much of the deployment information would need to be reconsidered.

It is important to note that the off-equator deployment site causes the proper setting on shadowgraph alignment devices like those on the LEAM and on the HFE electronics to be time-dependent. The alignment decals have been placed opposite the shadow angle expected at the nominal time of deployment. If these units are aligned at any other time, consideration should be given to the fact that the sun relative azimuth increases with time. See Figure 3-13.

The slope of the surface in the immediate vicinity of the Central Station has an effect on the temperature control of that unit. If the local surface slopes up, particularly toward the north, it tends to reduce the efficiency of the thermal radiating surfaces and to cause higher thermal plate temperatures. Figure 3-12 illustrates the effect of local terrain slope on the temperatures of the electronic units in the Central Station. The surface slopes could result from deployment of the equipment at the bottom of a crater. The best location for the Central Station is on top of a knoll with the local surface sloping away from the equipment.



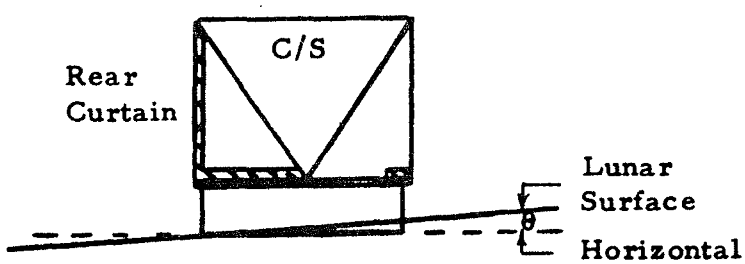


Figure 3-12. Effect of Surface Slope on Thermal Control

3.3.4 Deployment Sequence Hold Points

Under those circumstances which indicate that the normal sequence for deployment of ALSEP might be significantly interrupted, consideration must be given to completion of certain tasks if once they are initiated. Included among such tasks are the following:

a. During off-loading of ALSEP from LM the sequence of tasks should not be interrupted in such a way as to leave the SEQ bay doors open for more than 30 minutes.

b. Once the fuel capsule has been removed from its cask it is necessary, both for crew safety and equipment integrity, that the deployment continue uninterrupted until all items have been offloaded from Subpackage 2 and the cables have been connected to Subpackage 1. This sequence requires approximately 20 minutes. If time permits, it is preferable to continue this sequence through to the point where Subpackage 1 is erected and activated. This latter activity requires an additional 40 minutes.

c. If it is anticipated that the drilling operations will be interrupted for more than 30 minutes, it will be important to take into consideration the constraints on storage of the ALSD described in Section 4.0.

3.3.5 Delayed Deployment Effects

Since the shadow direction is used to provide a reference for orientation of ALSEP equipment during its deployment, it is important to recognize the changes in shadow direction relative to true west which occur at the Taurus-Littrow site during the Apollo 17 lunar stay time (Figure 3-13.)

The alignment decals described in the experiment sections identify the positions of the gnomon shadows for proper alignment, if the shadowgraphs are used at the time presently designated for ALSEP deployment at 0100 hours GMT on 12 December 1972.

If the ALSEP deployment time is significantly delayed from nominal, the gnomon shadow on the LEAM should be aligned to the appropriate shadow angle indicated in Figure 3-13.

The crew should be alerted to expect that nominal alignment shadow settings will be "off nominal" if, for any reason, they are checked during a later EVA.

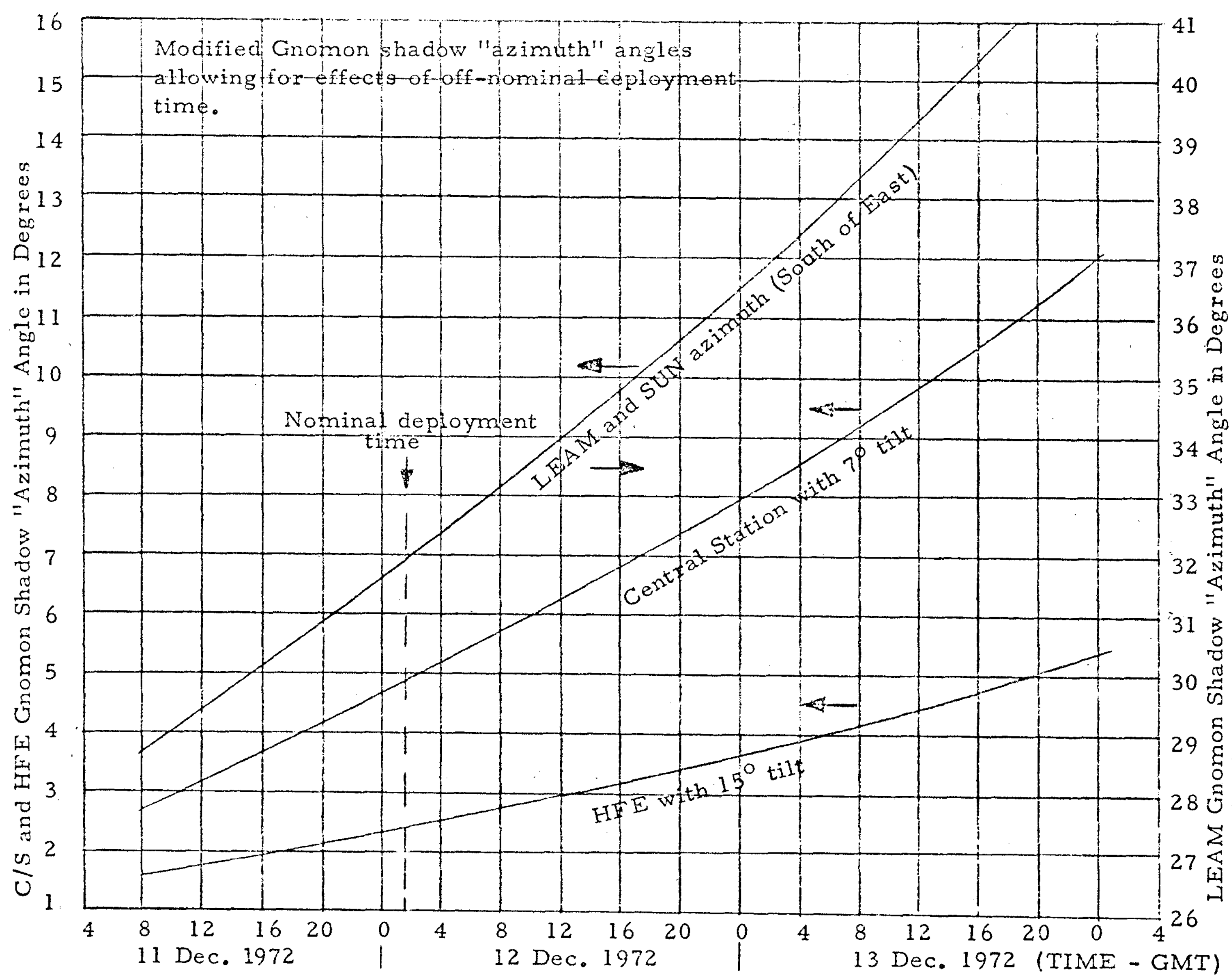


Figure 3-13. Shadow angles at ALSEP deployment

3.3.6 ALSEP Central Station Command Constraints

3.3.6.1 Critical Commands

Certain functions of ALSEP Array E which can be modified by ground command have operational constraints associated with them such that the associated commands should be considered as CRITICAL. The octal commands listed in Table 3-15 should be considered critical for the reasons stated.

In addition, whenever Array E is operating in any LSP mode and hence limited system data is available, extreme caution should be observed in commanding any non-LSP functions.

3.3.6.2 Modification of Normal Operation by Commands

The normal operational mode implicit in the telemetry values given can be modified extensively by ground command. A major feature of Array E is the increased redundancy in Central Station functions. The "normal" configuration of these functions will be considered as:

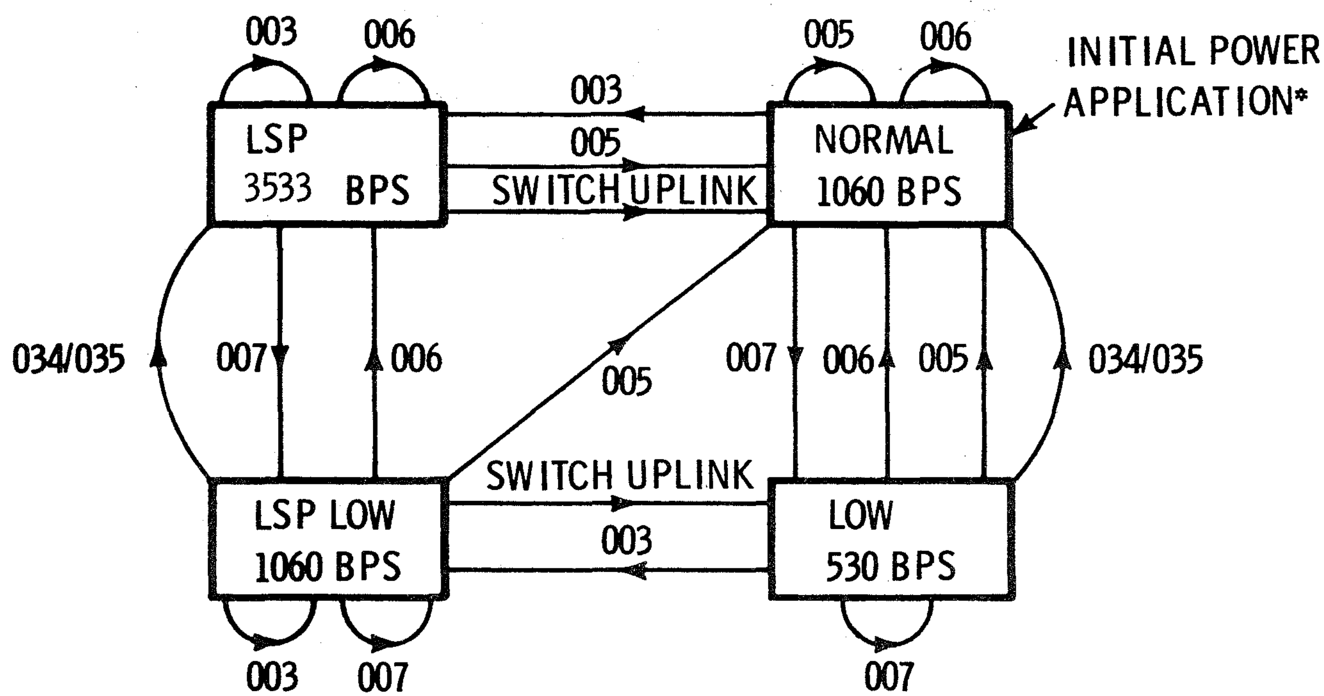
- Normal Data Rate (1060 bits per second)
- Uplink A/Power Routing 'PRI' (W)
- Transmitter A
- Digital Data Processor X
- Analog Data Processor X/Power Routing 'PRI' (W)
- PCU 2
- PCU Transfer to 1
- APM ENABLED

TABLE 3-15.

CRITICAL COMMANDS

COMMAND		CRITICALITY
No.	Description	
013	Trans. A OFF	All telemetry data becomes inoperative
037	Exp. 1 Stby. Pwr. ON	• Suppresses all LMS data • When followed by 041, deactivates LMS thermal control
043	Exp. 2 Stby. Pwr. ON	• Suppresses all LEAM data • When followed by 044, deactivates LEAM thermal control
046	Exp. 3 Stby. Pwr. ON	• Suppresses all HFE data • When followed by 050, deactivates HFE thermal control
053	Exp. 4 Stby. Pwr. ON	• Suppresses all LSG data • When followed by 054, deactivates LSG thermal control
112	LEAM Mirror Cover Release	Not to be executed prior to LM liftoff
114	LEAM Sensor Cover Release	Not to be executed prior to LM liftoff
156	LSP Transmitter Pulses ON	Not to be executed prior to LM liftoff
127, 132, 134	LMS Dust Cover Release	Not to be executed prior to LM liftoff

Because this configuration can be modified both by command and by automatic protection circuits, Array E has a much more complex roadmap through the available operational modes. Figure 3-14 provides an illustration of the interactions between various commands which alter the mode and data rate. Figure 3-15 is a similar illustration of the effects of ground commands, simulated commands (such as circuit breaker signals) and power initialization signals on the uplink configuration.



LEGEND:

BOXES INDICATE MODE AND BIT RATE CONFIGURATIONS

LINES INDICATE SWITCHING PATHS (NUMBERS ON LINES ARE OCTAL COMMANDS)

*MAY ALSO OCCUR AT PCU SWITCHOVER, UNDER CERTAIN CONDITIONS

Figure 3-14. Data Rate and Mode Configuration Switching

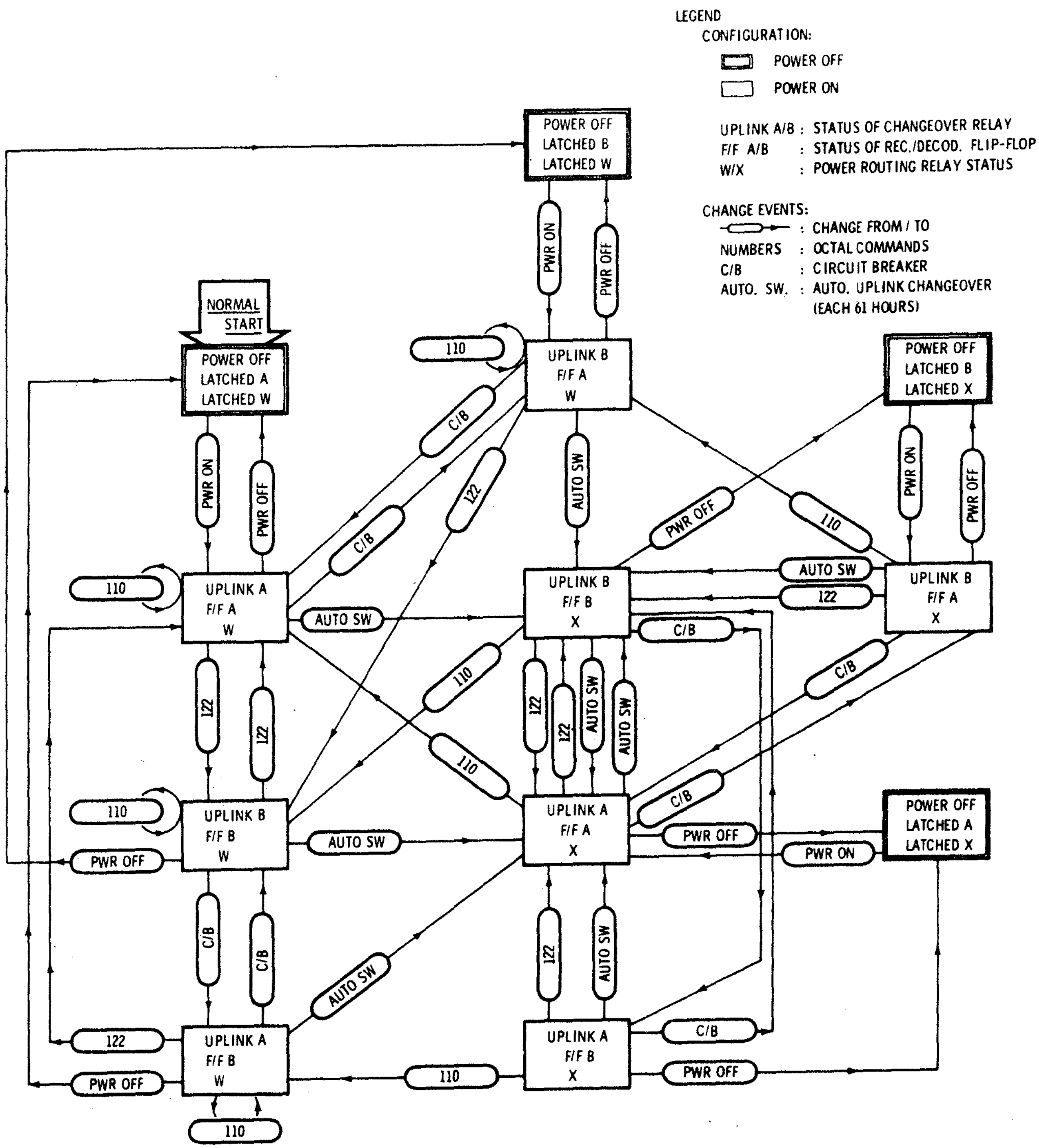


Figure 3-15. Uplink Configuration Switching

3.3.6.3 Crew-Initiated Commands

A "Reset Power" Astronaut Switch is provided near the Central Station carry-handle for use by the crew only at the request of MCC. This switch, located to the left of the LSP DSBL/ENBL switch, would be rotated first clockwise and then counterclockwise to simulate a command to select PCU 2. The switch has DPDT contacts for redundancy and is spring loaded CCW, however, deliberate rotation through the sequence from CCW to CW and back to CCW is preferred. When rotated CW, the switch opens the RTG to PCU line and simultaneously applies RTG Power to the PC #2 select relay coil for transfer to PC #2 setting. CCW rotation removes RTG Power from the PC #2 select relay coil and applies RTG Power to PC #2.

3.3.6.4 Command Verification Word Generation

During DP Formatting Code transmission, with the few exceptions described below, word 7 (Figure 3-5) will always contain the CVW corresponding to a command received during the previous frame period. This applies even if the contents of the command register are not capable of being decoded to give an Array E command. The parity bit ("one") downlinked as part of the CVW (i.e., Message Acceptance Pulse, MAP) simply shows that bits 1 through 7 following the address were the complement of bits 8 through 14. It is independent of whether the command word was physically decoded or a functional change was initiated. If MAP bit is zero, bits 1-7 were not complements of bits 8-14, respectively and no command is executed.

The exceptions to the receipt of a command verification word are as follows:

(a)	CMD 003	LSPE Formatting ON	CVW will never be transmitted.
(b)	CMD 005 CMD 006 CMD 007	DP Formatting ON Normal Bit Rate Slow Bit Rate	CVW are always transmitted but will not normally be observed unless the ground system is already in the required mode or bit rate. In DP Formatting, normal bit rate, there is a 1 in 16 chance that a 007 CVW will be before the bit-rate changes. In DP Formatting, slow bit rate, there is 1 in 13 chance of a 006 CVW before the bit rate change occurs.
(c)	CMD 012 CMD 013 CMD 014 CMD 015	Transmitter A ON Transmitter A OFF Transmitter B OFF Transmitter B ON	Any change from "RF carrier" to "no RF carrier," or vice versa, will not give a CVW. If A is ON, and B is switched ON or OFF, then a CVW will be received if the ground system can ride over the random RF carrier phase change. If B is ON, then a CVW should always be received for A ON or A OFF.
(d)	Power switching commands, in particular PDR, APM and Experiment power commands.		Power transients in excess of approximately 10 watts may sometimes cause a loss of CVW, particularly if the Reserve Power is very high or very low. Under normal operating conditions, it is possible that no CVW will be lost. Tendency of CVW loss increases at low temperatures.

(e)	CMD 034 CMD 035	DDP X Select DDP Y Select	If the DDP is already in the required state, then a CVW will always be received. If a DDP changeover actually takes place, then it may be assumed that a CVW will not be received, since the probability of a DDP change without sync loss is almost certainly less than 1 in 1500.
(f)	CMD 122	Switch Uplink	If the uplink actually switches, then a CVW will not be received. If the uplink does not switch, then a CVW will be received.
(g)	CMD 060 CMD 062	PC #1 Select PC #2 Select	Although it is theoretically possible for a CVW to be received under certain conditions, a PC changeover will normally not give a CVW. The most likely reason for receiving a CVW is that the system is already in the required state.

(h) No CVW will be transmitted for any command while the ALSEP System is in LSPE Data Mode.

3.3.7 Spurious Command Verification Words (CVW)

3.3.7.1 The earlier ALSEP arrays transmit noise-induced random CVW, without parity (i.e., no MAP), at intervals of 1 to 4 hours. The uplink integrity requirements for Array E are equivalent to a maximum of one random CVW in about 400 hours, but theoretical analysis and test both predict a random CVW rate closer to one in 15 years. Spurious CVW which cannot be explained by the systematic process described in Paragraph 3.3.7.2 below should be treated as possible indication of partial uplink failure, and should be fully investigated.

3.3.7.2 When Array E recognizes its own address (Octal 151) in the bit-stream to another ALSEP, it will enter its command sequence and finally transmit a CVW without MAP. These CVW are completely systematic and predictable, and are of no significance operationally. However refined the decoding system may be, there is no way to prevent them. They are as shown on the following page.

As recommended in Paragraph 3.3.7.1 above, CVW other than those listed in this table and definitely associated with the relevant command to another ALSEP, should be fully investigated.

TABLE 3-16. SPURIOUS COMMAND VERIFICATION WORDS

	ALSEP SYSTEM ADDRESSED	OCTAL COMMAND	SPURIOUS CVW FROM ARRAY E
1.	Apollo 14, Either Address (Octal 025 or 065)	054 055	077 177
2.	Apollo 15, Either Address (Octal 016 or 116)	060 061 062 063 064 065 066 067	017 037 057 077 117 137 157 177
3.	Any, Except Apollo 15 and Apollo 17	064	177
4.	Any, Except Apollo 17	022 026 044 045 111 113 122 151 164	177 177 177 177 177 177 177 177 177

3.3.8 Central Station Unscheduled (or Spurious) Status Changes

3.3.8.1 Array E will not be subject to the noise-induced random status changes which occur in other ALSEP arrays at intervals of two to four weeks. The Command Decoder in Array E has been completely redesigned in order to satisfy a new specification requiring not more than one spurious command execution in 6 years. Theoretical analysis and practical test results both predict a spurious execution rate due to noise of less than once in 6000 years. Any spurious status change which is accompanied by the appropriate CVW should be fully investigated.

3.3.8.2 At turn-on, PC changeover and execution of Command Octal 110, the Array E Central Station may be subject to some unscheduled status changes. The basic cause in each case is the relatively high V_{CC} level at which TTL/54L logic gates cease to function as logic gates. A voltage-sensitive switch effectively prevents any relay in the Central Station PDU from responding to spurious commands at turn-on and PC changeover, and the various power reset circuits ensure that all counter and flip-flops (except those in the APM's) are correctly set at turn-on, but several circuits are not protected. It has been found that very few of the theoretically possible spurious responses actually occur; and it has also been established, over many tests on three systems, that the anomalous behavior pattern for each system is extremely stable. The following summary is based upon Flight system characterization during thermal/vacuum testing; it lists the highly probable and the possible but improbable unscheduled status changes, with the recommended corrective actions.

a. Central Station Turn-On

AB-13, "APM Status," may read "APM Off." This spurious status has been observed in the Flight system. Corrective Action: Transmit Command Octal 027, "APM #1 ON" or Command Octal 115, "APM #2 ON." "APM Off" is theoretically the only spurious status change which can occur at turn-on, and no others have been observed during test.

b. Command Octal 110 - "Uplink/ADP Power Routing W Select"

The purpose of this command is to preset the positions of two relays before final stowage and flight. There is no rationale for its use during lunar operations, and it strongly recommended that it is not transmitted.

If the uplink relay has been correctly preset to the "W" position, and if there has not been an automatic uplink switchover, then Command Octal 110 will have no effect other than to produce a 110 CVW.

If an automatic uplink switchover has occurred, and the relay is in the "X" position, then many spurious changes are theoretically possible, although the Flight system showed no changes from normal status during test. The possible changes are:

(1) Change in AB-18, "Uplink Switch Delay Status" to "Enabled" or "Not Delayed" status.

Corrective Action - Transmit Command Octal 174 "Delay Uplink Switchover."

(2) Change in AB-15 "Periodic Commands Status."

Corrective Action - 104 or 105, as required.

(3) Change in DP or LSP Formatting modes. (Note: Command 110 should not be transmitted during LSP Formatting since there is too little information available about the system via the housekeeping channels.)

Corrective Action - Transmit Command Octal 005, "DP Formatting ON," or Command Octal 003, "LSP Formatting ON," as appropriate.

The above have a theoretically fairly high probability of occurring. The two remaining spurious responses are theoretically possible, but have an extremely low probability of occurrence.

(4) "Lock-up" of the Command Decoder, preventing reception of any commands, as indicated by repeated "spacecraft reject."

Corrective Action - Direct remote site to remove and then reapply modulation. Lock-up will be removed in 5 milliseconds.

(5) One or more (possibly up to ten) spurious commands with one CVW transmitted.

Corrective Action - Obtain complete housekeeping check, including experiment modes, and correct by command, as necessary. (The probability of this spurious response is so low that in practice it can be ignored.)

c. Command Octal 062 "PC #2 Select" (Assuming PC #1 currently in use.)

(1) APM may be "Off." (This has been observed.)

Corrective Action - Transmit Command Octal 115, "APM #2 Select."

(2) Systematic, complete ripple-off of all loads, followed by ripple-off lock-out.

Corrective Action - Transmit Command Octal 032, "Ripple-Off Reset." Command 7 Watt and 14 Watt dumps, and/or experiments back to required states.

No other spurious commands are theoretically possible.

d. Command Octal 060 "PC #1 Select" (Assuming PC #2 currently in use.)

(1) APM may be "Off." (This has been observed.)

Corrective Action - Transmit Command Octal 027, "APM #1 ON."

(2) Possible changes in formatting mode and bit rate.

Corrective Action - Transmit Command Octals 003, "LSP Formatting ON;" 005, "DP Formatting ON;" 006, "Normal Bit Rate;" or 007 "Slow Bit Rate," as appropriate.

(3) Change in AB-18, "Uplink Switch Delay Status."

Corrective Action - Transmit Command Octal 174, "Delay Uplink Switchover."

(4) Change in AB-15, "Periodic Command Status."

Corrective Action - Transmit Command Octal 104, "Periodic Commands Enable" or Command Octal 105, "Periodic Commands Inhibit," as required.

(5) Ripple-off circuit will be simultaneously locked out and generating a continuous "LSPE Standby" command - peculiar to Flight system.

Corrective Action - Transmit Octal Command 032, "Ripple-Off Reset." This will remove anomalous condition. Then command LSPE to required state.

Note: It is theoretically possible for other dumps or experiments to be rippled off, but the Flight system consistently behaves in the way described above, and may be expected to continue to do so.

(6) Spurious execution of any command, except those terminating in the PDU.

Corrective Action - Review housekeeping and experiment mode data, and transmit appropriate commands to restore status.

Note: This is a theoretical possibility only. The flight system has not generated any spurious commands, apart from those already listed, throughout its test program. Similar stable behavior may be assumed during lunar operations. Of the 474 possible sources of spurious commands in three Array E systems, less than ten have actually exhibited spurious behavior.

(7) Datum of Uplink Switch/Periodic Commands counter may be disturbed. This may not be detected for several hours, but it is not of any permanent importance.

Corrective Action - There is no corrective action possible as far as ALSEP is concerned. Operator should note possibility of the datum shift and establish new datum over the next cycle by observing automatic change in AB-18, "Uplink Switch Delay Status."

(8) Some experiments may change mode, but not On/Off/Standby power status, as a direct response to the primary power transient.

Corrective Action - Review experiment status information and re-status by command, as necessary.

(9) Systematic generation of Octal Command 111, "LEAM Cal," if the power transient drops the +5 Volt line below approximately 3 volts. Under nominal power conditions this will normally occur. The command has no permanent effect upon the experiment and no corrective action is necessary. (Note that no similar systematic mechanism exists on any other command line.)

3.3.9 Telemetry Data Limits

The primary purpose of ALSEP is to provide data from the numerous scientific sensors. For this reason the scientific data channels must be recognized to contain fundamental information on lunar physical phenomenon and hence do not have prescribed limits within which the data must fall. All science sensors have command-selectable operating modes which permit the principal investigator to tailor the instrument sensitivity and/or operation to suit the activity of the science parameter being measured.

On the other hand, the engineering data channels provide information on the operational status or performance of the equipment. The expected values of data appearing on these channels during normal operation have been listed in Section 3.2. If one of these parameters should exceed its range of normal operation, the cause should be ascertained and the implications evaluated.

To assist the operators in situations where an engineering parameter exceeds the stated "normal operation" limits, the measurement data tables in Section 3.2 identify classes of limits which are subject to the following interpretations:

a. Test Limits (T): These limits identify the most extreme values of the related parameter recorded under the most severe environmental conditions encountered during the ALSEP test program. They do not imply a condition of impending damage. They do represent those values beyond which there is no operational experience.

b. Measurement Limits (M): These limits denote those values of the parameter beyond which no meaningful data will be available regarding that parameter. They are the limits established by the Array E Calibration Curves described in ATM 1095. In general, the limits agree with the "Range" Column of Table 2 in the measurements requirements document, SE-33 Rev. A. Where minor differences occur, they are due primarily to sensor circuit performance as defined by the calibration curve-fit equation; in each case the measurement limit exceeds the test limit.

c. Failure Limits (F): These limits identify the value of a parameter at which it is known that damage to hardware or permanent degradation of data will occur.

When the value of a parameter exceeds the normal operating values or any of these red-line values, it is expected that the operators will instigate remedial action. Any corrective action to be taken under a particular situation will normally be defined in the Final Systems Mission Rules for ALSEP Array E.

3.4 CENTRAL STATION COMMANDS

3.4.1 Command Operations

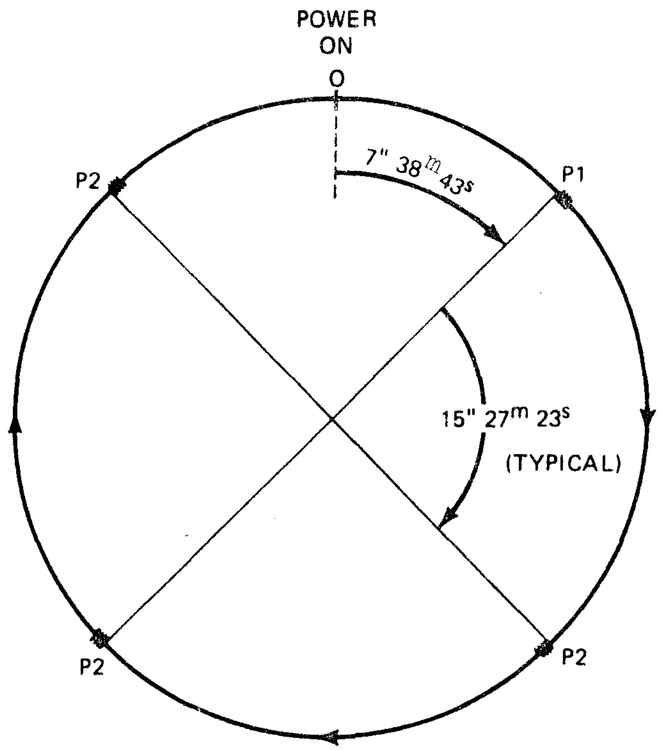
3.4.1.1 Array E Uplink. Control of certain functions of Array E is exercised by means of command signals transmitted through the ALSEP uplink. These signals which originate at the control console in Mission Control Center are coded with the Array E address and are routed to the active MSFN remote site for transmission to the moon on an RF carrier having a frequency of 2119.0 MHz.

The 79 Array E command signals are identified by octal numbers as shown in Table 3-22. These 79 command signals can be used to change 112 functions throughout the system. Descriptions of these functional changes are given in this section.

Unlike previous ALSEP Systems, Array E commands have only one address code (Octal 151). Although complete redundancy of uplink components is provided, only one set is energized at any given time. The same address provides access to both Array E uplink channels. An internally-generated signal causes the alternate uplink channel to be activated each 61.8 hours of operation. If performance of the uplink channel in use is satisfactory, this change-over can be delayed one period by command (CMD 174). From Figure 3-16, it can be seen that this delay command is effective only if issued more than 4 minutes after the time designated "P_1." Provided that the uplink in use can decode it satisfactorily, CMD (Octal) 122 will cause an immediate changeover to the redundant uplink, irrespective of any previous CMD (Octal)174. The CMD 174 is not cancelled by the subsequent CMD 122.

3.4.1.2 Internally Generated Commands

3.4.1.2.1 Periodic Commands - Together with the signal described above to select the alternate uplink components, two LEAM Calibrate (CMD 111) and other simulated command signals are generated periodically. The sequence of simulated commands (identified by their octal code numbers) is presented in Figure 3-16. Commands 065 and 131, being spares, do not initiate any functional changes in Array E outside of the command decoder. These LEAM CAL commands are inhibited when CMD 105 is in effect.



PERIODIC TIME	SCHEDULED EVENTS
P_1	IF NOT DELAYED BY PREVIOUS CMD 174: • SELECT ALTERNATE UPLINK COMPONENTS • SELECT BACKUP POWER ROUTING FOR UPLINK IF NOT INHIBITED BY PREVIOUS CMD 105: • ACTIVATE CMD 111 (LEAM CALIBRATE) • ACTIVATE CMD 065 (NO FUNCTION)
$P_1 + 3^m\ 37.4^s$	• ENABLE "ALTERNATE UPLINK SELECT" CIRCUIT IF NOT INHIBITED BY PREVIOUS CMD 105: • ACTIVATE CMD 111 (LEAM CALIBRATE)
$P_1 + 7^m\ 14.8^s$	• ACTIVATE CMD 131 (NO FUNCTION)
	IF NOT INHIBITED BY PREVIOUS CMD 105:
P_2	• ACTIVATE CMD 111 AND CMD 065
$P_2 + 3^m\ 37.4^s$	• ACTIVATE CMD 111
$P_2 + 7^m\ 14.8^s$	• ACTIVATE CMD 131

Figure 3-16. Timing of Periodic Commands

3.4.1.2.2 Locally Generated (Simulated) Commands - As on previous ALSEP arrays, the majority of the power circuit protection is provided by the generation, internal to the system of simulated commands which alter the power distribution. These simulated commands are associated with three levels of power problems, namely:

a. An abnormally high current in any of the circuits listed in Table 3-17 will cause the designated command to be generated internally to change the power routing as shown. Operation of the circuit breakers does not influence the normal command lines and/or relay drivers in any way.

b. Reduction of the available reserve current below a stated minimum will initiate the sequence of simulated commands listed in Table 3-18. The sequence is initiated when the voltage across the regulator resistor drops below (approximately) 0.185 volts corresponding to about 0.8 watts of reserve power. At this point, the total reserve current (at 16.3V) will be approximately 49 milliamps. The first simulated command in this sequence (CMD 021) is issued 121 milliseconds later if that condition still exists. The remaining commands, if needed to raise DA-08 above the threshold, follow at 7.5 millisecond intervals.

c. If, for any reason, the voltage on the +12V, -12V or +5V supply lines deviate outside the limits shown in Table 3-19, an internal command will be generated in the operating Power Converter (PC) which simulates the functions of CMD 060 or CMD 062. Whether the standby PC is activated by this simulated command is dependent on the status of the PC Autoselect relay (monitored by AB-16). This simulated command is only initiated if the fault condition exists for 300 ± 50 milliseconds for low voltage conditions, the delay is only 5 milliseconds for high voltage conditions.

3.4.1.2.3 Major Power-Consuming Commandable Functions - Certain functions, which can be activated by ground-command, cause a significant increase in the power consumption of the system. Hence, before these commands are issued, it is important to ensure that adequate reserve power is available. Some of these commandable functions are listed in Table 3-20.

TABLE 3-17. CURRENT-LIMIT COMMANDS

Power Circuit	Max. Current * (ma)	Simulated Command	
		Octal	Function
LMS Operate	560	037	LMS Standby
LEAM Operate	560	043	LEAM Standby
HFE Operate	560	046	HFE Standby
LSG Operate	560	053	LSG Standby
LSP Operate	560	056	LSP Standby
Transmitter A	760	013	Trans. A. OFF
Transmitter B	760	014	Trans. B. OFF
Diplexer Switch	150	014	Trans. B. OFF
DDP 'X'	270	035	DDP 'Y' Select
DDP 'Y'	270	034	DDP 'X' Select
ADP 'X'	(5V) 330 (±12V) 150	025	ADP 'Y' Select
ADP 'Y'		024	ADP 'X' Select
Rec./Decod.	(5V) 330 (+12V) 330 (-12V) 150	122	Alternate Rec/Decod.

* Within 10%.

TABLE 3-18. RIPPLE-OFF COMMANDS

"Ripple-Off" Commands			Change in DA-08 (1) (If Normal Function Previously Energized)	
Seq. No.	Simulated Command Octal	Function	Lunar Noon 2	Lunar Night 2
1	021	7^WExt. Load OFF	+450 ma	+450 ma
2	023	14^WExt. Load OFF	+860 ma	+860 ma
3	037	LMS STANDBY	+160 ma	+220 ma
4	043	LEAM STANDBY	-110 ma	+100 ma
5	046	HFE STANDBY	-12 ma	+206 ma
6	053	LSG STANDBY	-50 ma	+200ma
7	056	LSP STANDBY	+350 ma	+350 ma
8	—	"RIPPLE" DISABLE	—	—

1) "+" indicates increase in reserve current.
"-" indicates decrease in reserve current.

2) $\pm$ 10%

TABLE 3-19. POWER-CONVERTER CHANGE-OVER LIMITS

Measurement		CMD 060 (062) Initiated If	
No.	Parameter	Less Than (1)	(1) Greater Than
AE-09	+12V Supply	+10.8±0.25	+12.9 ±0.25
AE-10	+ 5V Supply	+0.9	Not monitored
AE-11	-12V Supply	not monitored	-3.8

1. Voltage levels refer to component supply lines. Voltage level out of PCU where actually monitored by autoswitch sensor are numerically about 0.7 volts greater. +5V and -12V levels are monitored only to a gross presence/absence level and exact switching points are not specified. The +0.9V and -3.8V switching levels are derived from PCU circuit analysis rather than tests.

TABLE 3-20.

CHANGES IN SYSTEM RESERVE POWER RESULTING FROM CENTRAL STATION COMMANDS

CMD No.	Functional Mode Changes		Approximate Reserve Power Change (watts)
	From	To	
012	Trans. A OFF	Trans. A ON	9.2
015	Trans. B OFF	Trans. B ON	9.4
017	7^W PDR OFF	7^W PDR ON	7.3
022	14^W PDR OFF	14^W PDR ON	14.5
036	LMS Power OFF	LMS Oper. Power ON	11.0 (Day) 12.1 (Night)
042	LEAM Power OFF	LEAM Oper. Power ON	3.4 (Day) 6.6 (Night)
045	HFE Power OFF	HFE Oper. Power ON	3.9 (Day) 10.3 (Night)
052	LSG Power OFF	LSG Oper. Power ON	3.2 (Day) 7.0 (Night)
055	LSP Power OFF	LSP Oper. Power ON	5.3

3.4.2 Command Summary

A total of 79 different octal command (CMD) signals can be decoded by Array E to initiate 112 functional changes in the operating mode of the system. Of these 79 CMD signals, 38, when addressed to other ALSEP systems, initiate functions similar to those on Array E. The remainder have CMD codes the same as on other arrays but initiate different functions. Of the 128 possible combinations available in the CMD code only these 79 will yield valid responses. Twenty-five of the invalid CMD codes are decoded but unterminated. Twenty-four are not decoded. The assignment within the system of commandable functions is illustrated in Table 3-21.

For reference purposes, the addresses of operational ALSEP systems are as follows:

	For ALSEP on Apollo				
	12	14	15	16	17
Addresses	130/30	25 / 65	116/16	62 / 144	151
Address Complements	47/147	152 / 112	61/161	115 / 33	26

☐ Addresses or complements having the same code as an assigned command.

TABLE 3-21.

COMMAND SUMMARY

ARRAY E Equipment Item	NO. OF COMMANDS
Data Processor	4
Power Distribution Unit (Power Switching)	29
Power Conditioning Unit	8
Command Decoder	5
Lunar Mass Spectrometer	7
Lunar Ejecta and Meteorites	4
Heat Flow Experiment	10
Lunar Surface Gravimeter	7
Lunar Seismic Profiling	5
TOTAL	79

3.4.3 Command Distribution

The functional changes in Array E which can be initiated by octal commands are distributed throughout the system as shown in Table 3-22.

TABLE 3-22 COMMANDABLE FUNCTIONS

Termination Point	Command Nomenclature	Octal Command
Data Processor	DP Formatting ON	005
	Normal Bit Rate	006
	Slow Bit Rate	007
	LSP Formatting ON	003
Command Decoder	Ripple OFF Reset	032
	Periodic Commands Enable	104
	Periodic Commands Inhibit	105
	Switch Uplink	122
	Delay Uplink Switchover	174
Power Cond. Unit	APM #1 ON	027
	APM #1 OFF	031
	APM #2 ON	115
	APM #2 OFF	113
	Select PC #1	060
	Select PC #2	062
	PC Auto Select #1	120
	PC Auto Select #2	121

TABLE 3-22.(Continued)

Termination Point	Command Nomenclature	Octal Command
Power Dist. Unit	Transmitter A ON	012
	Transmitter A OFF	013
	Transmitter B OFF	014
	Transmitter B ON	015
	PDR #1 ON	017
	PDR #1 OFF	021
	PDR #2 ON	022
	PDR #2 OFF	023
	SELECT ADP X	024
	SELECT ADP Y	025
	DDP X Select	034
	DDP Y Select	035
	Experiment 1 Power ON	036
	Experiment 1 Power Standby	037
	Experiment 1 Power OFF	041
	Experiment 2 Power ON	042
	Experiment 2 Power Standby	043
	Experiment 2 Power OFF	044
	Experiment 3 Power ON	045
	Experiment 3 Power Standby	046
	Experiment 3 Power OFF	050
	Experiment 4 Power ON	052
	Experiment 4 Power Standby	053
	Experiment 4 Power OFF	054
	EXP 5 Power ON	055
	EXP 5 Power STANDBY	056
	EXP 5 Power OFF	057
	ADP Power Relay X Select	107
	Uplink/ADP Relay 'W' Select	110

TABLE 3-22. (Concluded)

Termination Point	Command Nomenclature	Octal Command
Lunar Surface Gravimeter	Slave Heater Power ON	063
	Slave Heater Power OFF	064
	Command Execute	067
	Command Decoder Power ON	070
	Command Decoder Power OFF	071
	Step Command Counter UP	072
	Step Command Counter DOWN	074
LEAM	LEAM Calibrate HIGH/LOW	111
	LEAM Mirror Cover Release	112
	LEAM Sensor Cover Release	114
	LEAM Heater ON/OFF/AUTO	117
LMS Experiment	LMS Load Command #1	123
	LMS Load Command #2	124
	LMS Load Command #3	125
	LMS Load Command #4	127
	LMS Load Command #5	132
	LMS Load Command #6	133
	LMS Execute and Clear	134
Heat Flow Experiment	Normal (Gradient) Mode Select	135
	Low Conductivity Mode Select	136
	High Conductivity Mode Select	140
	HF Full Sequence Select	141
	HF Probe #1 Sequence Select	142
	HF Probe #2 Sequence Select	143
	HF Subsequence #1	144
	HF Subsequence #2	145
	HF Subsequence #3	146
	HF Heater Advance	152
LSP Experiment	Transmitter Pulses ON	156
	Transmitter Pulses OFF	162
	Amplifier Gain Normal	163
	Amplifier Gain Low	164
	Geophone Calibrate	170

3.4.4 Central Station Command Descriptions

3.4.4.1 Uplink Switching Commands (Including ADP Power Routing)

- 110 ADP/Uplink Redundant Power Routing, Primary Select

This CMD actuates a pair of latching relays in the non-redundant section of the PDU, to the position that provides the basic, redundant, routing of +5 VDC from PCU 1 and PCU 2 to the ADP/Uplink selection relays. This CMD has the opposite effect of CMD 107 for ADP PWR routing and of a 61-hr. pulse for uplink PWR routing. This CMD would serve to clear a malfunction in either the decoder or the ADP selection relay, if one should occur in the backup routing. The primary routing is preset to be energized at initial lunar activation. Repeated application of CMD 110 has no further effect.

- 122 RCVR/Decoder Switch

This CMD, through the uplink switch flip-flop in the CMD decoder, actuates latching relays in the non-redundant section of the PCU to remove power from whichever set of uplink components is in use and apply power to the alternate, redundant, components. Three voltages (+5, +12 and -12) are switched for the CMD decoders and +12 VDC for RCVR's. Repeated application of CMD 122 causes repeated selection, alternating between RCVR/Decoder A and B. Transmission of CMD 122 does not actuate the backup power routing of +5 VDC to the decoder as does automatic switchover. After a PCU switchover, CMD 122 may be required twice for the next switchover (if it is from uplink B to uplink A). Note that CMD 122 and CMD 174 have no effect on each other. Periodic commands are enabled following an uplink switch and a CMD 122, which actually causes a switchover, will therefore also enable periodic commands.

- 174 RCVR/Decoder Switch Delay

This CMD sets a one-time inhibit circuit in the CMD decoder such that the next 61-hr. pulse does not cause switchover to the opposite RCVR/ Decoder. Repeated application of CMD 174, prior to arrival of a 61-hr. pulse, has no further effects; only one pulse is inhibited. Resetting to the no-delay condition occurs 3.5 minutes after the 61-hr. autoswitch pulse is generated, whether or not the switchover is actually inhibited or enabled. The application of power to ALSEP causes initialization in the no-delay configuration. Note that CMD 174 and CMD 122 have no effect on each other.

3.4.4.2 ADP Commands

- 024 ADP X Sel

This CMD actuates latching relays in the non-redundant section of the PDU to the position that applies +5 VDC, +12 VDC, and -12 VDC to the X unit of the analog data processor and removes +5 VDC, +12 VDC and -12 VDC from the Y unit. ADP X is preset to be energized at initial lunar activation. Repeated application of CMD 024 has no further effect. Switching ADP's in either the DP or LSP format, normal or slow data rate, results in a temporary loss of frame count but no change in data rate.

- 025 ADP Y Sel

This CMD actuates latching relays in the non-redundant section of the PDU to the position that applies +5 VDC, +12 VDC and -12 VDC to the Y unit of the analog data processor and removes +5 VDC, +12 VDC and -12 VDC from the X unit. Repeated application of CMD 025 has no further effect. Switching ADP's in either the DP or LSP format, normal or slow data rate, results in a temporary loss of frame count but no change in data rate.

- 107 ADP Redundant Power Routing, Backup Select

This CMD actuates a latching relay in the non-redundant section of the PDU to the position that provides an alternate, redundant routing of +5 VDC from PCU 1 and PCU 2 to the ADP selection relays. This CMD would be applied if it appeared that both ADP's were operating simultaneously. An alternative would be to switch PCU's. The 61-hour pulse does not switch ADP routing. Repeated application of CMD 107 has no further effect.

3.4.4.3 DDP Mode and Bit Rate Commands

- 006 Normal Bit Rate Sel

This CMD selects the DDP timing configuration such that in the DP format mode the downlink data rate is 1060 BPS. In the LSP format mode the downlink data rate is 3533.3 BPS. The application of PWR to ALSEP causes initialization in the normal bit rate configuration. When a change from low bit rate to normal bit rate is commanded, in either DP or LSP format, the change takes effect at the end of the 64-word data frame, following receipt of CMD 006, for whichever DDP is operational. Repeated application of CMD 006 has no further effect.

- 007 Low Bit Rate Sel

This CMD selects the DDP timing configuration such that in the DP format mode the downlink data rate is 530 BPS. In the LSP format mode the downlink data rate is 1060 BPS. When a change from normal bit rate to low bit rate is commanded, in either DP or LSP format, the change takes effect at the end of the 64-word data frame, following receipt of CMD 007, for whichever DDP is operational. Repeated application of CMD 007 has no further effect.

- 005 DP Format On

This CMD selects the DDP configuration that inhibits inputs from the LSPE to the modulator, enables inputs from other experiments, and enables data demands to all experiments other than the LSPE. When switching from LSPE format to DP format by CMD 005, in either LSPE normal data rate (3533.3 BPS) or LSPE low data rate (1060 BPS) the resulting DP data rate will be normal (1060 BPS). CMD 005 takes effect at the end of the 64-word data frame, following receipt, for whichever DDP is operational (but is not outputting data). The application of PWR to ALSEP causes initialization in the DP format configuration. Repeated application of CMD 005 has no further effect.

- 003 LSP Format On

This CMD selects the DDP configuration that enables inputs from the LSP to the modulator, inhibits inputs from the other experiments, and inhibits data demands to other experiments. When switching from DP format to LSP format by CMD 003, the resulting LSP data rate will be normal or low (3533.3 BPS or 1060 BPS). CMD 003 takes effect at the end of the 64-word data frame, following receipt, for the DDP in operation at that time. Repeated application of CMD 003 has no further effect.

3.4.4.4 DDP Power Commands

- 034 DDP X Sel

This CMD actuates two latching relays, one in each PDU, to the position that applies +5 VDC to the X unit of the digital data processor and removes +5 VDC from the Y unit. DDP X is preset to be energized at initial lunar activation. Repeated application of CMD 034 has no further effect. Switching DDP's in either the DP or LSPE format, normal or slow data rate, results in normal data rate in the same format following a temporary loss of sync.

- 035 DDP Y Sel

This CMD actuates two latching relays, one in each PDU, to the position that applies +5 VDC to the Y unit of the digital data processor and removes +5 VDC from the X unit. Repeated application of CMD 035 has no further effect. Switching DDP's in either the DP or LSPE format, normal or slow data rate, results in normal data rate in the same format following a temporary loss of sync.

3.4.4.5 XMTR Power Commands

- 012 XMTR A On

This CMD actuates a pair of latching relays, one in each PDU, to the position that applies +29 VDC to XMTR A. XMTR A is preset to be energized at initial lunar activation. Repeated application of CMD 012 has no further effect.

- 013 XMTR A Off

This CMD actuates a pair of latching relays, one in each PDU, to the position that removes +29 VDC from XMTR A. Note that there is no XMTR heater to replace the load in the central station when both XMTR's are off, but APM compensation will occur if necessary. Repeated application of CMD 013 has no further effect.

- 014 XMTR B Off

This CMD actuates a pair of latching relays, one in each PDU, to the position that removes +29 VDC from XMTR B and +12 VDC from the diplexer switch. Note that there is no XMTR heater to replace the load in the central station when both XMTR's are off but APM compensation will occur if necessary. XMTR B is preset to be deenergized at initial lunar activation. Repeated application of CMD 014 has no further effect.

- 015 XMTR B On

This CMD actuates a pair of latching relays, one in each PDU, to the position that applies +29 VDC to XMTR B and +12 VDC to the diplexer switch. In the energized state, the diplexer switch connects XMTR B to the antenna; hence, if both XMTR's are commanded on simultaneously, the output of XMTR B will be radiated downlink. The output of XMTR A will be dissipated in a dummy load in the diplexer switch. Repeated application of CMD 015 has no further effect.

3.4.4.6 Periodic CMD Enable and Inhibit

- 104 Per CMD Enable

This CMD actuates circuitry in the CMD decoder to enable output of periodic commands (Figure 3-16) every 15.46 hours except for the first output which is at 7.65 hours. The application of power to ALSEP causes initialization in the enable configuration. Repeated application of CMD 104 has no further effect.

- 105 Per CMD Inhibit

This CMD actuates circuitry in the CMD decoder to inhibit output of periodic CMDS. Repeated application of CMD 105 has no further effect. A sequence of commands 104 and 105, alternating enable/inhibit, does not produce spurious per CMD pulses.

3.4.4.7 PCU Commands

- 060 PCU 1 Sel

This CMD actuates a latching relay in the PCU to the position that applies 16.3 ± 0.5 VDC from the RTG to PCU 1 and disconnects PCU 2 from the RTG. In this position, PCU 1 provides power for the ALSEP system via PDU 1. Repeated application of CMD 060 has no further effect. In normal operation, CMD 121 should be transmitted immediately before CMD 060, unless PC auto 2 switch is already selected. PCU 1 is preset to be energized at initial lunar activation.

- 062 PCU 2 Sel

This CMD actuates a latching relay in the PCU to the position that applies 16.3 ± 0.5 VDC from the RTG to PCU 2 and disconnects PCU 1 from the RTG. In this position, PCU 2 provides power for the ALSEP system via PDU 2. In normal operation, CMD 120 should be transmitted immediately before CMD 062, unless PC auto 1 switch is already selected. Repeated application of CMD 062 has no further effect.

- 120 PC Auto 1 SW Sel

This CMD activates a relay in the PCU to the position that enables automatic switchover from PCU 2 to PCU 1, if the +12 VDC line goes overvoltage longer than 5 ms, or if the +12 VDC, +5 VDC, or -12 VDC lines go undervoltage longer than 300 ms. In this position, automatic switchover from PCU 1 to PCU 2 is inhibited. PC auto 1 SW sel is preset to be energized at initial lunar activation; hence, if normal start-up occurs, CMD 121 should be transmitted as early as possible. Repeated application of CMD 120 has no further effect. In normal operation CMD 120 should be transmitted before CMD 062, unless PC auto 1 SW is already selected. An internally generated PCU switchover is an abnormal condition requiring caution in the subsequent use of CMD 120.

- 121 PC Auto 2 SW Sel

This CMD actuates a relay in the PCU to the position that enables automatic switchover from PCU 1 to PCU 2, if the +12 VDC line goes overvoltage longer than 5 ms, or if the +12 VDC, +5 VDC, or -12 VDC lines go under voltage longer than 300 ms. In this position, automatic switchover from PCU 2 to PCU 1 is inhibited. Repeated application of CMD 121 has no further effect. In normal operation, CMD 121 should be transmitted before CMD 060, unless PC auto 2 SW is already selected. An internally generated PCU switchover is an abnormal condition requiring caution in the subsequent use of CMD 121.

3.4.4.8 APM Commands

- 027 APM 1 On

This CMD actuates a flip-flop in the PCU to the position that allows RTG input power to be diverted to a power dissipation resistor rated at 30 watts maximum if (1) there are more than 2 watts of reserve power on PCU 1, and (2) the thermal plate temp is above the temp switch 1 value: 60°F close, 80°F open. The application of power to PCU 1 causes initialization in the APM 1 on configuration. Repeated application of CMD 027 has no further effect.

- 031 APM 1 Off

This CMD actuates a flip-flop in the PCU to the position that inhibits APM 1 from dissipating RTG power. Repeated application of CMD 031 has no further effect.

- 115 APM 2 On

This CMD actuates a flip-flop in the PCU, to the position that allows RTG input power to be diverted to a 30-watt, maximum power dissipation resistor if (1) there are more than 2 watts of reserve power on PCU 2, and (2) the thermal plate temp is above the temp switch 2 value: 60°F close, 80°F open. The application of power to PCU 2 causes initialization in the APM 2 on configuration. Repeated application of CMD 115 has no further effect.

- 113 APM 2 Off

This CMD actuates a flip-flop in the PCU to the position that inhibits APM 2 from dissipating RTG power. Repeated application of CMD 113 has no further effect.

3.4.4.9 PDR Commands

- 017 PDR 1 On

This CMD actuates two latching relays (in series) in the non-redundant section of the PDU, to the position that applies +29 VDC to a 7-watt power dissipation resistor, and is used as a backup means of PWR/thermal control if the APM cannot cope with the load. Repeated application of CMD 017 has no further effect.

- 021 PDR 1 Off

This CMD actuates two latching relays (in series) in the non-redundant section of the PDU, to the position that removes +29 VDC from the 7-watt power dissipation resistor. PDR 1 is preset to be in the off condition at initial lunar activation. Repeated application of CMD 021 has no further effect.

- 022 PDR 2 On

This CMD actuates two latching relays (in series) in the non-redundant section of the PDU, to the position that applies +29 VDC to a 14-watt power dissipation resistor, and is used as a backup means of PWR/thermal control if the APM cannot cope with the load. Repeated application of CMD 022 has no further effect.

- 023 PDR 2 Off

This CMD actuates two latching relays (in series) in the non-redundant section of the PDU, to the position that removes +29 VDC from the 14-watt power dissipation resistor. PDR 2 is preset to be in the off condition at initial lunar activation. Repeated application of CMD 023 has no further effect.

3.4.4.10 Experiment Power Switching

- 036 EXPER 1 Oper (LMS)

This CMD actuates latching relays, in both PDU's, to the position that applies +29 VDC to the operating line of the LMS. Repeated application of CMD 036 has no further effect.

- 037 EXPER 1 STBY (LMS)

This CMD actuates latching relays, in both PDU's, to the position that removes +29 VDC operational power from the LMS, if it was in the operate mode, and applies +29 VDC to the standby line. In the off mode, CMD 037 does not control PWR and the experiment remains off. Repeated application of CMD 037 has no further effect.

- 041 EXPER 1 Off (LMS)

This CMD actuates latching relays, in both PDU's, to the position that removes all +29 VDC power from the LMS, whether it was previously in the operate mode or the standby mode. The experiment relays are preset to be in the off mode at initial lunar activation. Repeated application of CMD 041 has no further effect.

- 042 EXPER 2 Oper (LEAM)

This CMD actuates latching relays, in both PDU's, to the position that applies +29 VDC to the operating line of the leam. Repeated application of CMD 042 has no further effect.

- 043 EXPER 2 STBY (LEAM)

This CMD actuates latching relays, in both PDU's, to the position that removes +29 VDC operational power from the LEAM, if it was in the operate mode, and applies +29 VDC to the standby line. In the off mode, CMD 043 does not control PWR and the experiment remains off. Repeated application of CMD 043 has no further effect.

- 044 EXPER 2 Off (LEAM)

This CMD actuates latching relays, in both PDU's, to the position that removes all +29 VDC PWR from the LEAM, whether it was previously in the operate mode or the standby mode. The experiment relays are preset to be in the off mode at initial lunar activation. Repeated application of CMD 044 has no further effect.

- 045 EXPER 3 Oper (HFE)

This CMD actuates latching relays, in both PDU's, to the position that applies +29 VDC to the operating line of the HFE. Repeated application CMD 045 has no further effect.

- 046 EXPER 3 STBY (HFE)

This CMD actuates latching relays, in both PDU's, to the position that removes +29 VDC operational power from the HFE, if it was in the operate mode, and applies +29 VDC to the standby line. In the off mode, CMD 046 does not control PWR and the experiment remains off. Repeated application of CMD 046 has no further effect.

- 050 EXPER 3 Off (HFE)

This CMD actuates latching relays, in both PDU's, to the position that removes all +29 VDC PWR from the HFE, whether it was previously in the operate mode or the standby mode. The experiment relays are preset to be in the off mode at initial lunar activation. Repeated application of CMD 050 has no further effect.

- 052 EXPER 4 Oper (LSG)

This CMD actuates latching relays, in both PDU's, to the position that applies +29 VDC to the operating line of the LSG. Repeated application of CMD 052 has no further effect. Note that when switching EXPER 4 OFF, the LSG may automatically switch to EXPER 4 STBY. If this occurs, as indicated by AB-05, repeat CMD 052 and LSG will switch to the Operate mode.

- 053 EXPER 4 STBY (LSG)

This CMD actuates latching relays, in both PDU's, to the position that removes +29 VDC operational power from the LSG, if it was in the operate mode, and applies +29 VDC to the standby line. In the off mode, CMD 053 does not control PWR and the experiment remains off. Repeated application of CMD 053 has no further effect.

- 054 EXPER 4 Off (LSG)

This CMD actuates latching relays, in both PDU's, to the position that removes all +29 VDC PWR from the LSG, whether it was previously in the operate mode or the standby mode. The experiment relays are preset to be in the off mode at initial lunar activation. Repeated application of CMD 054 has no further effect.

- 055 EXPER 5 Oper (LSP)

This CMD actuates latching relays, in both PDU's, to the position that applies +29 VDC to the operating line of the LSP. Astro SW 2 is also in this line and TM will show oper mode regardless of the state of astro SW 2. Repeated application of CMD 055 has no further effect.

- 056 EXPER 5 STBY (LSP)

This CMD actuates latching relays, in both PDU's, to the position that removes +29 VDC operational power from the LSP, if it was in the operate mode, and applies +29 VDC to the standby line. The LSP has no standby mode. In the off mode, CMD 056 does not control PWR and the experiment remains off. The experiment relays are preset to be in the STBY mode at initial lunar activation. Repeated application of CMD 056 has no further effect.

- 057 EXPER 5 Off (LSP)

This CMD actuates latching relays, in both PDU's, to the position that removes all +29 VDC pwr from the LSP, whether it was previously in the operate mode or the standby mode. Repeated application of CMD 057 has no further effect.

3.4.4.11 Ripple-Off Reset Command

- 032 Ripple-off Reset

This CMD resets the counter in the ripple-off sequencer, thus restoring the ripple-off capability after the counter has run to the end and locked itself out. The lock-out feature is provided in case a malfunction in the ripple-off circuitry causes erroneous ripple-off. If a reset by CMD 032 is followed by a second (erroneous) ripple-off, CMD 032 should be flagged as critical. When no malfunction exists in the ripple-off circuitry, repeated application of CMD 032 has not further effect. In normal ALSEP start-up, the ripple-off counter is reset by the turn-on PWR transient.

SECTION 4.0. HEAT FLOW EXPERIMENT

4.1. HFE Deployment Criteria

TABLE 4-1. HEAT FLOW EXPERIMENT DEPLOYMENT CRITERIA

PARAMETER	CRITERIA
HFE Electronics Package Site Selection	Deploy the HFE Electronics Package 7.5 to 9 meters (25 to 30 feet) due north of Central Station (ALSEP Subpackage #1). Distance is limited by a 9-meter (30-foot) cable. HFE Electronics Package should be placed in an approximately level area, removed from any surface irregularities or rocks that may obscure the field-of-view of the sunshield reflector.
Electronics Package Alignment	Align the HFE Electronics Package so that the shadow cast by the UHT on the partial compass rose falls within 3 degrees of the Shadow Line decal. See Figure 4-1. Radiator must face north away from equator and the Central Station. Boyd bolts must be removed so that they will not fall into radiator. Alignment of HFE package is accomplished by rotating package until shadow cast by UHT covers alignment decal.
Electronics Package Leveling	Level the HFE Electronics Package to within ± 5 degrees of the 15-degree tilt angle for maximum utilization of the thermal sunshield utilizing the bubble level. Bubble should be free from case circle to be within 5 degrees of the 15-degree tilt angle.
HFE Probe Deployment	Deploy the probes 5 meters (16 to 18 feet) east and west of the electronics package along the sun line. The two bore holes must be a minimum of 9 meters (30 feet) apart. Probe separation is limited by length of cables. Probe cable positioning must be known. The nearest HFE probe must be 6 meters (20 feet) minimum from the LACE (mass spectrometer), 9 meters (30 feet) minimum from the RTG, 5.2 meters (17 feet) minimum from the LSPE antenna, and at least 5.2 meters (17 feet) from all other experiments and debris.
Drill HFE Bore Holes with Apollo Lunar Surface Drill (ALSD)	Use the ALSD to drill the two HFE bore holes at least 2.44 meters deep with at least 9 meters (30 feet) between the two bore holes. The bore holes should be straight enough that the HFE probes, when inserted in the bore stem casings, are within 15 degrees of the true vertical. The bore stem casing in each of the HFE bore holes should protrude above the lunar surface approximately 20 to 30 cm.

TABLE 4-1. HEAT FLOW EXPERIMENT DEPLOYMENT CRITERIA (Continued)

PARAMETER	CRITERIA
Drill HFE Bore Holes with Apollo Lunar Surface Drill (ALSD) (continued)	Whenever ALSD is placed on the lunar surface, it should be handled with the lanyard and oriented with the battery end down and with the back of the battery facing the sun. Do not place the ALSD in the shade. Normal drilling rate is one inch per second. If drilling rate is less than 5 inches per minute with the first bore stem section, remove bore stem and choose new location approximately 1 meter away. If unsuccessful there, move to another location; then, if successful, continue drilling until 10 minutes of ALSD power-ON time have elapsed. Each hole should be $1\frac{1}{2}$ diameters from the rims of "fresh" craters more than 1 meter across. Each hole should be 3 or more diameters from boulders more than 1 meter across. Try to avoid having a "fresh" crater greater than 2 meters across between bore holes. Try to avoid having a "fresh" crater greater than 5 meters across between the HFE bore holes and the core sample hole. Disturbance of the lunar surface within 17 feet of probes should be minimal. The area around the probe holes should not be cluttered with debris within a radius of 17 feet. Once the HFE probe is in the hole, do not try to remove it or the bottom hole latch will be damaged. Use probe emplacement tool to insert HFE probe into bore stem casing. Emplacement tool should be attached to top of probe at the first thermal shield. When inserted to proper depth, index on tool should be P1. Astronaut will report actual depth reading to MCC. Attach emplacement tool to second thermal shield and insert shield to depth indicated by tool stripe marked F1. Astronaut will then use emplacement tool to measure length of bore stem protruding above lunar surface and also report this reading to MCC. The reading should be between A7 and B6.

TABLE 4-1. HEAT FLOW EXPERIMENT DEPLOYMENT CRITERIA (Concluded)

PARAMETER	CRITERIA
Drill HFE Bore Holes with Apollo Lunar Surface Drill (ALSD) (concluded)	Emplace the third thermal shield as a cap at top of bore stem. Align each HFE probe cable as it exits stem so that the section of cable covered by a 5-inch black strip runs due south.
LGE Core Sample	After the two HFE bore holes have been drilled, the ALSD will be used to obtain a deep core sample as part of the Lunar Geology Investigation (S-059). This core hole should be drilled approximately 15 meters north of the deployed HFE probes.

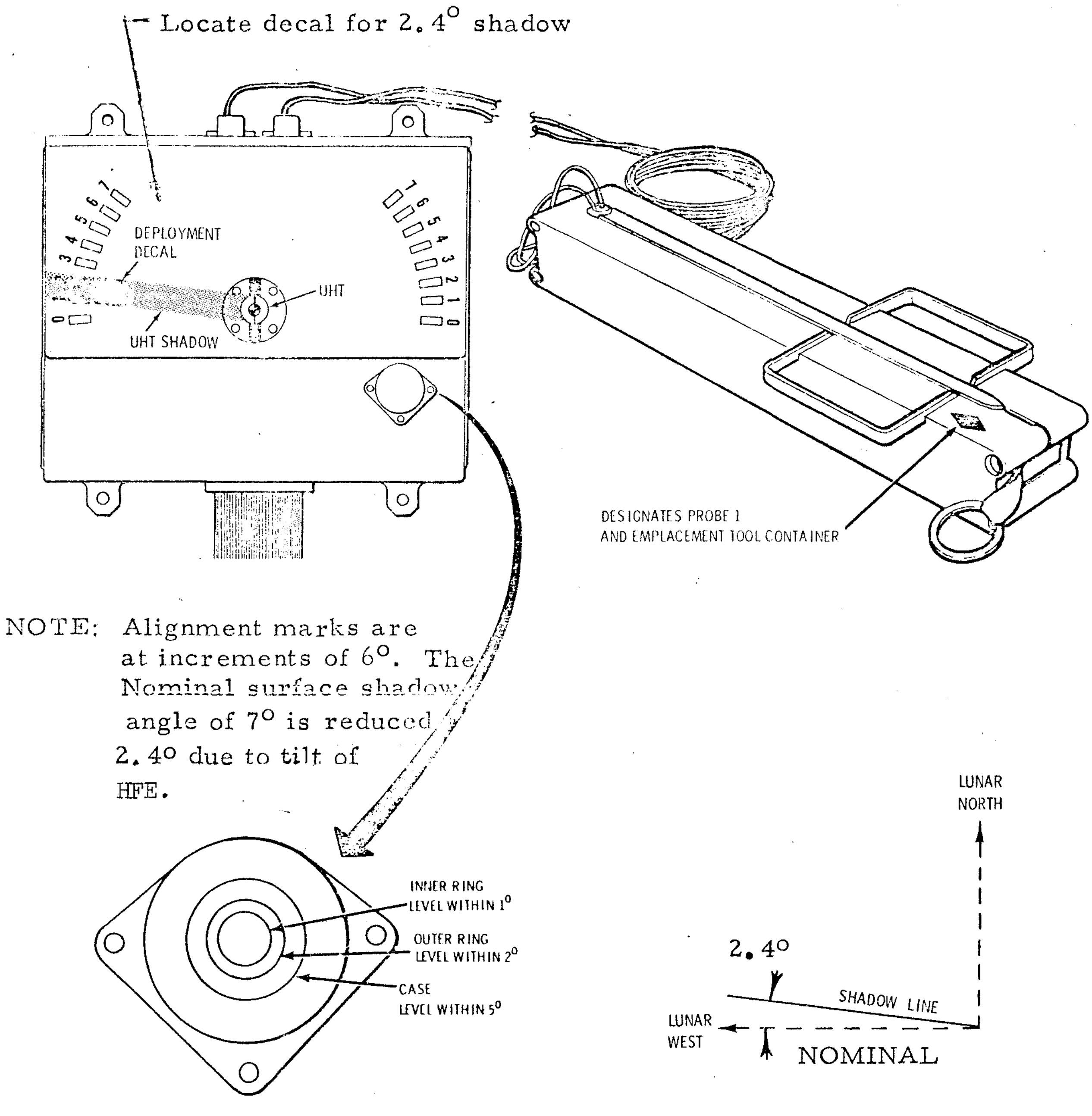


Figure 4-1. HFE Level and Alignment Indicators

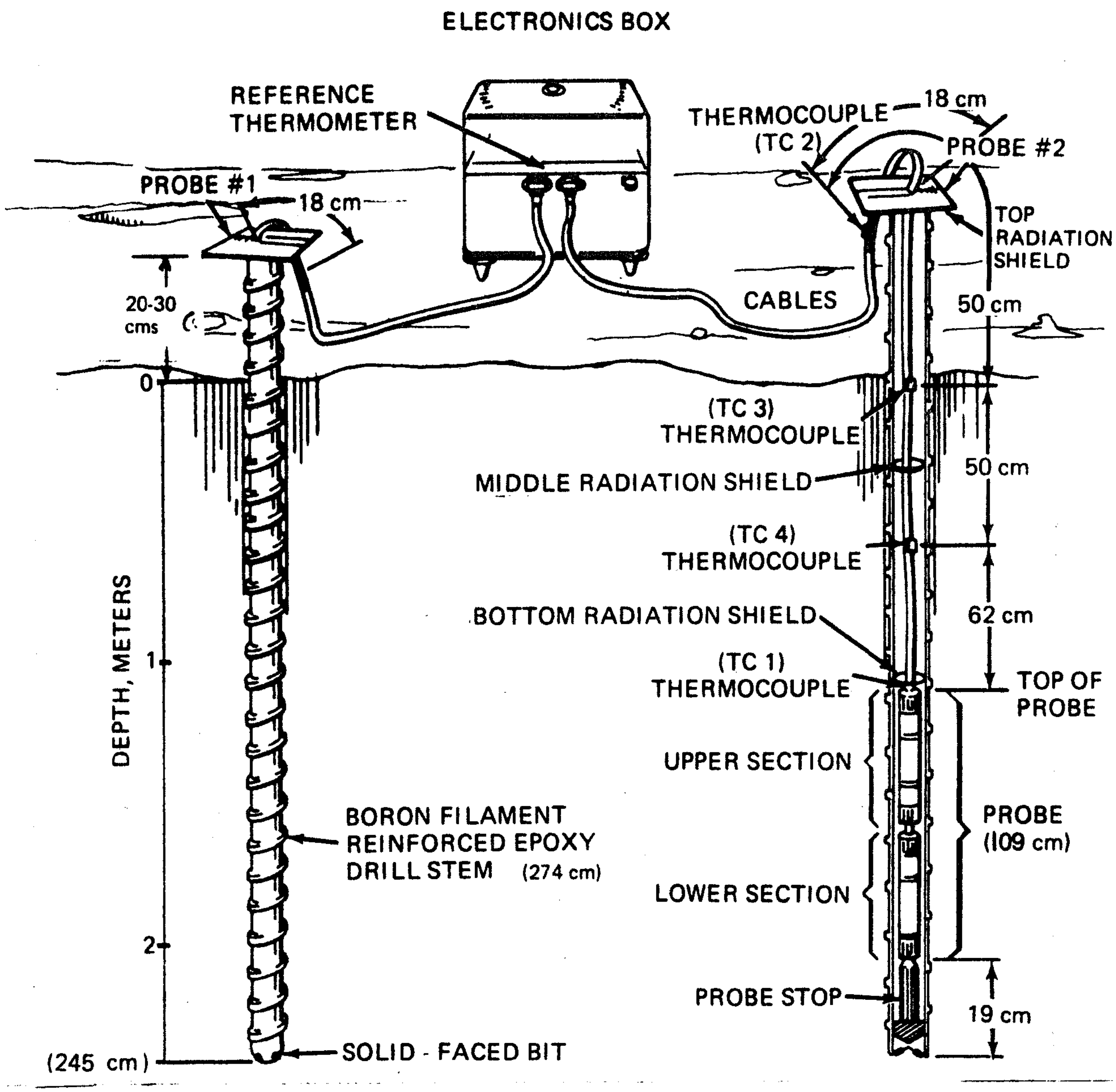


Figure 4-2. Heat Flow Probes Deployed

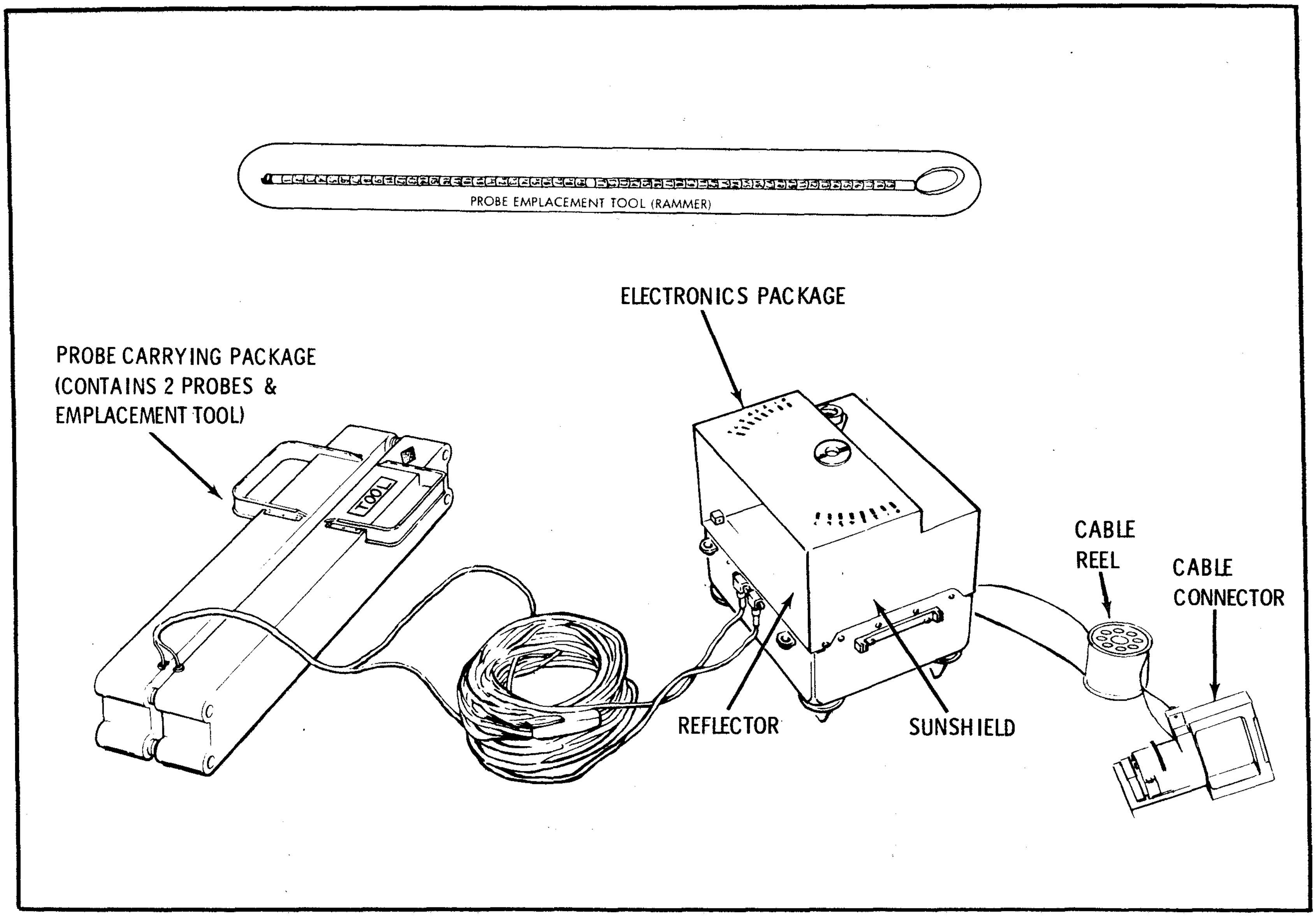


Figure 4-3. HFE Components

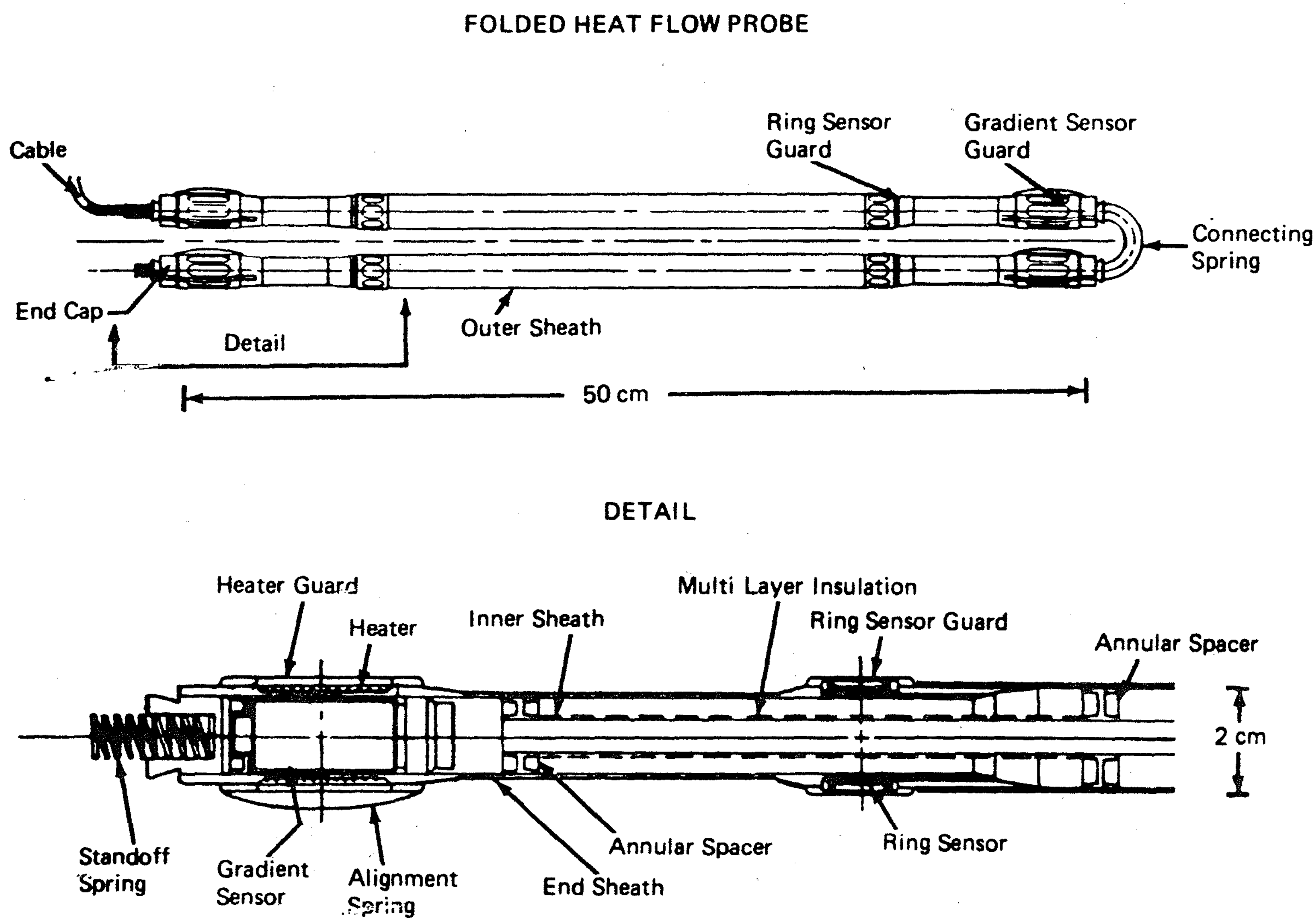


Figure 4-4. HFE Probe Details

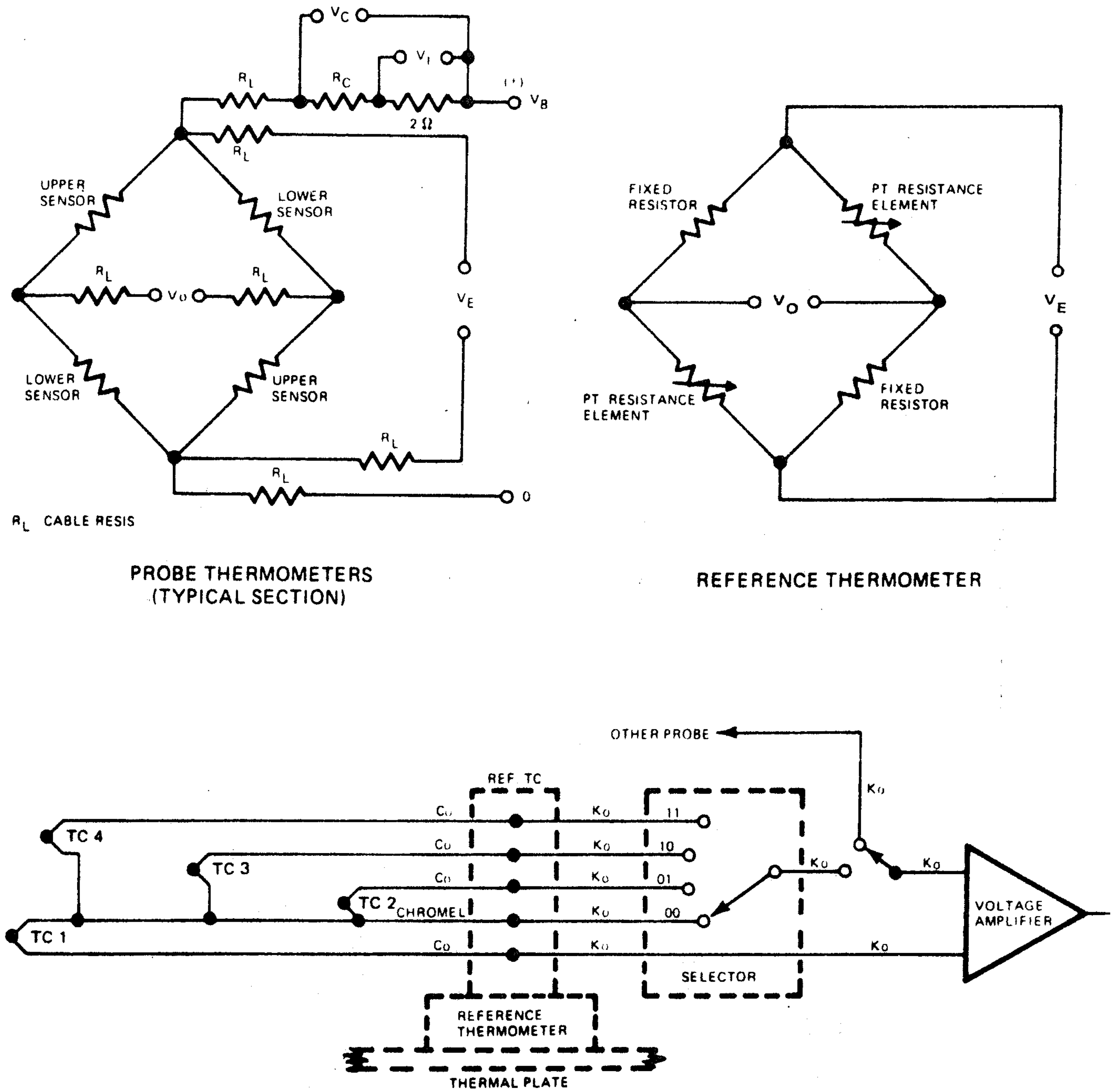
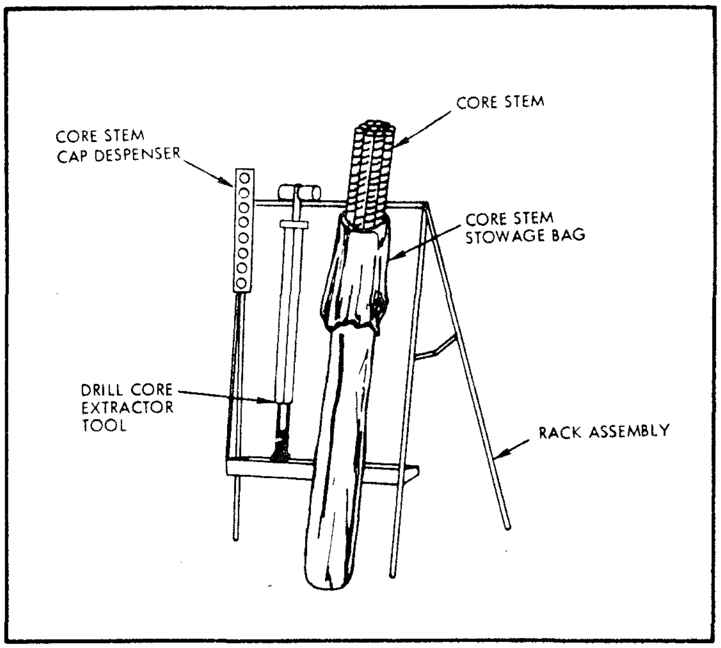


Figure 4-5. HFE Sensor Circuit Configuration



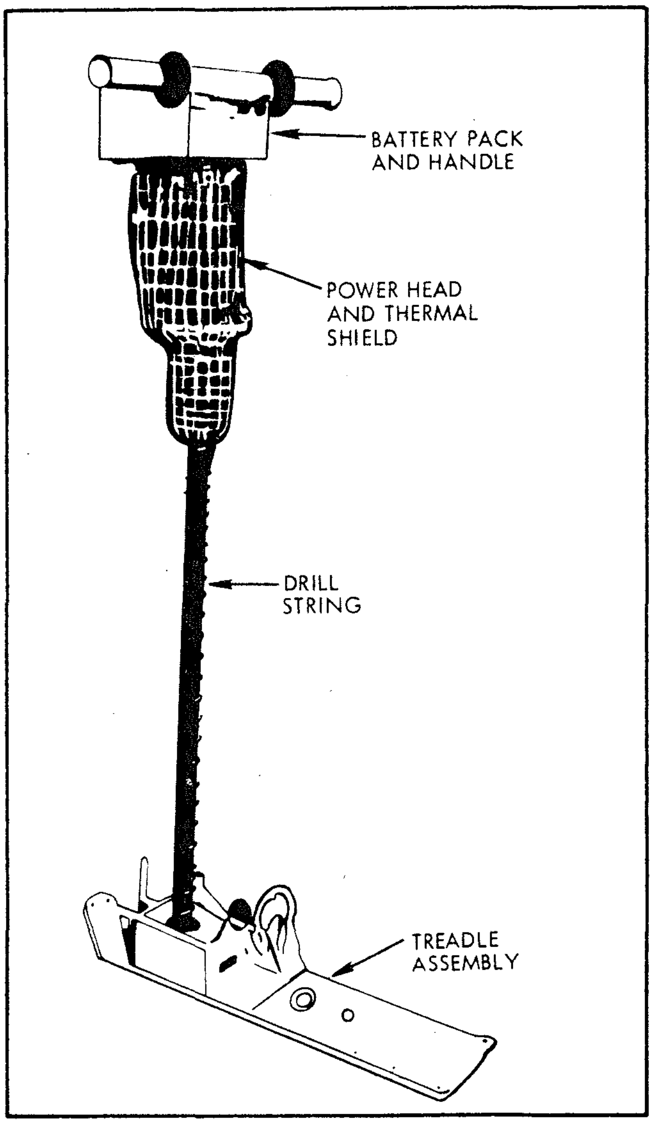


Figure 4-6. Apollo Lunar Surface Drill Components

4.2 HFE OPERATIONAL DATA

4.2.1 HFE Scientific Data

The two Heat Flow Experiment sensor probes (Figure 4-4) provide temperature measurement sensors at various locations down the specially-drilled holes in which they are emplaced. The temperature responses of the sensors in one of the circuit configurations shown in Figure 4-5 are measured. The series of voltage measurements are listed in Table 4-2. These measurements constitute the primary scientific data from the HFE instrument from which it is possible to derive the absolute temperature measured by each sensor, the thermal gradients along each probe and in conjunction with local electrical heating the thermal properties of the lunar sub-surface material.

The "Measurement-Numbers" listed in Table 4-2 are the designations used on the Mission Control Center printer display to identify the parameters derived from these primary scientific measurements. The interpretation of these, and other, designations used on the printer display are provided in Table 4-3. The values of these computed parameters to be expected during normal operation are provided in Table 4-4. Additional data on the HFE Scientific Data Measurements are provided in the "Measurements Requirements Document - Array E", SE-33.

TABLE 4-2.

IDENTIFICATION OF HFE MEASUREMENT CONFIGURATIONS

PROBE 1 MEASUREMENTS									HEATER
Sci. Mode	Meas. No.	Sensor & Section	Circuit (Fig. 4-5)	V_B	Meas. in HFE Word 0	1	2	3	
1 and 2	DTH 11	Grad/Up	Bridge	$\pm 4^V$	$+V_E$	$+V_O$	$-V_E$	$-V_O$	
	DTH 12	Grad/Lo	Bridge	$\pm 4^V$	$+V_E$	$+V_O$	$-V_E$	$-V_O$	
	DTL 11	Grad/Up	Bridge	$\pm 0.4^V$	$+V_C$	$+V_O$	$-V_C$	$-V_O$	
	DTL 12	Grad/Lo	Bridge	$\pm 0.4^V$	$+V_C$	$+V_O$	$-V_C$	$-V_O$	
	T 11	Grad/Up	Bridge	$\pm 4^V$	$+V_E$	$+V_I$	$-V_E$	$-V_I$	
	T 12	Grad/Lo	Bridge	$\pm 4^V$	$+V_E$	$+V_I$	$-V_E$	$-V_I$	
	TCR 1	- -	Ref. Bridge	± 0.5	$+V_E$	$+V_O$	$-V_E$	$-V_O$	
	TC 1	- -	Thermcpl.	-	1	2	3	4	
3	DT 111	Ring/Up	Bridge	$\pm 4^V$	$+V_E$	$+V_O$	$-V_E$	$-V_O$	1
	DT 112	Ring/Up	Bridge		$+V_E$	$+V_O$	$-V_E$	$-V_O$	2
	DT 123	Ring/Lo	Bridge		$+V_E$	$+V_O$	$-V_E$	$-V_O$	3
	DT 124	Ring/Lo	Bridge		$+V_E$	$+V_O$	$-V_E$	$-V_O$	4
	T 111	Ring/Up	Bridge		$+V_E$	$+V_I$	$-V_E$	$-V_I$	1
	T 112	Ring/Up	Bridge		$+V_E$	$+V_I$	$-V_E$	$-V_I$	2
	T 123	Ring/Lo	Bridge		$+V_E$	$+V_I$	$-V_E$	$-V_I$	3
	T 124	Ring/Lo	Bridge		$+V_E$	$+V_I$	$-V_E$	$-V_I$	4

TABLE 4-2. (Concluded)

IDENTIFICATION OF HFE MEASUREMENT CONFIGURATIONS

PROBE 2 MEASUREMENTS									HEATER
Sci. Mode	Meas. No.	Sensor & Section	Circuit (Fig. 4-5)	V_B	Meas. in HFE Word 0	1	2	3	
1 and 2	DTH 21	Grad/Up	Bridge	$\pm 4^V$	$+V_E$	$+V_O$	$-V_E$	$-V_O$	
	DTH 22	Grad/Lo	Bridge	$\pm 4^V$	$+V_E$	$+V_O$	$-V_E$	$-V_O$	
	DTL 21	Grad/Up	Bridge	$\pm 0.4^V$	$+V_C$	$+V_O$	$-V_C$	$-V_O$	
	DTL 22	Grad/Lo	Bridge	$\pm 0.4^V$	$+V_C$	$+V_O$	$-V_C$	$-V_O$	
	T 21	Grad/Up	Bridge	$\pm 4^V$	$+V_E$	$+V_I$	$-V_E$	$-V_I$	
	T 22	Grad/Lo	Bridge	$\pm 4^V$	$+V_E$	$+V_I$	$-V_E$	$-V_I$	
	TCR 2	- -	Ref. Bridge	$\pm 0.5^V$	$+V_E$	$+V_O$	$-V_E$	$-V_O$	
	TC 2	- -	Thermcpl.	-	1	2	3	4	
3	DT 211	Ring/Up	Bridge	$\pm 4^V$	$+V_E$	$+V_O$	$-V_E$	$-V_O$	1
	DT 212	Ring/Up	Bridge		$+V_E$	$+V_O$	$-V_E$	$-V_O$	2
	DT 223	Ring/Lo	Bridge		$+V_E$	$+V_O$	$-V_E$	$-V_O$	3
	DT 224	Ring/Lo	Bridge		$+V_E$	$+V_O$	$-V_E$	$-V_O$	4
	T 211	Ring/Up	Bridge		$+V_E$	$+V_I$	$-V_E$	$-V_I$	1
	T 212	Ring/Up	Bridge		$+V_E$	$+V_I$	$-V_E$	$-V_I$	2
	T 223	Ring/Lo	Bridge		$+V_E$	$+V_I$	$-V_E$	$-V_I$	3
	T 224	Ring/Lo	Bridge		$+V_E$	$+V_I$	$-V_E$	$-V_I$	4

TABLE 4-3.

HFE SCIENCE DATA DISPLAY

Display Heading	Data Interpretation
MEAS.	For interpretation see Table 4-2.
RATIO	The result of combining the measurement words from a particular bridge configuration in the ratio $\frac{\text{Word 1 - Word 3}}{\text{Word 0 - Word 2}}$
RB	The value of bridge resistance (ohms) derived from the application of a calibration curve to the associated value of RATIO
VALUE (°K)	The temperature derived for each probe/section from a. bridge resistance value of the absolute temperature measurement (T) b. ratio value of the differential temperature measurement c. polynominals containing configuration and calibration factors.
GAIN	Measurement system gain for reference temperature and thermocouple measurements
OFFSET	Measurement system offset for reference temperature and thermocouple measurements referred to the amplifier input.

TABLE 4-4.

HFE COMPUTED SCIENTIFIC DATA

Meas.	Frame	DESCRIPTION	Normal Operating Range	
			Low	High
DTH	--	Temp. Difference @ HI Sensitivity		
		.Ratio	-.0058	+.0058
		.Bridge Resistance (ohms)	352	452
		.Value (°K)	- 2	+ 2
DTL	--	Temp. Difference @ LO Sensitivity		
		.Ratio	-.058	+.058
		.Bridge Resistance (ohms)	352	452
		.Value (°K)	- 20	+ 20
T	--	Absolute Temperature		
		.Ratio	+.0046	+.0058
		.Bridge Resistance (ohms)	352	452
		.Value (°K)	200	250
TCR	--	Reference Temperature (°K)	285	328
TC	--	Thermocouples (°K)	70	350
GAIN	--	Amplifier Gain	994	1001
OFFSET	--	Amplifier Offset	+.000130	+.000220

4.2.2 HFE Engineering Data

Information on the HFE equipment performance and operational status is provided in 4 analog measurements and 6 mode status indicators. The values of the analog engineering measurements to be expected during normal operation are listed in Table 4-5. The status indicators are described in Table 4-6.

4.2.3 HFE Operational Modes

The HFE has 3 basic measurement modes, namely

- Gradient Mode (Mode 1)
- Conductivity Modes:
  - low (Mode 2)
  - high (Mode 3)

Each of these modes of operation has a unique set of measurement sequences which can be selected or modified by ground command. Measurement data are listed in the "Measurements Requirements Document - Array E", SE-33.

Initial application of supply power to the HFE places the instrument in Mode 1 with its full sequence of measurements. This mode is also referred to as the normal mode of operation. This full sequence of measurements has a period of 7.25 minutes at normal data rate. The command sequences for selecting subsets of the full HFE measurement cycle during Modes 1 and 2 are:

- 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 preceded or followed by command 146 selects a subset consisting of thermocouple measurements only.

TABLE 4-5.

HFE ANALOG ENGINEERING MEASUREMENTS

Meas. No.	Frame	DESCRIPTION	Normal Operating Range		Nominal	Measurement Limits	
			Low	High		Low	High
AH-1	29	+ 5 Volt Supply	+ 3.5	+ 5.5	+ 5	+ 0.09	+ 7.11
(1) AH-2	45	- 5 Volt Supply	- 3.5	- 5.5	- 5	- 2.90	- 8.84
AH-3	55	+ 15 Volt Supply	+12.0	+15.5	+15	+ 1.17	+20.63
(1) AH-4	74	- 15 Volt Supply	-12.0	-15.5	-15	-10.98	-19.95

NOTE 1: The engineering values for these measurements are a function of the concurrent value of AH-3. The following calibration curves should be used:

07: when AH-3 = 14^v
08: when AH-3 = 15^v
09: when AH-3 = 16^v

TABLE 4-6.

HFE OPERATIONAL STATUS INDICATORS

Parameters	Meas. No.	Indication
Science Mode	DH-90	
. Gradient		1
. Low Conductivity		2
. High Conductivity		3
Measurement Configuration	DH-91	(See Table 4-2)
. Wheatstone Bridge		DT
. Total Resistance		T
. Reference Bridge		TCR
. Thermocouple		TC
. High Sensitivity		H
. Low Sensitivity		L
HFE Data Word	DH-92	(Not Displayed - See Table 4-2)
Heater Status	DH-93	
. Heater Designation		
- Probe 1		H11/H12/H13/H14
- Probe 2		H21/H22/H23/H24 (See Table 4-9 for physical location)
. Heater Circuit	DH-93	ON/OFF
. Heater Supplies		
- High Conductivity	AH-6	ON/OFF
- Low Conductivity	AH-7	ON/OFF

In the conductivity modes the main characteristic is the programming of the heaters built into each probe. These heaters are selected by means of repeated use of CMD 152 as detailed in Table 4-9. The temperature sensors used and the heat excitation applied are both different in Modes 2 and 3. For Low Conductivity (Mode 2) measurements the same sensors are used as in Mode 1. The heater excitation provides 0.002 watts of power. For High Conductivity (Mode 3) measurements small (ring bridge) sensors are used. These elements are located toward the middle of each probe section approximately 10 centimeters from each heater. When energized in this mode the selected heater dissipates 0.5 watt. As shown in Table 4-9, the ring bridge sensor is governed by the heater selection.

Transferring in and out of Mode 3 generally requires a sequence of ground commands, as follows:

(a) The command sequence for transfer from Modes 1 or 2 to Mode 3 is:

CMD 140, preceded or followed by
CMD 144 and CMD 142

(b) The command sequence for transfer out of Mode 3,

- to Mode 1 is: CMD 135, followed by CMD 141
- to Mode 2 is: CMD 136, followed by CMD 141

(CMD 141 selects full measurement cycle)

Command decoder signals representative of octal commands 135, 136, 140 and 152 are stored within the HFE for execution at the time of the next 90-frame pulse event. For this reason, successive issuance of these commands should be delayed by approximately one minute.

4.2.4 HFE Power Demands

The HFE electronics unit has a double-threshold thermal-control system in which maximum electrical power is dissipated internally at temperatures below 20°C and the dissipation is minimized at temperatures above 30°C. This programming of electrical power for thermal control is reflected in the power profiles for each operating mode as shown in Figure 4-7. Since the only monitor of power usage during system operation is the display of reserve power (CS-60, or CS-61), the transition between major power states will appear as approximately 110% of these changes (due to power conversion losses).

Operating temperature predictions for the HFE electronics package are shown in Figure 4-8.

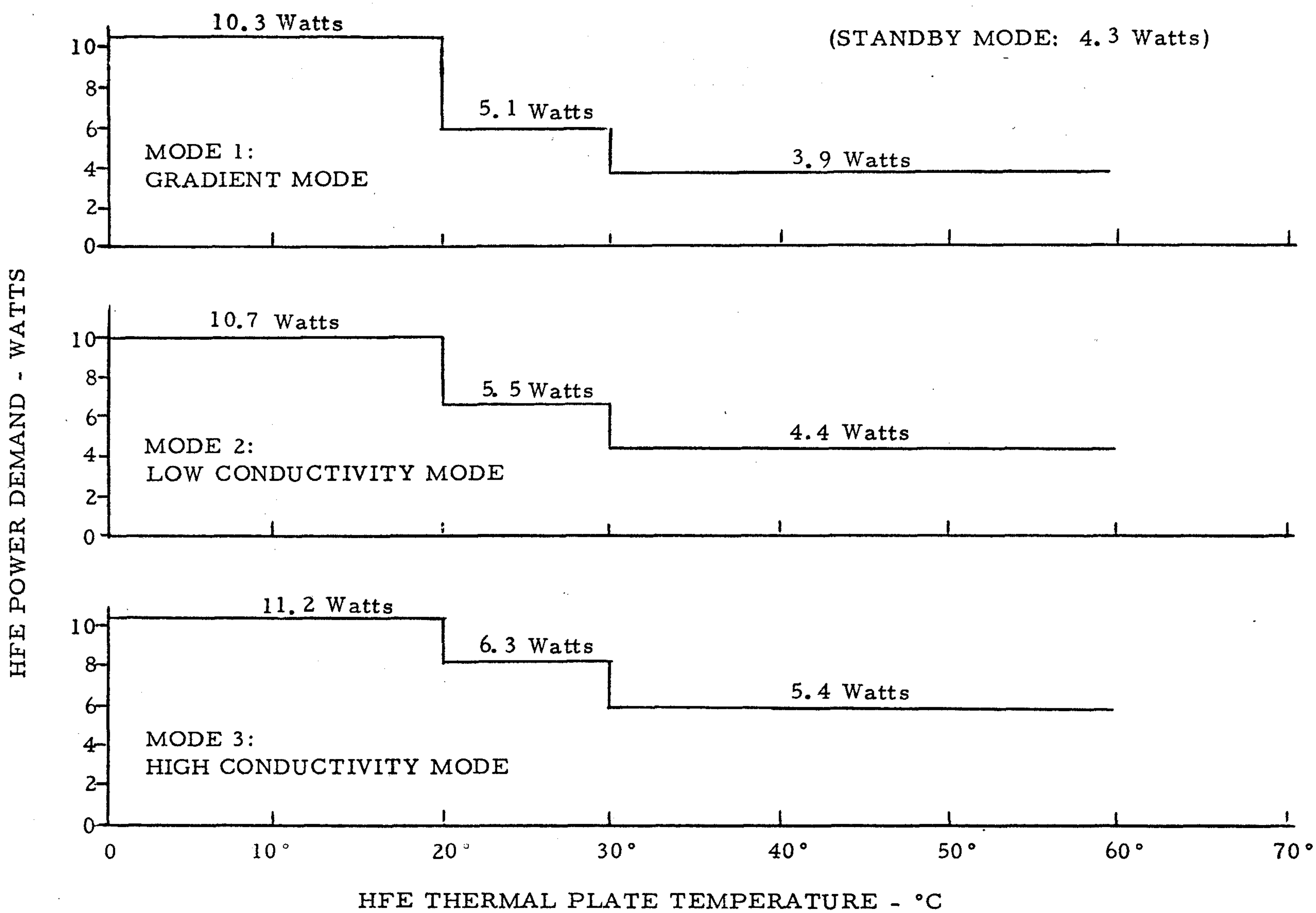


Figure 4-7. HFE Power Profile

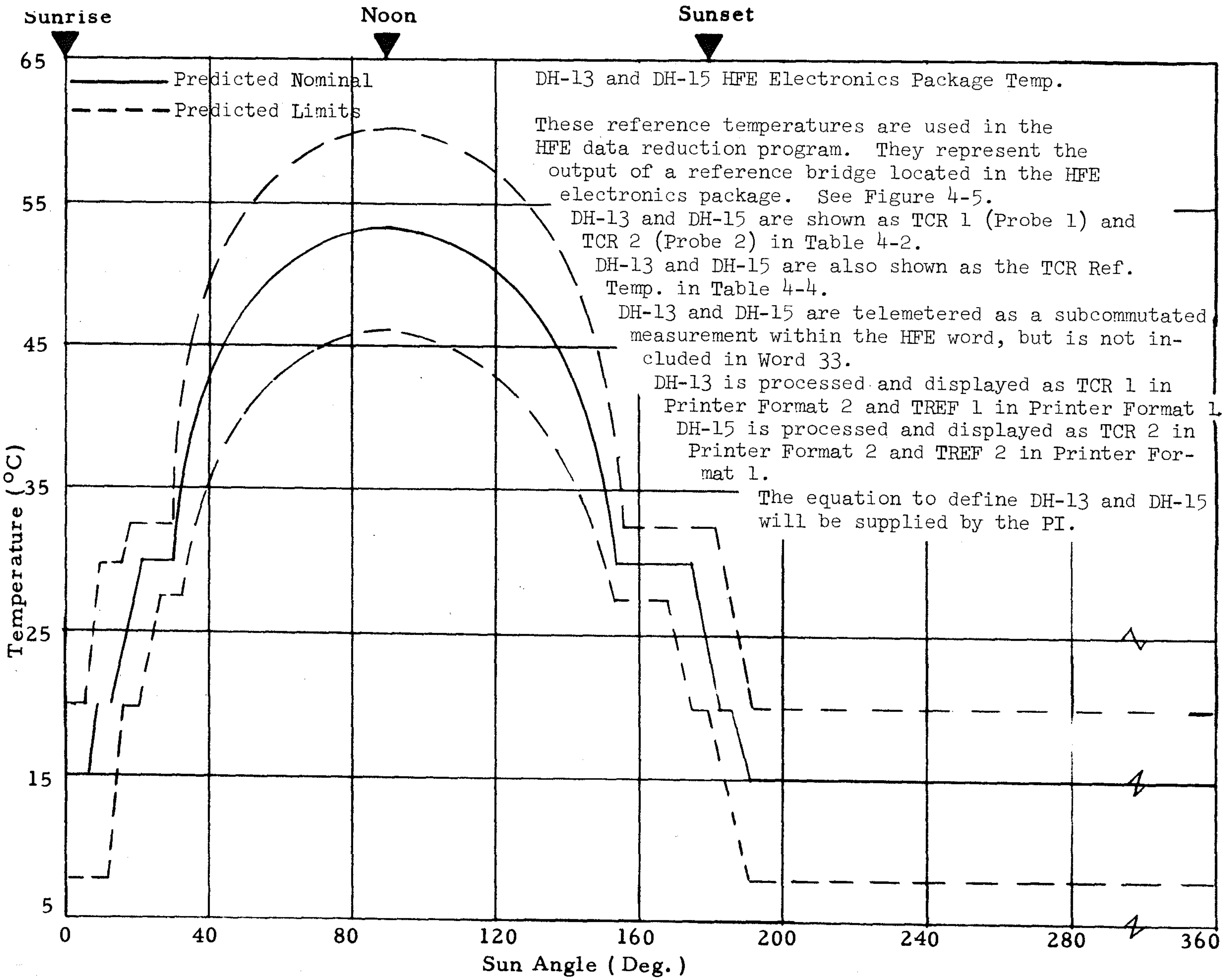


Figure 4-8. HFE Temperature Predictions

4.2.5 Apollo Lunar Surface Drill (ALSD)

The Apollo Lunar Surface Drill (ALSD) is part of the equipment complement for the Apollo 17 Mission and serves two purposes. First, as a necessary item of ancillary equipment for the Heat Flow Experiment, it provides the means by which the astronaut will drill two 1.0"-diameter holes approximately 8 feet deep into which the two HFE probes will be placed. Second, as part of the Lunar Geology Experiment, the ALSD will be used to drill a third hole about 10 feet deep to obtain a core sample of the lunar subsurface which is returned to Earth for detailed laboratory analysis. The characteristics of the drill are listed in Table 4-7.

Emplacement of the two HFE probes makes it necessary for the two sets of bore stems to remain in the bore holes, functioning as casing to facilitate insertion of the heat probes without danger of cave-ins. The HFE probe emplacement tool is a telescoping tube with an open clip at the end to engage the Heat Flow probe cable. This tool is packaged with HFE probe 1 in the container marked with the red diamond as shown in Figure 4-3. It is marked every two centimeters with alphanumeric characters to indicate the depth to which the HFE probe has been emplaced in the bore stem casing as well as the depth to which the bore stem assembly has been drilled into the subsurface. Reading from the bottom to the top of the probe emplacement tool, the coding is consecutively A1 through A9, B1 through B9, C1 through C8, F1 through F9, J1 through J9, K1 through K8, L1 through L9, N1 through N9, P1 through P9, T1 through T9, V1 through V9 and Y1 through Y9. See Table 4-8 for interpretation of the markings. An orange mark is painted on the emplacement tool covering P1 to designate nominal hole depth, and another orange mark covering F1 indicates the depth to which the middle radiation shields should be pushed.

TABLE 4-7.

APOLLO LUNAR SURFACE DRILL DATA

CHARACTERISTICS	VALUE
ALSD Total Weight	31.8 lbs.
ALSD Volume	7.0 x 9.6 x 22.7 in. (less Bore and Core Stems)
. Battery - Yardney PM-5	16 cells
Cell Assembly	AgO-Zn
Electrolyte	40% KOH; 17cc/Cell
Open Circuit Voltage - Full Charge	29.6 ± 0.5 vdc
Operating Voltage	23.0 ± 1.0 vdc
Operating Current	18.75 amps
Capacity	300 watt-hours, min.
Cell Operating Pressure	8 ± 3 psia
Case Operating Pressure	5 ± 1 psia
Weight	7.28 lbs.
Operating Temperature Range	+20° to 225°F
. Power Head	
Load Speed	9300 RPM
Output Spindle Speed	280 RPM
Percussion Rate	2270 Blows/Minute
Energy per Blow	39 inch-pounds
Blows per Revolution of Bit	8.1
. Bore String Assemblies - 2 sets	3 Stems per Set
Assembled length	108 inches
Bore Stem Length	54" (Lower), 28" (Top Two)
Weight - Bore Stem Set	1.8 lbs.
Bore Stem Composition	Axially aligned Boron filaments between layers of circumferentially wrapped epoxy-impregnated fiberglas.
Bore Stem Coupling	Titanium (threaded)
Cutting Transport	Two helical flutes; 1-inch lead
Bore Stem Drill Bit	Closed face; 5 peripheral tungsten carbide cutters; 1 center tungsten-carbide cutter.
Bore Stem Drill Bit Cutting Diameter	1.125 inches

TABLE 4-7. (Concluded)

APOLLO LUNAR SURFACE DRILL DATA

CHARACTERISTICS	VALUE
. Core String Assembly	
Total Length - 8 Core Stems	120 inches
Core Stem Lengths	7 ea. @ 16.75 inches 1 ea. @ 15.25 inches
Weight - Core Stem Assy.	2.6 lbs
Core Stem Composition	6Al - 4V Titanium
Core Stem Coupling	Double, Acme-type, 1-inch lead threads.
Cutting Transport	Two externally machined helical flutes; 1-inch lead.
Core Stem Drill Bit	Open face steel body, 5 tungsten-carbide cutters.
Core Stem Drill Bit Cutting Diameter	1.032 inches
. Drilling Times	
(a) High torque; 30-amp battery drain	25 minutes drilling time available
(b) Medium torque; 25-amp battery drain	30 minutes drilling time available
(c) Low torque; 20-amp battery drain	38 minutes drilling time available
(d) No torque, no load; 19-amp battery drain	44 minutes drilling time available

Note: Based on a 13-amp hour battery capacity and the drilling times shown, the percentage of the total available battery capacity expended during each minute of drilling time varies from about 2.25% to 4% per minute.

TABLE 4-8.

HEAT FLOW EMPLACEMENT TOOL INDICATIONS

Tool Marking	Centimeters from Top of Probe	Tool Marking	Centimeters from Top of Probe	Tool Marking	Centimeters from Top of Probe
	-3 (TC1)		74		146
A1		J1		P1	
	4		76		148
A2		J2		P2	
	6		78		150
A3		J3		P3	
	8		80		152
A4		J4		P4	
	10		82		154
A5		J5		P5	
	12		84		156
A6		J6		P6	
	14		86		158
A7		J7		P7	
	16		88		160
A8		J8		P8	
	18		90		162 TC2
A9		J9		P9	
	20		92		
	20		92		166
B1		K1		T1	
	22		92		168
B2		K2		T2	
	24		96		170
B3		K3		T3	
	26		98		172
B4		K4		T4	
	28		100		174
B5		K5		T5	
	30		102		176
B6		K6		T6	
	32		104		178
B7		K7		T7	
	34		106		180
B8		K8		T8	
	36				182
B9				T9	
	38				184
	38		110		184
C1		L1		V1	
	40		112 TC3		186
C2		L2		V2	
	42		114		188
C3		L3		V3	
	44		116		190
C4		L4		V4	
	46		118		192
C5		L5		V5	
	48		120		194
C6		L6		V6	
	50		122		196
C7		L7		V7	
	52		124		198
C8		L8		V8	
			126		200
		L9		V9	
			128		202
	56		128		202
F1		N1		Y1	
	58		130		204
F2		N2		Y2	
	60		132		206
F3		N3		Y3	
	62 TC4		134		208
F4		N4		Y4	
	64		136		210
F5		N5		Y5	
	66		138		212
F6		N6		Y6	
	68		140		214
F7		N7		Y7	
	70		142		216
F8		N8		Y8	
	72		144		218
F9		N9		Y9	
	74		146		220

Middle Radiation Shield Depth

Probe Nominal Depth

4.3 HFE CONSTRAINTS AND LIMITATIONS

4.3.1 HFE Deployment Constraints

Constraints on the deployment of the HFE are covered in Section 4.1.

It is highly desirable that the core sample (part of the Lunar Geology Investigation) be taken within 16 meters of the deployed HFE probes.

4.3.2 HFE Operational Constraints

The minimum and maximum operating temperatures of the electronics packages are 273°K and 333°K, respectively. Beyond these limits, the data accuracy is impaired. The value of TREF 1 (Printer format 1), or TCR 1 (Format 2), should be monitored to ensure the temperature is in the desired range.

When operating in Mode 1, the HTR status should read "OFF". See Table 4-9 for heater sequence.

The operational power to the HFE should not be deactivated during lunar night unless the standby heater is energized.

The red-line limits for the analog engineering measurements are listed in Table 4-5.

4.3.3 ALSD Constraints

After removal of the ALSD subsystem from the LM descent stage, but prior to HFE/ALSD deployment, it may be necessary to temporarily leave the ALSD on the lunar surface. If the ALSD is to be left on the lunar surface for 30 minutes or longer, the ALSD must be placed on the surface with the battery end down and the back of the battery oriented toward the sun. The battery must not be shaded by the bore stems or treadle. The ALSD must not be left in the shadow of the LM.

The output of the ALSD battery is generally proportional to battery temperature. Within the limits of the expected lunar surface and ALSD temperature excursions, a higher battery output will result from a higher battery temperature. Figure 4-9 illustrates the expected temperature history of the battery as affected by exposure time to the sun at various sun elevation angles. During drilling operations at sun elevations less than 22° (i.e., prior to 12 Dec., 14 hrs. GMT) the battery thermal shroud shall be removed. If, after the battery thermal shroud has been removed, drill operations are delayed for 30 minutes or longer, and if the sun angle is less than 22°, then the shroud must be replaced onto the battery until drilling operations are resumed. Figure 4-10 can be used as a guide in predicting the necessity to reinstall the shroud. The orientation of the shrouded drill during this period should be battery end down on the lunar surface with the back of the battery facing the sun.

The ALSD battery need not be rested between hole drilling operations in expectation that the battery will recover or rejuvenate itself. The recovery of battery voltage with time is insignificant.

When all drilling operations are completed, ensure that the ALSD is not left in the vicinity of the LMS. This is intended to avoid contamination of the LMS area by such outgassing components as the ALSD battery.

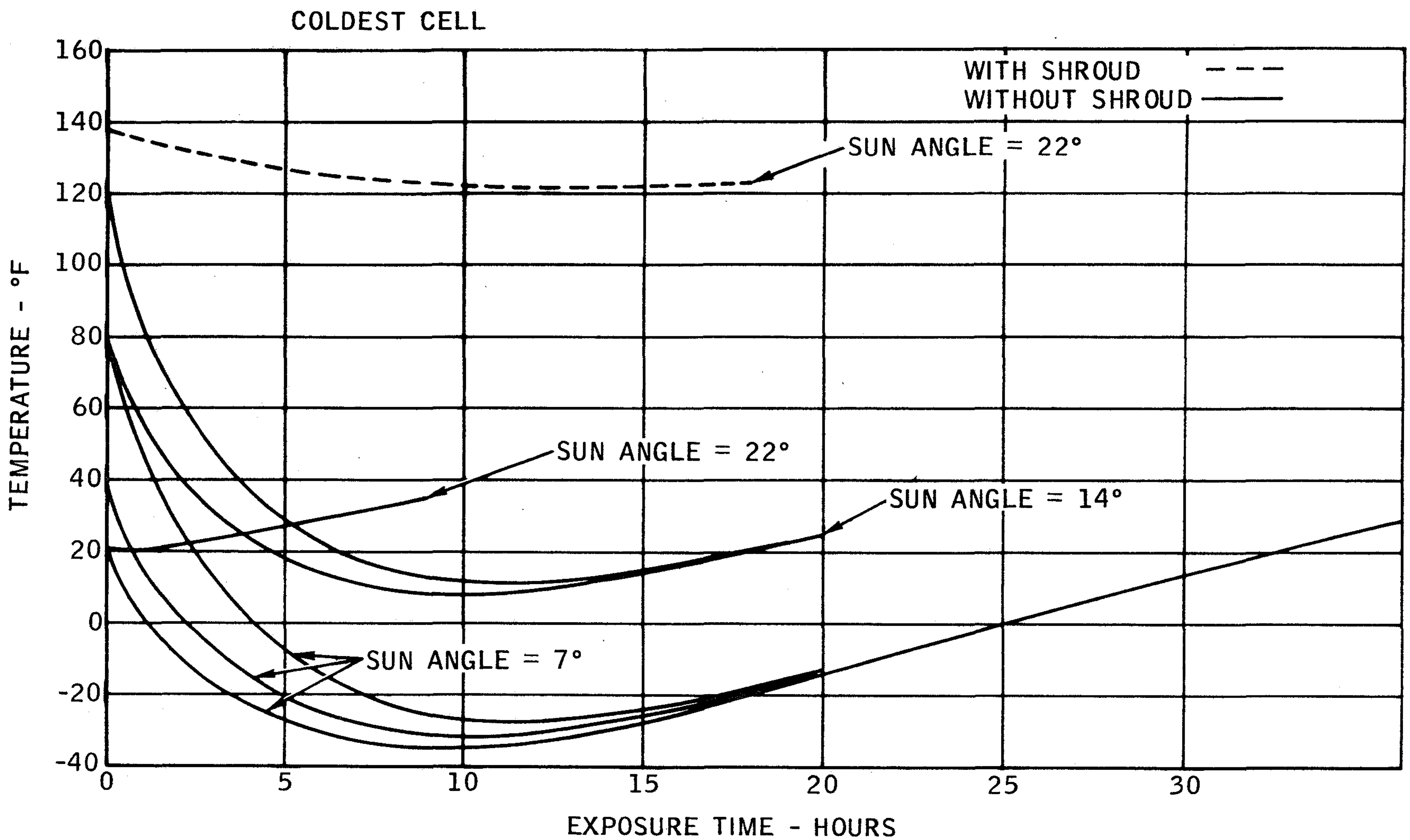


Figure 4-9. ALSD Battery Temperature Forecast

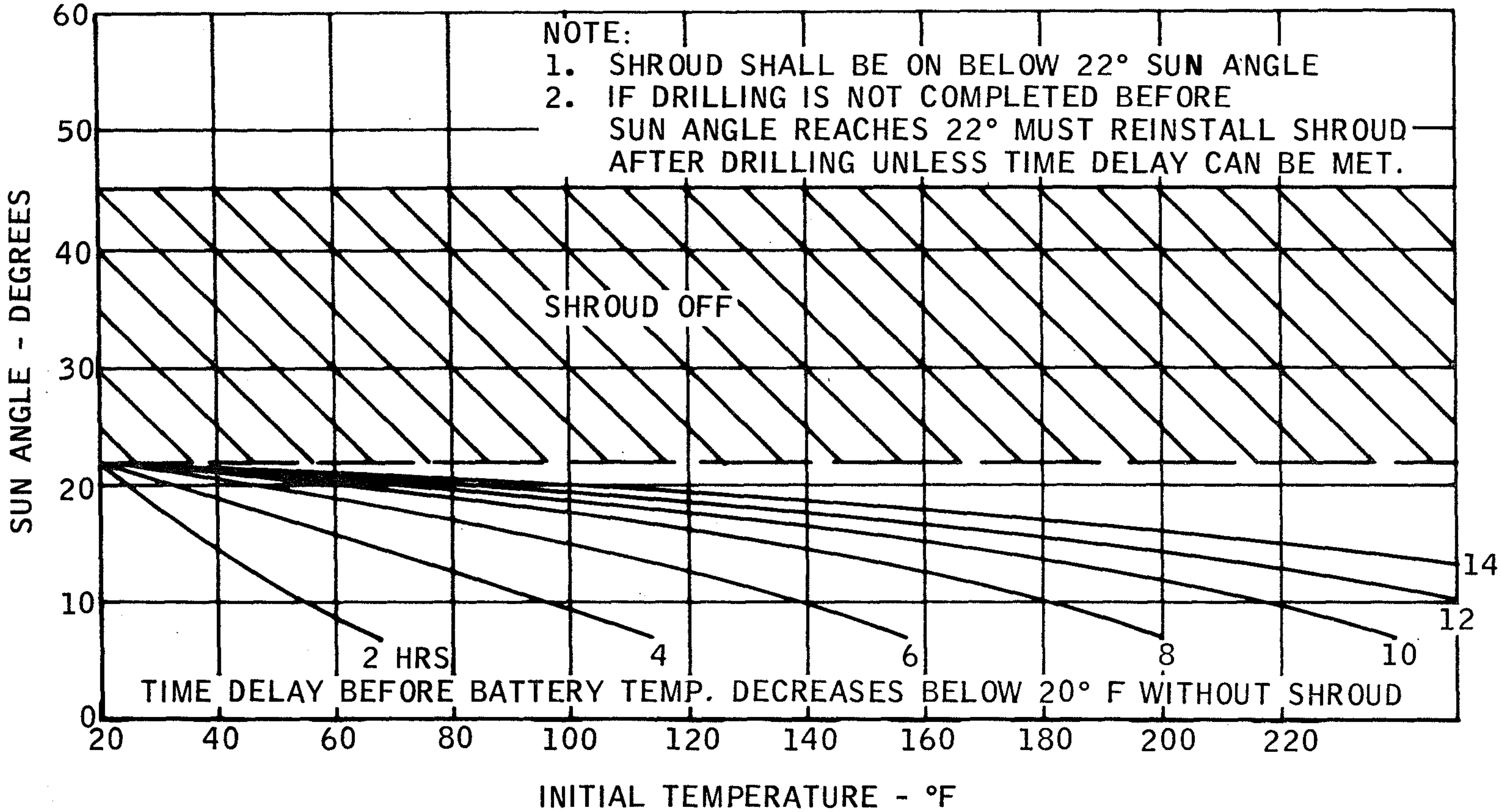


Figure 4-10. Effect of ALSD Thermal Shroud

4.4 HFE COMMANDS

- 135 HFE Mode 1 Sel

Places the HFE in the normal (gradient) mode of operation in which measurements are obtained from the gradient sensor, reference sensors and cable thermocouples. CMD 135 also turns off the probe heater current supply. To transfer from Mode 3 to Mode 1, 135 must be followed by 141. At power turn-on, the HFE initializes in Mode 1.

Note that the HFE input buffer holds this command for execution at the 90-frame mark; thus, sequential commands must be transmitted at least 54 seconds apart.

- 136 HFE Mode 2 Sel

Places the HFE in the low conductivity (Mode 2) mode of operation in which measurements, and sequences, are identical to Mode 1. It also turns on the probe heater current supply in the low (ring source) mode allowing heaters to be activated by CMD 152. In transferring from Mode 3 to Mode 2, CMD 136 must be followed by CMD 141.

- 140 HFE Mode 3 Sel

Places the HFE in the high conductivity (Mode 3) mode of operation in which measurements are obtained from the ring sensors under the control of the heater sequence programmer. Note that CMD 144 must also be transmitted before valid data will be obtained in Mode 3. Either command may be transmitted first. CMD 140 also turns on the probe heater current supply in the high conductivity or heat pulse, mode if a heater On state is selected by CMD 152.

- 141 HFE Seq/Ful Sel

Overrides the effect of CMDs 142 through 146 causing the measurement sequence programmer (MSP) to perform its full 16-state cycle of operation in Mode 1 or Mode 2. If transmitted during Mode 3 operation, this CMD will cause invalid operation until CMD 144 is executed. At power turn-on, the HFE initializes the Seq/Ful.

- 142 HFE Seq/P1 Sel

In Modes 1 and 2 causes HFE to provide probe 1 measurements only. In Mode 3 this CMD doubles the recognized data rate.

- 143 HFE Seq/P2 Sel

In Modes 1 and 2 causes HFE to provide probe 2 measurements only. If transmitted during Mode 3 operation, recognizable Mode 3 data will not be produced.

• 144 HFE Load 1

Used alone in Modes 1 and 2, it causes the selection of only the high sensitivity bridge measurement data. In Mode 3 CMD 144 must be executed to obtain valid data. CMDs 145 and 146 may be used in Mode 1 following CMD 144 to select low sensitivity differential and absolute temperature measurements respectively. The effect of CMD 144 is cleared by subsequent use of CMD 141.

• 145 HFE Load 2

This is a 1-state command used in combination with either CMD 144 (Preceding 145) or CMD 146 (Preceding or following 145) to program the MSP. As stated above, 144-145 yields low sensitivity differential temperature data only. CMDs 145-146 yield cable thermocouple data only. Execution of this latter CMD in Mode 3 causes invalid data until CMD 144 is executed. The effect of CMD 145 is cleared by subsequent execution of CMD 141.

• 146 HFE Load 3

This is a 1-state command used with CMDs 144 and 145 to program the MSP. When preceded by CMD 144, it yields absolute temperature data only. When preceded or followed by CMD 145, it yields only thermocouple data. Execution of this CMD in Mode 3 causes invalid data until CMD 144 is executed.

• 152 HFE Htr Steps

This is a 16-state command which controls the selection and energizing of the 4 heater elements in each probe in accordance with sequence listed in Table 4-9. The excitation applied to the selected heater is dependent on the operational mode of the HFE.

TABLE 4-9.

DETAILED DESCRIPTION OF COMMAND 152-HFE HEATER SEQUENCE

(1) Sequence No.	MODE 3 PRINTOUT DISPLAY(2) Measurements(3)	MODE 3 PRINTOUT DISPLAY(2) HTR. State		Ring Bridge Selected
1	DT111 & T111	H12	OFF	K11
2	DT112 & T112	H12	ON	
3	DT121 & T121	H14	OFF	K12
4	DT122 & T122	H14	ON	
5	DT113 & T113	H11	OFF	K11
6	DT114 & T114	H11	ON	
7	DT123 & T123	H13	OFF	K12
8	DT124 & T124	H13	ON	
9	DT211 & T211	H22	OFF	K21
10	DT212 & T212	H22	ON	
11	DT221 & T221	H24	OFF	K22
12	DT222 & T222	H24	ON	
13	DT213 & T213	H21	OFF	K21
14	DT214 & T214	H21	ON	
15	DT223 & T223	H23	OFF	K22
16	DT224 & T224	H23	ON	

Configuration		
Probe 1	Upper Section	H11 (K11) H12
	Lower Section	H13 (K12) H14
Probe 2	Upper Section	H21 (K21) H22
	Lower Section	H23 (K22) H24

Notes:

1. Each CMD 152 is executed only at the time of the ALSEP 90th frame mark.
2. When HFE is in Mode 2, the selected heater is energized in low current mode. The measurement sequence is independently selected.
3. When HFE is in Mode 3, the selected heater is energized in high current mode and the ring bridge measurement sequence is: high sensitivity differential temperature (DT), followed by ambient temperature (T); on the selected bridge only.

SECTION 5.0 LUNAR SURFACE GRAVIMETER

5.1 LSG Deployment Criteria

TABLE 5-1. LUNAR SURFACE GRAVIMETER DEPLOYMENT CRITERIA

PARAMETER	CRITERIA
Deployment Site	Select level spot, free of material which might shadow the instrument and perturb its thermal control. Surface slope should not exceed 5 degrees. LSG should be 7.6 meters due west of Central Station, limited by 9.1-meter cable with normal slack. See Figure 2-6. The minimum allowable angle between the LSG cable and the LSPE antenna cable is 25 degrees. However, a 45-degree angle is preferred to eliminate cross talk. Remove dust cover at the LSG deployment site.
Sunshade Deployment	Remove all Boyd bolts before deploying sunshade. Raise sunshade by handle until it reaches locked, fully deployed position. With sunshade raised and locked, tilt sunshade to predetermined angle for landing site latitude. Read and report tilt indicator to MCC. Indicator should read 20.
Emplacement, Alignment	Use UHT to emplace LSG on the surface. Point tilted sunshade toward the equator. Using UHT as lever, align LSG so plane of sunshade is parallel to sun's shadow within ± 3 degrees. When the edge of the shadow cast by upper east panel falls on line inside lower west panel, alignment is within 3 degrees. See Figure 5-1.
Leveling	Apply force to UHT handle to firmly embed leveling legs in lunar surface. Level the LSG within ± 2.7 degrees. When bubble is within target circle, instrument is level within ± 2.7 degrees. Use UHT to move LSG until it is level.
Gimbal Caging Release	Hold UHT to maintain leveling and alignment and pull on lanyard ring attached to top of sunshade until orange flag disappears inside radiator. Make visual check that uncaging did not change alignment or level. Report level and alignment readings to MCC. See Figure 5-2.

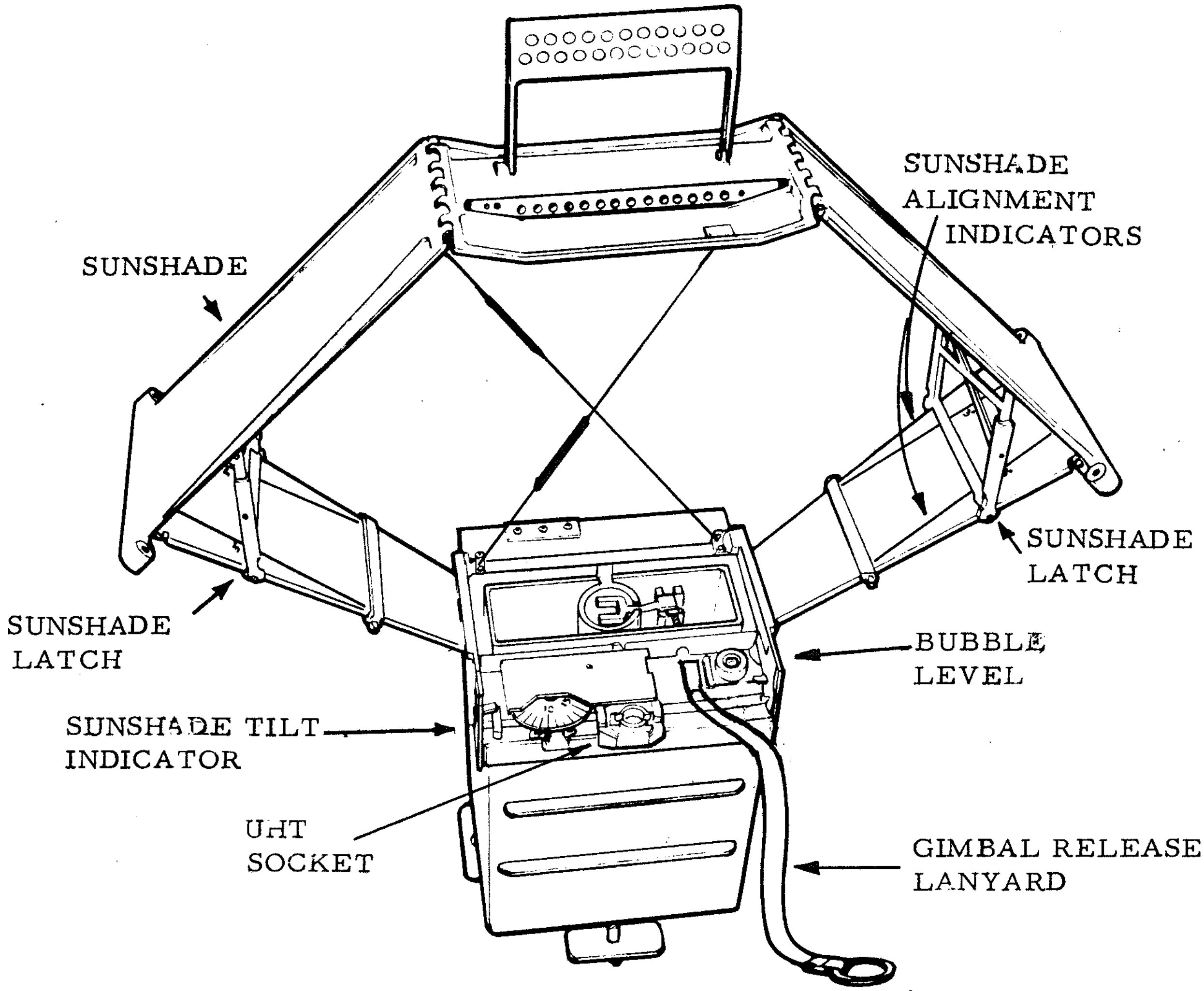


Figure 5-1. Lunar Surface Gravimeter Deployed

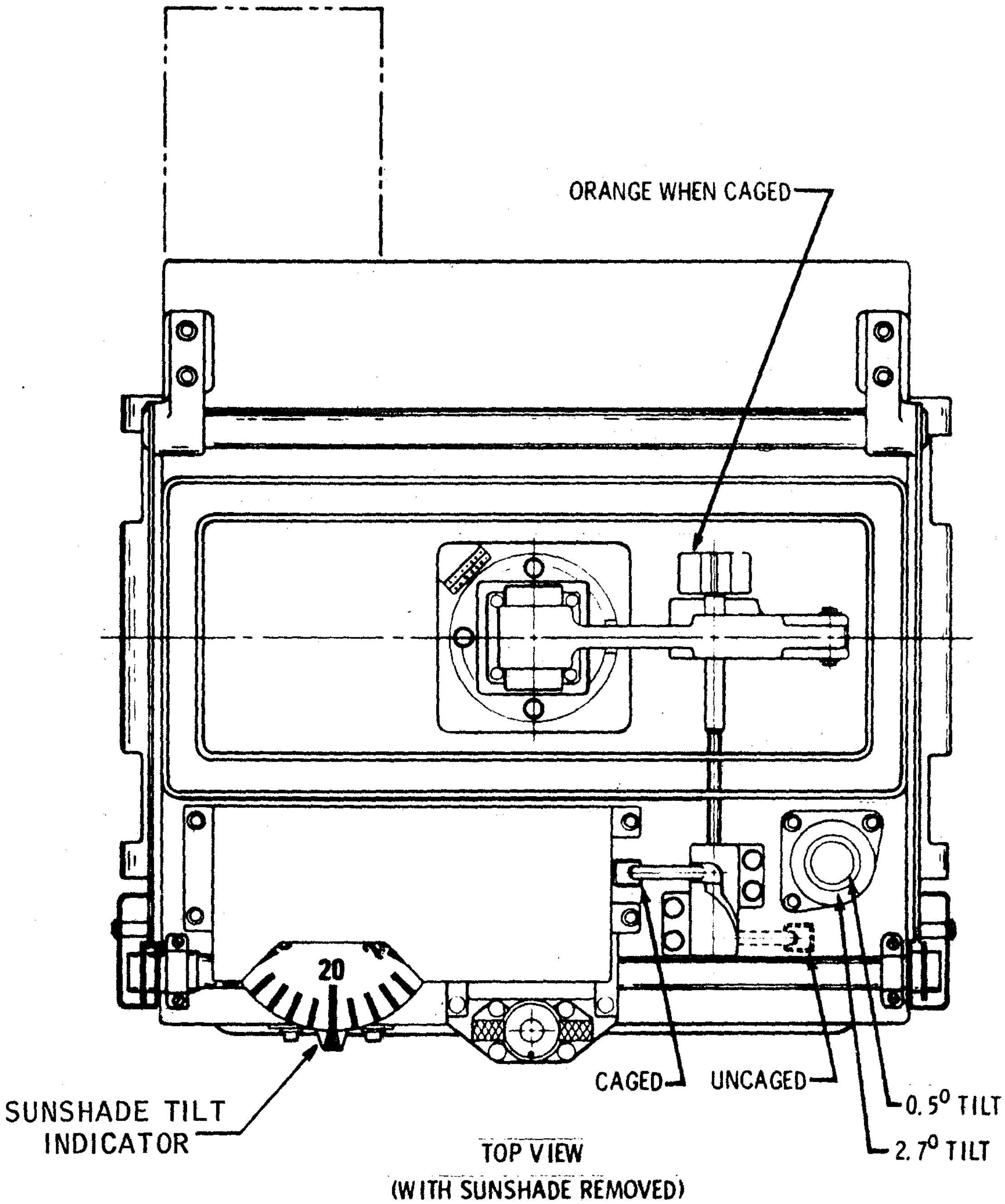


Figure 5-2. LSG Deployment Indicator

5.2 LSG OPERATIONAL DATA

5.2.1 LSG Scientific Data

The Lunar Surface Gravimeter detects and measures the vertical component of gravity in three different frequency bands, namely:

- dc to 0.048 hertz (tidal deformations)
- 0.00083 to 0.48 hertz (free-mode oscillations)
- 0.05 to 16 hertz (seismic disturbances)

These three measurements are provided separately and constitute the primary scientific data from the LSG instrument. The same voltage signals which are digitized in the LSG to produce these three measurements are also channeled to the Central Station and sub-commutated with the engineering parameters in ALSEP word 33. Although the digital resolution and the data rate are both reduced in this latter process, these measurements represent the same primary scientific data. Detailed information on measurement parameters, sequences and ranges is listed in the "Measurement Requirements Document - Array E, SE-33."

5.2.2 LSG Engineering Data

Information on the LSG instrument performance and operational status is provided by 11 measurements and 9 mode status indicators. The values of the measurements to be expected during normal operations are listed in Table 5-2. The status indicators are described in Tables 5-3, 5-4 and 5-5.

Table 5-2. LSG Engineering Measurements

Meas. No.	ALSEP Word 33 Channel No.	DESCRIPTION	Normal Operating Range Low	Normal Operating Range High	Limite See Note 1 Low	Limite See Note 1 High
AG-04	68	Sensor Temperature (°C)	49	52	49.05(T) 49.05(M)	52.21(T) 52.21(M)
AG-05	89	Sensor Housing Pressure (Torr)	0.5	30	0(T) 0(M)	50(T) 50(M)
AG-06	54	Mass Position (Volts)	2.3	3.9	1.6 (T) 0.0 (M)	4.6 (T) 5.0 (M)
AG-07	24	Oscillator Voltage	14	16	14.0 (T) 13.0 (M)	16.0 (T) 17.0 (M)
AG-08	38	+15 V Power Converter Voltages	14.25	15.75	14.1 (T) 0.2 (M)	15.9 (T) 30.0 (M)
AG-09	53	-15 V Power Converter Voltages	-14.25	-15.75	-14.1 (T) - 0.2 (M)	-15.9 (T) -30.0 (M)
AG-10	69	+ 5 V Power Converter Voltages	4.75	5.25	4.8 (T) 0.1 (M)	5.4 (T) 10.0 (M)

Note 1: Legend - (M) Measurement Limit, (T) Test Limit. See Section 3.3.9.

Table 5-3. LSG Status Indicators

PARAMETER	MEAS. NO.	INDICATION
Mass Change Motor Power	DG-12	OFF/ON
Slewing Motor Status	DG-13	
- Power OFF		OFF
- Power ON, Slewing		ON, SL
- Power ON, Not Slewing		ON, N/SL
Tilt Motor Power	DG-14	OFF/ON
LSG Command Decoder Power	DG-15	OFF/ON
Instrument Housing Heater Power	DG-16	OFF/ON
Pressure Transducer Power	DG-17	OFF/ON
Seismic Gain	DG-18	LOW/HIGH

Table 5-4. LSG Control Temperature Indicator (DG-11)

Sensor Temperature Control		Sensor Temperature Control	
Indicator	Temperature (°C)	Indicator	Temperature (°C)
000000	49.055	000001	50.655
100000	49.105	100001	50.706
010000	49.155	010001	50.756
110000	49.205	110001	50.806
001000	49.255	001001	50.856
101000	49.305	101001	50.906
011000	49.355	011001	50.956
111000	49.405	111001	51.006
000100	49.455	000101	51.056
100100	49.505	100101	51.106
010100	49.555	010101	51.156
110100	49.605	110101	51.206
001100	49.655	001101	51.256
101100	49.705	101101	51.306
011100	49.755	011101	51.356
111100	49.805	111101	51.406
000010	49.855	000011	51.456
100010	49.905	100011	51.506
010010	49.955	010011	51.556
110010	50.005	110011	51.606
001010	50.055	001011	51.656
101010	50.105	101011	51.706
011010	50.155	011011	51.756
111010	50.205	111011	51.806
000110	50.255	000111	51.856
100110	50.305	100111	51.906
010110	50.355	010111	51.956
110110	50.405	110111	52.006
001110	50.455	001111	52.056
101110	50.505	101111	52.106
011110	50.555	011111	52.156
111110	50.605	111111	52.206

Table 5-5. LSG Command Function Indicator (DG-19)

Command Counter Indication		Command Function
00000	0	No Function
00001	1	Read Shaft Encoder
00010	2	Mass Change Motor ON
00011	3	Bias In
00100	4	Bias Out
00101	5	Integrator, Normal Mode
00110	6	Integrator, Short Mode
00111	7	Seismic Low Gain
01000	8	Seismic High Gain
01001	9	Sensor Beam Caged
01010	10	Sensor Beam Uncaged
01011	11	Coarse Screw Servo ON
01100	12	Tilt, Mass Chg., Press. Trans. & Screw Servo OFF
01101	13	Pressure Transducer ON
01110	14	Mass Change Increment
01111	15	Gross Slew Up/Tilt Increment Up
10000	16	Gross Slew Down/Tilt Incr. Down
10001	17	Vernier Slew Up
10010	18	Vernier Slew Down
10011	19	Fine Screw Servo ON
10100	20	North/South Tilt Servo ON
10101	21	East/West Tilt Servo ON
10110	22	X o o o o o — Set Temperature Control Indicator Digits (See Table 5-4)
10111	23	o X o o o o — Set Temperature Control Indicator Digits (See Table 5-4)
11000	24	o o X o o o — Set Temperature Control Indicator Digits (See Table 5-4)
11001	25	o o o X o o — Set Temperature Control Indicator Digits (See Table 5-4)
11010	26	o o o o X o — Set Temperature Control Indicator Digits (See Table 5-4)
11011	27	o o o o o X — Set Temperature Control Indicator Digits (See Table 5-4)
11100	28	Temperature Reset
11101	29	Post Amp. Gain Increment
11110	30	Post Amp. Gain Reset
11111	31	No Function

5.2.3 LSG Operational Modes

In the normal operational mode of the LSG a complete sample of all the measurements and indicators described above is provided each 0.6 second. In that same time period 31 samples of seismic data are provided.

An interim operational mode is provided which inhibits all of these measurement signals and provides, for 90 ALSEP frames, repeated measurements of the positions of the Coarse and Fine centering adjustments. These are high-resolution (19-bit) measurements and if displayed in decimal form will normally range from 64 to 3464 for the coarse screw and from 64 to 2842 for the fine. At the 90-frame mark following this series of readings the LSG operational mode automatically reverts to normal.

During transfer to the lunar surface three portions of the LSG are caged mechanically as a precaution against transportation shocks. Before operation these must be released. Firstly, the gimbal, from which the whole sensor pivots, must be uncaged by the crew through use of the gimbal release lanyard (see Figures 5-1 and 5-2). The sensor mass is uncaged by the first execution of the command displayed as 00010 (Table 5-5) and will be adjusted initially by using the mass change increment command 01110. Finally, the sensor beam is released by executing the command displayed as 01010 (Table 5-5). Note that whenever subsequent mass changes are made, the sensor beam must be caged.

Initial operations in "setting-up" the LSG will be directed toward three objectives:

A. Centering the seismic sensor in its measurement range, through:

- mass selection
- coarse and fine beam adjustments (each of which have two commandable rates)

Two mass increments are provided each of which, when added or removed, will produce a change in tidal output (DG-02) equivalent to 680 times the total tidal scale range. Lesser adjustments are made by command, to the extent required, in accordance with the four slewing rates selectable, as follows:

	Effect of Each Command For Post-Ampl. Gain of 12 (% of total seismic scale)	
	Gross Increment (01111/10000)	Vernier Increment (10001/10010)
Coarse Screw (01011)	2330	17.6
Fine Screw (10011)	18.2	0.138

B. Aligning the sensor with the gravity vector by tilting the sensor on the gimbal by shifting its center of mass using the "tilt" motors.

C. Adjusting the control point of the sensor temperature until the seismic sensor is operating at a condition of minimum temperature sensitivity.

3.7.4 LSG Power Demands

Because of the close temperature control of the LSG, the power demand of the instrument is directly related to the ambient temperature. This is illustrated in Figure 5-3. The commandable functions which require significant power when implemented are listed in Table 5-6 together with the anticipated change in system reserve power (CS-60/CS-61) when executed.

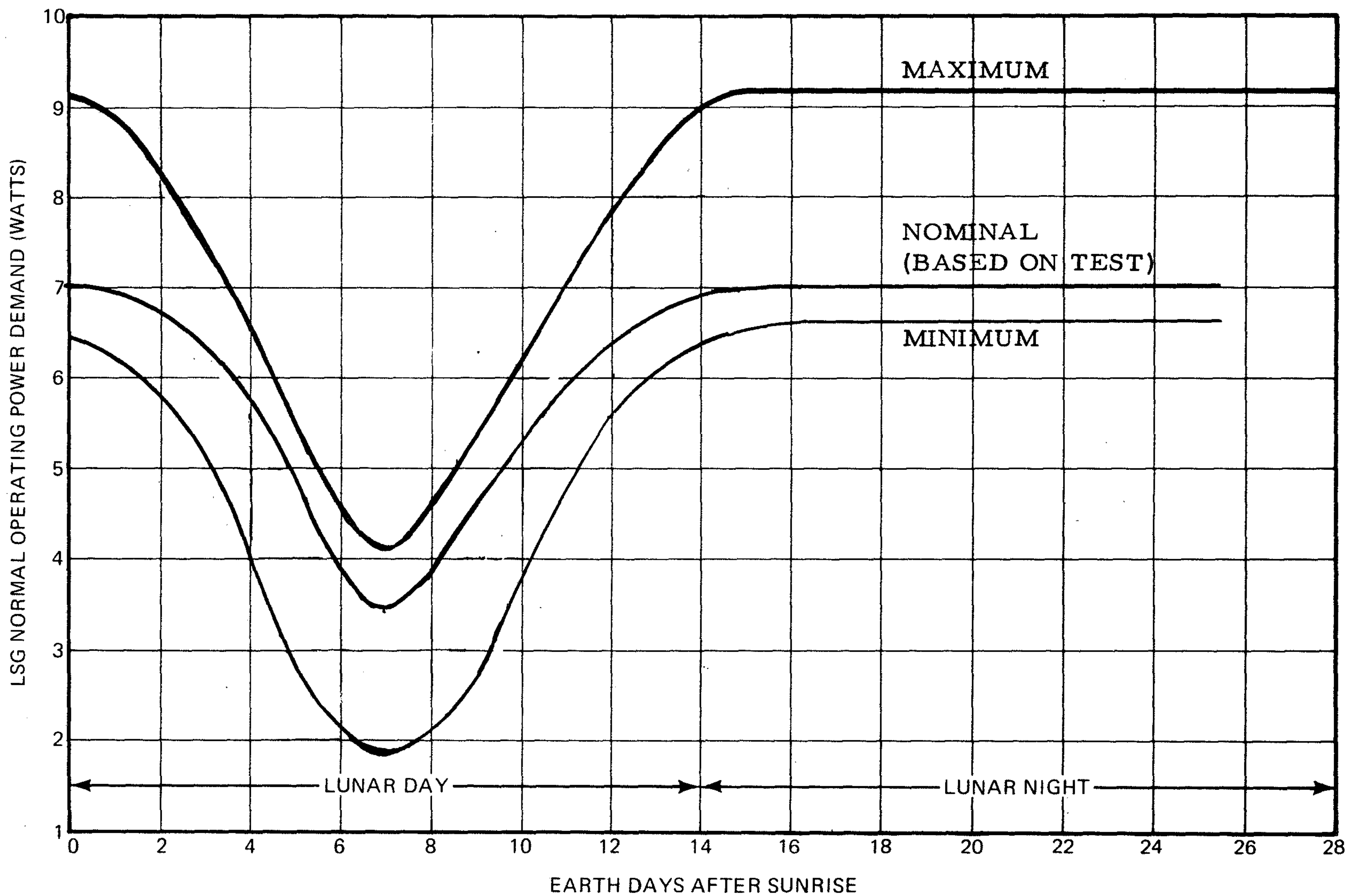


Figure 5-3. LSG Normal Operating Power

TABLE 5-6.

POWER DEMAND OF LSG TEMPORARY MODES

Mode Event	Associated Change in Reserve Power (watts)
Command Decoder ON	0.4
Mass Change Motor ON	1.8 to 4.4*
Uncage Motor ON	2.2
Slew Motor	1.3
Tilt Motor	1.2
Instrument Housing Heater ON	0.0 to 7.3**
Standby Power ON	-2.7 to 0.0

* If the motor is allowed to operate against the end-stop, there is a 10-watt transient occurring repetitively at about 10 Hz.

** Value shown is maximum range. Lunar night maximum is not expected to exceed 4.8 watts.

5.3 LSG CONSTRAINTS AND LIMITATIONS

5.3.1 LSG Deployment Constraints

The constraints on deployment of the LSG are covered in Section 5.1.

5.3.2 LSG Operational Constraints

The LSG is initialized, after deployment, through an extensive series of commands in a prescribed sequence. The major elements of this sequence, after release of the gimbal by the astronaut, are as follows:

- Perform initial check of equipment performance and status.
- Uncage mass change unit.
- Release sensor beam and proceed to bring seismic output "on-scale."
- Adjust tilt.
- Establish sensor temperature at optimum value for sensor stability.

During this initialization process the following operational precautions should be observed:

- The screw servo (DG-13) and the tilt servo (DG-14) should not be energized simultaneously.
- Mass changing is inhibited when the housing heater is enabled (even though the printer display of DG-12 indicates ON).
- Sensor Beam Cage/Uncage command is inhibited when the housing heater is enabled.
- As stated in Paragraph 5.2.3, the "coarse shaft" encoder reads 64 at the upper limit of shaft rotation, 3464 at the lower limit of shaft rotation. Hence limit-to-limit rotation of the coarse level shaft is equivalent to a change of 3400 in the encoder reading. If, for any reason, the encoder reading should indicate that the shaft is nearing a limit of its travel and further adjustment is needed, an incremental mass may be added to or removed from the sensor beam to restore slewing capability. One incremental mass is equivalent to a change of 3060 in the encoder reading. Hence, if the "coarse shaft" encoder is reading:

< 3124, a mass increment may be added,

> 404, a mass increment may be removed

to restore balance with the leveling shaft within its adjustment range.

The Mass Change motor should not be operated if the reserve power is less than approximately 14 watts.

5.4 LSG COMMANDS

5.4.1 LSG Command Operations

As shown in Table 3-21, there are seven octal commands assigned to LSG operation. An expanded command capability is accomplished in the LSG by using five of these CMD signals to control a 5-stage, reversible, command counter. Thirty of the possible 32 discrete states of this counter are used to select a commandable function of the LSG. The status of this command counter is displayed on the LSG Printer format (See Table 5-5). Selection of a specific functional change may be made by:

a. repeatedly sending CMD 072 to advance the counter to the desired read-out value,

b. repeatedly sending CMD 074 to countdown to the desired read-out value,

c. send CMD 070 (to set the command counter to zero) and proceed as in (a) or (b) to reach the desired command counter read-out.

After selection is made, these commandable functions are initiated by CMD 067.

5.4.2 LSG Octal Command Descriptions

- 063 LSG Htr On

This CMD actuates a latching relay in the LSG to the position that applies +29 VDC slave heater power to the LSG instrument housing. This heater is slaved to the temperature of the heater box by two sensors, one on the instrument housing, using a differential output by means of a bridge circuit. Repeated application of CMD 063 has no further effect. The slave heater is preset to be in the ON condition at initial lunar activation.

- 064 LSG Htr Off

This CMD activates a latching relay in the LSG to the position that removes +29 VDC slave heater power from the LSG instrument housing. Repeated application of CMD 064 has no further effect. The slave heater is preset to be in the ON condition at initial lunar activation.

- 067 LSG CMD EX

This CMD causes execution of one of the 30 encoded LSG CMD's as contained in its 5-stage CMD register which is shifted up/down by octal CMD's 072/074. Execution does not clear the register. Repeated application of CMD 067 will cause repeated execution of the selected encoded CMD.

- 070 LSG Decoder On

This CMD actuates a latching relay in the LSG to the position that applies +5 VDC power to the CMD counter and the associated CMD decoding circuitry within the LSG, allowing the 5-stage CMD register counter to be stepped up/down and enabling the LSG encoded CMD execution function. Application of CMD 070 always resets the register counter to 00000. Repeated application of CMD 070 has no further effect unless the register has been stepped, in which case the register clears. The command decoder is preset to be in the ON condition at initial lunar activation. This command may be used operationally as a shortcut to get to the low end of the register.

- 071 LSG Decoder Off

This CMD actuates a latching relay in the LSG to the position that removes +5 VDC power from the CMD decoder within the LSG. Repeated applications of CMD 071 have no further effect. The CMD decoder is preset to be in the ON condition at initial lunar activation.

- 072 LSG Step Up

This CMD advances the 5-stage CMD register counter of the LSG to the next higher binary value, thus representing a new encoded CMD function, if executed. Of the 32 possible states, 30 are used (excluding 00000 and 11111), and the register state is read out in the TM. Repeated application of CMD 072 advances the counter setting until it reaches 11111, after which CMD 072 sets the counter to 00000, etc.

- 074 LSG Step Down

This CMD reduces the value in the 5-stage CMD register counter of the LSG to the next lower binary value, thus representing a new encoded CMD function, if executed. Of the 32 possible states, 30 are used (excluding 00000 and 11111), and the register state is read out in the TM. Repeated application of CMD 074 reduces the counter setting until it reaches 00000, after which CMD 074 sets the counter to 11111, etc.

5.4.3 LSG Encoded Command Descriptions

- 00000 and 11111 have no functional effect

- 00001 Read Shaft Encoders

This CMD inhibits all other signals to the LSG digital multiplexer and replaces them with data from the shaft encoders on the coarse and fine screw servo shafts. These two encoders are read out in the ALSEP data words assigned to LSG as 19-bit readings, as indicated by Table 22 of SE-33. Starting at the ALSEP frame mark, the first four words read out are:

ALSEP Word 4	Coarse Encoder	First 9 Bits (MSB)
ALSEP Word 6	Coarse Encoder	Last 10 Bits (LSB)
ALSEP Word 8	Fine Encoder	First 9 Bits (MSB)
ALSEP Word 10	Fine Encoder	Last 10 Bits (LSB)
etc.		

In the MSB words a filler bit (binary one) is inserted as the first bit of the 10-bit ALSEP word. The shaft encoder data readout starts at the first ALSEP 90-frame mark following execution of CMD 00001 (binary) and continues until the next ALSEP 90-frame mark after which normal LSG scientific data readout is reactivated. Repeated applications of CMD 00001 (binary) will cause shaft encoder data readout for additional blocks of 90 frames if transmitted during the shaft encoder operating mode. Application of operational power to the LSG causes initialization in the normal data mode.

- 00010 Mass Change Motor On

This CMD activates the LSG mass changing servo control and, at turn-on, resets the 5-bit mass change increment counter to zero so that subsequent increment CMD's can step the counter up to the desired functional state; additional mass change features are:

- Mass changing is inhibited when the instrument housing heater is on but the status TM responds to execution of CMD 00010 (binary), indicating that the servo control is enabled. Motor drive requires the Instrument Housing Heater be turned Off.

- There are 10 functional states controlled by the increment CMD, 01110 (binary).

- The counter status is read out in the TM as an analog voltage value and the zero counter setting is defined as state 1.

- At turn-on, the mechanism always drives to state 1 which is against the stop.

- 00010 Mass Change Motor On (Continued)

  - The backlash (or hystersis) states (e.g. 2, 4, 6, 8, and 10) are designed to decouple the drive train from the sensor mass change mechanism. This prevents mechanical coupling except when changing states.

  - The mass change motor control is a servo feedback design and, when activated, will drive the motor until a "null" is achieved for the desired operating state. When at a null the motor control will operate in a limit cycle mode. It is not recommended that the motor be left in this state for prolonged periods.

  - Turn-off of the control, by CMD 01100 (binary) causes the mechanism state to be retained until the next turn-on.

  - Since turn-on clears the register, repeated application of CMD 00010 (binary) causes no further change provided that no increment CMD's are executed between turn-on CMD's.

  - A time period of approximately 10 seconds is required to drive the mass change mechanism between odd numbered slots (1-3, 3-5, etc.) and approximately 2 seconds are required to drive from an odd to even numbered slot. Since the numbered slots represent a servo position, time is cumulative and approximately 50 seconds are required to drive from slot number ten to slot number one.

- 00011 Bias In Sel

This CMD actuates a latching relay to the position that applies constant DC bias (approximately +13 volts) to the sensor bridge drive circuit of the LSG sensor electronics. Repeated application of CMD 00011 (binary) has no further effect. This bias relay is preset to be in the OFF condition at initial lunar activation.

- 00100 Bias Out Sel

This CMD actuates a latching relay to the position that removes the bias (+13 VDC) from the sensor bridge drive circuit of the LSG sensor electronics. Repeated application of CMD 00100 (binary) has no further effect. The bias relay is preset to be in the OFF condition at initial lunar activation.

- 00101 Integrator Normal Mode Sel

This CMD causes closed-loop operation of the LSG sensor electrostatic system in which the output of the integrator is fed back to control the plate drive to the sensor. Repeated application of CMD 00101 (binary) has no further effect. The integrator is preset to be in the SHORT mode at initial lunar activation.

- 00110 Integrator Short Mode Sel

This CMD causes the LSG integrator output to be short-circuited which puts the electrostatic system in an open-loop configuration. Repeated application of CMD 00110 (binary) has no further effect. The integrator is preset to be in the SHORT mode at initial lunar activation.

- 00111 Seismic Low Gain Sel

This CMD selects the low-gain configuration of the seismic output circuit of the LSG sensor. Repeated application of CMD 00111 (binary) has no further effect. The seismic gain is preset to be in the Low Gain mode at initial lunar activation.

- 01000 Seismic High Gain Sel

This CMD selects the high-gain configuration of the seismic output circuit of the LSG sensor which inserts an additional amplifier and filter into the circuit. Repeated application of CMD 01000 (binary) has no further effect. The seismic gain is preset to be in the Low Gain mode at initial lunar activation.

- 01001 Sensor Beam Cage

This CMD activates a circuit to perform the LSG sensor beam caging operation. Initiation of the CMD causes charging of a capacitor which turns on an FET which supplies drive current to the caging motor until the RC time constant turns off the FET. This time constant is approximately 7.5 seconds. The initiation of CMD 01001 (binary) also selects the state of a double-pole relay which controls the direction of motor drive, causing the relay to move to the position where the motor operates in the direction to cage the sensor beam. Repeated application of CMD 01001 (binary) results in clutch action to prevent further driving of the gears in the caged direction. The instrument housing heater and the Mass Change motor control must be OFF to drive the Beam Caging motor.

- 01010 Sensor Beam Uncage

This CMD activates a circuit to perform the LSG sensor beam uncaging operation. Initiation of the CMD causes charging of a capacitor which turns on an FET which supplies drive current to the caging motor until the RC time constant turns off the FET. This time constant is approximately 7.5 seconds. The initiation of CMD 01010 (binary) also selects the state of a double-pole relay which controls the direction of motor drive, causing the relay to move to the position where the motor operates in the direction to uncage the sensor beam. Repeated application of CMD 01010 (binary) results in clutch action to prevent further driving of the gears in the uncaged direction. The instrument housing heater and the Mass Change motor control must be OFF to drive the Beam Caging motor.

- 01011 Coarse Screw Motor On

This CMD activates LSG screw servo circuits to enable acceptance of up and down slew CMD's, either gross or vernier. Initiation of CMD 01011 (binary) also selects a relay position such that the drive power, when applied, will be fed to the motor of the coarse screw of the LSG sensor. Repeated application of CMD 01011 (binary) has no further effect unless transmitted while the Screw Motor is slewing. If this occurs, the motor operation will terminate and the control logic will reset. Turn-off of the screw servo circuits is accomplished by CMD 01100 (binary). The servo power control is preset to be in the off condition at initial lunar activation.

- 01100 Tilt, Mass Change, Screw Motor and Pressure Transducer OFF

This CMD deactivates LSG circuits which are activated by individual binary CMD's as follows:

Tilt:	10100 or 10101
Mass Change:	00010
Screw Motor:	01011 or 10011
Pressure Transducer:	01101

Repeated application of CMD 01100 (binary) has no further effect. The power controls are preset to be in the off condition at initial lunar activation.

- 01101 Pressure Transducer On

This CMD activates a thermal conductivity type of pressure transducer to measure the LSG instrument housing internal pressure via the ALSEP housekeeping, AG-05. Repeated application of CMD 01101 (binary) has no further effect. Turn-off of the pressure transducer is accomplished by CMD 01100 (binary). The pressure transducer is preset to be in the off condition at initial lunar activation.

- 01110 Mass Change Increment

This CMD steps the 5-bit counter of the LSG mass changing servo control circuitry, when the circuit has been activated by CMD 00010 (binary). When the circuit is activated, the counter automatically resets to zero (state 1) and each increment CMD steps it one step up (to the next higher state). States 1 through 10 are functional states of the counter and control the mass changing servo. The backlash or hysteresis states (2, 4, 6, 8, 10) are designed to decouple the drive chain from the sensor mass change mechanism so there is no mechanical coupling except when changing states. Repeated application of CMD 01110 (binary) causes repeated steps and the tenth increment CMD will select state 1 again.

- 01111 Gross Slew Up/Tilt Increment Up

This CMD causes operation in the up direction of the selected LSG screw motor or selected tilt motor, if they have been previously enabled by one of the individual binary CMD's as follows:

Coarse Screw Motor On:	01011
Fine Screw Motor On:	10011
North/South Tilt Motor On:	10100
East/West Tilt Motor On:	10101

For the screw motor, execution of CMD 01111 (binary) sets a 15-bit counter to zero and starts counting. After a count of 16,384 steps of the stepping motor, corresponding to a period of 308 seconds, the counter times out and inhibits motor operation. A relay which controls the direction of motor drive is activated to the proper setting by execution of the CMD. For the tilt servos, execution of CMD 01111 (binary) enables data gate pulses to step a timeout counter clock which was also reset by the CMD. The timeout of the clock corresponds to 2 revolutions of the tilt motor, in the up direction.

Repeated application of CMD 01111 (binary) causes repeated increments of gross slew up or tilt up; however, the proper time interval between CMD's must be observed.

- 10000 Gross Slew Down/Tilt Increment Down

This CMD causes operation in the down direction of one of the two LSG screw servo motors or one of the two tilt motors, if they have been previously enabled by one of the individual binary CMD's as follows:

Course Screw Motor On:	01011
Fine Screw Motor On:	10011
North/South Tilt Motor On:	10100
East/West Tilt Motor On:	10101

For the screw motors, execution of CMD 10000 (binary) sets a 15-bit counter to zero. After 16,384 steps of the stepping motor (about 308 seconds) in the down direction, it times out and inhibits further operation. A relay which controls the direction of motor drive is actuated by execution of the CMD.

For the tilt motors, execution of CMD 10000 (binary) enables data gate pulses to step a timeout counter clock which was also reset by the CMD. The timeout of the clock corresponds to 2 revolutions of the tilt motor, in the down direction.

Repeated application of CMD 10000 (binary) causes repeated increments of gross slew down or tilt down; however, the proper time interval between CMD's must be observed.

- 10001 Vernier Slew Up

This CMD causes operation in the up direction of the selected screw motor, if it has been previously enabled by one of the individual binary CMD's as follows:

Coarse Screw Motor On:	01011
Fine Screw Motor On:	10011

Execution of CMD 10001 (binary) sets a 15-bit counter to zero after which data gate pulses step the counter down to zero; a period of 2.5 seconds corresponding to 128 steps of the stepper motor, in the up direction. A relay which controls the direction of motor drive is actuated by execution of the command.

Repeated application of CMD 10001 (binary) causes repeated vernier slew up of whichever screw servo motor has been enabled.

- 10010 Vernier Slew Down

This CMD causes operation in the down direction of one of the two LSG screw servo motors, if they have been previously enabled by one of the individual binary CMD's as follows:

Coarse Screw Servo On:	01011
Fine Screw Servo On:	10011

Execution of CMD 10010 (binary) sets a 15-bit counter to 256 after which data gate pulses step the counter down to zero; a period of 2.5 seconds corresponding to 128 steps of the stepper motor, in the down direction. A relay which controls the direction of motor drive is actuated by execution of the CMD.

Repeated application of CMD 10010 (binary) causes repeated vernier slew down of whichever screw servo motor has been enabled.

- 10011 Fine Screw Servo On

This CMD activates LSG screw servo circuits to enable acceptance of up and down slew commands, either gross or vernier. Screw servo activation is inhibited when the tilt servo control is on and vice versa. Initiation of CMD 10011 (binary) also selects a relay position such that the drive power, when applied, will be fed to the fine screw of the LSG sensor. Repeated application of CMD 10011 (binary) has no further effect. Turn-off of the screw servo circuits is accomplished by CMD 01100 (binary). The servo power control is preset to be in the Off condition at initial lunar activation.

- 10100 North/South Tilt Motor On

This CMD activates LSG tilt logic circuits to enable acceptance of an up or down tilt increment command. Initiation of CMD 10100 (binary) also selects a relay position such that the drive power, when applied, will be fed to north/south tilt motor. Repeated application of CMD 10100 (binary) has no further effect. Turn-off of the tilt circuits is accomplished by CMD 01100 (binary). The tilt control is preset to be the Off condition at initial lunar activation.

- 10101 East/West Tilt Motor On

This CMD activates LSG tilt servo circuits to enable acceptance of an up or down tilt increment command. Initiation of CMD 10101 (binary) also selects a relay position such that the drive power, when applied, will be fed to the east/west tilt motor. Repeated application of CMD 10101 (binary) has no further effect. Turn-off of the tilt servo circuits is accomplished by CMD 01100 (binary). The tilt control is preset to be in the Off condition at initial lunar activation.

- 10110 Sensor Temperature 1 Select

This command is one of six used to select the control set point of the Heater Box Temperature Controller. The Temperature Controller is designed to provide 64 temperature set points at 0.05°C increments. Thus, the temperature can be adjusted within ± 1.6°C around the nominal operating point to find the sensor inversion point on the lunar surface and maintain operation at that point. The Sensor Temperature 1 Select command increases the control set point by 0.05°C. The command activates a relay which removes a resistor from the temperature control bridge circuit. When activated, the Sensor Temperature 1 Select status on TM is indicated. The Sensor Temperature 1 Select relay is preset to be in the ON condition at initial activation on the lunar surface.

- 10111 Sensor Temperature 2 Select - Preset ON

See CMD 10110, Sensor Temperature 1 Select.

- 11000 Sensor Temperature 3 Select - Preset OFF

See CMD 10110, Sensor Temperature 1 Select.

- 11001 Sensor Temperature 4 Select - Preset ON

See CMD 10110, Sensor Temperature 1 Select.

- 11010 Sensor Temperature 5 Select - Preset ON

See CMD 10110, Sensor Temperature 1 Select.

- 11011 Sensor Temperature 6 Select - Preset OFF

See CMD 10110, Sensor Temperature 1 Select.

- 11100 Sensor Temperature Relay Reset

This command resets the six relays used in the LSG heater box temperature control circuit. Repeated application of CMD 11100 has no further effect. The temperature select relays are preset as stated for each of the six commands.

- 11101 Post Amp Gain Increment

This CMD advances the count of a 4-stage register controlling the gain of the post-amplifier of the LSG sensor. The status of this register is not read out in the TM. Repeated application of CMD 11101 (binary) causes the counter setting to advance in repeated increments until it reaches 15, after which it resets to zero and continues in the same sequence. When operational power is applied to the LSG, the initial gain setting is unpredictable.

- 11110 Post Amp Gain Reset

This CMD resets the counter of the 4-stage register controlling the gain of the post-amplifier of the LSG sensor, resulting in the lowest gain setting. Repeated application of CMD 11110 (binary has no further effect.

SECTION 6.0 LUNAR SEISMIC PROFILING EXPERIMENT

6.1 LSP Deployment Criteria

TABLE 6-1. LUNAR SEISMIC PROFILING DEPLOYMENT CRITERIA

PARAMETER	CRITERIA
Geophone Module Site Selection	Deploy Geophone Module 9 meters (30 feet) south of the Central Station. Pick as smooth and level a site as possible for emplacement of Geophone Module and geophones. Deploy a marker flag to mark the location for orientation of the four geophones. Marker flags also serve as anchors for the geophones.
Geophone Emplacement	Deploy the four geophones so that their relative locations are as shown in Figure 6-1, based on the shadow line through this location. Deploy marker flag at each geophone location and at the geophone module package (Figure 6-2) to aid in the determination of the actual location of the four geophones. A gnomon will be emplaced within the triangle beside the third geophone. Geophones should be emplaced on flat terrain if possible, not in craters. Geophones should be deployed so that three of them comprise the vertices of an equilateral triangle with the fourth in the center of the triangle. This will be visually determined by the astronaut sighting along the marker flags and should be in a straight line.
Geophone Vertical Alignment	Vertical alignment of each geophone is very critical since complete loss of data from a geophone occurs if it is 15 degrees or more off vertical. Geophone spike should be vertical within 7 degrees.
Geophone Cables	If geophone cables are deployed over depressions more than two feet deep, the astronaut must insure that the cable has enough slack to follow the contour of the lunar surface.
LSPE Enable	After deploying the geophones, return to the Central Station and rotate Astronaut Switch #2 clockwise to enable the LSPE electronics. If left in the counterclockwise position, LSPE operation is inhibited.
LSPE Transmitter Antenna Deployment	Deploy the LSPE Transmitter Antenna 40 feet (12 meters) northwest of the Central Station. Antenna will be mounted on the HFE subpallet from ALSEP Subpackage #1. See Figure 6-3.

TABLE 6-1. LUNAR SEISMIC PROFILING DEPLOYMENT CRITERIA (Continued)

PARAMETER	CRITERIA
LSPE Transmitter Antenna Deployment (Concluded)	Extend telescoping whip antenna to full 63-inch length before mounting it in the socket on the HFE subpallet. When fully extended, the astronaut will have extracted 11 antenna sections from the stowage tube -- 5 with the first grip ring and 6 with the second grip ring.
Explosive Packages Deployment	During EVA #1, the astronauts will remove the two EP transport frames on the experiment pallet which are stowed in Quad III of the LM. All of the eight LSPE explosive packages on the two transport frames must be placed in the sun on the lunar surface for at least two hours before they are deployed and activated. This is necessary to insure that the timer within each explosive package has reached the minimum operating temperature of +40°F. See Figures 6-4 and 6-5. Explosive packages will be deployed as shown in Figure 6-6. Before starting out on the LRV geology traverse during EVA #1, the astronauts will stow on the LRV the EP pallet which contains EP's #5, #6, #7, and #4. During the EVA #1 traverse, the astronauts will deploy: EP #6 (1 lb.) EP #5 (3 lbs.) EP #7 (1/2 lb.) During the EVA #2 traverse, the astronauts will deploy: EP #4 (1/8 lb.) EP #1 (6 lbs.) EP #8 (1/4 lb.) During EVA #3, the astronauts will deploy: EP#2 (1/4 lb.) EP#3 (1/8 lb.) The #1, 6-pound EP must be deployed at the greatest distance from the LSPE geophone array, but should not exceed 2.5 kilometers. The #4 and #3 1/8-pound EP's must be deployed a minimum of 150 meters from the geophone array.

TABLE 6-1. LUNAR SEISMIC PROFILING DEPLOYMENT CRITERIA (Concluded)

PARAMETER	CRITERIA
Explosive Packages Deployment (Concluded)	As each EP is deployed on the lunar surface, the astronaut will extend the telescoping whip antenna. The explosive package may be lowered to the surface using the extended receiving antenna. Pull the three rings in sequence. MCC must be informed by voice communications of the exact time when pull ring #3 is pulled so that the time of detonation may be accurately forecast.
Precautions	One of the safety devices provided in the LSPE is an Astronaut Switch located above the carry handle on the ALSEP Central Station. This switch controls the power to the LSPE and is preset to the counter-clockwise DISABLE position. The astronaut must rotate this switch clockwise to the ENABLE position or the LSPE can never be activated. The astronauts must identify the location of each deployed EP. The pull rings on the EP's should be pulled with a minimum delay between each pin removal.

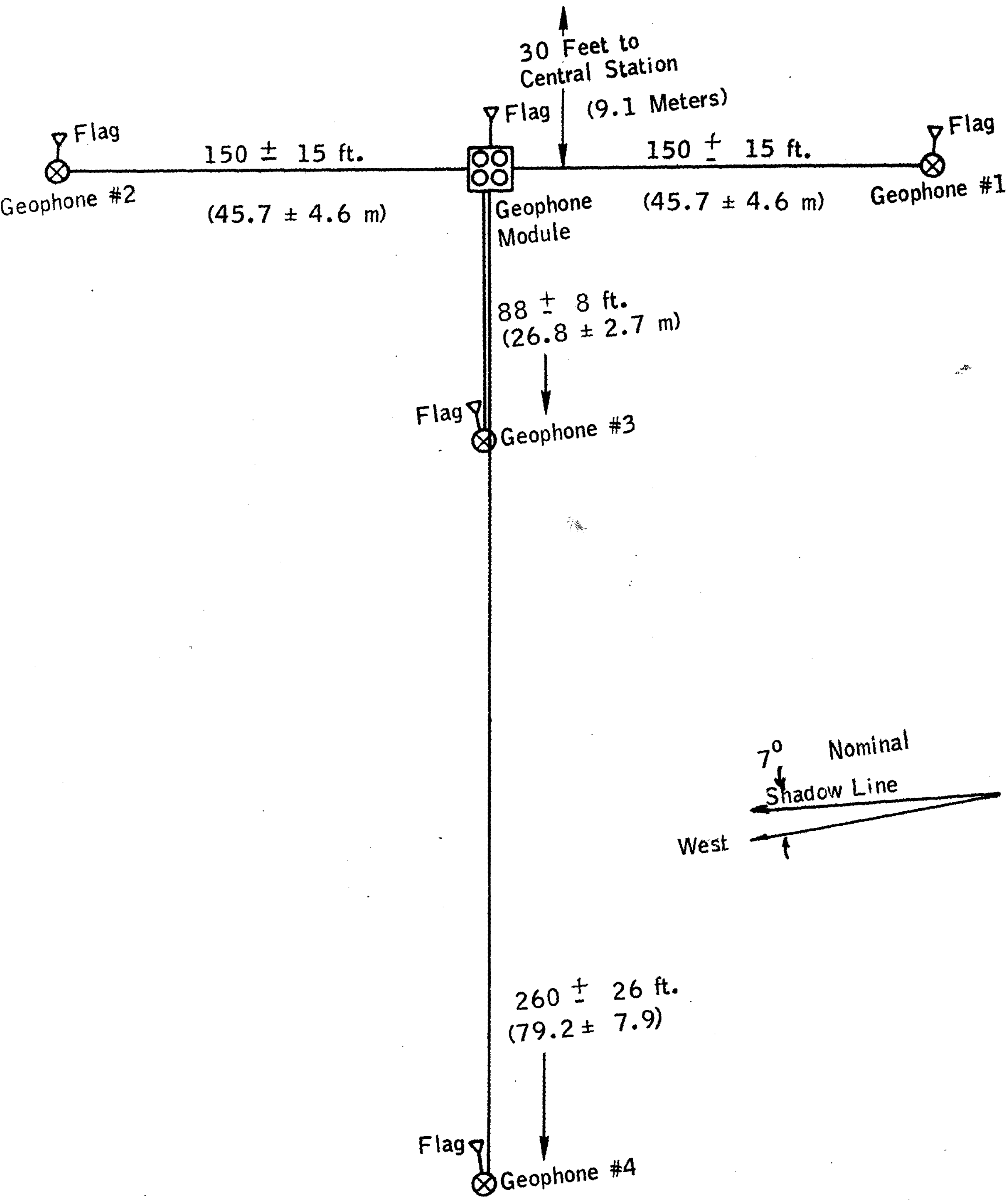


Figure 6-1. LSPE Geophones Deployed

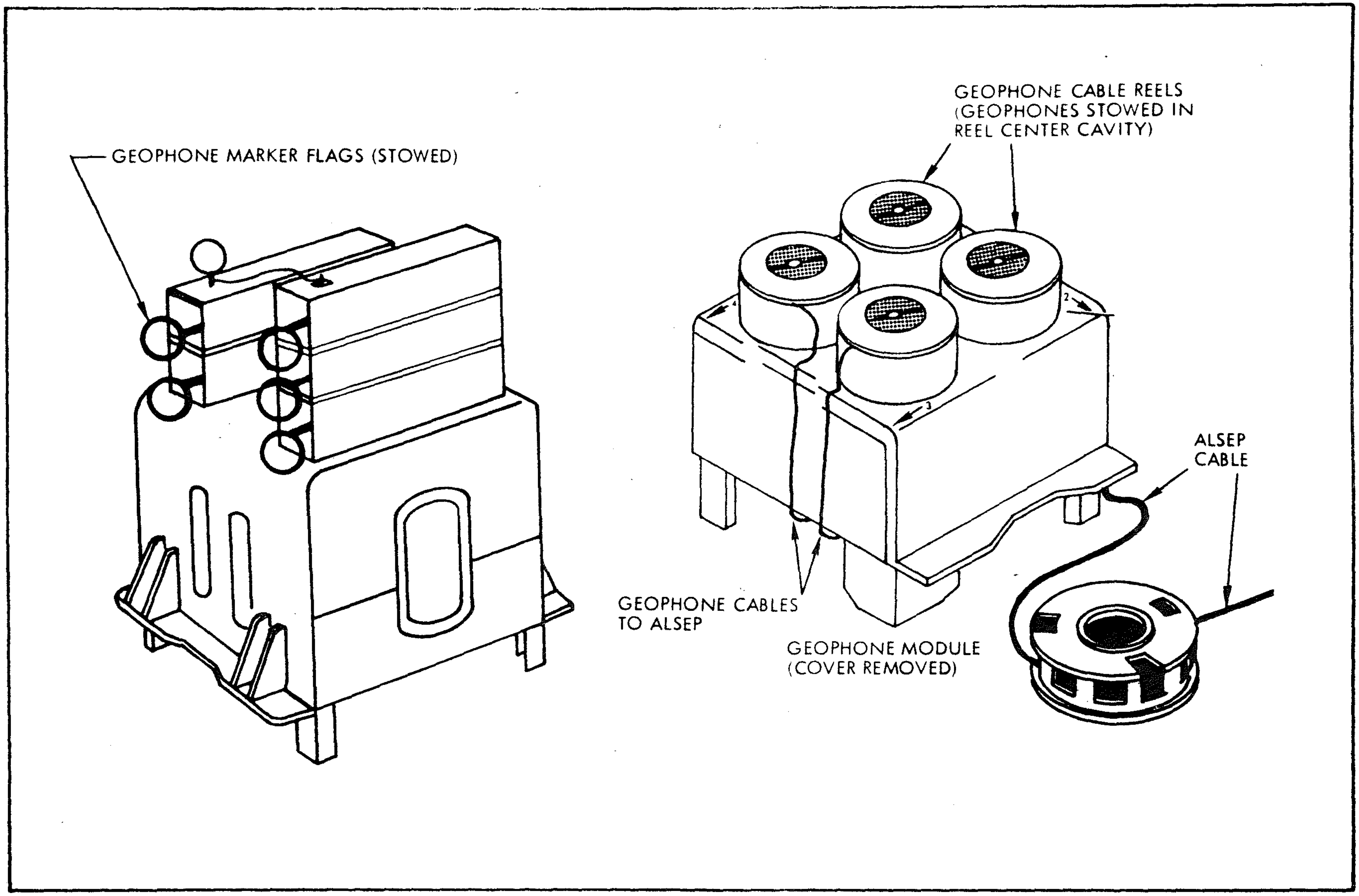


Figure 6-2. LSPE Geophone Module

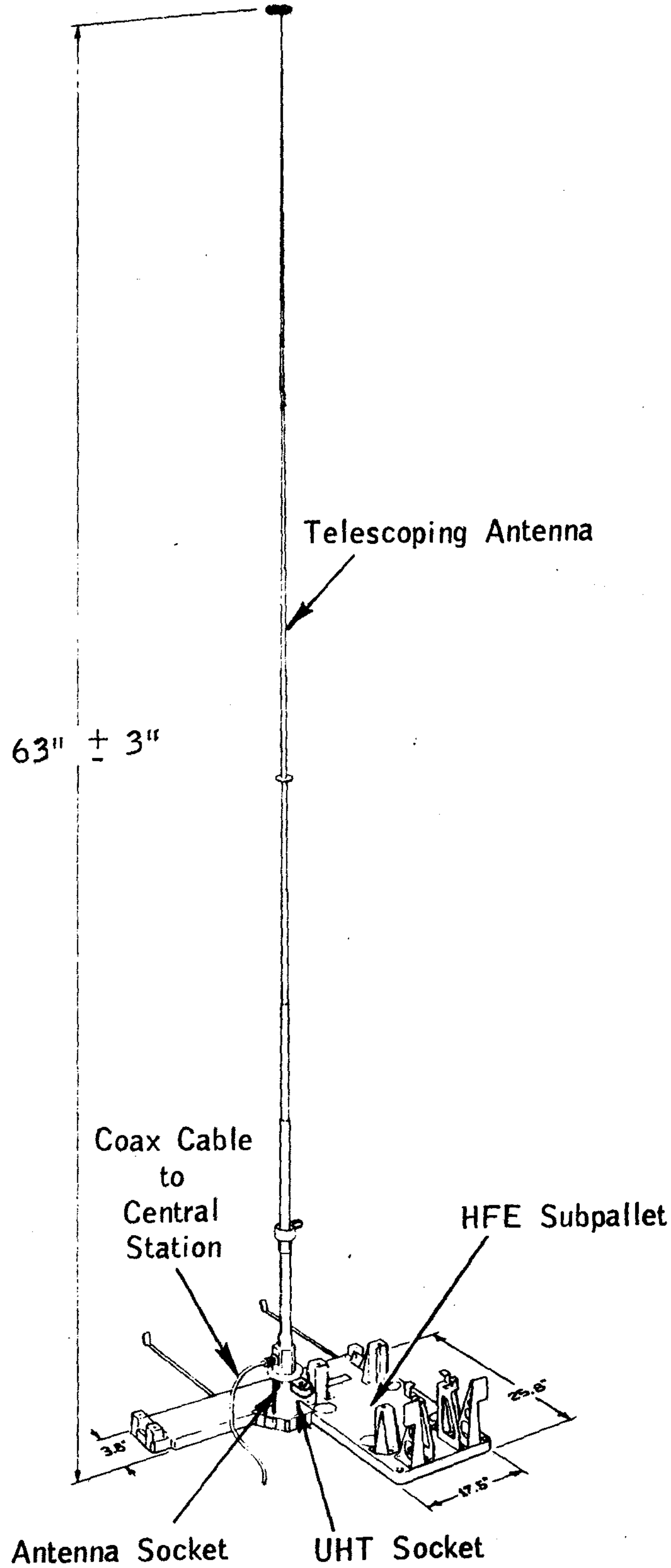
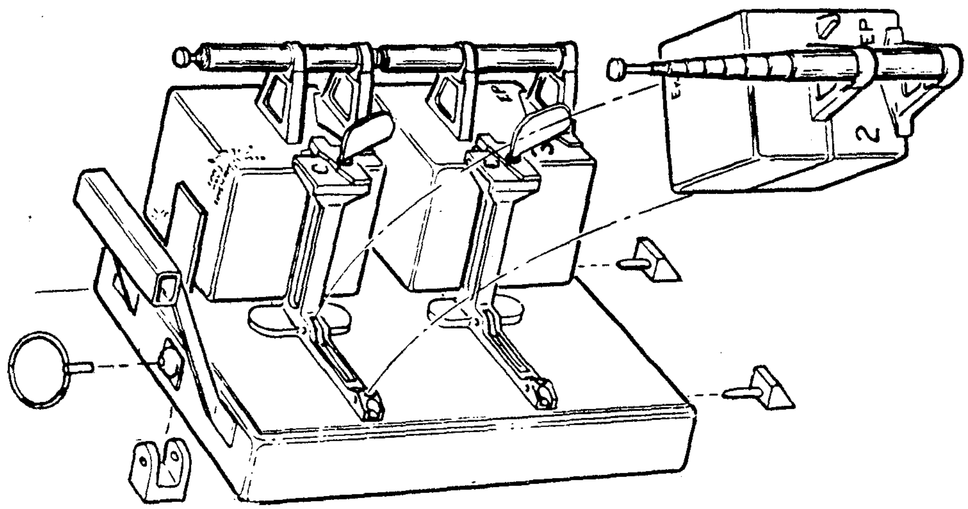


Figure 6-3. LSPE Transmitting Antenna

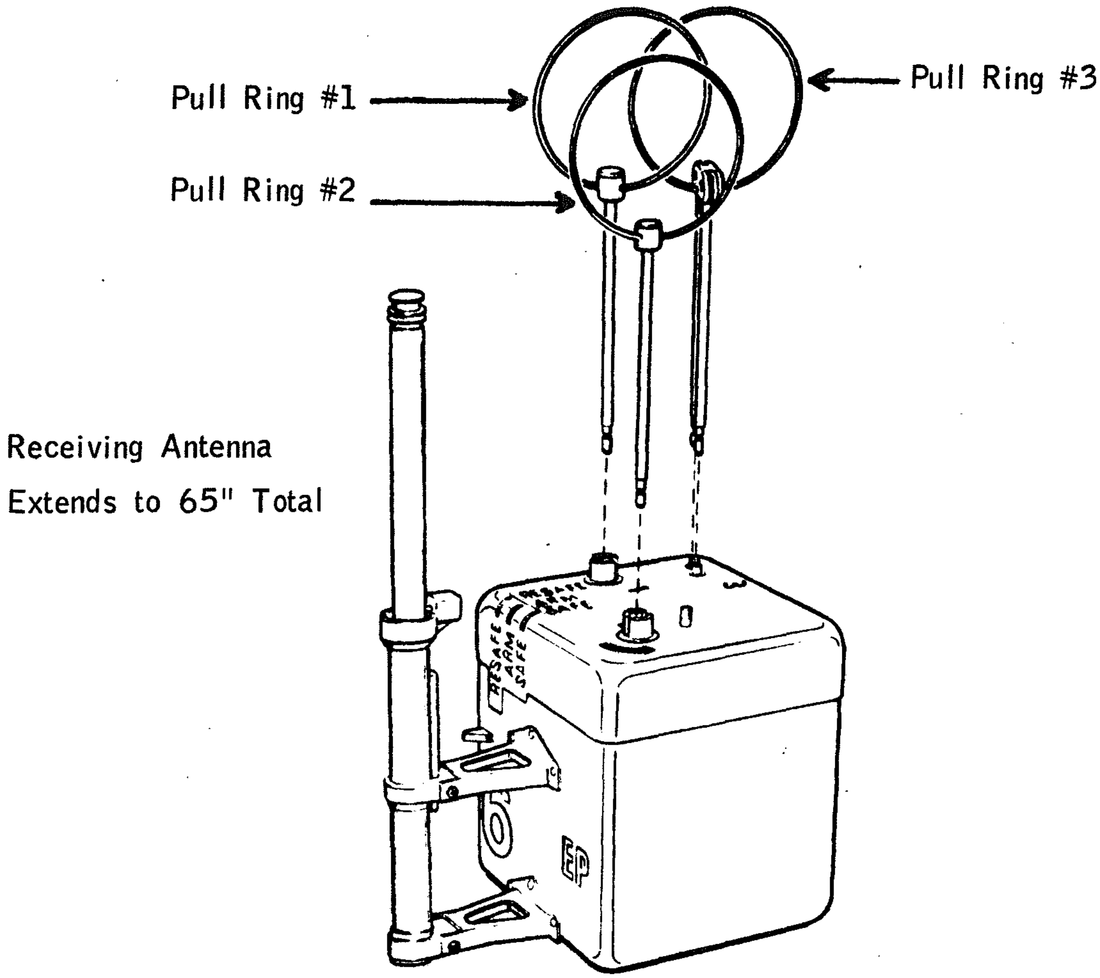


There are 2 Explosive Package Pallets
There are 4 Explosive Packages on each Pallet

Deployment Sequence

EVA #1	EVA #2	EVA #3
EP #6 1 lb. charge	EP #4 1/8 lb. charge	EP #2 1/4 lb. charge
EP #5 3 lb. charge	EP #1 6 lb. charge	EP #3 1/8 lb. charge
EP #7 1/2 lb. charge	EP #8 1/4 lb. charge	

Figure 6-4. LSPE Explosive Package Pallets

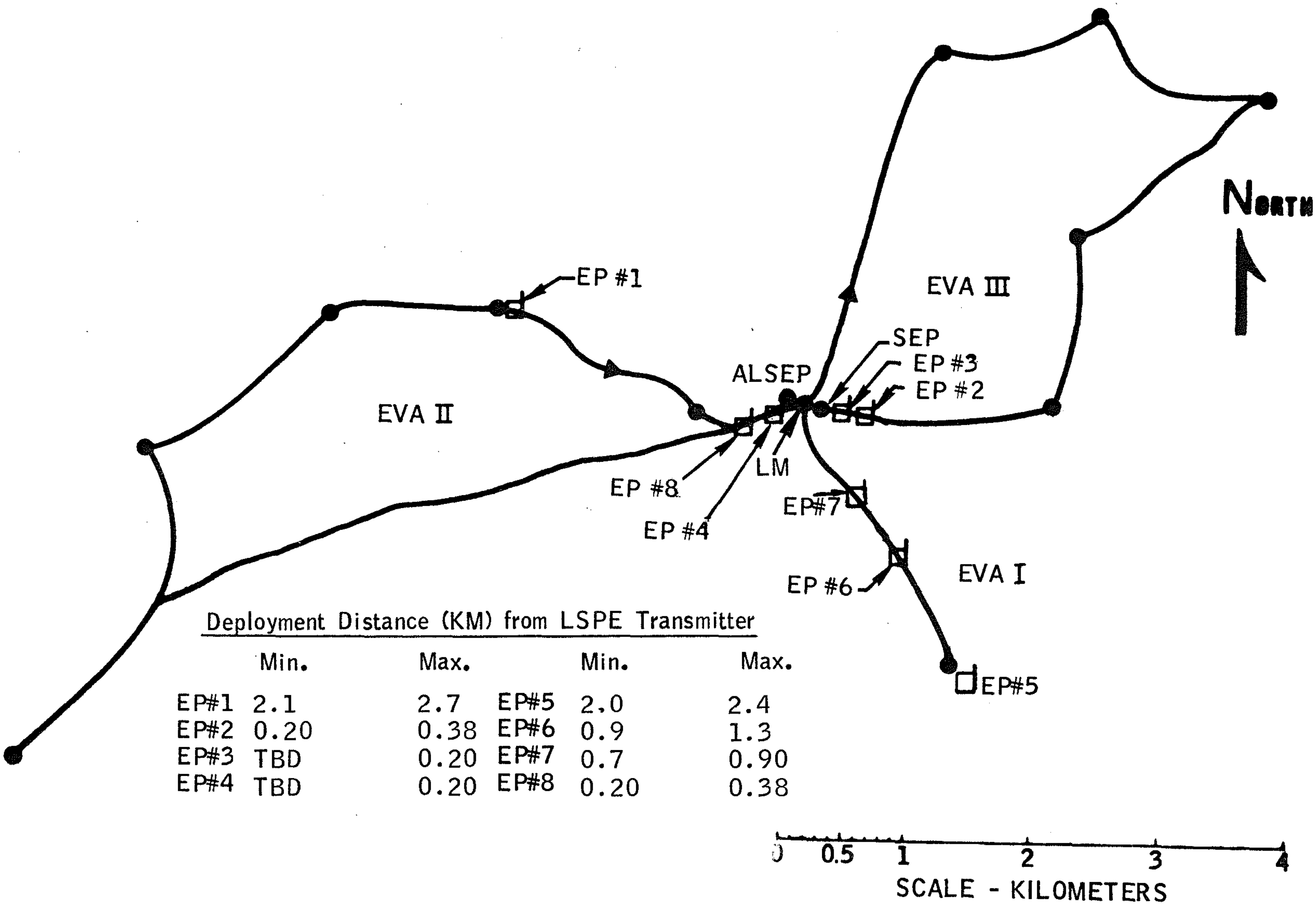


Pull Ring #1: Pulls 1 Pin to Start Safe/Arm Slide Timer

Pull Ring #2: Swing Up Ring; Rotate 90° CCW:
Pull Pin to Release Safe/Arm Plate

Pull Ring #3: Pulls 2 Pins to Free Firing Pin and
Start Thermal Battery Timer

Figure 6-5. LSPE Explosive Package



Deployment Distance (KM) from LSPE Transmitter

	Min.	Max.		Min.	Max.
EP#1	2.1	2.7	EP#5	2.0	2.4
EP#2	0.20	0.38	EP#6	0.9	1.3
EP#3	TBD	0.20	EP#7	0.7	0.90
EP#4	TBD	0.20	EP#8	0.20	0.38

Figure 6-6. LSPE Explosive Packages Deployed

6.2 LSPE OPERATIONAL DATA

6.2.1 LSPE Scientific Data

The four geophones of the LSPE are electromagnetic devices which translate the motion of the lunar surface to electrical signals in the frequency range of 2 to 20 Hz. The output of each geophone is amplified, filtered, log compressed, digitized in the A/D Converter and then transmitted to earth through the ALSEP Central Station.

Seismic signals from natural events are sensed by the geophones; however, the primary objective is to detect the seismic signals from the detonation of eight explosive packages which are emplaced by the Apollo 17 astronauts. These signals, when correlated with detonation time and the location of both the energy source and the geophone, are used to determine the velocity of the seismic signal.

The nominal output of each scientific data channel for signal levels of 18 db above the system noise level is 166 millimicrons per second to 50 microns per second in the frequency range of 2 to 20 Hz. The scientific data channels are DP-01, DP-06, DP-11 and DP-16 as shown in the "Measurements Requirements Document - Array E," SE-33-A.

6.2.2 LSPE Engineering Data

Information on the performance and operational status of the LSPE electronics unit (mounted in the Central Station) is only provided when Array E is in the LSPE operating mode (and LSPE has operational power applied). Four analog measurements are provided to enable certain electrical and thermal parameters to be monitored. The values of these parameters during normal operation are listed in Table 6-2, together with the four Central Station parameters that are made available to monitor system performance. One analog measurement of the temperature of the LSPE electronics is provided when Array E is in the General operating mode and is active regardless of whether power is applied to the LSPE or not. The LSPE operational status indicators are identified in Table 6-3.

TABLE 6-2.

LSPE ENGINEERING MEASUREMENTS

Meas.	Frame	DESCRIPTION	Normal Operating Range Low	Normal Operating Range High	Nominal	Limits (See Note 1) Low	Limits (See Note 1) High
LSP OPERATING MODE							
DP-02	---	A/D Calibration No. 1	1.31	1.35	1.33	1.29(T) 1.23(M)	1.37(T) 1.43(M)
DP-05	---	A/D Calibration No. 2	3.91	3.95	3.93	3.89(T) 3.69(M)	3.97(T) 4.17(M)
DP-03	---	DC/DC Converter Output	11.0	12.8	+12	11.0 (T) 10.0 (M)	12.8(T) 15.0 (M)
DP-14	---	Electronics Temperature (°F)	0	130	----	-10 (T) -50 (M)	158 (T) 200 (M)
AE-03	---	PCU #1 Input Voltage	15.8	16.4	----	0.1 (M)	16.5 (M)
AE-04	---	PCU Input Current (amps)	4.1	4.8	----	0.1 (M)	6.2 (M)
AE-24	---	Reserve Current (amps)	0.3	2.7	----	0.0 (M)	5.0 (M)
AT-16	---	Thermal Plate #6 (Temp -°F)	+4	+117	----	-40 (M)	205 (M)
DP-10	---	Geophone Calibration Pulse Amplitude (2) ON	1.9	2.10	2.00	1.75(T) 1.75(M)	2.25(T) 2.25(M)
		OFF	0.0	0.04	0.025	0.01(T) 0.01(M)	0.10(T) 0.10(M)
GENERAL OPERATING MODE							
AP-01	25	LSP Electronics Internal Temperature (°F)	4	129	----	-40 (M)	190 (M)

Note 1: Legend - (M) Measurement Limits, (T) Test Limits. See Sect. 3.3

2: Geophone Calibration pulse is on for 1.5 ± 0.5 seconds after sending CMD 170. It is off at all other times.

TABLE 6-3.

LSPE STATUS INDICATORS

PARAMETER	MEAS. NO.	INDICATION
Calibration Pulse	DP-18	OFF/ON
Geophone Amplifier Gain	DP-19	Normal/Low
Experiment Power Status	AB-04/AB-05	
- Operating Power On (1)		ON
- Standby Power On (2)		STBY
- Power Off		OFF
Transmitter Pulses On (3)	DP-20	OFF/ON

(1) Operating Power is applied to the LSPE only if the Astronaut Switch on Central Station is in the "ENBL" position (clockwise).

(2) Standby power is not applied to the LSPE; telemetry indicates relay setting.

(3) With transmitter pulses on, status is indicated in subframe 1 (DP-20) once every 29.55 seconds.

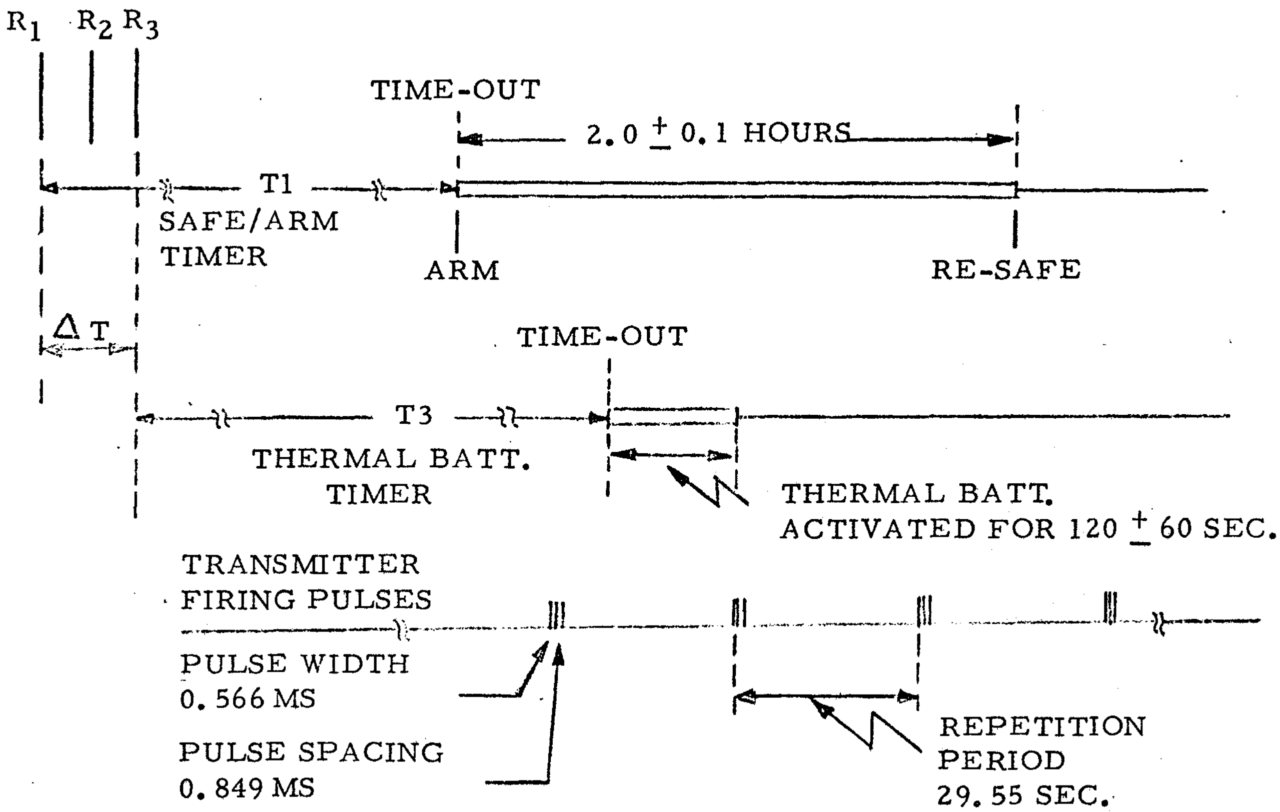
6.2.3 LSPE Operational Modes

The normal operation of LSPE precludes normal operation of all other Array E science sensors and the majority of non-LSPE engineering sensors. Normal LSPE operation, as defined on the previous pages, requires Array E to be in LSPE mode with data being provided at 3,533 bits per second. Whenever LSPE is operated in this fashion, the geophone sensors will provide measurements of the ambient seismic activity at their deployed locations.

For the seismic information to be derived from the detonation of the 8 explosive packages, Array E must be in this LSPE operating mode at the time of detonation of each package as dictated by the ignition timing unique to each package. The timing associated with each package is described in Figure 6-7.

6.2.4 LSPE Power Demands

Since the performance of no part of the LSPE outside of the Central Station is temperature-critical, this equipment makes no demand for general thermal control power. It is important to note that LSPE has no Standby mode regardless of the telemetered indication of power distribution to EXP 5. Hence the LSPE power demand in the operating mode is the same regardless of ambient temperature, namely 5.3 watts.



EP NO.	T1 (HRS)	T3 (HRS)
4 & 6	89.75±0.45	90.75±0.45
1 & 5	90.75±0.45	91.75±0.45
2 & 7	91.75±0.45	92.75±0.45
3 & 8	92.75±0.45	93.75±0.45

NOTES:

1) R_1, R_2 and R_3 represent pull rings used by the Astronaut to remove Exp. Pkg. Pins.

2) T1 starts when R_1 is pulled to extract Pin.

3) T3 starts when R_3 is pulled to extract Pin. ΔT is the delay between T1 start and T3 start.

4) At T1 time-out, Safe/Arm Slide moves to "Arm" position. Arm status continues for 2 + 0.1 hours after which the slide moves to the "Re-Safe" position.

5) At T3 time-out, Thermal Battery powers circuits for 120 ± 60 seconds.

6) T3 time-out must occur within 2 ± 0.1 hours of T1 time-out.

Figure 6-7. Timing of Explosive Package Detonations

TABLE 6-4. LSPE EP DETONATION PLAN

EP No.	Transport Module No.	EP Charge Size-Lbs.	Deployment Distance - Kilometers		Nominal Deployment Time - Hr. Min.		Detonation Time	
			Max.	Min.	EVA	EVA Time	After Deployment - Hours	After LM Liftoff - Hrs:Min.
6	2	1	1.3	0.9	1	4:16	90.75 ± 0.45	23:38
5	2	3	2.4	2.0	1	5:28	91.75 ± 0.45	25:50
7	2	1/2	0.9	0.7	1	5:49	92.75 ± 0.45	27:11
4	2	1/8	0.2	TBD	2	0:55	90.75 ± 0.45	42:47
1	1	6	2.7	2.1	2	5:17	91.75 ± 0.45	48:09
8	1	1/4	.38	.20	2	6:11	93.75 ± 0.45	51:03
2	1	1/4	.38	.20	3	5:59	92.75 ± 0.45	73:21
3	1	1/8	0.2	TBD	3	6:04	93.75 ± 0.45	74:52

Note: The times given above are based on the following planned Mission Event GET times:

Landing	113:02
Start EVA #1	116:40
Start EVA #2	139:10
Start EVA #3	162:40
LM Liftoff	188:03
TEI	236:15

6.3 LSPE CONSTRAINTS AND LIMITATIONS

6.3.1 LSPE Deployment Constraints

The constraints on the deployment of the LSPE components are given in Section 6.1.

The antennas on the LSPE Explosive Packages must be fully extended prior to being emplaced on the lunar surface. It is also important that the 3 pull rings (see Figure 6-5) be removed from each package before final deployment. The crew is required to report to MCC when pull ring #3 on each package is pulled so that the time of detonation may be forecast (see Figure 6-7).

One of the safety devices provided in the LSPE experiment is an Astronaut Switch located above the carry handle on the Central Station. This switch controls the power to the LSPE and is initially set in the counterclockwise DISABLE position. It is mandatory that this switch be rotated clockwise to the ENABLE position or the LSPE can never be activated. The actual decal markings are DSBL/ENBL.

The LSPE RF link constraints require that the maximum distance between the LSPE transmitting antenna and any deployed Explosive Package be no more than 3.5 kms (2.18 miles). The minimum separation between any deployed Explosive Package and the LM or the ALSEP is 152 meters (500 feet).

6.3.2 LSPE Operational Constraints

It will be essential, during the initial operational phase of Array E to maintain an accurate log of the times of activation of each Explosive Package (see Figure 6-7). The success of the LSPE operational support (having ALSEP and Mission Control Center properly configured) is entirely dependent on the proper forecasting of the time of detonation of each Explosive Package.

To maintain adequate surveillance on total system performance during the explosive detonation period, it is recommended that Array E be restored to normal mode to monitor equipment performance and status, if the forecast time of next detonation exceeds two hours.

The LSPE transport modules with their Explosive Packages must be stowed in the sun for at least 1.8 hours prior to EP deployment. This can be accomplished either mated to the LRV pallet or the Quad III pallet on the lunar surface. This warm-up time is necessary to insure that the timers within each EP reach a minimum operating temperature of 40°F prior to deployment and activation.

6.4 LSPE COMMANDS

- 156 LSPE Pulses On

This CMD is required to activate the pulse function of the 41.2 MHZ LSPE Xmtr which transmits time-coded fire pulse sets (3 per set) at 29, 55-sec intervals and AGC pulses once per LSPE subframe (169.8 millisec). One fire pulse set will trigger detonation of an explosive package provided that timer-controlled functions in the explosive package are in the proper configuration to accept, arm, and execute the firing input, AGC pulses desensitize the explosive package receiver to ambient noise and EMI. CMD 156 is to be transmitted to switch the LSPE Xmtr pulse function on from a time 90 minutes before the first normal arm time through the detonation of the last explosive package in each group of four, presence of LSPE Xmtr pulse function is read out in the LSPE TM, repeated application of CMD 156 has no further effect.

- 162 LSPE Pulses Off

This CMD deactivates the pulse function of the LSPE Xmtr if the function was activated by application of a CMD 156. Repeated application of CMD 162 has no further effect. When the LSPE is activated by application of operational power, the LSPE Xmtr pulse function will be in the deactivated mode.

- 163 LSPE Gain Norm

This CMD switches the four LSPE geophone amplifier channels back to the normal, high-gain mode, if the amplifier had been switched to the low gain mode by application of a CMD 164. The ratio of normal to low gain is nominally 10 but may vary from 8 to 12.5 (20 + 2 DB). Repeated application of CMD 163 has no further effect. When the LSPE is activated by application of operational power, the LSPE will be in the geophone amp normal gain mode.

- 164 LSPE Gain Low

This CMD is required to switch the four LSPE geophone amplifier channels to the low-gain mode of operation. The ratio of normal to low gain is nominally 10 but may vary from 8 to 12.5 (20 + 2 DB). Repeated application of CMD 164 has no further effect.

- 170 LSPE GEO CAL

This CMD causes the seismic detection system to switch to the calibration mode for approximately 1.5 sec. This produces a relative calibration of all four geophone channels for comparison to an absolute preflight calibration, to detect any changes in such parameters as geophone resonant frequency and system sensitivity. The calibration signal is fixed, showing lower response at low gain. Repeated application of CMD 170 causes repeated switchovers to the calibration mode.

SECTION 7.0 LUNAR ATMOSPHERIC COMPOSITION EXPERIMENT (LUNAR MASS SPECTROMETER)

7.1 LACE/LMS Deployment Criteria

TABLE 7-1. LUNAR ATMOSPHERIC COMPOSITION DEPLOYMENT CRITERIA

PARAMETER	CRITERIA
Sensor Venting	Prior to removal of the LACE from the Subpackage #1 pallet, the astronaut will pull the lanyard ring on the instrument, allowing the escape of the krypton gas with which the sensor was backfilled on earth.
LACE Deployment	The LACE will be deployed 14 meters (45 feet) or more east-northeast of the Central Station. See Figure 2-5. The deployment location shall be such that surrounding equipment and natural terrain features, e.g., boulders will not be in the plane containing the entrance aperture of the instrument within a radius of 15 meters.
Alignment	The instrument should be oriented so that the base-plate lies nearly in an east-west plane with the cable exit to the south. The cable should run due south of the LMS for 1 or 2 meters and then run west-southwest to the Central Station. See Figure 7-1.
Leveling	The LACE will be leveled within ± 15 degrees. When the bubble in the bubble level is free from the edge of the window, the instrument is leveled. If the LACE is not level, do not embed the instrument, but reposition it in a more level location.
Sensor Activation	After the LACE has been deployed on the lunar surface, the astronaut will use the UHT as a lever, moving in the direction of the arrow, to snap the breakseal. Carefully deposit the breakseal a sufficient distance away so that the resulting dust cloud will not settle on the instrument. Verify that the LACE is still level within ± 15 degrees and is not embedded in the lunar surface. Not until after the LSPE explosive packages have been detonated will an uplink command be sent from MCC to release the dust cover and expose the thermal radiation mirrors. The LACE can thermally survive a full lunar day in Standby with the dust cover on.
Precaution	The final discarded location for the ALSD should not be near the LACE. The ALSD battery will outgas and could perturb the science data.

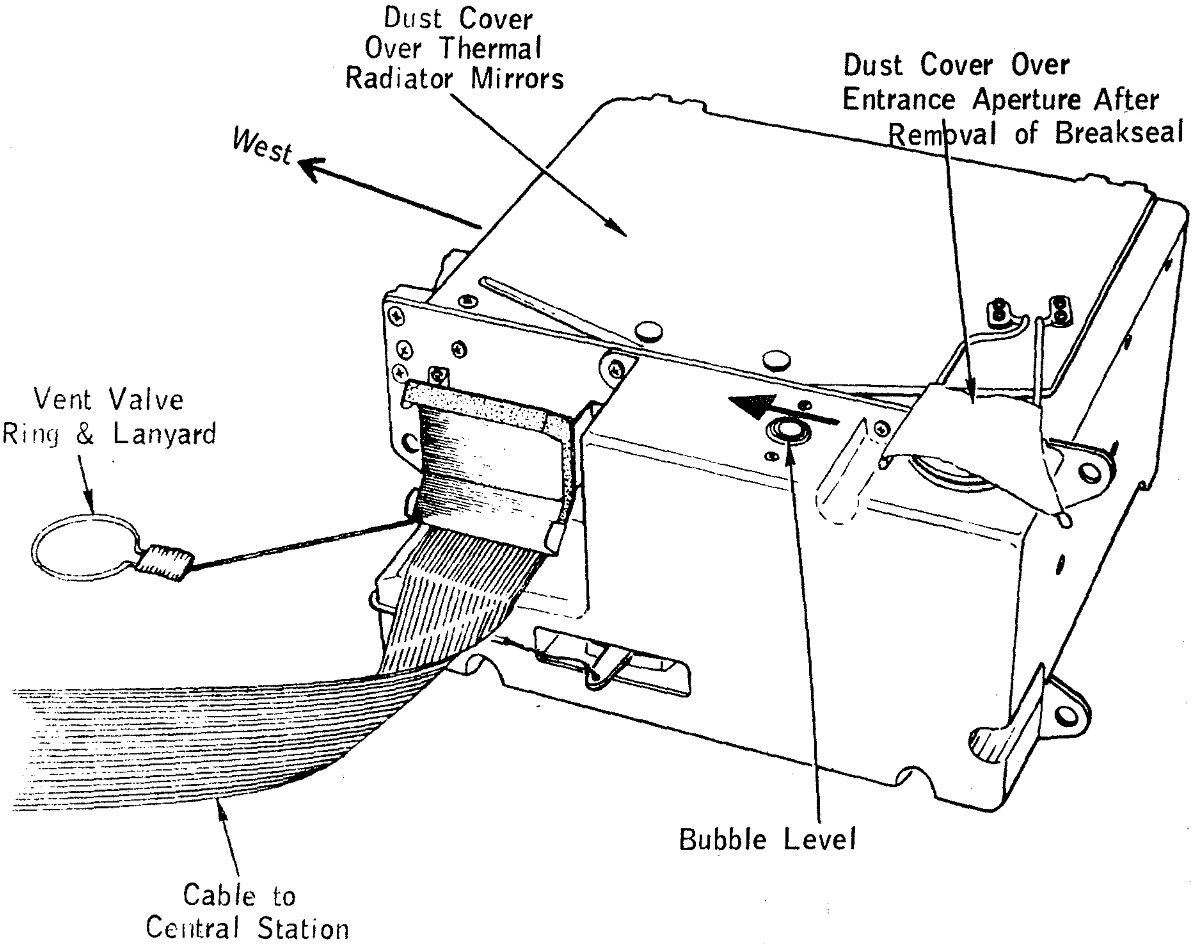


Figure 7-1. Lunar Atmospheric Composition Experiment (Lunar Mass Spectrometer)

7.2 LACE/LMS OPERATIONAL DATA

7.2.1 LACE Scientific Data

The LACE provides measurements of the relative number of atoms and molecules having masses within the following ranges of atomic mass units:

1 to 4 amu.
12 to 48 amu.
27 to 110 amu.

These measurements are provided by three sensors which count the number of neutral particles which pass through associated apertures after being ionized and accelerated through a fixed magnetic field. These counts constitute the primary scientific data from the LACE and, when correlated with a complete series of accelerating voltage steps and/or with time, they permit analysis of the lunar atmospheric composition.

The three scientific measurements as telemetered from the moon are processed in Mission Control Center to provide decimal readouts of the particle counts from each analyzer. Each decimal readout can range from 0 to 1212416 and represents the number of particles having masses corresponding to the electrical and geometric configuration of each analyzer. The configurations and operating modes are listed in Section 7.2.3.

7.2.2 LACE Engineering Data

The performance and operation of the LACE is portrayed through the 16 analog measurements and the 10 status indicators provided in the engineering data. The values of the analog measurements to be expected when the LACE is operating normally are listed in Table 7-2. The status indicators are identified in Tables 7-3 and 7-4. Table 7-4 lists only those command register indications which, if executed by CMD 134, result in valid functional changes. The general command operations associated with the LACE are described in Section 7.4

TABLE 7-2.

LACE/LMS ENGINEERING MEASUREMENTS

Meas. No.	ALSEP Word 33 Channel Nos.	DESCRIPTION	Normal Operating Range Low	Normal Operating Range High	Nominal	Limits (1)(Meas. Range)* Low	Limits (1)(Meas. Range)* High
AM-02	40-2	Input Current (milliamps)	220	450		8	622
AM-12 (2)	40-12	Filament 1 Current (amps)	1.18	1.43		0.2	2.5
AM-13 (2)	40-13	Filament 2 Current (amps)	1.18	1.43		0.4	2.6
AM-11 (3)	40-11	Emission Current (microamps)	100	250		-6.1	453.6
AM-03	40-3	Ion Pump Current (microamps)	0.01	30		0	52
AM-44	-44	Sweep Voltage	0	1420		0	1500
AM-04	40-4	Ion Pump Voltage	3000	3700		-3676	+25690
AM-14 (3)	40-14	Multiplier Voltage	0	-3000			
AM-07	40-7	+12 VDC (Supply Voltages)	11.9	12.1		0.1	16.0
AM-08	40-8	+5 VDC (Supply Voltages)	4.6	5.4		0.1	10.5
AM-09	40-9	-12 VDC (Supply Voltages)	-12.1	-11.9		-20.1	-0.2
AM-10	40-10	-15 VDC (Supply Voltages)	-15.1	-14.9		-15.8	-0.1
AM-41(4)	-41	Electronics (°F)	-10	+115		-31(-14)	+206(+160)
AM-05	40-5	Analyzer Baseplate (°C) (Temp.)	-160	+150		-236	+182
AM-06	40-6	Ion Source (°C) (Temp.)	-60	+200		-79	+277
AM-15	40-15	L. V. Pwr. Supply (°F) (Temp.)	-5	+140		-31	+206

* See Note 5.

Note 1: For the significance of "Meas. Range" see Sect. 3.3.9.
Note 2: Only one (or neither) will be active and give valid data.
Note 3: Multiple calibration measurements; dependent on AM-41 value.
Note 4: AM-41 "Test" limits are shown in parentheses.
Note 5: Test measurements will be added as an amendment.

TABLE 7-3.

LACE/LMS OPERATIONAL STATUS INDICATORS

Parameter	Meas No.	Indication
Multiplier Voltage	DM-12	Low/High
Discriminator Level	DM-13	Low/High
Mass Step	DM-14	
. Background or Calibrate		BKG/CAL
. Accel Voltage Stepping		Sweeping
Accel Voltage	DM-15	
. Automatically Stepping		Auto Step
. Fixed (Manual Stepping)or OFF		Lock
Ion Pump	DM-16	Off/On
Dust Cover	DM-17	
. In Place		
. Removed		
Bake-Out Heater	DM-18	Bypass/Enable
Multiplier and Sweep H.V.	DM-19	Off/On
Filaments	DM-20	Off/On
Command Register	DM-01	(See Table 7-4)

TABLE 7-4.

LACE/LMS COMMAND STATUS INDICATOR

Commandable Function	CMD Pair	Indication
Step, Mult., Sweep HV ON and Back-up Heater Off	123 - 124	110000 - STP SWP HV ON
Lock (Sweep Hold) J-Plate Voltage Step, and Fixed Mode Select	123 - 125	101000 - SWP HOLD & J V STP
One-Step (Sweep Advance)	123 - 127	100100 - SWP ADV
Emission/Filaments OFF and Mode Select ENABLE	123 - 132	100010 - EMISON/FIL OFF
Filament #1 ON & Mode Select Inhibit	123 - 133	100001 - FIL 1 ON
Filament #2 ON & Mode Select Inhibit	124 - 125	011000 - FIL 2 ON
Mult. High and Back-up Heater ON	124 - 127	010100 - MULT H & B HTR ON
Mult. Low	124 - 132	010010 - MULT LOW
Disc. High J-Plate Voltage Step Enable, and Cyclic Mode Select	124 - 133	010001 - DIS H & J V STP ENABLE
Disc. Low and J-Plate Voltage Step Inhibit	125 - 127	001100 - DIS L & J V STP INHIBIT
Bakeout Enable	125 - 132	001010 - BAKEOUT ENABLE
Bakeout Disable	125 - 133	001001 - BAKEOUT DISABLE
Dust Cover Removal	127 - 132	000110 - DUST CVR REMOVE
Ion Pump ON	127 - 133	000101 - ION PUMP ON
Ion Pump, Mult and Sweep HV OFF	132 - 133	000011 - ION P MU SWP HV OFF

7.2.3 LACE Operational Modes

In the "normal" operating mode of the LACE, the accelerating potential, which defines the mass numbers being analyzed, is automatically cycled through a series of 1350 values. This normal operating cycle also includes background and calibration measurements. The emission control is in the fixed mode with the filament bias at -70 volts.

By command (Table 7-4), this automatic sequence can be stopped and the accelerating potential set to a particular, fixed value by advancing the sequence manually.

A third operational mode, called cyclic mode, is selected by the following octal command sequence:

(1) 123/132/134 (Required only if a filament is ON)
(2) 124/133/134
(3) 125/127/134
(4) 123/133/134 or 124/125/134

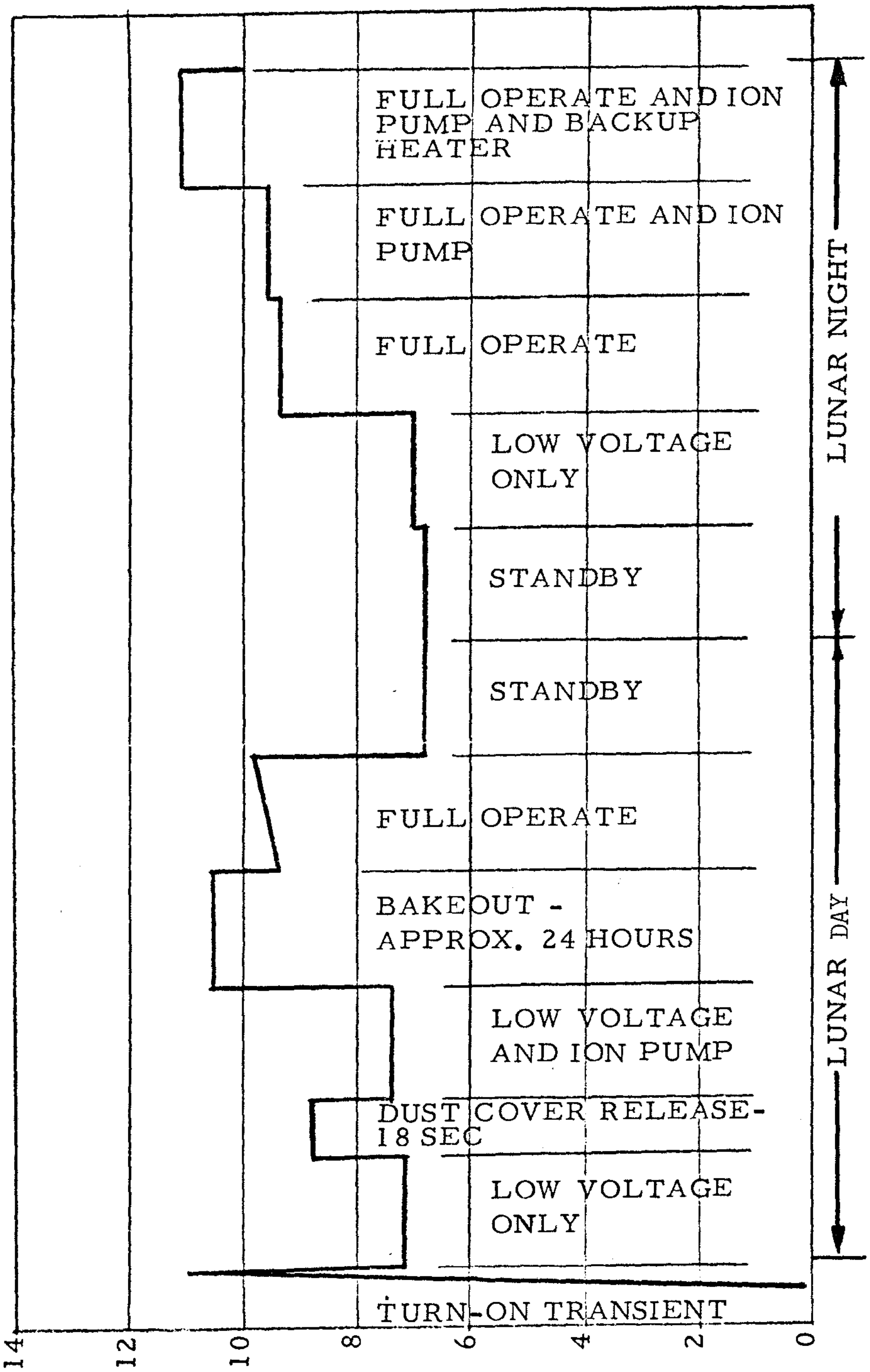
This mode is generally used in conjunction with the normal mode, that is, with the accelerating potential cycling. In the cyclic mode, the ionization electron energy level is changed after each sweep of the mass spectra by selecting sequential values of filament bias, namely, -70^V, -18^V, -25^V, and -20^V. The ionization potential pertinent to each mass spectra is inferred from the measurement of emission current.

A fourth operating mode, called the Bakeout mode, can be activated only when LACE is in Standby. This mode must be enabled when LACE has operate power supplied (by CMD sequence 125/132 and 134). It is not initiated until LACE is commanded to Standby (by CMD 037) after being enabled.

7.2.4 LACE Power Demands

The LACE power demands are dependent on the operating mode and on the temperature of the electronics. These variations in power demand are illustrated in Figure 7-2. This power demand will be reflected in the display of supply current (AM-02). In addition the changes in power demand will be registered in the display of reserve power.

An illustration of LACE electronics temperature variations with sun angle is shown in Figure 7-3.



LACE/LMS TOTAL POWER - WATTS

Figure 7-2. LACE Power Profile

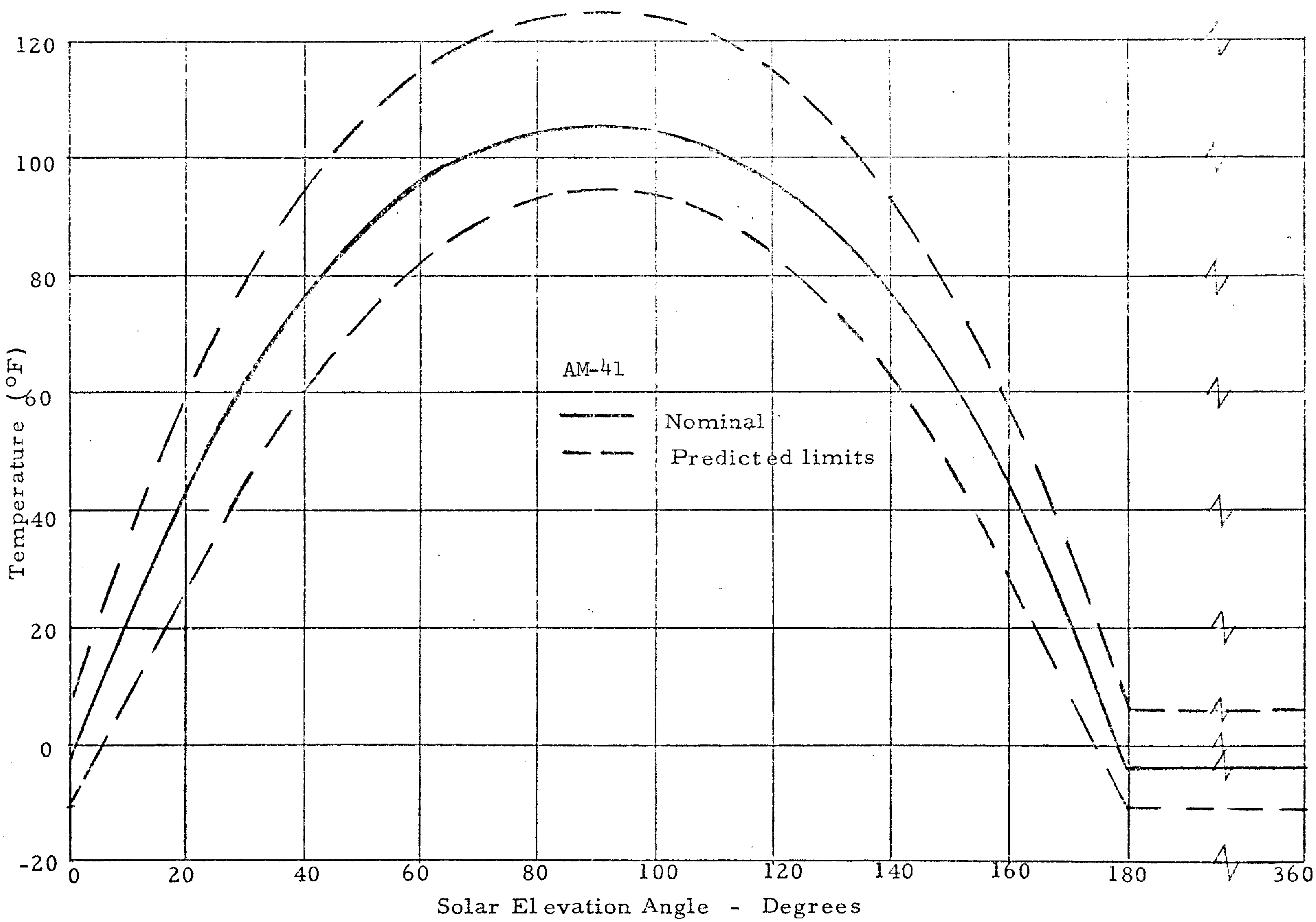


Figure 7-3. LACE Electronics Temperature Predictions

7.3 LACE CONSTRAINTS AND LIMITATIONS

7.3.1 LACE Deployment Constraints

Although a dust shield is provided over the sensor opening, caution should be exercised during deployment to ensure that dust is not inadvertently kicked up on the LACE in this area.

7.3.2 LACE Operational Constraints

During the initialization of the LACE on the lunar surface, certain events must be performed in a prescribed sequence. The primary events in this sequence are listed below.

- Vent sensor (using vent pull ring)
- Break sensor aperture seal
- Perform brief check of equipment performance and status
- Wait for conclusion of LSP explosive operations
- Remove dust cover
- Perform bake-out sequence
- Near lunar sunset, initiate full operational sequence

The initial sequence of LACE commands associated with this routine is shown in Table 7-5.

TABLE 7-5.

LACE INITIAL COMMAND SEQUENCE

Step No.	Function Command	CMD No.	Approx. Time	Objectives
1.	LACE Power On	CD-13	After ALSEP Deployment	1. Verify Flag Status (High volts, filaments off).
2.	LACE Execute Command	CM-7	Immediately after Step 1	2. Verify CMD Ver. words.
3.	LACE Power Off		20 minutes after Step 1	3. Insure bakeout enable position. 4. Verify electrical connection to Central Station
4.	LACE Power On	CD-13	After LSPE Operations (Prior to Lunar Noon)	1. Bakeout ion source 2. Monitor Ion source temperature 3. Dust cover removal
5.	Dust Cover Removal	CA-13	Shortly after Step 4	
6.	Bakeout enable	CA-11	Shortly after Step 4	
7.	Power Standby (3 hrs)	CD-14		
8.	Power On	CD-13	3 hrs after Step 7	
9.	Repeat 6, 7, 8 three times			
10.	Ion Pump On	CA-14	1st Lunar day/ night when radiator plate temperature is $<20^{o}F$	1. Put LACE in Full Operation
11.	Ion Pump Off	CA-15	When pressure indicates $<10^{-8}$ TORR	
12.	Filament #1 On	CA-5	Shortly after Step 11	1. Put LACE in Full Operation
13.	Step, Mult,, Sweep HV On	CA-1	Shortly after Step 12	

7.4 LACE COMMANDS

7.4.1 LACE Command Operations

As shown in Table 7-4, the commandable functions of LACE are selected by sending two of six octal commands and are initiated by a CMD 134. Since only this procedure will result in valid functional response, it is essential that the status of the LACE command storage readout be monitored closely during any LACE command sequence. If, for any reason, an incorrect octal command is stored in the LACE register, or the register shows more than two commands stored, it will be necessary to send sufficient octal commands to fill all 6 register positions before transmitting a CMD 134. This procedure will clear the error without adverse functional effect. Prior to full operation, the experiment must be exercised by a special command sequence to verify status, bake out the ion source and remove the dust cover. This sequence is shown in Table 7-5.

7.4.2 LACE Octal - Command Descriptions

The complete LACE octal command (CMD) inventory consists of 6 command register load commands and 1 command to cause execution of the contents of that register. The only register configurations which, when executed, initiate valid functional responses are detailed in Section 7.4.3. Each register-load CMD controls a separate bit in the register, as follows:

CMD	123	124	125	127	132	133
CMD Register Display	X	X	X	X	X	X

- 134 LACE CMD EX

This CMD causes execution of the LACE CMD displayed in its CMD register. Execution also clears the register. Repeated application of CMD 134 has no further effect.

- Application of operational power to the LACE causes initialization of the CMD register in the clear state (000 000).
- If an incorrect CMD load is received by the register, it will not affect the instrument unless executed by CMD Octal 134. Incorrect loads may be cleared by sending additional CMDs to fill the register (111 111) and then executing by sending CMD 134.

7.4.3 LACE Encoded-Command Descriptions

- 123 & 124 Step, Mult, Sweep HV On & Backup Heater Off

This combination of CMD's, when followed by the execute CMD (Octal 134):

- applies power to the electron multiplier HV power supply,
- enables the digital sweep control and sweep HV power supply,
- removes power from the backup heater circuit,
- inhibits turn-on of the ion pump HV power supply.

Note that the ion pump interlock is a one-way inhibit; operation of CMD 123/124/134 is never inhibited.

The digital sweep control is locked (sweep hold) by the CMD combination 123/125; the two HV power supplies are commanded off by 132/133; and the backup heater is energized by 124/127 (each combination executed by CMD 134).

Repeated execution of 123/124/134 has no further effect. Application of operational power to the LACE causes initialization in the lock mode and with the HV power supplies off. The initial state of the backup heater may be on or off (unpredictable).

- 123 & 125 Lock (Sweep Hold), J-Plate Voltage Step, & Fixed Mode Select

This combination of CMD's, when followed by the execute CMD (Octal 134), causes the following changes in LACE:

- deactivates the digital sweep control, to lock its stepping function and hold the sweep HV output at the existing value,

- advances the J-plate voltage sequencer of the ion source emission control by one step if the sequencer has been enabled by 124/133/134,

- selects the fixed mode of operation of the emission control circuit if it has been enabled by 123/132/134.

Reactivation of automatic sweep stepping is performed by 123/124/134. The sweep goes to background mode and holds until the next 90-frame mark at which time normal stepping starts at the beginning of the counter sequence (background).

Application of operational power to the LACE causes initialization in the lock mode, with J-plate stepping inhibited at the last commanded level but with power applied to the J-plate sequencer circuit. Repeated execution of 123/125/134 causes repeated stepping of the J-plate voltage sequencer through its four states, provided the sequencer has been enabled by commands 124/133/134. The nominal voltages (± 2 volts, as a function of temperature) for the two J-plates (J-1 and J-2) are:

Plate	State 1	State 2	State 3	State 4
J-1 J-2	-37.5 -44.5	-24.5 -33.0	-31.5 -39.5	-42.0 -47.5

- 123 & 127 One Step (Sweep Advance)

This combination of CMD's, when followed by the execute CMD (Octal 134), causes the LACE digital sweep control to advance one step if it has been previously locked by 123/125/134. Repeated application of 123/127/134 causes repeated stepping of the digital sweep control through its 1350 steps, or more if desired.

- 123 & 132 Emission/Filaments Off, & Mode Select Enable

This combination of CMD's, when followed by the execute CMD (Octal 134), deactivates a portion of the LACE emission control power supply to remove power from the LACE ion source filaments. It also enables the mode select portion of the emission control circuit. After sending 123/132/134, either the fixed mode emission or cyclic mode emission may be selected as follows:

Fixed Mode:	123/125/134
Cyclic Mode:	124/133/134

Repeated application of CMD 123/132/134 has no further effect. Application of operational power to the LACE causes initialization in the filament-off mode corresponding to CMD 123/132/134. Turn-on of the filaments (including emission control) is accomplished by one of the two CMD's:

Filament #1 On:	123/133/134
Filament #2 On:	124/125/134

- 123 & 133 Filament #1 On & Mode Select Inhibit

This combination of CMD's, when followed by the execute CMD (Octal 134), causes power to be applied to filament #1 of the LACE ion source and selects relay positions such that the filament bias voltages are applied to the correct filaments. This CMD combination (123/133/134) has no effect unless the emission/filaments are off by prior execution of CMD's 123/132/134; specifically, filament #1 cannot be turned on if filament #2 is on. Also, this CMD combination inhibits the mode select circuitry; specifically, the mode of emission not being used cannot be selected without first going to the filament off and mode select state (CMD 123/132/134). Repeated application of CMD 123/133/134 has no further effect. Application of operational power to the LACE causes initialization in the filament-off and mode select enable state.

- 124 & 125 Filament #2 On & Mode Select Inhibit

This combination of CMD's, when followed by the execute CMD (Octal 134), causes power to be applied to filament #2 of the LACE ion source and selects relay positions such that the filament bias voltages are applied to the correct filaments. This CMD combination (124/125/134) has no effect unless the emission/filaments are off by prior execution of CMD's 123/132/134; specifically, filament #2 cannot be turned on if filament #1 is on. Also, this CMD combination inhibits the mode select circuitry; specifically, the mode of emission not being used cannot be selected without first going to the filament off and mode select state (CMD 123/132/134). Repeated application of CMD 124/125/134 has no further effect. Application of operational power to the LACE causes initialization in the filament-off and mode select enable state.

- 124 & 127 Multiplier High & Backup Heater On

This combination of CMD's, when followed by the execute CMD (Octal 134), steps the LACE electron multiplier HV power supply from its normal (low) value to its high value, a step of 600 VDC (two operational values in the output range of -2200 to -3000 VDC). This voltage is supplied to all three electron multiplier tubes. CMD 124/127/134 also applies power to the LACE backup heater. Selection of the alternate conditions by CMD is as follows:

Multiplier Low:	124/132/134
Backup Heater Off:	123/124/134

Repeated application of CMD 124/127/134 has no further effect. Application of operational power to the LACE causes initialization in the multiplier-low state. The initial state of the backup heater may be on or off (unpredictable).

- 124 & 132 Multiplier Low

This combination of CMD's, when followed by the execute CMD (Octal 134), steps the LACE electron multiplier HV power supply from its high value (if previously commanded high by 124/127/134) to its normal low value, a step of 600 VDC (two operational values in the output range of -2200 to -3000 VDC). This voltage is supplied to all three electron multiplier tubes. Repeated application of CMD 124/132/134 has no further effect. Application of operational power to the LACE causes initialization in the multiplier-low state.

- 124 & 133 Discriminator High, J-Plate Voltage Step Enable, & Cyclic Mode Select

This combination of CMD's, when followed by the execute CMD (Octal 134), causes the following changes in LACE:

- selects the higher of the two levels for the preamp discriminator threshold control,

- enables the J-plate voltage sequencer of the ion source emission control so that it can accept the step CMD (123/125/134),

- selects the cyclic mode of emission if it has been enabled by CMD's 123/132/134.

Repeated application of CMD combination 124/133/134 has no further effect. The lower of the two levels for the preamp discriminator threshold control is selected, and J-plate voltage step is inhibited by CMD's 124/127/134. Application of operational power to the LACE causes initialization in the latter (low/inhibit) mode.

- 125 & 127 Discriminator Low & J-plate Voltage Step Inhibit

This combination of CMD's, when followed by the execute CMD (Octal 134), causes the following changes in LACE:

- selected the lower of the two levels for the preamp discriminator threshold control,

- inhibits the J-plate voltage sequencer of the ion source emission control so that it cannot accept the step CMD (123/125/134).

Repeated application of CMD combination 125/127/134 has no further effect. The higher of the two levels for the preamp discriminator threshold control is selected. The J-plate voltage step enabled, and the cyclic mode selected by CMD's 124/133/134. Application of operational power to the LACE causes initialization in the low/inhibit mode corresponding to CMD 125/127/134.

- 125 & 132 Bakeout Enable

This combination of CMD's, when followed by the execute CMD (Octal 134), selects a relay position such that a subsequent command of the LACE to standby power will perform bakeout of the LACE sensor and bypass the LACE survival heater. To discontinue bakeout after it is in process, the LACE must be commanded either to operational power or off. Prior to a LACE standby CMD, repeated execution of CMD's 125/132/134 has no further effect. To cancel this command, prior to LACE standby, the bakeout bypass command (125/133/134) must be executed. When operational power is applied to the LACE, from either standby or off, it is possible for the relay to receive signals driving it to the opposite position. At LACE turn-on, the bypass state is assured by transmitting CMD 134 with no load in the LACE register; that is, a binary reading of 000 000.

- 125 & 133 Bakeout Bypass

This combination of CMD's, when followed by the execute CMD (Octal 134), selects a relay position such that a subsequent command of the LACE to standby power will not perform bakeout of the LACE sensor and will operate the survival heater. Repeated application of CMD 125/133/134 has no further effect, if there has been no bakeout enable CMD in between. When operational power is applied to the LACE, from either standby or off, it is possible for the relay to receive signals driving it to the opposite position. At LACE turn-on, the bypass state is assured by transmitting CMD 134 with no load in the LACE register; that is, a binary reading of 000 000.

- 127 & 132 Dust Cover Removal

This combination of CMD's, when followed by the execute CMD (Octal 134), activates the circuits of a burn-wire device for a period of 12 to 20 seconds to release the dust cover which protects the LACE thermal control mirror. This burn-wire severs a cord causing minimum release of gas which could contaminate the LACE science measurements. Repeated execution of CMD's 127/132/134 causes repeated activation of the burn-wire. Removal of the mirror cover is scheduled after LM ascent. Prior to removal, the extent of LACE operations is constrained by thermal control limitations.

- 127 & 133 Ion Pump On

This combination of CMD's, when followed by the execute CMD (Octal 134), energizes the LACE ion pump which applies a high-vacuum pumping action to the LACE gas analyzer (sensor). Repeated application of CMD's 127/133/134 has no further effect. If the HV power supplies are on (CMD's 123/124/134), the ion pump on CMD, 127/133/134, is inhibited and, to turn on the pump, the HV power supply off CMD, 132/133/134, must be executed first. Turn-off of the ion pump is accomplished by CMD's 132/133/134. Application of operational power to the LACE causes initialization in the pump-off mode.

- 132 & 133 Ion Pump, Multiplier, and Sweep HV Off

This combination of CMD's, when followed by the execute CMD (Octal 134), removes power from the following LACE circuits:

- ion pump,
- electron multiplier HV power supply,
- sweep HV power supply.

The ion pump is turned on by 127/133, and the two HV power supplies are turned on by 123/124 (each combination executed by CMD 134).

Repeated application of 132/133/134 has no further effect. Application of operational power to the LACE causes initialization in the pump and HV off mode corresponding to CMD's 132/133/134.

<u>Cyclic Mode Operation Sequence</u>

123/132/134*
124/133/134
125/127/134
123/133/134 or 124/125/134

*Required only if a filament is On.

This sequence of LACE CMD's activates a cyclic mode operation of the emission control circuit in which the 1350 sweep steps are programmed to occur with four different values, in succession, of the filament bias, as follows:

Filament Bias	Sweep Steps		
-70 VDC	First	1350	Steps
-18 VDC	Second	1350	Steps
-25 VDC	Third	1350	Steps
-20 VDC	Fourth	1350	Steps
-70 VDC	Fifth	1350	Steps
etc.		etc.	

The sequence can start at any of the bias voltages depending on prior operation of the LACE. To return to the fixed mode of operation of the emission control circuit requires the following sequence of CMD's: 123/132/134, 123/125/134, 123/133/134 (or 124/125/134), and 123/124/134.

SECTION 8.0 LUNAR EJECTA AND METEORITE EXPERIMENT

8.1 LEAM Deployment Criteria

TABLE 8-1. LUNAR EJECTA AND METEORITE EXPERIMENT DEPLOYMENT CRITERIA

PARAMETER	CRITERIA
LEAM Deployment Site	Remove the LEAM from Subpackage #2 and deploy the instrument approximately 8 meters (25 feet) southeast of the Central Station as shown in Figure 2.6. The LEAM should not be placed adjacent to a boulder or crater, but preferably on a gently sloping hummock as high above the average level as reasonable. The East and West sensors require a free 120-degree field-of-view with the look angle of the East sensor aligned 25 degrees north of east to hopefully intercept interstellar particles. There should be no boulder extending more than 10 degrees above the horizontal within the field-of-view of the East and West sensors. Any debris from the unpacking of the experiments should be piled out of the sensors' field-of-view to avoid any possible thermal reflections directed at the sensors.
Leveling and Alignment	When the four legs have been deployed and the pin in the UHT swivel socket removed, level the instrument within ± 5 degrees with the aid of the bubble level. See Figures 8-1, 8-2, and 8-3. Simultaneously align the LEAM within ± 5 degrees of the decal marking by observing the shadow cast by the gnomon on the partial compass rose on the top of instrument. The degree mark where the shadow falls on the compass rose must be reported to MCC.

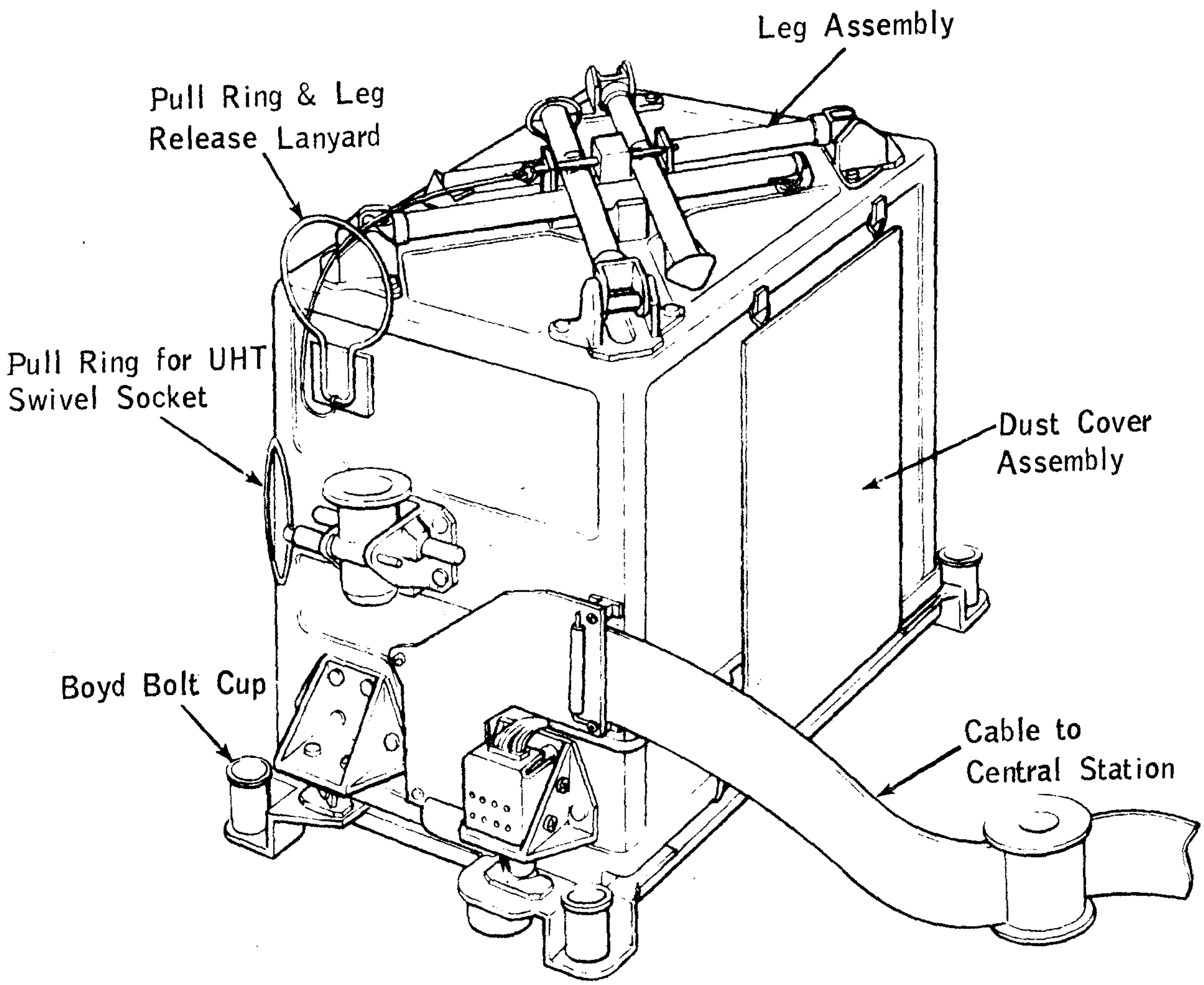


Figure 8-1. LEAM In Upside-Down Stowed Position

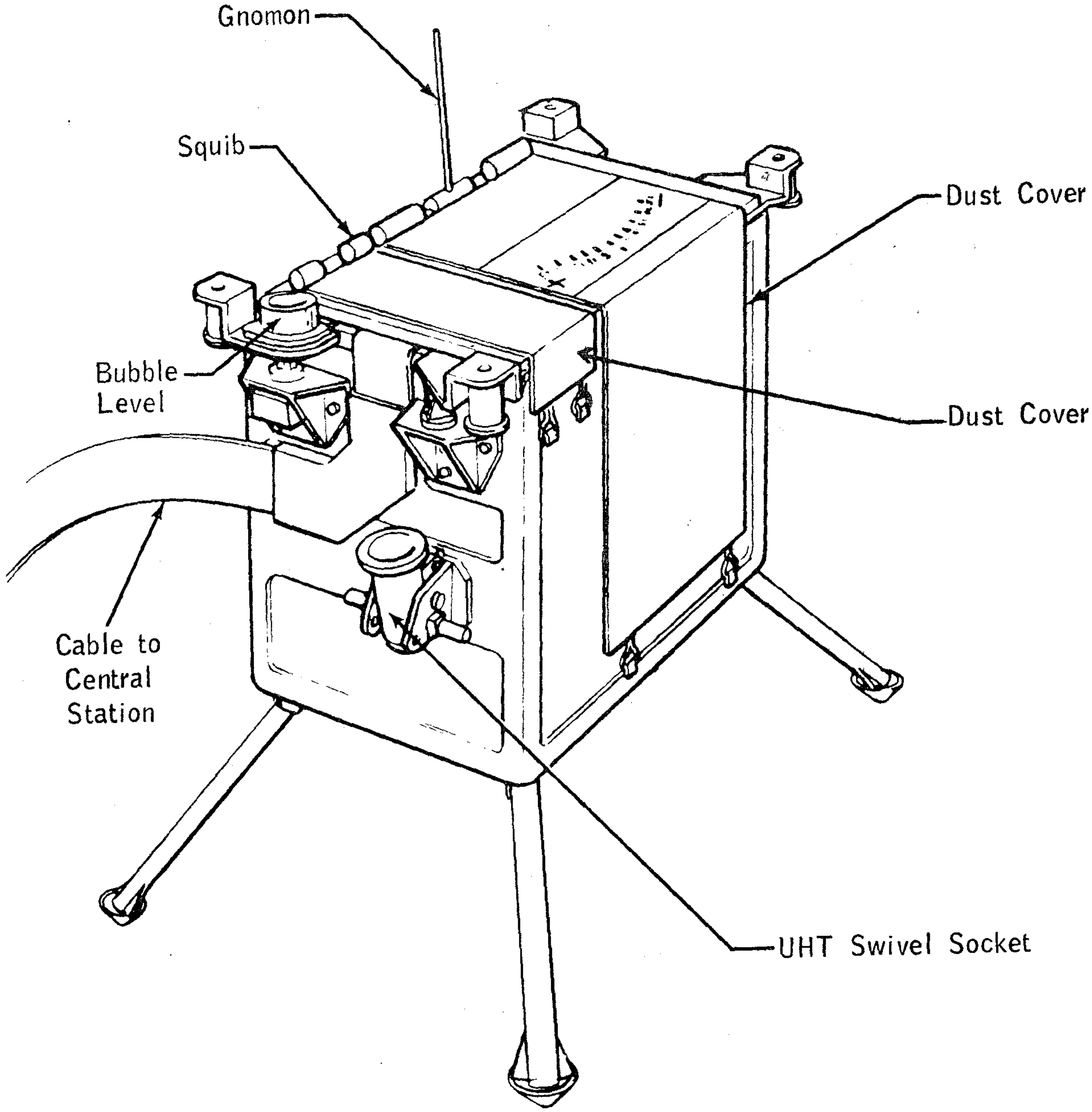


Figure 8-2. LEAM Deployed

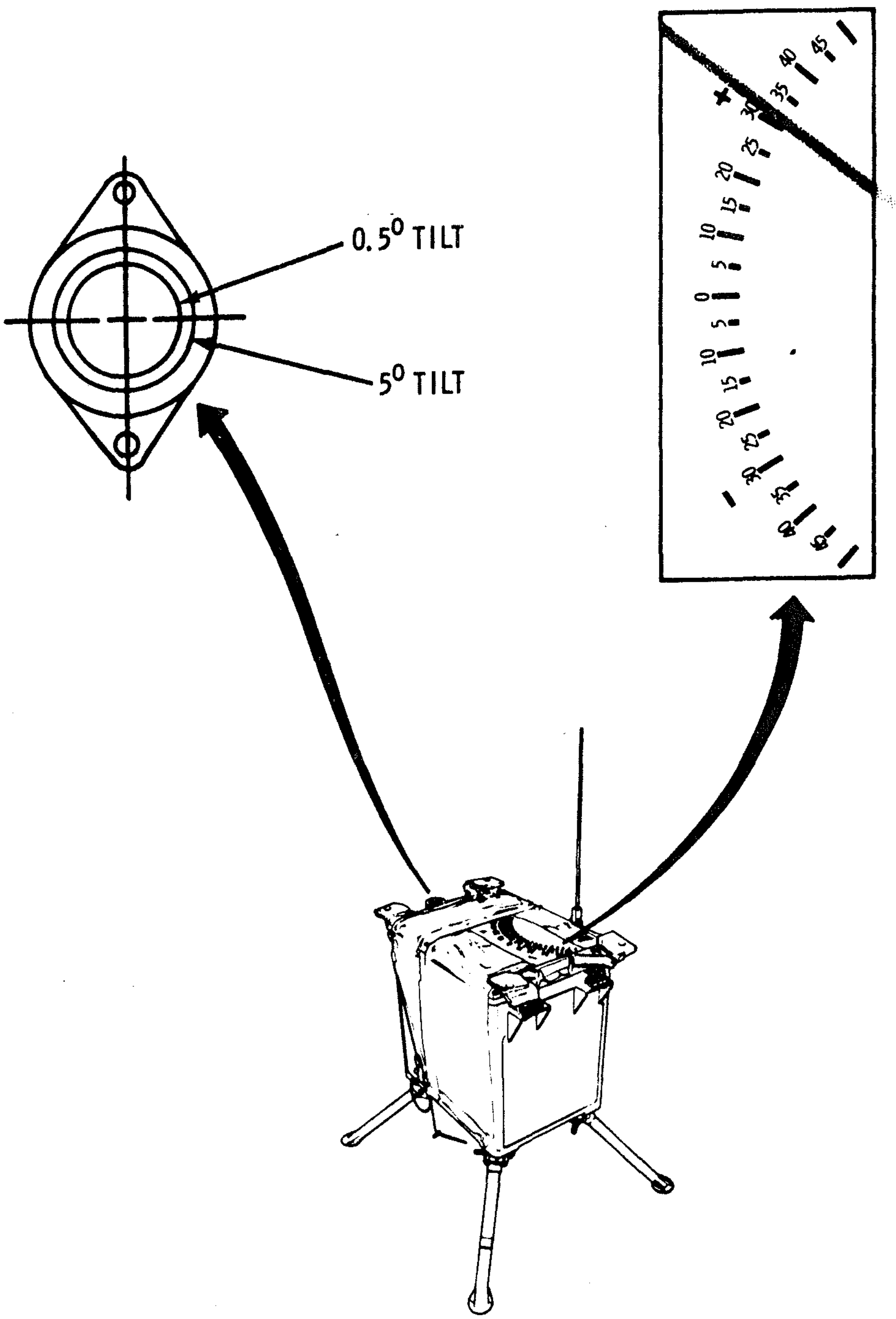


Figure 8-3. LEAM Level and Alignment Indicators

8.2 LEAM OPERATIONAL DATA

8.2.1 LEAM Scientific Data

Each of the three Lunar Ejecta and Meteorite sensors provides a variety of measurements suitable for deriving certain physical and dynamic properties of a particle impinging on that sensor. These measurements, which constitute the primary scientific data from the LEAM, are listed in Table 8-2 together with the associated measurement ranges. Measurement sequences are defined in the "Measurement Requirements Document - Array E," SE-33.

TABLE 8-2.

LEAM SCIENTIFIC MEASUREMENTS

Sensor	Measurement		
	Parameter	No.	Range
Up (Dual)	Front Film ID	DJ-01	
	Front Film PHA (Pulse Height Analysis)	DJ-02	
	Front Film Accumulator	DJ-03	
	Rear Film ID	DJ-04	
	Rear Film PHA	DJ-05	
	Rear Film Accumulator	DJ-06	
	Front Collector ID	DJ-07	
	Microphone PHA	DJ-08	
	Microphone Accumulator	DJ-09	
	Rear Collector ID	DJ-10	
	Elapsed Time	DJ-11	
East (Dual)	Front Film ID	DJ-12	
	Front Film PHA	DJ-13	
	Front Film Accumulator	DJ-14	
	Rear Film ID	DJ-15	
	Rear Film PHA	DJ-16	
	Rear Film Accumulator	DJ-17	
	Front Collector ID	DJ-18	
	Microphone PHA	DJ-19	
	Microphone Accumulator	DJ-20	
	Rear Collector ID	DJ-21	
	Elapsed Time	DJ-22	
West (Single)	Film ID	DJ-23	
	Collector ID	DJ-24	
	Film PHA	DJ-25	
	Film Accumulator	DJ-26	
	Secondary Microphone Accumulator	DJ-27	
	Main Microphone PHA	DJ-30	
	Main Microphone Accumulator	DJ-31	

8.2.2 LEAM Engineering Data

The performance of the LEAM instrument is monitored through the use of the 9 analog measurements and 3 status indicators provided in the engineering data. The values of the analog parameters to be expected when the LEAM is operating normally are given in Table 8-3.

Although the measurement of electronics temperature designated AJ-11 is valid whether or not power is applied to the LEAM, only normal values to be expected when LEAM is operating are listed. See Figure 8-4. The status indicators are identified in Table 8-4.

TABLE 8-3.

LEAM ENGINEERING MEASUREMENTS

Meas. No.	Frame	DESCRIPTION	Operating Range		Nominal	Red Line See Note 1	
			Low	High		Low	High
AJ-01	83-1	+5 Volt Supply	+4.25	+5.7	+5.00	0.0 (M)	5.70 (M)
AJ-10	84-5	-5 Volt Supply	-4.7	-5.6	-5.18	0.0 (M)	-5.75 (M)
AJ-06	84-1	Up – Microphone Electronics Temperatures (°F)	-20	+150		-20 (T) -75 (M)	165 (T) 237 (M)
AJ-07	84-2	East – Microphone Electronics Temperatures (°F)	-20	+150		-20 (T) -75 (M)	165 (T) 237 (M)
AJ-08	84-3	West – Microphone Electronics Temperatures (°F)	-20	+150		-20 (T) -75 (M)	165 (T) 237 (M)
AJ-09	84-4	Central Electronics Temp (°F)	-20	+150		-20 (T) -75 (M)	165 (T) 237 (M)
AJ-11	85	Internal Structure Temp (°F)	-20	+150	See Fig. 8-4	-20 (T) -55 (M)	170 (T) 230 (M)

Note 1: Legend -(M) Measurement Limits, (T) Test Limits. See Sect. 3.3.9.

TABLE 8-4.

LEAM OPERATIONAL STATUS INDICATORS

Parameter	Meas. No.	Indication
Sensor Dust Cover	AJ-02	
. In Place		ON
. Removed		OFF
Mirror Dust Cover	AJ-03	
. In Place		ON
. Removed		OFF
Supply Voltages (+ 5 V, -5V & + 12V)	AJ-04	0 - 5 volts
. Normal		0.7 ± 0.2 volts
. Abnormal		0-0.5 & 0.9-5.0
Bias Voltages (-7 V & +24 V)	AJ-05	0 - 5 volts
. Normal		0.4 ± 0.2 volts
. Abnormal		0-0.2v & 0.6-5v
Heater Power	DJ-29	AUTO - NOT AUTO

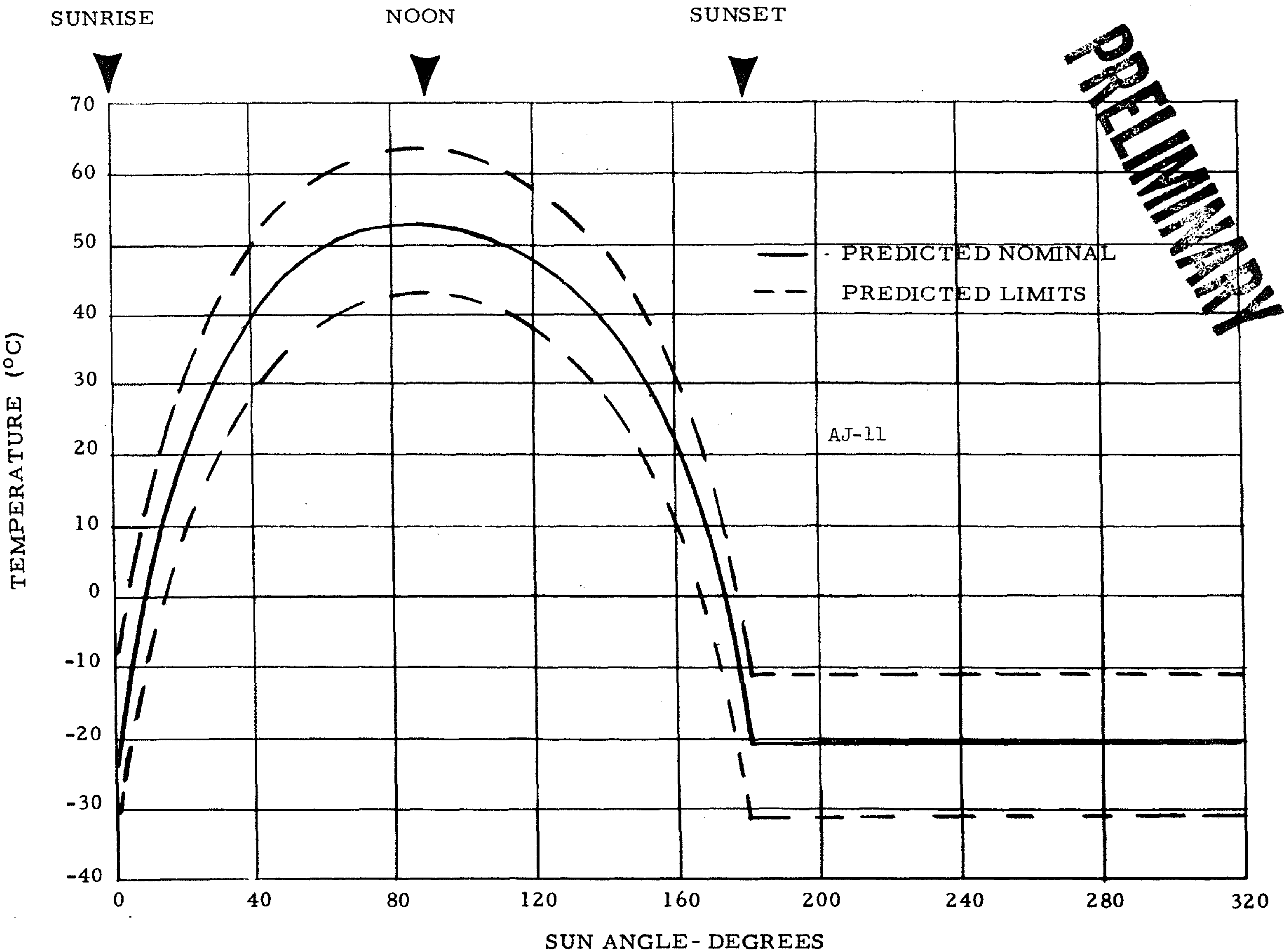


Figure 8-4. **LEAM Int al Structure Temperature** Predict

Temperature-Sun Angle
Curves for AJ-06,
AJ-07, AJ-08, and
AJ-09 to be supplied
as an amendment.

8.2.3 LEAM Operational Modes

The LEAM has a single, continuous operating mode of operation in which it is poised to measure the characteristics of the impact of a particle on one of the three sensors. This mode is interrupted briefly by a calibration mode which is activated every 15.5 hours by the periodic command generator (see Figure 3-16).

8.2.4 LEAM Power Demands

The power demands of LEAM during both day and night operation are illustrated in Figure 8-5. Following removal of the dust covers, no power demands result from commanding these functions.

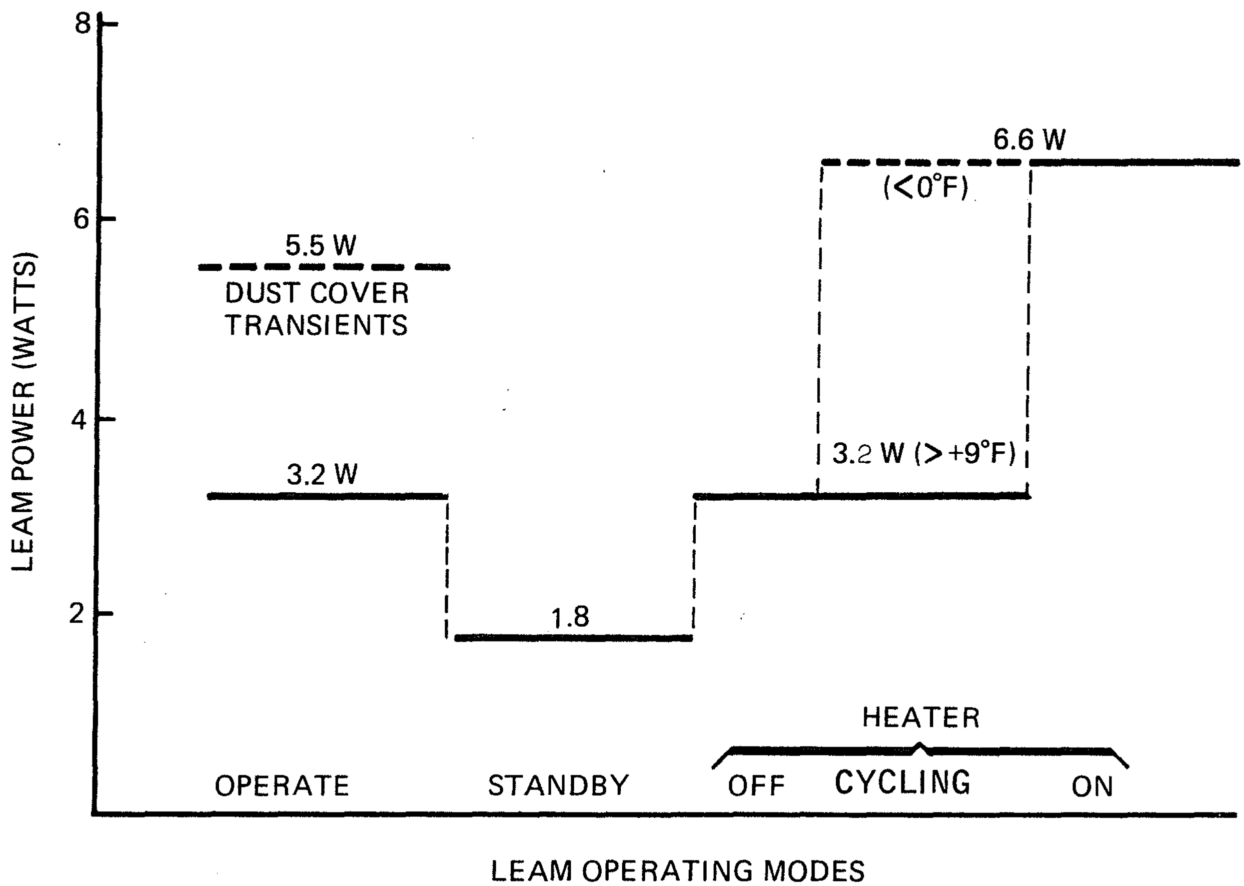


Figure 8-5. LEAM Power Profile

8.3 LEAM CONSTRAINTS AND LIMITATIONS

8.3.1 LEAM Deployment Constraints

The constraints on LEAM deployment are covered in Section 8.1.

8.3.2 LEAM Operational Constraints

To verify and check operation, the LEAM will be turned On shortly after deployment for a period of approximately two hours. Immediately after turn-on, two calibrate commands (CMD III) should be sent, separated by at least two minutes. Dust covers are to be left in place. Following verification of performance, the LEAM will be commanded to Standby and left in this mode until after all LSPE Explosive Packages have been detonated. When the ALSEP system is returned to the 1060 bit rate with DP formatting, the LEAM should be turned On and the mirror dust cover will be released. Operate in this mode until approximately 48 hours after lunar sunset, then release the sensor dust cover.

During lunar daytime operation, AJ-09, LEAM Central Electronics Temp. should not exceed 150°F.

8.4 LEAM COMMANDS

8.4.1 Periodic LEAM Commands

Together with CMD 174 (described in Section 3) which selects alternate uplink components, two LEAM Calibrate (CMD 111) and other simulated command signals are generated periodically. The sequence of simulated commands, identified by their octal code numbers, was shown in Figure 3-16. Commands 065 and 131, being spares, do not initiate any functional changes in Array E outside of the command decoder. These LEAM Calibrate commands are inhibited when CMD 105 is in effect.

8.4.2 LEAM Command Descriptions

- LEAM CAL

This is a two-state CMD to select alternately, upon successive transmission, the two LEAM calibration levels called mode one and mode two*. Each activation of the calibration circuits produces a single input pulse to the LEAM sensor buffer amplifiers to calibrate the overall sensor electronics and data storage system. The response of LEAM to CMD 111 is delayed until previously recorded data has been transmitted to ALSEP.

Mode one provides signal pulses to each:

- front film amplifiers 3 and 4 (4),
- main microphone amplifiers (3),
- secondary microphone amplifier (1),
- rear film and all collector amplifiers (28)**,

Mode two provides signal pulses to each:

- front film amplifiers 1 and 2 (4),
- main microphone amplifiers (3),
- all rear film amplifiers (10)**.

Notes:

* The calibration level of mode two is lower than mode one.
** Rear film signals are delayed to verify elapsed time circuitry; delay is longer in mode two.

- 112 LEAM MIR CVR GO

This CMD activates the circuits of a redundant firing mechanism to release the dust cover which protects the LEAM thermal control mirror. After cover release, CMD 112 has no further effect. Removal of the mirror dust cover is scheduled after LM ascent and after the last LSPE Explosive Package has been detonated. Prior to removal, the extent of LEAM operation is constrained by thermal control limitations.

- 114 LEAM SEN CVR GO

This CMD activates the circuits of a redundant firing mechanism to release the dust covers which protect the LEAM sensors. After cover release, CMD 114 has no further effect. Removal of the sensor dust cover is scheduled 48 hours after lunar sunset.

- 117 LEAM HTR Step

This is a three-state CMD which, upon successive transmission, steps repetitively through three LEAM heater control modes: On, Off, and Automatic. In the automatic (normal) mode, a circuit controls the heater operation to maintain LEAM above a minimum temperature. The on and off modes bypass the automatic control circuit and cause the heater to remain on or off regardless of temperature. The heater on/off status is read out in the TM, along with temperature data; application of operational power to the LEAM causes initialization in the automatic mode.

When Standby (survival) power is applied to the LEAM:

1. The automatic circuit is energized and controls operation of the 3.2-watt heater (1.8 watts always on).

2. CMD 117 has no effect.

3. Temperature is read out in the TM.

SECTION 9.0 SURFACE ELECTRICAL PROPERTIES

9.1 SEP Deployment Criteria

TABLE 9-1. SURFACE ELECTRICAL PROPERTIES EXPERIMENT DEPLOYMENT CRITERIA

PARAMETER	CRITERIA
Removal from LM	When the right-hand experiment pallet stowed in Quad III of the LM has been removed, the SEP can be removed. The SEP transmitter can be left on the pallet in the sun.
SEP Receiver Deployment	The SEP should be removed from the LM and the Receiver deployed on the LRV early during EVA #1. The SEP Receiver will be mounted on the SEP bracket at the aft end of the LRV. See Figures 9-1 and 9-4. Read and report to MCC the temperature reading of the SEP Receiver. Mount the Receiver antenna on the LRV.
SEP Transmitter Deployment	Near the end of EVA #1 after the ALSEP has been deployed, the SEP Transmitter can be removed from the Quad III pallet which was temporarily placed on a LM footpad. The SEP Transmitter should be deployed over a reasonably smooth area so that the antenna dipole pairs may be deployed in straight lines (without kinks), lie reasonably flat (essentially in continuous contact with the lunar surface), and so that one dipole pair is orthogonal to the other. See Figures 9-2 and 9-3. The Transmitter site should be selected so that no large metallic object other than the transmitter housing, which is symmetrically located at the center, is within a circle formed by the antenna as a radius (35 meters). The Transmitter should be deployed a minimum of 70 meters from any other metallic object and at least 100 meters from the LM. The Transmitter-to-LRV line-of-site during the initiating phases of the traverse should not include the LM. Deploy the four legs of the SEP Transmitter in numbered sequence: 1, 2, 3, 4. Remove and discard antenna reel clamps before positioning Transmitter. Place Transmitter on lunar surface with arrow on top of housing pointing directly toward sun.

TABLE 9-1. SURFACE ELECTRICAL PROPERTIES EXPERIMENT DEPLOYMENT CRITERIA (Continued)

PARAMETER	CRITERIA
SEP Transmitter Alignment	Observe shadow cast by null meter gnomon on partial compass rose and align Transmitter such that gnomon shadow falls on preset marker. Report alignment setting to MCC.
SEP Transmitter Leveling	Observe bubble level and level Transmitter to within ± 3 degrees of vertical. Bubble must be within outer scribed circle on face of level indicator. Report level indication to MCC.
SEP Transmitter Emplacement	Concurrently with the leveling procedure, the legs should be "scrunched" into the lunar surface to provide a firm, stable emplacement so that the antenna deployment procedure will not disturb the alignment and leveling of the Transmitter package.
SEP Transmitter Antenna Deployment	The four antenna elements can be oriented by utilizing the LRV, its guidance system and resulting tracks to lay out the position for the antennas. The four antennas can then be deployed in a straight line along the LRV tracks. Deploy antenna element #1 in a straight line for its full 35-meter length. Similarly deploy elements #2, #3, and #4. The Transmitter antenna pairs must be deployed so that they are orthogonal to each other within ± 10 degrees. Each Transmitter antenna dipole (two elements) must be straight within ± 10 degrees. One of the deployed Transmitter antennas (dipole) should be parallel to the direction of the traverse. It is especially important that the LRV be driven in the same direction for the first 300 meters to facilitate data reduction.
Transmitter Realignment	Without disturbing deployed antenna elements, realign Transmitter so that gnomon shadow falls within ± 5 degrees of the 0-degree marker on partial compass rose. Report setting to MCC.
Transmitter Releveling	Relevel Transmitter to within 3 degrees of vertical. Report level indication to MCC.

TABLE 9-1. SURFACE ELECTRICAL PROPERTIES EXPERIMENT DEPLOYMENT CRITERIA (Continued)

PARAMETER	CRITERIA
Solar Panel Deployment	Rotate the Carry Handle to the proper operating position, either HOT or COLD as directed in real-time by MCC. The COLD position will be used if the sun angle is less than 20 degrees at time of deployment. The HOT position will be used if the sun angle is greater than 20 degrees. Deploy the solar panels, then remove thermal cover. Place the Transmitter ON/OFF/STANDBY switch in the STANDBY position. Check bubble level to insure that Transmitter is still level within ± 3 degrees.
SEP Operational Sequences	At the end of EVA #1, open Receiver radiator covers. Read and report to MCC the Receiver temperature. Adjust radiator covers as instructed by MCC. Nominally, cover "A" is open and "B" closed. Dust exposed radiator surface after all crew operations. At the beginning of EVA #2, open radiator cover "B", the larger of the two covers. Read and report the temperature to MCC. Place the Receiver switch in STANDBY, then close both radiator covers and notify MCC of the time when this was done. This operation should occur approximately 20 minutes before the Receiver is switched to the ON position. When the LRV has been driven to the SEP Transmitter location, place the Transmitter ON/OFF/STANDBY switch in the ON position. Open Receiver radiator cover "B" and switch the Receiver ON. Place the DSEA switch in the ON position. Read and report Receiver temperature to MCC. Close both radiator covers and proceed with the EVA #2 traverse. At the end of the EVA #2 traverse, open both Receiver radiator covers. Switch the Receiver and the DSEA to OFF. Read and report Receiver temperature to MCC. Adjust radiator covers as directed by MCC. Nominally, cover "A" will be open and "B" closed. Dust exposed radiator surface after all crew operations.

TABLE 9-1. SURFACE ELECTRICAL PROPERTIES EXPERIMENT DEPLOYMENT CRITERIA (Concluded)

PARAMETER	CRITERIA
SEP Operational Sequences (Concluded)	At the beginning of EVA #3, open Receiver radiator cover "B". Read and report temperature to MCC. If directed by MCC, place the Receiver switch in STANDBY with both covers closed for a warm-up period. Prior to the EVA #3 traverse on the LRV, open radiator cover "B". Place the Receiver and DSEA switches in the ON position. Close both radiator covers and proceed with EVA #3. Open Receiver radiator cover "B" at all major science stops during the EVA #3 traverse and place the DSEA ON/OFF switch in the OFF position; then close radiator cover. At the end of the science stop, open radiator cover "B", switch the DSEA to ON, and close the cover. At the end of EVA #3, the SEP Transmitter must be turned OFF to avoid interference with the Lunar Sounder, Exp. No. S-209.
Tape Retrieval	At the end of EVA #3, turn Receiver OFF, then remove the Data Storage Electronics Assembly (DSEA) containing the science data on magnetic tape. Place the DSEA in a Sample Collection Bag for return to MSC and delivery to the PI.

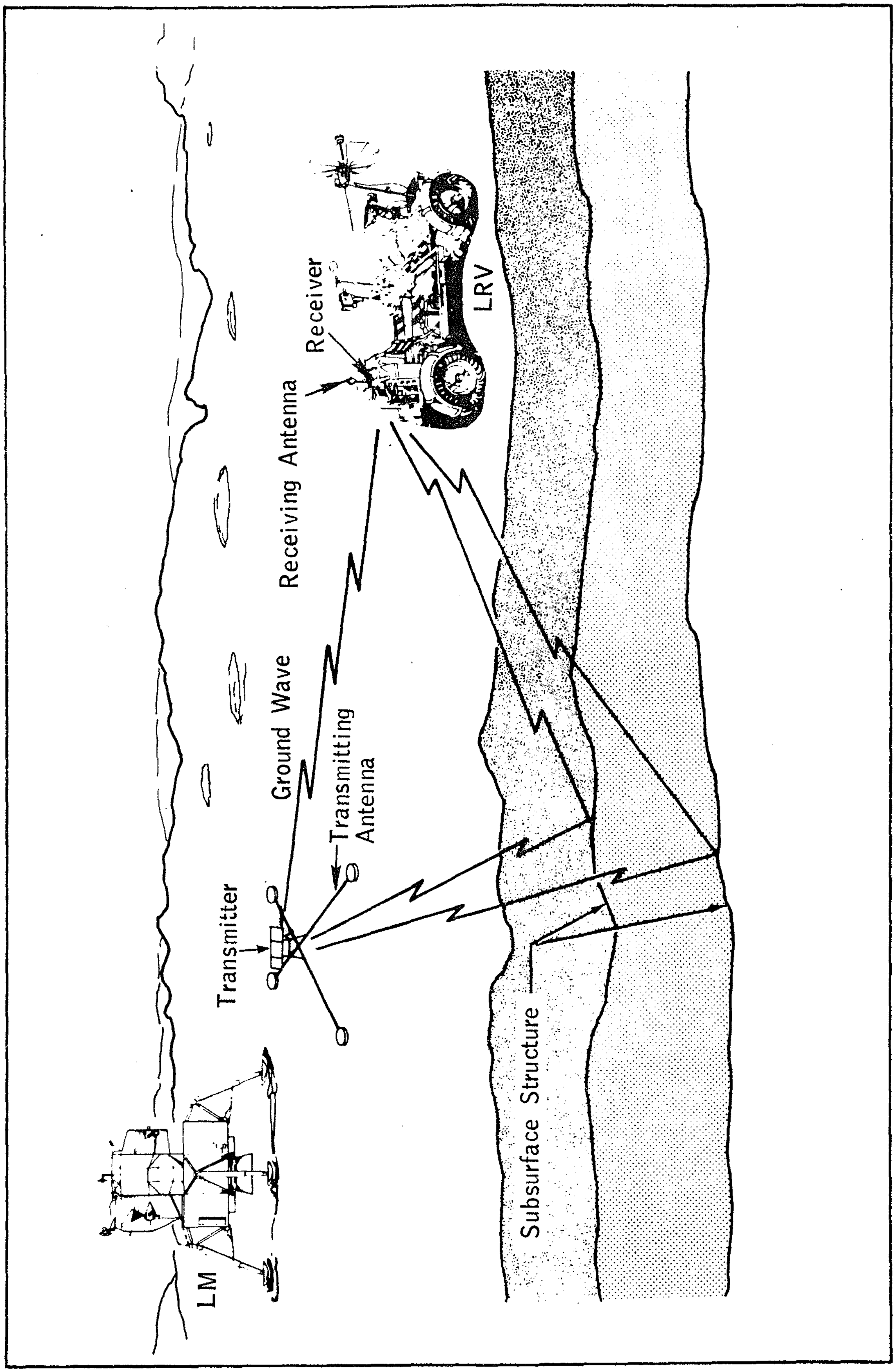


Figure 9-1. Surface Electrical Properties Experiment

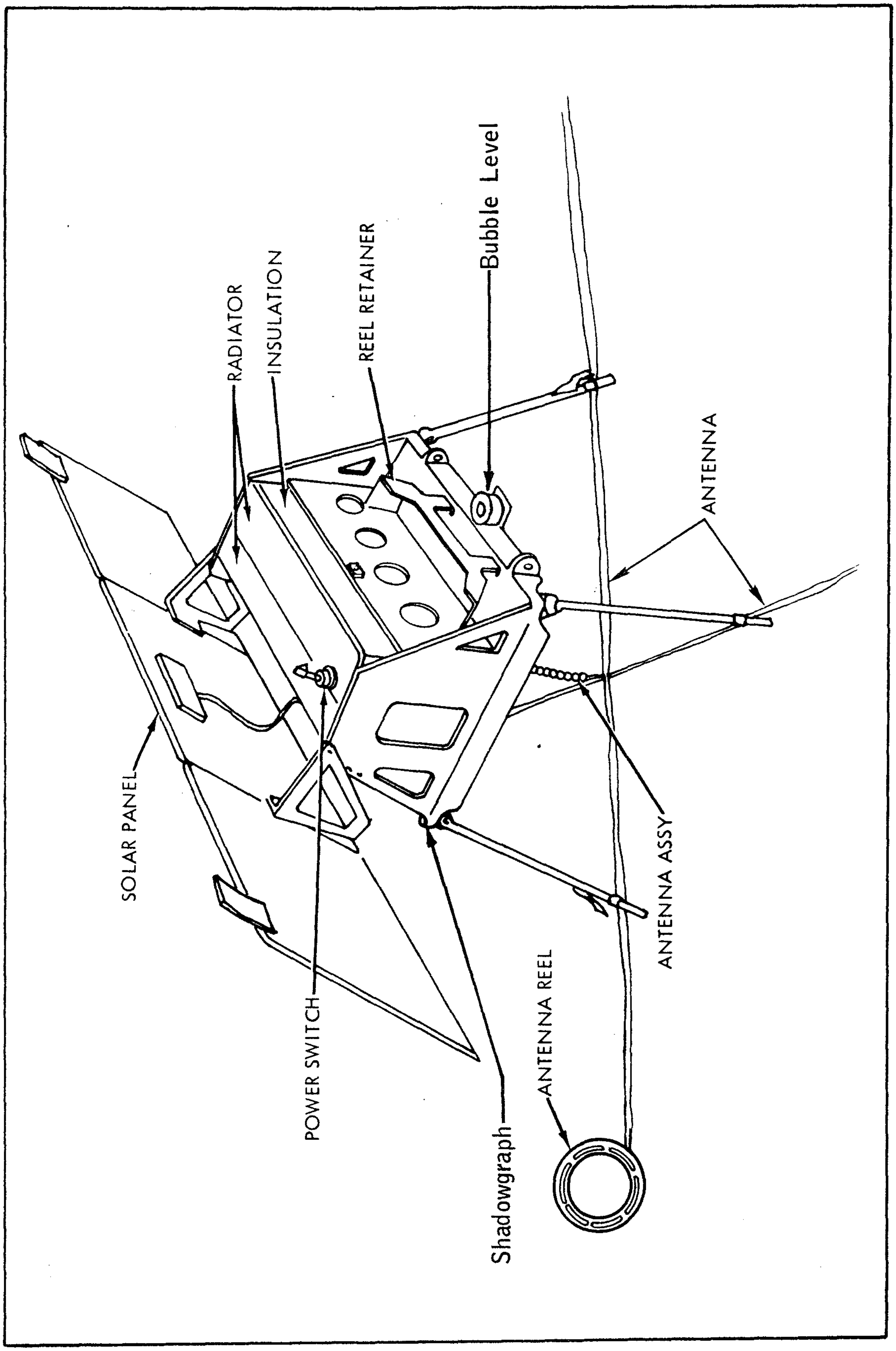


Figure 9-2. SEP Transmitter Deployed

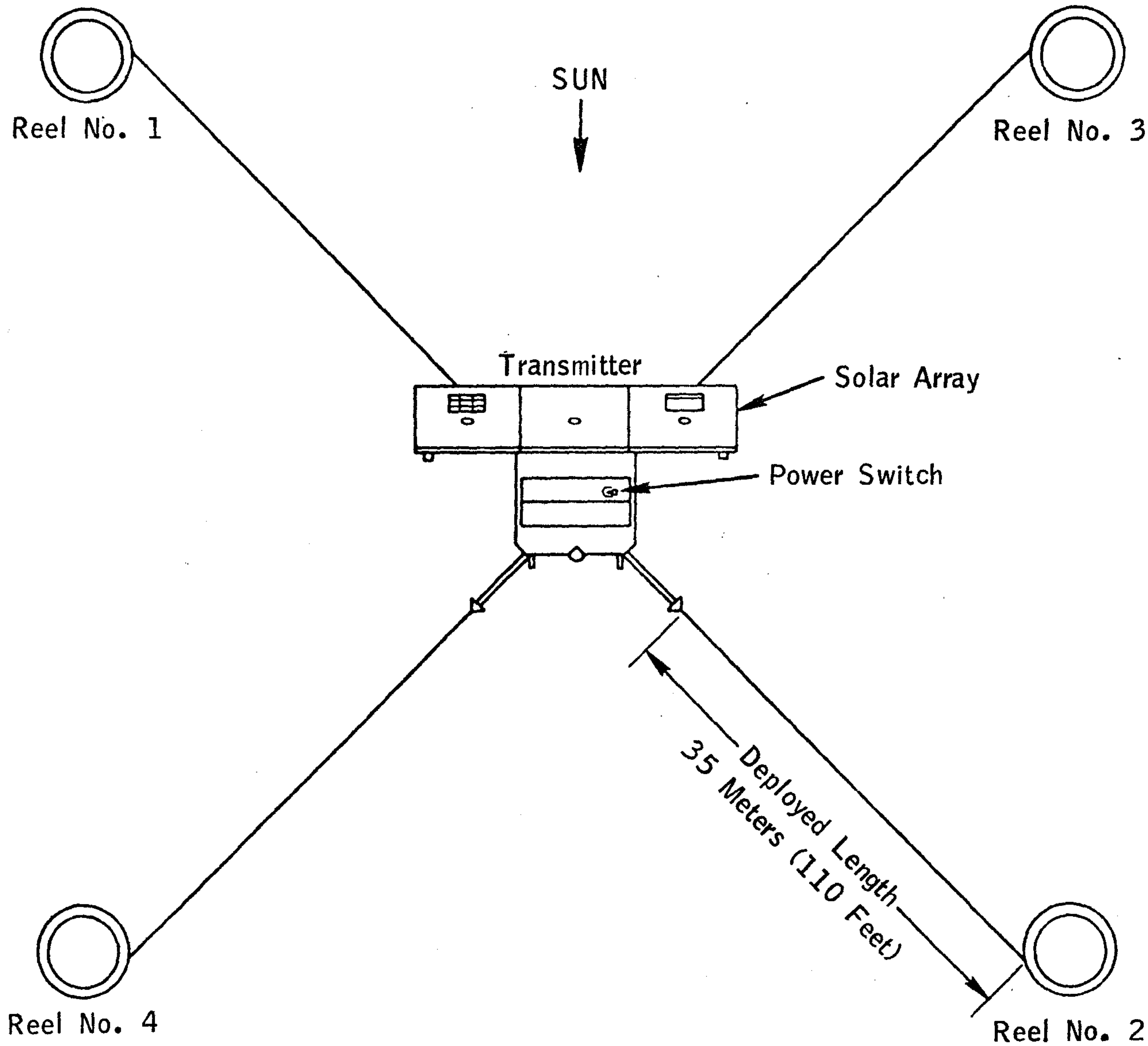


Figure 9-3. SEP Transmitter and Antennas Deployed

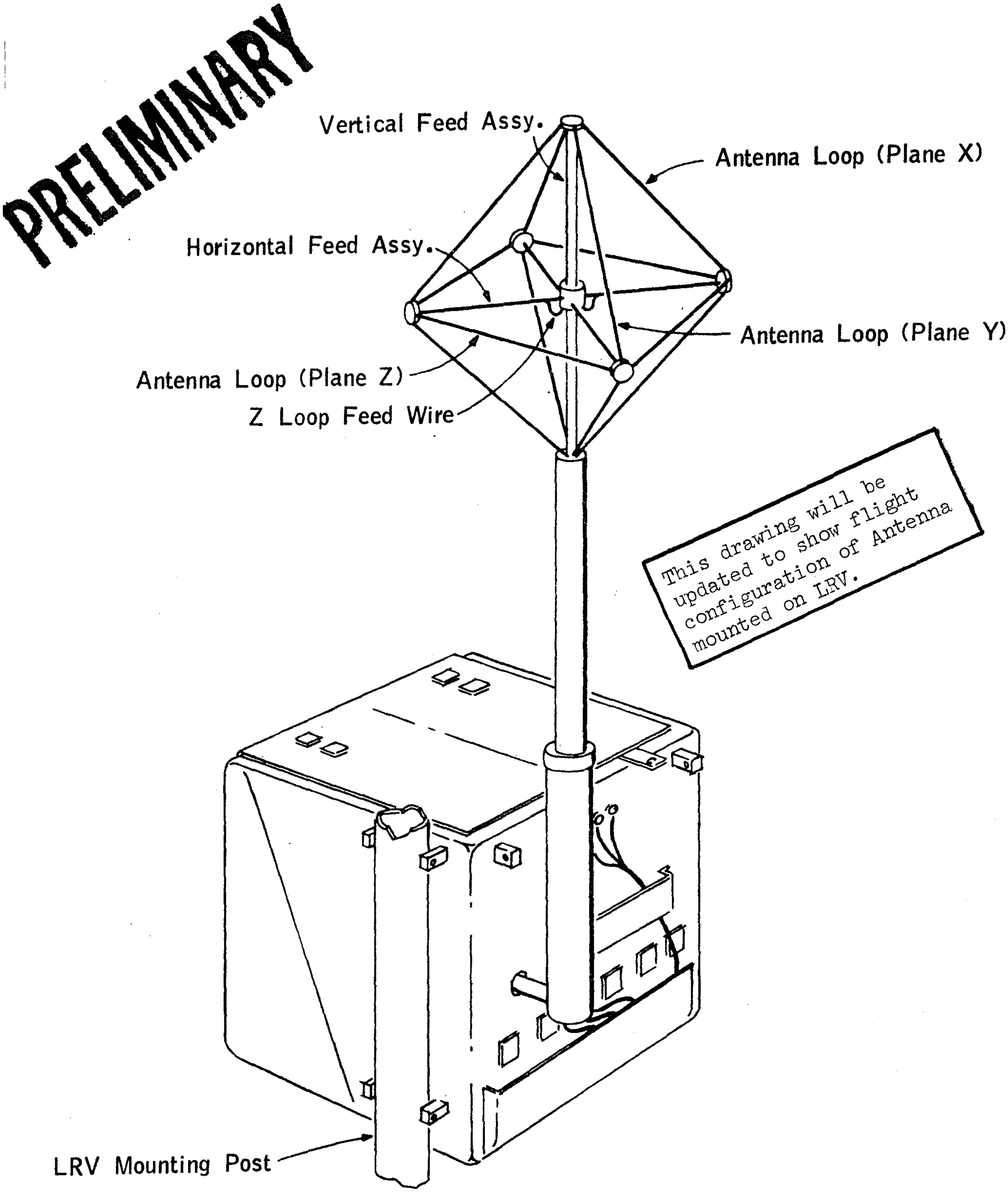


Figure 9-4. SEP Receiver and Antenna Deployed

9.2 SEP OPERATIONAL DATA

9.2.1 SEP Transmitter Operational Data

The criteria used to set the solar panels is that if the solar elevation angle at the time of transmitter deployment is less than 20 degrees then the solar panel positioning tabs will be set in the "C" or cold position. If the solar elevation angle at the time of transmitter deployment is more than 20 degrees, the solar panel deployment tabs will be set in the "H" or hot position.

The orientation of the entire transmitter antenna should be within $\pm$ 5 degrees of the preplanned deployment orientation.

The transmitter antennas should be positioned such that there is an angle of 90 $\pm$ 10 degrees between adjacent antenna elements. In addition, the straightness of the antennas should be such that there is an angle of 180 $\pm$ 10 degrees between elements in the same antenna.

9.2.2 SEP Receiver Operational Data

The maximum allowable temperature for the DSEA is nominally 115°F (Flight Unit #3: 114.8°. Flight Unit #4: 116.0°). At this temperature, the "hot" thermostat shuts off all power to the Receiver. If the Receiver temperature indicator reaches 95°F, corrective action may be requested by MCC.

SEP Receiver operational data to be supplied November 1, 1972:

a) Conversion table: TBD
   Actual SEP Receiver Temp. vs
   Thermometer indication.

b) Parametric temperature data: TBD
   Radiator cover position vs
   Sun elevation angle.

The limits for the low temperature thermostats are such that the heater circuit will be activated any time the Receiver is in the Standby mode and the thermostat temperature is at or below 22.9°F for Flight Unit #3 or 23.2°F for Flight Unit #4. The heater circuit will continue to be active until the thermostat temperature is elevated to 25.2°F for Flight Unit #3 or 24.6°F for Flight Unit #4. For thermostat temperatures above 25.2/24.6, the heater circuit will be inactive for the Receiver in any mode of operation. When the heater is on, the power consumption of the heater is 40 watts. This consists of a 10-watt heater on the battery and a 30-watt heater on the T structure.

The total running time of the DSEA recorder is ten hours. However, fifteen minutes of recorder time will be utilized in ground test activities. Therefore, nine and three quarter hours of record time will be available for lunar surface operations. The power consumption of the DSEA recorder is four watts when the recorder is operating.

The power consumption of the SEP receiver in STBY is zero watts when the heater is not activated. The power consumption of the SEP receiver in the ON mode is 3.9 watts (less the DSEA).

The Receiver thermal covers are to remain closed at all times during the EVA's with the exception of the times when the crew is operating switches or reading the thermometer. Between EVA's the 20% (or "A" portion) of the thermal cover is left open. The initial configuration of the Receiver will be with the Receiver in the OFF mode with the covers closed. At the end of EVA 1 the "A" cover will be opened and will remain open between EVA 1 and EVA 2.

The thermal covers will remain closed at all EVA stops during the conduct of the EVA's except to change switch positions and reading the thermometer. If any redline temperature is reached during the EVA, a real-time decision will be made regarding the need to open all or part of the radiator cover during the remainder of the EVA and/or at EVA stops.

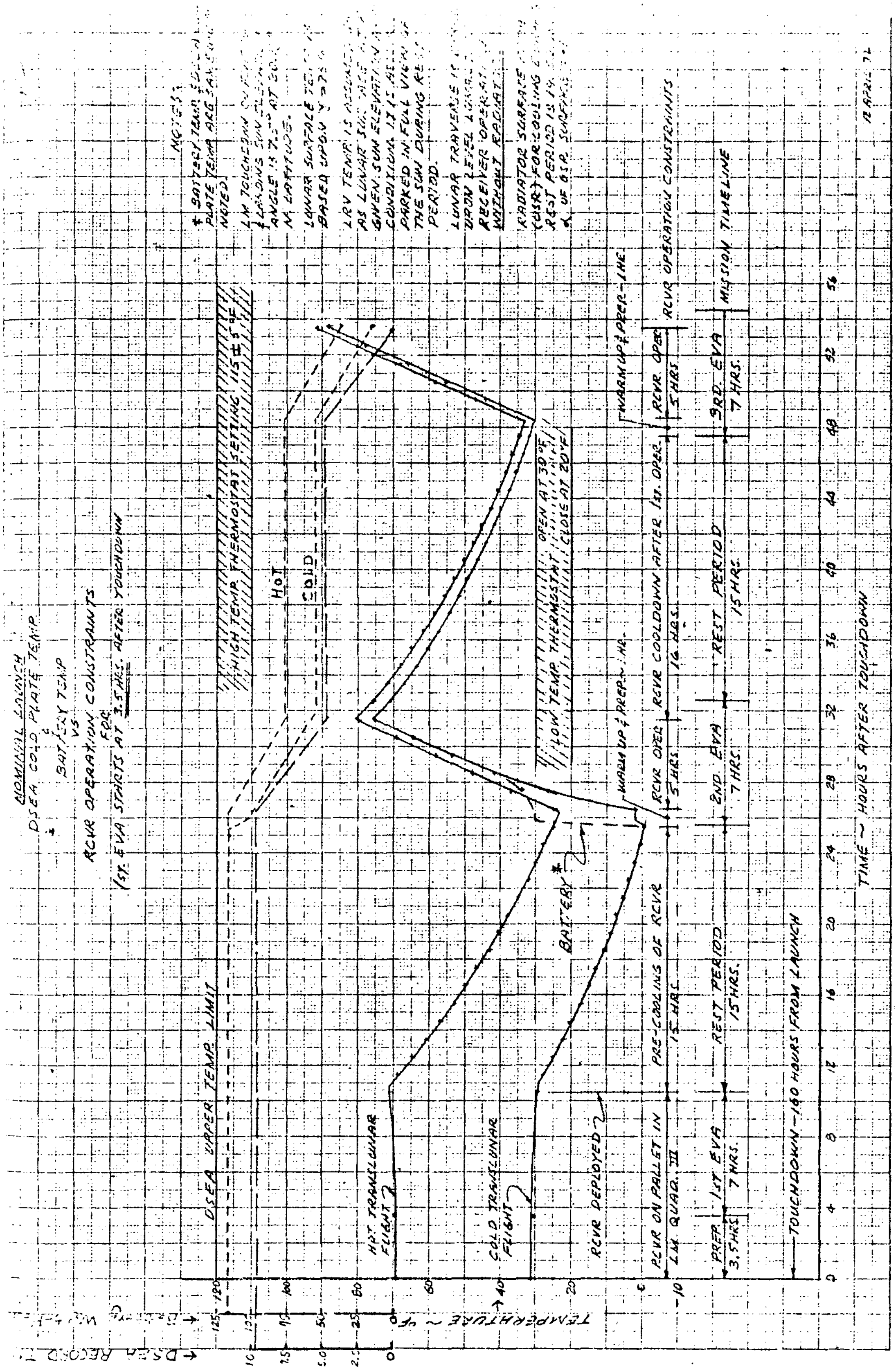


Figure 9-5. SEP Temperatures for Nominal Launch, Nominal EVA

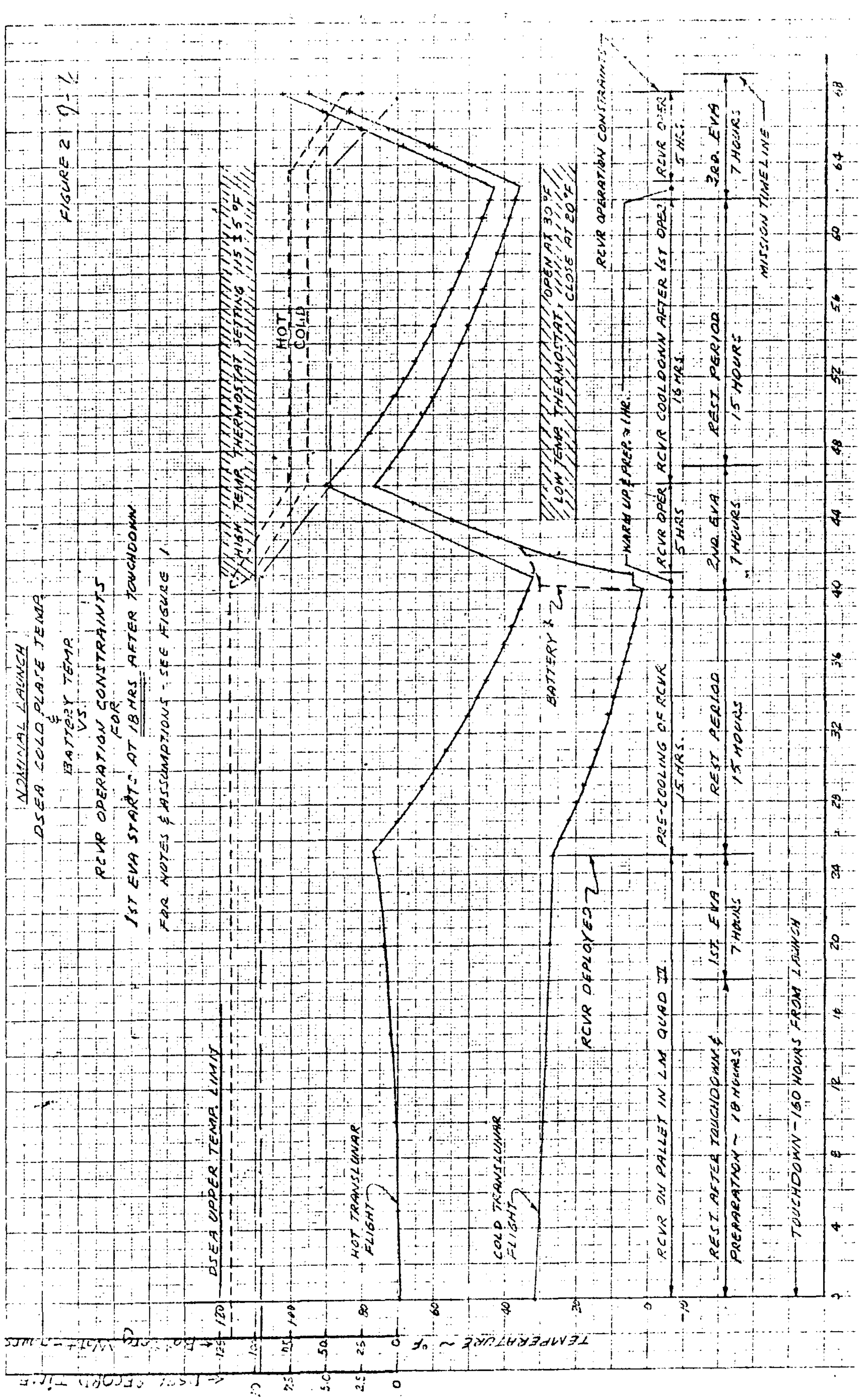


Figure 9-6. SEP Temperatures for Nominal Launch, Delayed EVA

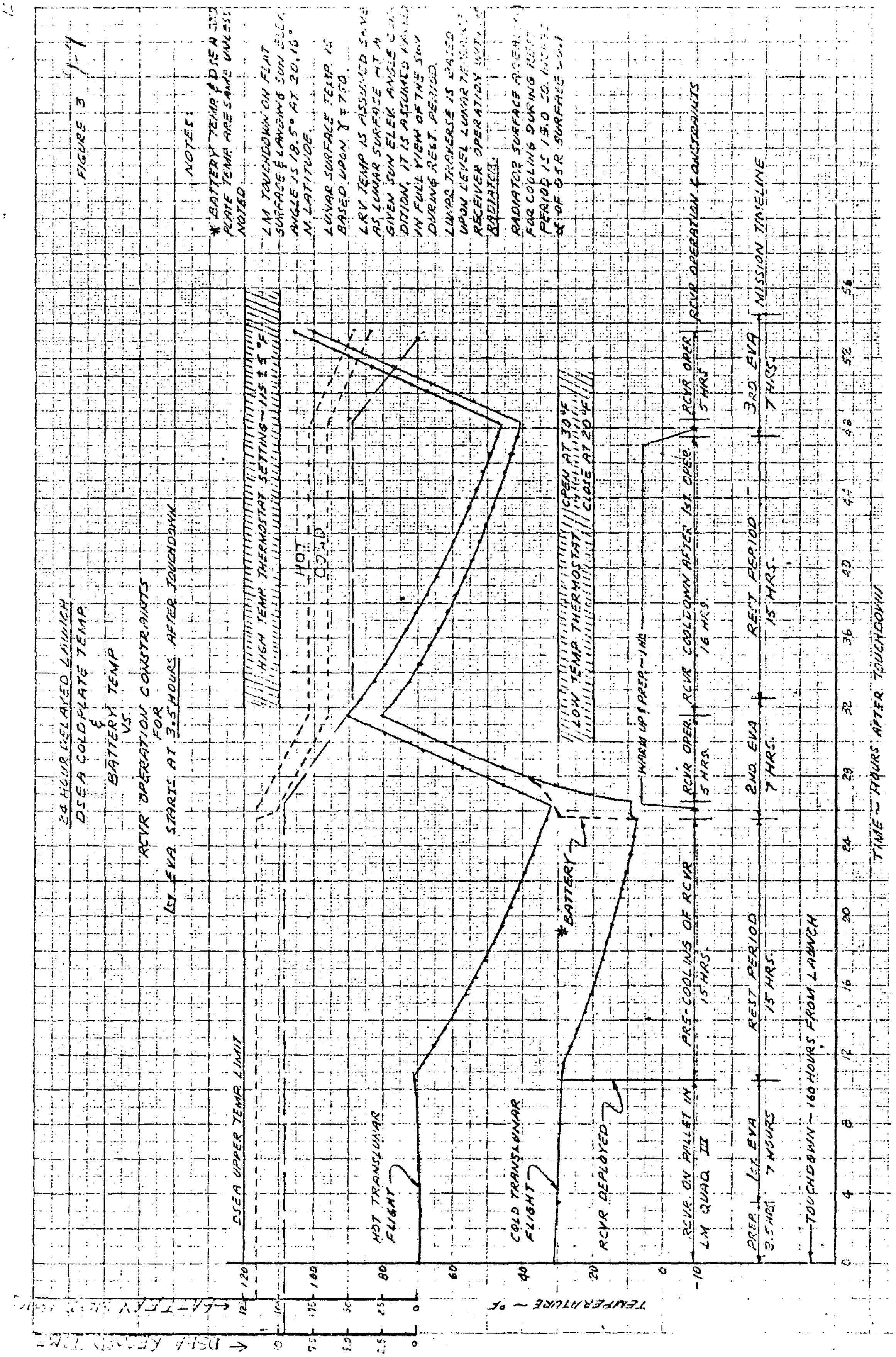


Figure 9-7. SEP Temperatures for Delayed Launch, Nominal EVA

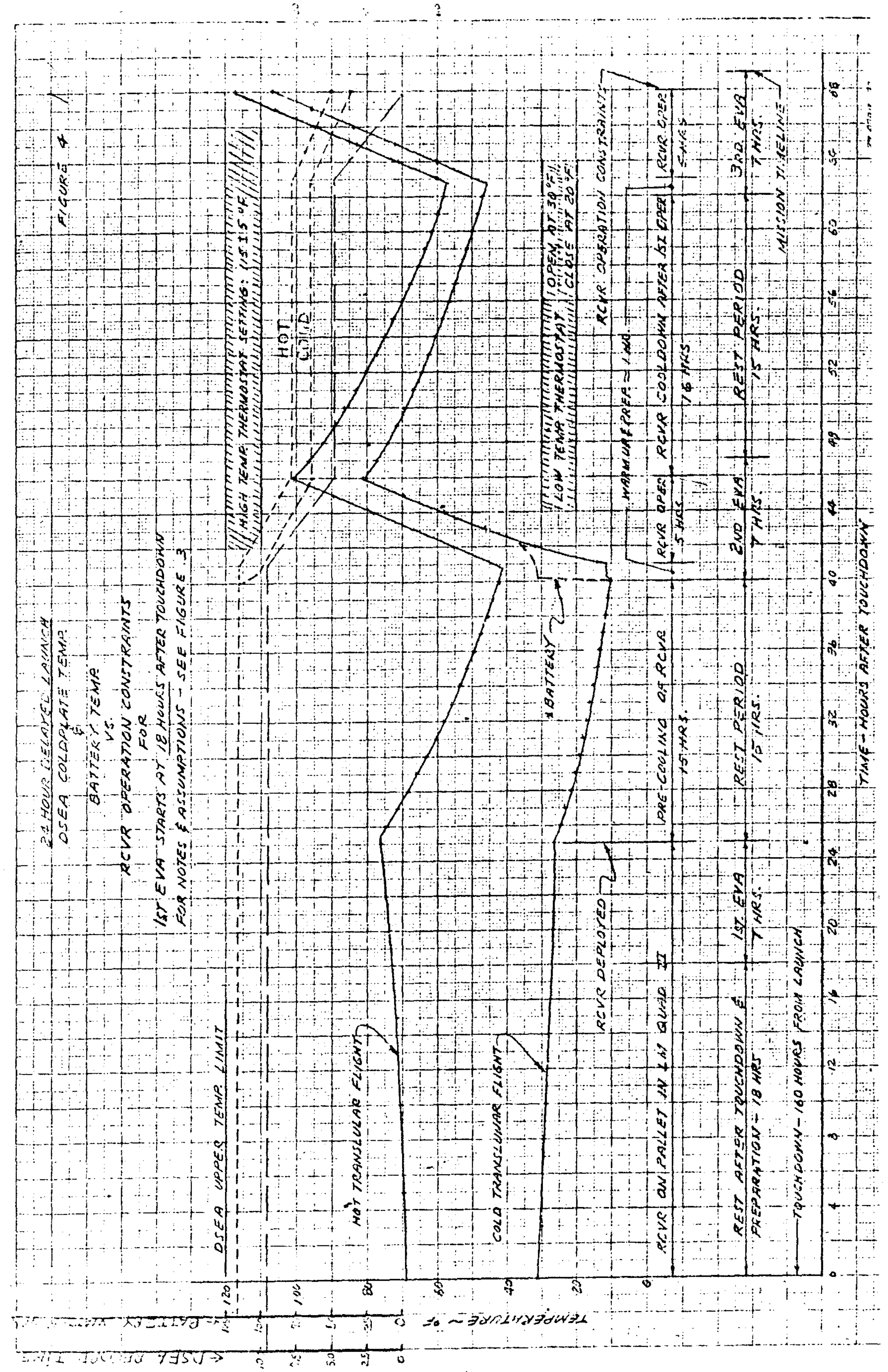


Figure 9-8. SEP Temperatures for Delayed Launch, Delayed EVA

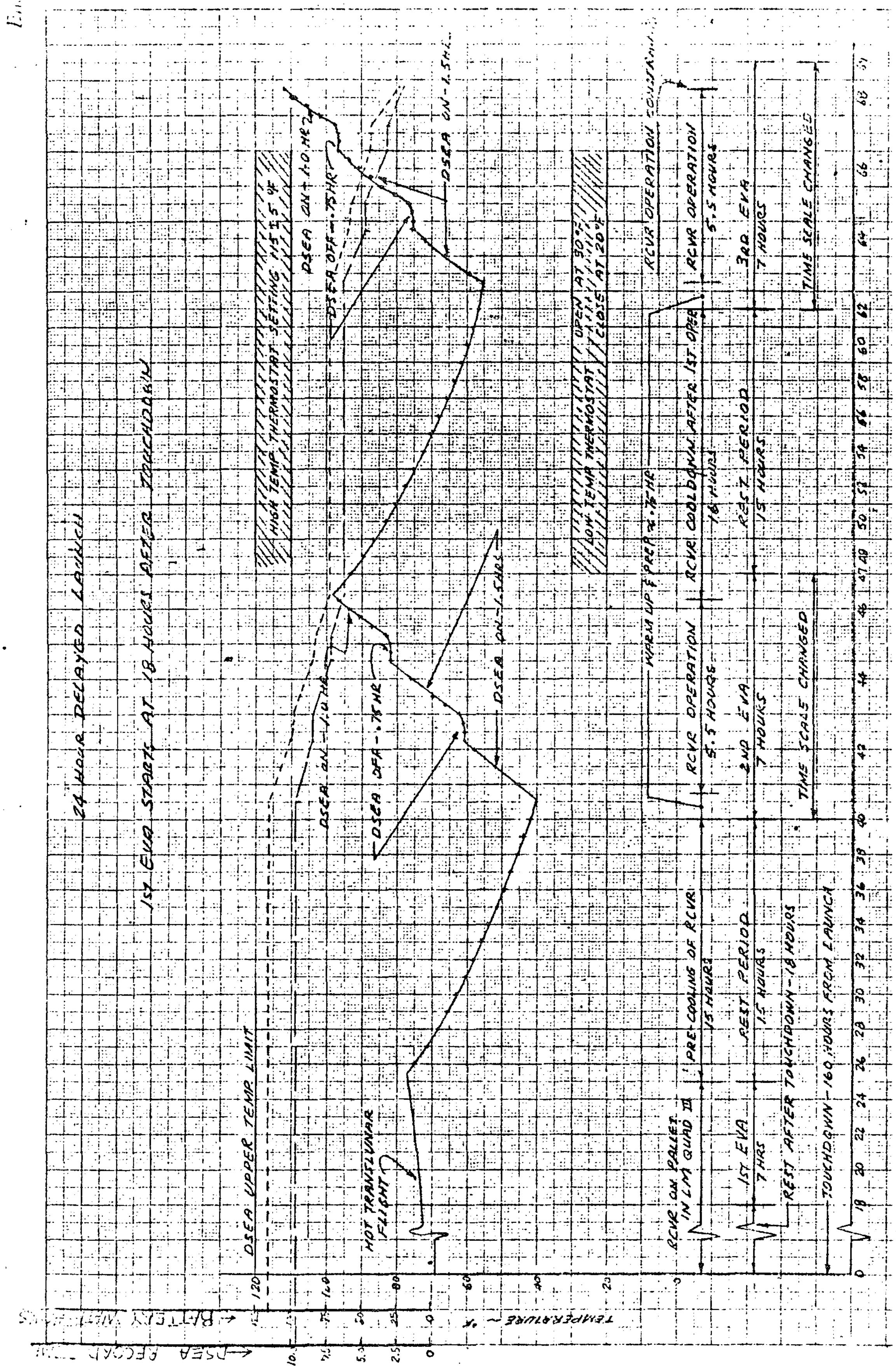


Figure 9-9. SEP Temperatures for Delayed Launch, Delayed EVA, Delayed SEP Deployment

9.3 SEP CONSTRAINTS AND LIMITATIONS

9.3.1 SEP Transmitter Constraints

The only thermal constraint in Quad III for the SEP Transmitter is that the Quad III blankets should remain closed until the time of the Quad III pallet removal. After Quad III pallet removal, this pallet should be positioned on end by leaning against one of the LM leg struts. The Transmitter should remain on the pallet and the pallet front surface should be positioned to within ± 15 degrees normal to the solar vector.

9.3.2 SEP Receiver Constraints

While in Quad III, the SEP Receiver will have ample thermal protection provided the Quad III blankets remain closed and the SEP Receiver thermal flaps remain closed. If the Receiver is deployed during EVA 1 at the time of Quad III pallet removal, there will be no thermal constraints on the Receiver; i.e., the Receiver will be mounted on the LRV aft pallet post and the thermal flaps will remain closed with the Receiver OFF. If the Receiver is deployed at some later time during the lunar surface activity, the course of action will depend on the exact temperature of the Receiver as determined from the Receiver temperature meter.

When the DSEA is removed from the Receiver, it is planned that it will be placed in the same bag as the film cartridges. This bag should be positioned such that the DSEA temperature does not exceed 150°F.

The DSEA should be turned Off at all major science stops during EVA 3 to conserve tape and power.

SECTION 10.0 TRAVERSE GRAVIMETER EXPERIMENT

10.1 TGE Deployment Criteria

TABLE 10-1. TRAVERSE GRAVIMETER DEPLOYMENT CRITERIA

PARAMETER	CRITERIA
Initial Deployment	The TGE should remain in the Quad III equipment bay no longer than 20 hours or overheating of the TGE circuits may occur. Remove the pallet from the Quad III equipment bay and install it on the LRV. Remove and dispose of launch latches from the display and radiator covers. Place the ON/STBY switch, located under the TGE display panel protective cover, in the ON position. Press the READ pushbutton and report the temperature reading to MCC. Ensure that the display panel protective cover is closed. Wait a minimum of 5 minutes, preferably 20 minutes, for the experiment to reach thermal equilibrium before initiating a measurement cycle.
Initial Gravity and Bias Measurements	Early during EVA #1, make one Gravity measurement and then one Bias measurement on the lunar surface in the vicinity of the LM, followed by a Gravity measurement after the TGE has been placed in its traverse position on the LRV. See Figures 10-1 and 10-2. (Preferred sequence.) A Gravity measurement is taken as follows: a) Press the GRAV pushbutton to initiate the measurement cycle. b) For a Gravity measurement, the MEAS indicator light on top of the display panel cover should flash for 0 to 20 seconds, indicating that the TGE is in its leveling cycle. If the indicator light extinguishes after flashing, the TGE base is positioned more than 15 degrees off horizontal and the leveling loops cannot properly level the VSA assembly. If this is the case, the TGE should be realigned and another measurement initiated. c) When the MEAS indicator light stops flashing and is steadily illuminated, this indicates that the leveling cycle is complete and the TGE is in a measurement cycle.

TABLE 10-1. TRAVERSE GRAVIMETER DEPLOYMENT CRITERIA (Continued)

PARAMETER	CRITERIA
Initial Gravity and Bias Measurements (Concluded)	The operator should not touch the TGE while the MEAS indicator light is illuminated. A vibration will cause an erroneous measurement and may cause the GRAVITY display to output a reading of 000 as the first three digits when the READ pushbutton is pressed. d) When the MEAS indicator light goes off, this indicates that the measurement cycle is complete. Press READ pushbutton to initiate display of the Gravity measurements and the temperature information. Open the display panel cover. If seven zeroes are displayed in the GRAVITY/BIAS display, the TGE is positioned more than 15 degrees off horizontal and must be realigned. The GRAVITY/BIAS and TEMP displays will illuminate for 15 seconds. The displays may be reactivated by pressing READ again. The astronaut will read the 9-digit display, report it to MCC, then close the display panel cover. A Bias measurement is taken as follows: a) Press the BIAS pushbutton to initiate the measurement cycle. b) For a Bias measurement, the LEVEL/MEASURE indicator light on top of the display panel cover should flash for 90 to 110 seconds, indicating that the TGE is in its leveling cycle. Otherwise, indicator light operation is the same as for a Gravity measurement. c) When the MEAS indicator light goes off, press the READ pushbutton and report the 9-digit reading to MCC. Install the TGE in the Traverse position on the LRV and take another Gravity measurement according to the same procedure followed for a Gravity measurement on the lunar surface. See Figure 10-2.

TABLE 10-1. TRAVERSE GRAVIMETER DEPLOYMENT CRITERIA (Continued)

PARAMETER	CRITERIA
Normal Traverse Measurements	During the EVA #1 traverse with the LRV, a Gravity measurement will be taken at each science stop with the TGE mounted on the LRV. The astronauts will report to MCC the gravity reading and the time when the measurement was initiated. See Figure 10-3. MCC should read back and confirm all readings transmitted by the astronaut. It is highly desirable that the gravity readings be transmitted prior to moving the LRV. It is preferred that the TGE Gravity measurement be taken as early as possible at the beginning of each science stop. At the end of the EVA #1 LRV traverse, a Gravity measurement will be taken on the LRV when the LRV has been parked near the LM. Gravity measurements taken at the beginning and end of each EVA should be taken at a location within 15 meters of the base station (parked LRV) location. (Preferred sequence.) Before leaving the LRV, place the TGE on the lunar surface in the shade of the LM and open the radiator cover. Cover should remain open until the next traverse. The TGE must then be switched from ON to STANDBY. During the EVA #2 and EVA #3 traverses, the TGE operational procedures will be similar to those for EVA #1 as follows: a) Switch TGE from STANDBY to ON. Press the READ pushbutton and transmit a temperature reading to MCC. b) Close both the radiator cover and the display panel cover before starting out on the LRV traverse. c) Take TGE Gravity measurements with the TGE mounted on the LRV at the LM location and at each science stop. Transmit readings to MCC. d) Upon return to the LM at the end of each traverse, take a Gravity measurement with the TGE mounted on the LRV. e) Place the TGE on the lunar surface in the shade of the LM. Open the radiator cover.

TABLE 10-1. TRAVERSE GRAVIMETER DEPLOYMENT CRITERIA (Concluded)

PARAMETER	CRITERIA
Precautions	A Bias measurement will normally be taken only once, at the beginning of the first EVA traverse. However, should an unexpected event happen to the TGE such as dropping it, insulation damage, or a shift in the Gravity reading at the LM location, a Bias measurement may have to be made after this event to determine TGE performance. For all TGE measurements taken while the TGE is mounted on the LRV, MCC must insure that no movement of the LRV or the television camera is allowed for at least 3 minutes after a measurement is initiated. When performing the first TGE measurements on the lunar surface, the GRAV measurement should be taken prior to the BIAS measurement and the reading reported to MCC. If the sensor has been overstressed, the GRAV reading will indicate this condition and consequently the BIAS measurement, which might damage the sensor, would then not be performed. A test is under consideration to determine if the motion of the camera will interfere with the TGE. This test, to be performed on the lunar surface at the beginning of EVA #1, will consist of operating the TGE with and without the camera in operation. The difference in readings will be used to determine if the camera will be inhibited during TGE operation. The details of this test will be included in this section if the test is approved. After the BIAS pushbutton has been depressed to take a bias measurement, DO NOT turn the STANDBY-ON switch from ON to STANDBY for at least 90 seconds after the measurement is initiated or damage to the sensor may result.

Figure 10-1. Traverse Gravimeter Deployed on Lunar Surface

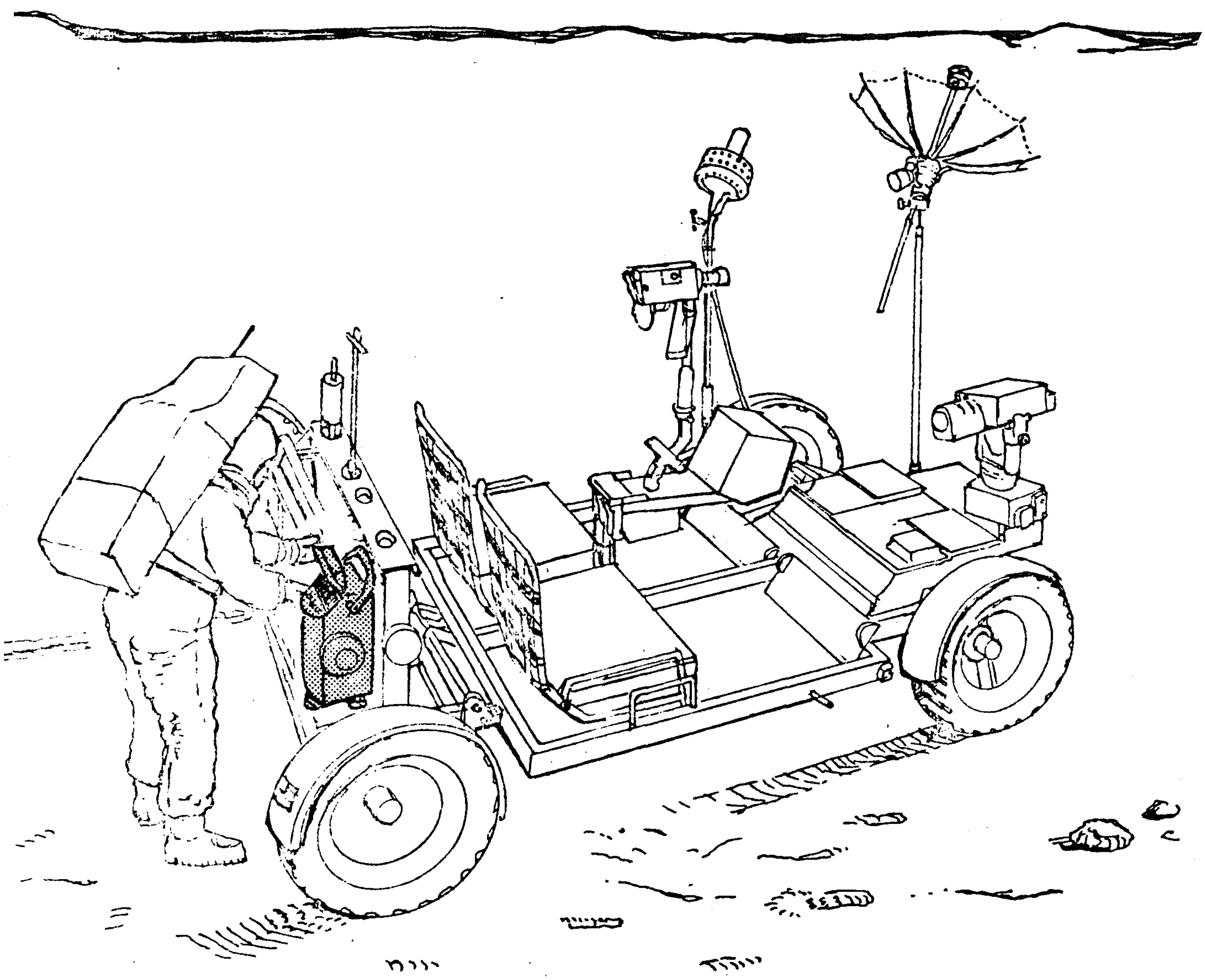


Figure 10-2. Traverse Gravimeter Deployed on LRV

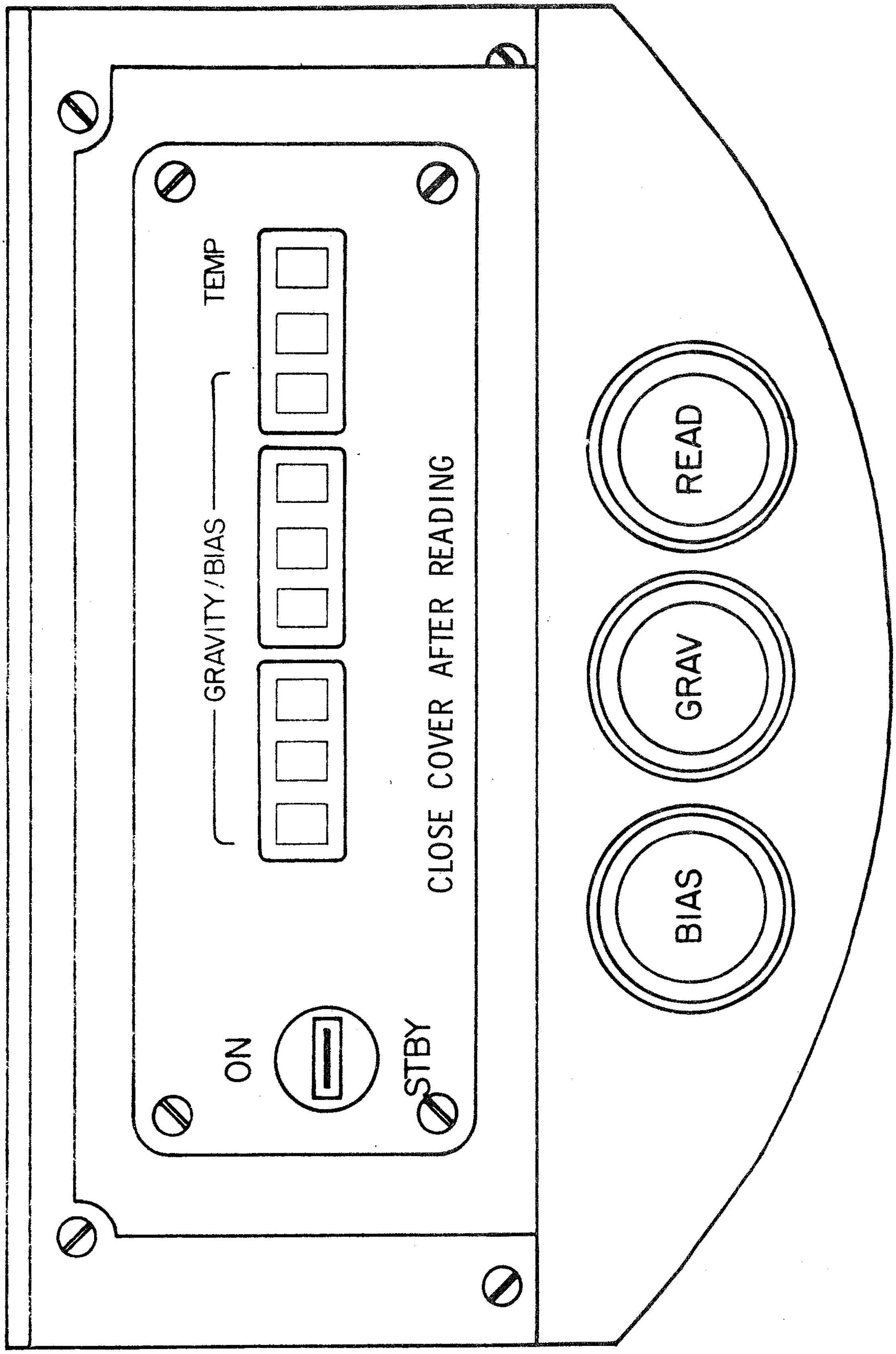


Figure 10-3. Traverse Gravimeter, Control and Display Panel

10.2 TGE OPERATIONAL DATA

10.2.1 TGE Temperature Data

The temperature alarms which appear in the eighth digit of the display as well as the thermostatic temperature control of the I-oven and battery are carried out by Klixon switches. When ordered, these switches have a tolerance of $\pm$ 3°F on their actuation temperature. Furthermore the change in temperature which will reinstate them to their original condition is between 2 and 5°F (i.e., control error band).

Table 10-2 shows the nominal temperatures for each of the switch closures and the significance of each digit of the display. Furthermore the implication of the eighth digit on the sign of the ninth display digit (P-oven temperature shift) is shown.

Table 10-3 shows the measured temperatures at which each of the five switches actuates for both Flight System No. 1 (FS-1) and Flight System No. 2 (FS-2 or Qual Model).

Figures 10-4, 10-5, and 10-6 show the thermal response of the TGE during the lunar surface period for a Hot, Cold, and Normal mission, respectively.

TABLE 10-2.

TGE TEMPERATURE ALARMS AND CODES

(As Seen In 8th and 9th Display Digits)

EIGHTH DIGIT			NINTH DIGIT
Digit	I-Oven (T_I)	Battery (T_B)	Shift of P-Oven Temperature from Original Set Point
0	$60 < T_I < 95^{\circ}F$	$47^{\circ}F < T_B$	+ .009°F per unit of ninth digit
1	$60 < T_I < 95^{\circ}F$	$47^{\circ}F < T_B$	- .009°F per unit of ninth digit
2	$60 < T_I < 95^{\circ}F$	$40 < T_B < 47^{\circ}F$	+ .009 °F per unit of ninth digit
3	$60 < T_I < 95^{\circ}F$	$40 < T_B < 47^{\circ}F$	- .009 °F per unit of ninth digit
4	$95 < T_I < 110^{\circ}F$	$47^{\circ}F < T_B$	+ .009 °F per unit of ninth digit
5	$95 < T_I < 110^{\circ}F$	$47^{\circ}F < T_B$	- .009 °F per unit of ninth digit
6	$110^{\circ}F < T_I$	$47^{\circ}F < T_B$	+ .009 °F per unit of ninth digit
7	$110^{\circ}F < T_I$	$47^{\circ}F < T_B$	- .009 °F per unit of ninth digit

TABLE 10-3.

TGE THERMOSTAT AND ALARM SWITCH CLOSURE POINTS

(By Measurements)

Switch and Function \ Model	Flight System No. 1 (FS-1)	Flight System No. 2 (FS-2)
40°F (Battery Heater)	39.5°F	42.°F
47°F (Battery Cold Alarm)	45°F	44.°F
60°F (I-Oven Heater)	57°F	56.1°F
95°F (I-Oven Warm Alarm)	95.5°F	98°F
110°F (I-Oven Hot Alarm)	109°F	109.3°F

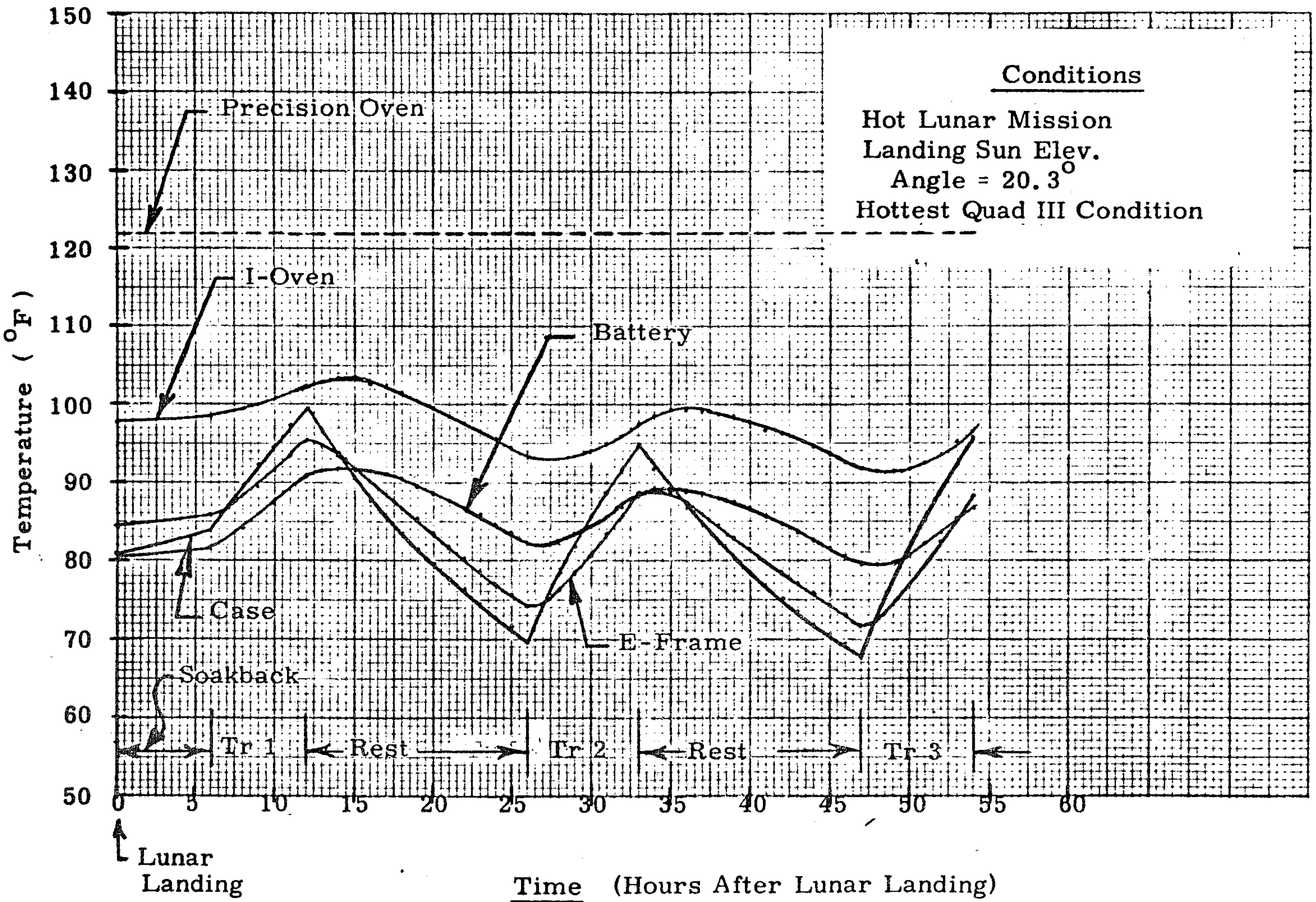


Figure 10-4. TGE Hot Mission Thermal Response

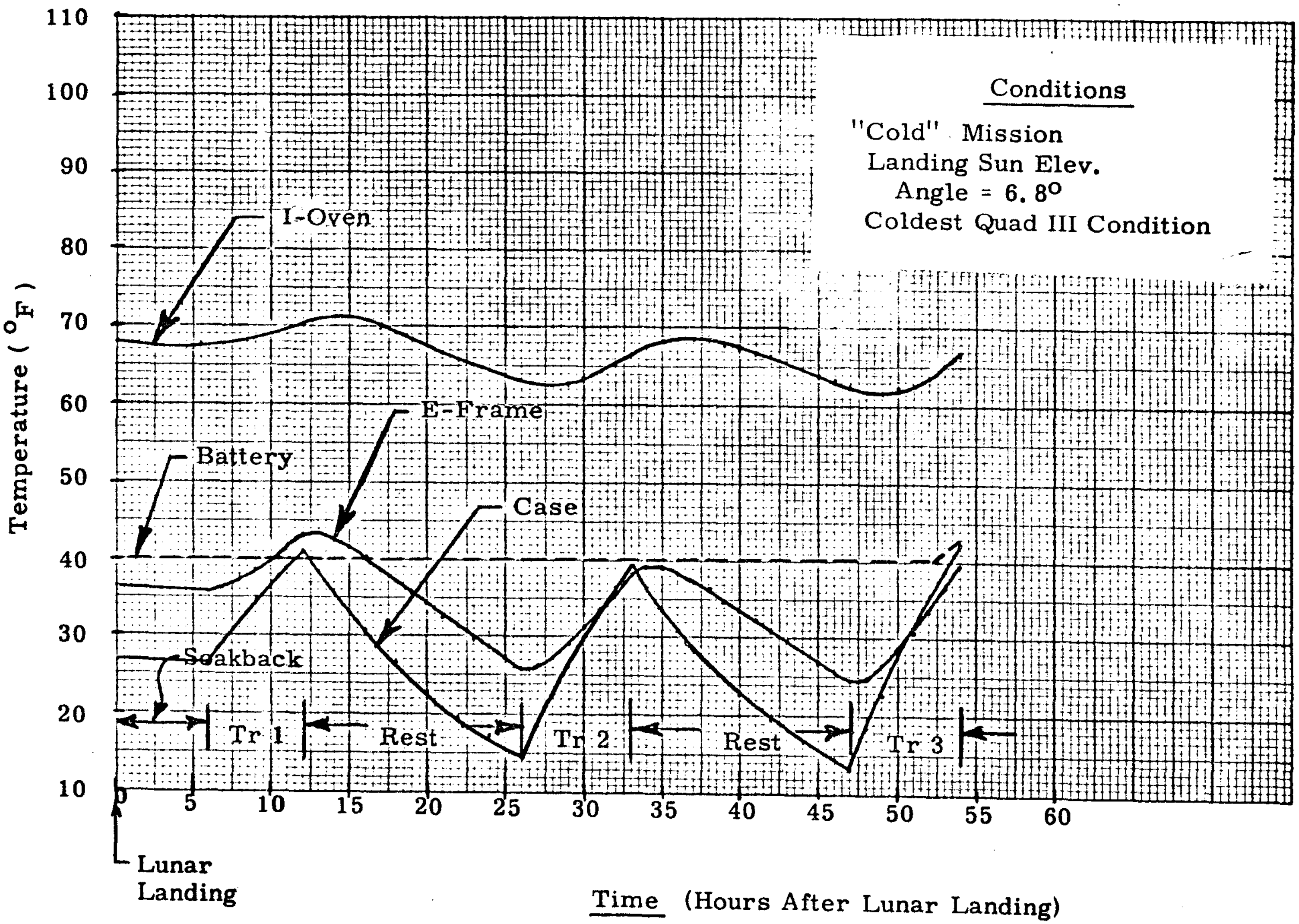


Figure 10-5. TGE Cold Mission Thermal Response

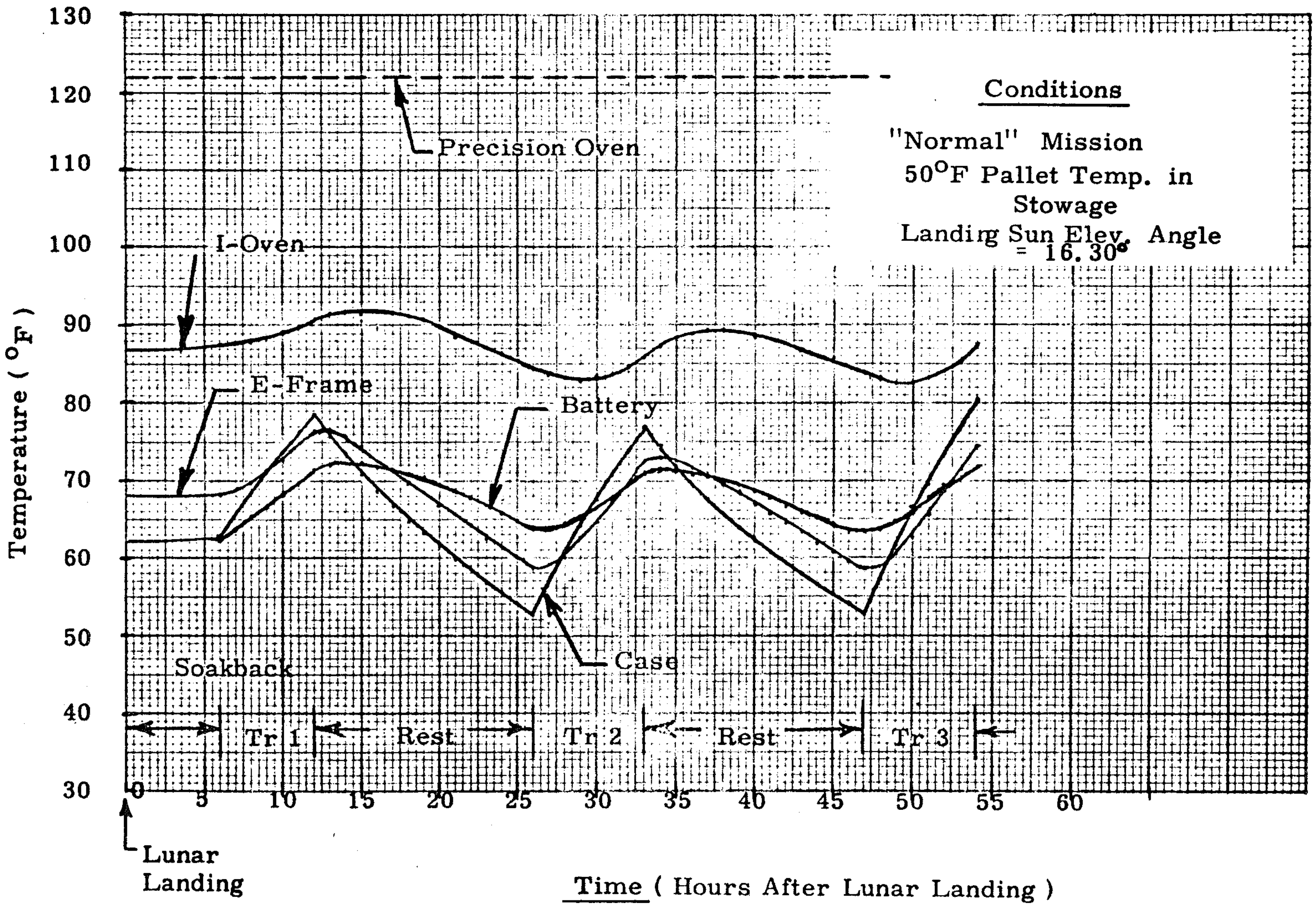


Figure 10-6. TGE Normal Mission Thermal Response

10.2.2 TGE Conversion VSA Frequency to Mgals

The value of gravity measured by the TGE can be computed from the following relationships which are applicable to the normal Gravity and Bias modes of operation:

$$\Delta f = K_0 + K_1 g + K_2 g^2 + K_3 g^3 \text{ (Normal Gravity)}$$

$$\Delta f = K_0 - K_1 g + K_2 g^2 - K_3 g^3 \text{ (Bias Measurement)}$$

where:

K_0 = VSA bias (Hz)

K_1 = VSA Scale Factor (Hz/g)

K_2 = VSA Second Order Term (Hz/g^2)

K_3 = VSA Third Order Term (Hz/g^3)

Δf is the VSA string difference frequency which is calculable from one of the following relationships:

$$\Delta f = \frac{1.152 \times 10^9}{D} \qquad \text{(on earth)}$$

$$\Delta f = \frac{1.92 \times 10^8}{D} \qquad \text{(on moon in Gravity mode)}$$

$$\Delta f = \frac{4.8 \times 10^7}{D} \qquad \text{(on moon in Bias mode)}$$

where D is the 7 digit gravity value from the first seven digits of the TGE display.

10.2.3 TGE Power Data

Listed below are the amp-hours consumed by the TGE in order to affect a bias measurement, normal gravity measurement and to activate the data display. These values are exclusive of power required for Stand-by and Operate modes (also listed) and thermal control.

Bias Measurement: 0.1 A-hr. ~0.8 w-hr.
Gravity Measurement: 0.04 A-hr. ~0.32 w-hr.
Read Mode 0.008 A-hr. ~0.064 w-hr.

	Current	Power
OPERATE --	190 ma	(1.5 watts)
STANDBY --	50 ma	(0.4 watts)

Table 10-3 shows the actual values of the thermostatic switch points. Both the battery and I-oven heaters are controlled in a "bang-bang" mode with the following power levels when the battery is a normal 7.5 volts:

I-oven: 3-watts

Battery: 1-watt

The precision oven temperature is governed by a proportional controller with a maximum power dissipation of 1.3 watts when the battery voltage is 7.5 volts.

10.3 TGE CONSTRAINTS AND LIMITATIONS

10.3.1 TGE Deployment Constraints

See Table 10-1 for Deployment Criteria.

It is requested that the TGE be removed from Quad III and the hardmount pins removed within 20 hours after lunar landing.

Once the pallet is removed from Quad III and placed on the LRV, the handle should be pulled away from its stowage lock position, and then the two side pins may be removed. The bottom pin may be removed before or after the TGE is placed on the lunar surface. It is necessary that this pin be removed before the TGE is replaced on the pallet. A visual check should be made to insure that the bottom pin has fallen clear.

For all measurements, the TGE must be level to within 15 angular degrees on each axis.

10.3.2 TGE Operational Constraints

There are certain operational constraints which should be adhered to in order to prevent possible TGE overheat or component degradation.

Prior to the beginning of rest periods the TGE should be removed from the LRV pallet and placed as close as possible to the middle of the LM shadow cast on the lunar surface. At this time the radiator dust cover should be flipped open (180° rotation). At the beginning of a subsequent EVA the radiator dust cover should be closed and the TGE placed on the LRV pallet again.

The READ button should not be depressed more than twice in successive 18-second intervals. If a third reading is required in successive intervals, the astronaut should wait at least two minutes.

The display cover should be opened only to read the display. At all other times (including button-pushing) the cover should be closed. When TGE Gravity measurements are made, the LRV shall be parked so that it is not inclined more than 15 angular degrees from horizontal in either direction.

Predictable numbers (610 XXX XXX or 730 XXX XXX) will result if the Phaselock Loop does not capture. The appearance of this number may require further measurements to be made on the lunar surface in a Phaselock Loop "BYPASS" mode.

The appearance of 3 zero's in the first three display numbers would indicate that the instrument (or LRV) was bumped during a measurement. If the source cannot be found, BYPASS measurements may be recommended.

If the Level/Measure light flashes and then goes out without having been on steadily, the TGE needs to be placed on a more level location (within (15° of horizontal). The display, if it were to be read at this point, would be 000 000 0xx (xx temperature data).

10.3.3 TGE Temperature Constraints

If at the beginning of the first EVA it is observed that a 6 or a 7 appears in the 8th display digit, the TGE should not be taken on that traverse. Rather it should undergo normal rest period cooling in the LM shadow.

10.3.4 Phaselock Loop Bypass

A Bypass measurement is performed by depressing the GRAV and READ pushbuttons simultaneously. Additional Bypass measurements can be made by simply depressing the GRAV pushbutton.

To put the TGE back in the normal mode, toggle the switch from ON to STANDBY and back to ON.

A Bypass measurement is indicated by a "0" in the first digit.

SECTION 11.0 LUNAR NEUTRON PROBE EXPERIMENT

11.1 LNPE Deployment Criteria

TABLE 11-1. LNPE DEPLOYMENT CRITERIA

PARAMETER	CRITERIA
Site Selection	The site chosen for the LNPE is determined by the site chosen for the Deep Drill Core Sample (part of the Lunar Geology Investigation). The LNPE must be at least 25 meters from the RTG when deployed or the science data will be degraded by radiation from the RTG. The LNPE should be shielded from the RTG by natural lunar features if possible; i.e., behind a boulder or in a small crater.
Thermal Protection	The LNPE is stowed on the MESA to the moon. The LNPE is stowed on the LRV for transportation to the deployment site, and should be wrapped in the thermal bag provided and/or kept shaded from direct sunlight. The upper red-line temperature limit for the plastic detector is 70°C (158°F).
Emplacement and Activation	The LNPE will be inserted into the 3.3-meter hole created by removal of the deep core sample. The treadle assembly will be placed over the hole to prevent cave-ins. Emplacement and activation of the LNPE should be accomplished immediately, following the ALSD drilling operations to maximize the time the LNPE is activated. The LNPE must be emplaced and activated for a minimum of 24 hours. Unscrew the orange cap from the top of the lower probe section. Remove and discard the Teflon insert. Invert the cap and use it as a tool to depress and rotate the keyed head (tang) at the top of the section 180° from the OFF to the ON position, thus aligning the Boron Target with the plastic detector and activating the lower section. When activated, the keyed head will pop up, exposing white portion of the probe's central rod. (The keyed head is at the upper portion of the central rod.) Put cap nearby for use later. Report the time of activation of the lower probe to MCC. Remove and discard dust cap from the bottom of the upper probe section. Screw the upper section to the lower section. See Figure 11-1. Activate the upper section of the probe by depressing the lever on the upper handle and rotating the handle 180° clockwise from OFF to ON. This causes

PARAMETER	CRITERIA
Emplacement and Activation (Concluded)	the Boron Target and plastic detector to become aligned. Report the time of activation of the upper probe to MCC. Insert the 2-meter probe into the hole. The probe may be hammered in or drilled in with the ALSD if necessary. Report the time of insertion to MCC. The diameter of the upper handle of the probe is larger than the hole in the treadle (and diameter of core stem) so that the LNPE cannot drop below the lunar surface. Cover the emplaced LNPE with the thermal bag.
Retrieval	At the end of the final EVA, the probe will be removed from the hole and separated into two sections. Both sections must be rotated to the OFF position. Reinstall the cap on top of the lower probe section. (The OFF position for the lower section is obtained by depressing the keyed head and rotating 180°. When this section is in the OFF position, an orange ring will be showing just below the keyed head of the central rod.) Report the times of probe removal and deactivation of both probe sections to MCC. If required, the extension handle, treadle, and extractor tool may be used to remove the probe from the hole. Place the two probe sections in the thermal bag for return to the LM. At the LM the probe shall be placed in a storage bag for return to MSC and delivery to the PI.

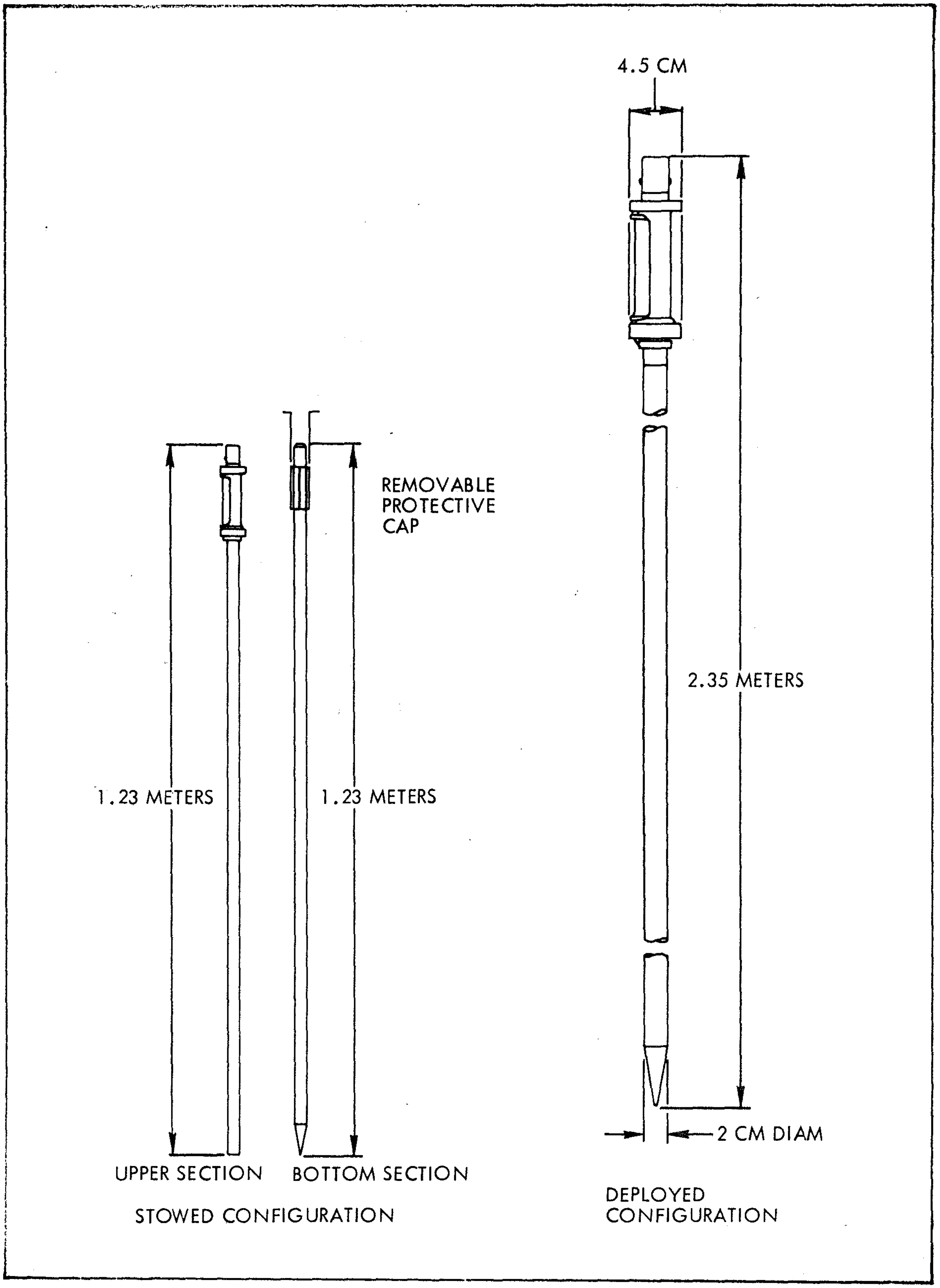


Figure 11-1. Lunar Neutron Probe Experiment

11.2 LNPE OPERATIONAL DATA

(TBD)

11.3 LNPE CONSTRAINTS AND LIMITATIONS

11.3.1 LNPE Deployment Constraints

Deployment constraints are included in Table 11-1, LNPE Deployment Criteria.

11.3.2 LNPE Thermal Constraints

The LNPE should be wrapped in its thermal blanket from the time it is removed from its stowage location in the MESA until it is emplaced. Similarly, after the LNPE is removed, it should be wrapped in its thermal blanket for its return trip to the LRL. The upper red-line limit for the plastic detector portion of the LNPE is 70°C (158°F).

If the LNPE must be exposed to the sun, uncovered, the maximum exposure times for various sun elevation angles is shown in Table 11-2.

If the LNPE is wrapped in its thermal bag, there is no time limit on its exposure to the sun on the lunar surface.

If the LNPE can be only partially deployed, it should be left uncovered for not more than 30 minutes.

TABLE 11-2. LNPE EXPOSURE CONSTRAINTS

	Sun Elevation Angle				
	10°	20°	30°	40°	50°
Maximum Uncovered Exposure Time	TBD	TBD	1 Hour	30 Min.	15 Min.

SECTION 12.0 COSMIC RAY DETECTOR

PRELIMINARY

12.1 Cosmic Ray Detector Deployment Criteria

TABLE 12-1. COSMIC RAY DETECTOR DEPLOYMENT CRITERIA

PARAMETER	CRITERIA
Deployment Location	The Cosmic Ray experiment consists of two parts, a SUN detector and a SHADE detector. These two parts are not interchangeable. Decals are provided on the back face of each detector, opposite the detector face. The decals read "SUN" and "SHADE." The experiment hardware is stowed in a documented sample bag and will be transported to the lunar surface in an equipment transfer bag. The bag must be opened in the shade of the LM. The box and sliding cover are separated by pulling in opposite directions on the two rings connected to opposite ends of the box and cover. This can be done by hanging the entire experiment on the ring attached to the SHADE section and pulling it open.
SHADE Detector Deployment	The SHADE (slide) detector will be immediately deployed by hanging it on the hook on the left edge of the LRV deployment station. Maximum allowable exposure of the SHADE detector to the sun is 60 seconds. SHADE detector should face away from the sun with a view of the dark sky. There should be minimum obstructions in its field of view during the exposure period.
SUN Detector Deployment	The SUN (box) detector should be deployed against one of the LM struts by hanging it on a velcro strap. The strut chosen should allow the SUN detector surface to be perpendicular to the sun line $\pm$ 30 degrees of azimuthal deviation. There should be minimum obstructions in its field of view during the exposure period. The time of deployment of the two detectors must be reported to MCC.
Retrieval	It is highly desirable that both parts of the experiment be deployed for as long a period as is practical, with a minimum exposure time of 24 hours. The SUN detector should be retrieved first and carried into the shade of the LM, then mated with the SHADE detector. The complete experiment will be stowed in a contingency sample bag for return to MSC and delivery to the Principal Investigator. The time of retrieval of the experiment must be reported to MCC.

TABLE 12-1. COSMIC RAY DETECTOR DEPLOYMENT CRITERIA (Concluded)

PARAMETER	CRITERIA
Precautions	The deployment locations and deployment procedures should be such that they minimize the contamination of the two exposed detectors with lunar dust. The experiment hardware should be handled insofar as possible with the rings and velcro strap. Do not touch the two detector surfaces. If a solar flare should occur after the experiment has been deployed, the two parts should be retrieved, mated and stowed as soon as reasonably possible.

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