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DATA CHANGE NOTIFICATION FORM
CSM/LM SPACECRAFT OPERATIONAL DATA BOOK
SNA-8-D-027

VOLUME V PART ____

DATE March 8, 1972

AMENDMENT 10

PAGE 1 OF 170 + 5 tabs

SHORT TITLE OF CHANGE Add Appendix E containing data pertaining to the Apollo 16 ALSEP Array D.

CHANGE DESCRIPTION

Complete new Appendix E for Apollo 16 ALSEP Array D plus four other lunar surface experiments.

CONTRACTOR SUBSYSTEM APPROVAL

PHONE ____

CONTRACTOR MANAGEMENT APPROVAL

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NASA COMMENTS

SEC 3-7-72

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CHANGE AUTHORITY PD4 EXT

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ASPO APPROVAL, J. R. SEVIER,
CHIEF, OPERATIONS ANALYSIS BR.

DATE 3/8/72

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SNA-8-D-027 (V)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CSM/LM SPACECRAFT OPERATIONAL DATA BOOK

VOLUME V
ALSEP DATA BOOK

APPENDIX E

APOLLO 16 ALSEP ARRAY D

MARCH 1972

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

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

CSM/LM SPACECRAFT OPERATIONAL DATA BOOK

VOLUME V

APPENDIX E

APOLLO LUNAR SURFACE EXPERIMENTS PACKAGE

APOLLO 16 ALSEP ARRAY D

Prepared by
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Science Missions Support Division
Science and Applications Directorate
Manned Spacecraft Center
Houston, Texas

March 8, 1972

APOLLO 16 ALSEP ARRAY D

APPENDIX E

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ILLUSTRATIONS (Concluded)

APOLLO 16 ALSEP ARRAY D

APPENDIX E

TABLES

SECTION 1

INTRODUCTION

1.1 PURPOSE

The Apollo Lunar Surface Experiments Package (ALSEP) Data Book Appendix E presents parametric data defining the operational capabilities and limitations of Apollo 16 ALSEP Array D and its constituent subsystems. The information is intended for use in mission planning, support studies and real-time missions operations. It is planned that Apollo 16 ALSEP Array D will be deployed on Apollo Mission AS-511 (Apollo 16) comprised of CSM-113 and LM-11.

1.2 CONTENT

The complete CSM/LM Spacecraft Operational Data Book consists of six 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	ALSEP Data Book
Volume VI	CSM Experiments Data Book
Volume VII	LCRU/GCTA Data Book

This Appendix E to Volume V is divided into five sections pertaining to Apollo 16 ALSEP Array D.

Although they are not specifically ALSEP experiments, four other lunar surface experiments are described in this document because they constitute part of the science experiments complement to be deployed on the lunar surface at the Descartes site at the time of Apollo 16 ALSEP Array D deployment.

1.3 ALSEP ABBREVIATIONS AND ACRONYMS

ALHT	Apollo Lunar Hand Tools
ALSD	Apollo Lunar Surface Drill
ALSEP	Apollo Lunar Surface Experiments Package
ASE	Active Seismic Experiment
ASI	Apollo Standard Initiator
EVA	Extravehicular Activity
FCA	Fuel Capsule Assembly
FTT	Fuel Transfer Tool
GLA	Grenade Launcher Assembly
HFE	Heat Flow Experiment
LM	Lunar Module
LP	Long Period
LPM	Lunar Portable Magnetometer
LRL	Lunar Receiving Laboratory
LRV	Lunar Roving Vehicle
LSM	Lunar Surface Magnetometer
LSUC	Lunar Surface Ultraviolet Camera
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
PSE	Passive Seismic Experiment
RSST	Resettable, Solid-State Timer
RTG	Radioisotope Thermoelectric Generator
SEQ	Scientific Equipment Bay in LM
SP	Short Period
SWC	Solar Wind Composition
TM	Telemetry
UHT	Universal Handling Tool
UV	Ultraviolet

SECTION 2

CONFIGURATION

2.1 EQUIPMENT COMPOSITION

Apollo 16 ALSEP Array D is made up of the central station and radioisotope thermoelectric generator used in previous arrays plus the four scientific data sensors identified in Table 2-1. Also included in Table 2-1 are the four non-ALSEP data sensors.

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

TABLE 2-1 APOLLO 16 LUNAR SURFACE SCIENCE DATA SENSORS

ALSEP SCIENTIFIC DATA SENSOR	PRINCIPAL INVESTIGATOR (PI)
Passive Seismic Experiment (PSE) NASA Exp. No. S-031	Dr. Gary V. Latham Lamont-Doherty Geological Observatory
Active Seismic Experiment (ASE) NASA Exp. No. S-033	Dr. Robert L. Kovach Stanford University
Lunar Surface Magnetometer (LSM) NASA Exp. No. S-034	Dr. Palmer Dyal NASA Ames Research Center
Heat Flow Experiment (HFE) NASA Exp. No. S-037	Dr. Marcus G. Langseth Lamont-Doherty Geological Observatory
NON-ALSEP SCIENTIFIC DATA SENSOR	**PRINCIPAL INVESTIGATOR (PI)**
Solar Wind Composition (SWC) NASA Exp. No. S-080	Dr. Johannes Geiss University of Berne Switzerland
Cosmic Ray Detector (Sheets) NASA Exp. No. S-152	Dr. Robert L. Fleischer GE Research and Development Center
Lunar Portable Magnetometer (LPM) NASA Exp. No. S-198	Dr. Palmer Dyal NASA Ames Research Center
Lunar Surface Ultraviolet Camera (LSUC) NASA Exp. No. S-201	Dr. G. Carruthers Naval Research Laboratory

TABLE 2-2

MAJOR COMPONENTS OF ARRAY D

Major Components	Part No.	Serial No.
Passive Seismometer		
- Sensor/Shroud Assembly	2348460-9	8
- Stool	2344723-501	3
Active Seismic Experiment	2330750-6	-
- Mortar Package Assembly	2334500-5	7
- Thumper/Geophone Assembly	2334772-4	6
- Mortar Package Pallet Assembly	2339380	1
Lunar Surface Magnetometer	2330657	3
Heat Flow Experiment	2345430-101	4
Fuel Capsule	47D300400G1	6330005
Fuel Cask, Mounting	2338660	8
Radioisotope Thermoelectric Generator	47 E 300779	6320012
Central Station		
- ASE Electronics	2334468	6
- PSE Electronics	2334670	2
- Central Electronics	2345182	9
- Antenna	2330307	5
- Antenna Aiming Mechanism	2339175	9

TABLE 2-3

ALSEP ARRAY D PHYSICAL CHARACTERISTICS

SUBPACKAGE NO. 1	
Dimensions:	25.2" x 27.1" x 21.6"
Weight:	144.68 pounds
SUBPACKAGE NO. 2	
Dimensions:	25.2" x 27.3" x 21.6"
Weight:	87.68 pounds
EQUIPMENT EXTERNAL TO LM	
RTG Fuel Capsule, Cask and Mounting - Weight:	57.65 pounds
TOTAL ALSEP WEIGHT	290.01 pounds

2.2 STOWED CONFIGURATION

ALSEP is carried to the Moon stowed in the descent stage of the Apollo Lunar Module. The instrumentation is packaged to mount in the Scientific Equipment (SEQ) bay and the radioisotope fuel capsule is stowed in a special cask mounted externally. These locations are shown in Figure 2-1, and the configurations of the stowed packages are shown in Figures 2-2 and 2-3.

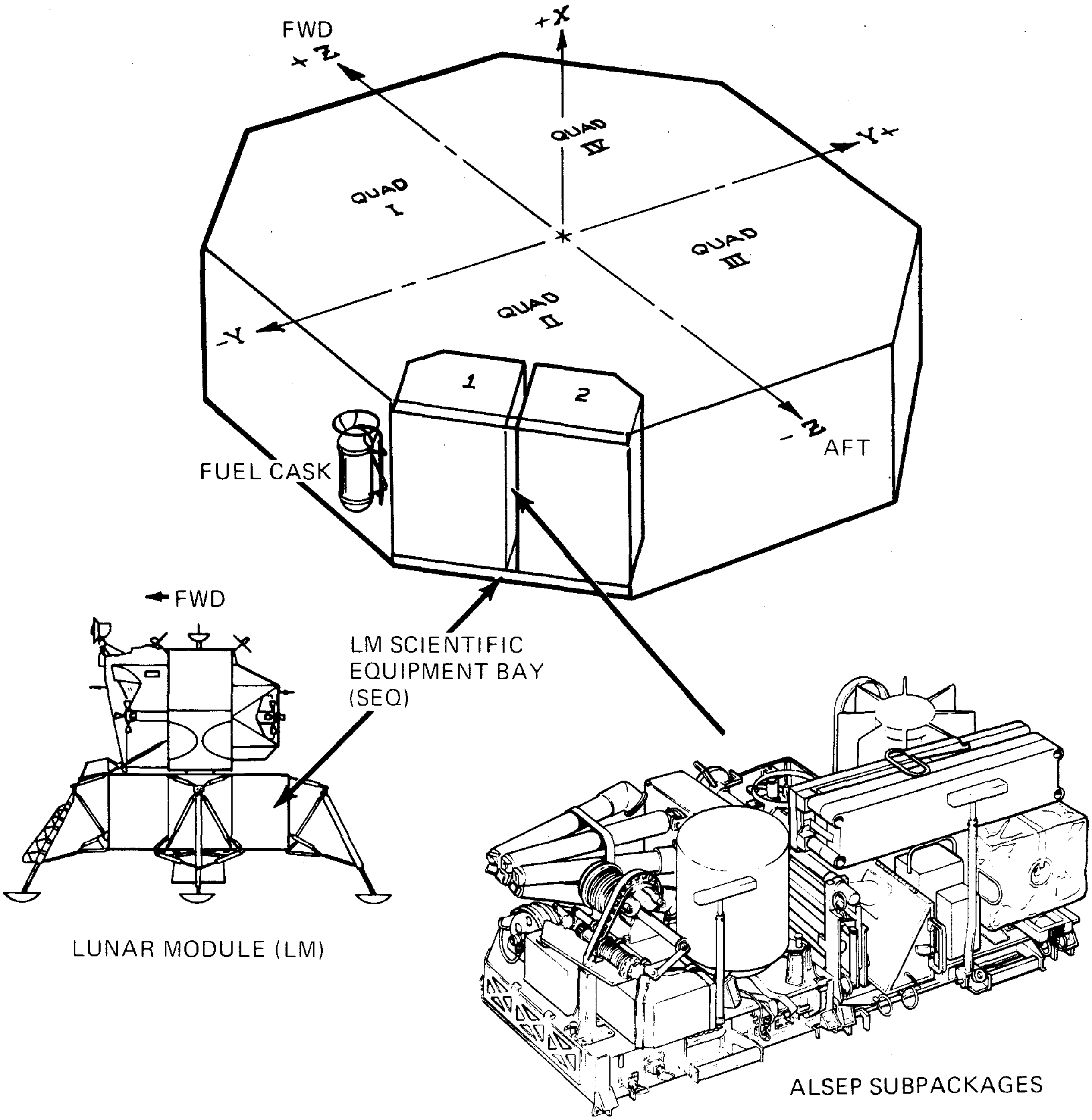


Figure 2-1 ALSEP/LM Interface

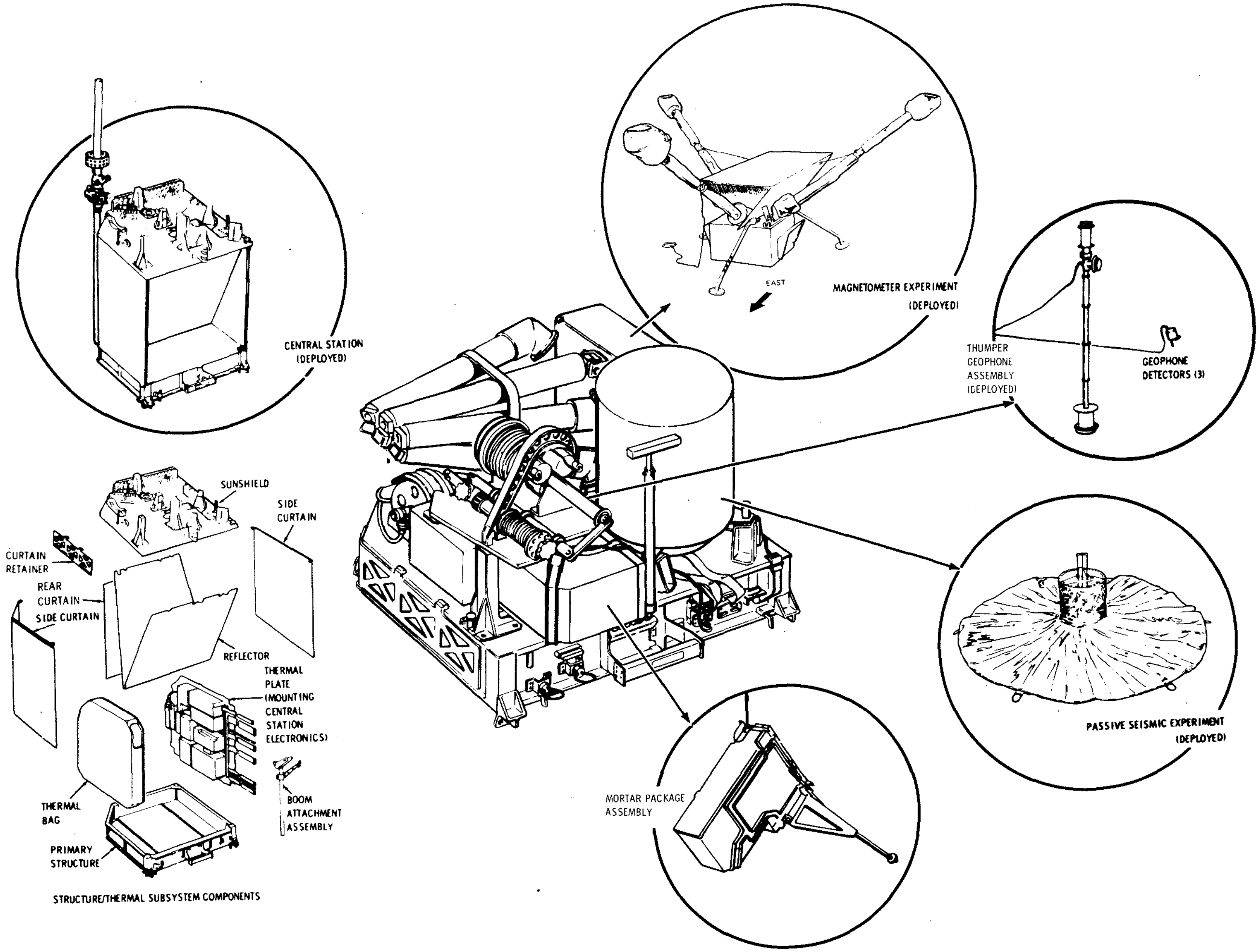


Figure 2-2 ALSEP Array D Subpackage No. 1

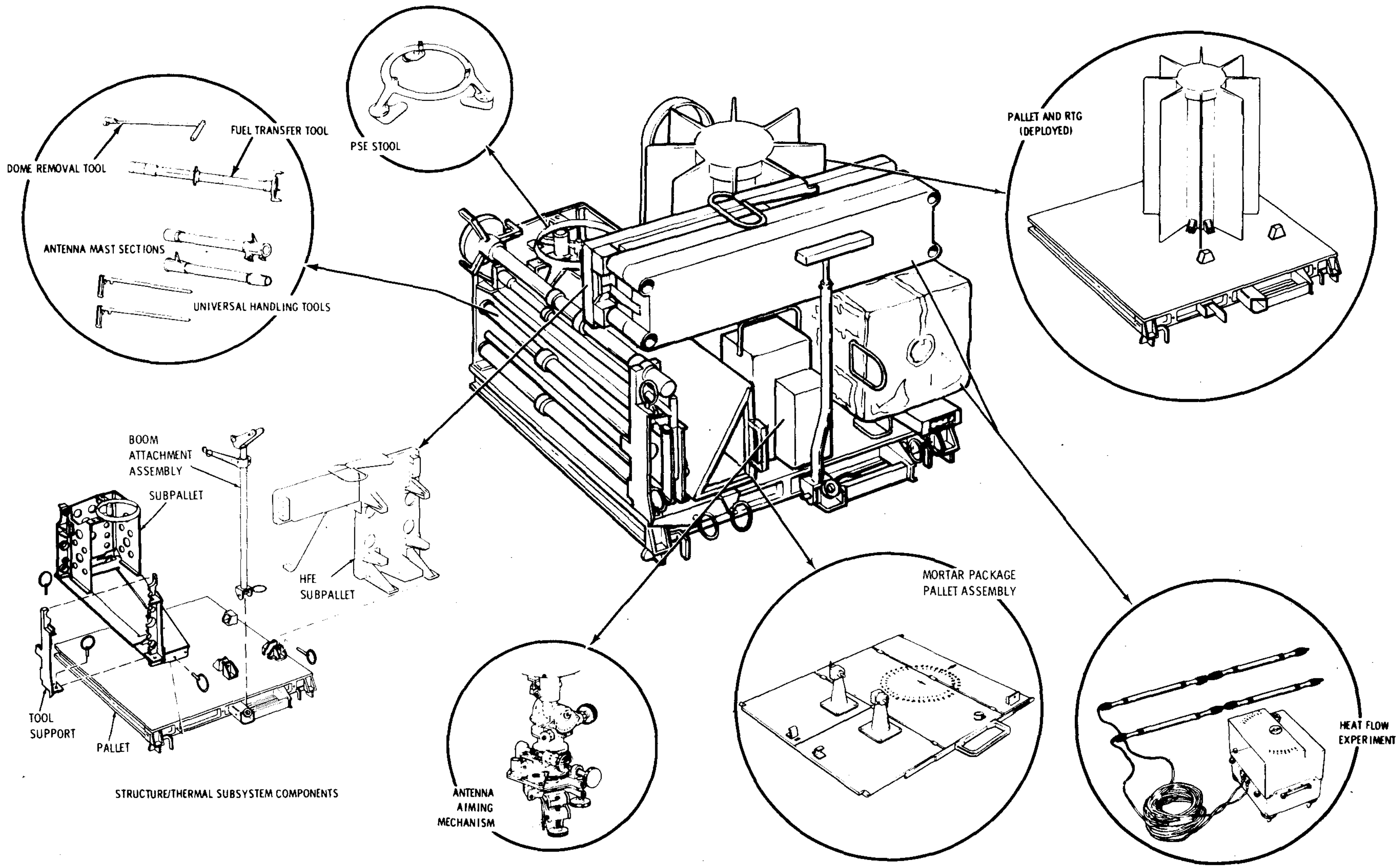


Figure 2-3 ALSEP Array D Subpackage No. 2

2.3 DEPLOYED CONFIGURATION

At the deployment site the crew performs disassembly operations and distributes the components on the lunar surface as shown in Figure 2-4. This deployed configuration is specifically designed for a lunar landing site in the Descartes region. When properly deployed the major components will appear as shown in Figures 2-5 through 2-8. Detailed deployment requirements for the system and its components are given in Section 3.1.

The deployed configurations for the four non-ALSEP experiments are shown in Figures 2-9 through 2-12.

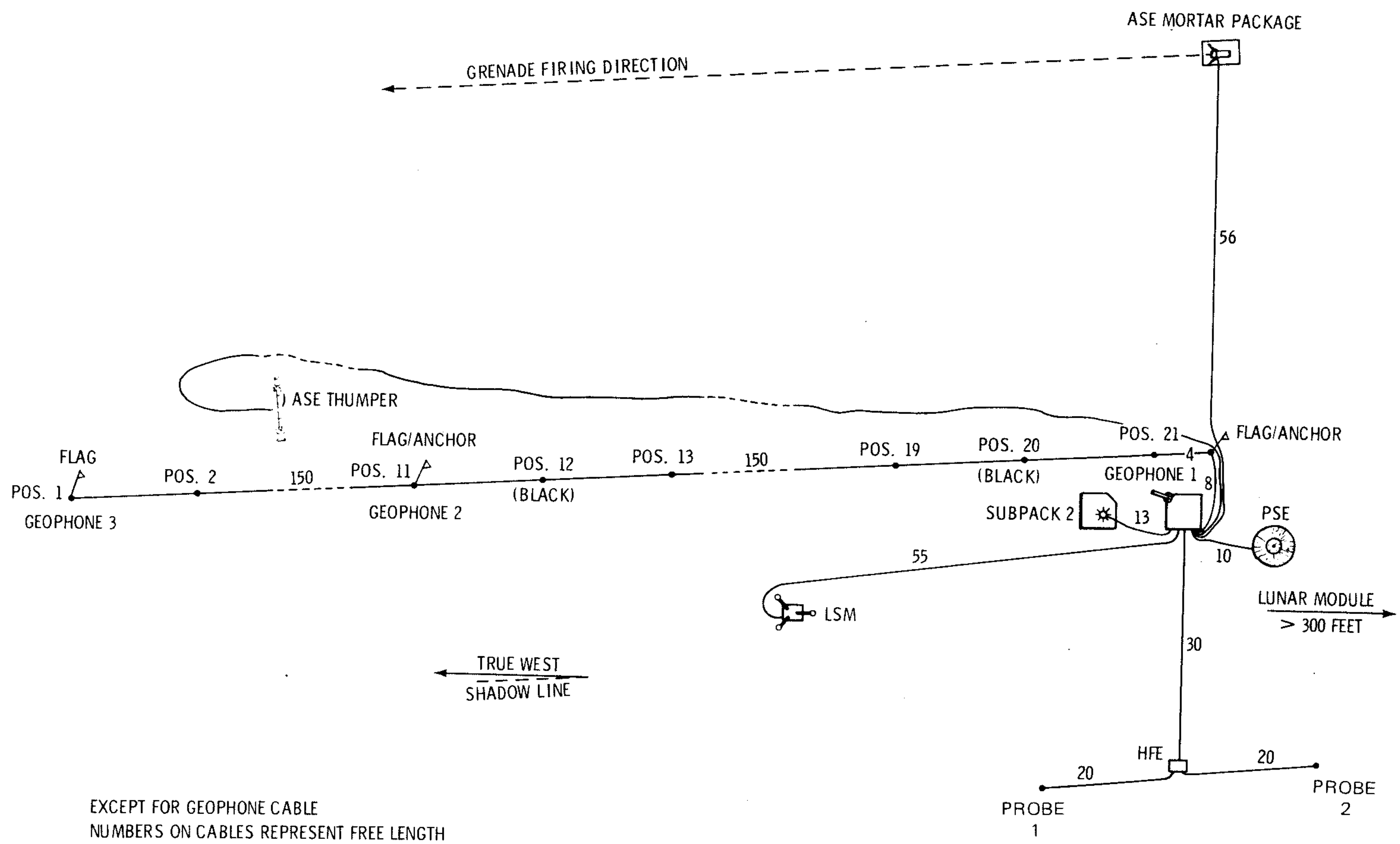


Figure 2-4 Array D General Deployment Configuration

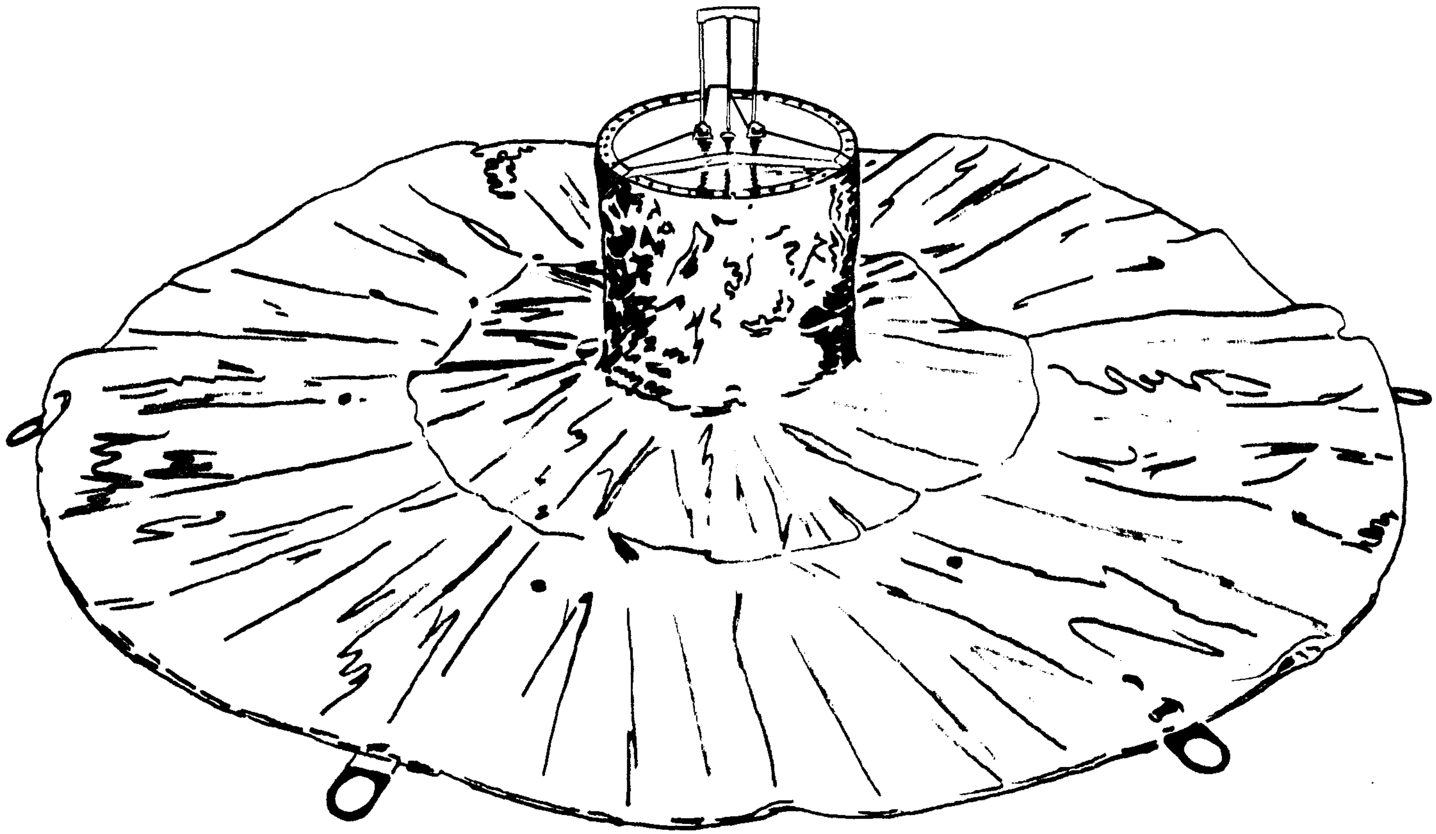


Figure 2-5 Passive Seismic Experiment Deployed Configuration

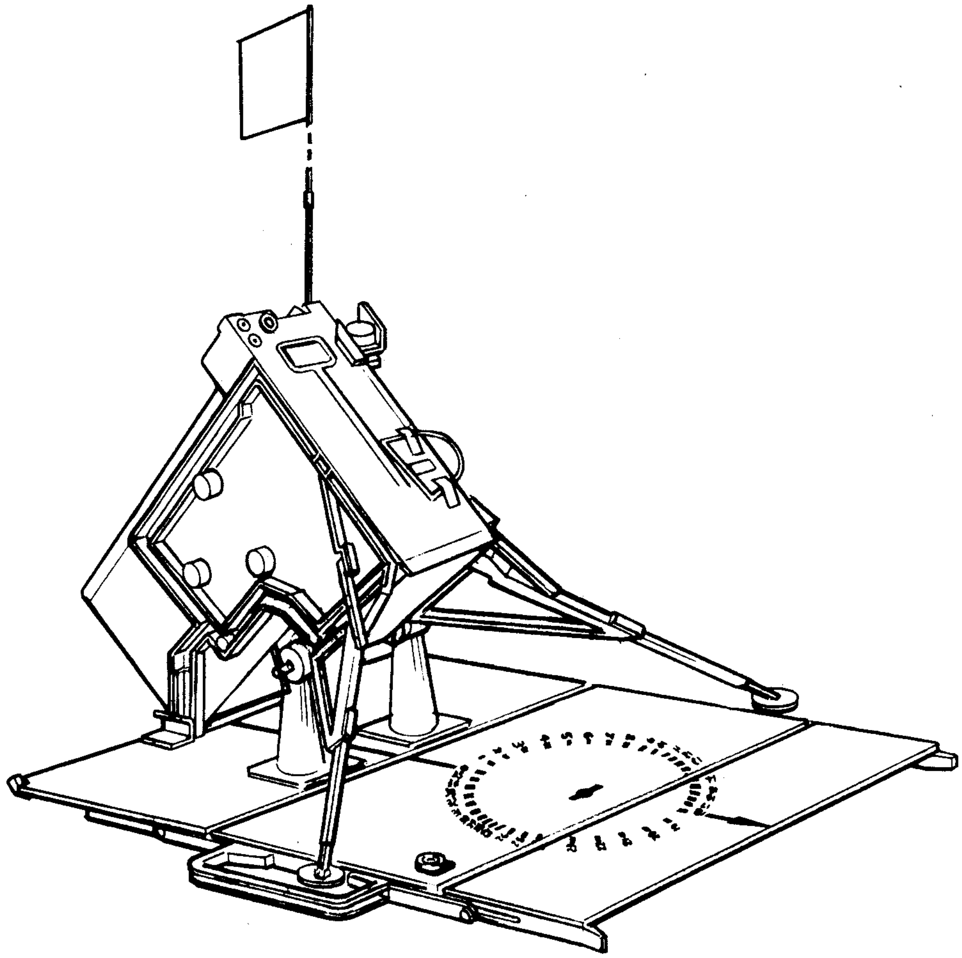


Figure 2-6 ASE Mortar Package Deployed Configuration

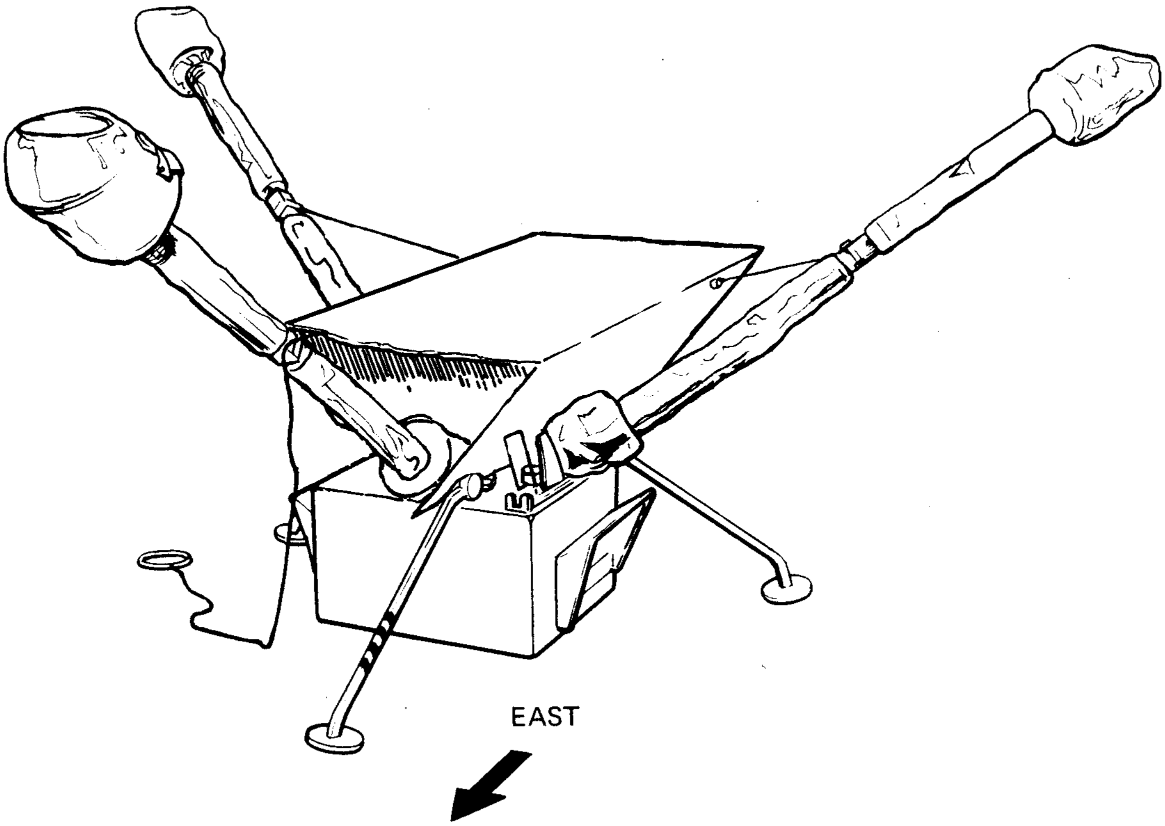


Figure 2-7 Lunar Surface Magnetometer Deployed Configuration

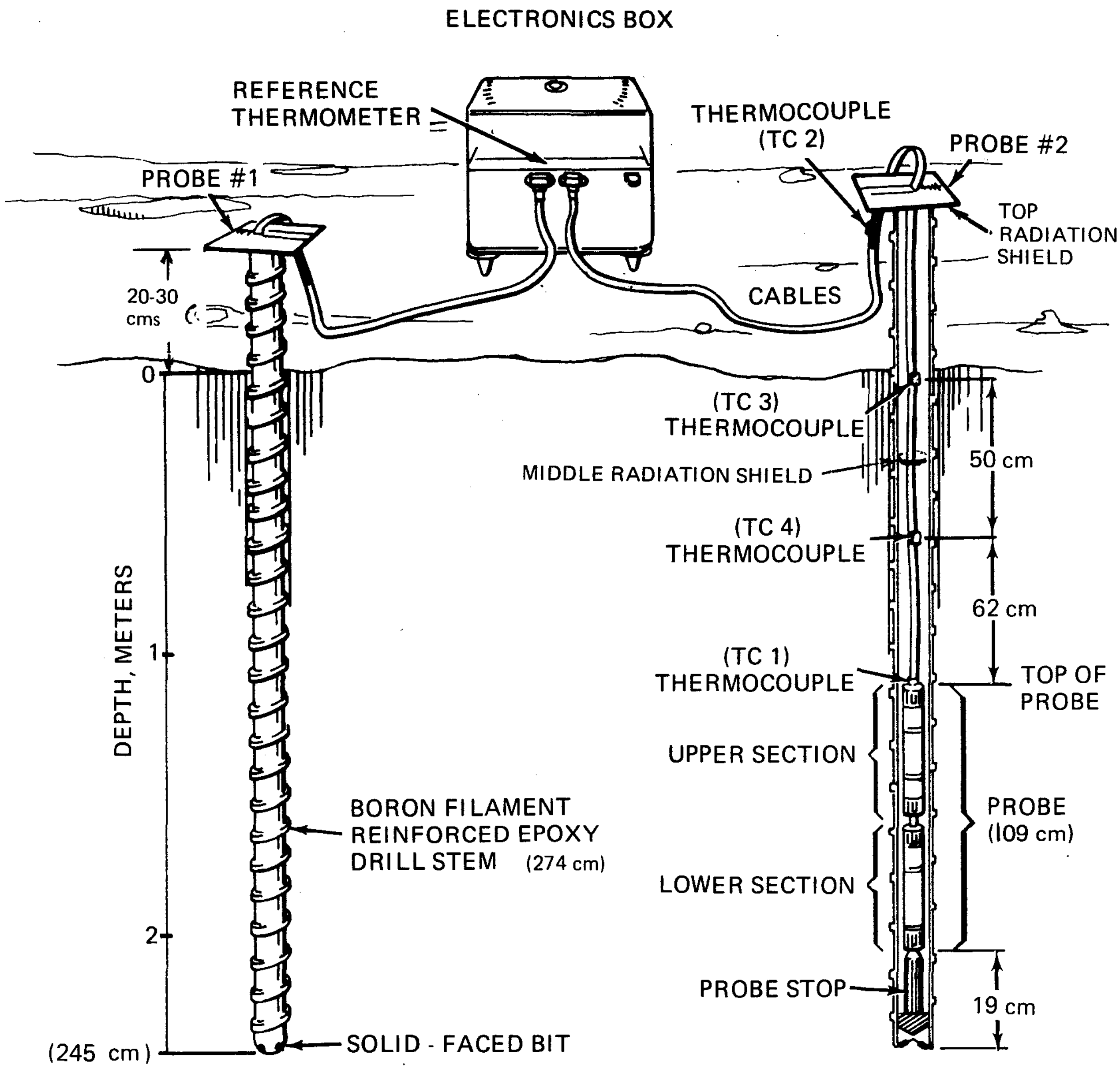


Figure 2-8 Heat Flow Experiment Deployed Configuration

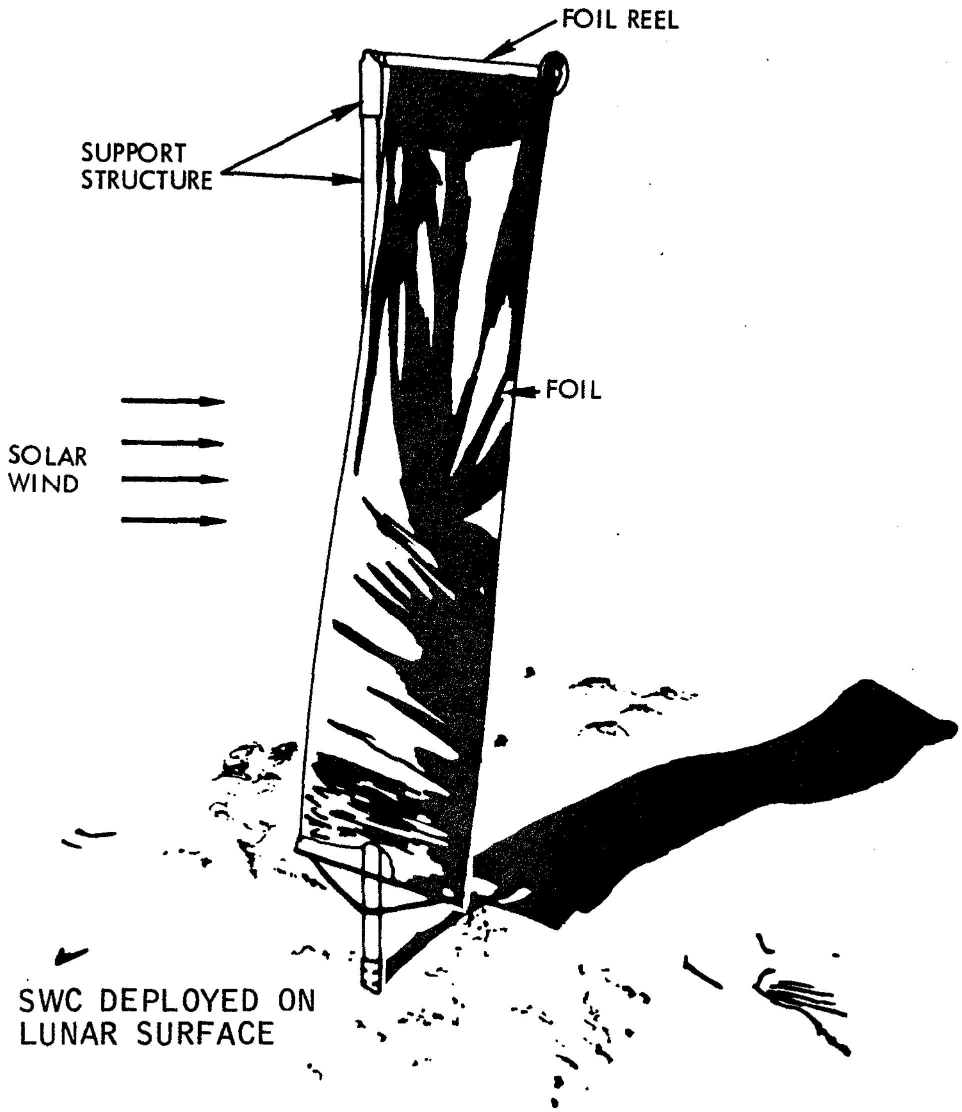
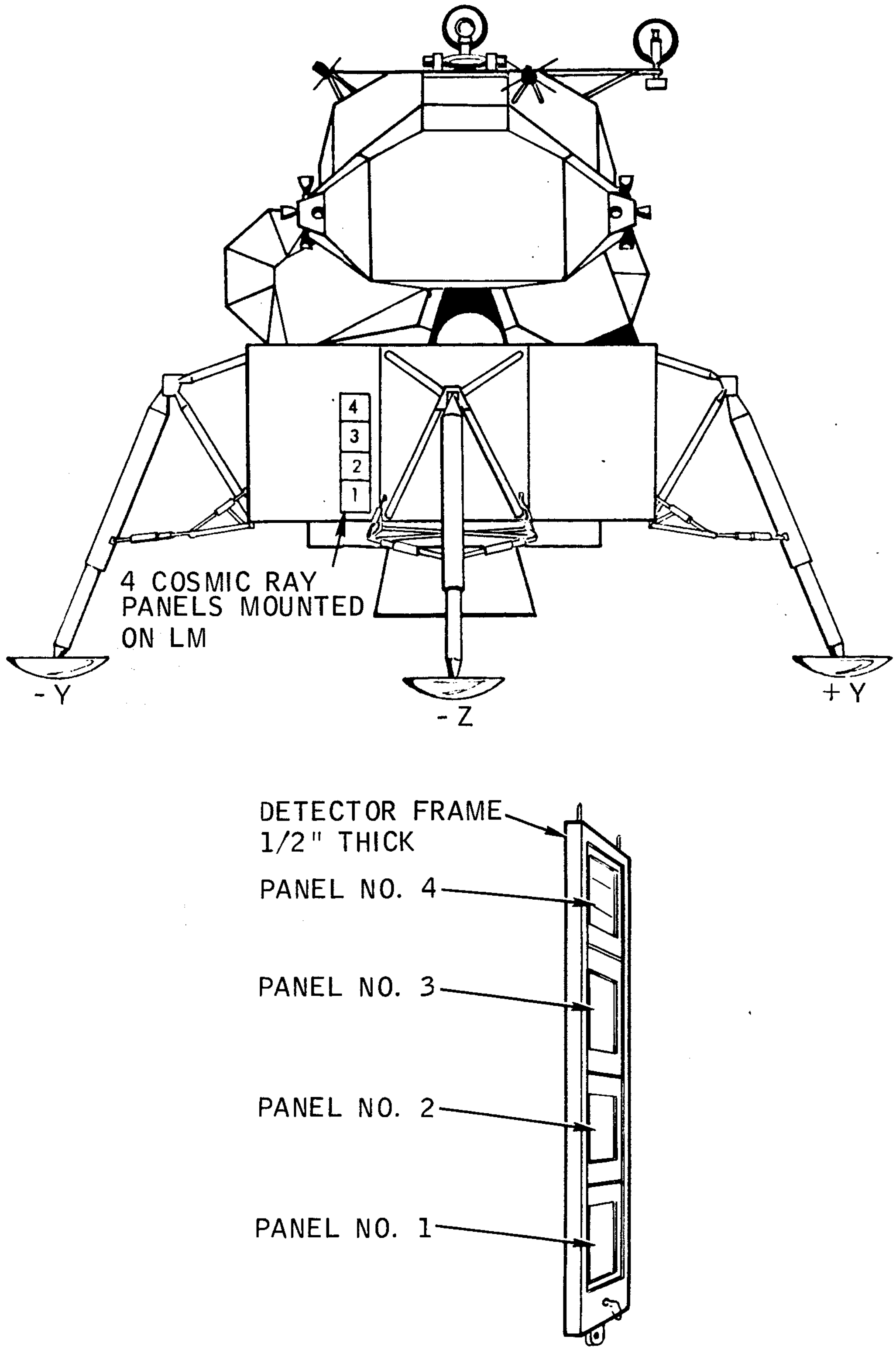


Figure 2-9 Solar Wind Composition Deployed Configuration



COSMIC RAY DETECTOR FRAME MOUNTING DETAIL

Figure 2-10 Cosmic Ray Detector Deployed Configuration

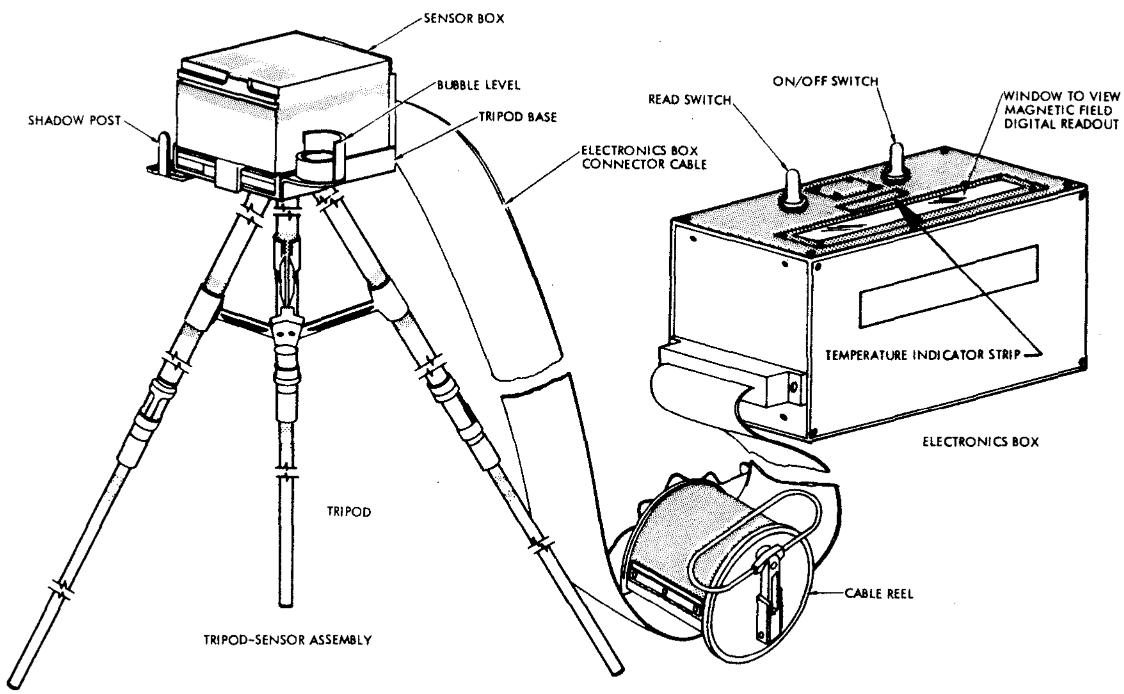


Figure 2-11 Lunar Portable Magnetometer Deployed Configuration

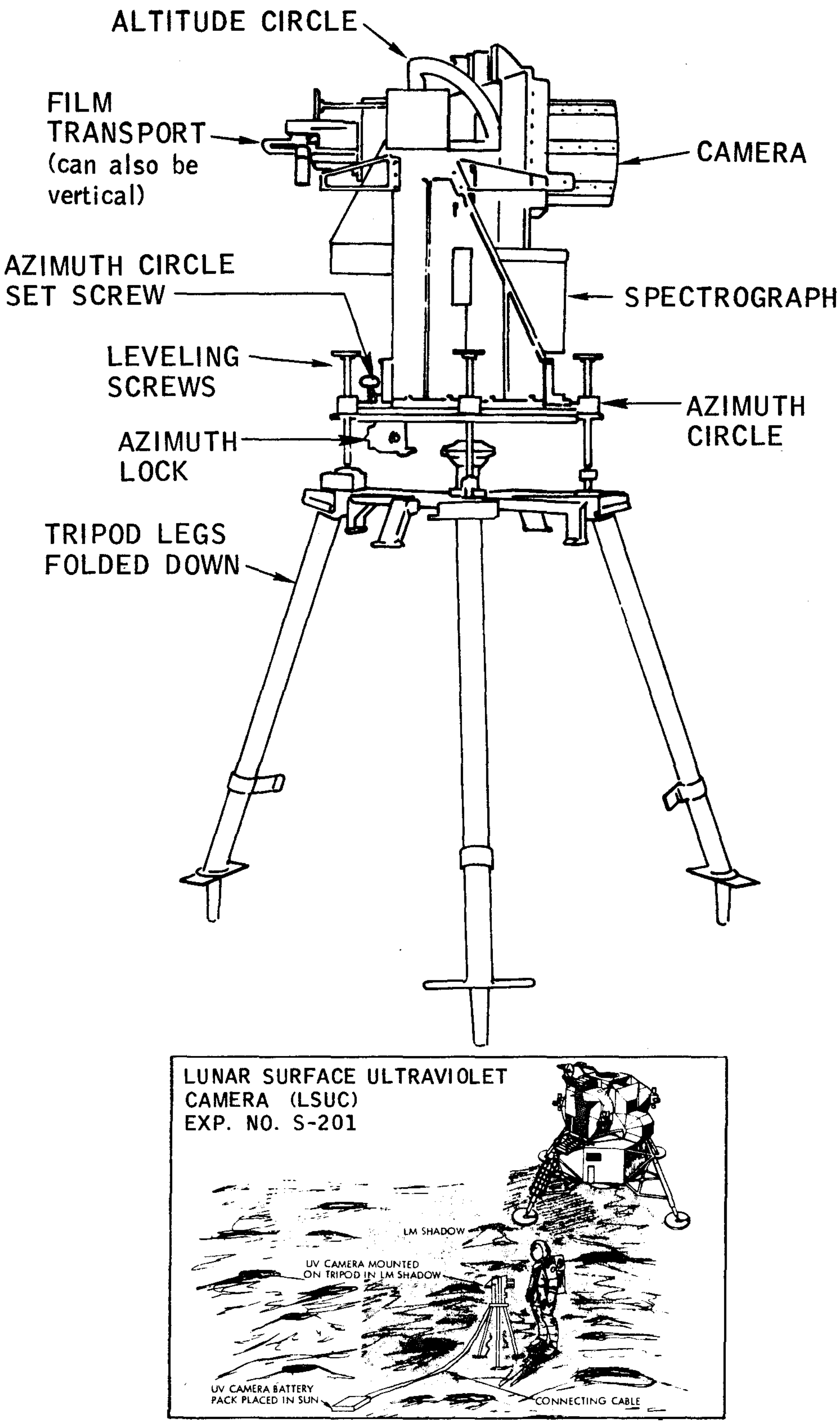


Figure 2-12 Lunar Surface Ultraviolet Camera Deployed Configuration

SECTION 3

APOLLO 16 ALSEP (ARRAY D) OPERATIONAL DATA

INTRODUCTION

This section presents information on what is designated "normal" operation of ALSEP Array D. Normal operation is considered to be that functional condition of a properly deployed system in which each experiment is providing optimum data under the prevailing environmental conditions. Hence, science data parameters do not generally have predictable operating values. The measurement ranges of these parameters are listed where these values are significant to equipment operation. Engineering data parameters are considered to be those which indicate the operational status or performance of the equipment.

The data provided by Array D is transmitted on a carrier having a nominal frequency of 2276.0MHz. A complete set of Active Seismic Experiment (ASE) measurements is provided at a rate of 10,600 bits per second in a sequence of thirty-two 20-bit words. This data is transmitted only when Array D is in the High Data Rate mode of operation as selected by octal command 003. The science and engineering measurements from the other units in the system are provided at 1060 bits per second in repetitive sequences of sixty-four 10-bit words. The assignment of words to each equipment item is as shown in Figure 3.0. The parameters represented in, or derived from these measurement words can be generally classified as shown in Table 3.0. In the High Data Rate mode of operation: a) the 10,600 bits per second clock to the ASE is enabled; b) the data demand signals to the other experiments in the system are inhibited; and c) the 1060 bits per second clock, frame marks, even frame marks, 90th frame mark and data gate signals to the other experiments are not interrupted.

A Low Data Rate (530 bits per second) mode is provided. This mode is expected to be used only at those times when MSFN has difficulty extracting the downlink data at normal data rate.

Listed in the following subsections is the range of values to be expected during normal operation for each engineering parameter. The parameters listed are those displayed in Mission Control Center and the values provided are in the units used on the hard copy printed display. Where applicable a nominal value is also stated.

Critical operating conditions as revealed by off-nominal values of the engineering telemetry are discussed in detail under Operational Constraints and Limitations (Section 4).

1 C	2 C	3 C	4 SS	5 Me	6 SS	7	8 SS
9 SLx	10 SS	11 SLy	12 SS	13 SLz	14 SS	15	16 SS
17 Mx	18 SS	19 My	20 SS	21 Mz	22 SS	23 HF	24 SS
25 SLx	26 SS	27 SLy	28 SS	29 SLz	30 SS	31	32 SS
33 E	34 SS	35 STx / STz	36 SS	37 STy / ST	38 SS	39	40 SS
41 SLx	42 SS	43 SLy	44 SS	45 SLz	46 CV	47	48 SS
49 Mx	50 SS	51 My	52 SS	53 Mz	54 SS	55	56
57 SLx	58 SS	59 SLy	60 SS	61 SLz	62 SS	63	64 SS

	Legend	Parameter	
	C	Control	
	CV	Command Verification	
	E	General Engineering	
	HF	Heat Flow	
	Me	Magnetometer engineering	
	Mx	X-axis	Magnetometer science
	My	Y-axis	Magnetometer science
	Mz	Z-axis	Magnetometer science
	SLx	X-axis	Long Period Seismic
	SLy	Y-axis	Long Period Seismic
	SLz	Z-axis	Long Period Seismic
	SS	Short Period (Z-axis) Seismic	
Even Frames only	STx	X-axis	Tidal Seismic
Even Frames only	STy	Y-axis	Tidal Seismic
Odd Frames only	STz	Z-axis	Tidal Seismic
Odd Frames only	ST	Seismometer Temperature	

Figure 3.0 Word Assignments in Normal Mode Data Frame

TABLE 3.0

SUMMARY OF MEASURED PARAMETERS

Equipment	MEASURED PARAMETERS		
		Engineering	
	Science	Word 33	Other Words
Normal Data Rate Mode			
Central Station (Incl. RTG)	--	67	--
PSE	7	8	1
ASE	--	4	--
LSM	3	--	24
HFE	64	6	4
Array D	74	85	29
High Data Rate Mode			
Central Station (Incl. RTG)	--	4	
ASE	3	11	

NOTE: Measurements provided in Low Data Rate mode are the same as in Normal Data Rate mode, except LSM data is invalid.

3.1 DEPLOYMENT OPERATIONS

The first lunar surface operations for ALSEP entail removal of the equipment from the Lunar Module and transfer to the deployment site by the Apollo crew. These activities, as scheduled, will take 2 hours and include the tasks listed in Table 3.1-1. The detailed sequence of deployment activities for each crewman will be found in the Apollo 16 Lunar Surface Procedures.

During traverse and deployment of Subpack 2 the crew must be aware of the temperatures of equipment stowed around the RTG. These temperatures are indicated by Tempilabels located as listed in Table 3.1-2. To ensure proper performance of the equipment certain deployment aids are provided to assist in leveling and algnment. The criteria for proper deployment are detailed in the following sections.

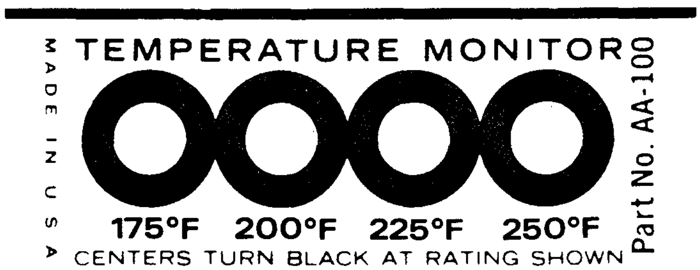
TABLE 3.1-1

ALSEP DEPLOYMENT ACTIVITIES BY FLIGHT CREW

Commander Activities	Lunar Module Pilot Activities
Offload ALSEP	
	Open SEQ Bay Doors Offload ALSEP Packages Fuel RTG
Offload Drill	Configure ALSEP For Traverse Close SEQ Bay Doors
ALSEP Traverse	
Drive LRV to ALSEP site	Walk to ALSEP site with ALSEP in barbell configuration
ALSEP System Interconnect	
Connect RTG to Central Station	Connect HFE to Central Station Deploy HFE
Deploy PSE Offload ASE Deploy LSM	. Set up Drill . Implant Drill Stem #1 . Insert Probe #1
Erect Central Station Activate Central Station	. Implant Drill Stem #2 . Insert Probe #2 . Align Electronics
Deploy Geophones	Deploy Geophone Flag/Anchors
Conduct Thumper Experiment	Deploy Mortar Pallet
Deploy Mortar Package	

TABLE 3.1-2

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.

Equipment Item	Tempilabel Location
Subpackage #2 Pallet	Bottom
Dome Removal Tool	Center of Handle
Fuel Transfer Tool	Forward of Flange
Carry Bar	Near the Subpackage End of Each Section (2 labels)
Universal Handling Tools (2)	One on Each Side of the Handle (2 labels)
RTG Cable Reel	Top
Antenna Gimbal Container	(a) Top (b) Side (Facing RTG)
ASE Pallet	(a) Stowage Cover (b) Pallet Rib
HFE Subpallet	Handle
Heat Flow Experiment	Connector

3.1.1 Array D Deployment

The crew shall select an area which is approximately 300 feet (E-W) by 100 feet (N-S) located more than 300 feet west of LM. (See Figure 2-4). Since all equipment uses sun compasses for alignment, the site must not be shaded from the Sun.

The area shall be generally level and free from craters (comparable in size to the instruments) particularly in those areas where equipment is to be placed.

At the equipment locations the area shall be free from boulders and debris which might significantly restrict the view of space as seen by the thermal control surfaces.

The general arrangement of equipment shall be as shown in Figure 2-4.

3.1.2 Central Station Deployment

The Central Station shall be placed at the eastern edge of the deployment site more than 300 feet west of LM with the open (carry handle) side of the station facing south. The site should be approximately horizontal since nothing should restrict the view of space seen by the thermal control surfaces.

3.1.2.1 Central Station Leveling

While the sunshield is still down in stowed position, the station shall be leveled to within 5° as indicated by the level bubble being free of the case circle (see Figure 3.1-1).

3.1.2.2 Central Station Alignment

The astronaut shall align the Central Station to assure proper thermal control. This is done by positioning the Central Station so that the alignment mark on the "S" compass rose is covered by the gnomon shadow within 5 degrees. (See Figure 3.1-1.)

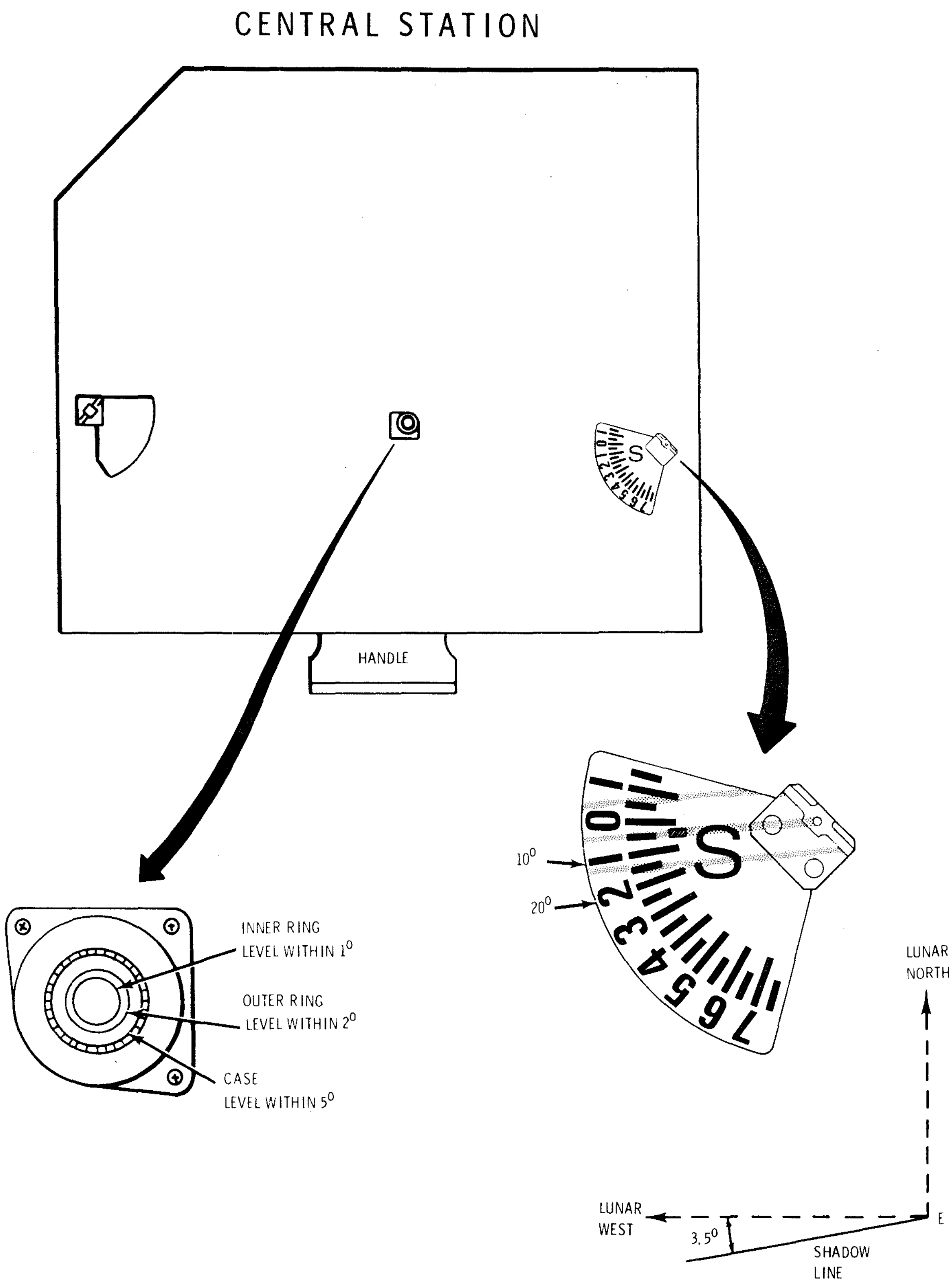


Figure 3.1-1 Central Station Level and Alignment Indicators

3.1.3 Central Station Antenna Deployment

While still in its stowage container, the antenna aiming mechanism shall be mounted on the mast with the arrow pointed toward the Sun. This ensures that the alignment shadow graph is on the east side of the mechanism.

3.1.3.1 Antenna Azimuth Setting: The coarse azimuth dial on the antenna aiming mechanism will be indicating approximately 18 when the mechanism is first mounted on the mast. The crew will turn the azimuth-setting knob (Figure 3.1-2) counterclockwise until simultaneously

(a) the index mark on the coarse scale lies between 24 and 25, and

(b) the index mark on the fine scale indicates 68.

These settings are time-dependent and apply only at nominal deployment times. Refer to Section 4.1 fcr azimuth dial settings at other than nominal times.

3.1.3.2 Antenna Elevation Setting: The coarse elevation dial will be indicating approximately 13 when the mechanism is first mounted on the mast. The crew will turn the elevation-setting knob (Figure 3.1-2) counterclockwise until simultaneously

(a) the index mark on the coarse scale lies between 16 and 17, and

(b) the index mark on the fine scale indicates 59.

3.1.3.3 Antenna Leveling: The mechanism shall be leveled to within 0.5° by adjusting the two leveling screws until the bubble on the level indicator is free of the case circle. (See Figure 3.1-2.)

3.1.3.4 Antenna Alignment: The mechanism shall be aligned relative to the Sun's shadow by turning the shadow adjust knob (Figure 3.1-2) until the post shadow covers the alignment decal within 0.5 degree.

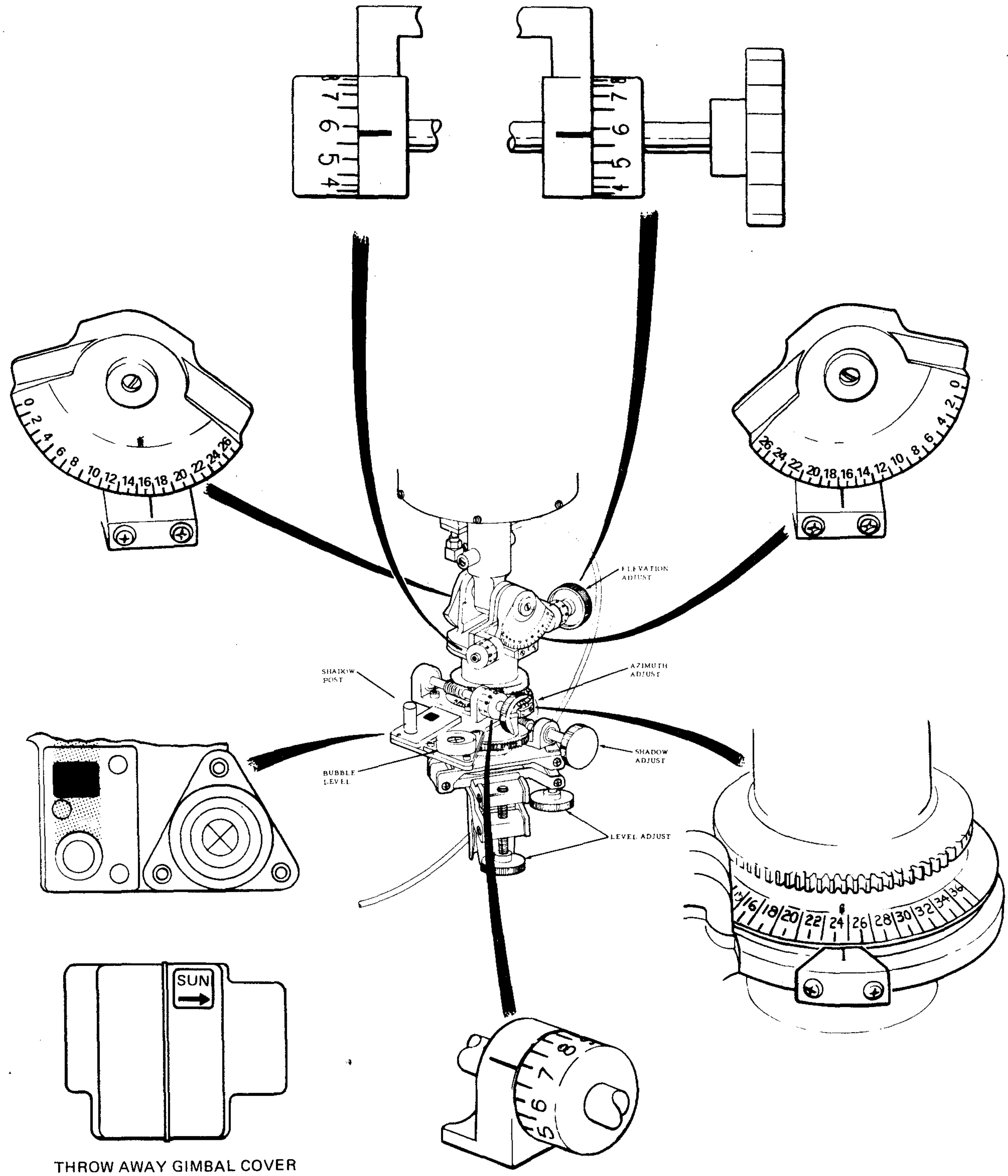


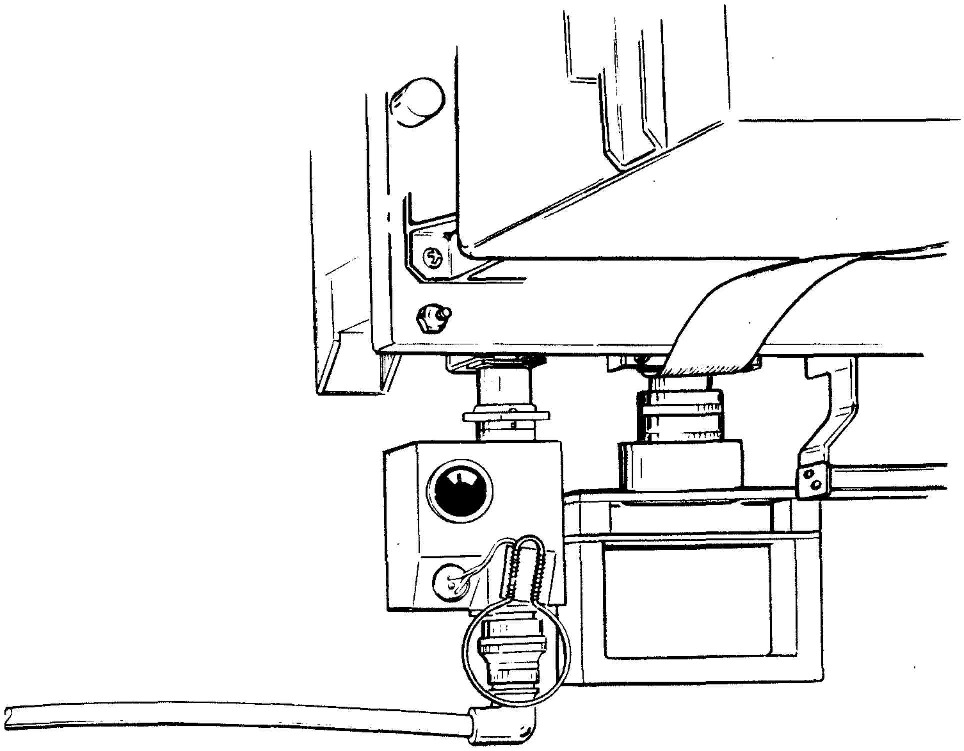
Figure 3.1-2 Antenna Level and Alignment Indicators

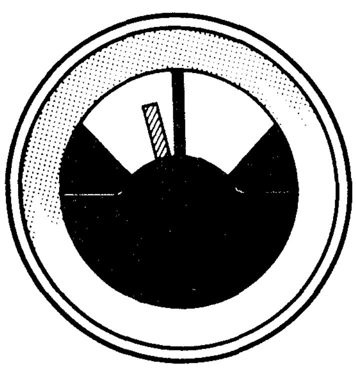
3.1.4 Radioisotope Thermoelectric Generator Deployment

Subpackage 2 shall be placed 9 to 12 feet (limited by a 13-foot cable) west or northwest of the Central Station in a relatively flat area. No part of the RTG shall be within the field of view of the open (south) side of the Central Station. Adequate separation shall be maintained between the RTG and the Central Station to avoid contact of RTG by the crew during station deployment.

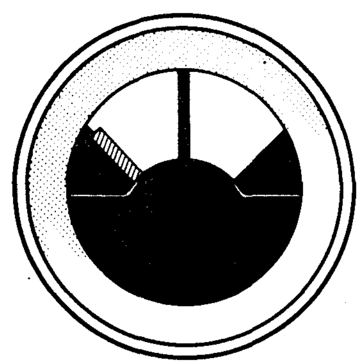
3.1.4.1 RTG Leveling and Alignment: There are no leveling and alignment constraints on the RTG but the cable exit from Subpackage 2 should be toward the Central Station.

3.1.4.2 RTG Electrical Initiation: After pulling the shorting switch lanyard, the astronaut will read ammeter (see Figure 3.1-3) on Shorting Switch Box to confirm a value greater than zero. After connecting the RTG to the Central Station, the meter will be read 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.





a. Nominal Configuration: 1^{st} & 2^{nd} Reading (RTG Short-circuited)



b. Nominal Configuration: 3^{rd} Reading (RTG Short Removed)

Figure 3.1-3 RTG Current Indicator

3.1.5 Passive Seismic Experiment Deployment

The PSE sensor shall be located 8 to 9 feet directly east of the Central Station as limited by the 10-foot cable. The surface shall be contoured and compacted to ensure that the bottom of the emplaced sensor does not contact the surface. The cable shall be untwisted and lie flat on the surface under the deployed thermal shroud.

3.1.5.1 PSE Alignment: Before removing the PSE girdle, the sensor will be aligned with the arrow(Figure 3.1-4) pointing toward the Sun within 20 degrees. When the girdle is removed, the crew shall verify that the gnomon deploys properly.

3.1.5.2 PSE Leveling: The PSE sensor, after the shroud is deployed, shall be manually leveled within 5 degrees. (5 degrees is the limit of the automatic leveling gimbal). The bubble should be free of the case circle for the sensor to be level within 5 degrees (see Figure 3.1-4).

3.1.5.3 PSE Deployment Recording: When leveling and alignment are complete, the crew shall report the compass rose reading to within 1 degree and take a photograph showing the position of the gnomon shadow on the compass rose.

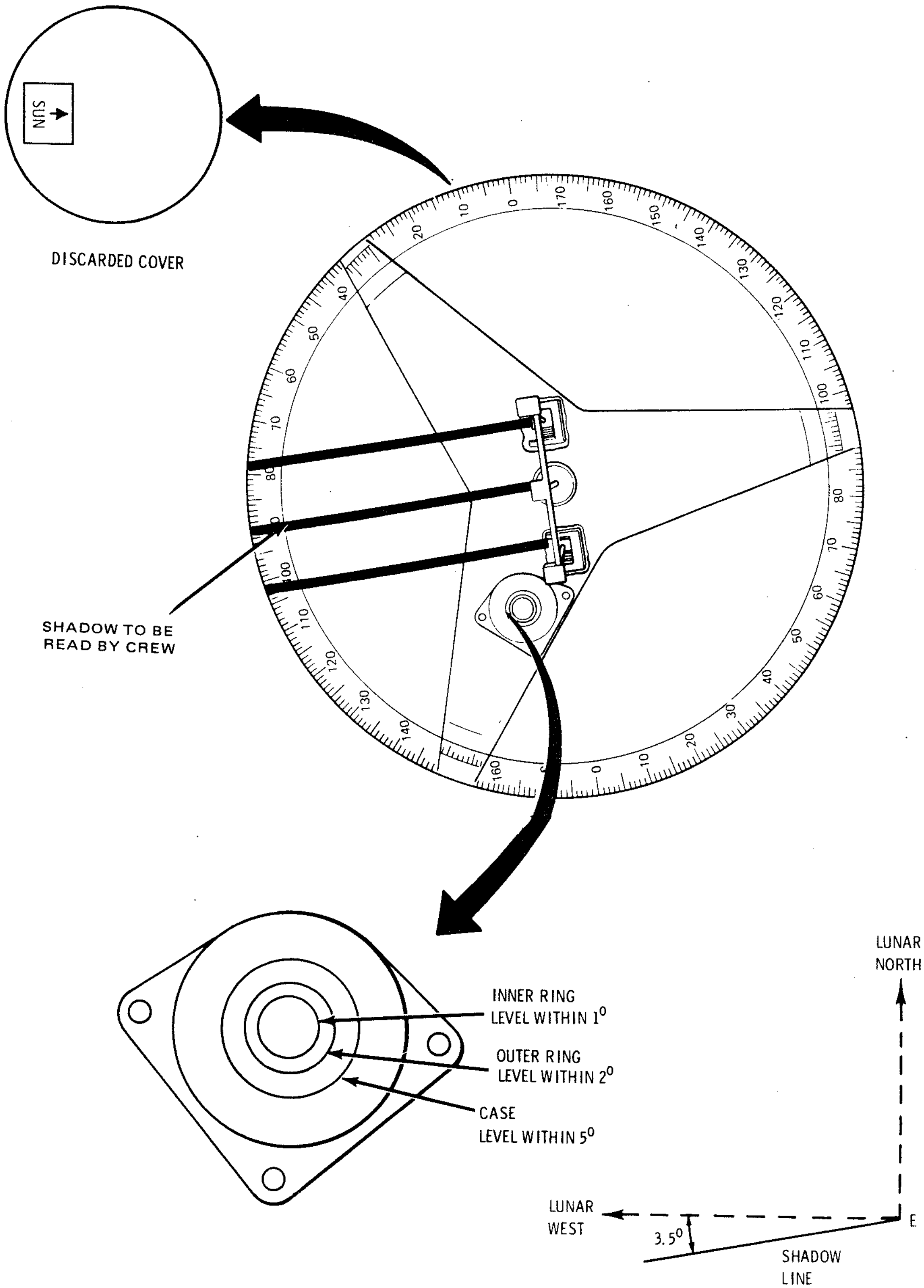


Figure 3.1-4 PSE Level and Alignment Indicators

3.1.6 Active Seismic Experiment Deployment

The geophone cable shall be deployed and the flag and flag/ anchors emplaced as shown in Figure 2-4. The terrain over which the cable is laid shall be free from obstacles which interfere with geophone placement or thumper actuation.

During the operation of the Thumper, the impact plate shall be placed firmly on the surface within 1 foot of the location identified on the geophone cable by the 3" long, white markers.

The Mortar Package pallet shall be deployed on a suitable level area at least 40 feet north of the Central Station. It must be emplaced so that maximum coupling between the pallet and soil is achieved and that all four stakes are completely embedded to their full length (7 inches).

The Mortar Package when mounted on the pallet shall be configured as shown in Figure 2-6. Before leaving the ALSEP deployment site for the last time, the crew shall remove the safety rods and ARM the Mortar Package.

3.1.6.1 ASE Alignment: The three ASE Geophones shall be emplaced within 3° of a line drawn down-sun from the flag/anchor located north of the Central Station. They shall be emplanted in the soil with the spike vertical within 7 degrees. (The sensitive element of the geophone may not operate at angles greater than 15° off vertical.)

The firing direction of the Mortar Package shall be parallel (within 5°) to the line of geophones. This alignment shall be determined by initial placement of the pallet (without stakes deployed) on the surface east of geophone 1 with the alignment arrow on the pallet pointing away from the geophones and visually aligned with the "best fit" line designated by the flags at the geophone deployment sites. An intersection of the UHT shadow with the compass rose on the pallet (see Figure 3.1-5) defines the proper pallet alignment. When the pallet is finally emplaced (more than 40 feet north of the Central Station) it shall be aligned with stakes deployed, so that the shadow position on the compass rose is the same as observed during the alignment test. The bubble level on the pallet is provided to help reduce alignment errors due to pallet tilt.

3.1.6.2 ASE Leveling: After mounting the Mortar Package to the Pallet, the assembly shall be leveled to within 5 degrees as indicated by the bubble level on the Mortar Package (see Figure 3.1-5).

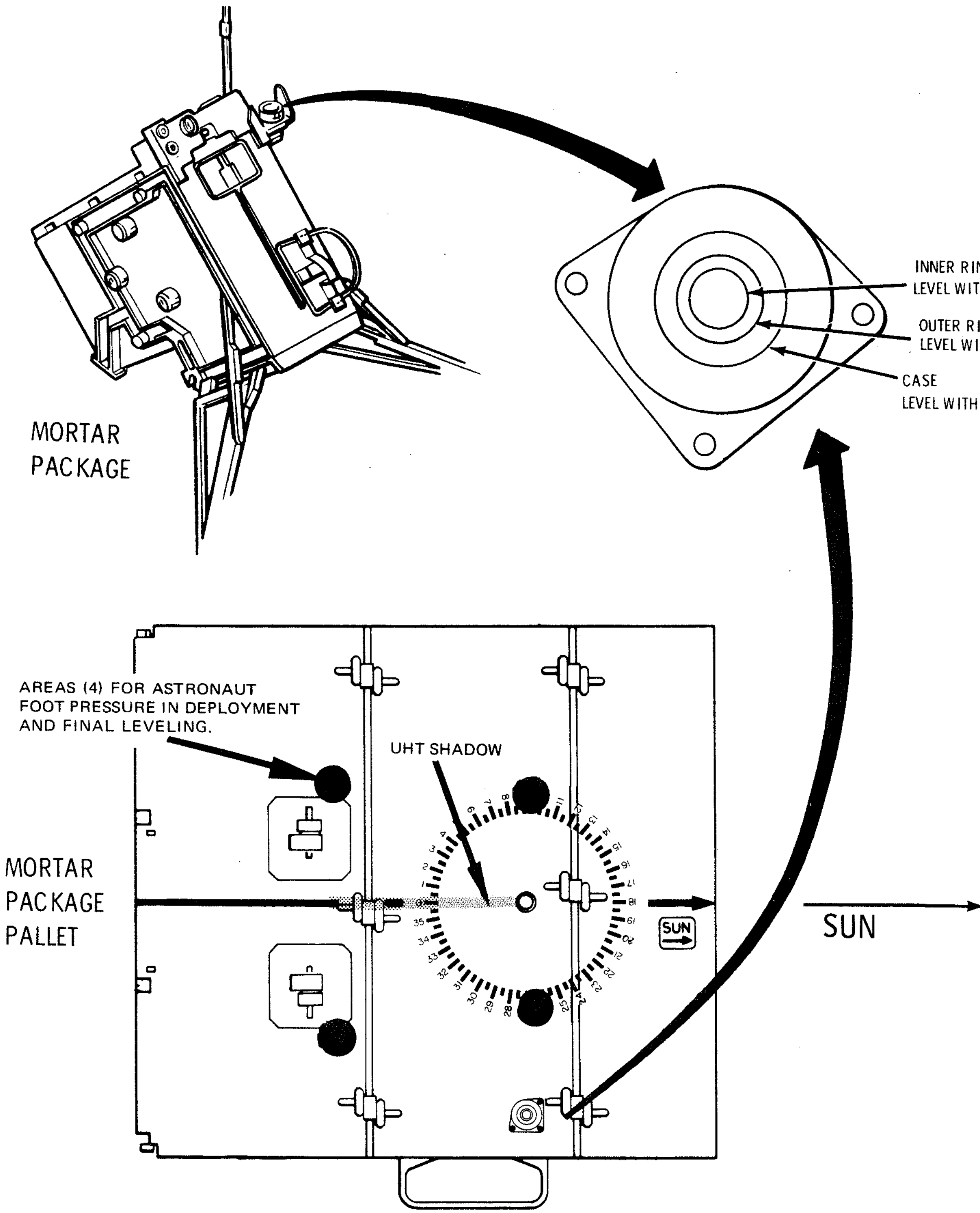


Figure 3.1-5 ASE Level and Alignment Indicators

3.1.7 Lunar Surface Magnetometer Deployment

The LSM shall be deployed 45 to 50 feet from the Central Station as limited by the 55-foot cable. It shall be located approximately west-southwest from the Central Station on a level spot free from debris. The thermal curtain shall not be deployed until the LSM is properly aligned and leveled.

3.1.7.1 LSM Alignment: The crew shall deploy the shadowgraph alignment aid, ensuring that it is tilted to the proper angle. The LSM shall be properly aligned when the shadow dot lies within 3 degrees of the zero-degree position shown in Figure 3.1-6.

3.1.7.2 LSM Leveling: The LSM level is adjusted by using the UHT to rotate the leveling screw located near each mounting leg (see Figure 3.1-6). Proper level (within 3° of horizontal) is attained when the bubble of the level indicator is free of the case circle.

3.1.7.3 LSM Deployment Recording: When leveling and alignment are complete, the crew shall report the location on the shadow dot on the shadow graph and take a close-up photograph of the shadow graph.

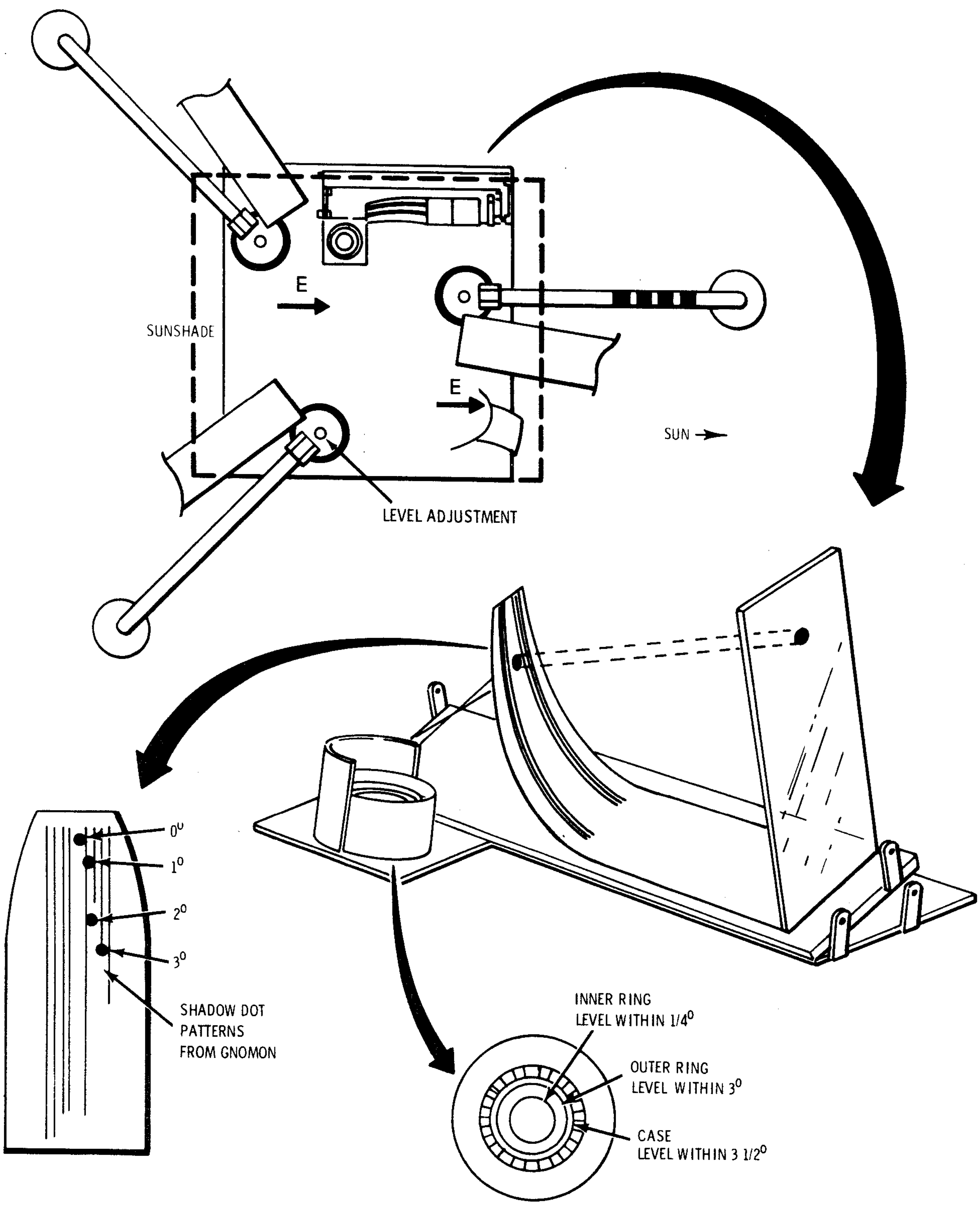


Figure 3.1-6 LSM Level and Alignment Indicators

3.1.8 Heat Flow Experiment Deployment

The HFE electronics shall be placed 25 to 30 feet south of the Central Station (as limited by the 30-foot cable) in an area generally flat and free from debris, particularly on the south (thermal radiator) side of the unit. It is important that the cups from the mounting Boyd bolts not be left on the thermal radiator.

The HFE probes shall be placed in holes 16 to 18 feet from the electronics at locations as shown in Figure 3.1-7. It is important that the probes be located at least 17 feet from all other equipment (including debris). Probes 1 and 2 are to be emplaced on a line through the electronics unit which is parallel with the local shadow direction at the time of deployment. Probe 1 is that probe stored with the emplacement tool in the packet identified with the red diamond. The probe cables should not be crossed. When the probes have been emplaced in the bore stems, it is necessary to insure that the black section of each of the probe cables, indicating the location of a thermocouple, is oriented north of the bore stems. Deployment along a north-south line will result in a nearly time invariant direct solar flux on the thermocouple during the lunar day, so that the heat balance is more clearly defined. As a consequence, a more accurate calculation of lunar surface brightness temperatures during the lunar day will be possible.

Deployment to the north of the borestem, for a site in southerly latitudes, i.e., Descartes, removes the possibility of shading of the thermocouple by the borestem and uppermost radiation shield. The reflected energy from the radiation shield is also avoided. Thus the solar flux and total energy input during the lunar day is more easily defined.

3.1.8.1 HFE Alignment: The thermal radiator (open side) of the HFE electronics shall be deployed facing south (away from the Central Station). The unit is properly aligned when the shadow of the UHT (mounted in its socket) falls across the alignment decal (see Figure 3.1-7). This alignment decal indicates the shadow position if this unit is deployed at the nominal time in the EVA 1 sequence. For alignment at non-nominal times see Section 4.1.

3.1.8.2 HFE Leveling: HFE electronics shall be leveled within 5° of horizontal by ensuring that the bubble in the level indicator (Figure 3.1-7) is free of the case circle.

The holes in which the probes are inserted shall be vertical to within 15° as determined visually by the crew during the drilling operations.

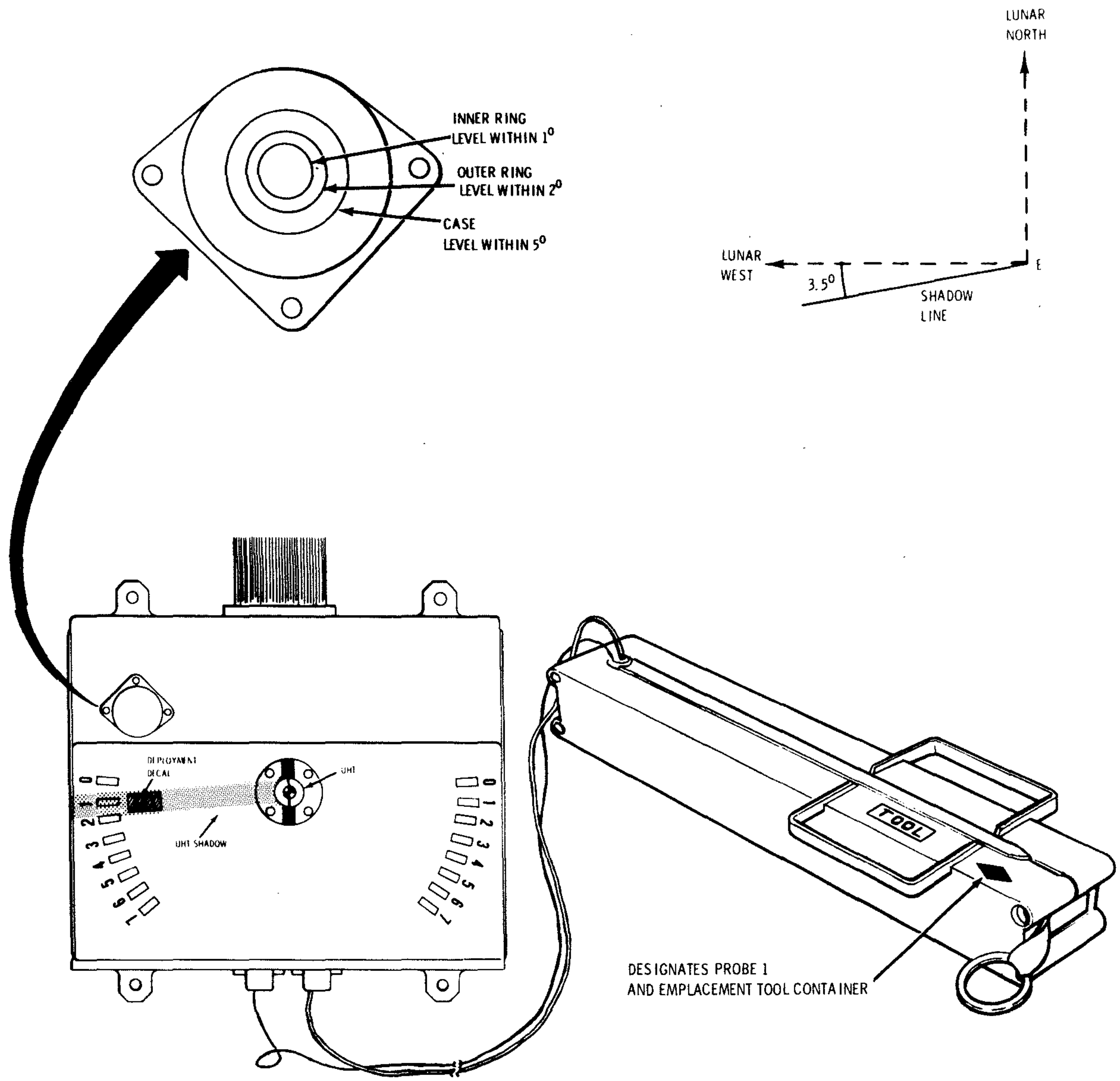


Figure 3.1-7 HFE Level and Alignment Indicators

3.1.9 Solar Wind Composition (SWC) Deployment

Although it is not one of the ALSEP experiments, the SWC is briefly described here because it is part of the science experiments complement to be deployed on the lunar surface at the time of Apollo 16 ALSEP Array D deployment. The SWC will be deployed to determine the elemental and isotopic composition of the noble gases and other selected elements in the solar wind by measuring entrapped particles on an exposed aluminum foil sheet.

The SWC hardware consists of a metallic telescopic pole approximately 4 cm in diameter and 38 cm in length when collapsed. In the stowed position, the foil is enclosed in the tubing and rolled up on a spring-driven reel. The instrument weighs 430 g. When extended on the lunar surface, the pole is approximately 1.5 meters long; a 30 cm by 130 cm foil area will be exposed. Only the foil assembly will be recovered at the end of the last EVA; it will be rolled up on the spring-driven reel, placed in a Teflon bag and returned to earth. The reel handle is color coded to give the exact angular position of the reel and the portion of foil rolled around it. Detailed analyses of this portion of the foil are expected to yield the angular distribution of the arriving solar-wind ions.

The Solar Wind Composition (SWC) experiment shall be deployed as shown in Figure 2-9, from 60 to 100 feet from the LM. This distance should prevent dust due to crew activities or the residue of gases vented from the LM from settling on the aluminum foil. The site should be upstream of the LM, relative to the solar wind.

The SWC foil sheet will be unfurled and placed in a vertical position on its staff so that the plane of the foil is perpendicular to the solar rays. Foil should be deployed as soon as possible and retrieved as late as possible within the limitations of the EVA timelines in order to provide maximum exposure to the solar wind on the lunar surface. After return to earth, a spectrometric analysis of the particles entrapped in the foil allows quantitative determination of the helium, neon, argon, krypton, and xenon composition of the solar wind.

Accurate times must be recorded for foil deployment and retrieval in order to arrive at exposure time. Photographs of the deployed experiment are required to determine exact foil orientation in relation to the sun.

3.1.10 Cosmic Ray Detector Deployment

Although it is not one of the ALSEP experiments, the Cosmic Ray Detector is briefly described here because it is part of the science experiments complement to be deployed on the lunar surface at the time of Apollo 16 ALSEP Array D deployment.

The Cosmic Ray experiment is designed to measure, at the lunar surface, the flux, energy, spectrum, and the isotopic and charge distribution of solar cosmic rays heavier than helium, especially the abundant elements from carbon to iron, in the energy range up to 100 Mev/nucleon.

The instrument package consists of four types of detector material mounted on a panel: lexan polycarbonate plastics, aluminum foil, feldspar and pyroxene crystals, and mica sheets. This panel, which is bolted to the side of the LM, is exposed by the crew during the lunar stay time. At the end of the lunar surface mission the panel is returned to earth for detailed analysis.

The Cosmic Ray Detector shall be deployed as shown in Figure 2-10. To achieve maximum lunar surface exposure, the detector array should be activated as soon as possible by pulling the red ring and lanyard. However, this should not be done while the RTG is still in the vicinity of the LM. Exposure of the neutron detector portion of the experiment to the radiation from the RTG would degrade the data.

Detector panels are sensitive to dust. If dust accretion proves to be excessive, dusting or early retrieval of the detector array may be required. The astronaut should report on the amount of dust on the exposed panel surfaces at the time he activates the experiment. Photos of the array taken before and after activation will also aid in the determination of dust accretion.

The red-line limit for the actual temperature of the Lexan plastic sheets is 130°F. Above this temperature, the plastic will tend to fuse and degrade the scientific data. Figures 3.1-8 through 3.1-12 illustrate the increase in temperature with varying sun angles (lunar stay time), dust coverage and LM pitch angles.

On the left and right sides of the panel assembly are temperature indicators which will be viewed and reported to MCC by the astronaut when he activates experiment, a second time during EVA 2, preferably early in the EVA, and finally during retrieval of the experiment. If the temperature indicators are in the shade, this should be reported. These two temperature indicators include three spots each which sucessively turn black when 120°F, 130°F and 140°F are reached. However, a black 140-degree spot is not a red-line limit.

Prior to the end of the final EVA, the astronaut will release the detector assembly from its mounting frame by pulling the white ring and lanyard. After moving the assembly to the MESA, the astronaut will release the individual detector panels by pulling the blue ring and lanyard. The panels will be removed from the frame, folded and placed in a stowage bag. The panels must be protected against dust during the retrieval procedure.

When the panels are stowed in the stowage bag, the astronaut will report to MCC the readings of six temperature indicators whose locations and temperature-indicating spots are as follows:

a) Front, left side of panel #2. 120°, 130°, 140°F.

b) Front, right side of panel #2. 120°, 130°, 140°F.

c) Stowage bag. 120°, 140°, 160°, 180°F.

d) Back of Panel #1. 120°, 140°, 160°, 180°F.

e) Back of Panel #4. 120°, 140°, 160°, 180°F.

f) Back of Panel #4. 120°, 160°, 200°, 240°, 280°, 320°, 360°, 400°F.

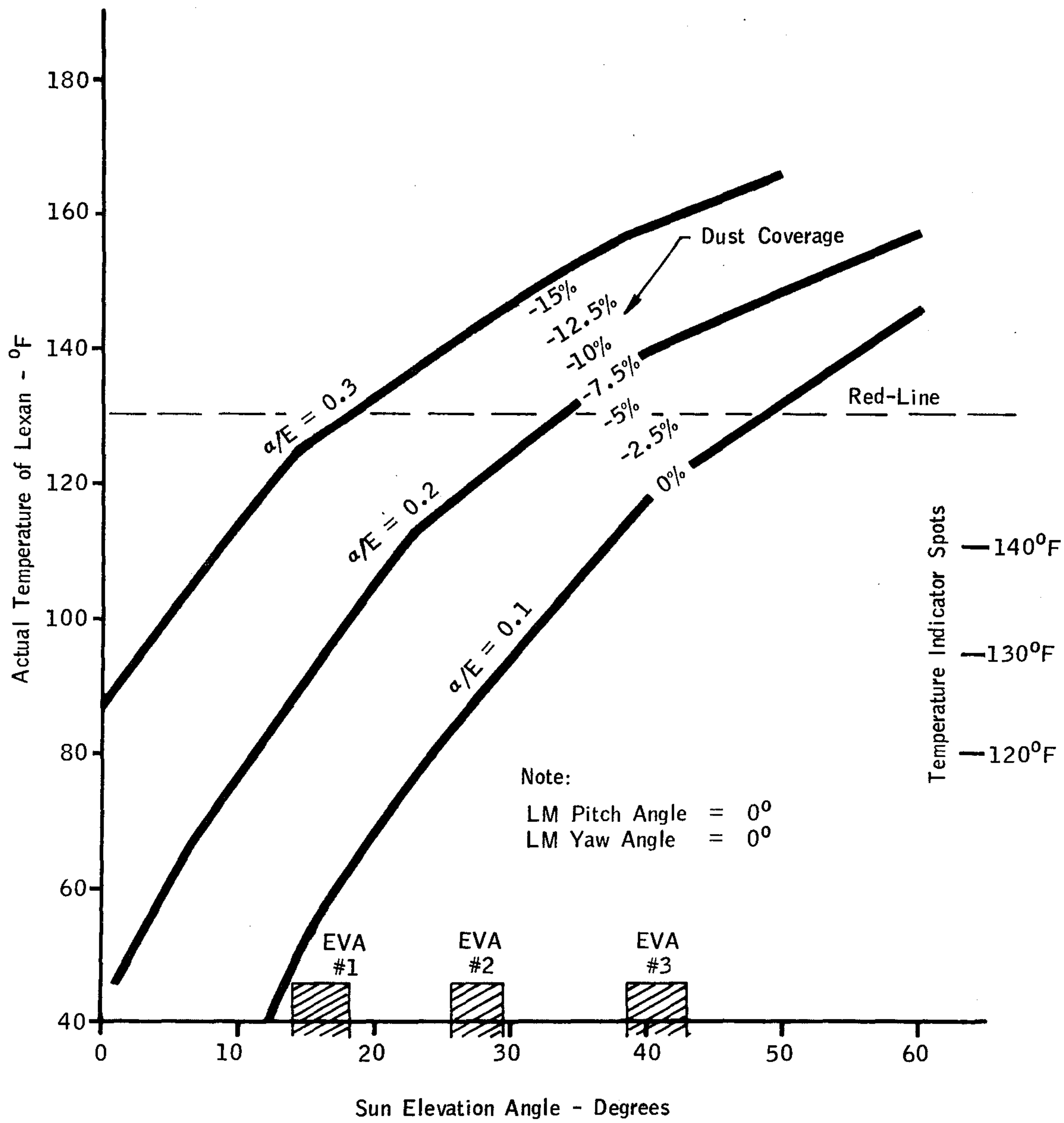


Figure 3.1-8 Cosmic Ray Detector Temperature Excursions at LM Pitch Angle of 0°

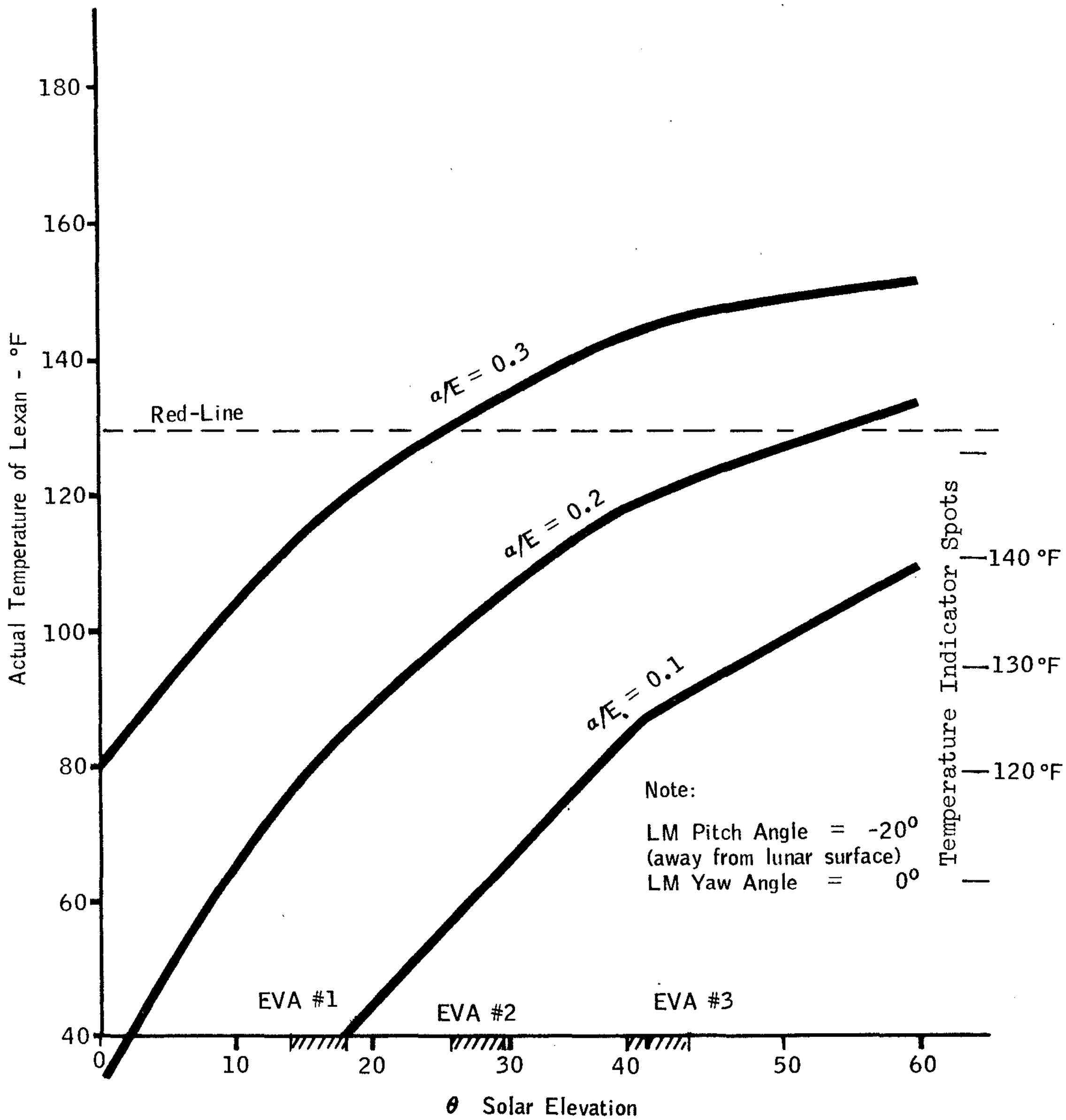


Figure 3.1-9 Cosmic Ray Detector Temperature Excursions at LM Pitch Angle of -20°

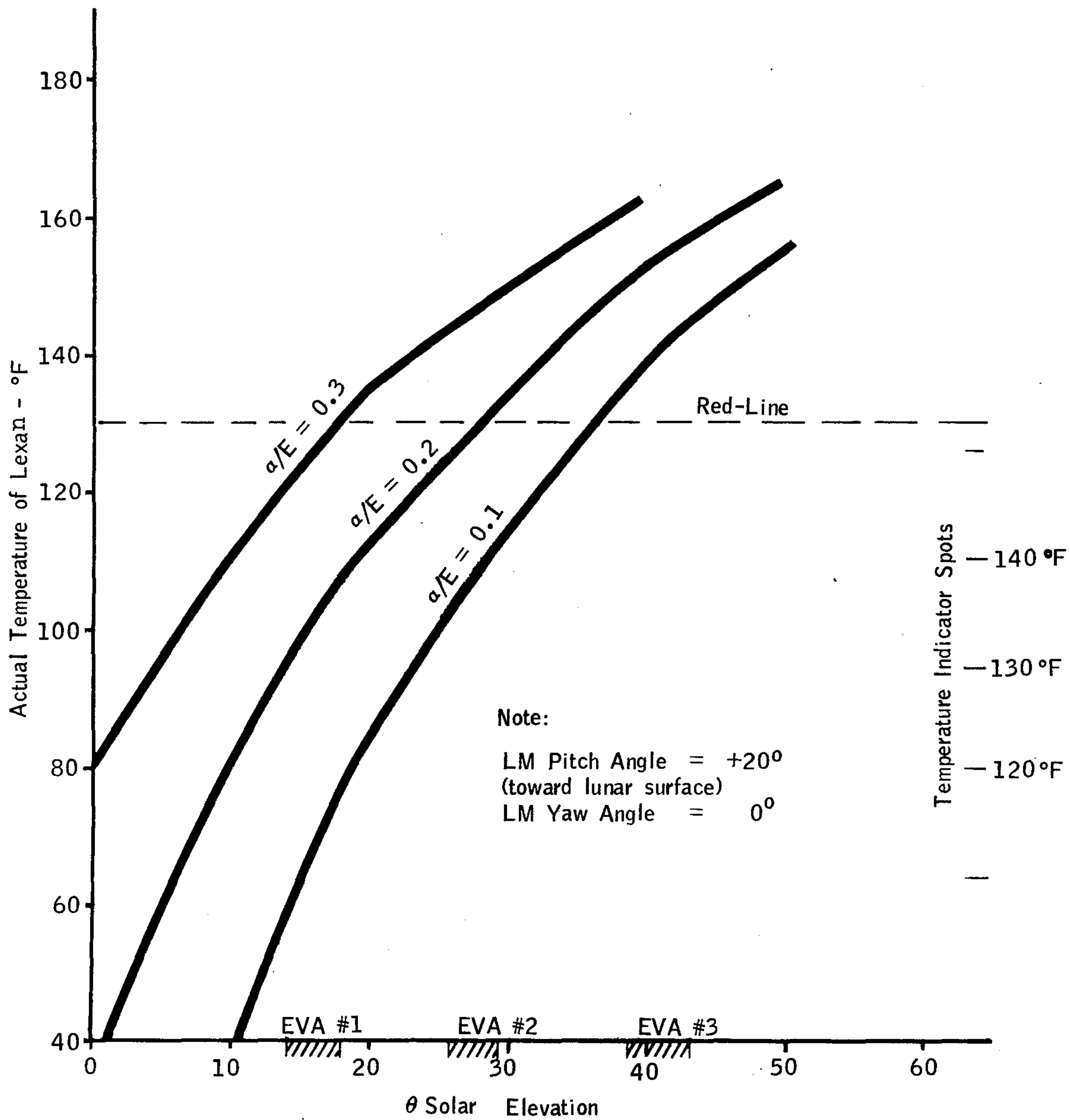


Figure 3.1-10 Cosmic Ray Detector Temperature Excursions at LM Pitch Angle of +20°

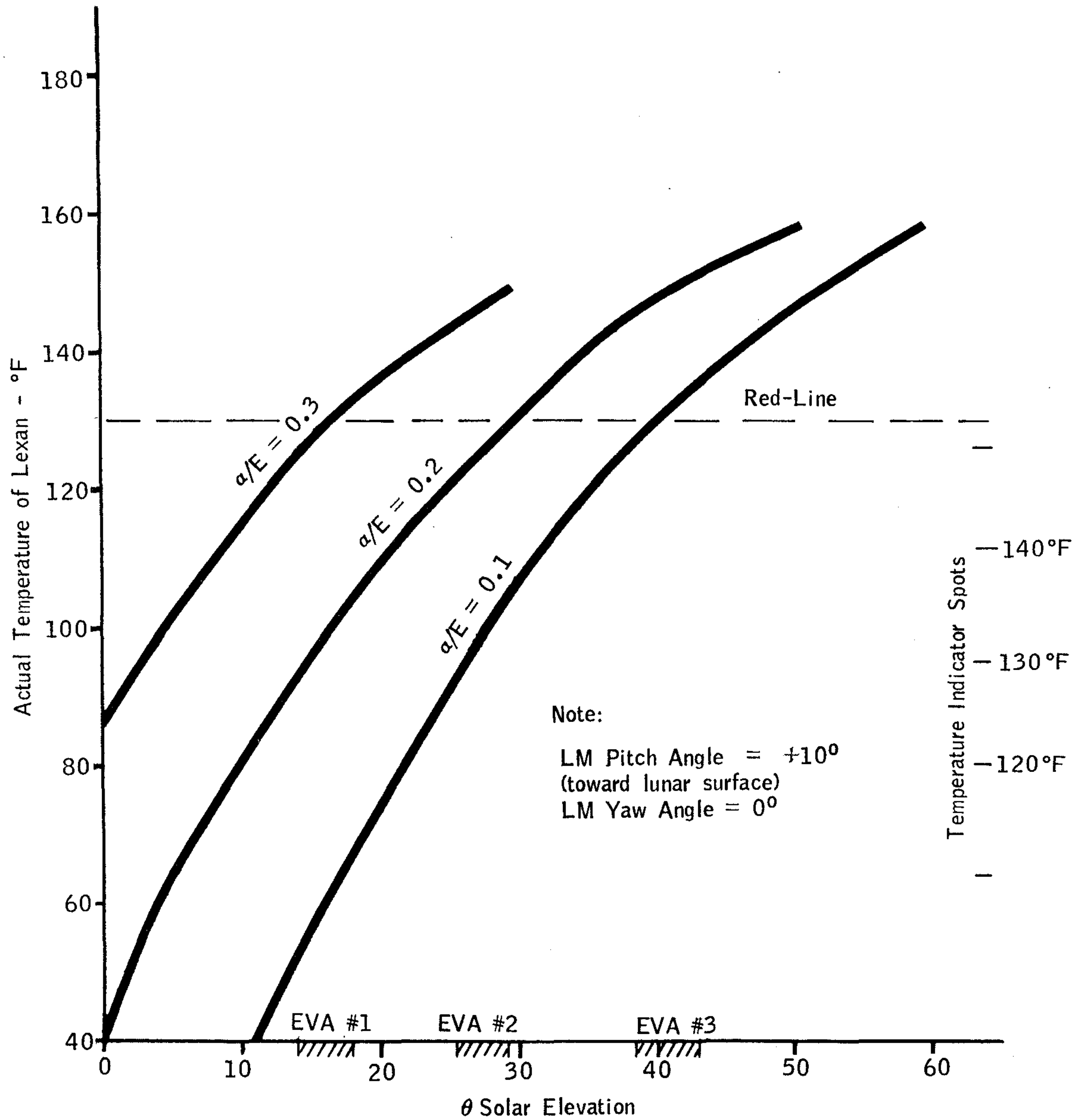


Figure 3.1-11 Cosmic Ray Detector Temperature Excursions at LM Pitch Angle of +10°

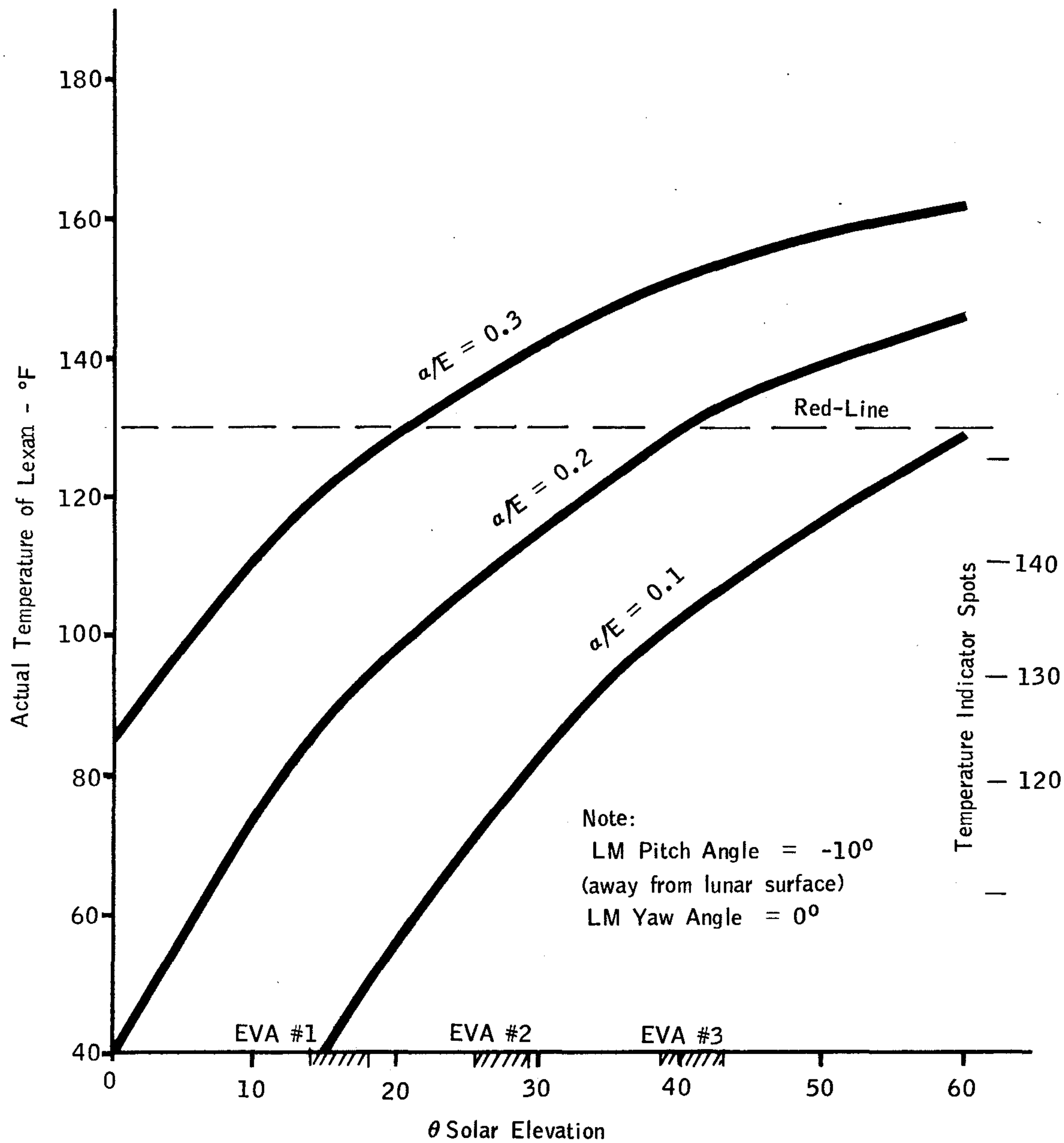


Figure 3.1-12 Cosmic Ray Detector Temperature Excursions at LM Pitch Angle of -10°

3.1.11 Lunar Portable Magnetometer (LPM) Deployment

Although it is not one of the ALSEP experiments, the LPM is briefly described here because it is part of the science experiments complement to be deployed on the lunar surface at the time of Apollo 16 ALSEP Array D deployment. The deployed configuration of the LPM is shown in Figure 2-11.

The LPM will be utilized to obtain more scientific data concerning the lunar magnetic field to aid in the determination of the location, strength and dimensions of local magnetic sources. The hardware for the LPM consists of three orthogonal, fluxgate, magnetic sensors in a sensor assembly to be deployed on a tripod and an electronics package containing three digital readouts, one each for the X, Y, and Z axis. The sensor assembly and the electronics package are connected by a 50-foot, flat, ribbon cable. The tripod includes a shadowgraph and bubble level for sensor alignment.

The LPM shall be deployed by first removing the hardware from Quad III of the LM and placing it in its assigned transport position on the LRV. The astronaut will observe and report to MCC the readings of the temperature labels on the LPM electronics box. These readings should confirm that the thermal integrity of the experiment has been maintained during the outbound flight. This indicator, located between the two switches on the top of the box, includes four spots which successively turn black when temperatures of 100°, 125°, 150° and 175°F are reached. Note that 175°F is not a red-line limit.

To reduce magnetic interference, the LPM must be deployed a minimum of 250 feet from the LM and 50 feet from the LRV, PLSS and other deployed equipment. The LPM shall never be placed closer than 2 feet (1 gauss) to the Lunar Surface Ultraviolet Camera which contains a very strong magnet.

3.1.11.1 LPM Site Point Measurements

One set of site point measurements will be taken at a spot in the general landing area, properly situated away from the LM and other equipment. In this procedure, X, Y, and Z axis readings are taken in each of three orthogonal orientations of the sensor, identified as positions 1, 2, and 3. MCC will record all readings as they are reported by the astronaut.

Site point measurements will be made by the astronaut as follows:

a) Deploy the LPM on the LRV a minimum of 250 feet away from the LM.

b) Flip the Power switch on the electronics box to the On position.

c) Carry the sensor assembly, mounted in the #1 position on the tripod, approximately 50 feet away from the electronics box mounted on the LRV. A 6-inch white stripe on the 50-foot ribbon cable indicates that approximately 47 feet of cable has been unreeled. Level the sensor on the tripod within five degrees using the bubble level. Align the sensor within three degrees of the sun line using the shadowgraph. Report bubble level and shadowgraph readings to MCC.

d) Return to the LPM electronics box on the LRV. Wait 60 seconds for the instrument to stabilize. Flip the Display switch to the Read position.

e) Read and report to MCC the values on the X, Y, and Z digital displays sequentially. Flip the Display switch Off and then flip it immediately back to the Read position.

f) Repeat the meter reading and reporting procedures in step e) two more times to obtain an average of the instantaneous samples.

After completion of the measurement procedures in position #1, two more sets of readings will be made. The second set of readings requires that the sensor be rotated 180 degrees from top to bottom, to the #2 position. The third set of readings requires that the sensor be rotated 180 degrees from front to back, to the #3 position. At sensor positions #2 and #3, procedures d) e), and f) will be repeated. If any realignment or releveling is required, it must be reported to MCC. When the site point measurement procedures have been accomplished, both the Display switch and Power switch will be turned Off. Then the sensor, tripod and reeled-up cable will be returned to the LRV and stowed for transport. The sensor will remain in position #3 for all subsequent traverse measurements.

3.1.11.2 LPM Traverse Measurements

At least four traverse measurements are required to define the magnetic field relationships in the area of the Apollo 16 Descartes landing site. These traverse measurements will be made at different locations during one or more of the geological traverses.

The LRV will be used to transport the LPM to the traverse measurement locations. The electronics box will remain mounted on the LRV while the astronaut deploys the sensor assembly and tripod approximately 50 feet from the LRV.

The procedures for each traverse measurement are as follows:

a) Flip the Power switch on the electronics box to the On position.

b) Deploy the sensor assembly, mounted in the #3 position on the tripod, approximately 50 feet away from the LRV. Level the sensor on the tripod within five degrees using the bubble level. Align the sensor within three degrees of the sun line using the shadowgraph. Report bubble level and shadowgraph readings to MCC.

c) Return to the LPM electronics box on the LRV. Wait 60 seconds for the instrument to stabilize. Flip the Display switch to the Read position.

d) Read and report to MCC the values on the X, Y, and Z digital displays sequentially. Flip the Display switch off and then flip it immediately back to the Read position.

e) Repeat the meter reading and reporting procedures in step d) two more times to obtain an average of the instantaneous samples.

X-, Y-, and Z- axis sensor readings will be taken by the astronaut, transmitted over the voice channel, and recorded by MCC. The astronaut will also photograph each site point and sensor head location to allow the PI to accurately establish the physical location of the several sets of magnetic field measurements.

The sensor assembly, tripod, and reeled cable will be returned to the LRV and stowed, except that after the final measurement, the readings of the temperature monitor on the electronics box will be reported and the magnetometer will be turned off and left on the lunar surface.

At the last stop where the LPM is to be operated, the astronaut will first take readings in the normal manner and then perform a special test. The astronaut will collect and document a lunar sample of igneous rock with a mass of 1 to 3 kilograms and place this rock on top of the sensor. Then a second set of readings will be taken with the rock atop the sensor. This arrangement should be photographed before the rock is retrieved for return to earth.

The PI will provide real-time support at the MCC to assess the magnitude and gradient of the magnetic field and to suggest to the geological traverse planning team possible sample selections and traverse measurement locations.

3.1.12 Lunar Surface Ultraviolet Camera Deployment

After the astronaut has opened the protective bag with the two ripcords provided, he will deploy the UV Camera in the shadow of the LM as shown in Figure 2-12. The astronaut will unfold the three legs of the experiment and place the camera near the south edge of the shadow of the LM eight to twelve feet from the +Z foot pad. The LSUC must be leveled within two degrees then oriented so that the camera aperture points down sun; then the azimuth circle will be adjusted to read zero. The LSUC must remain within the shadow of the LM throughout its operation life. More than 20 minutes in sunlight will raise the camera's temperature above 120°F and will ruin the film. Figure 3.1-13 shows the optimum locations for the UV Camera in the shadow of the LM.

The green battery pack will be removed from the camera assembly and placed on the lunar surface in direct sunlight about 10 feet south of the camera itself. The battery pack should be oriented so that the Tempilabel is visible to the astronaut and should remain in direct sunlight for at least the first two-thirds of the lunar-surface stay time. Brief shading by the LM leg struts is acceptable. The eight spots on the Tempilabel will successively turn black at 10-degree intervals from 100°F to 170°F. The astronaut will report the condition of the Tempilabel to MCC during UV Camera deployment and again at the beginning of the third EVA. If five of the spots have turned black, the battery pack must be moved into the shade so that its temperature will not rise above 150°F. However, the battery pack should not be left in the shade more than seven hours maximum to avoid a too-low temperature.

There is a second Tempilabel affixed to the film transport box. This 8-spot indicator, identical to the one on the battery pack, will be monitored after the film has been returned to MSC to determine the highest temperature to which the film was subjected during the mission.

The astronaut will unscrew two of the three leveling screws, then use all three while watching the bubble level to level the camera within two degrees. Then the astronaut will release the azimuth release and rotate the camera to point as accurately as possible down sun before resetting the azimuth release. The astronaut will then loosen the azimuth scale lock and rotate the azimuth scale until the zero degree mark is opposite the pointer and reset the azimuth scale lock.

When the UV Camera has been deployed, leveled and aligned, the astronaut will turn the power switch to the On position, point the camera at the first target and verify that the film transport gears advance when power is applied.

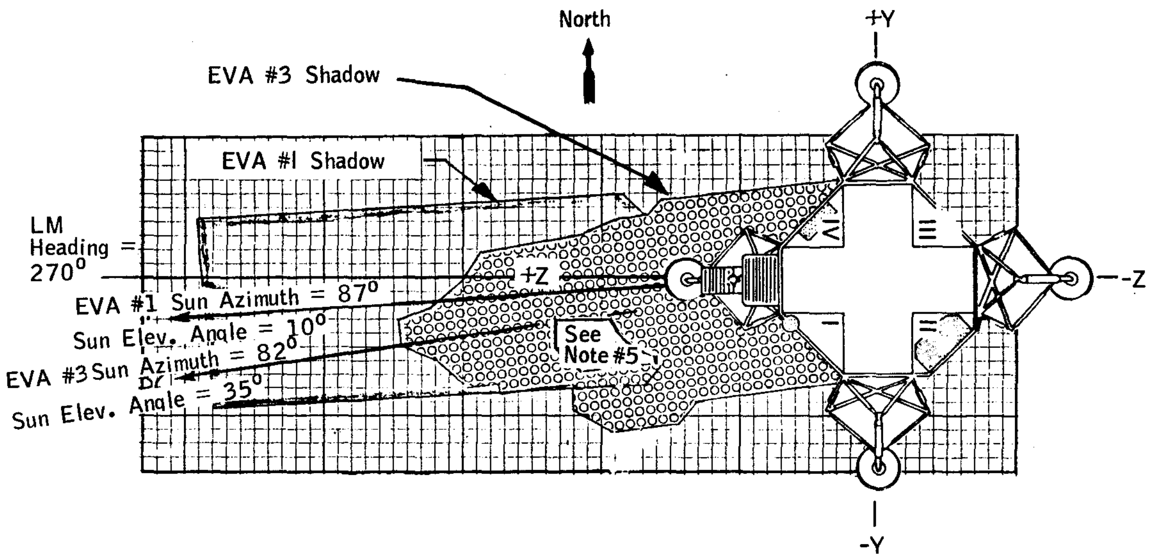
The azimuth (AZ) and elevation (EL) settings for each of the camera's targets are printed on a card attached to the camera. However, each time the camera is to be aimed at a target, the AZ and EL settings will be transmitted by voice from MCC to the astronaut and he will repeat them as settings are made. At specific times defined in the Lunar Surface Procedures document, the astronaut will return to the UV Camera, press the RESET switch, and aim at another target. The astronaut should leave the vicinity of the UV Camera as soon as possible after performing the necessary procedures so that the vented gases from his life support system do not fog the film.

Before aiming the UV Camera at a new target, the astronaut will press the RESET switch to advance the film one frame and start a new exposure sequence. Using the AZ and EL settings for the next target, the astronaut will aim the camera and leave the vicinity after reporting the settings.

The second target is earth, for which three short exposures are highly desirable. After pressing the RESET switch and aiming the camera with AZ and EL circles, the astronaut will look through the tube sight on the left side of the camera, center the earth accurately by adjusting AZ and EL, and report the new settings to MCC. If the new AZ setting differs from that expected, MCC will request the astronaut to change the AZ to predicted setting. This requires loosening the AZ scale lock and setting the prescribed AZ for earth, then re-tightening the AZ scale lock. He then will wait about 30 seconds until he sees the film transport handle move through 90° indicating a mode change and starts counting seconds after the film transport gears advance the film. At 15 seconds he presses RESET and counts to 5 seconds, then presses RESET, waits 1 second and presses RESET again, then leaves the UV Camera. The film advances each time the RESET switch is pressed.

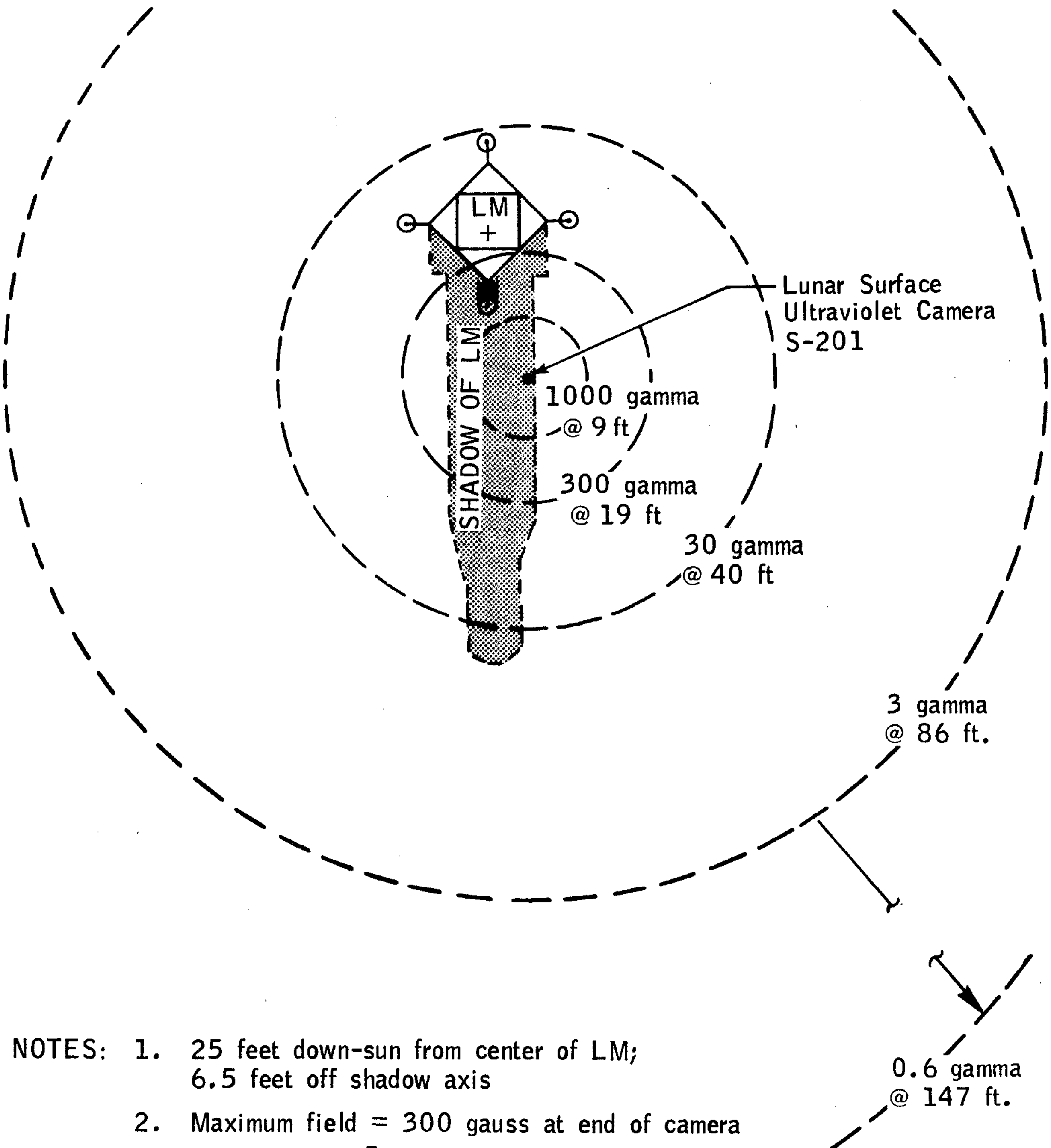
When all targets have been photographed, the astronaut will return to the UV Camera for the last time and immediately press the RESET switch four times to clear the last data film frame out of the film gate. He then will pull a small pip pin on the film transport box, twist the box one-quarter turn clockwise and remove the box from the camera for stowage in the LM. It is highly desirable to avoid getting dust in the film transport box, which will be stored in a beta-cloth bag for LM and CM transport back to earth.

Since all the science data from this experiment is contained on the film, care should be exercised during camera operation, film retrieval, stowage and return to earth to insure the integrity of the film. Figures 3.1-14, 3.1-15 and 3.1-16 illustrate the strong magnetic field associated with the UV Camera.



Notes:
1. Launch at T + 0
2. Nominal LM Landing.
3. Assume No LM Tilt
4. Assume Smooth Lunar Surface
5. Area shown is the envelope of satisfactory locations for the UV Camera, given all constraints

Figure 3.1-13 Optimum Location for UV Camera in LM Shadow



NOTES: 1. 25 feet down-sun from center of LM; 6.5 feet off shadow axis

2. Maximum field = 300 gauss at end of camera

3. 1 gauss = 10^5 gamma

Figure 3.1-14 Magnetic Field of Lunar Surface Ultraviolet Camera

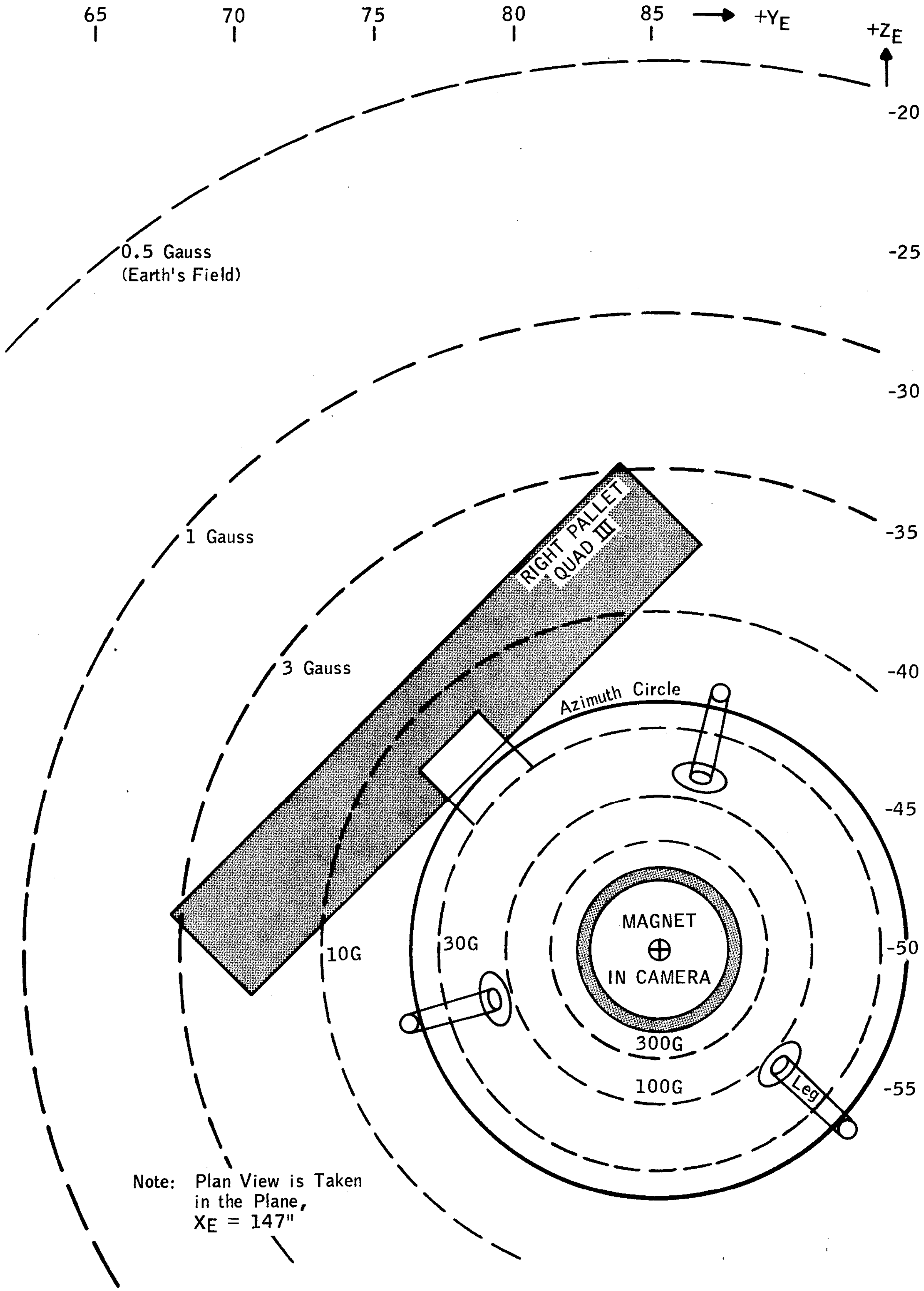


Figure 3.1-15 LSUC Magnetic Field Contours -- Plan View

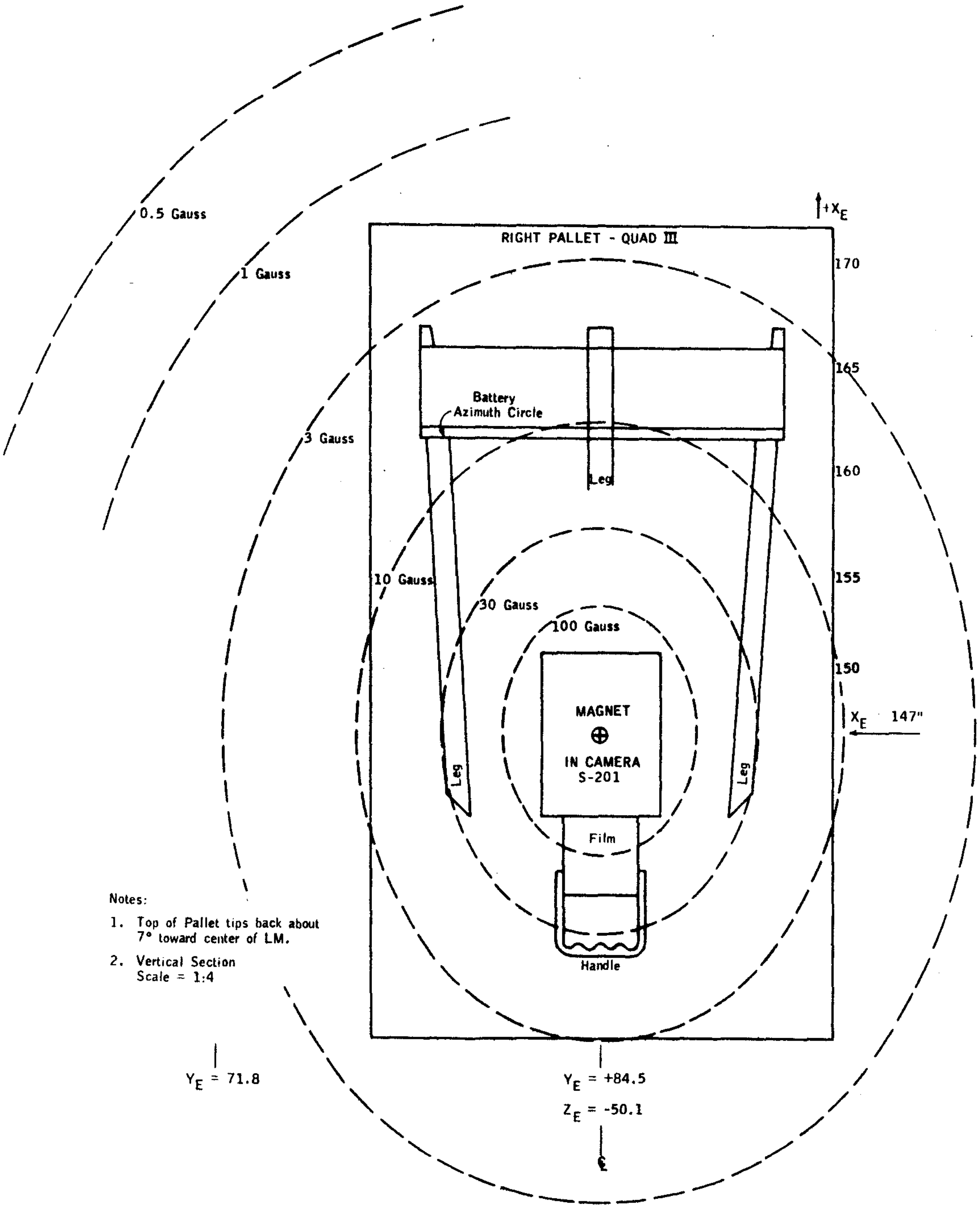


Figure 3.1-16 LSUC MAGNETIC FIELD CONTOURS — VERTICAL SECTION

3.2 CENTRAL STATION OPERATIONAL DATA

When operating in Normal (or Low) Data Rate Mode, sixty-seven engineering sensors provide information on 73 status and performance parameters of the Central Station and the Radioisotope Thermoelectric Generator (RTG). These can be classified as follows:

Central Station

. 13 structure temperatures	(see Table 3.2-1)
. 18 module temperatures	(see Table 3.2-2)
. 23 electrical parameters	(see Table 3.2-3)
. 13 configuration status	(see Table 3.2-5)

Radioisotope Thermoelectric Generator

. 5 Temperatures	(see Table 3.2-4)

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 MSFN receiving station, namely:

- received signal strength
- command verification word content
- downlink carrier frequency

The range of values expected for each analog measurement during normal lunar surface operations is given in Tables 3.2-1 through 3.2-4. When operating in High Data Rate Mode, 4 of these engineering measurements are selected for display. These parameters are listed in Table 3.2-6.

TABLE 3.2-1

STRUCTURAL TEMPERATURE DATA

Meas. No.	Frame	Description	Normal Oper. Range (°F)		Nominal Refce Fig.	Red-Line Limits (°F) (1)	
			Low	High		Low	High
AT-1	27	Sunshield (Top Side)	-300	+160	3.2-1	-360 (M)	+304 (M)
AT-2	42	Sunshield (Under Side)	-300	+160	3.2-1	-360 (M)	+304 (M)
AT-3	4	Thermal Plate (No. 1)	16	116	3.2-2	-10 (T) -40 (M)	+140 (T) +205 (M)
AT-4	28	Thermal Plate (No. 2)	12	113	3.2-2	-10 (T) -40 (M)	+140 (T) +205 (M)
AT-5	43	Thermal Plate (No. 3)	7	127	3.2-2	-10 (T) -40 (M)	+140 (T) +205 (M)
AT-6	58	Thermal Plate (No. 4)	17	133	3.2-2	-10 (T) -40 (M)	+140 (T) +205 (M)
AT-7	71	Thermal Plate (No. 5)	23	122	3.2-2	-10 (T) -40 (M)	+140 (T) +205 (M)
AT-8	59	West Side Structure	-210	+200	3.2-3	-360 (M)	+304 (M)
AT-9	87	East Side Structure	-210	+200	3.2-3	-360 (M)	+304 (M)
AT-10	15	Bottom Structure	-210	+160	3.2-4	-360 (M)	+304 (M)
AT-11	88	Power Dump Module	-215	+270	3.2-5	-360 (M)	+304 (M)
AT-12	60	Insulation (Inner)	-12	+115	3.2-2	-360 (M)	+304 (M)
AT-13	72	Insulation (Outer)	-160	+150	3.2-3	-360 (M)	+304 (M)

Note 1: Red-Line Limit Legend: (M) Measurement Limit, (T) Test Limit.
See Section 4.3

TABLE 3.2-2(a)

ELECTRONIC MODULE TEMPERATURE DATA

Meas. No.	Frame	Description	Normal Oper. Range (°F)		Nominal (Ref$\underline{ce}$ Fig.)	Red-Line Limits (°F)(1)	
			Low	High		Low	High
AT-23	18	Transmitter A Crystal	+10	+135	3.2-2	-10 (T) -44 (M)	+158 (T) +186 (M)
AT-24	19	Transmitter A Heat Sink	+10	+135	3.2-2	-10 (T) -44 (M)	+158 (T) +186 (M)
AT-25	31	Transmitter B Crystal	+10	+135	3.2-2	-10 (T) -44 (M)	+158 (T) +186 (M)
AT-26	32	Transmitter B Heat Sink	+10	+135	3.2-2	-10 (T) -44 (M)	+158 (T) +186 (M)
AT-27	33	Analog Data Processor (Base)	0	+125	3.2-2	-10 (T) -40 (M)	+158 (T) +205 (M)
AT-28	34	Analog Data Processor (Internal)	0	+150	3.2-2	-10 (T) -40 (M)	+170 (T) +205 (M)
AT-29	46	Digital Data Processor (Base)	0	+125	3.2-2	-10 (T) -40 (M)	+158 (T) +205 (M)
AT-30	47	Digital Data Processor (Internal)	+5	+135	3.2-2	-10 (T) -40 (M)	+170 (T) +205 (M)
AT-31	48	Command Decoder (Base)	0	+125	3.2-2	-10 (T) -40 (M)	+158 (T) +205 (M)

Note 1: Red-Line Limit Legend: (M) Measurement Limit, (T) Test Limit.
See Section 4.3.

TABLE 3.2-2(b)

ELECTRONIC MODULE TEMPERATURE DATA

Meas. No.	Frame	Description	Normal Oper. Range (°F)		Nominal (Refce Fig.)	Red-Line Limits (°F) (1)	
			Low	High		Low	High
AT-32	49	Command Decoder (Internal)	0	+125	3.2-2	-10 (T) -40 (M)	+160 (T) +205 (M)
AT-33	61	Command Demodulator	+5	+130	3.2-2	-10 (T) -40 (M)	+160 (T) +205 (M)
AT-34	62	Power Distr. Unit (Base)	0	+130	3.2-2	-10 (T) -40 (M)	+158 (T) +205 (M)
AT-35	63	Power Distr. Unit (Internal)	+35	+155	3.2-2*	-10 (T) -40 (M)	+160 (T) +205 (M)
AT-36	64	PCU 1 (Oscillator)	+10	+145	3.2-2*	-10 (T) -40 (M)	+158 (T) +205 (M)
AT-37	76	PCU 2 (Oscillator)	+10	+145	3.2-2*	-10 (T) -40 (M)	+158 (T) +205 (M)
AT-38	77	PCU 1 (Regulator)	+10	+180	3.2-2**	-10 (T) -40 (M)	+190 (T) +205 (M)
AT-39	78	PCU 2 (Regulator)	+10	+180	3.2-2**	-10 (T) -40 (M)	+190 (T) +205 (M)
AT-40	16	Receiver (Case)	0	+125	3.2-2	-10 (T) -221 (M)	+130 (T) +355 (M)

Note 1: Red-Line Limit Legend: (M) Measurement Limit, (T) Test Limit. See Section 4.3.

* Add 30°F to Value in Figure 3.2-2.

** Add 60°F to Value in Figure 3.2-2.

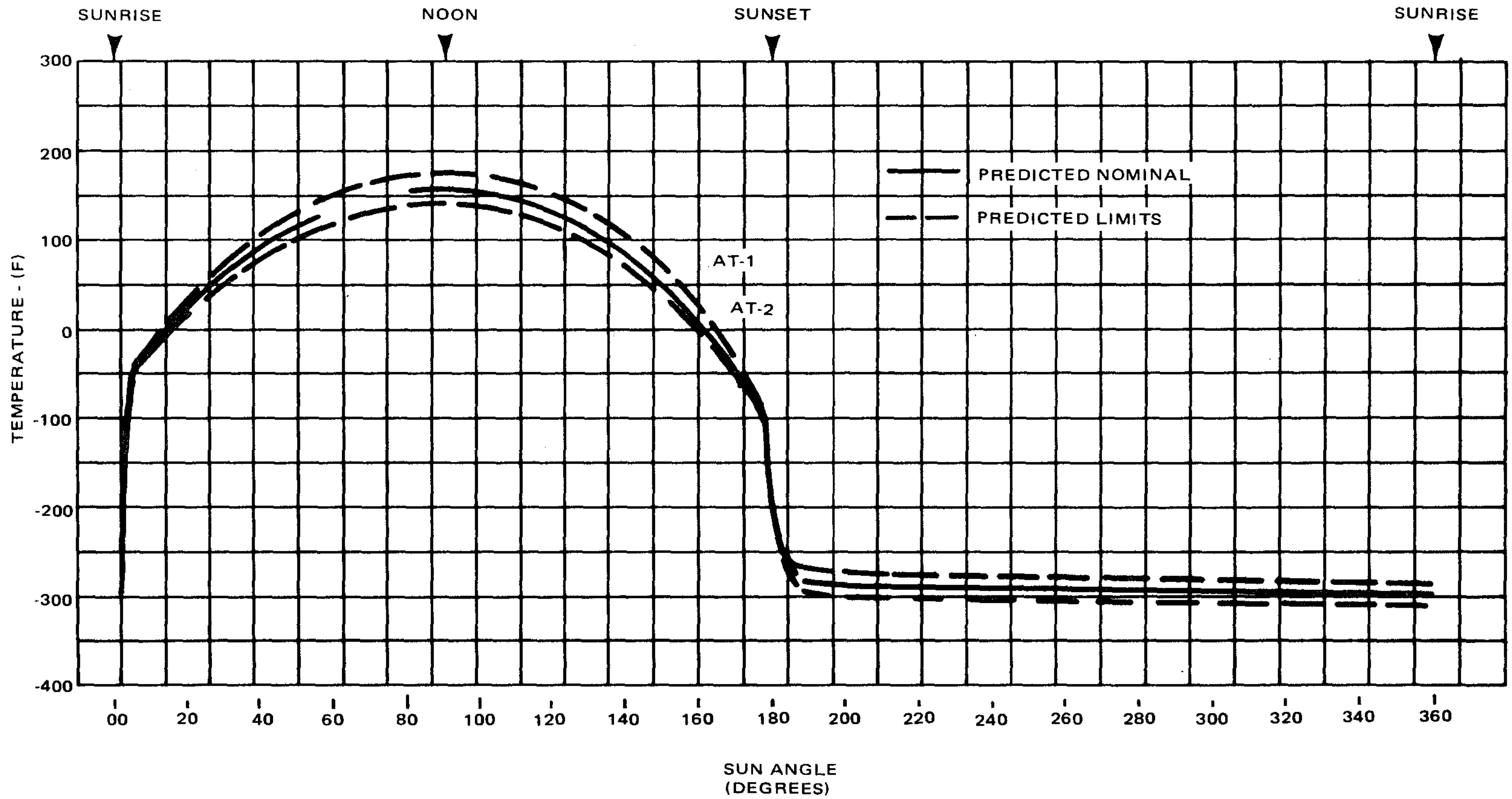


Figure 3.2-1 Normal Sunshield Temperatures

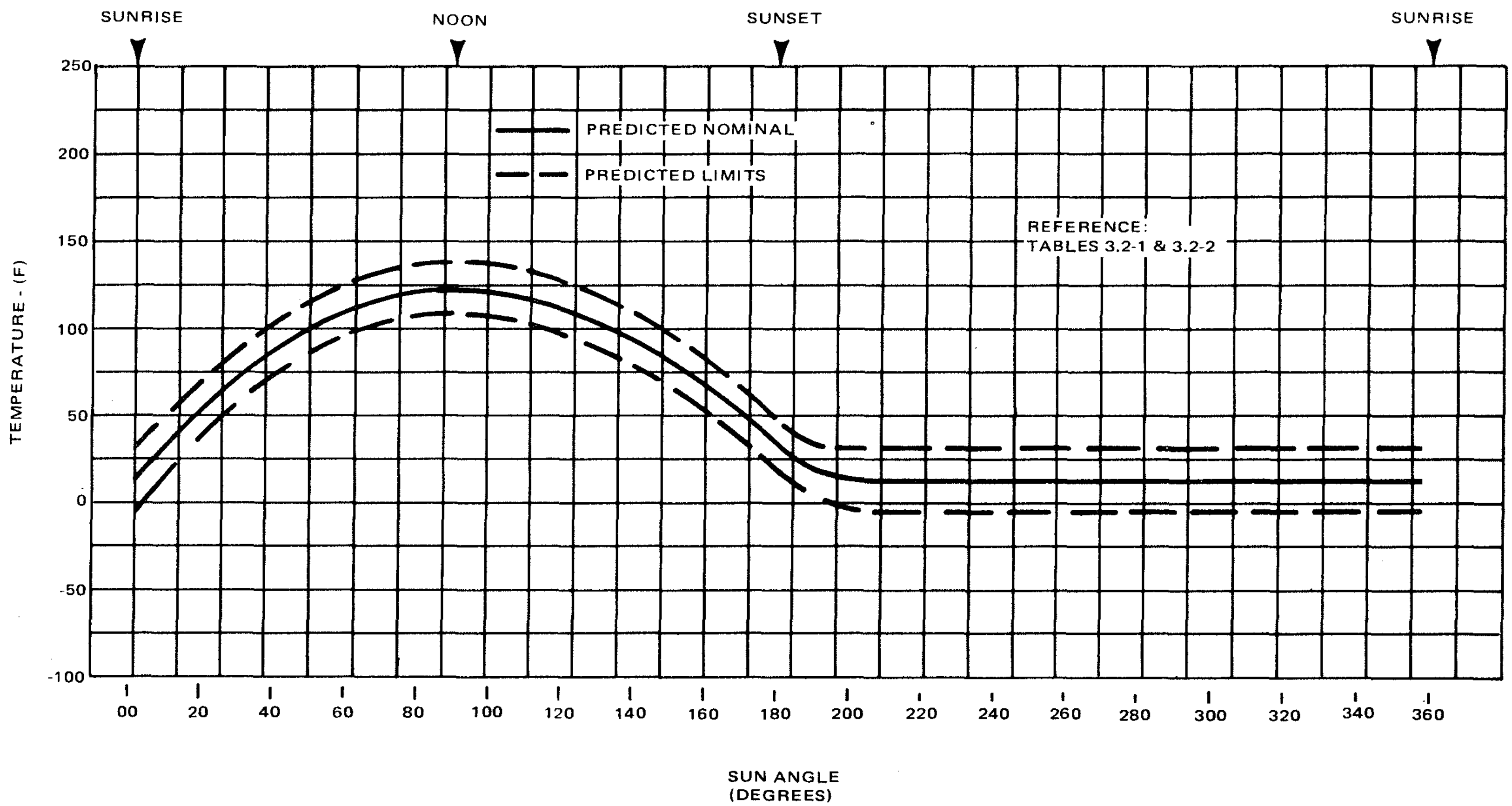


Figure 3.2-2 Normal Thermal Plate Temperatures

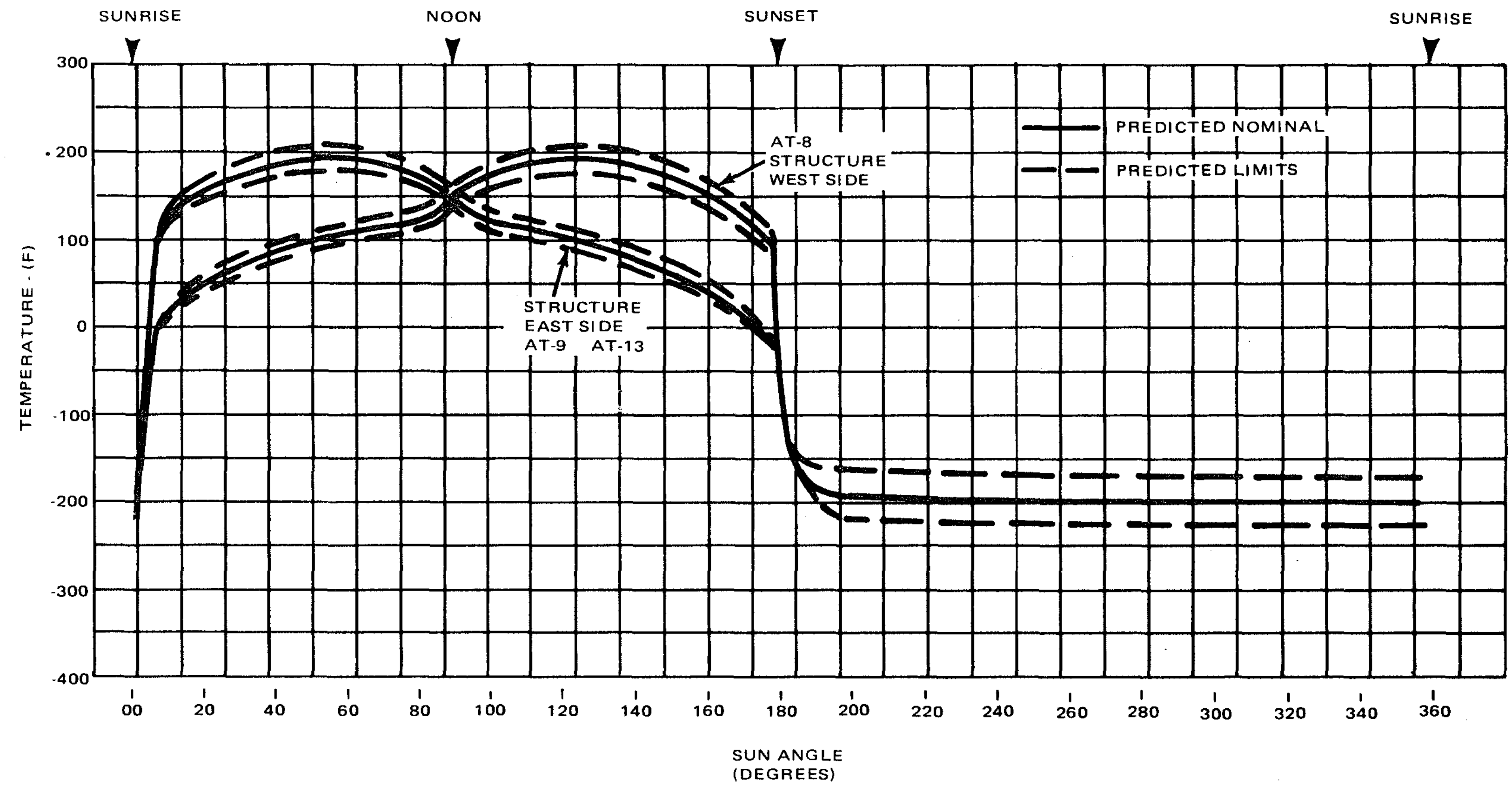


Figure 3.2-3 Normal Primary Structure Side Temperatures

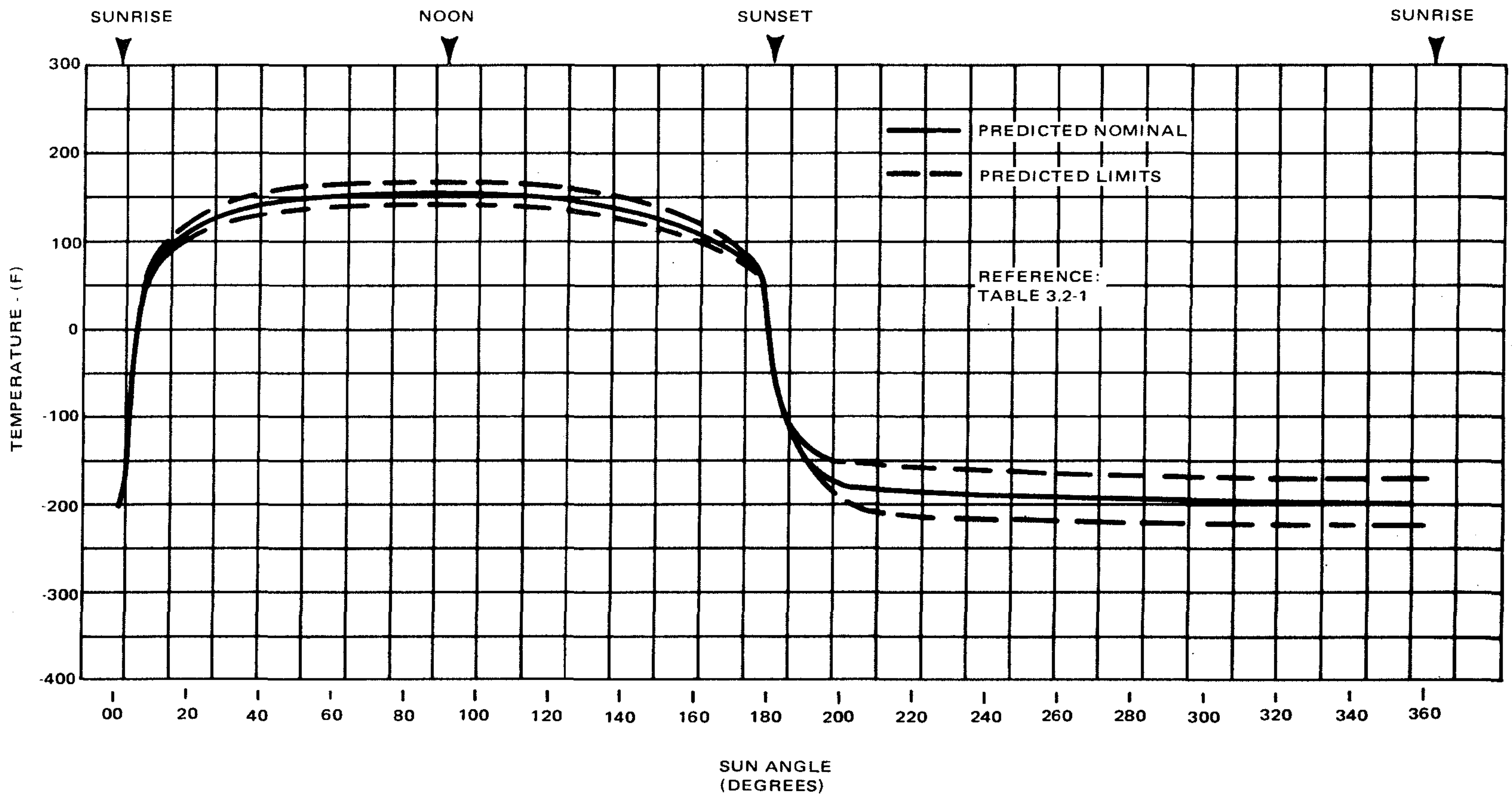


Figure 3.2-4 Normal Primary Structure Bottom Temperatures

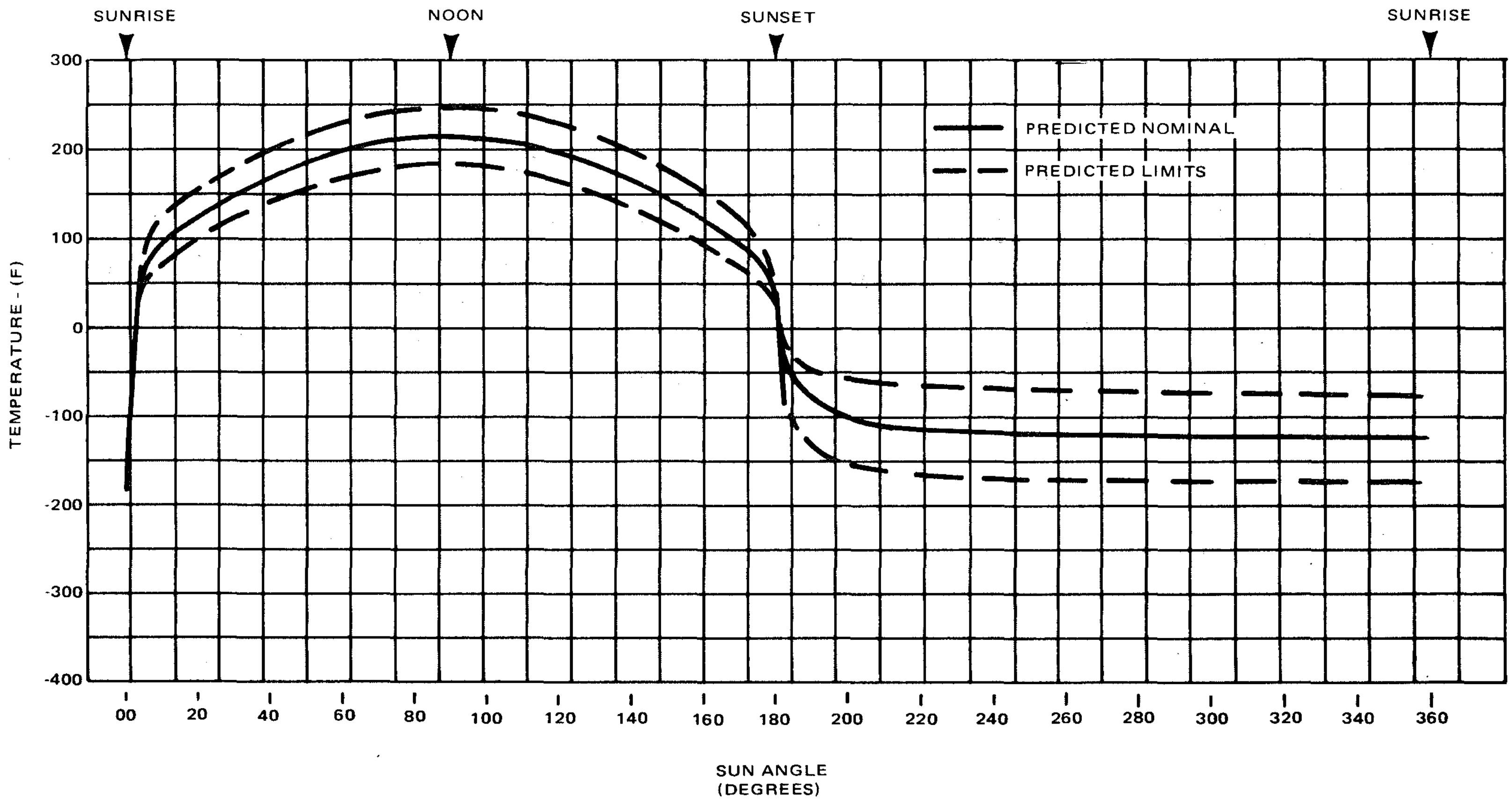


Figure 3.2-5 Normal PDM Temperatures

TABLE 3.2-3(a)

CENTRAL STATION ELECTRICAL DATA

Meas. No.	Frame	Description	Normal Oper. Range		Nominal	Red-Line Limits (1)	
			Low	High		Low	High
AE-1	2	ADC Calibr. Voltage (volts)	0.24	0.26	0.25	0.22 (T) 0.04 (M)	0.28 (T) 5.00 (M)
AE-2	3	ADC Calibr. Voltage (volts)	4.72	4.78	4.75	4.70 (T) 0.04 (M)	4.80 (T) 5.00 (M)
AE-3	1	PCU Input Voltage (volts)	15.8	16.2	16.0	15.0 (T) 0.25 (M)	17.5 (T) 21.30 (M)
AE-4	5	PCU Input Current (amps) (3)	3.9	4.3	---	3.5 (T) -0.54 (M)	----- 6.60 (M)
AE-5	56 & 8	PCU 1 Reserve Current (amps)	0.3	2.7	---	0.1 (T) -0.84 (M)	----- 3.26 (M)
AE-6	41 & 13	PCU 2 Reserve Current (amps) (2)	0.3	2.7	---	0.1 (T) -0.84 (M)	----- 3.26

Note 1: Red-Line Limit Legend - (M) Measurement Limit, (T) Test Limit. See Section 4.3.

Note 2: Redundant Function, Not Normally Active.

Note 3: See Table 3.2-3(e).

TABLE 3. 2-3(b)

CENTRAL STATION ELECTRICAL DATA

Meas. No.	Frame	DESCRIPTION	Normal Operating Range		Nominal	Red-Line Limits[1]	
			Low	High		Low	High
AE-7	20	PCU Output Voltage (volts)	28. 5	29. 1	29	28. 5 (T) 0. 28(M)	29. 4 (T) 35. 27(M)
AE-8	35	PCU Output Voltage (volts)	14. 9	15. 4	15	14. 8 (T) 0. 14(M)	15. 4 (T) 18. 16(M)
AE-9	50	PCU Output Voltage (volts)	11. 9	12. 1	12	11. 8 (T) 0. 12(M)	12. 1 (T) 15. 03(M)
AE-10	65	PCU Output Voltage (volts)	4. 8	5. 4	5	4. 8 (T) 0. 05(M)	5. 4 (T) 6. 02(M)
AE-11[3]	79	PCU Output Voltage (volts)	-11. 9	-12. 7	-12	-11. 8 (T) - 7. 91(M)	-12. 7 (T) -16. 14(M)
AE-12[3]	80	PCU Output Voltage (volts)	-5. 9	-6. 2	-6	-5. 8 (T) -1. 13(M)	-6. 2 (T) -7. 63(M)

NOTE 1: Red-Line Limit Legend--(M) Measurement Limit, (T) Test Limit. See Section 4. 3
NOTE 3: See Table 3. 2-3(e)

TABLE 3.2-3(c)

CENTRAL STATION ELECTRICAL DATA

Meas. No.	Frame	DESCRIPTION	Normal Operating Range Low	Normal Operating Range High	Nominal	Red-Line Limits[1] Low	Red-Line Limits[1] High
AE-15[3]	51	Transmitter A RF Power (dbm)	29.6	29.8	-	27 (T) 27 (M)	32 (T) 32 (M)
AE-16[2][3]	66	Transmitter B RF Power (dbm)	30.5	31.3	-	27 (T) 27 (M)	32 (T) 32 (M)
AE-17[3]	81	Transmitter A Input Current (milliamps)	380	435	-	250 (T) -13.5(M)	475 (T) 606 (M)
AE-18[2][3]	22	Transmitter B Input Current (milliamps)	325	380	-	250 (T) 25.9(M)	475 (T) 602.6(M)
AE-19	21	Signal Level, Rcvr. A (dbm)	-92.3[4]	-74.1[4]	-	-110 (T) -110 (M)	-60 (T) -60 (M)
AE-20	36	Signal Level, Rcvr. B (dbm)	-92.3[4]	-74.1[4]	-	-110 (T) -110 (M)	-60 (T) -60 (M)

NOTE 1: Red-Line Limit Legend: (M) Measurement Limit, (T) Test Limit. See Section 4.3.
NOTE 2: Redundant Functions, not normally active
NOTE 3: See Table 3.2-3(e)
NOTE 4: Values valid only when uplink carrier active

TABLE 3.2-3(d)

CENTRAL STATION ELECTRICAL DATA

Meas. No.	Frame	DESCRIPTION	Normal Operating Range		Nominal	Red-Line Limits[1]	
			Low	High		Low	High
CS-1	-	AE-3 x AE-4	61.5	70.0	-	-	-
CS-2	-	AE-3 x AE-5	4.8	44.0	-	1.0 (T)	50 (T)
CS-3	-	CS-2 - 4.2 $(AE\text{-}5)^2$	4.4	14.6	-	-	-
CS-4[2]	-	AE-3 x AE-6	4.8	44.0	-	1.0 (T)	50 (T)
CS-5[2]	-	CS-4 - 4.2 $(AE\text{-}6)^2$	4.4	14.6	-	-	-

NOTE 1: Red-Line Limit Legend - (T) Test Limit. See Section 4.3.
NOTE 2: Redundant functions, not normally active.

TABLE 3. 2-3(e)

MULTIPLE-CALIBRATION MEASUREMENTS

Measurement		Calibration Dependent On		Printout Indication
No.	Description	Parameter	Value	
AE-4	PCU Input Current	PCU Selected	PCU 1	06
			PCU 2	07
AE-11	PCU Output (-12V)	AE-7	28.5 V	06
			29.0 V	07
AE-12	PCU Output (-6V)		29.5 V	08
AE-15	Trans 'A' RF Power	AT-24	-22°F	01
AE-16	Trans 'B' RF Power	AT-26	+14°F	02
AE-17	Trans 'A' Input Current	AT-24	86°F	03
AE-18	Trans 'B' Input Current	AT-26	100°F	04
			122°F	05
			-10°F	01
AE-19	Receiver 'A' Signal Level	AT-40	+10°F	02
			+75°F	03
AE-20	Receiver 'B' Signal Level		+100°F	04
			+140°F	05

NOTE: These electrical measurements have calibration characteristics which are dependent on the concurrent value of another parameter. For proper evaluation of the engineering values of these parameters it is essential that the appropriate calibration printout be indicated.

TABLE 3.2-4

RTG TEMPERATURE DATA

Meas. No.	Frame	DESCRIPTION	Normal Operating Range		Nominal	Red-Line Limits (Measurement Range)[1]	
			Low	High		Low	High
AR-1	6	Hot Frame #1, (°F)	1060	1135	-	959 (M)	1138 (M)
AR-2	37	Hot Frame #2, (°F)	1060	1135	-	956 (M)	1135 (M)
AR-3	52	Hot Frame #3, (°F)	1060	1140	-	961 (M)	1142 (M)
AR-4	7	Cold Frame #1, (°F)	415	505	-	404 (M)	588 (M)
AR-5	67	Cold Frame #2, (°F)	Intermittent		-	402 (M)	585 (M)
AR-6	82	Cold Frame #3, (°F)	405	500	-	403 (M)	586 (M)
CS-18	--	AR-1 minus AR-4, (°F)	660	690	-	-	-

NOTE 1: Red-Line Limit Legend: (M) Measurement Limit. See Section 4. 3.

TABLE 3.2-5(a)

CENTRAL STATION STATUS INDICATORS

MEAS. NO.	PARAMETER/STATUS	INDICATION
AB-4 and AB-5	Experiment Power Status (All Experiments)	
	- Standby Power ON	ON
	- Operational Power ON	OFF
	- All Power OFF	OFF
AB-5	Heater Power Status	
	- Heater 1 Energized	HTR 2 OFF
	- Heater 2 Energized	HTR 2 ON
	- Both Heaters 1 & 2	HTR 2 OFF
AB-6	Receiver 'A' Power Status	OFF/ON
AB-7	Receiver 'B' Power Status	OFF/ON
AB-8 and AB-9	Uplink Signal Status (Receivers 'A' and 'B')	
	- Carrier ON	PRESENT
	- Carrier OFF	ABSENT
AB-10	Data Processor	
	- 'X' Selected	'X' ON/'Y' OFF
	- 'Y' Selected	'X' OFF/'Y' ON

TABLE 3.2-5(b)

CENTRAL STATION STATUS INDICATORS

MEAS. NO.	PARAMETER/STATUS	INDICATION
AZ-1	Timer "18-Hour" Pulse Event	> 128 or < 32 (Alternately)*
AZ-2 AZ-3	No. 1 "48.5-Day" Pulse Events No. 2	
	- Up to 48.5 days after turn-on, or reset	< 32
	- More than 48.5 days after turn-on (if not reset)	> 128
DA-2	Frame Count	0 to 89
DA-3	Data Rate	
	-530 bps	LBR
	-1060 bps	NBR
DA-4	System Identification	ALSEP - 3
DA-5	Command Message Received	(Yes/No)**

*Initial condition indeterminate

**Panel Light Indication

TABLE 3.2-6

CENTRAL STATION ENGINEERING MEASUREMENTS
DURING HIGH DATA RATE MODE

Meas. No.	Frame	Description	Normal Oper. Range		Nominal	Red-Line Limits[1]	
			Low	High		Low	High
AE-3	-----	PCU Input Voltage (Volts)	15.8	16.2	16.0	15.0(T) 0.25(M)	17.5(T) 21.30(M)
AE-4	-----	PCU Input Current (amps)	3.9	4.3	----	3.5(T) -0.54(M)	---- 6.60(M)
AR-1	-----	Hot Frame #1 (°F)	1060	1135	----	959(M)	1138(M)
AR-4	-----	Cold Frame #1 (°F)	415	505	----	404(M)	588(M)

NOTE 1: Red-Line Limit Legend: (T) Test Limit, (M) Measurement Limit
See Section 4.3.

3.3 COMMAND OPERATIONS

A total of 77 commands have valid responses in ALSEP Array D. These are described in Section 5. In order for a command to be recognized by this array the uplink carrier data (command code and its complement) must be preceded by (a) an octal 62 if it is to be addressed to Command Decoder A or (b) an octal 144 if it is to be addressed to Command Decoder B. The following subsections describe some of the command operations peculiar to Array D.

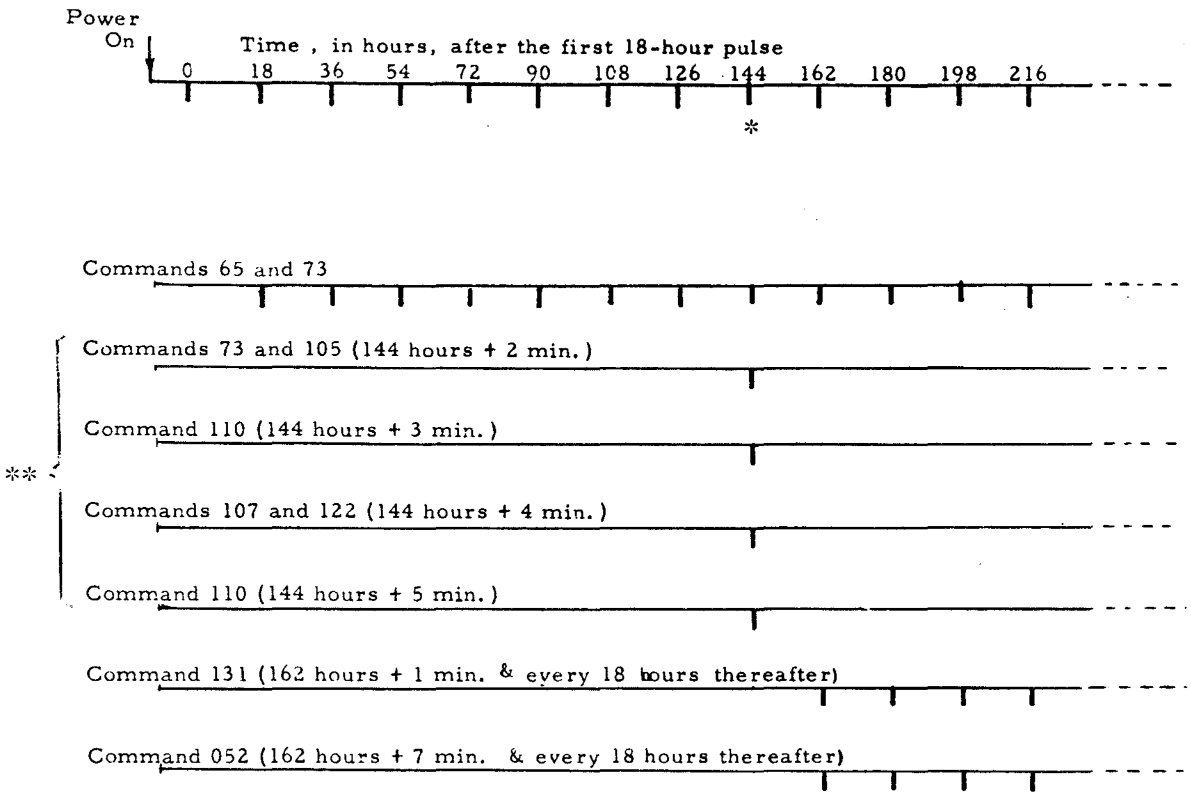
3.3.1 Delayed Command Sequence

The Resetable Solid State Timer (RSST) provides the timing pulses for activation of the delayed command sequencer. The resultant sequence of commands is illustrated in Figure 3.3 . Note that, since there is no Receiver circuit breaker to reset, this function is not provided in Array D. No response in the Command Verification word (46) should be expected following any of these commands.

The timer is able to "remember" its position in the 97-day countdown sequence even though there is a power loss lasting up to 30 seconds.

3.3.2 Commandable Power Changes

Some commandable functions, when implemented, cause a significant change in the system power usage. An indication of these changes is provided in the display of calculated system reserve power (CS-2, or CS-4). Table 3.3 lists the changes to be expected in this parameter following implementation of certain commandable functions associated with the Central Station. Similar information for experiment functions are listed in Tables 3.4-3 and 3.6-3.



* 144 hour "pulse" occurs 137 to 153 hours after system activation. All delayed commands will be repeated in 144 hours following each activation of the power reset circuit.

** Commands 105, 107, 110 and 122 initiate no functions in Array 'D'.

Figure 3.3 Delayed Command Sequence

TABLE 3.3

CHANGES IN SYSTEM RESERVE POWER RESULTING
FROM CENTRAL STATION COMMANDS

CMD NO.	FUNCTIONAL MODE CHANGE FROM	TO	CS-2/CS-4 CHANGE (WATTS)
017	PDR 1 OFF	PDR 1 ON	-7.3
021	PDR 1 ON	PDR 1 OFF	+7.3
022	PDR 2 OFF	PDR 2 ON	-14.9
023	PDR 2 ON	PDR 2 OFF	+14.9
036	PSE STANDBY	PSE ON	-0.8 to -5.8 (1)
037	PSE OFF	PSE STANDBY	-4.7
042	ASE STANDBY	ASE ON	-4.2 to -7.2 (2)
043	ASE OFF	ASE STANDBY	-0.3 to -3.3
045	LSM STANDBY	LSM ON	-3.6 to -10.2 (3)
052	HFE STANDBY	HFE ON	+0.5 to -5.9
053	HFE OFF	HFE STANDBY	-4.5
055	HTRS OFF	HTR 1 ON	-10.7
056	HTR 1 ON	HTR 2 ON	+5.2
057	HTR 2 ON	HTRS OFF	+5.5

Notes: (1) -0.8^{W} at Lunar noon/-5.8^{W} at Lunar night (derived from PSE subsystem test data)
(2) -7.2^{W} at Lunar noon/-4.2^{W} at Lunar night
(3) 6.6 watt variation

3.4 PASSIVE SEISMIC EXPERIMENT (PSE)

The PSE senses the dynamic deflections and tilt of the surface on which it is deployed and resolves these data into their orthogonal components. The outputs of these long-period sensors together with the signals from a short-period vertical seismometer constitute the primary scientific data of this experiment.

3.4.1 PSE Science Data

The seismic data provided by the PSE is detailed in Table 3.4-1.

Note that on Array D the ALSEP data word 24 has been restored to the PSE for short-period seismic measurements, as on arrays prior to A-2.

3.4.2 PSE Engineering Data

The performance and operational status of the PSE equipment can be derived by monitoring the engineering data channels listed in Table 3.4-2.

The majority of these engineering measurements are indicators of the status of various operational functions and hence the associated data have no normal (or abnormal) values except as a reflection of certain command sequences. The sensor temperature measurement (DL-7) is a continuous indication having a resolution of approximately 0.03°F. During thermal vacuum testing this parameter maintained a value between 124.0 and 127.7 under simulated conditions. The seismic sensor cannot be damaged by temperatures within the measurement range of DL-7. But the output of the sensor can be expected to drift if the sensor temperature exceeds this controlled range.

TABLE 3.4-1

PSE SCIENTIFIC MEASUREMENTS

Meas. No.	Frame	DESCRIPTION		Normal Operating Range		Nominal	Red-Line Limits (Measurement Range)	
				Low	High		Low	High
DL-1	-	X-Axis Long Period Seismic Deflection in Microns at Gain Setting of	-30db	-	-	-	-5.0	+5.0
DL-2	-	Y-Axis Long Period Seismic Deflection in Microns at Gain Setting of	-20db	-	-	-	-1.6	+1.6
DL-3	-	Z-Axis Long Period Seismic Deflection in Microns at Gain Setting of	-10db	-	-	-	-0.5	+0.5
			0db	-	-	-	-0.17	+0.17
DL-4	-	X-Axis (microradians)	Tidal Deflection	-	-	-	-25	+25
DL-5	-	Y-Axis (microradians)	Tidal Deflection	-	-	-	-25	+25
DL-6	-	Z-Axis (milligals)	Tidal Deflection	-	-	-	-4	+4
DL-8	-	Z-Axis Short Period Seismic Deflection in Microns at Gain Settings of	-30db	-	-	-	-7.8	+7.8
			-20db	-	-	-	-2.5	+2.5
			-10db	-	-	-	-0.78	+0.78
			0db	-	-	-	-0.25	+0.25

TABLE 3.4-2

PSE ENGINEERING DATA

Parameter	Meas. No.	Indication
Sensor Temperature	DL-7	107.1 °F to 142.9 °F
Amplifier Gain		
. Long Period X & Y	AL-1	
. Long Period Z	AL-2	0/-10/-20/-30 db
. Short Period Z	AL-4	
Level Direction	AL-3	POS/NEG
Level Speed	AL-3	
. X or Y : 152 to 305 μrad/sec . Z : 20 to 40 mgals/sec		HIGH
. X or Y : 5.1 to 17.7 μrad/sec . Z : 0.67 to 2.34 mgals/sec		LOW
Levelling Mode	AL-5	AUTO/FORCED
Coarse Level Sensor	AL-5	IN/OUT
Thermal Control	AL-6	
. Mode		AUTO/FORCED
. Selected Mode Status		ON/OFF
Calibration Status	AL-7	
. Long Period		ON/OFF
. Short Period		ON/OFF
Sensor Status	AL-8	
. Caged		Caged
. Arm		Arm
. Uncage		Uncage
. (Following CMD 065, when uncaged)		OT

Figure 3.4 is a diagrammatic representation of the power required by the PSE equipment in certain operating modes or during transfer between modes. Since the only indication of power usage during system operation is the calculated value of reserve power (CS-2, or CS-4), Table 3.4-3 lists the changes in this parameter expected during certain changes in PSE functional mode.

3.4.3 PSE Turn-On Sequence

In the stowed configuration, the delicate PSE seismometers are protected by a caging device. To put the PSE into operation, the PSE Uncage Arm/Fire Command 073 will be sent twice. If the uplink subsystem should fail, uncaging can be accomplished in any number of ways by utilizing various combinations of Timer 18-hour output pulses and the one-time delayed command automatically generated by the Delayed Command Sequencer 137 to 153 hours after Central Station activation.

The PSE receives a Short Period Calibrate command every 18-hours from the Timer. The 18-hour Timer pulses are routed through the PDU as well as the Delayed Command Sequencer. If the PSE has not been previously uncaged, these repetitive pulses will Arm and Fire the PSE Uncaging mechanism. Subsequent commands will provide a Short Period Calibrate pulse for the short period seismometer.

The PSE will be turned on, uncaged, leveled, calibrated and put in the scientific operational mode before the LM leaves the lunar surface. Before the PSE is uncaged, the PSE housekeeping/engineering data measurements AL-1 through AL-8 in Word 33 will be monitored to insure that the preset states for the 15 PSE command functions are correct. Refer to octal commands 063 through 103 shown in Table 5.3-2.

3.4.4 PSE Operational Mode

Heater power will be turned off before a Level Motor is turned on. The order of leveling will be such that the Z-axis is leveled last.

The Feedback Filter must be switched Out for any leveling operation and switched In for the normal scientific mode.

It will not be necessary to turn a Level Motor Off before commanding a change in direction, mode or speed.

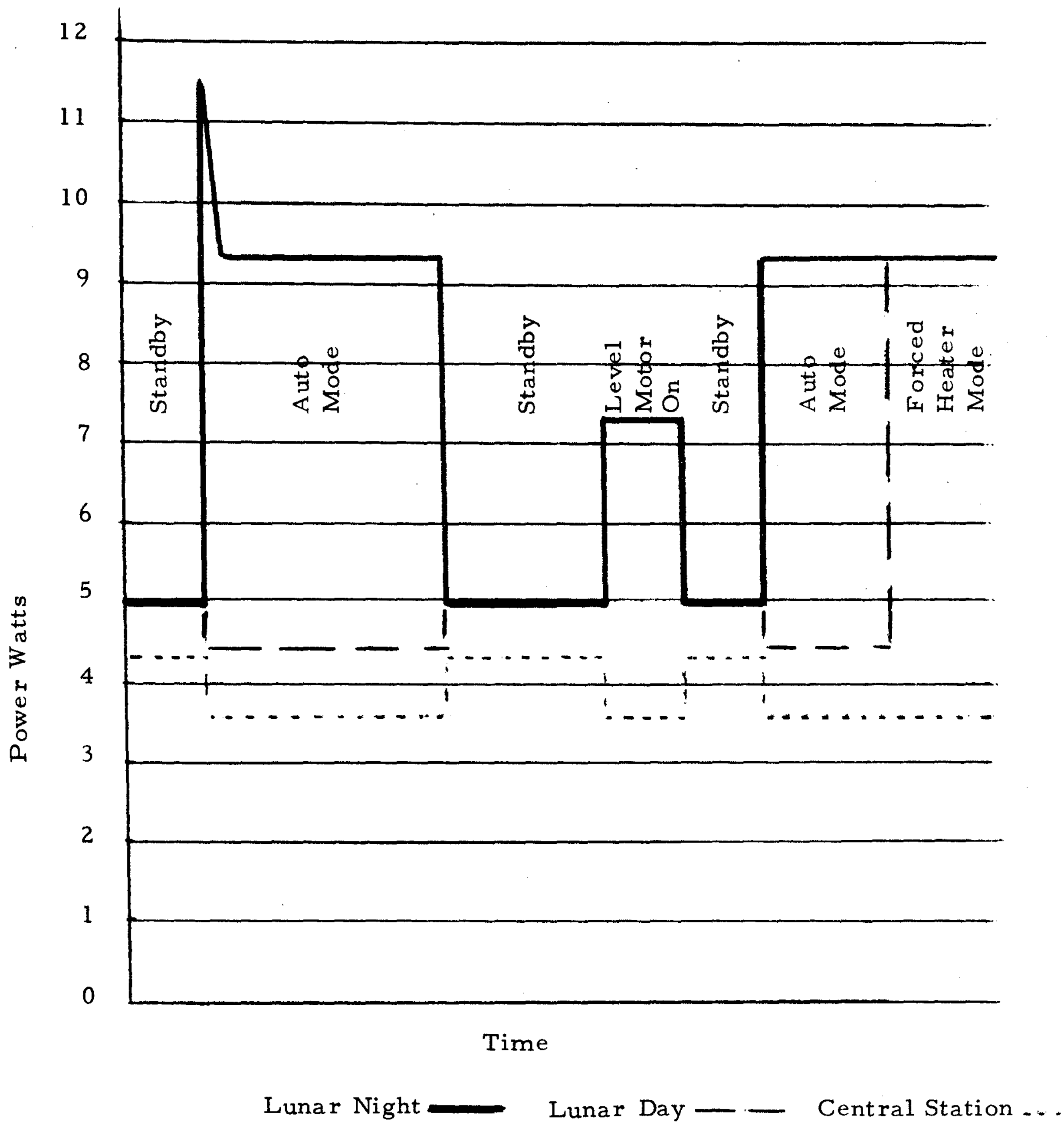


Figure 3.4 PSE Power Profile

TABLE 3.4-3

CHANGES IN SYSTEM RESERVE POWER RESULTING FROM PSE COMMANDS

CMD No.	Functional Mode Change From	Functional Mode Change To	Changes in CS-2/CS-4 (Watts)
036	Standby	Operate	-0.8 to -5.8
041	Standby	OFF	+ 4.7
070	Level Motor OFF	Level Motor ON	-2.8
076	Thermal Control OFF	Auto ON	-5.0
076	Thermal Control OFF	Manual ON	-5.0

The Coarse Level Sensor will be commanded In only for the normal initial leveling sequences of axes x and y.

If the PSE needs to be turned Off, the first command to be sent would be Command 037, Standby; then Command 041, Off. The Off mode is considered highly critical (see Table 4. 2) because both the instrument electronics and the Standby heater power are deactivated and there is no electrical thermal control for the sensor.

It is undesirable to allow a Level Motor to run past its rotational stop. Although there would be no damage to the gear train, the movable mass might stick at the stop.

3.5 ACTIVE SEISMIC EXPERIMENT (ASE)

The ASE senses, at three known locations, the dynamic deflections of the lunar surface resulting from natural seismic energy release or from artificial impacts provided by activating the thumper or exploding the grenades. The outputs of the three geophones constitute the primary scientific data from this experiment.

3.5.1 ASE Science Data

The seismic measurements provided by the ASE and the associated ranges of measurement are given in Table 3.5-1. These measurements are displayed only in analog form and two log-decompression functions are available to linearize the display response for either low-level or high-level signals.

3.5.2 ASE Engineering Data

The performance of the ASE can be derived by monitoring the engineering data channels listed in Table 3.5-2.

To support the interpretation of the geophone output data the time of occurrence of certain events is measured. These "real time" events include:

- the firing of the thumper (as monitored by a pressure switch on the ASI mounting plate)
- the breaking of the first range-line breakwire during each grenade launch (located approximately 16 inches from the start of the range-line).
- the breaking of the second range-line breakwire during each grenade launch (indicating 25 feet of travel since the "first breakwire" event)
- grenade impact (signified by loss of grenade transmitter signal).

The manner of displaying the timing of these events is given in Table 3.5-3.

TABLE 3.5-1

ASE SCIENTIFIC MEASUREMENTS

Meas.	Frame	DESCRIPTION		Normal Operating Range		Nominal	Red-Line Limits (Meas. Range)	
				Low	High		Low	High
DS-1	--	Geophone 1	Vertical Velocity of Seismic Disturbance (microns/sec)	--	--	--	-20.8	+37.0
DS-2	--	Geophone 2		--	--	--	-20.8	+37.0
DS-3	--	Geophone 3		--	--	--	-20.8	+37.0

TABLE 3.5-2(a)

ASE ANALOG ENGINEERING MEASUREMENTS
(Normal Data Rate Mode)

Meas. No.	Frame	Description	Normal Oper. Range (°C)		Nominal Ref^{ce} Fig.	Red-Line Limits[1] (°C)	
			Low	High		Low	High
AS-1	25	Central Electronics Temp. (°C)	-10	+60	3.5-1	-20 (T) -71 (M)	+85 (T) +110 (M)
AS-2	40	Mortar Box Temp. (°C)	-50	+85	3.5-1	-60 (T) -74 (M)	+85 (T) +111 (M)
AS-3	44	GLA Temp. (°C)	-66	+85	3.5-1	-60 (T) -71 (M)	+85 (T) +110 (M)
AS-4	73	Geophone Temp. (°C)	-130	+78	3.5-2	-73 (T) -232 (M)	+127 (T) +177 (M)

Note 1: Red-Line Limit Legend: (M) Measurement Limit, (T) Test Limit.
See Section 4.3.

TABLE 3.5-2(b)

ASE ANALOG ENGINEERING MEASUREMENTS
(High Data Rate Mode)

Meas. No.	Frame	Description	Normal Oper. Range		Nominal (Reference Fig.)	Red-Line Limits (1)	
			Low	High		Low	High
AS-1	---	Central Electronics Temp. (°C)	-7	+60	See Figure 3.5-1	-20(T) -71 (M)	+85 (T) +110 (M)
AS-3	---	GLA Temp. (°C)	-66	+85	See Figure 3.5-1	-20 (T) -71 (M)	+85 (T) +110 (M)
DS-6	---	Roll Angle(2)(4) (degrees)	---	---	0	-12 (T) -15 (M)	+12 (T) +15 (M)
DS-7	---	Pitch Angle(3)(4) (degrees)	---	---	0	-12 (T) -15 (M)	+12 (T) +15 (M)
DS-5	---	Mortar Box Ground (mv.)	-10	+400	0	-20 (M)	5000 (M)
DS-8	---	Geophone Cal. Voltage (volts)	+2.00	+2.50	+2.25	0.04 (M)	5.00 (M)
DS-10	---	1.25 Cal. (volts)	1.15	1.35	1.25	0.04 (M)	5.00 (M)
DS-11	---	3.75 Cal. (volts)	3.65	4.05	3.75	0.04 (M)	5.00 (M)

Note 1: Red Line Limit Legend: (M) Measurement Limit, (T) Test Limit, (F) Failure Limit. See Section 4.3.

Note 2: Measures Rotation Around an Axis in the Plane of the Grenades and 45° From the Launch Axes. 0° Indicates the Plane of the Grenades is Vertical.

Note 3: Measured in the Plane of the Grenades. 0° Indicates Nominal Launch Elevation.

Note 4: See Table 3.5-2(c).

TABLE 3.5-2(c)

MULTIPLE-CALIBRATION MEASUREMENTS

Measurement		Calibration Dependent On		Printout Indication
No.	Description	Parameter	Value	
			-20°C	01
DS-6	Roll Angle (degrees)	GLA	0°C	02
		Temperature	+25°C	03
DS-7	Pitch Angle (degrees)	(AS-3)	+55°C	04
			+82°C	05

Note: These angle measurements have calibration characteristics which are dependent on the concurrent value of another parameter. For proper evaluation of the engineering values of these parameters it is essential that the appropriate calibration printout be indicated.

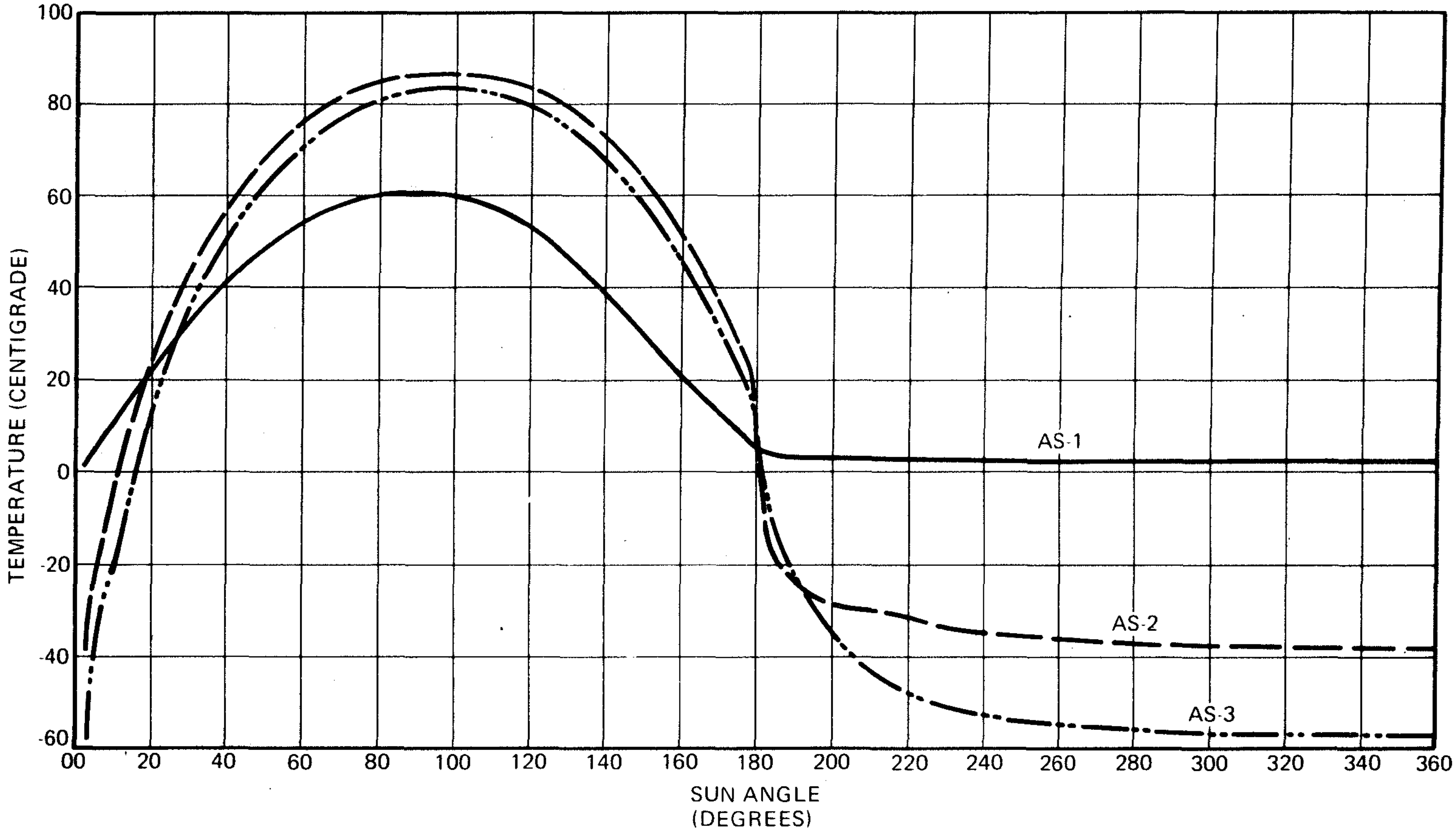


Figure 3.5-1 Normal ASE Package Temperatures

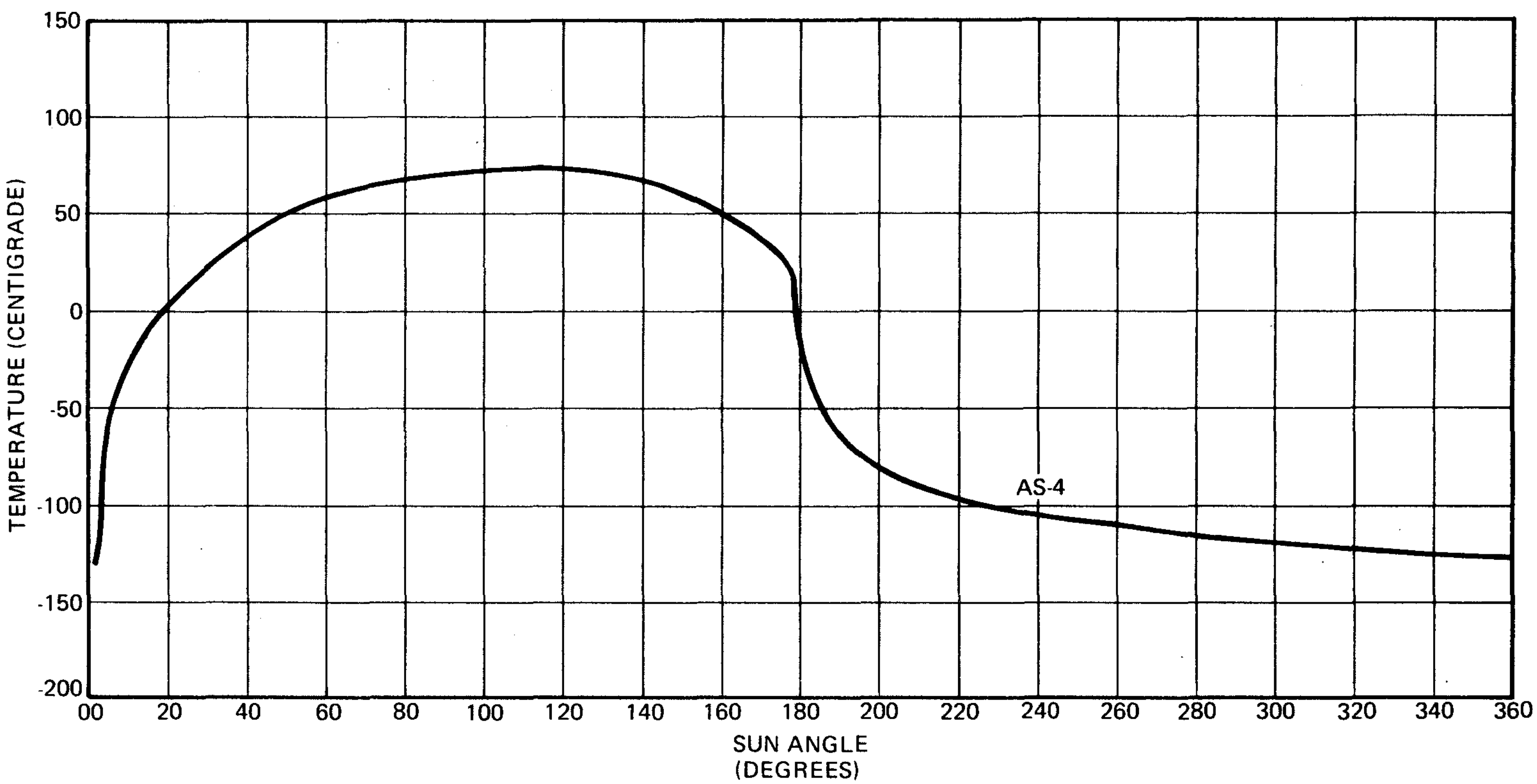


Figure 3.5-2 Normal ASE Geophone Temperatures

TABLE 3.5-3

ASE REAL TIME EVENT INDICATORS

Meas. No.	Parameter	Indication
DS-18	Identification of the High Data Rate frame (32-word sequence) immediately following the frame during which a Real Time Event occurred.	"Mark"
DS-19	Identification of the 20-bit word in the prior frame during which a Real Time Event occurred.	PCM count
DS-20	Identification of the bit in the word identified by DS-19 and DS-20 during which the Real Time Event occurred.	0 thru 19

3.5.3 Thumper Operation

The geophone cable (with geophones attached) unreels from the thumper with the thumper power cable as the astronaut walks down the geophone deployment line. When the geophones have been implanted as stated in Section 3.1.6, and the astronaut is ready to proceed with the thumper mode of the Active Seismic Experiment, he must verify with MCC that ALSEP is operating properly in High Data Rate Mode and that he is clear to initiate the thumper.

Interpretation of the geophone response to each "thump" is predicted on an assumed location of the thumper in relation to the geophones. These assumed locations are identified by 3-inch long, white markers at 15-foot intervals along the geophone cable. It is evident that this method of identifying thumper locations assumes a relatively straight geophone cable.

Although there are 21 Apollo Standard Initiators (ASI) mounted on the thumper and 21 positions on the initiator selector switch, two of these ASI's (numbers 20 and 21) were spent during tests prior to the Apollo 16 mission. Hence only selector positions 1 through 19 represent "live" thumper activity. For this reason two thumper positions (12 and 20) have been deleted and their locations, although not to be used, are shown in Figure 2-4 as having black markers.

A geophone calibration shall be initiated (CMD 156) at the beginning and at the conclusion of each ASE operational period, namely, the thumper sequence, the grenade-firing sequence, and each passive listening period.

It is necessary for the temperature of certain oven-mounted elements in the ASE electronics to have stabilized before the calibration of the ASE instrument is valid. Figure 3.5-3 indicates, as a function of electronics temperature, the time after ASE operational power is applied when the instrument should be providing valid data. It is important to note that the measure of ASE electronics temperature (AS-1) is not valid when the ASE operational power is On during transmission at Normal data rate. A suitable alternative indication of the temperature of the ASE electronics is provided by AT-6.

A minimum of 4 seconds must be allowed after rotating the Thumper "arm/fire" knob to the "ARM" position, before depressing the knob to fire the selected Apollo Standard Instructor.

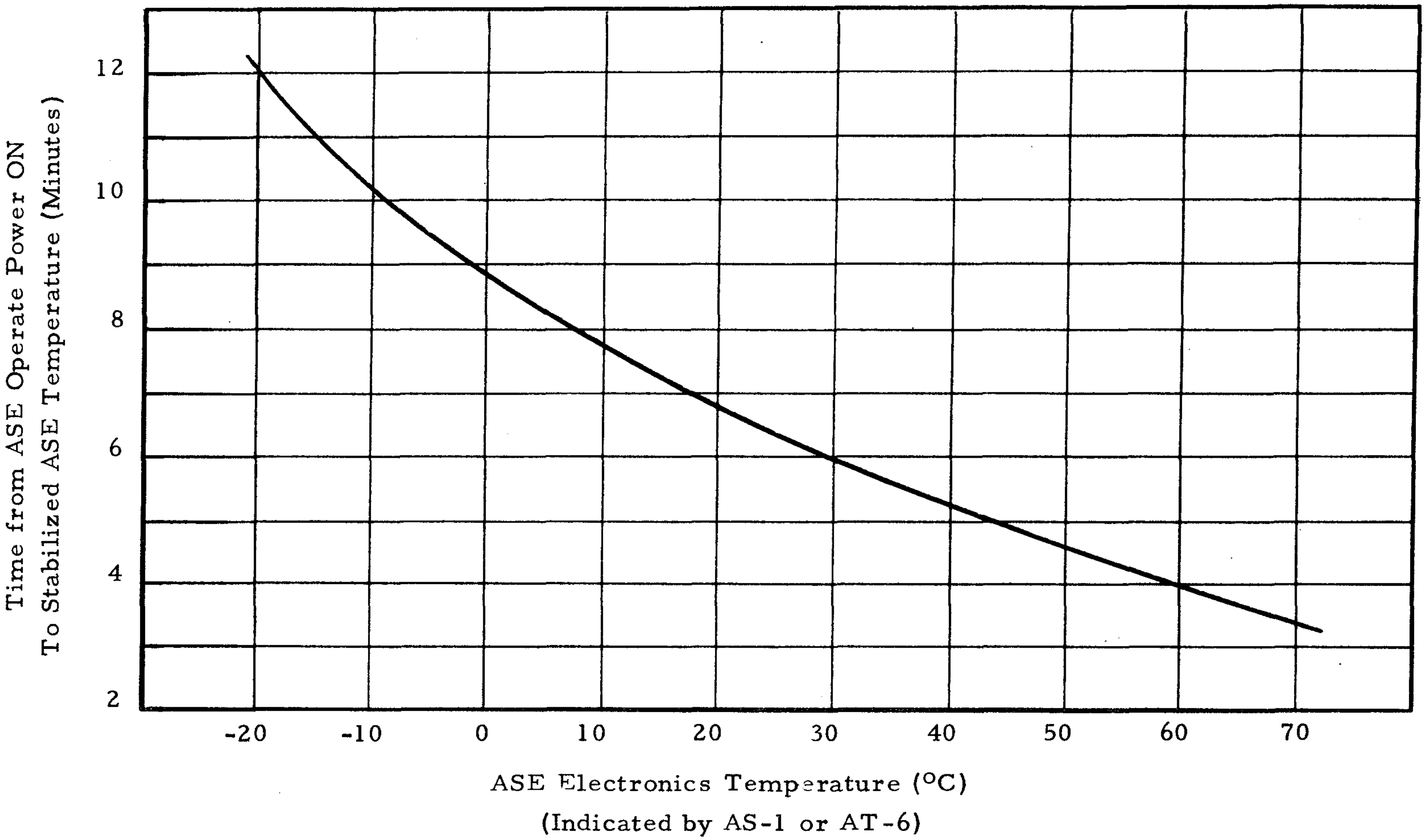


Figure 3.5-3 Stabilization Time for ASE Electronics

Because operation of the ASE in its grenade-firing mode is temperature limited (all ASE temperatures must be above -20°C), it is evident from Figures 3.5-1 and 3.5-2 that this ASE mode will be conducted during a lunar daytime period. It is important to note that the temperature limits predicted for the Mortar Package (AS-2 & AS-3) in Table 3.5-2 (a) are valid only if the canopy cover is intact on the Mortar Package. When the first grenade leaves its launch tube, this cover is removed. The temperature change resulting from this change in configuration is dependent on incident Sun angle (see Figure 3.5-4). No firing of a grenade has been performed during the test program at values of AS-3 greater than 85°C. For this reason the start of the grenade-firing sequence should be scheduled to permit firing of all grenades before the GLA temperature approaches 85°C.

Figure 3.5-5 is a graphic representation of the nominal range of each grenade and the maximum and minimum range that would occur if the initial velocity varied by ± 10%. The elevation angle of the grenade tubes is considered to be a constant 45 degrees.

A minimum of 60 seconds must be allowed between the "Arm Grenade" and "Fire Grenade" commands to insure that the grenade-firing circuit is adequately charged to its firing potential.

Figure 3.5-6 is a diagrammatic representation of the power required by the ASE equipment in its various operating modes and of the gross effect of ambient temperature (lunar day and lunar night) on the ASE power demand.

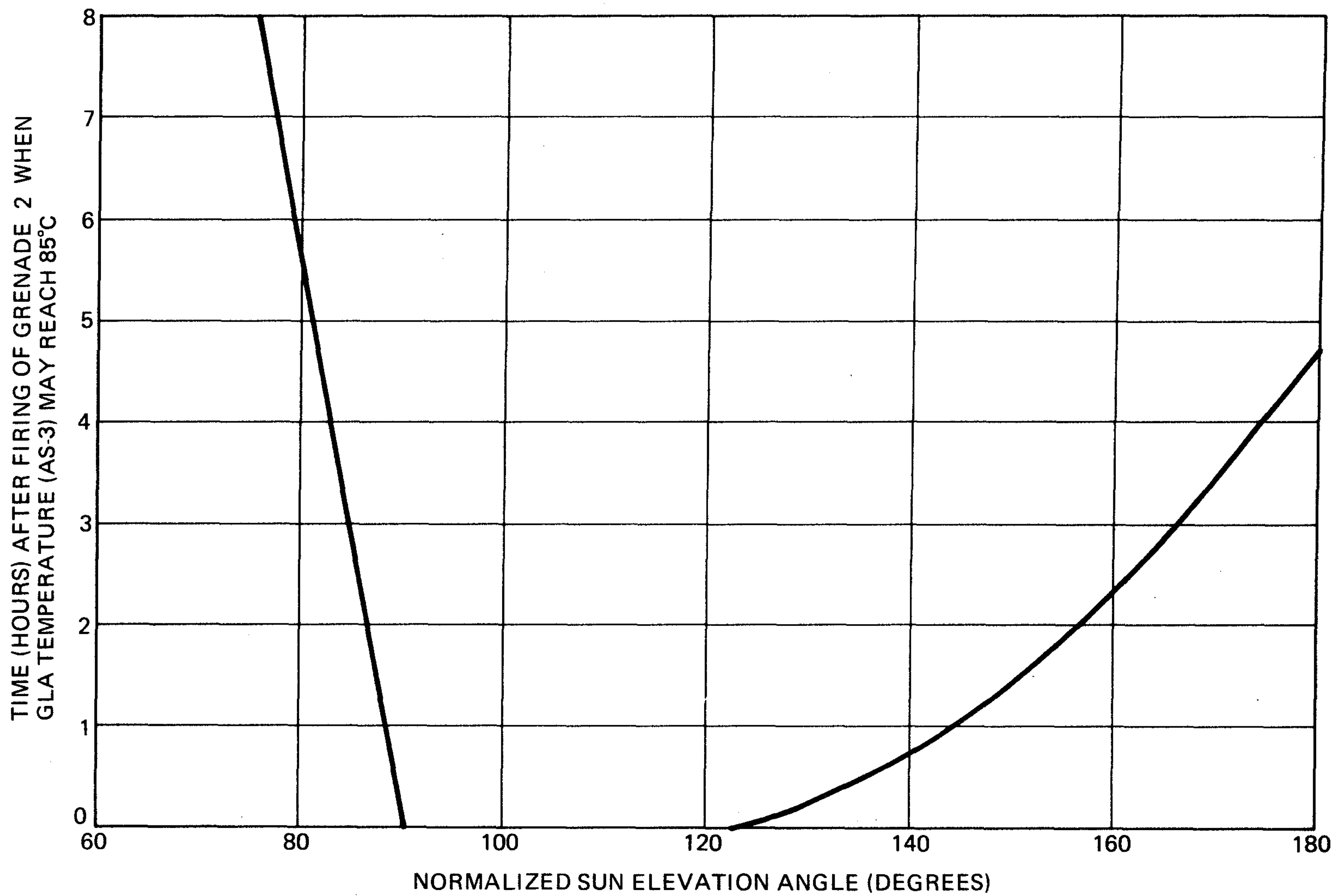


Figure 3.5-4 GLA Temperature Change after First Grenade Launch

Grenade	1	2	3	4
● Nominal				
Range, ft	5000	3000	1000	500
Mean velocity, fps	163.165	126.387	72.970	51.597
Lunar flight time, sec	43.337	33.569	19.381	13.704
● +10% vel. dispersion				
Range, ft	6050	3630	1210	605
Mean velocity, fps	179.482	139.026	80.267	56.787
Lunar flight time, sec	47.671	36.925	21.319	15.083
● -10% vel. dispersion				
Range, ft	4050	2430	810	405
Mean velocity, fps	146.849	113.749	65.673	46.438
Lunar flight time, sec	39.003	30.212	17.443	12.334

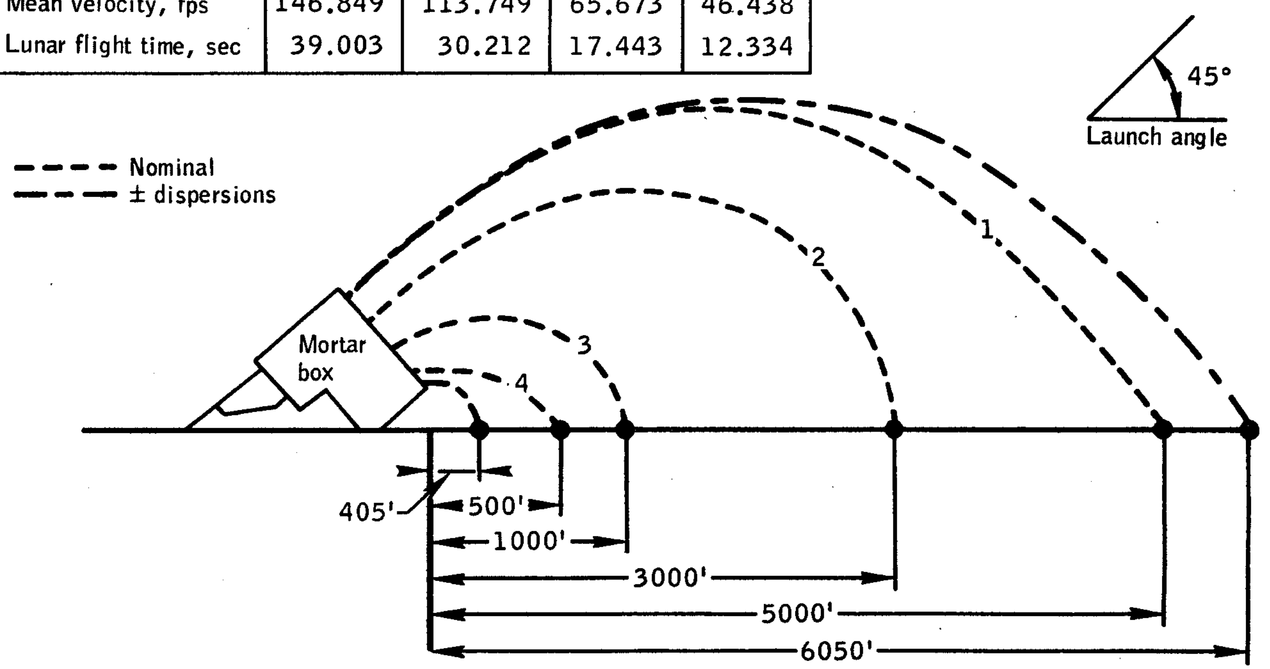


Figure 3.5-5 Range Deviations of the ASE Grenade Launcher

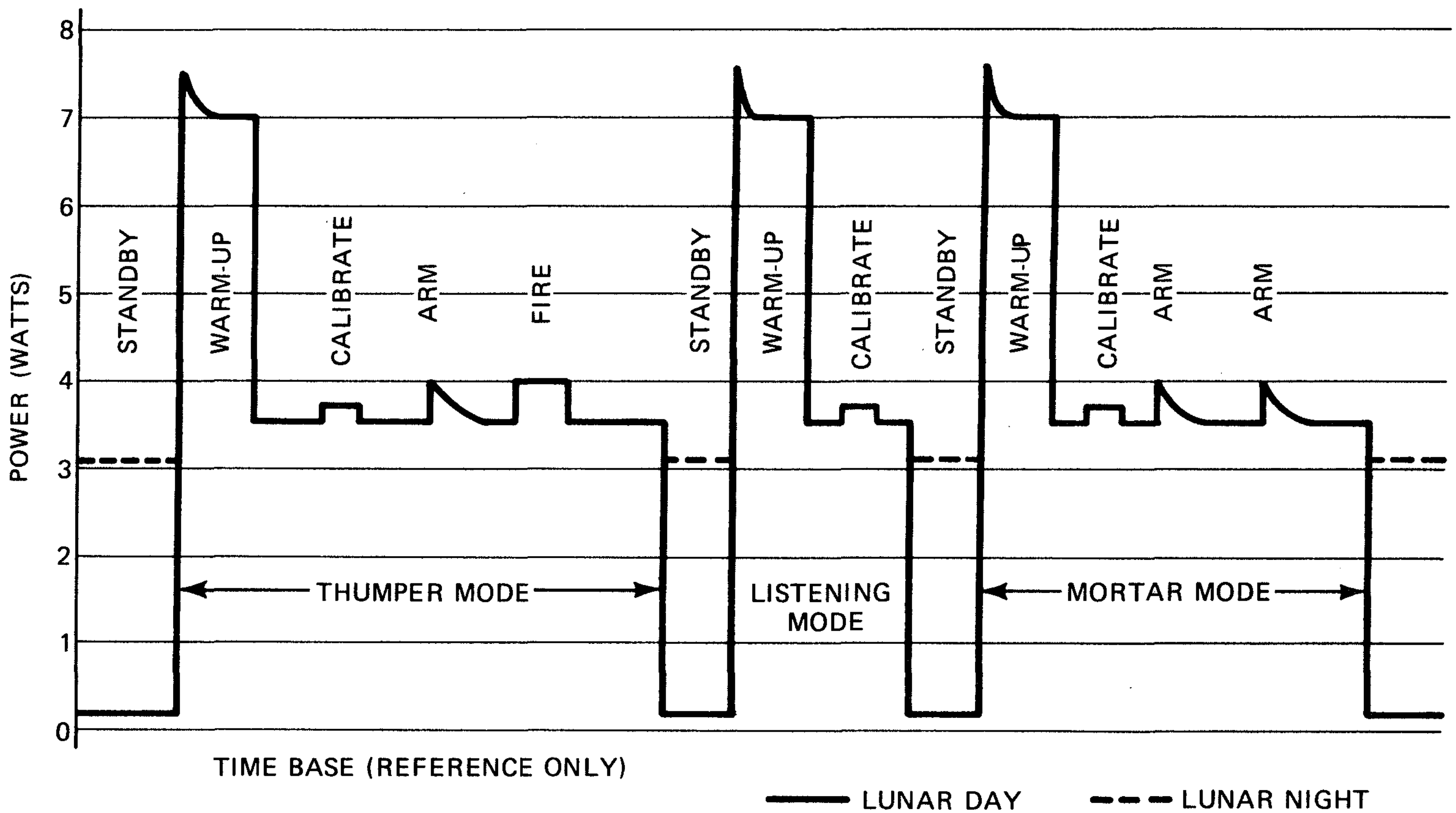


Figure 3.5-6 ASE Power Profile

3.6 LUNAR SURFACE MAGNETOMETER (LSM)

The LSM measures the components of the local magnetic field induced in three orthogonal sensors. The data provided by these three sensors constitute the primary scientific information from this instrument. Eight analog measurements and 16 mode status indicators are provided to support interpretation of the data and permit evaluation of the equipment performance.

3.6.1 LSM Scientific Data

The three magnetic field measurements provided by the LSM each have three ranges, namely

± 50 gamma
± 100 gamma
± 200 gamma (preset range)

These are selected by successive executions of octal command 123, the selected range being identified in engineering measurement DM-16 and displayed as shown above on the hard copy printout.

3.6.2 LSM Engineering Data

The performance and operational status of the LSM instrument can be derived by monitoring the 24 engineering parameters. The 8 analog measurements are identified in Table 3.6-1 together with their measurement ranges and expected range of values during normal operation. The operational status indicators are identified in Table 3.6-2.

Figure 3-6 is a diagrammatic representation of the power required by the LSM in certain operating modes or during transfer between modes. Since the only indication of power usage during system operation is the calculated value of reserve power (CS-2, or CS-4), Table 3.6-3 lists the changes in this parameter which can be expected during certain changes in LSM operational mode.

TABLE 3.6-1

LSM ANALOG ENGINEERING MEASUREMENTS

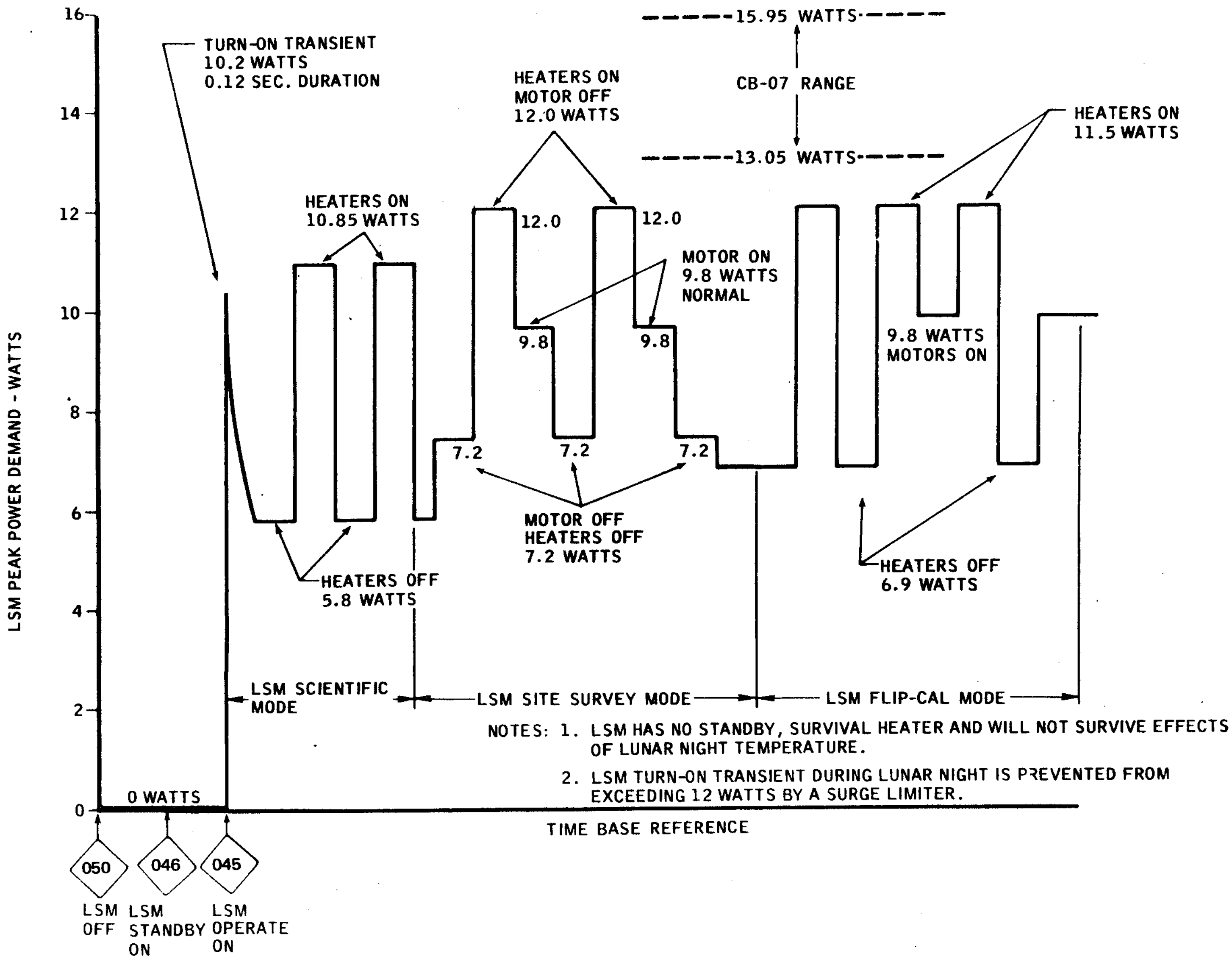
Meas. No.	Frame	DESCRIPTION	Normal Operating Range		Nominal	Red Line Limits	
			Low	High		Low	High
DM-1	-	X-axis Sensor Temperatures (°C)	+30	+85	-	-50 (M)	+85 (M)
DM-2	-	Y-axis Sensor Temperatures (°C)	+30	+85	-	-50 (M)	+85 (M)
DM-3	-	Z-axis Sensor Temperatures (°C)	+30	+85	-	-50 (M)	+85 (M)
DM-4	-	Base Temperature (°C)	-35	+75	-	-50 (M)	+85 (M)
DM-5	-	Internal Temperature (°C)	-30	+82	-	-50 (M)(F)	+85 (M)
DM-6	-	Tilt (degrees) in North-South plane	-	-	-	-15 (M)	+15 (M)
DM-7	-	Tilt (degrees) in East-West plane	-	-	-	-15 (M)	+15 (M)
DM-8	-	Supply Voltage (volts)	4.9	5.1	5.0	0 (M)	+ 6 (M)

Note 1 - Red-line limit legend: (M) Measurement Limit, (F) Failure Limit. See Section 4.3.

TABLE 3.6-2

LSM STATUS INDICATORS

Parameter	Meas. No. (DM)	Indication
Flip Position (All Axes)	9, 10, 11	0°/90°/180°/Fail
Gimbal Position	12, 13, 14	
- Before Site Survey		0°
- After Site Survey		90°
Temp. Control Status	15	
- Control Sensor		
. X axis		X
. Y axis		Y
- Control OFF		Y
Heater Power	28	OFF/ON
Science Meas. Range (gamma)	16	±50/±100/±200
Offset Field, All Axes (%)	17, 18, 19	0/±25/±50/±75
Offset Axes Address	21	X/Y/Z/OFF
Calibrate Mode Status	20	
. ON		CAL
. OFF		SCI
Calibrate Inhibit Status	23	ON/OFF
Filter Status	23	IN/OUT



NOTES: 1. LSM HAS NO STANDBY, SURVIVAL HEATER AND WILL NOT SURVIVE EFFECTS OF LUNAR NIGHT TEMPERATURE.

2. LSM TURN-ON TRANSIENT DURING LUNAR NIGHT IS PREVENTED FROM EXCEEDING 12 WATTS BY A SURGE LIMITER.

Figure 3-6. LSM Peak Power Profile

TABLE 3.6-3

CHANGES IN SYSTEM RESERVE POWER
RESULTING FROM LSM COMMANDS

Octal Command	Functional Mode Change		Change in CS-2/CS-4 (watts)
	From	To	
045	Standby/OFF	Operate	-3.6 to -10.2
046	Operate	Standby	+3.6 to +10.2
050	Standby	OFF	0
131	Science	Calibrate (flip-cal)	-1.1 to -6.2
133	Science	Site Survey	-1.5 to -6.8

3.6.3 LSM Site Survey

A site survey, one of the three modes of LSM operation, is performed after and only after the completion of the fourth (4th) calibration (flip-cal) sequence after initial LSM operation. The Site Survey mode is initiated by execution of CMD 133 at which time the instrument automatically cycles through what is called the X-axis survey. When each sensor has returned to its 180° position, as indicated by DM-9, DM-10 and DM-11, the instrument is ready for initiation of the Y-axis survey by execution of a second CMD 133. A third CMD 133 is required to initiate the Z-axis survey after which the LSM is automatically returned to the science (SCI) mode. The purpose of the site survey is to identify and locate any magnetic influences inherent in the deployment site so that they can be accounted for in the interpretation of the LSM data relative to the sensing of magnetic flux. The LSM site survey will be performed after the LM has left the lunar surface.

3.6.4 LSM Scientific Mode

The LSM does not have a Standby mode as do the other instruments. The operational power is either On or Off. When the LSM is commanded to "Standby" (CMD043) the LSM is effectively Off.

The normal On condition is the scientific mode during which magnetic field sensing is accomplished.

LSM data are not useable or intelligible when the downlink telemetry data are transmitted at the low bit rate (530 bps).

3.6.5 LSM Calibration

A Flip-Cal sequence is performed automatically at 18-hour intervals, after an initial delay of 162-hours plus 1 minute, upon receipt of a command generated in the Central Station by the Delayed Command Sequencer. The Flip/Cal sequence will also be performed on receipt of ground command 131, Flip/Cal Initiate.

The purpose of the Flip/Cal mode is to determine the absolute accuracy of the flux-gate sensors and correct any drift from their laboratory calibration.

3.7 HEAT FLOW EXPERIMENT (HFE)

The HFE senses a number of temperatures at various locations in two specially-drilled holes. Each temperature is transformed into a series of voltage measurements for transmission to Earth.

These measurements, together with data on 10 engineering parameters, constitute the information from which it is possible to derive the rate of heat flow.

The HFE consists of an electronics package and two probes that measure temperature gradient, absolute temperature and thermal conductivity in two 8-foot bore holes. The bore holes are drilled with the Apollo Lunar Surface Drill (Section 3.7.7), and in each hole is placed a probe consisting of identical upper and lower sections. The temperatures are sensed by platinum resistance thermometers in a bridge configuration and by thermocouple junctions in the probe cable. The physical configuration of the sensors is shown in Figure 3.7-1 and the circuit configurations used for measurement purposes are shown in Figure 3.7-2. Heaters are located at each end of the four probe sections to introduce heat into the lunar material through the walls of the bore hole during the conductivity measurements.

3.7.1 HFE Operational Data

The basic HFE scientific data provided in the ALSEP downlink are all voltage measurements. To obtain a suitable indication of each required temperature, measurements are accumulated in the Mission Control Center computer, processed in accordance with the associated circuit configuration, converted to engineering units and displayed to the operators. Hence, the information available for evaluation of HFE scientific performance is a highly-processed version of the downlink data. Information on the 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 3.7-1. The status indicators are described in Table 3.7-2.

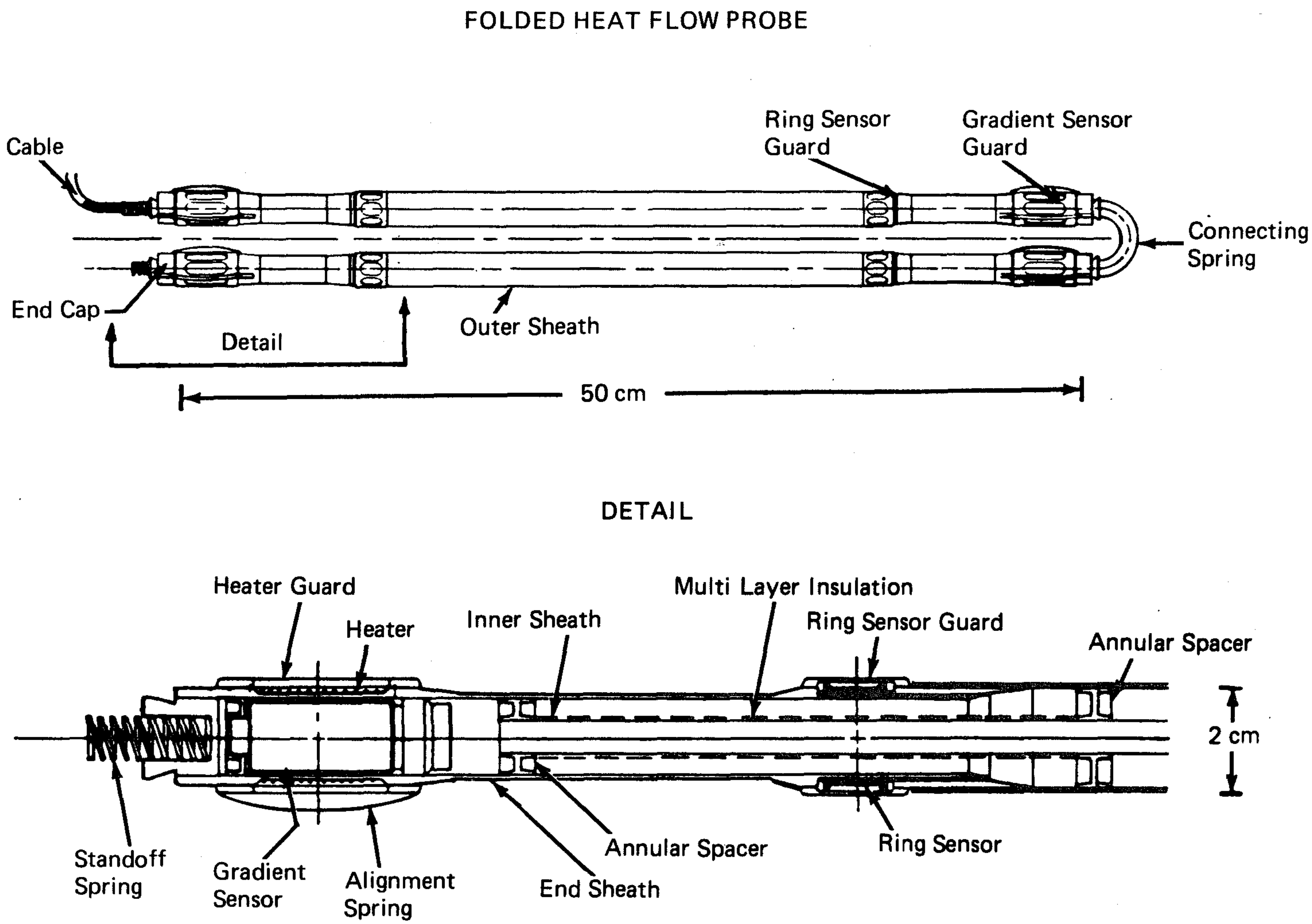


Figure 3.7-1 HFE Sensor Configuration

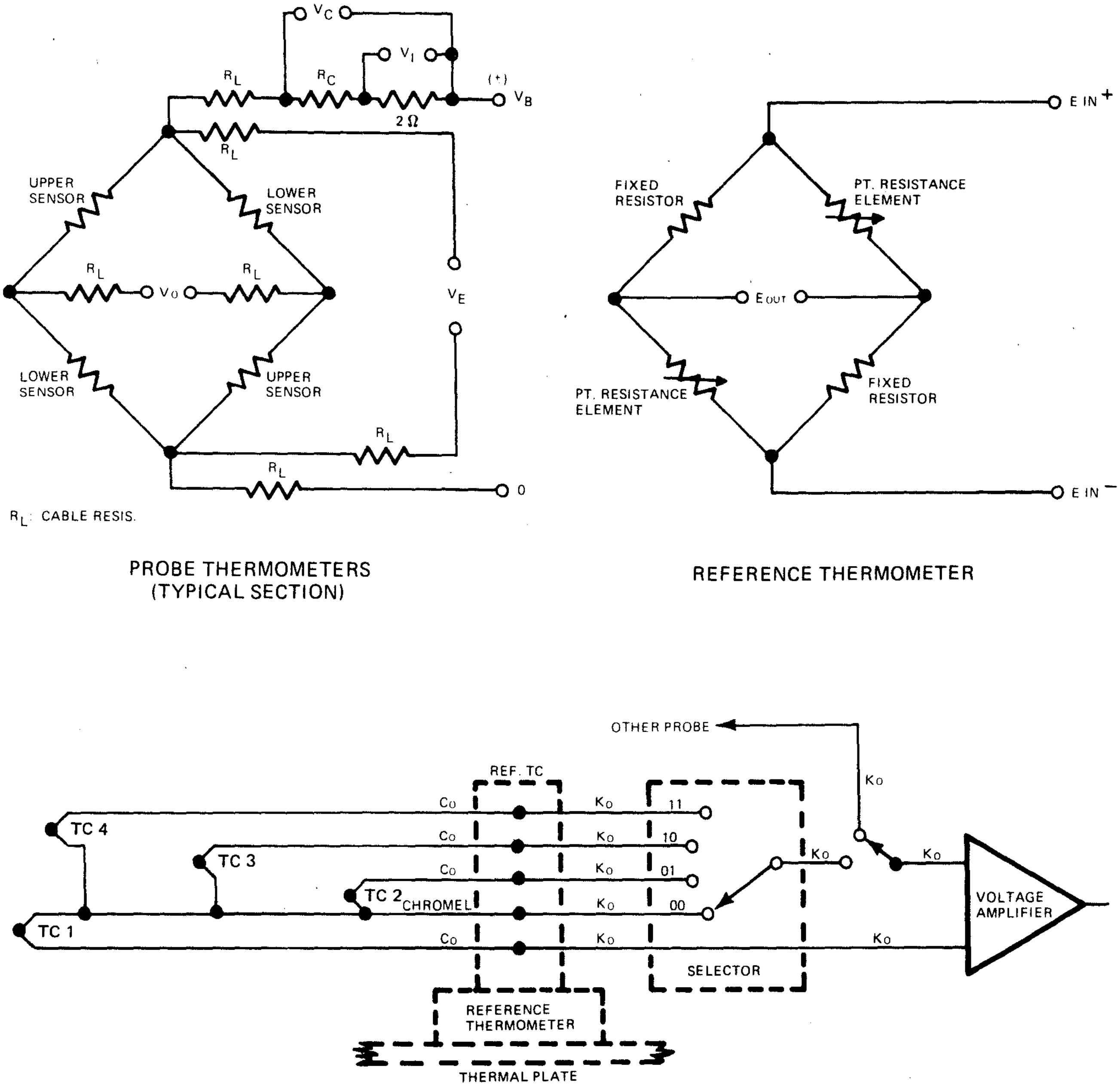


Figure 3.7-2 HFE Sensor Circuit Configuration

TABLE 3.7-1

HFE ANALOG ENGINEERING MEASUREMENTS

Meas. No.	Frame	DESCRIPTION	Normal Operating Range		Nominal	Red-Line Limits (Meas. Range)	
			Low	High		Low	High
AH-1	29	Supply Voltages (volts)	+ 4.0	+ 5.5	+ 5	+ 0.09	+ 7.11
(1) AH-2	45		- 4.0	- 5.5	- 5	- 2.90	- 8.84
AH-3	55		+14.0	+15.5	+15	+ 1.17	+20.63
(1) AH-4	74		-14.0	-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 3.7-2

HFE ENGINEERING STATUS INDICATORS

Parameters	Meas. No.	Indication
Science Mode	DH-90	
. Gradient		1
. Low Conductivity		2
. High Conductivity		3
Measurement Configuration	DH-91	(See Table 3.7-3)
. Wheatstone Bridge		DT
. Total Resistance		T
. Reference Bridge		TCR
. Thermocouple		TC
. High Sensitivity		H
. Low Sensitivity		L
HFE Data Word	DH-92	(Not Displayed)
Heater Status	DH-93	
. Heater Designation		
- Probe 1		H11/H12/H13/H14
- Probe 2		H21/H22/H23/H24 (See Table 5.3-6 for Physical Location)
. Heater Circuit	DH-93	ON/OFF
. Heater Supplies		
- High Conductivity	AH-6	ON/OFF
- Low Conductivity	AH-7	ON/OFF

TABLE 3.7-3(a)

IDENTIFICATION OF HFE MEASUREMENT CONFIGURATIONS

PROBE 1 MEASUREMENTS									HEATER
Sci. Mode	Meas. No.	Sensor & Section	Circuit (Fig. 3.7-2)	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	$+4^V$	$+V_E$	$+V_I$	$-V_E$	$-V_I$	
	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 3.7-3(b)

IDENTIFICATION OF HFE MEASUREMENT CONFIGURATIONS (CONT.)

PROBE 2 MEASUREMENTS									HEATER
Sci. Mode	Meas. No.	Sensor & Section	Circuit (Fig. 3.7-2)	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

3.7.2 HFE Gradient Mode of (Mode 1)

When the supply voltage of 29 volts is applied to the HFE, the instrument comes on automatically in Mode 1 full sequence, the gradient mode. The measurement circuitry sequences through the voltage measurements listed in Table 3.7-3 and telemeters a complete sequence every 7.25 minutes at normal data rate (1060 bits per second). Gradient Mode 1 will be considered the normal mode during lunar operations. By sending the appropriate HFE commands, the measurements can be selected in a number of subsequences (see Table 5.3-5).

3.7.3 HFE Conductivity Modes (Mode 2 and Mode 3)

In Mode 2, the low conductivity mode, the same sequence of measurements as in gradient mode 1 are made except that one of the heaters, which can be selected by command, is energized with 0.002 watt of power.

In Mode 3, the high conductivity mode, temperature and temperature differences are monitored at the ring bridges, which are small sensors located toward the middle of the probe sections, approximately 10 centimeters from the heaters. In this mode, a heater selected by command is turned on with 0.5 watt of power. The appropriate ring bridge is selected automatically when the heater location is selected by command.

The temperature decay of the sensor near the active heater is observed to obtain additional information about the thermal properties of the lunar material after completion of the heater portion of the Mode 3 conductivity experiment. This observation is accomplished by periodically sampling the appropriate bridges in either Mode 1 or Mode 3 with the heater off and requires monitoring of the data for an additional 12 hours.

Mode 1 operation is initiated automatically at HFE turn-on and is continued for approximately 500 hours. Temperature and temperature difference measurements made during this initial observation period are used to determine the magnitude and the decay rate of temperature transients induced by probe emplacement and to establish the phase and amplitude of temperature variations due to periodic solar heating of the lunar surface. Accurate measurement of these effects is necessary for proper evaluation of the HFE conductivity experiments.

3.7.4 HFE Command Sequencing

(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)

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.

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 issuances of these commands should be delayed by approximately one minute.

3.7.5 HFE Thermal Control

The temperature of the HFE electronics package is monitored as DH-13, the thermocouple reference junction. Active thermal control is maintained by varying the average power dissipated within the electronics package. This is accomplished by the use of the two thermostats.

When the internal temperature is above 30°C, both thermostats are open and the logic gates of the HFE switch power ON and OFF to circuits which are not required 100% of the time. This has the effect of lowering the average power dissipation and, therefore maintains a lower HFE temperature. As the internal temperature decreases below 30°C, a thermostat closes and the power gating stops, thus increasing the average power dissipation and temperature. As the internal temperature decreases below 20°C, a second thermostat closes and supplies power to a 4.2 watt heater which is mounted on the HFE thermal control plate.

This same heater is used in the standby mode to provide 4.2 watts of power during periods when operational power to the HFE is turned Off. The standby mode power is controlled through the Power Distribution Unit.

Figure 3.7-3 is a diagrammatic representation of the power required by the HFE during normal operation in each science mode. Since the only monitor of power usage during system operation is the display of reserve power (CS-2, or CS-4) the transition between major power states will appear as approximately 110% of these changes due to power conversion losses.

3.7.6 HFE Science Data Interpretation

Interpretation of the display of HFE science data on the operational printout is somewhat different than for the other experiments. The accumulation rate for HFE science data is relatively slow. This coupled with the extensive computations performed on the telemetered parameters means that evaluation of individual sensor performance is determined at a much slower rate than on most ALSEP experiments. It is the intent of this section to describe the science data display only sufficiently to facilitate an operational evaluation of the values presented.

The computed science data is displayed under the special headings listed in Table 3.7-4. The range of values to be expected for these computed scientific parameters are listed in Table 3.7-5.

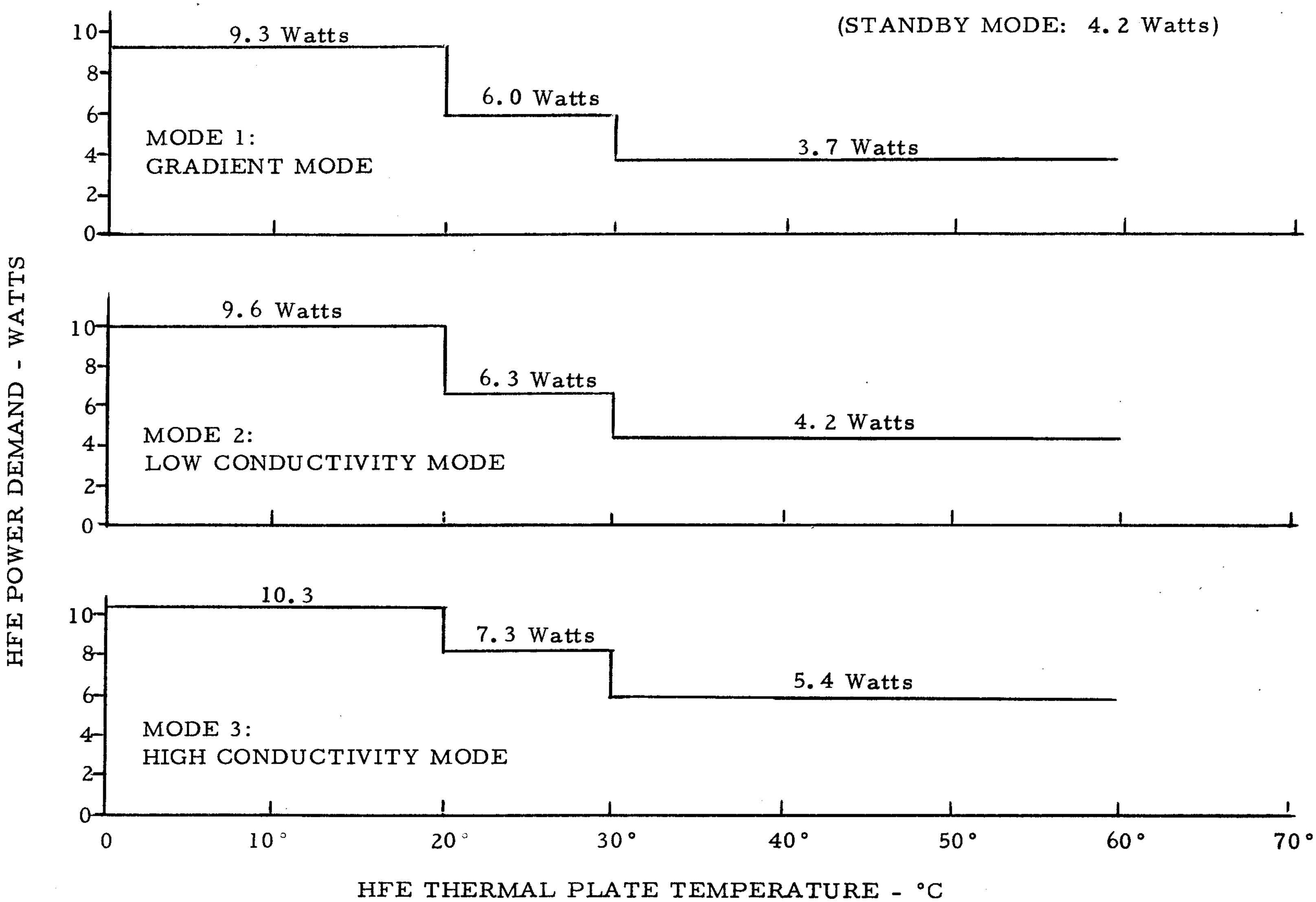


Figure 3.7-3 HFE Power Profile

TABLE 3.7-4

HFE SCIENCE DATA DISPLAY

Display Heading	Data Interpretation
MEAS.	For interpretation see Table 3.7-3
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 3.7-5

HFE COMPUTED SCIENTIFIC DATA

Meas.	Frame	DESCRIPTION	Normal Operating Range		Nominal	Red-Line Limits	
			Low	High		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)	278	328	----	273 (T)	333 (T)
TC	--	Thermocouples (°K)	90	350	----	----	----
GAIN	--	Amplifier Gain	994	1001	----	950	1050
OFFSET	--	Amplifier Offset	+.000004	+.000016	----	-.000100	+.000100

3.7.7 Apollo Lunar Surface Drill (ALSD)

The Apollo Lunar Surface Drill (ALSD), although not an ALSEP hardware item, is described here because it is part of the equipment complement for the Apollo 16 Mission and serves two experiments. First, as a necessary item of ancillary equipment for the Heat Flow Experiment, it provides the means by which the astronaut will drill two 1.125-inch diameter holes approximately eight feet deep into which the two HFE probes will be placed. Second, as part of the Lunar Geology Investigation, S-059, the ALSD will be used to drill a third hole, one inch in diameter, about eight feet deep and obtain a core sample of the lunar subsurface for return to the LRL and subsequent geological investigation.

The drill which will be employed to produce the lunar subsurface holes is a hand-held, battery powered, rotary-percussion drill. Drill specifications are shown in Table 3.7-6. The ALSD, two sets of fiberglass bore stems consisting of three sections per set and one set of core stems consisting of six sections are stowed for the outbound flight in the Modularized Equipment Stowage Assembly (MESA). During the inbound flight, the core stem assembly with core sample inside is returned in two pieces of three sections each to minimize disturbance of the core sample.

Emplacement of the HFE probes makes it necessary for the two sets of bore stems to remain in the bore holes, functioning as casings 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 a red diamond as shown in Figure 3.1-7. 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 3.7-7 for interpretation of the markings. An orange mark is painted on the emplacement tool covering P1 to designate nominal hole depth; another orange mark covering F1 indicates the nominal position for the radiation shield at the top of the probe.

In drilling the two HFE bore holes, the astronaut will couple the bore stem sections to the drill spindle and to each other using the threaded titanium couplings.

The core sample, a part of the Lunar Geology Investigation, is obtained by drilling the string of six titanium core stems approximately eight feet into the lunar subsurface and then removing the core string with the core sample inside.

An adapter is required between the drill spindle and the titanium core stem sections because the core stems are smaller in diameter than the bore stems. Once connected, this adapter remains locked onto the drill spindle. Each core stem has an acme thread at each end which directly matches the acme thread on the drill adapter. There are six titanium core stems in the set, one of which includes the open face drill bit. Each core stem, as well as each bore stem, is marked at the top end with a six-inch white band of paint. To remove the ALSD power head from the core stem sections or the bore stem sections, the astronaut will use the ALSD wrench.

When the core string has been drilled to an acceptable depth, the astronaut will hold up on the drill to prevent any further penetration and operate the drill for about ten seconds to clear the external flutes. Then the astronaut will pull out the core string manually. If this is not possible, the core extractor, a jack-like device stowed on the LRV, will be used to extract the core string.

The core string with core sample inside will be separated into two lengths of three sections each. The ends of the core stems will be capped and the two lengths packed in a special bag for return to the LRL.

If the drilling operations in the lunar subsurface are accomplished as anticipated, there will be about 50 percent of the battery's energy capacity remaining after all operations have been accomplished. The output of the ALSD battery is generally proportional to temperature so that, within limits, a higher battery power output results from a higher battery temperature. It is not feasible to allow the battery to rest and recover itself between each hold drilling operation because the amount of battery recovery per unit of time is near zero.

Voice communications from the astronaut are required so that MCC personnel can determine drill penetration rate, drilling progress, and estimate remaining battery capacity. As a minimum requirement, the astronaut should give time hacks for drill on and off times, report the type of drill resistance and any changes in drilling torque. He should also report periodically on drilling progress and drill penetration rate in terms of the number of stems completely or partially drilled into the subsurface.

TABLE 3.7-6(a)

APOLLO LUNAR SURFACE DRILL DATA

CHARACTERISTICS	VALUE
ALSD Total Weight	29.5 lbs.
ALSD Volume	7.0 x 9.6 x 22.7 in.
. 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 3.7-6(b)

APOLLO LUNAR SURFACE DRILL DATA (Continued)

CHARACTERISTICS	VALUE
. Core String Assembly	
Total Length - 6 Core Stems	100 inches
Core Stem Lengths	5 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 3.7-7

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

Middle Radiation Shield Depth

Probe Nominal Depth

SECTION 4

OPERATIONAL CONSTRAINTS AND LIMITATIONS

Under normal circumstances ALSEP Array D when properly deployed will perform as outlined in Section 3. As described in that Section, certain functions can be altered by ground command. This section contains information on certain deployment alternatives, the operational constraints on the use of the command link to modify equipment performance and the limitations in telemetered data.

4.1 DEPLOYMENT CONSTRAINTS

4.1.1 Thermal Effects

The performance of ALSEP Array D 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 9° south latitude in anticipation of deployment at Descartes. 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 Descartes is chosen for deployment of Array D, much of the information in Sections 3.1 and 3.2 would need to be reconsidered.

It is important to note that the off-equator deployment site causes the proper setting on a shadowgraph alignment device like that on the HFE electronics to be time-dependent. The alignment decal has been placed opposite the shadow angle expected at the nominal time of deployment. If this unit is aligned at any other time, consideration should be given to the fact that the shadow angle increases one degree each 10 hours. (See Sec. 4.1.3)

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 in the north-south direction, it tends to reduce the efficiency of the thermal radiating surfaces and to cause higher thermal plate temperatures. Figure 4.1-1 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.

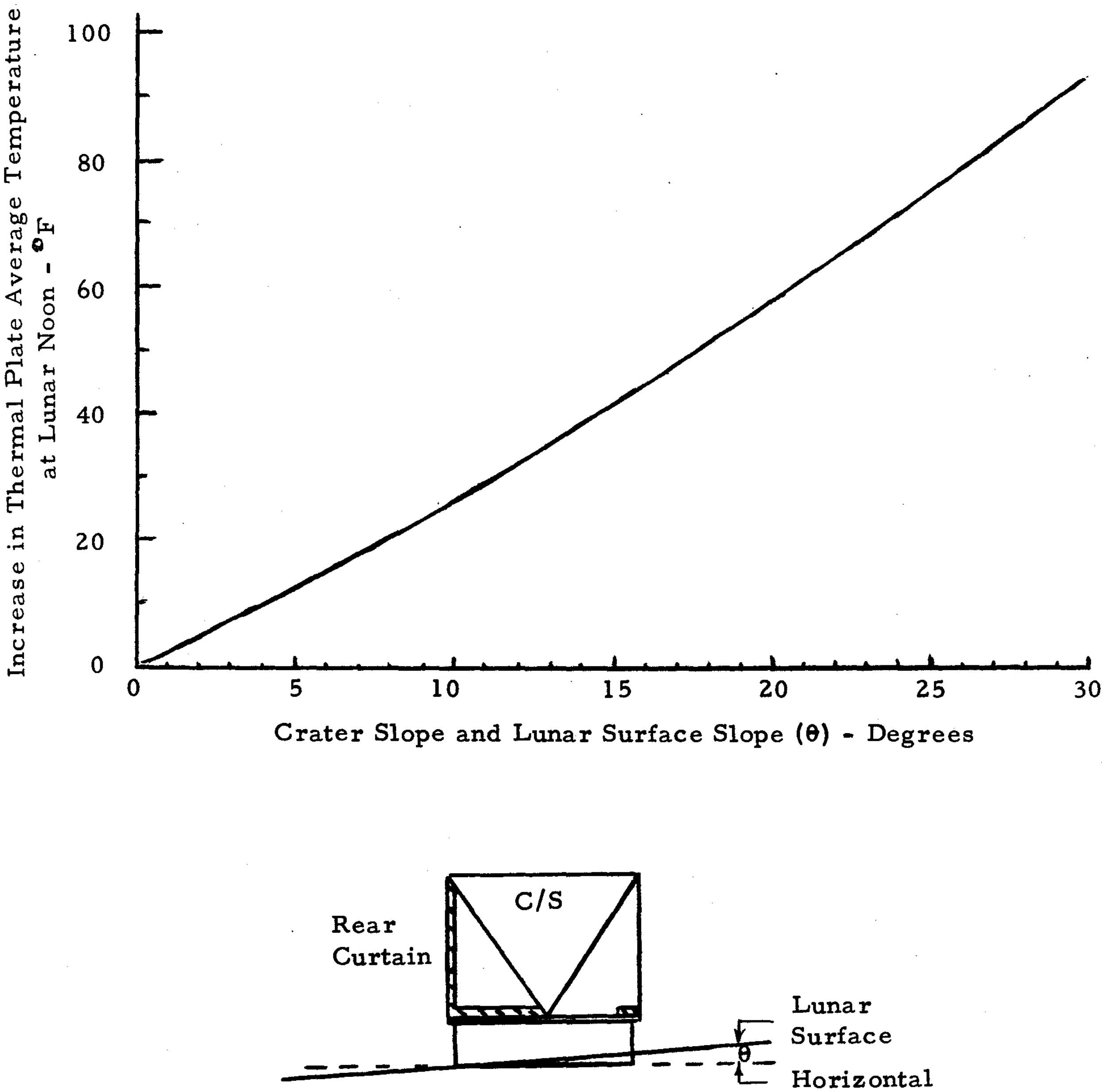


Figure 4.1-1 Effect of Surface Slope on Thermal Control

4.1.2 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 integrety, 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 25 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 45 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 4.7.3 .

4.1.3 Delayed Deployment Effects

Since the shadow direction is used to provide a secondary 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 Descartes site during the Apollo 16 lunar stay time (Figure 4.1-2).

The alignment decals described in Section 3.1 identify the positions of the gnomon shadows for proper alignment, if the shadowgraphs are used at the time presently designated for ALSEP deployment (03 hours GMT on 21 April 1972).

If the ALSEP deployment time is significantly delayed from nominal, the gnomon shadow should be aligned to the appropriate shadow angle indicated in Figure 4.1-2. The corresponding azimuth scale settings on the antenna aiming mechanism are also given in Figure 4.1-2.

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.

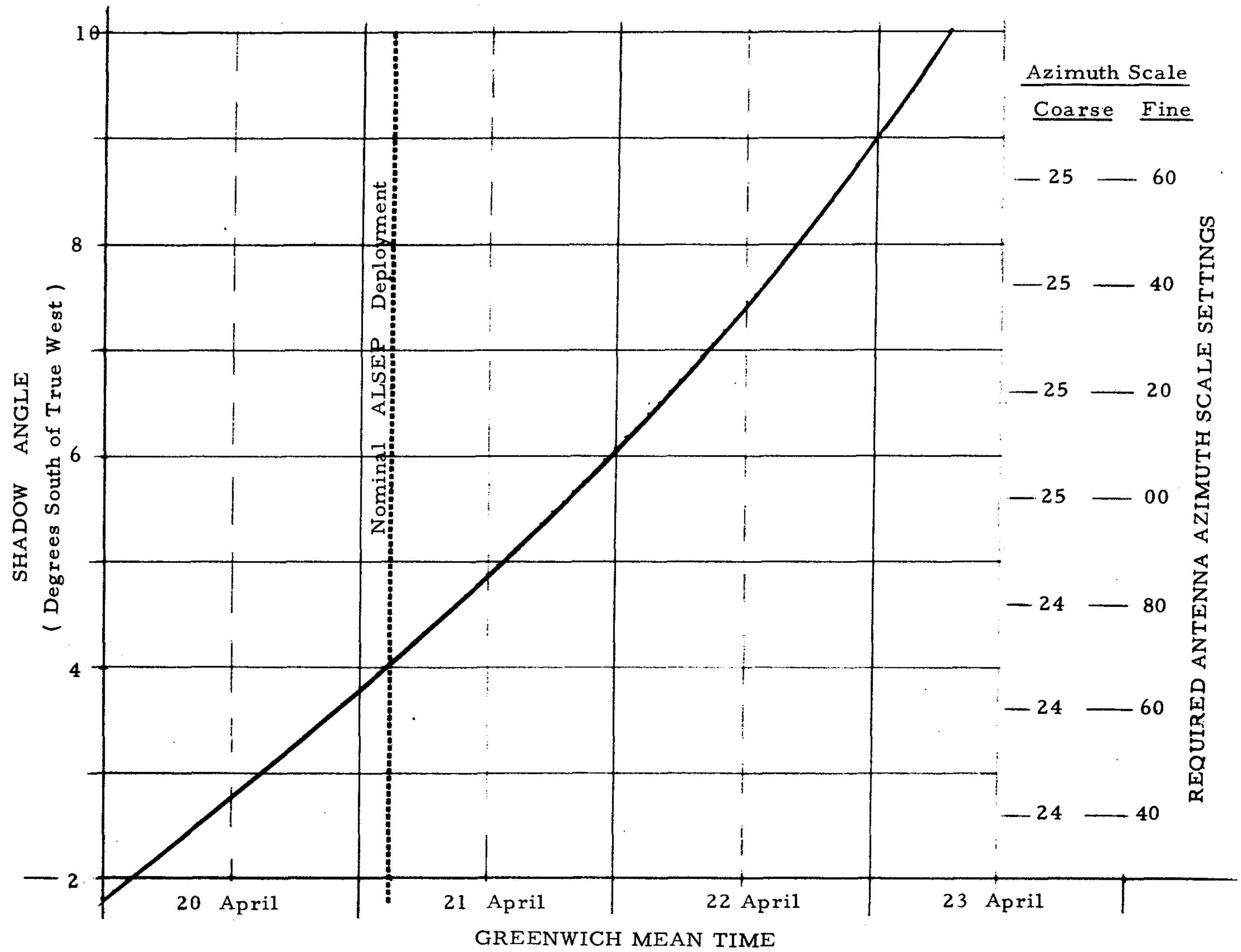


Figure 4.1-2 Shadow Angles at Array D Deployment

4.2 COMMAND CONSTRAINTS

4.2.1 Critical Commands

Certain functions of ALSEP Array D are purposely controllable in MCC but because of the impact they have on system performance the associated commands should be considered as CRITICAL. The commands listed in Table 4.2 should be considered critical for the reasons stated.

Extreme caution should be observed in commanding non-ASE functions while ALSEP is operating in High Data Rate mode.

4.2.2 Modification of Normal Operation by Commands

Only a limited number of measured engineering parameters can have their normal value, as stated in Section 3, modified deliberately by ground command, if conditions require it. Typical of those that can are the measurements from temperature sensors located near commandable heaters (see Table 3.3). Most commands which have a significant power change associated with their implementation (see Tables 3.3-1, 3.4-3 and 3.6-3) will cause some change in the temperature and reserve current measurements of the Power Conditioning Unit, and in the temperature of the Power Dissipation Module.

4.2.3 Command Redundancies

In consideration of the number of ALSEP systems in operation on the Moon, it is important to recognize that several commandable functions have different octal designations for the same function on different arrays. This is particularly evident in the power control commands to experiments, heaters, and power dumps. Caution must be exercised in selecting the octal command designation from the list of commandable functions pertinent to the system being addressed.

TABLE 4.2

CRITICAL COMMANDS

COMMAND No.	COMMAND Description	CRITICALITY
014	Transmitter OFF	• All telemetry data becomes inoperative
037	Exper. 1 Standby Power ON	• Suppresses all PSE data • When followed by 041, deactivates PSE thermal control
042	Exper. 2 Oper. Power ON	Critical during lunar night since Mortar Package thermal control is deactivated.
044	Exper. 2 Standby Power OFF	Critical during lunar night since Mortar Package thermal control is deactivated.
046	Exper. 3 Standby Power ON	• Suppresses all LSM data and deactivates its thermal control
007	Slow Bit Rate	• Makes LSM data unusable
053	Exper. 4 Standby Power ON	• Suppresses all HFE data • When followed by 054, deactivates its thermal control
060	PCU 1 Select	• Critical only if automatic switchover to PCU 2 has occurred.
127	Flip/Cal. Inhibit	• Overrides Delayed Command Sequencer function
133	Site Survey	• To be used after (and only after) 4 lunar surface flip/calibration sequences (131)
033	Timer Output Inhibit	• Not to be used unless time-actuated commands are not required

4.3 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. If one of these parameters should exceed its range of normal operation values, the system operators should alert the system performance analysts so that the implications on the condition may be determined.

To assist the operators in situations where an engineering parameter exceeds the stated "normal operation" limits, the measurement data tables in Section 3 identify three classes of "red-line" 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. <u>They do not imply</u> a condition of impending damage. <u>They do represent</u> 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.

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 alert the responsible authorities. Any corrective action to be taken under a particular situation will normally be defined in the Final Systems Mission Rules for ALSEP Array D.

4.4 PSE CONSTRAINTS AND LIMITATIONS

4.4.1 PSE Deployment Constraints

Proper deployment of the PSE is described in Figure 2-5 and Section 3.1.5. Since the lunar surface temperature near the seismic sensor strongly influences the sensor thermal stability, the proper deployment of the thermal shroud is important to the integrity of the tidal displacement measurements made by the seismometer.

4.4.2 PSE Thermal Constraints

The PSE shall operate at a preset mean temperature of 126° ±1°F. The thermal control subsystem will automatically control the PSE sensor temperature within the range of 124°F to 130°F. Normally, this is accomplished by the automatic PSE thermal control subsystem consisting essentially of a proportional heater and a superinsulating thermal shroud. The backup capability consists of manual and automatic command operation of the PSE heater. The maximum acceptable temperature range is ±18°F about the preset mean temperature. The sensor will not be permanently damaged if the measured temperature is at any value within the measurement range designated in Table 3.4-2. Heater power demand, in the Auto mode, is a function of the sensor temperature deviation from the set point. During deployment and initial operation, the sensor temperature is expected to be below the set point regardless of the solar angle. This will result in a maximum power demand of 10.5 watts to support the initial turn-on of the PSE.

The PSE sensor heater must be turned Off every time a leveling motor is activated. Only one leveling motor must be operated at a time. The order of leveling should always result in Z-axis leveling last in the sequence. A leveling motor should not be allowed to run past its stop.

If Command 037 is sent to put the PSE in Standby, then Command 076 will no longer control the sensor heater. Note that at no time does Command 076 control the heater for the PSE electronics module in the Central Station. The PSE must not be commanded Off during lunar night. Survival capability when non-operating is ensured in the Standby mode by activating a separate heating element.

The only red-line limits applicable to PSE data are the measurement limits for DL-7 which are 107.1°F to 142.9°F as listed in Table 3.4-2.

4.4.3 PSE Turn-On Constraints

The normal turn-on sequence for the PSE automatically puts certain command functions into a preset state. However, before leveling, the following prerequisite modes must be verified.

a. Feedback Filter: Out. (Command 101)
b. Coarse Level Sensor: In. (Command 102)
c. Level Mode: Automatic. (Command 103)
d. Thermal Control Mode and Status: AUTO/OFF (Command 076)
e. Reserve Power: Adequate per PSE Power Profile, Figure 3.4-1.

Note for mode (a) that the verification of Feedback Filter Out is a comparison of the long period seismic and long period tidal data on the recorders. However, if the PSE is initially off level, this check cannot be made.

Activation of the functional portion of the PSE may be delayed as long as 5 days after removal from the LM.

4.5 ASE CONSTRAINTS AND LIMITATIONS

4.5.1 ASE Deployment Constraints

Proper deployment of the ASE components is described in Section 3.1.6 Geophone data interpretation will be compromised by off-nominal deployment.

If it is not feasible to deploy the three geophones in a straight line, the crew should bring back a photograph of the line of geophones with some indication of direction.

If it is not possible to place the thumper within 1 foot of a white marker at the time of thumping, the crew should make a verbal report of the estimated distance.

Interpretation of the geophone data during the mortar mode depends on knowledge of location of the explosion relative to each geophone. The point of impact of each grenade is heavily dependent on the orientation of the mortar package at the time of grenade launch. This orientation will be precisely determined through analysis of close-up photographs of the mortar box as finally deployed (which should include some indication of shadow direction) and from the telemetered measurements of "pitch" and "roll" angles. These angle measurements are valid for deviations from nominal grenade launch angle up to 15 degrees. Hence leveling the Mortar Box so that the bubble level is "on-scale" (level within 5°) is necessary to ensure that the roll and pitch angle sensors are within their measurement ranges. Since the level of the Mortar Box is dictated by the level of the emplaced pallet, some care is needed in selecting a level area for deployment of the pallet.

4.5.2 ASE Operational Constraints

The grenades should not be fired if any one of the ASE temperature measurements AS-1, AS-2 or AS-3 are below -20°C (-4°F). Before commanding the ASE to Operate for any mode of operation, AS-1 should be above -20°C (-4°F). If AS-1 is -20°C, a minimum warm-up time of 12 minutes is required; at 30°C, 6 minutes are required; and at 60°C, 4 minutes are required.

Survival heater power for the Mortar Package Assembly is supplied only when the ASE is in Standby. Therefore, the ASE must be in Standby mode during lunar night when it is not operational.

During lunar night, if ASE temperature measurements AS-2 or AS-3 are below -20°C (-4°F) the ASE should not be commanded to Operate for the passive listening mode for longer than 30 minutes in any 10-hour period since switching the ASE from Standby to Operate removes survival heater power from the Mortar Package Assembly (MPA) heaters.

Roll Angle sensor measurement DS-6 and Pitch Angle sensor measurement DS-7 are calibrated as a function of GLA temperature AS-3; therefore, DS-6 and DS-7 must be corrected for temperature per the calibration data. Also, the Mortar Box Ground Monitor voltage measurement DS-5 must be subtracted from DS-6 and DS-7 readings to compensate for any voltage drop between the ASE electronics package in the Central Station and the MPA. In making actual range calculations, the roll and pitch angles must be corrected for true angles with respect to the GLA plane and to each launch tube.

4.6 LSM CONSTRAINTS AND LIMITATIONS

4.6.1 LSM Turn-On Constraints

The LSM will be commanded to perform a site survey sequence only once after the LSM is first put into operation on the lunar surface. The site survey must be preceded by exactly four Flip/Cal sequences. One Flip/Cal sequence should be performed prior to LM ascent.

There must be exactly four Flip/Calibrate cycles before a Site Survey is performed. The LSM Site Survey must not be performed while the astronauts are still on the lunar surface.

One of the delayed command functions initiated by the timer is LSM Flip/Calibrate which is triggered at 162 hours plus one minute and every 18 hours thereafter. This sequence can be initiated only after the Site Survey has been completed. Command 127, Flip/Cal Inhibit will prevent an execution of the delayed command if four Flip/Cal's have been completed but the Survey has not been completed.

4.6.2 LSM Operational Constraints

LSM data is not intelligible when the downlink telemetry data is transmitted at the low data rate of 530 bps.

Command 127, Flip/Cal Inhibit, must be considered highly critical because of the possibility of loss of uplink command capability. It is also important to recognize that use of Command 033 to inhibit the timer-initiated command sequences jeopardizes the automatic calibration of the LSM in the event of loss of command link.

The LSM does not have a Standby mode, only On and Off. Command 046 which turns the LSM Off should be given only in a contingency situation. If the LSM is commanded Off and its temperature drops as low as -50°C, the LSM may be permanently disabled. The LSM has no Standby/Survival heater and will not survive the effects of lunar night temperatures.

Red-line limits for LSM engineering analog measurements are shown in Table 3.6-1.

4.7 HFE CONSTRAINTS AND LIMITATIONS

4.7.1 HFE Deployment Constraints

Normal deployment of the HFE is described in Section 3.1.8.

4.7.2 HFE Operational Constraints

The temperature of the electronics package must be maintained between 273° and 333°K. 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 5.3-6 for heater sequence.

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

Whenever the high conductivity mode, Mode 3, is desired, Command 140, 144 and 142 must be sent.

The red-line limits for the analog engineering measurements are listed in Table 3.7-1.

4.7.3 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 4.7-1 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 21 Apr 17 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 4.7-2 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.

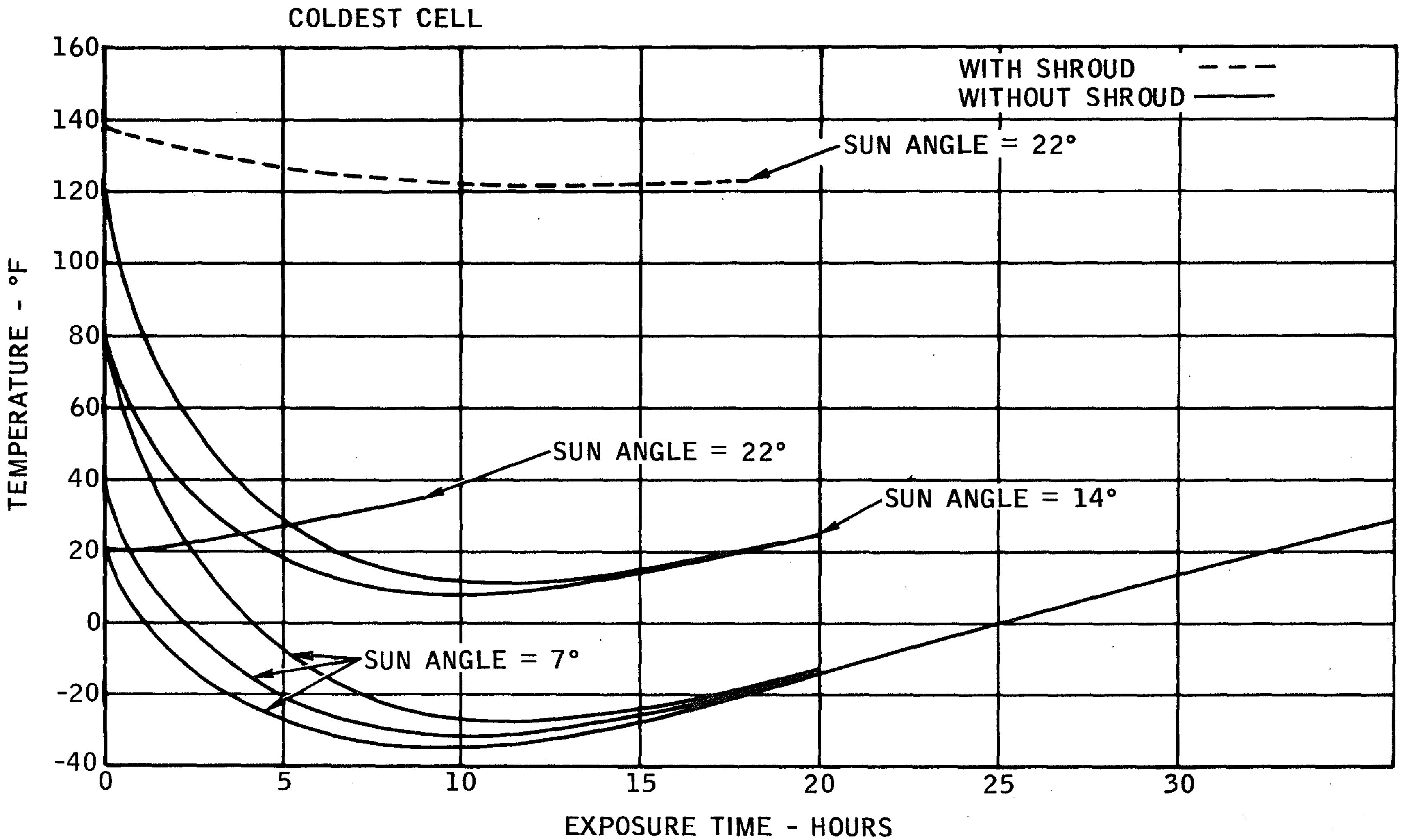


Figure 4.7-1 ALSD Battery Temperature Forecast

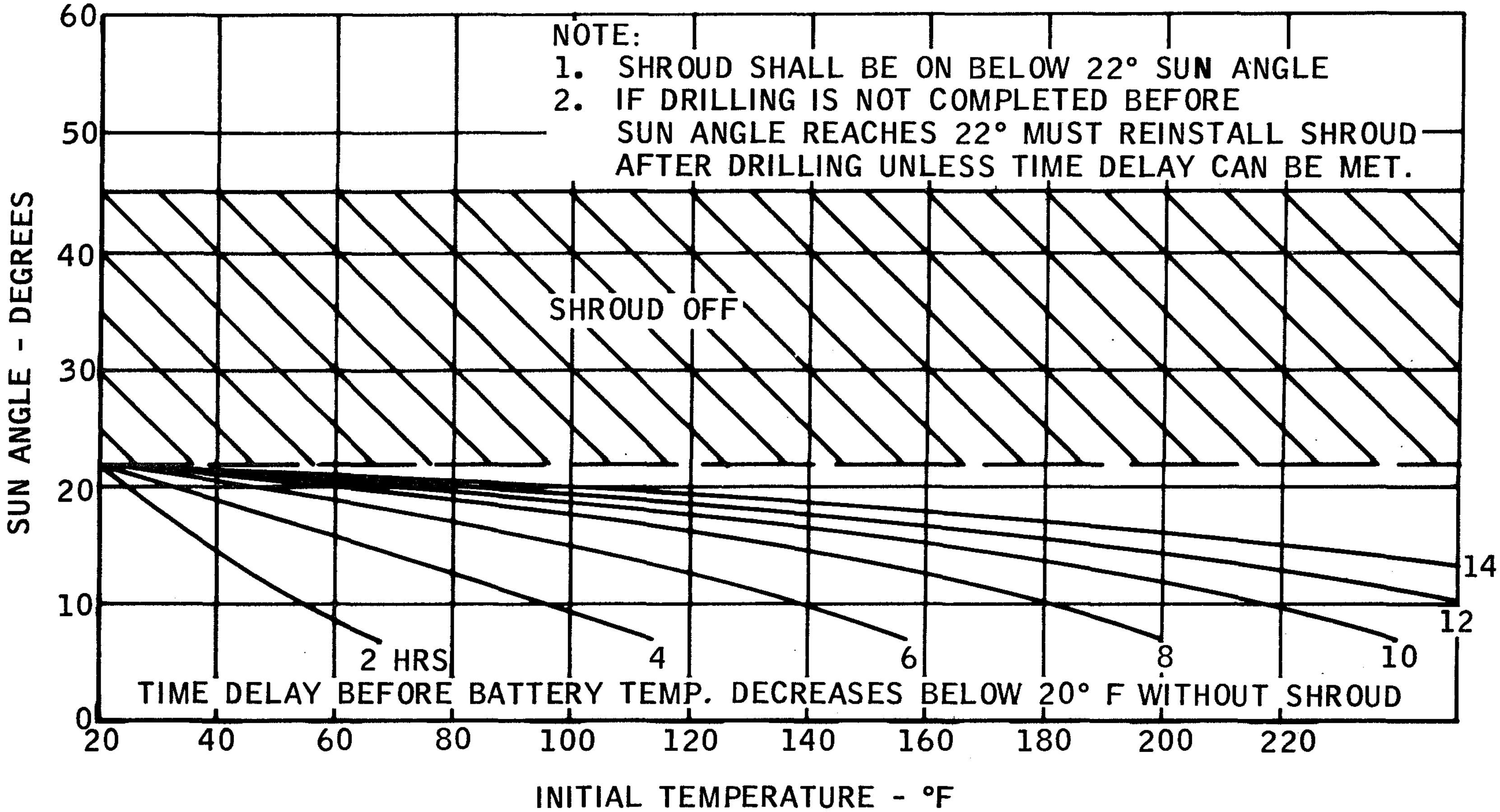


Figure 4.7-2 Effect of ALSD Thermal Shroud

SECTION 5

ALSEP ARRAY D COMMAND DESCRIPTIONS

5.1 COMMAND SUMMARY

There are a total of 77 different command signals which can be decoded by Array D to initiate functional changes in the operating mode of the system. These command signals control functions distributed throughout the equipment as shown in Table 5.1.

5.2 COMMAND DISTRIBUTION

The command signals for Array D, including assigned terminology and termination points, are listed in Table 5.2.

5.3 COMMAND DESCRIPTIONS

The functional changes initiated by the above command signals are described in the following tables:

Table 5.3-1	Central Station Command Descriptions
Table 5.3-2	Passive Seismic Experiment Command Descriptions
Table 5.3-3	Active Seismic Experiment Command Descriptions
Table 5.3-4	Lunar Surface Magnetometer Command Descriptions
Table 5.3-5	Heat Flow Experiment Command Descriptions
Table 5.3-6	Detailed Description of Command 152 - HFE Heater Sequence

TABLE 5.1

COMMAND SUMMARY

ARRAY D EQUIPMENT	NO. OF COMMANDS
Data Processor	5
Power Distribution Unit (Power Switching)	27
Power Conditioning Unit	2
Command Decoder	2
Timer	1
Passive Seismic Experiment	15
Active Seismic Experiment	7
Magnetometer	8
Heat Flow Experiment	10
TOTAL	77

FUNCTION	OCTAL CODE	NUMBER
Test Commands	1, 2, 4, 10, 20, 40, 100, 77, 137, 157, 167, 173, 175, 176	14
Addresses/Complements		20
No Command	0, 177	2
Commands assigned (Arrays A, C, A2, D)		94
Commands not presently assigned	154, 155, 160, 171, 172, 174	6

	For ALSEP on Apollo				
	12	14	15	16	17
Addresses	130/30	25/65	116/16	62/144	151/51
Address Complements	47/147	152/112	61/161	115/33	26/126

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

TABLE 5.2 (a)

COMMAND DISTRIBUTION

Octal Command	Symbol	Command Nomenclature
Data Processor		
003	CD-31	ASE High Bit Rate ON
005	CD-32	ASE High Bit Rate OFF
006	CD-33	Normal Bit Rate
007	CD-34	Slow Bit Rate
011	CD-35	Normal Bit Rate Reset
Power Dist. Unit		
012	CD-1	Transmitter "A" Select
013	CD-2	Transmitter ON
014	CD-3	Transmitter OFF
015	CD-4	Transmitter "B" Select
017	CD-5	PDR #1 ON
021	CD-6	PDR #1 OFF
022	CD-7	PDR #2 ON
023	CD-8	PDR #2 OFF
024	CD-9	DSS HTR 3 ON
025	CD-10	DSS HTR 3 OFF
034	CD-11	Data Processor "X" Select
035	CD-12	Data Processor "Y" Select
036	CD-13	Experiment 1 Operational Power ON
037	CD-14	Experiment 1 Standby Power
041	CD-15	Experiment 1 Standby OFF
042	CD-16	Experiment 2 Operational Power ON
043	CD-17	Experiment 2 Standby Power
044	CD-18	Experiment 2 Standby OFF
045	CD-19	Experiment 3 Operational Power ON
046	CD-20	Experiment 3 Standby Power
050	CD-21	Experiment 3 Standby OFF
052	CD-22	Experiment 4 Operational Power ON
053	CD-23	Experiment 4 Standby Power
054	CD-24	Experiment 4 Standby OFF
055	CD-25	DSS HTR 1 Select (10w)
056	CD-26	DSS HTR 2 Select (5w)
057	CD-27	DSS HTR 2 OFF

TABLE 5.2 (b)

Octal Command	Symbol	Command Nomenclature
Timer		
150	CR-1	Timer Reset
Command Decoder		
032	CD-36	Timer Output Accept
033	CD-37	Timer Output Inhibit
Power Cond. Unit		
060	CU-1	PCU #1 Select
062	CU-2	PCU #2 Select
Passive Seismic Exp.		
063	CL-1	Gain Change LPX, LPY
064	CL-2	Gain Change LPZ
065	CL-3	Calibration SP ON/OFF
066	CL-4	Calibration LP ON/OFF
067	CL-5	Gain Change SPZ
070	CL-6	Leveling Power X Motor ON/OFF
071	CL-7	Leveling Power Y Motor ON/OFF
072	CL-8	Leveling Power Z Motor ON/OFF
073	CL-9	Uncage Arm/Fire
074	CL-10	Leveling Direction Plus/Minus
075	CL-11	Leveling Speed Low/High
076	CL-12	Thermal Control Mode Auto/Manual
101	CL-13	Feedback Filter IN/OUT
102	CL-14	Coarse Level Sensor IN/OUT
103	CL-15	Leveling Mode Auto/Manual

TABLE 5.2 (c)

Octal Command	Symbol	Command Nomenclature
LSM Experiment		
123	CM-1	LSM Range Select
124	CM-2	Steady Field Offset
125	CM-3	Steady Field Address
127	CM-4	Flip/Cal Inhibit In/Out
131	CM-5	Flip/Cal Initiate
132	CM-6	LSM Filter (In/Out)
133	CM-7	Site Survey
134	CM-8	Temperature Control
Heat Flow Experiment		
135	CH-1	Normal (Gradient) Mode Select
136	CH-2	Low Conductivity Mode Select
140	CH-3	High Conductivity Mode Select
141	CH-4	HF Full Sequence Select
142	CH-5	HF Probe #1 Sequence Select
143	CH-6	HF Probe #2 Sequence Select
144	CH-7	HF Subsequence #1
145	CH-8	HF Subsequence #2
146	CH-9	HF Subsequence #3
152	CH-10	HF Heater Advance
Active Seismic Exp.		
156	CS-1	Geophone Calibrate
162	CS-3	ASE Grenade Sequential Single Fire
163	CS-4	ASE Grenade #1 Fire
164	CS-5	ASE Grenade #2 Fire
165	CS-6	ASE Grenade #3 Fire
166	CS-7	ASE Grenade #4 Fire
170	CS-8	Arm Grenade

TABLE 5.3-1 (a)

CENTRAL STATION COMMAND DESCRIPTIONS

Octal Command Number	Command Title	Command Description
003	High Data Rate On	Activates High Data Rate mode. (See Table 3.0-1). ASE must be in Operate mode for any measurements to be provided. Data rate: 10,600 bits per second.
005	High Bit Rate Off	If the Data Processor is in the high bit rate, this command returns the Data Processor to the rate last selected by 006 or 007. Preset mode.
006	Normal Bit Rate	Sets Data Processor to 1060 bps, normal bit rate, at the end of the word frame in progress, if in low bit rate. Preset condition.
007	Low Bit Rate	Sets Data Processor to 530 bps, low bit rate, at the end of the word frame in progress, if in normal bit rate.
011	Normal Bit Rate Reset	Resets Data Processor to 1060 bps normal bit rate, from either the high or low bit rate. Command is effective immediately, not delayed until the end of the word frame in progress. May cause "sync-loss" at MSFN ground station or error in command verification word.

TABLE 5.3-1 (b)

CENTRAL STATION COMMAND DESCRIPTIONS (CONT.)

Octal Command Number	Command Title	Command Description
012	Transmitter A Select	Selects Transmitter A. Preset condition.
013	Transmitter On	Turns selected Transmitter On and turns Transmitter heater Off. Preset condition. This command is effective regardless of the state of the transmitter turn-off event from the Timer.
014	Transmitter Off	Turns selected Transmitter Off and turns Transmitter heater On.
015	Transmitter B Select	Selects Transmitter B.
017	Power Dissipation Resistor #1 On	Applies power to 7-watt power dissipator on back of Central Station frame.
021	Power Dissipation Resistor #1 Off	Removes power from 7-watt power dissipator. Initial Condition.
022	Power Dissipation Resistor #2 On	Applies power to 14-watt power dissipator.
023	Power Dissipation Resistor #2 Off	Removes power from 14- watt power dissipator. Initial condition.
024	Data Subsystem Heater #3 On	Applies power to 10-watt thermo-statically-controlled heater for thermal support at temperatures below -10°F. Initial condition.

TABLE 5.3-1 (c)

CENTRAL STATION COMMAND DESCRIPTIONS (CONT.)

Octal Command Number	Command Title	Command Description
025	Data Subsystem Heater #3 Off	Removes power from thermostatically-controlled, 10-watt heater
032	Timer Output Accept	Enables the 18-hour and 1-minute timer pulses at the input to the Delayed Command Sequencer (Fig. 3.3-1). Initial condition.
033	Timer Output Inhibit	Inhibits the 18-hour and 1-minute timer output pulses, thus inhibiting the Delayed Command Sequencer. This command must be considered critical for the first 150 hours of ALSEP operation (see Table 4.2).
034	Data Processor X Select	Applies power to Data Processor X and selects Normal Data Rate mode. Removes power from Data Processor Y. Transmission of Command 034 may cause loss of sync or error in Command Verification Word. Preset condition.
035	Data Processor Y Select	Applies power to Data Processor Y and selects Normal Data Rate mode.
036	PSE Operational Power On	Applies operational power to PSE electronics and sensor.
037	PSE Standby Power On	Deactivates PSE. Applies power to PSE Standby heaters in Central Station and PSE sensor. Preflight condition.

TABLE 5.3-1 (d)

CENTRAL STATION COMMAND DESCRIPTIONS (CONT.)

Octal Command Number	Command Title	Command Description
041	PSE Standby Off	Removes power from both PSE Standby heaters in Central Station and sensor assembly. Command 041 has no effect if PSE is On. Command 037 must be sent first.
042	ASE Operational Power On	Applies operational power to ASE. Deactivates heaters in Mortar Package.
043	ASE Standby Power On	Deactivates ASE. Activates heaters in Mortar Package. Initial condition.
044	ASE Standby Off	Removes all power from ASE. Command 044 has no effect if ASE is On.
045	LSM Operational Power On	Applies operational and thermal control power to LSM.
046	LSM Standby Power On	Deactivates LSM completely. Initial condition.
050	LSM Standby Off	Has no effect if LSM is in Operate mode.
052	HFE Operational Power On	Applies operational power to HFE.
053	HFE Standby Power On	Deactivated HFE; activates HFE Standby Heater. Initial condition.

TABLE 5.3-1 (e)

CENTRAL STATION COMMAND DESCRIPTIONS (CONT.)

Octal Command Number	Command Title	Command Description
054	HFE Standby Off	Removes all power from HFE. Has no effect if HFE is in Operate mode.
055	DSS Htr. 1 On	Applies power to Htr. 1 (10-watts)
056	DSS Htr. 2 On	Applies power to Htr. 2 (5-watts)
057	DSS Htr. 2 Off	Removes power from Htr. 2. Has no effect if Htr. 1 is On.
060	PCU 1 Select	Applies power to PCU 1 and de-energizes PCU 2. If automatic switchover to PCU 2 has occurred, this command is highly critical. Preset condition.
062	PCU 2 Select	Applies power to PCU 2 and de-energizes PCU 1. This function is to be selected only during contingency operations.

TABLE 5. 3-2 (a)

PASSIVE SEISMIC EXPERIMENT COMMAND DESCRIPTIONS

Octal Command Number	Command Title	Command Description
063	Gain Change: Long Period - X and Y	Four-state command to alter sensitivity of PSE LP-X and LP-Y signals. Stepping sequence is -30, 0, -10, -20 db. Preset to -30 db.
064	Gain Change: Long Period - Z	Four-state command to alter sensitivity of PSE LP-Z signals. Stepping sequence is -30, 0, -10, -20 db. Preset to -30 db.
065	Calibration: Short Period - On/Off	Two-state command to turn the Short Period Calibration circuit On or Off. Preset to Off. (See CMD 073).
066	Calibration: Long Period - On/Off	Two-state command to turn the Long Period Calibration Circuit On or Off. Preset to Off.
067	Gain Change: Short Period - Z	Four-state command to alter sensitivity of SP-Z signals. Stepping sequence is -30, 0, -10, -20 db. Preset to -30 db.
070	Leveling Power: X-Motor On/Off	Two-state command turns X-axis motor On or Off. Only one level motor must be operated at a time. Preset Off.
071	Leveling Power : Y-Motor On/Off	Two-state command turns Y-axis motor On or Off. Only one level motor must be operated at a time. Preset Off.

TABLE 5.3-2 (b)

PASSIVE SEISMIC EXPERIMENT COMMAND DESCRIPTIONS (CONT.)

Octal Command Number	Command Title	Command Description
072	Leveling Power : Z-Motor On/Off	Two-state command turns Z-axis motor On or Off. Only one level motor must be operated at a time. Preset Off.
073	Uncage Arm/Fire	Two-state command. First transmission arms PSE actuator circuit. Second transmission fires actuator circuit and uncages all spring mass systems.
074	Level Direction : Plus or Minus	Two-state command to control direction of rotation of X-axis, Y-axis and Z-axis leveling motors. Preset to Plus.
075	Level Speed: Low/High	Two-state command to control speed of X-axis, Y-axis and Z-axis leveling motors. Preset to Low.
076	Thermal Control Mode: Auto/Manual	Four-state command. Sequentially steps through the following modes to control the PSE sensor heater: (a) Auto On: +29 volts is applied to heater; thermostat control is enabled. (b) Auto Off: +29 volts is removed from heater.

TABLE 5.3-2 (c)

PASSIVE SEISMIC EXPERIMENT COMMAND DESCRIPTIONS (CONT.)

Octal Command Number	Command Title	Command Description
076	Thermal Control Mode: Auto/Manual (Cont.)	(c) Manual On: +29 volts is applied to heater; thermostat control is by-passed. (d) Manual Off: +29 volts is removed from heater. Preset to Auto On. Has no effect when the PSE is in Standby.
101	Feedback Filter In/Out	Two-state command inserts or removes feedback loop filters from LP-X, LP-Y and LP-Z axes. Preset to Filter Out.
102	Coarse Level Sensor	Two-state command inserts or removes coarse level sensors controlling X-axis and Y-axis leveling motors. Preset to Sensor Out.
103	Leveling Mode: Auto/ Manual	Two-state command, controls the operational mode of the X-axis, Y-axis and Z-axis leveling motors. Preset to Automatic Leveling.

TABLE 5.3-3

ACTIVE SEISMIC EXPERIMENT COMMAND DESCRIPTIONS

Octal Command Number	Command Title	Command Description
156	Geophone Calibrate	Initiates the ASE geophone calibrate mode which lasts approximately 1 second. ASE reverts to normal operational mode when calibration is complete.
162	Grenade Sequential Fire	4-state command, always following CMD 170, to fire grenades in sequence 2-4-3-1.
163	Grenade #1 Fire	Fires grenade #1 (5,000-ft range)
164	Grenade #2 Fire	Fires grenade #2 (3000-ft range)
165	Grenade #3 Fire	Fires grenade #3 (1000-ft range)
166	Grenade #4 Fire	Fires grenade #4 (500-ft range)
170	Arm Grenades	Arms all grenades. Arm condition will be maintained permanently until a grenade is fired or ASE is disarmed. Disarm is accomplished by CMD 043 (ASE Standby).

TABLE 5.3-4 (a)

LUNAR SURFACE MAGNETOMETER COMMAND DESCRIPTIONS

Octal Command Number	Command Title	Command Description
123	LSM Range Select	Three-state command to alter sensitivity of LSM signals. Sequentially steps through three ranges: ± 200, ± 50 and ± 100 gammas full scale. Preflight range selection: ± 200 gammas.
124	Steady Field Offset	Seven-state command to control field offset of X-, Y- and Z-axis sensors by stepping through a sequence of the following seven values at one step per command: 0, +25, +50, +75, -75, -50, and -25 percent of full scale. Preset to 0 percent.
125	Steady Field Offset Address	Selects axis to which above offset command is directed. Stepping sequence is: Neutral, X-axis, Y-axis and Z-axis. Preset to the Neutral.
127	Flip/Cal Inhibit In/Out	Used to prevent inadvertent execution of the LSM Flip/Calibrate sequence (e.g., by the Delayed Command Sequencer). Command activates one of two states, Inhibit or Enable. Preset to Inhibit. Command is highly critical because of the posibility of Uplink loss.
131	Flip/Cal Initiate	Initiates the Flip/Cal Cycle. LSM returns to the normal scientific mode after Flip/Cal sequence has been completed.

TABLE 5.3-4 (b)

LUNAR SURFACE MAGNETOMETER COMMAND DESCRIPTIONS (CONT.)

Octal Command Number	Command Title	Command Description
132	LSM Filter In/Out	Two-state command to insert or remove digital filter. Preset condition: Filter In.
133	LSM Site Survey	Three-state command to initiate Site Survey sequence generator. Stepping sequence X-, Y-, and Z-axis survey. Preset to X-axis survey.
134	Temperature Control	Three-state command to select LSM thermal control sensor. Selection sequence: X, Y and Off. In the Off position, sensor heater power is removed. Preset to the X-axis thermostat.

TABLE 5.3-5 (a)

HFE COMMAND DETAILS

Octal Command Number	Command Title	Command Description
135	HFE Mode 1 Sel	Places the HFE in the normal (gradient) mode of operation in which measurements are obtained from the gradient sensors, 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. (See Section 3.7.4.)
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, or heat pulse, mode allowing heaters to be activated by CMD 152.

TABLE 5.3-5 (b)

HFE COMMAND DETAILS (CONT.)

Octal Command Number	Command Title	Command Description
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 & 2 causes HFE to provide probe 2 measurements only. The result of this CMD sent during Mode 3 will not be evident until return to Mode 1 or 2.
144	HFE Load 1	Used alone in Modes 1 & 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.

TABLE 5.3-5 (c)

HFE COMMAND DETAILS (CONT.)

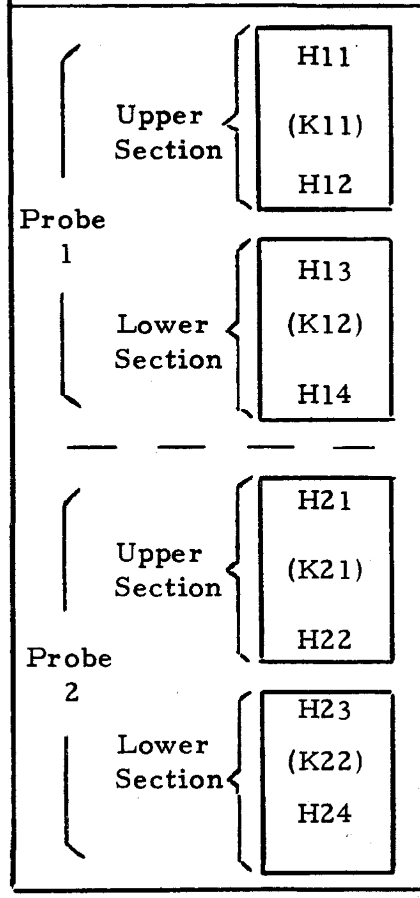
Octal Command Number	Command Title	Command Description
145	HFE Load 2	This is a 1-state command used in combination with either CMD 144 (Preceding 145) or CMD 146 (preceding or following 145) to program the MSP. As stated above, 144-145 yields low sensitivity differential temperature data only. CMDs 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 & 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 the sequence listed in Table 5.3-6. The excitation applied to the selected heater is dependent on the operational mode of the HFE.

TABLE 5.3-6

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



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 high sensitivity ambient temperature (T); on the selected bridge only.

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