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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO LUNAR SURFACE EXPERIMENTS PACKAGE SYSTEMS HANDBOOK

ALSEP 3

JANUARY 6, 1970

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PREPARED BY

FLIGHT CONTROL DIVISION

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MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

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PREFACE

This document has been prepared by the Flight Control Division, Manned Spacecraft Center, Houston, Texas. Information contained within this document represents the Apollo Lunar Surface Experiments Package (ALSEP) Systems Handbook as of January 6, 1970.

This document is intended for specialized use by Experiment Flight Controllers in real-time and near-real-time operations. This document, in conjunction with the ALSEP Familiarization Handbook, ALSEP MT-03, Rev B, will provide the Experiment Flight Controller with a thorough knowledge of ALSEP 3.

Comments regarding this handbook should be directed to the Lunar Surface Experiments Section of the Experiments Systems Branch. Revisions will be issued as required prior to the flight date.

Approved by:

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Chief, Experiments Systems Branch

for Melvin F. Brooks

Eugene F. Kranz
Chief, Flight Control Division

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INTRODUCTORY INFORMATION

1.1 ALSEP'S 1, 3, AND 4 ABBREVIATIONS AND ACRONYMS

NOTE

Due to reduction requirements, acronyms which would normally be in lower case, for example, "dc," will appear in upper case on drawings. The text will, however, conform to NASA standards.

ac	alternating current
ACCPT	accept
ACK	acknowledge
A/DC	analog-to-digital converter
Adc	amperes dc
ADD	address
AGC	automatic gain control
ALIGN	alignment
ALSEP	Apollo Lunar Surface Experiments Package
A/F	automatic/forced
AMPS	amperes
ANT	antenna
APP	approximate, approximately
ARM	armed
ASC	ascent
ASE	Active Seismic Experiment
AUTO	automatic
AZ	azimuth
B1	bottom location of structure temperature
BAS	base
BER	bit error rate
BPS	bits per second
C	centigrade
CAL	calibrate
CALC	calculated
CB	circuit breaker
CBL	cable
CCGE	Cold Cathode Gage Experiment (part of SIDE on ALSEP 1 and 4, separate MSC experiment on ALSEP 3)
CCGE/A, CCGE/D	analog and digital ID readout from CCGE
CCIG	Cold Cathode Ion Gage (instrument portion of CCGE)
CCW	counterclockwise
CH	channel
CH	change
CHAN	Channeltron; used in CPE as: CHAN/1 Channeltron P/S #1 CHAN/2 Channeltron P/S #2 CHAN/HI Channeltron Voltage Increase ON CHAN/LO Channeltron Voltage Increase OFF
CLD	cold
CMD	command
CNT	count

CNTS	counts
CNTR	counter
COMM	communications
CONV	converter
CPLEE or CPE	Charged-Particle Experiment (full name is Charged-Particle Lunar Environment Experiment)
CPS	cycles per second
CS	central station
CTL	control
CUR	current
CVR	cover
CVR/S	cover and seal (used on SIDE)
CVW	command verification word
CW	clockwise
db	decibels
dbm	decibels with respect to one milliwatt
dc	direct current
DEC	decoder
DECR	decrease
DEF	deflection
DEG	degrees
DESC	descent
DET	detector
DIG	digital
DIR	direction
DIR/V	direction and speed (used on PSE)
DISSIP	dissipation
DLAY	delay
D/P	data processor
DPLY	deploy
DRT	dome removal tool
DSS	Data Subsystem; components include: DSS/A Analog Data Processor DSS/D Digital Data Processor DSS/PROC Complete Data Processor (Redundant)
EGFU	Electronics/Gimbal-Flip Unit
ENBL	enable
EPS	Electrical Power System
eV	electron volts
EXP	experiment
EXT	external
F	fuse
F	Fahrenheit
FET	field effect transistor
FILT	filter
FLD	field
FREQ	frequency
FTT	fuel transfer tool
FWD	forward

GDT	gradient sensor delta temperatures (HFE)
GEO	geophone
GLA	Grenade Launch Assembly (a component of ASE)
GMBL	gimbal
GND	ground
GT	gradient sensor ambient temperatures (HFE)
HBR	high bit rate
HECPA	High-Energy Curved Plate Analyzer (a component of SIDE)
HFE	Heat Flow Experiment
HI	high
HTR	heater: On HFE there are two cases: HTR/HK High Conductivity Heater HTR/LK Low Conductivity Heater
HT/S	heat sink
HV	high voltage
Hz	hertz
ID	identification
IN	input
INCR	increase
IND	indication
INHIB	inhibit
INIT	initiate
INST	instrument
INSUL	insulation
INT	internal
K	Kelvin
kc	kilocycles
kHz	kilohertz
kV	kilovolts
LAT	latitude
LBR	low bit rate
LECPA	Low-Energy Curved Plate Analyzer (a component of SIDE)
LIM	limit
LM	Lunar Module
LO	low
LONG	longitude
L/O	local oscillator
LOS	loss of signal
LP	long period (PSE sensors)
LSB	least significant bit
LSD	least significant data
LSM	Lunar Surface Magnetometer
LVL	level

mA	milliampere
mAdc	milliamperes dc
MAP	message acceptance pulse
MAX	maximum
Mc	megacycle
MCC	Mission Control Center
MDE	mode
MEAS	measurement
MeV	million electron volts
MHz	megahertz
MIN	minimum
MOCR	Mission Operations Control Room
MOD	module
MODE	operating modes are defined as follows: For HFE MODE/G gradient mode MODE/HK high conductivity mode MODE/LK low conductivity mode
ms	millisecond
MSB	most significant bit
MSD	most significant data
MSFN	Manned Space Flight Network
MTR	motor; on PSE, the three motors are MTRX, MTRY, and MTRZ
MUX	multiplex
mV	millivolts
mW/cm^2	milliwatts per square centimeter
nA	nanoamperes
N/A	not applicable
NEG	negative
NORM	normal
NRZC	Non-Return to Zero Type C (Change)
OPER	operate
O/S	offset
OSC	oscillator
O/T	one-time
OUT	output
PA	power amplifier
pA	picoamperes
PCM	pulse code modulation
PCT	percent
PCU	Power Conditioning Unit
PDR	power dissipation resistor
PDU	Power Distribution Unit
PET	package elapsed time
PHYS	physical; on CPE used as follows: PHYS/AN Physical Analyzer (sensor assembly)
PKG	package

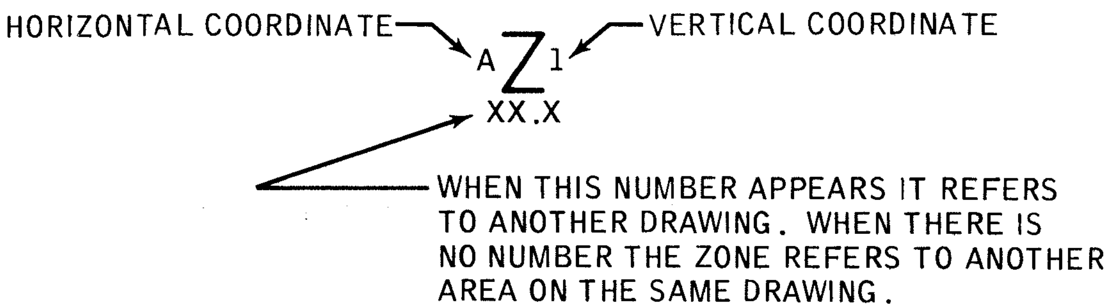
PL	plane
PLT	plate
PM	phase modulation
POS	positive
POSN	position
PRE/LIM	pre-limiting
PRE/REG	pre-regulator (a component of the SIDE power supply)
PRI	primary; on ALSEP used as follows: PRI/ST primary structure
P/S	power supply
PSE	Passive Seismic Experiment; also: PSE/LP long period sensors PSE/SP short period sensors PSE/LP/SP long and short period sensors Long period sensors are further defined as PSE/X, PSE/Y, and PSE/Z while PSE/XY denotes the two horizontal long period sensors
PWR	power
R	resistor (used as R1 and R2)
RCVD	received
RCVR	receiver
RDT	ring sensor delta temperature (HFE)
REF	reference
REG	regulator (also used as "register" on ALSEP)
REV	reverse
RF	radio frequency
RLY	relay
R/S	remote site
RST	reset
RT	rate (as in BIT RT, CNT RT, etc.)
RT	ring sensor ambient temperatures (HFE)
RTC	real-time command
RTG	Radioisotope Thermoelectric Generator
SCI	scientific
SEC	second
SEL	select
SEQ	sequence, sequential; used on HFE as: SEQ/FUL Full Sequence SEQ/P1 Probe 1 Sequence SEQ/P2 Probe 2 Sequence Used on ASE as: SEQ/S Sequential Single
SEQ	scientific equipment
SIDE	Suprathermal Ion Detector Experiment; also: SIDE/A, SIDE/D analog and digital voltages or readings SIDE/HE high-energy analog data SIDE/LE low-energy analog data SIDE/LHE least significant high-energy digital data SIDE/LLE least significant low-energy digital data

	SIDE/MHE most significant high-energy digital data
	SIDE/MLE most significant low-energy digital data
SIG	signal
SLA	Spacecraft Lunar Module Adapter
SNSR	sensor
SP	short period (PSE sensor)
SPST	single pole single throw
STA	status
STBY	standby
S/S	samples per second, signal strength
SWS	Solar Wind Spectrometer
SYNC	synchronization
SW	switch
SUP	supply
SYS	system
T	temperature (also used as "thermal" on ALSEP)
TC	thermocouple (on HFE, four cable ambient temperatures are read on each probe)
TEMP	temperature
THERM	thermal
TM	telemetry
UHT	Universal Handling Tool
USB	unified S-band
V	volts, velocity (used to indicate "speed" on PSE in "LVL DIR/V")
Vac	volts ac
Vdc	volts dc
VCO	voltage controlled oscillator
V/FILT	Velocity Filter, a component of SIDE
W	watts
W1, W2, W3	wall locations of structure temperature sensors
XMTR	transmitter
XTAL	crystal
XYZ } XYO }	axes of LSM, where XYO indicates X, or Y, or neither
Ø	phase

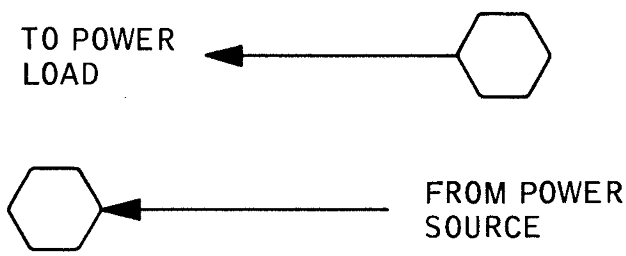
1.2 DRAWING SYMBOL STANDARDS

1.2.1 GENERAL DRAWING INFORMATION

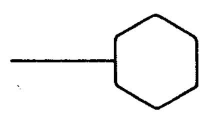
A. ZONE REFERENCE



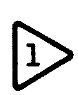
B. POWER INTRA-DRAWING ZONE REFERENCE



C. SYSTEM INTERCONNECT

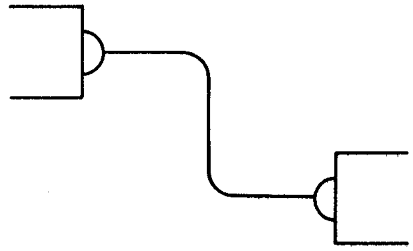


D. DRAWING NOTE REFERENCE



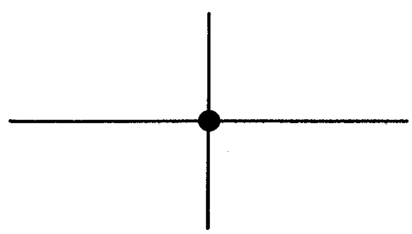
1.2.2 LINE LEGEND

A. RF CABLE

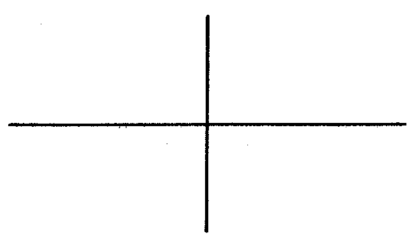


B. ELECTRICAL LINE, POWER AND CONTROL

1. ELECTRICAL, CONNECTED

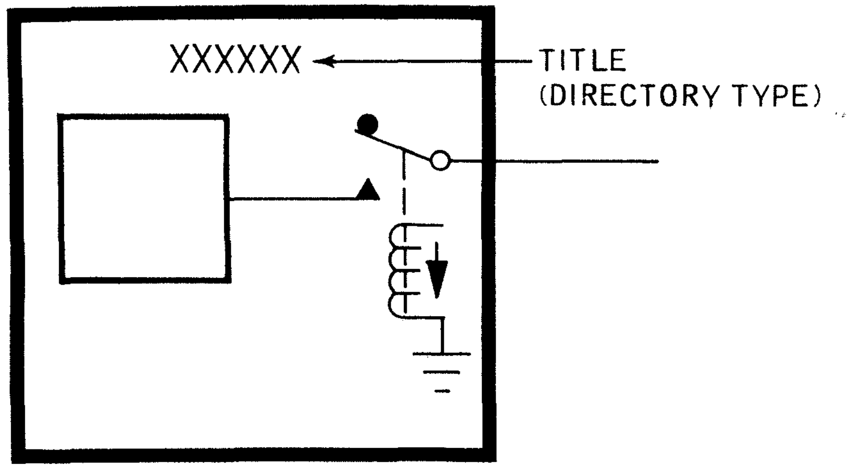


2. ELECTRICAL, CROSSOVER

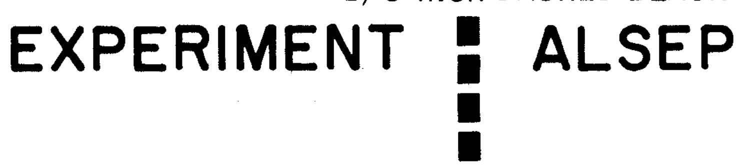


C. DIRECTIONAL FLOW ARROWS

D. COMPONENT ENCLOSURES (TYPICAL)

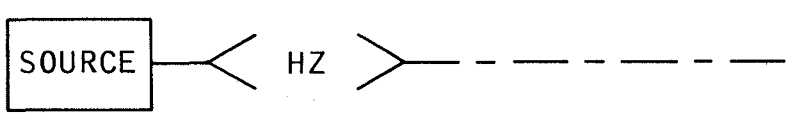


1. MAIN ENCLOSURE
   1/16-INCH SOLID BLACK LINE
2. SUB ENCLOSURE
   1/32-INCH SOLID BLACK LINE
3. COMPONENT ENCLOSURE WITH CREW (MANUAL CONTROL)
   1/16-INCH DASHED BLACK LINE
4. EXPERIMENT INTERFACE
   1/8-INCH DASHED BLACK LINE

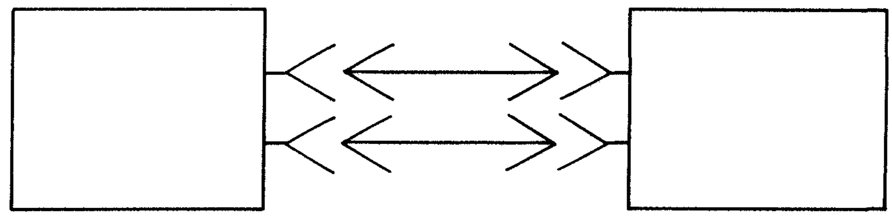


E. MECHANICAL LINKAGE

F. TIMING PULSES

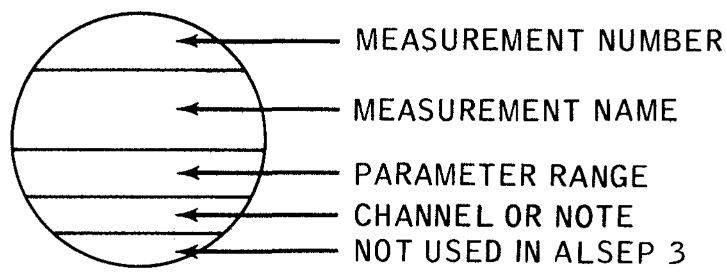


G. TWO-UNIT INTERFACE

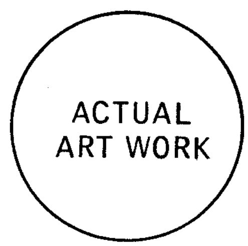


1.2.3 TELEMETRY SYMBOLS

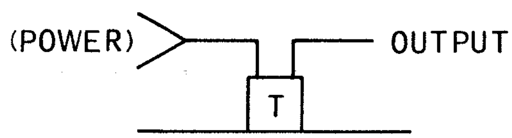
A. MEASUREMENTS TELEMETERED



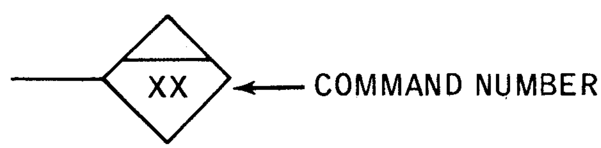
B. METERS



C. SINGLE SOURCE SENSOR



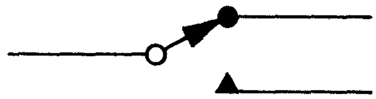
D. COMMANDS



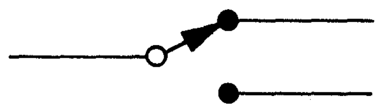
1.2.4 ELECTRICAL SYMBOLS

A. SWITCHES

1. MOMENTARY CONTACT

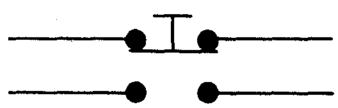


2. LATCHING CONTACT

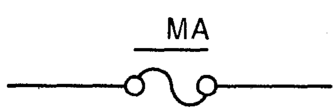


3. SOLID PUSHBUTTON

(PUSH TO OPEN)

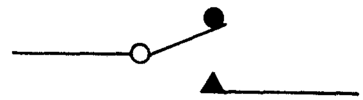


B. FUSES

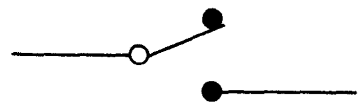


C. RELAYS

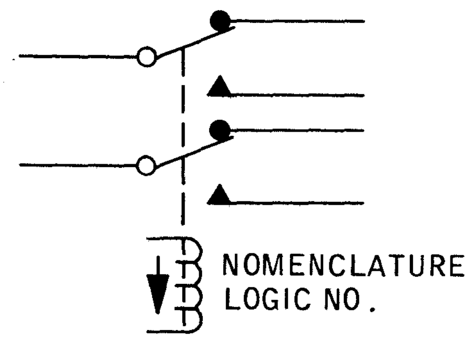
1. MOMENTARY CONTACTS



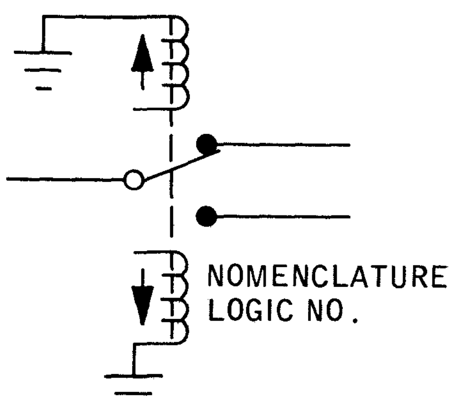
2. LATCHING CONTACTS



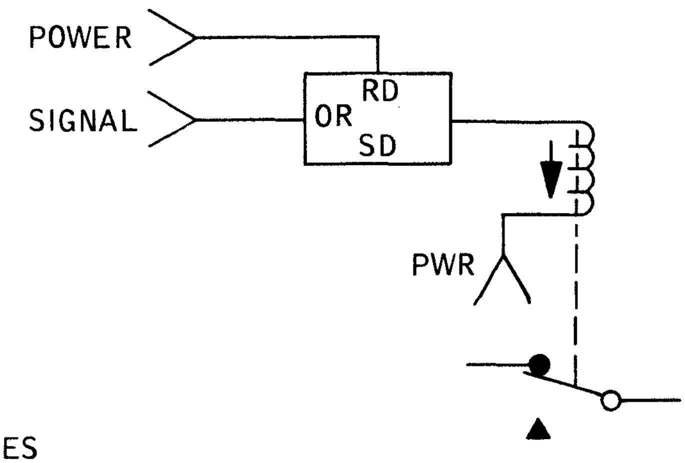
3. NON-LATCHING RELAY SHOWN IN DE-ENERGIZED POSITION



4. LATCHING RELAY

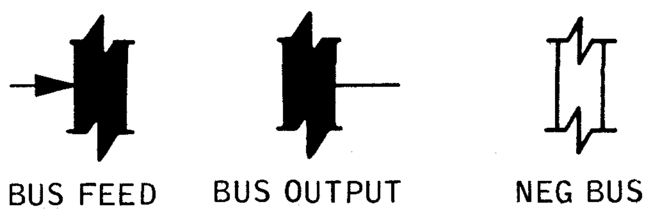


D. RELAY OR SOLENOID DRIVER



E. BUSES

1. SYMBOL (LENGTH MAY VARY)

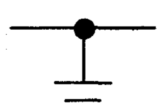


2. DESIGNATION

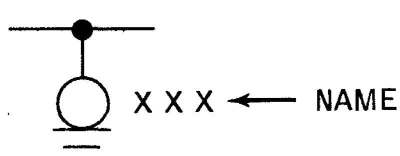
V_{XXX}

F. GROUNDS

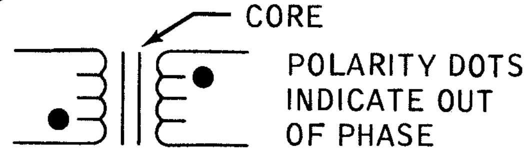
1. SYSTEM



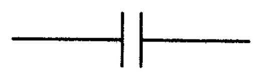
2. FLOATING OR CONTROLLED



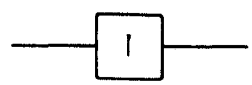
G. TRANSFORMERS



H. CAPACITOR

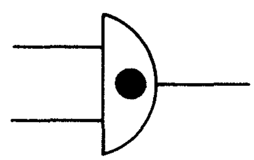


I. DIGITAL INVERTER

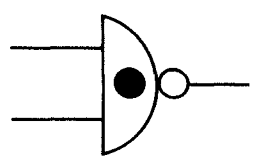


J. GATES

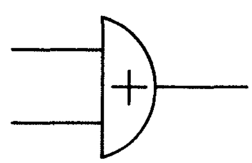
1. AND



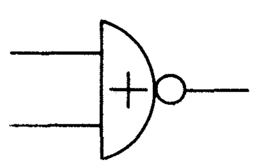
2. NAND



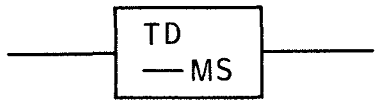
3. OR



4. NOR

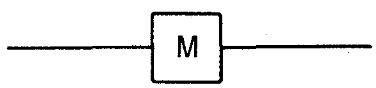


K. TIME DELAY

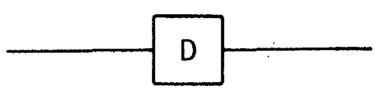


L. ELECTRICAL FILTER

M. MODULATOR

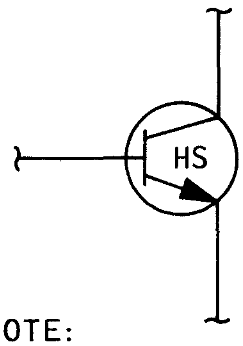


N. DEMODULATOR



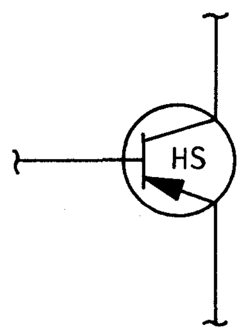
O. TRANSISTORS

1. NPN

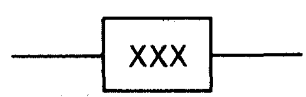


NOTE:
WHEN SHOWN, HS DENOTES HEAT SINK MOUNTED.

2. PNP



P. NON-AMPLIFYING DEVICE, IDENTIFIED

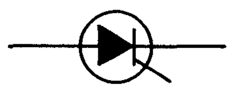


Q. DIODES

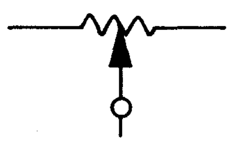
1. GENERAL

2. ZENER

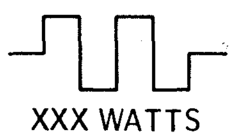
3. CONTROL RECTIFIER



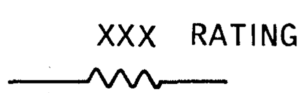
R. POTENTIOMETER



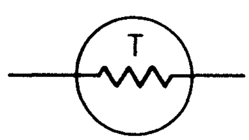
S. HEATER



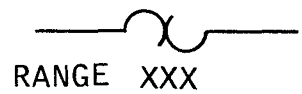
T. FIXED RESISTOR



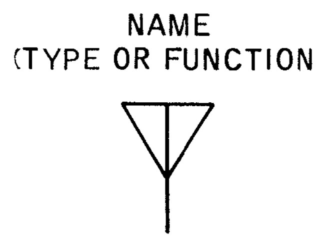
U. THERMISTOR



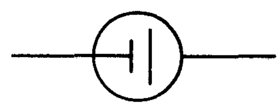
V. THERMOSTAT



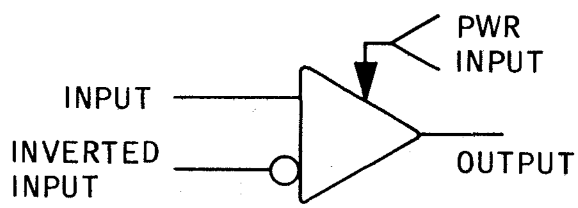
W. ANTENNA

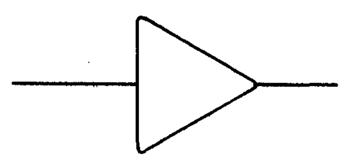


X. PHOTOELECTRIC CELL



Y. AMPLIFIER



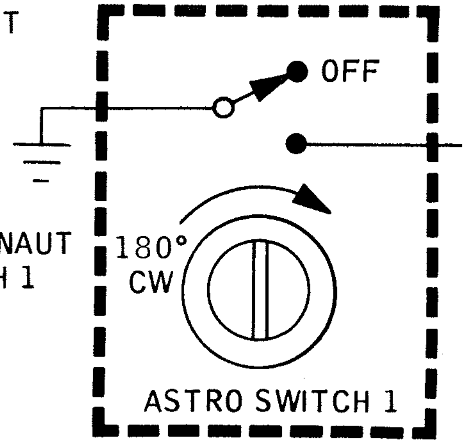


DC, PRE OR BUFFER
AS INDICATED

1.2.5 SPECIAL ALSEP SYMBOLS

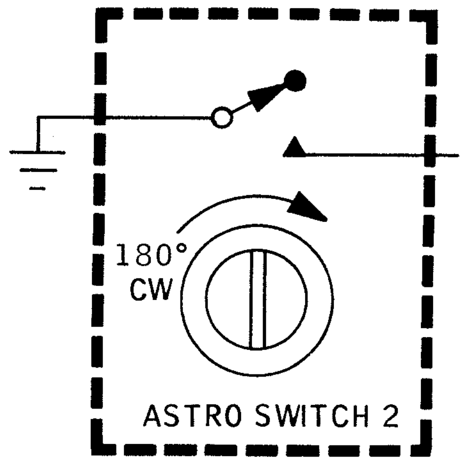
A. ASTRONAUT SWITCHES

1. ASTRONAUT SWITCH 1



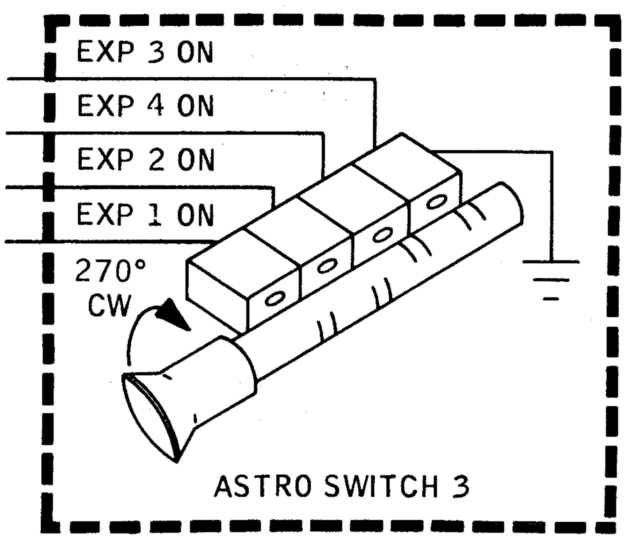
BY-PASSES PCU 1 HOLD OFF CIRCUIT

2. ASTRONAUT SWITCH 2



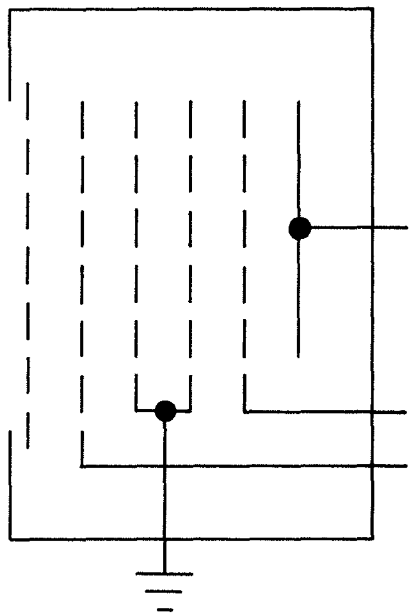
TURNS ON XMTR B, DATA PROCESSOR Y AND RESETS COMMAND RECEIVER CIRCUIT BREAKER

3. ASTRONAUT SWITCH 3

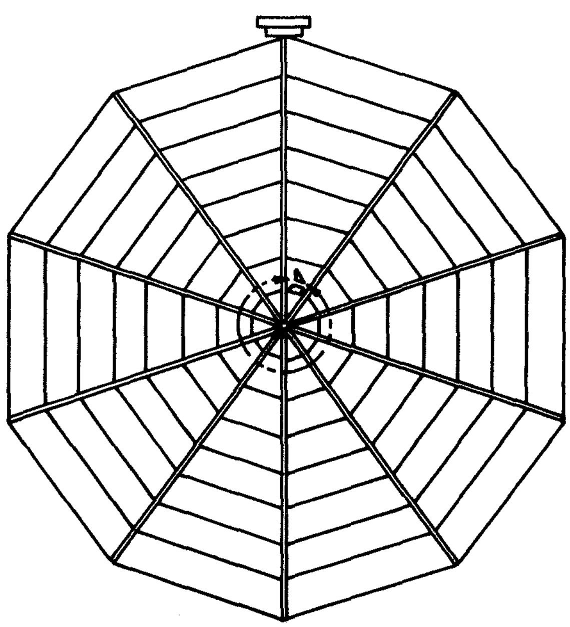


TURNS TO OPERATE, EXP 1 (HFE), EXP 2 (PSE), EXP 4 (CPLEE), AND EXP 3 (CCGE), IN THAT ORDER (MOMENTARY CONTACTS)

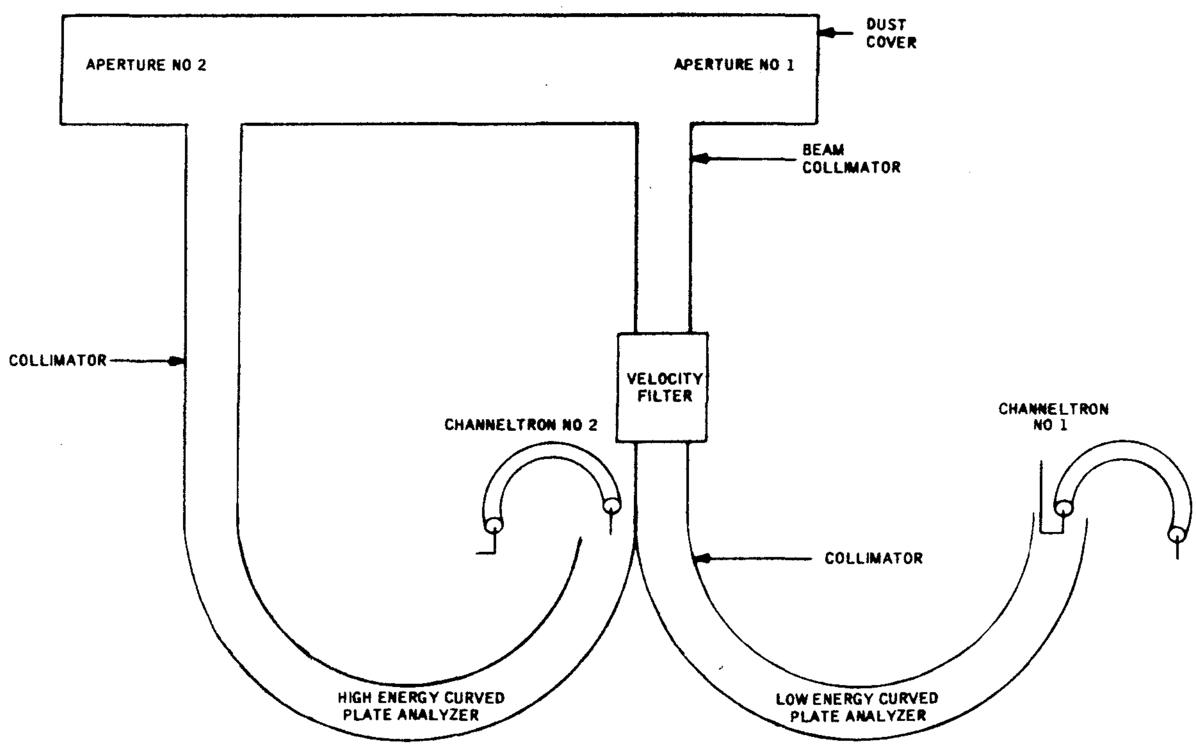
B. FARADAY CUP (SWS SENSOR)



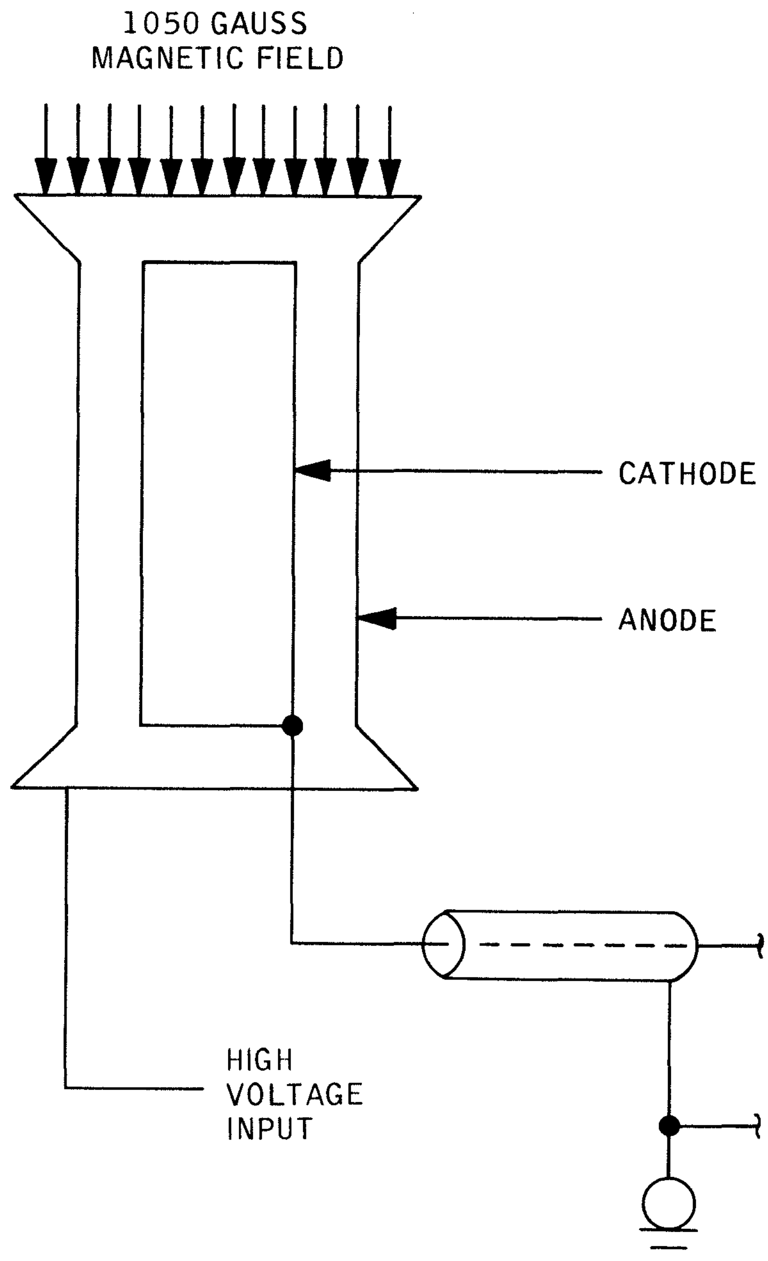
C. GROUND PLANE (USED ON SIDE)



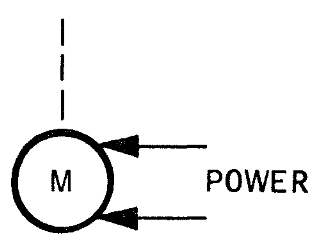
D. SIDE SENSOR ASSEMBLY



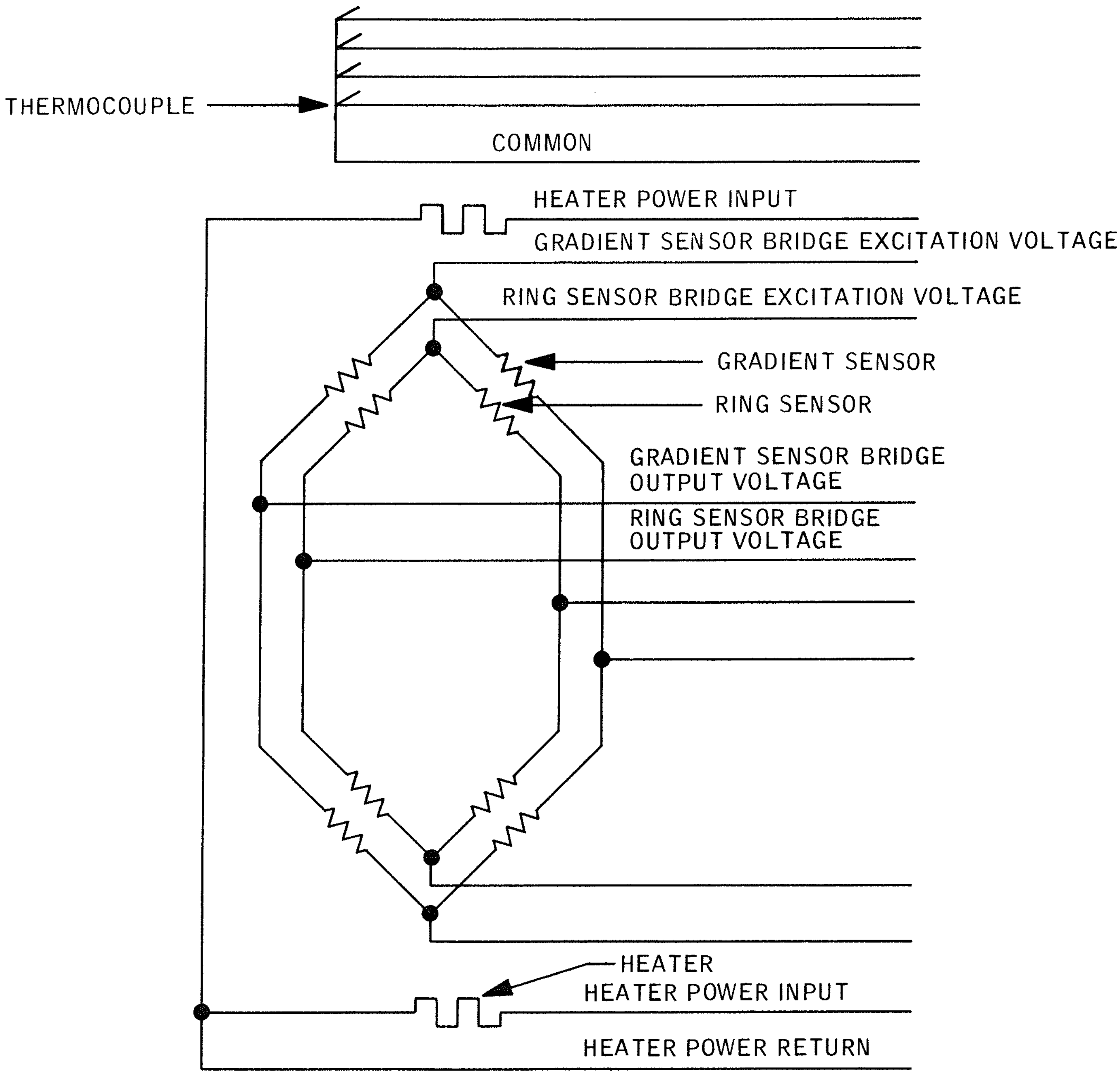
E. COLD CATHODE ION GAGE



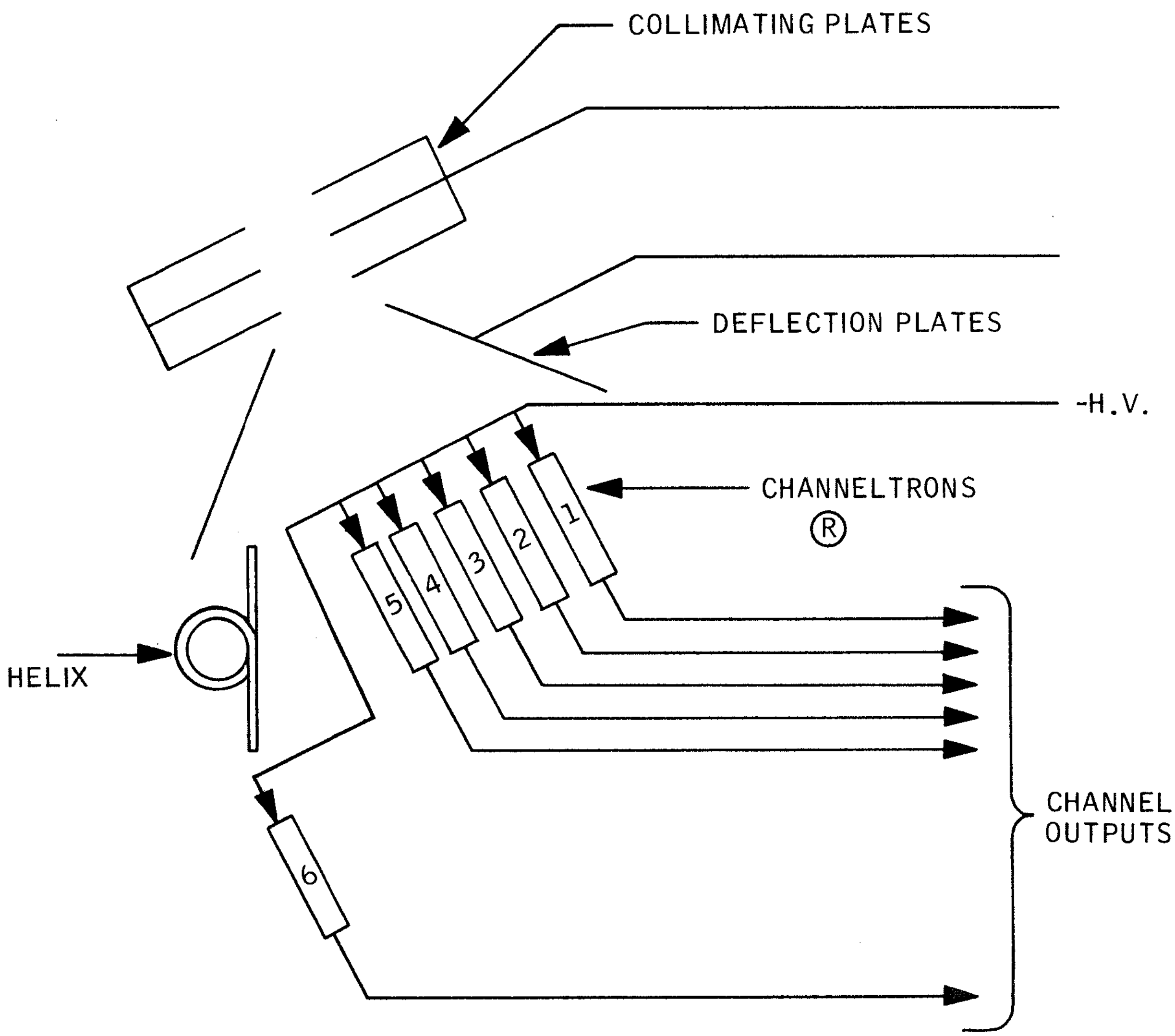
F. MOTOR (USED IN PSE AND LSM)



G. HEAT FLOW EXPERIMENT PROBE SECTION



H. CHARGED PARTICLE LUNAR ENVIRONMENT EXPERIMENT



SECTION 2

GENERAL DESCRIPTION

2.1 ALSEP DESCRIPTION

The Apollo Lunar Surface Experiments Package (ALSEP) system consists of a set of scientific instruments to be placed on the moon's surface by the Apollo flight crew. These instruments will remain on the moon to collect and transmit data for approximately 2 years. For self-sufficient operations, the ALSEP system includes a nuclear power supply, mechanical support, thermal protection, and data handling equipment. These supporting subsystems provide a flexible central station, containing the electrical power, command, telemetry, and structural/thermal subsystems, to operate with various combinations of the following scientific experiment subsystems: Passive Seismic, Active Seismic, Magnetometer, Solar Wind Spectrometer, Suprathermal Ion Detector/Cold Cathode Gage, Heat Flow, Charged-Particle Lunar Environment, and Cold Cathode Gage. Weight and volume restrictions of the Lunar Module preclude carrying all eight experiment subsystems on any flight. This ALSEP Systems Handbook deals with the ALSEP 3 package containing the HFE, PSE, CCGE, and CPLEE (Figures 2-1, 2-2, and 2-3).

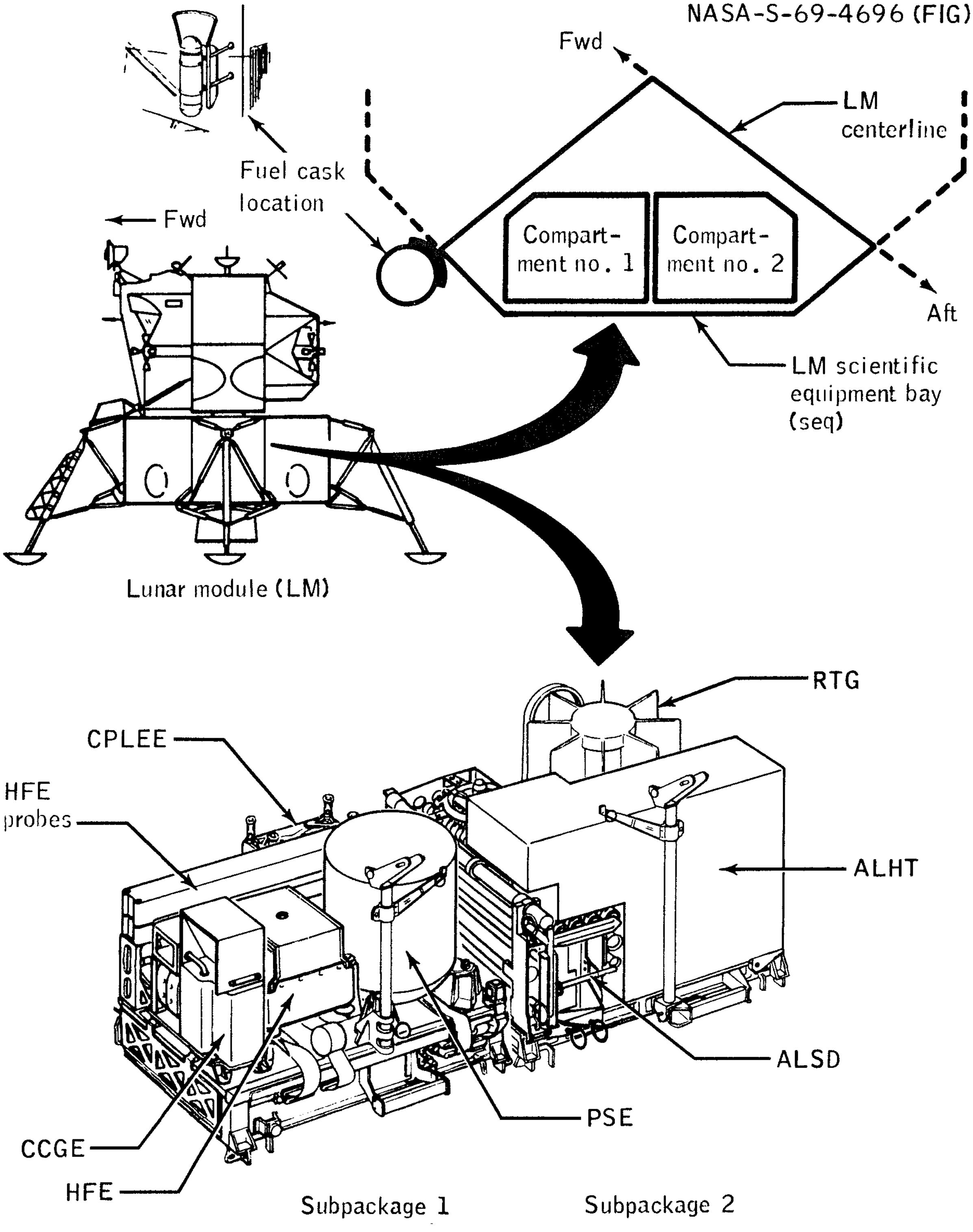


Figure 2-1. - ALSEP 3/LM interface.

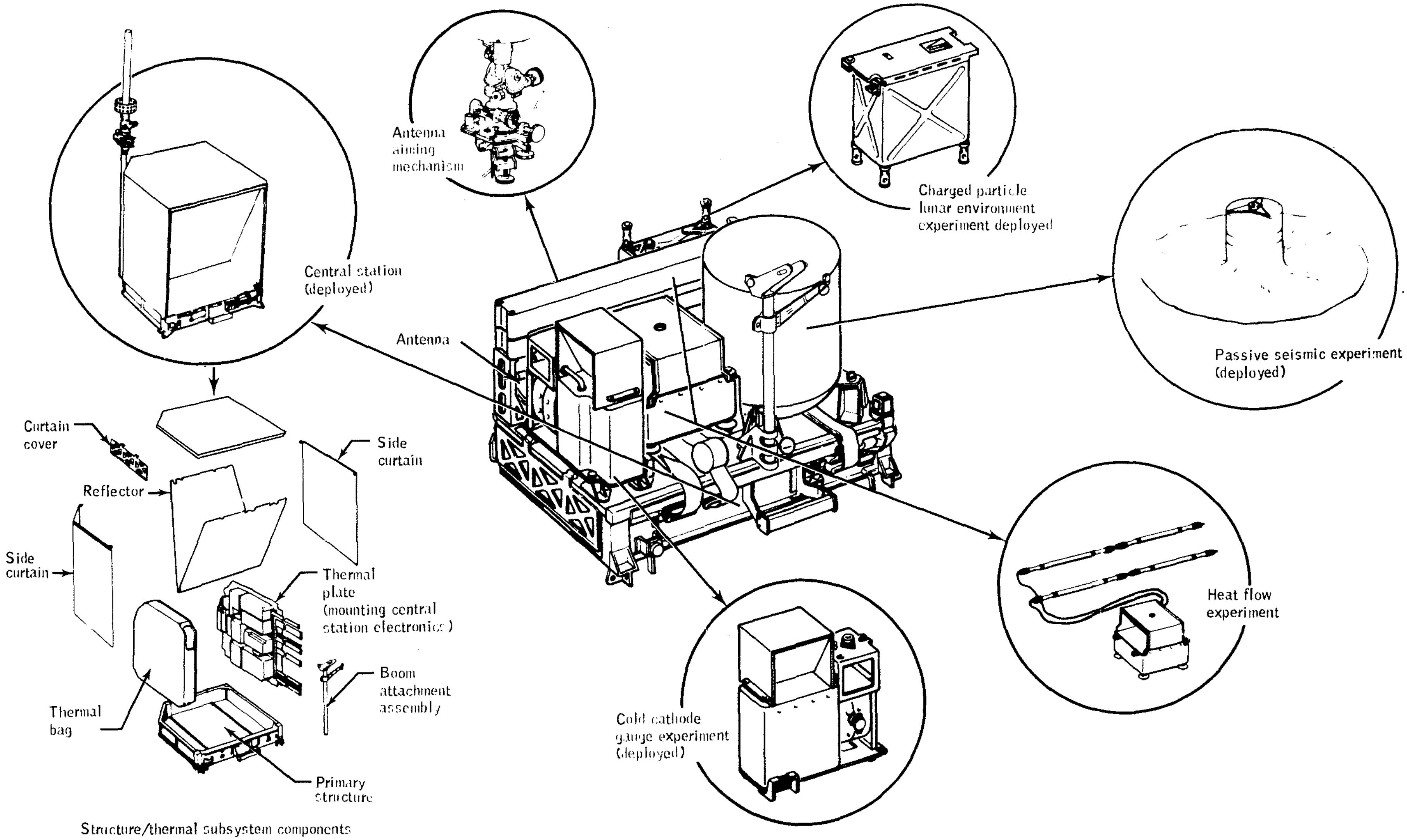


Figure 2-2. - ALSEP 3 subpackage no. 1.

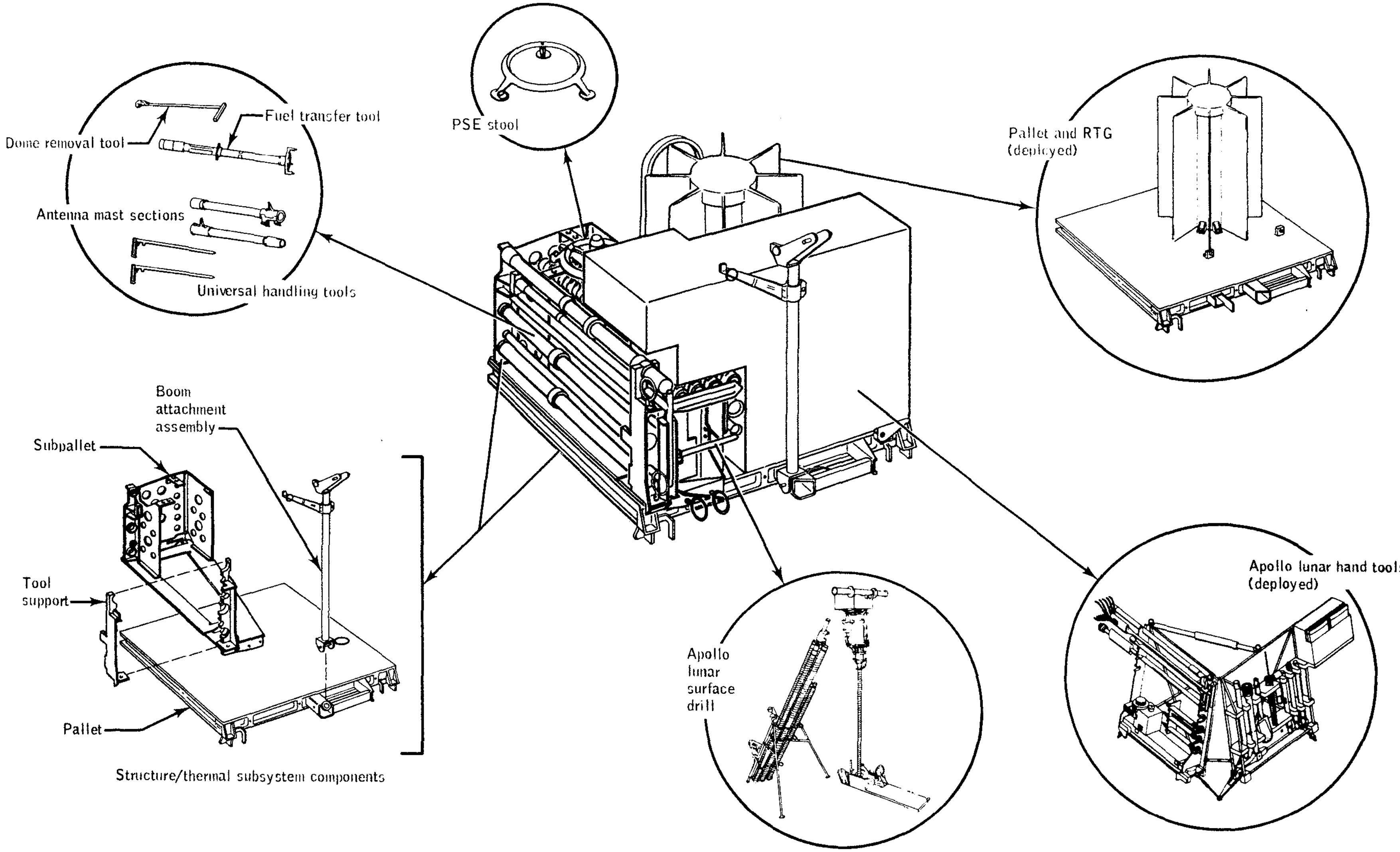
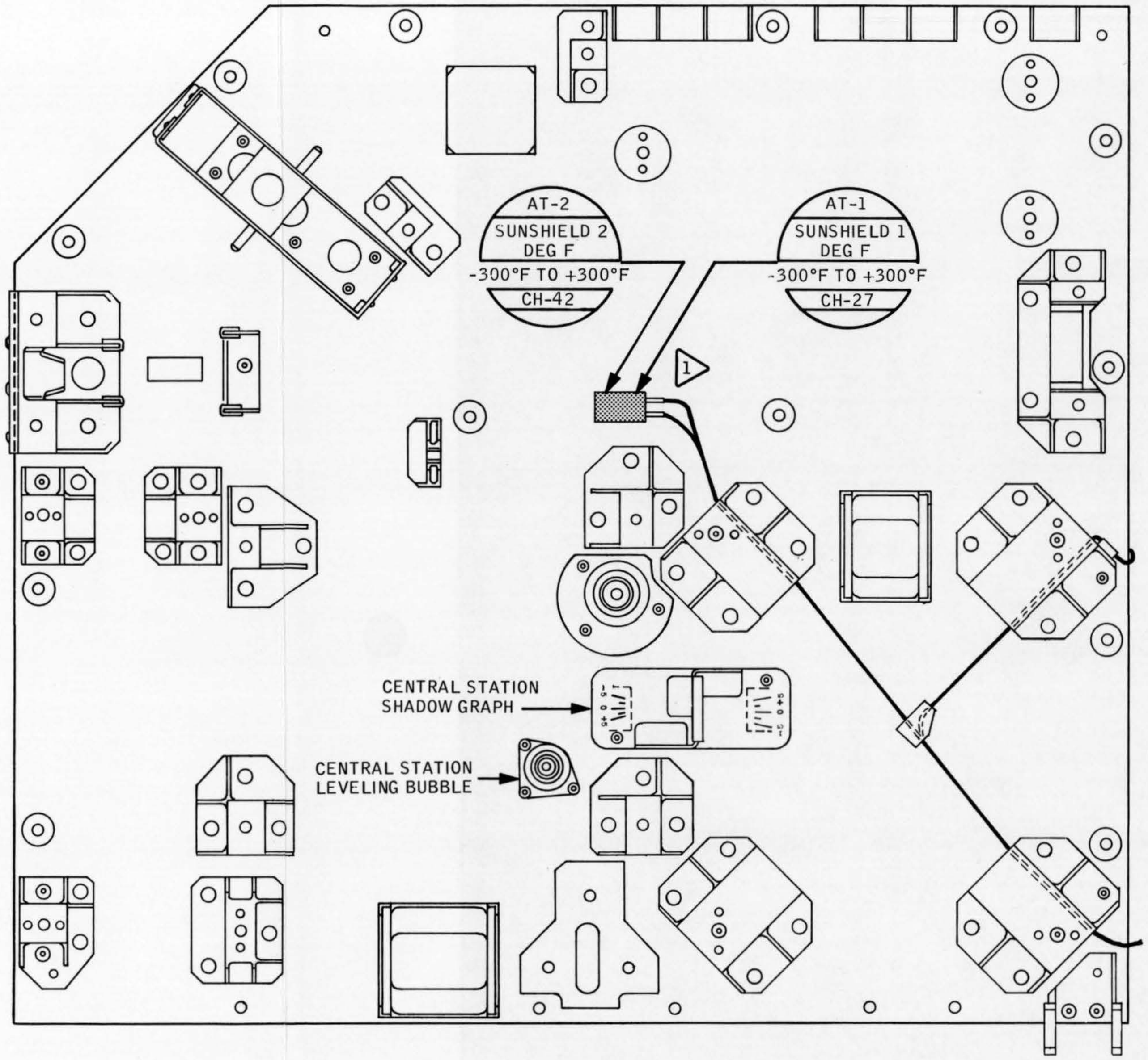


Figure 2-3. - ALSEP 3 subpackage no. 2.

LTR	DR	ENGR	DATE	APPROVAL



NOTES: 1 SENSOR AT-2 IS LOCATED DIRECTLY BELOW SENSOR AT-1 ON THE UNDERSIDE OF THE SUNSHIELD

SIGNATURES	DATE
DR Pat Sherrill	4-3-69
DSGN Bill Cornelius	12-30-69
QC Betty M. Taylor	12-30-69
ENGR Joseph L. James	12-31-69
APP Benton L. Sharpe	12-31-69
FEC Dean B. Parker	1-2-70
AUTH Don Bray	1-2-70

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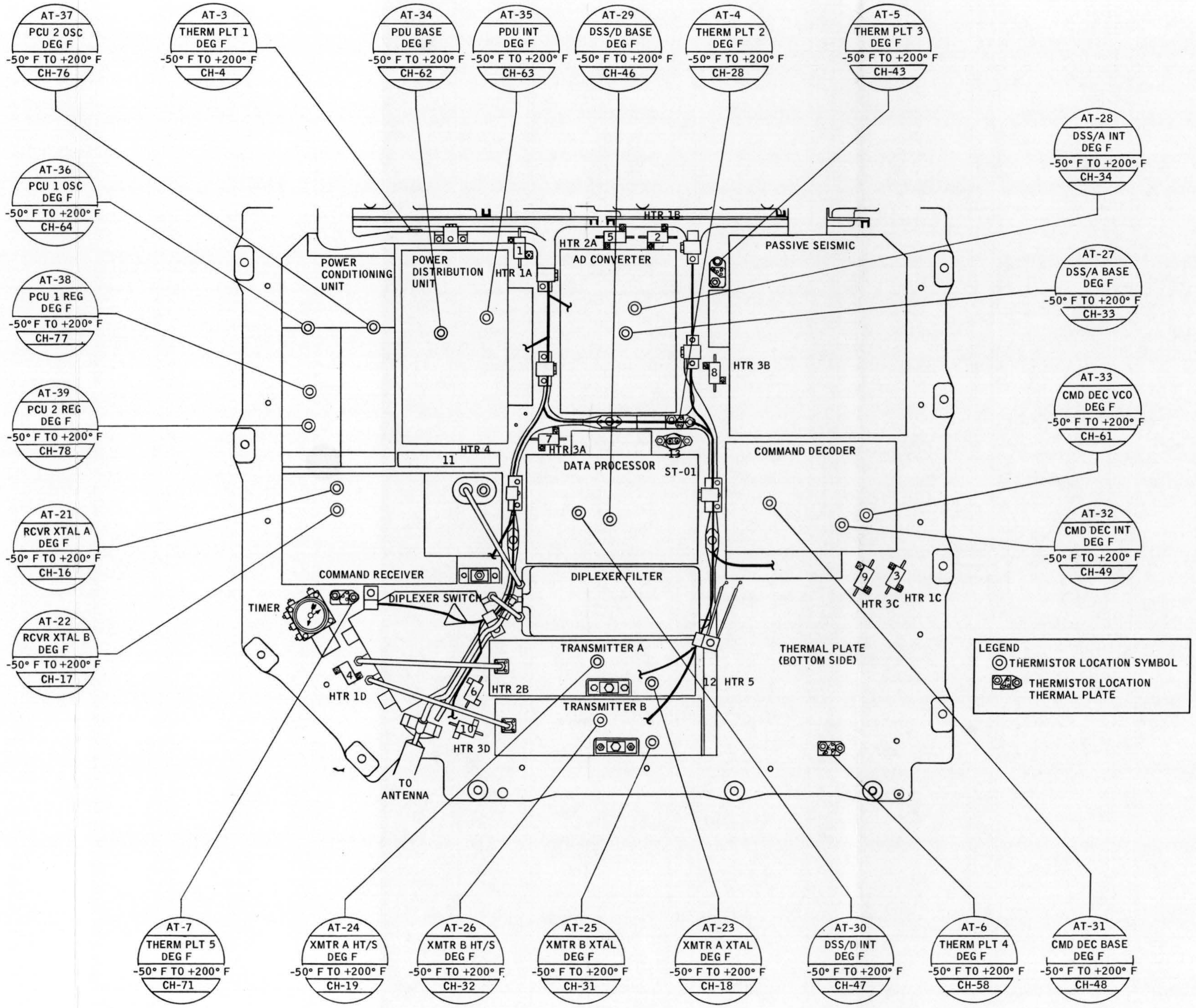
SUNSHIELD

ALSEP 3 | SIZE C | DWG NO 3.1

22 X 17 | PAGE 3-1 | SHEET OF



1. HTR 1A CENTRAL STATION HEATER 1
2. HTR 1B CENTRAL STATION HEATER 1
3. HTR 1C CENTRAL STATION HEATER 1
4. HTR 1D CENTRAL STATION HEATER 1
} DDS HTR 1 - TOTAL 10 WATTS- CONTROLLED BY CMD 055

5. HTR 2A CENTRAL STATION HEATER 2
6. HTR 2B CENTRAL STATION HEATER 2
} DSS HTR 2 - TOTAL 5 WATTS- CONTROLLED BY CMD 056

7. HTR 3A CENTRAL STATION HEATER 3
8. HTR 3B CENTRAL STATION HEATER 3
9. HTR 3C CENTRAL STATION HEATER 3
10. HTR 3D CENTRAL STATION HEATER 3
} DDS HTR 3 - TOTAL 10 WATTS- CONTROLLED BY CMD 024 AND/OR THERMOSTAT ST-01

11. HTR 4 COMMAND RECEIVER HEATER 1.25 WATTS
12. HTR 5 TRANSMITTER HEATER 8.4 WATTS
13. ST-01 SWITCH THERMOSTAT

SIGNATURES	DATE
DR Wade Williams	4-15-69
DSGN Bill Cornelius	12-30-69
QC [illegible]	12-30-69
ENGR Joseph J James	12-31-69
APP [illegible]	12-31-69
FEC Dean B. Fisher	1-2-70
AUTH Jon Bray	1-2-70

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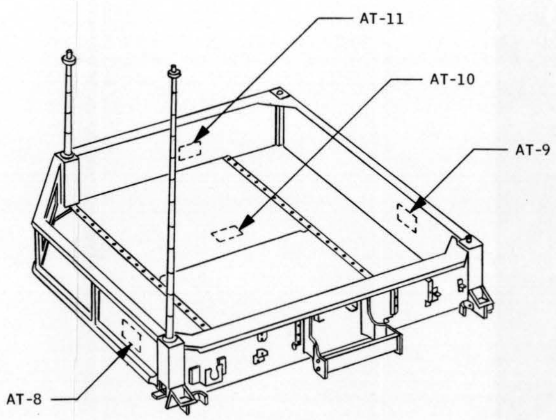
THERMAL PLATE

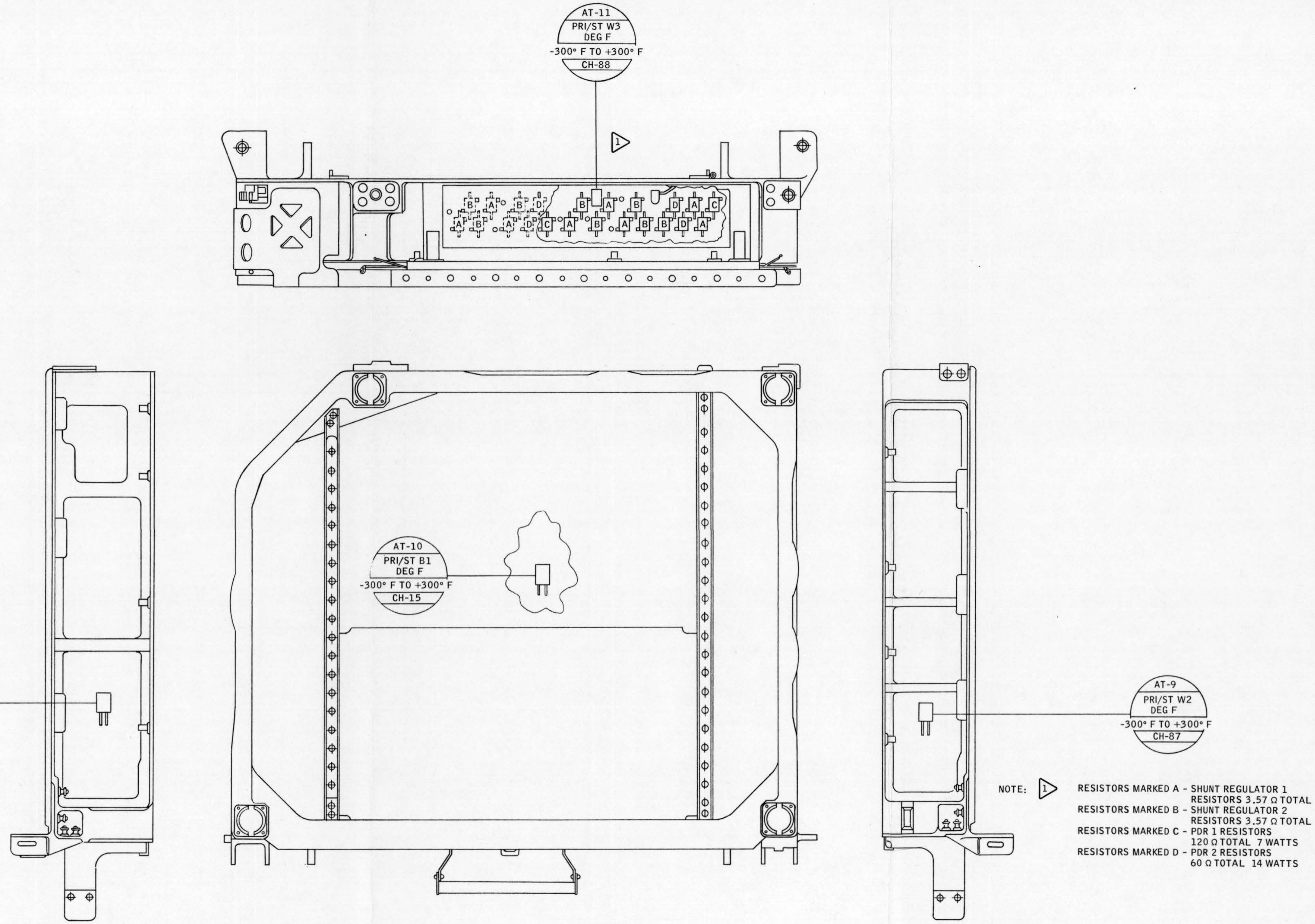
ALSEP 3 SIZE D DWG NO 3.2

34 X 22 PAGE 3-2 SHEET 1 OF 1

LTR	DR	ENGR	DATE	APPROVAL

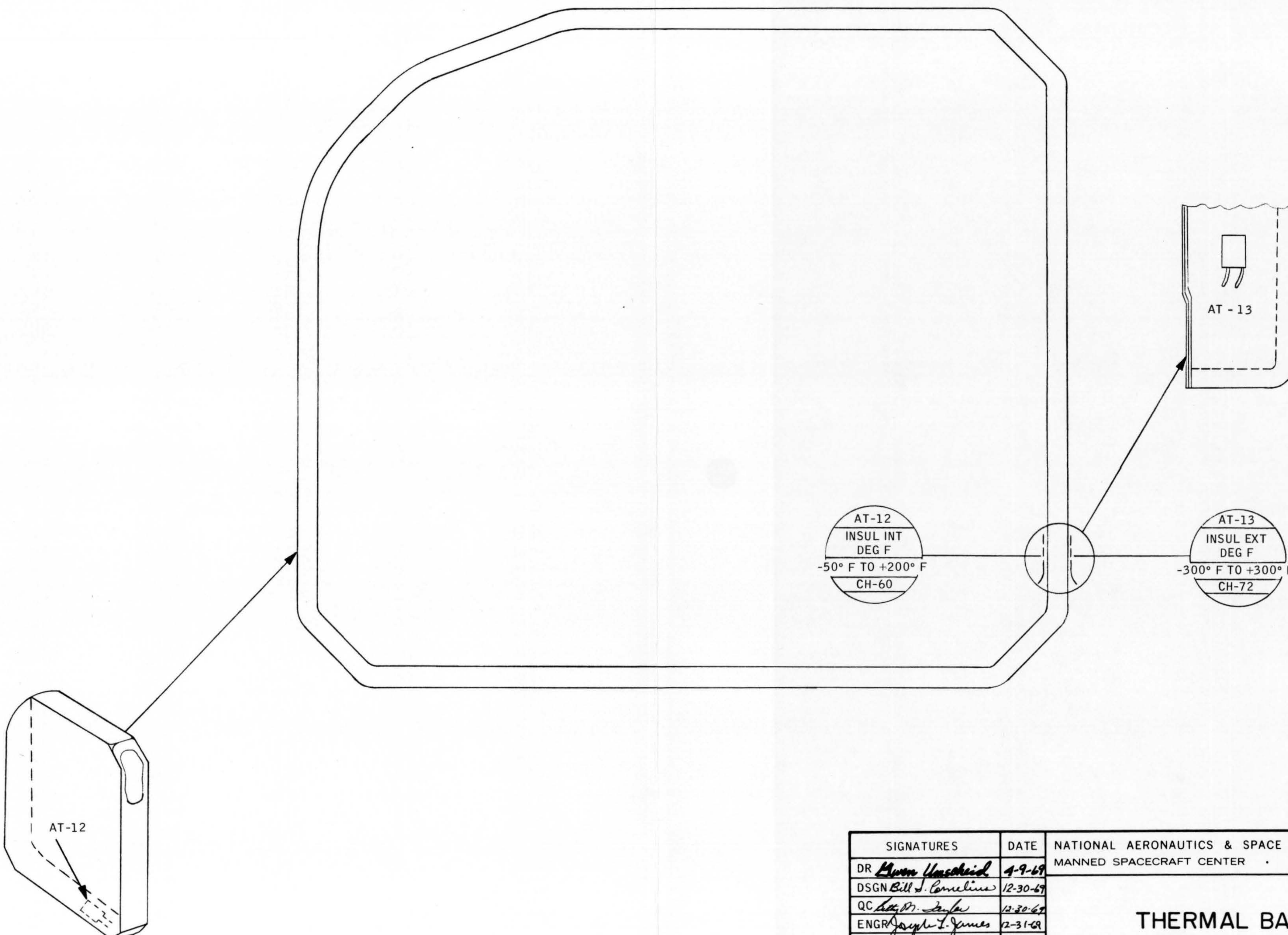


PRIMARY STRUCTURE



SIGNATURES	DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION MANNED SPACECRAFT CENTER · HOUSTON, TEXAS
DR Wade Williams	3-27-69	PRIMARY STRUCTURE
DSGN Bill Pomelina	12-30-69	
QC Betty M. Saylor	12-30-69	
ENGR Joseph L. James	12-31-69	
APP Burton L. Sharpe	12-31-69	
FEC Dean B. Rosko	1-2-70	ALSEP 3 · SIZE D · DWG NO 3.3
AUTH Don Bray	1-2-70	
		34 X 22 · PAGE 3-3 · SHEET 1 OF 1

LTR	DR	ENGR	DATE		APPROVAL



THERMAL BAG

SIGNATURES	DATE
DR Myron Unscheid	4-9-69
DSGN Bill J. Cornelius	12-30-69
QC Betty M. Taylor	12-30-69
ENGR Joseph L. James	12-31-69
APP Burton L. Sharpe	12-31-69
FEC Dean B. Fisher	1-2-70
AUTH Don Bray	1-2-70

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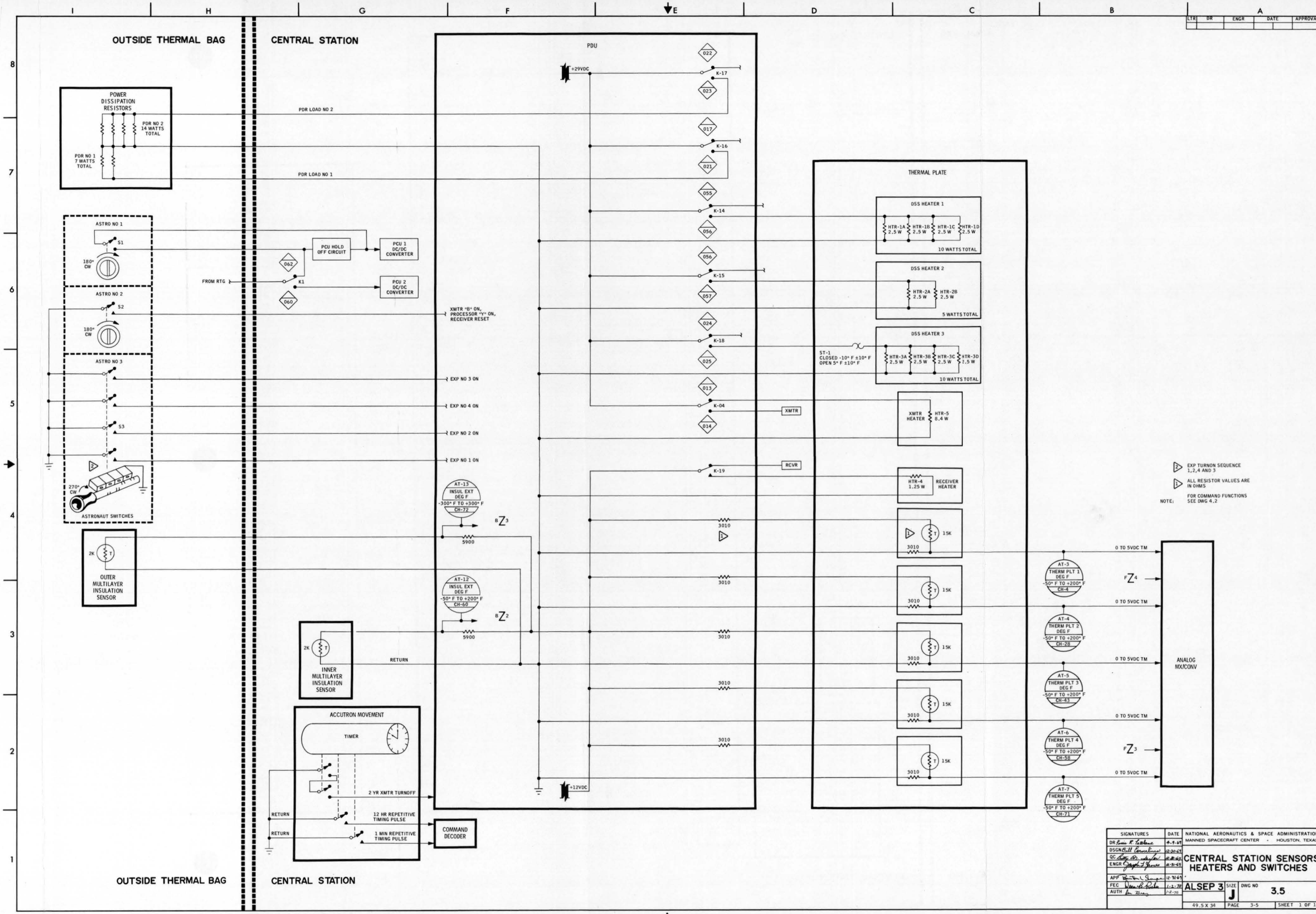
THERMAL BAG

ALSEP 3 | SIZE C | DWG NO 3.4

22 X 17 | PAGE 3-4 | SHEET 1 OF 1


OUTSIDE THERMAL BAG
CENTRAL STATION
POWER DISSIPATION RESISTORS
PDR NO 2 14 WATTS TOTAL
PDR NO 1 7 WATTS TOTAL
PDR LOAD NO 2
PDR LOAD NO 1
PDU
+29VDC
+12VDC
K-17
K-16
K-14
K-15
K-18
K-04
K-19
ASTRO NO 1
ASTRO NO 2
ASTRO NO 3
S1
S2
S3
180° CW
270° CW
ASTRONAUT SWITCHES
PCU HOLD OFF CIRCUIT
PCU 1 DC/DC CONVERTER
PCU 2 DC/DC CONVERTER
FROM RTG
K1
XMTR "B" ON, PROCESSOR "Y" ON, RECEIVER RESET
EXP NO 3 ON
EXP NO 4 ON
EXP NO 2 ON
EXP NO 1 ON
THERMAL PLATE
DSS HEATER 1
HTR-1A 2.5 W
HTR-1B 2.5 W
HTR-1C 2.5 W
HTR-1D 2.5 W
10 WATTS TOTAL
DSS HEATER 2
HTR-2A 2.5 W
HTR-2B 2.5 W
5 WATTS TOTAL
DSS HEATER 3
ST-1 CLOSED -10° F ±10° F OPEN 5° F ±10° F
HTR-3A 2.5 W
HTR-3B 2.5 W
HTR-3C 2.5 W
HTR-3D 2.5 W
10 WATTS TOTAL
XMTR
XMTR HEATER
HTR-5 8.4 W
RCVR
HTR-4 1.25 W
RECEIVER HEATER
AT-13 INSUL EXT DEG F -300° F TO +300° F CH-72
AT-12 INSUL EXT DEG F -50° F TO +200° F CH-60
5900
3010
15K
2K
OUTER MULTILAYER INSULATION SENSOR
INNER MULTILAYER INSULATION SENSOR
RETURN
AT-3 THERM PLT 1 DEG F -50° F TO +200° F CH-4
AT-4 THERM PLT 2 DEG F -50° F TO +200° F CH-28
AT-5 THERM PLT 3 DEG F -50° F TO +200° F CH-43
AT-6 THERM PLT 4 DEG F -50° F TO +200° F CH-58
AT-7 THERM PLT 5 DEG F -50° F TO +200° F CH-71
0 TO 5VDC TM
ANALOG MX/CONV
ACCUTRON MOVEMENT
TIMER
2 YR XMTR TURNOFF
12 HR REPETITIVE TIMING PULSE
1 MIN REPETITIVE TIMING PULSE
COMMAND DECODER
EXP TURNON SEQUENCE 1,2,4 AND 3
ALL RESISTOR VALUES ARE IN OHMS
FOR COMMAND FUNCTIONS SEE DWG 4.2
NOTE:
LTR DR ENGR DATE APPROVAL
SIGNATURES DATE
DR 4-9-69
DSGN 12-30-69
QC 12-30-69
ENGR 12-31-69
APP 12-31-69
FEC 1-2-70
AUTH 1-2-70
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MANNED SPACECRAFT CENTER · HOUSTON, TEXAS
CENTRAL STATION SENSORS HEATERS AND SWITCHES
ALSEP 3
SIZE J
DWG NO 3.5
49.5 X 34
PAGE 3-5
SHEET 1 OF 1

SECTION 4

ELECTRICAL POWER SUBSYSTEM

4.1 SYSTEM DESCRIPTION

The electrical power subsystem provides the electrical power for lunar surface operation of the ALSEP. Primary electrical power is developed by thermoelectric action with thermal energy supplied by a radioisotope source. The primary power is converted, regulated, and filtered to provide the six operating voltages for the ALSEP experiment and support subsystems.

The components are a radioisotope thermoelectric generator assembly, a fuel capsule assembly, a power conditioning unit, and a power distribution unit.

4.1.1 Radioisotope Thermoelectric Generator (RTG)

A. RTG Commands - No command capability.

B. RTG Telemetry - Six temperatures, one output voltage, and one output current (Tables 6-VIII and 6-X).

C. Output - 68 watts, nominal.

4.1.2 Power Conditioning Unit (PCU)

The PCU performs three major functions:

A. Voltage conversion

B. Voltage regulation

C. RTG protection

Each power conditioner consists of a dc-to-dc power converter (inverter and rectifiers), which converts the RTG 16-volt input to the six operating voltages, and a shunt current regulator to maintain the output voltages within approximately ±1 percent. The input voltage is also regulated by this action by maintaining a constant load on the RTG. It is necessary to keep a constant load on the generator to prevent overheating of the thermocouples in the RTG.

The +16 volts from the RTG is applied through the switching circuit to the selected dc-to-dc converter, applying power to the inverter and completing the shunt regulation circuit. Applying power to the inverter permits it to supply ac power to the rectifiers that develop the dc voltages applied to the filters. The outputs from the filters are the six operating voltages applied to the data subsystem. Output and input voltages are regulated by feedback from the +12-volt output to the shunt regulator. The +12-volt feedback is also applied to the switching circuit for over or under voltage determination and switching to the redundant inverter and regulator, if necessary. All the output voltages are regulated by the 12-volt feedback.

4.1.3 Power Distribution Unit (PDU)

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

4.1.3.1 Power-off sequencer.- (Refer to Drawing 4.2.) The power-off sequencer of the PDU detects minimum reserve power and sequentially turns to standby up to three preselected experiments to bring the power reserve within acceptable limits. The minimum reserve power is detected by monitoring the voltage across the shunt regulator transistor. This voltage is applied to an operational amplifier used as a level detector. An RC delay network is employed at the output of the level detector. The output of the delay is applied to a second level detector which drives the power-off sequencer logic. This arrangement turns on the power-off sequencer logic input gate when the reserve power drops below the levels as follows:

Reserve Power to Start Experiment Turn-Off (135 ms Delay):
0.78 watts ±0.57 watts

Experiment Turn-Off Sequence, via the Power-Off Sequencer, is as follows:

A. Experiment #4 (CPLEE)

B. Experiment #3 (CCGE)

C. Experiment #1 (HFE)

NOTE

Experiment #2 (PSE) is not in the turn-off sequence.

The sequencer decoding gates are connected so that upon turn-on of the logic input gate, an output ground level signal is provided during the count between 1 and 9 milliseconds to the CPLEE power standby relay driver. This relay removes experiment operate power and applies power to the standby line. If the overload persists, the ground level signal supplied to the CPLEE standby line is removed and a ground level signal is applied to the CCGE power standby command input during the next 8-millisecond period (when the count is between 9 and 17 milliseconds). If overloading persists, the sequencer could continue in the same manner until the Heat Flow Experiment (HFE) is in the standby mode. If, however, the overload is removed within the sequence, the counter will be reset in 2 milliseconds after a satisfactory power reserve signal is obtained, thus stopping the sequence. Note that the power OFF sequencer action places the experiments to standby ON from either an operational ON condition or from a standby OFF condition.

4.1.3.2 Temperature sensor circuit.- Operational amplifiers are used to amplify the resistive bridge outputs for the RTG hot and cold junction temperatures. The temperature sensors located on the RTG are platinum wire sensors (Drawing 4.1). Bridge excitation is 12 Vdc on both the hot and cold frame temperature circuits.

Nickel wire temperature sensors are used in dividers to monitor exposed structural temperature, multilayer bag insulation temperatures, and sunshield temperatures. The circuit is a simple divider consisting of 12 Vdc supplied through 5900 ohms and the sensor to ground. The output analog signal is taken across the sensor, providing a linear response from -300°F to +300°F. (Refer to Section 3 for sensor locations.)

Thermistor sensors are provided to monitor temperatures within the central station and subsystems. The sensor excitation is +12 Vdc. The sensor ranges are between -50°F and +200°F (Drawing 3.2).

4.1.3.3 Power control.- (Refer to Drawing 4.2) Power control is provided by ground commands and/or astronaut switch functions causing the command lines to go to ground potential, thus actuating relay drivers and their associated relays.

Four transistorized relay drivers, magnetic latching relays, and one magnetic latching relay acting as an overload sensor (circuit breaker) perform the control and circuit protection function for each experiment. The experiment standby power line is fused at 500 mA. Three command inputs are provided for each experiment power control circuit.

A. Experiment Operate Select command

B. Experiment Standby Select command

C. Experiment Standby OFF command

The three command inputs operate one or both of two power switching relays. One relay provides the selection of either standby power or operational power. The other interrupts the standby power line. The receipt of an Experiment Operate Select command will transfer the relay to a position which provides power through the current sensing coil of the circuit breaker relay to the experiment electronics. A second command, Standby OFF, operates the relay coil of the standby power interruption relay to open the circuit supplying power to the standby line. The Standby Select command, however, operates on both relays. The Standby Select command actuates both relays to the positions that supply power to the standby line. To place an experiment from OPERATE to standby OFF, the Standby Select command must be executed prior to the standby OFF command. DSS Htr 1 and DSS Htr 2 power control operates similar to experiment power control.

Circuit breaker resetting is provided by internally generating a Standby Select command using the contacts of a current sensing relay. Should an overcurrent condition exist through the sensing coil in series with the experiment operational power line, the contacts of the sensing relay break the Standby Select command line and apply a ground signal to each of two relay drivers. One relay driver operates the power select relay to the Standby Power position. The other driver operates the standby power interruption relay to close the contacts supplying power to the standby power line. Operation of the standby power interruption relay provides power to the reset coil of the overload sensing relay thereby resetting its contacts to permit normal Standby Select command inputs.

Transmitter power control and overload protection uses two power control relays, four overload sensing relays, and associated relay drivers. Four commands are required:

A. Transmitter On

B. Transmitter Off

C. Transmitter A Select

D. Transmitter B Select.

The Transmitter On and Off commands operate the double pole double throw relay which switches both +12 Vdc and +29 Vdc to the transmitter transfer relay. When the transmitter is off, +29 Vdc is switched to the 8.4-watt transmitter heater. If either Transmitter A or Transmitter B power line is overloaded, the contacts of the overload sensing relay transfers the transmitter select relay to supply power to the alternate transmitter. When power is transferred to the alternate transmitter, the circuit overload sensing relays are both reset and the normal command link inputs are restored. Diplexer switching power, required only when Transmitter B is selected, is obtained directly from the +12 Vdc Transmitter B power line.

The command receiver requires both +12 Vdc and -6 Vdc for operation. The -6 Vdc line is not provided with circuit protection. The +12 Vdc line is provided with overload protection which uses a magnetic latching circuit breaker relay. The circuit breaker will in turn actuate relay K-19 and therefore interrupt +12 Vdc. Since no redundancy of receivers exists, a 12-hour reset pulse is supplied to the breaker every 12 hours. If the receiver is tripped off, +12 Vdc is switched to the 1.25-watt receiver heater.

For data processor power control, redundant electronics are switched using standard magnetic latching relays. These relays are controlled by ground commands. Overload protection is not provided.

Power dissipation Resistor 1, power dissipation Resistor 2, and the central station DSS Heater 3 are switched off and on by ground command only.

Electronics for the dust detector consist of the following three functional areas which are illustrated in Drawing 7.1.

A. Power switching

B. Operational amplifiers

C. Temperature measurement

The power switching function switches +12 Vdc and -12 Vdc power to the amplifiers upon receiving a ground command. The switching function consists of a command flip-flop and power switching circuits. Power protection is provided by fuses. Note that power switching does not affect the temperature measurements.

TABLE 4-I.- PCU OVER AND UNDER VOLTAGE

Over and Under Voltage Sensing Circuit - An automatic switchover circuit in PCU 1 operates when the +12 Vdc bus varies outside of the following limits. The sensing circuit causes a switch from PCU 1 to PCU 2 only.

Sensing Circuit	Voltage Level	Time Delay
Over Voltage	+13 ± 0.25 Vdc	10 ms
Under Voltage	+11 ± 0.25 Vdc	300 ms

TABLE 4-II.- POWER CALCULATIONS

TM Symbol	Resultant (Watts)
(AE-3) x (AE-4)	= RTG Output Power
(AE-3) x (AE-5)	= Reserve Power PCU 1
(AE-3) x (AE-6)	= Reserve Power PCU 2

(RTG Output Power) - (Reserve Power) = PCU Input Power

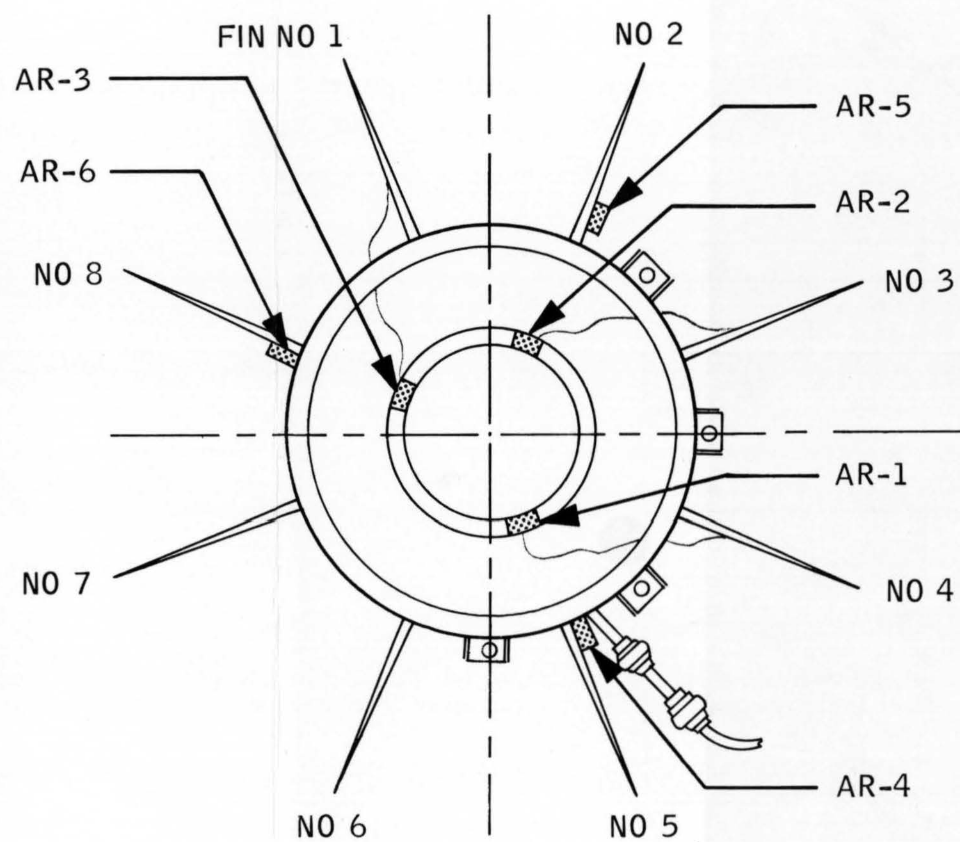
(AE-3) (AE-5) - $(AE\text{-}5)^2$ (4.2Ω) = Internal Reg #1 Dissipation

(AE-3) (AE-6) - $(AE\text{-}6)^2$ (4.2Ω) = Internal Reg #2 Dissipation

TABLE 4-III.- PDU RELAY INITIAL CONDITIONS

Initial condition is defined as the relay positions at time of activation of the lunar surface.

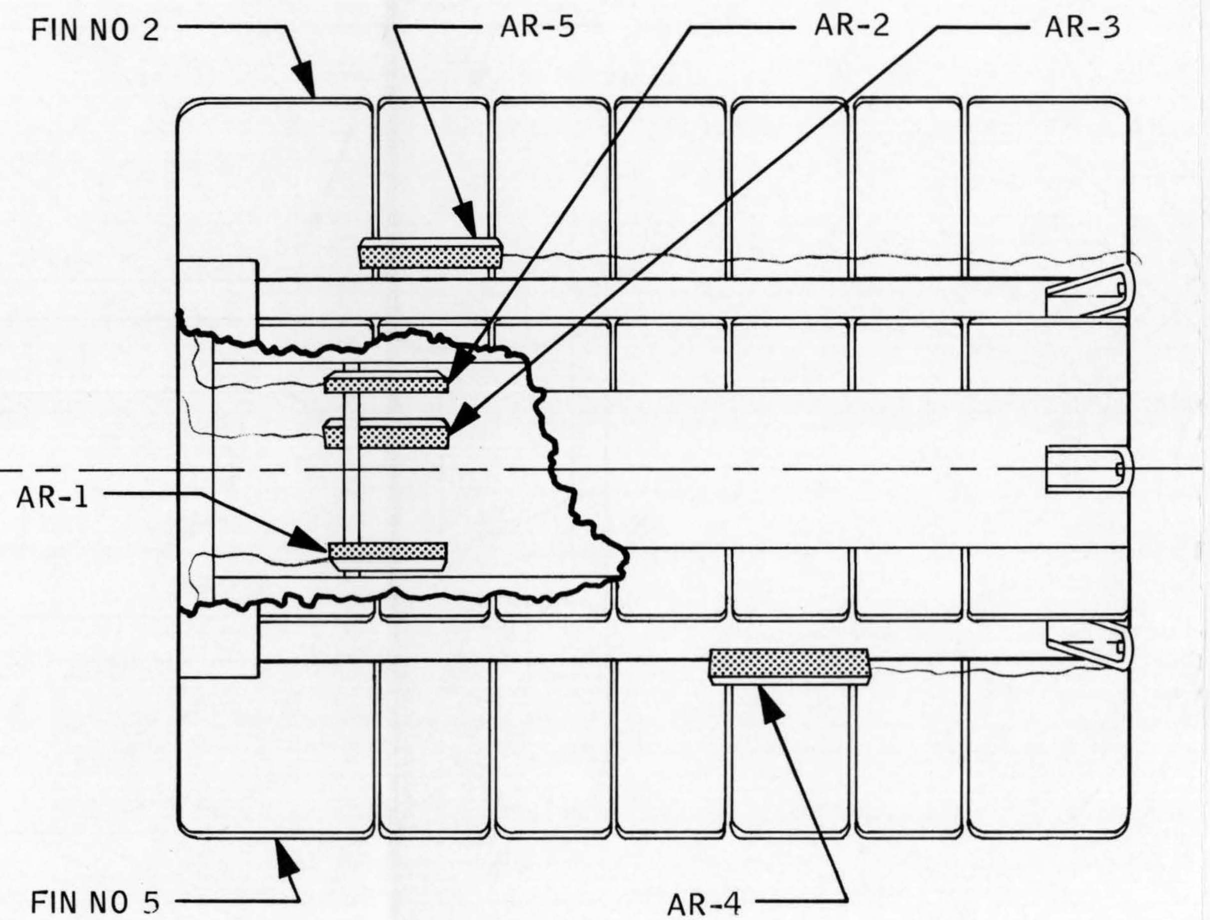
RELAY	FUNCTION	MONITOR	INITIAL CONDITION
K-01	PCU Select	AE-5	PCU 1 Selected
K-02, K-03	D/P Select	None	D/P X Selected
K-04	XMTR Off, XMTR Htr On	No Downlink	XMTR Off
K-05	XMTR A, XMTR B Select	AE-17	XMTR A Selected
K-06, K-07	Exp #1 Power Control	AB-4	Exp #1 in Stby
K-08, K-09	Exp #2 Power Control	AB-4	Exp #2 in Stby
K-10, K-11	Exp #3 Power Control	AB-5	Exp #3 in Stby
K-12, K-13	Exp #4 Power Control	AB-5	Exp #4 in Stby
K-14, K-15	DSS Htrs 1 and 2	AB-5	Off
K-16	PDR #1 On/Off	AE-5	Off
K-17	PDR #2 On/Off	AE-5	Off
K-18	DSS Heater 3 On/Off	AE-5	10-watt DSS Htr 3 On
K-19	Receiver Protection	Command Capability	Receiver On



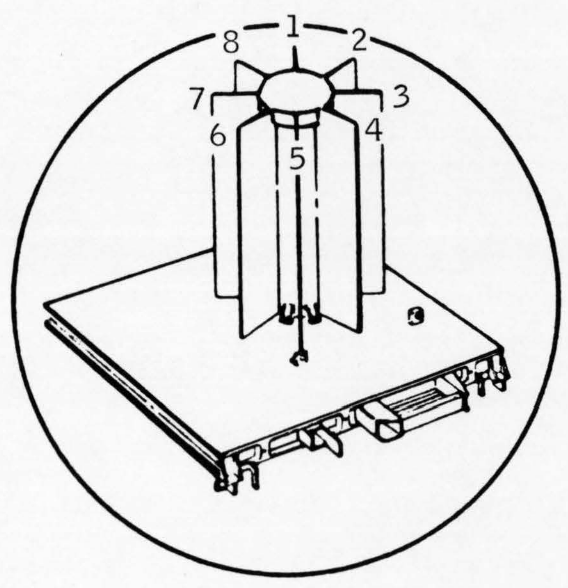
TOP VIEW

TM
DESIGNATIONS

AR-1
AR-2
AR-3
AR-4
AR-5
AR-6



SIDE VIEW



SIGNATURES	DATE
DR Pat Sherrill	3/21/69
DSGN Bill Cornelius	12-30-69
QC Ben Taylor	12-30-69
ENGR Joseph L. Jones	12-31-69
APP Burton L Sharpe	12-31-69
FEC Dean B Fisher	1-2-70
AUTH Don Bray	1-2-70

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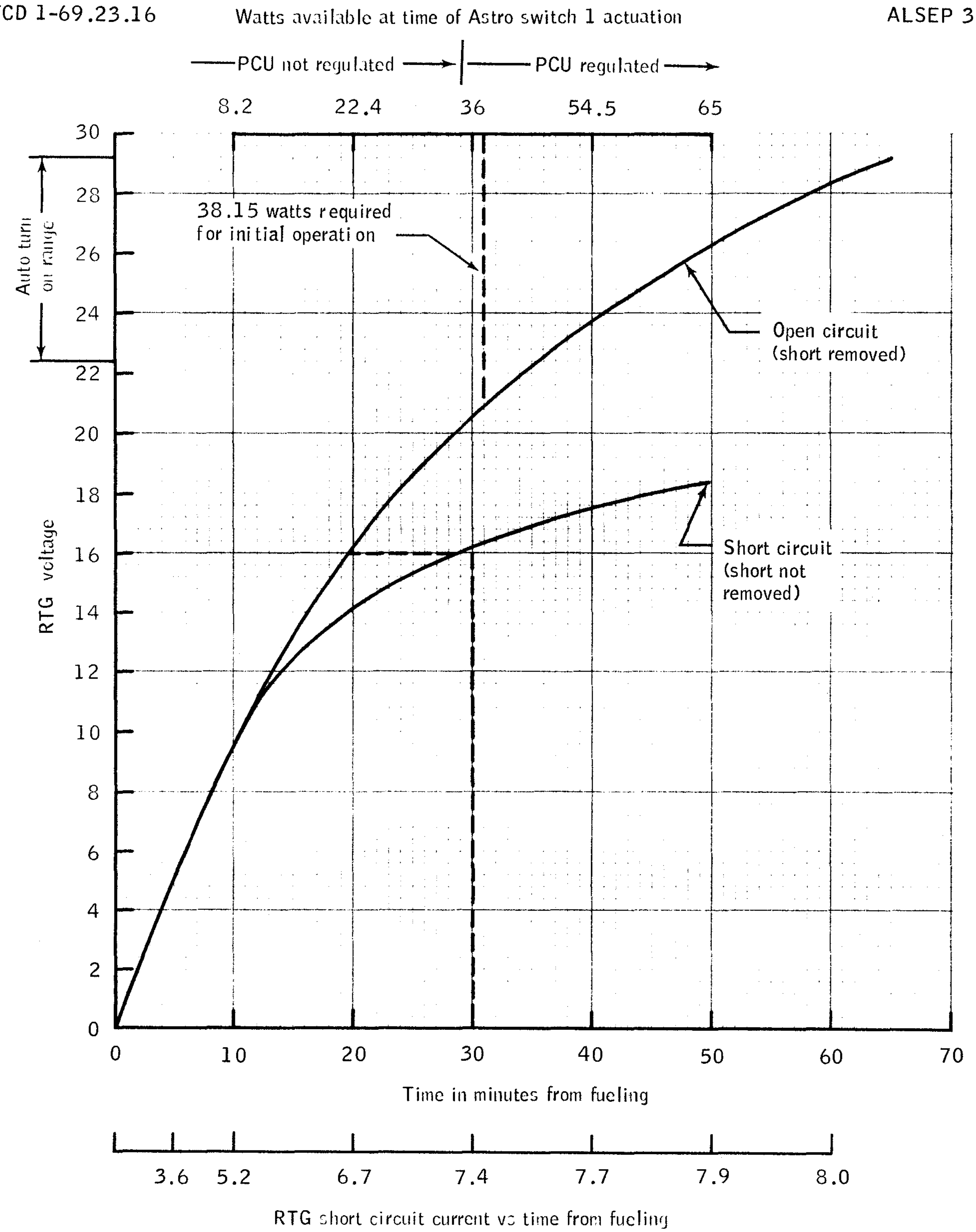
RTG TEMPERATURE SENSOR LOCATIONS

ALSEP 3	SIZE B	DWG NO. 4.1
17 X 11	PAGE 4-5	SHEET 1 OF 1



Example:

Short removed 30 minutes after fueling. Move horizontally from short circuit curve to open circuit curve. If Astronaut switch no. 1 is actuated 11 minutes later, the required 38.15 watts will be available.

Figure 4-1.- RTG warmup characteristics.

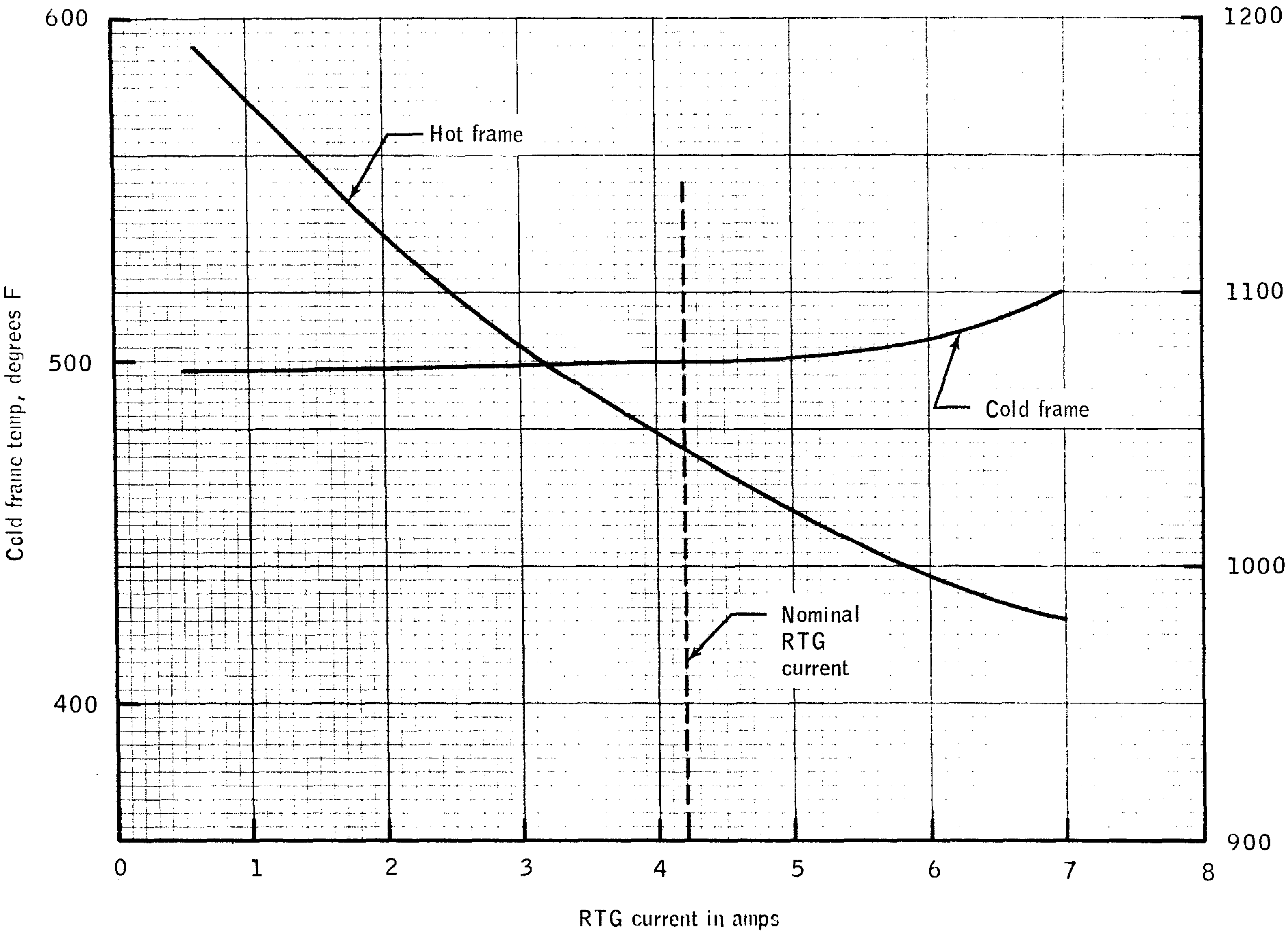


Figure 4-2.- RTG hot and cold frame temps vs RTG current.

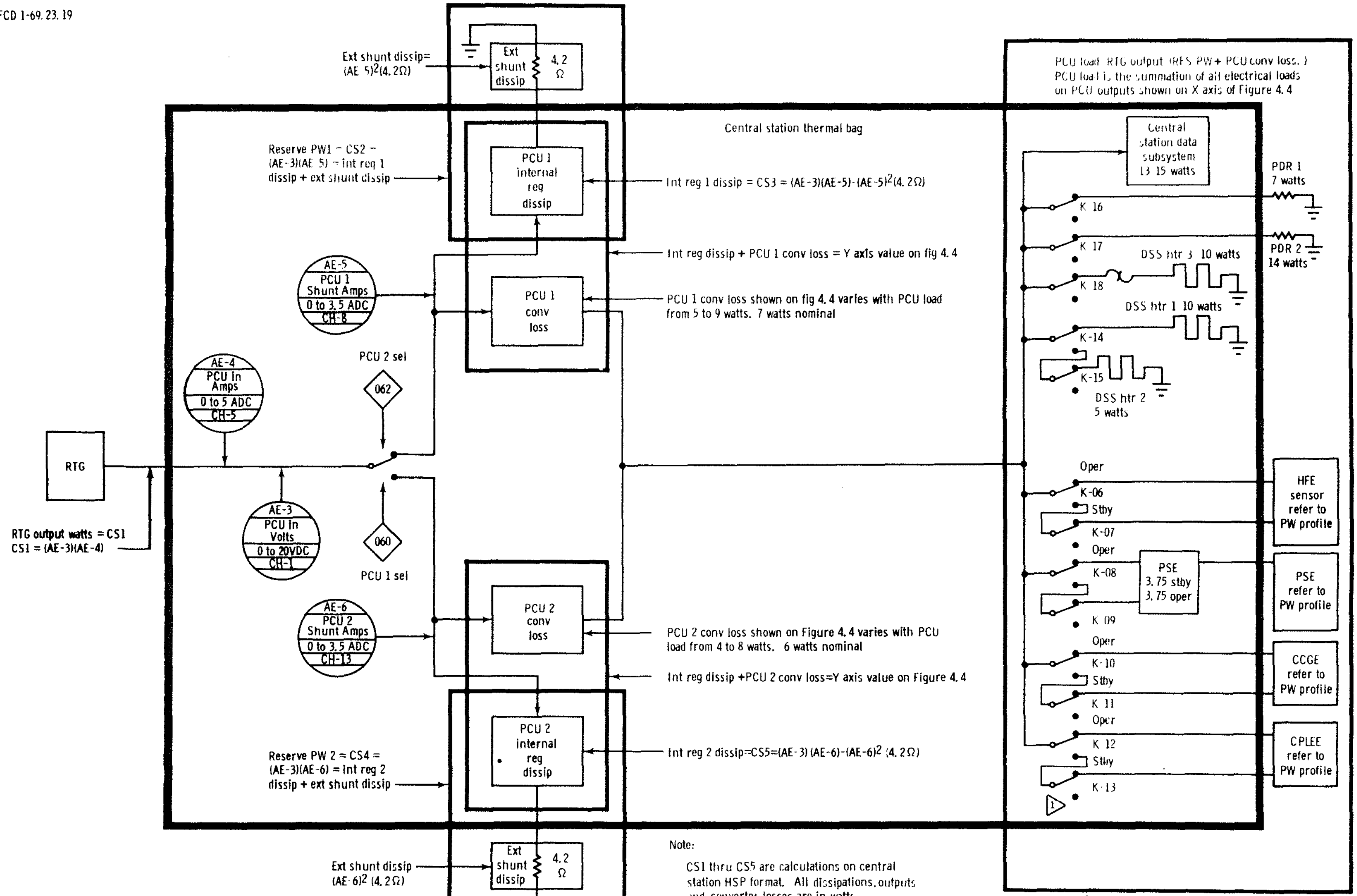


Figure 4-3. - ALSEP 3 power distribution.

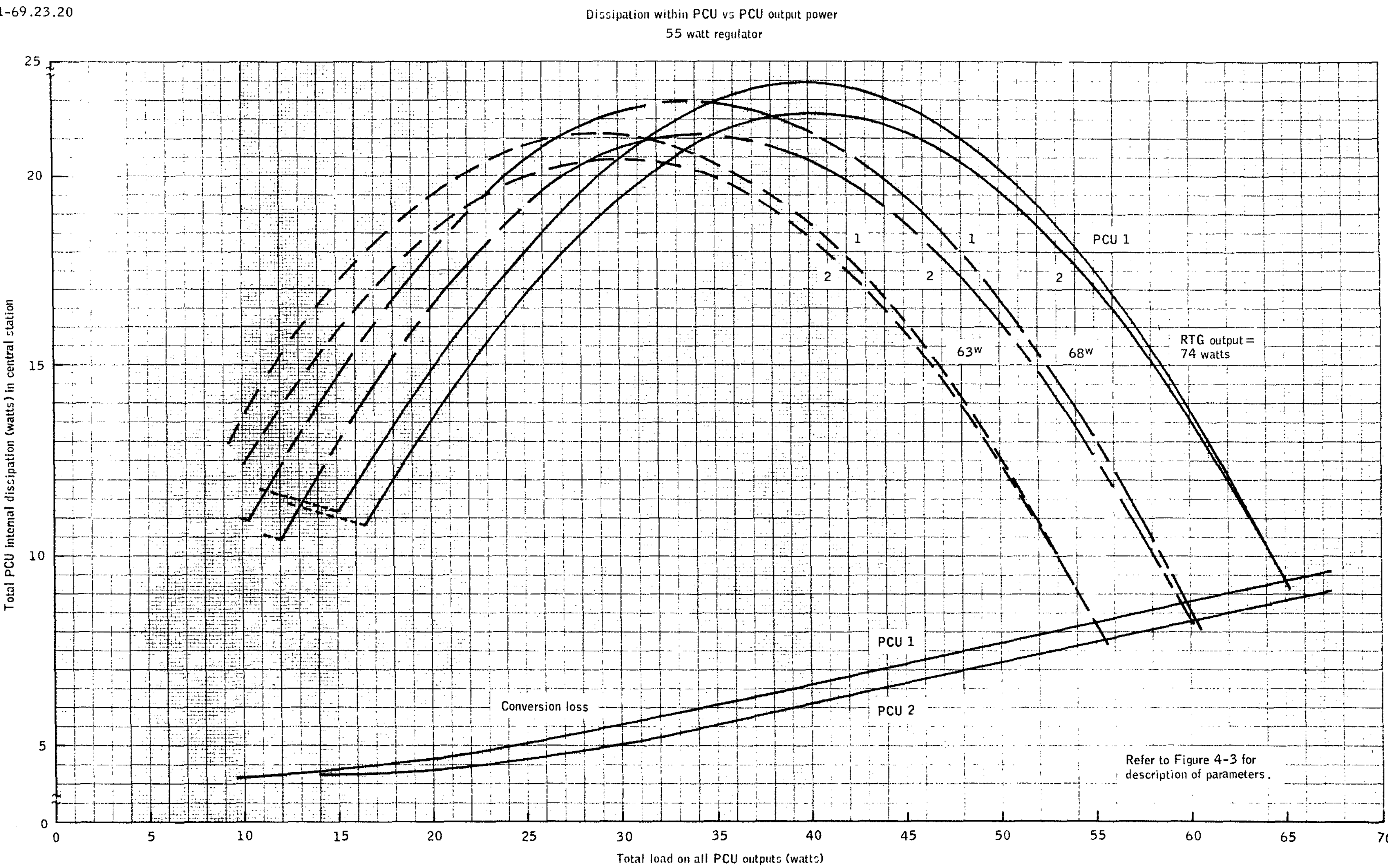


Figure 4-4.- PCU load vs RTG power output vs central station dissipation.

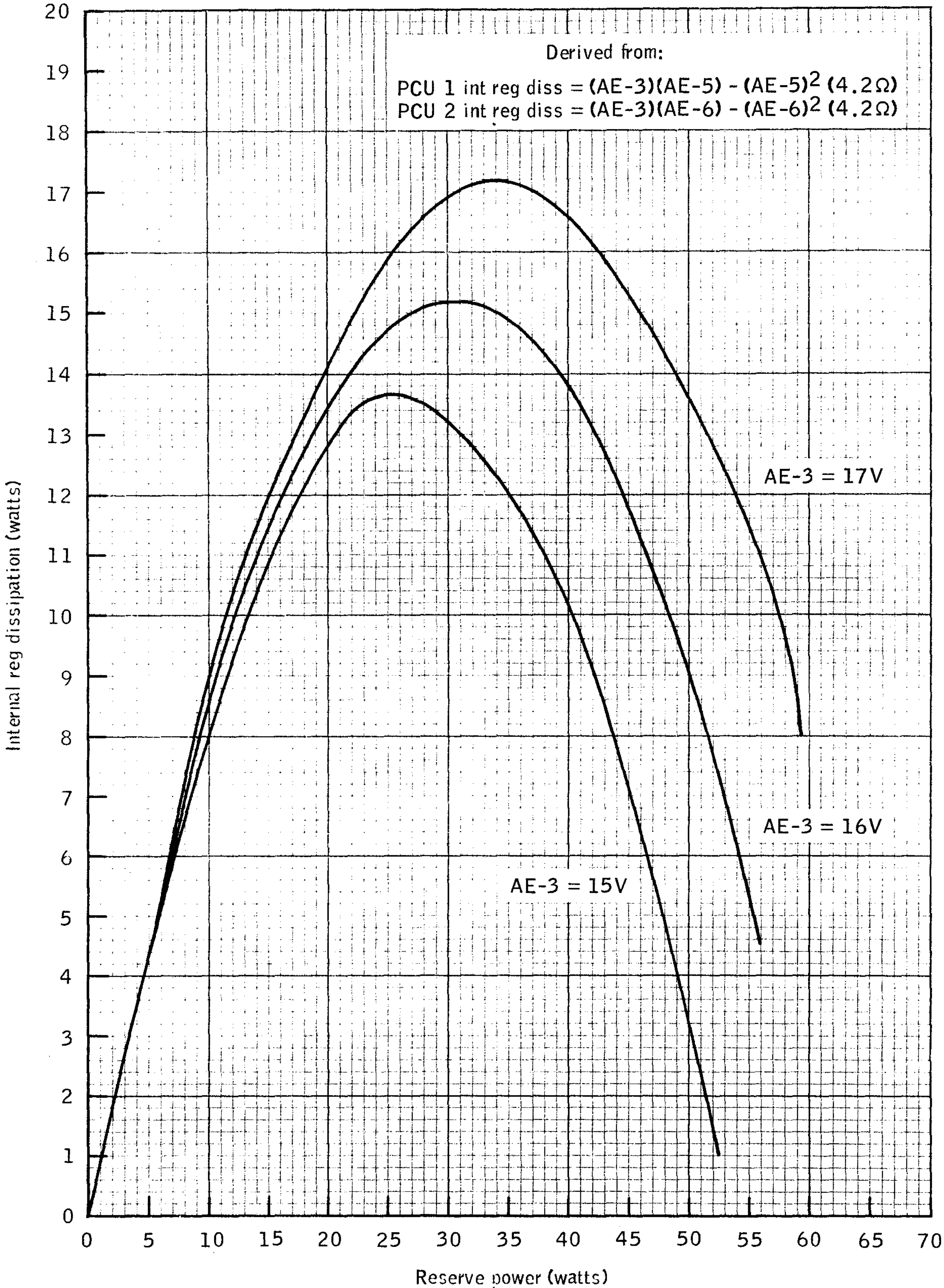


Figure 4-5.- Internal regulator dissipation.

TABLE 4-IV.- ALSEP 3 CIRCUIT BREAKER AND FUSE TABULATION

SYMBOL NUMBER	RATING	SUBSYSTEM	CIRCUIT	EFFECT
CB-01	110 to 225 mA	Command Receiver	+12 Vdc	Receiver overload causes breaker CB-01 to switch in 1.25W receiver heater. No protection for heater. Breaker reset by 12-hour timer.
CB-02	110 to 225 mA	Transmitter A	+12 Vdc	Transmitter A +12 Vdc overload causes breaker CB-02 to switch Transmitter B on. Breaker CB-02 is self-resetting.
CB-03	560 to 840 mA	Transmitter A	+29 Vdc	Transmitter A +29 Vdc overload causes breaker CB-03 to switch Transmitter B on. Breaker CB-03 is self-resetting.
CB-04	110 to 225 mA	Transmitter B	+12 Vdc	Transmitter B +12 Vdc overload causes breaker CB-04 to switch Transmitter A on. Breaker CB-04 is self-resetting.
CB-05	560 to 840 mA	Transmitter B	+29 Vdc	Transmitter B +29 Vdc overload causes breaker CB-05 to switch Transmitter A on. Breaker CB-05 is self-resetting.
CB-06	450 to 550 mA	HFE Instrument	+29 Vdc	HFE instrument overload causes breaker CB-06 to place HFE in standby. Breaker CB-06 is self-resetting.
CB-07	450 to 550 mA	PSE Instrument	+29 Vdc	PSE instrument overload causes breaker CB-07 to place PSE in standby. Breaker CB-07 is self-resetting.
CB-08	450 to 550 mA	CCGE Instrument	+29 Vdc	CCGE instrument overload causes breaker CB-08 to place CCGE in standby. Breaker CB-08 is self-resetting.
CB-09	450 to 550 mA	CPLEE Instrument	+29 Vdc	CPLEE instrument overload causes breaker CB-09 to place CPLEE in standby. Breaker CB-09 is self-resetting.
CB-10	450 to 550 mA	Thermal	+29 Vdc	Overload on 10-watt heater line (DSS Htr #1) causes CB-10 to switch in a 5-watt heater (DSS Htr #2). CB-10 is self-resetting.
F-01	250 mA	Dust Detector	-12 Vdc	A blown fuse F-01 will permanently disable the dust detector resulting in loss of photoelectric cell voltage TM parameters AX-04, AX-05, and AX-06.
F-02	250 mA	Dust Detector	+12 Vdc	A blown fuse F-02 will permanently disable the dust detector, resulting in loss of photoelectric cell voltage TM parameters AX-04, AX-05, and AX-06 and photoelectric cell temp TM parameters AX-01, AX-02, and AX-03.
F-03	500 mA	HFE Standby	+29 Vdc	A blown F-03 will permanently disable the HFE standby capability.
F-04	500 mA	PSE Standby	+29 Vdc	A blown F-04 will permanently disable the PSE standby capability.
F-05	500 mA	CCGE Standby	+29 Vdc	A blown F-05 will permanently disable the CCGE standby capability.
F-06	500 mA	CPLEE Standby	+29 Vdc	A blown F-06 will permanently disable the CPLEE standby capability.
F-07	500 mA	Thermal	+29 Vdc	A blown F-07 will permanently disable DSS Heater #2.

TABLE 4-V.- VOLTAGE DISTRIBUTION AND LOAD ANALYSIS

NOTE

Experiment operational power is defined as maximum nighttime steady state (e.g., PSE Operate). Experiment standby power is defined as maximum heater power (e.g., PSE Standby). The voltage distribution and load analysis represent measurements at an ambient temperature of 70°F.

VOLTAGE BUS	CIRCUIT	WATTS	mAdc	CIRCUIT PROTECTION (Drawing 4.2)
+29 Vdc ±1%	HFE Operate Standby	8.0 4.2	276 145	CB-06 500 mA ±10% F-03 500 mA
	PSE Operate Standby	6.8 4.5	234 155	CB-07 500 mA ±10% F-04 500 mA
	CCGE Operate Standby	7.0 4.8	242 165	CB-08 500 mA ±10% F-05 500 mA
	CPLEE Operate Standby	8.9 4.5	309 155	CB-09 500 mA ±10% F-06 500 mA
	DSS Heater #1 DSS Heater #2	10.0 5.0	345 172	CB-10 500 mA ±10% F-07 500 mA
	Transmitter A	6.6-9.45	228-308	CB-03 560 to 840 mA
	Transmitter B	6.6-9.45	228-308	CB-05 560 to 840 mA
	Transmitter Heater	8.4		None
	DSS Heater #3	10.0		None
	PDR 1	7.0		None
	PDR 2	14.0		None
	PDU	0.375		None
+15 Vdc ±1%	DSS/A	0.065		None
	PDU	0.075		None
+12 Vdc ±1%	Command Decoder	0.325		None
	Diplexer Switch	0.150	12.5	CB-04 110 to 225 mA
	DSS/A	0.150		None
	DSS/D	0.05		None
	Dust Detector	0.380	31.6	F-02 250 mA
	PCU	Negligible		None
	PDU	0.735		None
	Receiver	0.665	55.5	CB-01 110 to 225 mA
	Receiver Heater	1.25		None
	Temp Sensors	Negligible		None
	Transmitter A	0.500	41.7	CB-02 110 to 225 mA
	Transmitter B	0.500	41.7	CB-04 110 to 225 mA
+5 Vdc ±1%	Command Decoder	0.775		None
	DSS/A	1.10		None
	DSS/D	0.450		None
	PDU	0.085		None
	Relay Drivers	Negligible		None
-6 Vdc ±1%	Command Decoder	0.230		None
	PDU	Negligible		None
	Receiver	0.030		None
-12 Vdc ±1%	DSS/A	0.120		None
	Dust Detector	0.160	13.2	F-01 250 mA
	PDU	0.475		None

TABLE 4-VI.- COMMANDS CAUSING DELTA POWER

Tabulation of ΔP caused by command execution assumes the following conditions exist:

Transmitter	Off
PDR #1	Off
PDR #2	Off
DSS Heater 3	Off
Dust Detector	Off
HFE	Off
PSE	Off
CCGE	Off
CPLEE	Off
DSS Htr 1 and 2	Off

The ALSEP subsystems will demand electrical power from the PCU in the following amounts:

	Power (watts)	Current (mAdc)
Transmitter Heater	8.40	345.0
Receiver	0.70	60.5
DSS/D	0.50	94.2
DSS/A	1.44	247.0
Command Decoder	1.33	220.0
PDU	1.75	137.0
PCU (voltage regulation)	1.5	125.0
Distribution losses	1.5	
Total	17.12	

17.12 watts represents the base for the delta power demands caused by the execution of the following commands (refer to individual experiment power profiles):

Command	Delta Power (watts)	Delta Current (mAdc)	Notes
013 Transmitter On	1.0 1.15		XMTR A selected by CMD 012. XMTR B selected by CMD 015.
017 PDR #1 On	7.0		
022 PDR #2 On	14.0		
024 DSS Heater 3 On	10.0		Thermostatically controlled.
027 Dust Detector On	0.3		
036 Exp #1 Oper Sel (HFE)	3.8 8.0 9.0		Day operate mode. (HTR off) Night operate mode. (4.2-watt difference due to heater.) Turn on transient.
037 Exp #1 Stby Sel (HFE)	4.2		Survival heaters.
042 Exp #2 Oper Sel (PSE)	4.4 6.8 12.9		Day operate mode. Night operate mode. (2.4-watt difference due to heaters.) Turn on transient.
043 Exp #2 Stby Sel (PSE)	4.5		Survival Heaters.
045 Exp #3 Oper Sel (CCGE)	2.0 7.0 13.0		Day operate mode. Night operate mode. (5.0-watt difference due to heaters). Turn on transient.
046 Exp #3 Stby Sel (CCGE)	4.8		Survival heater.
052 Exp #4 Oper Sel (CPLEE)	2.9 6.0 7.0		Day operate mode. Night operate mode. (3.1-watt difference due to thermostatically controlled heater). Turn on transient.
053 Exp #4 Stby Sel (CPLEE)	4.5		Survival heater.
055 DSS Htr 1 Sel	10.0		Commandable heater.
056 DSS Htr 2 Sel	5.0		Commandable heater.
070 Level Power X Motor (PSE)	3.05		Normal steady state power. Exp #1 (PSE) must be operational.
071 Level Power Y Motor (PSE)	3.05		Same as CMD 070 (X motor)
072 Level Power Z Motor (PSE)	3.05		Same as CMD 070 (X motor)
076 Thermal Control Mode (PSE) Auto Forced Off	 0.2 to 2.35 2.77 0.0		 Proportional heater. Heater on continuously. Heater off. Exp #2 (PSE) must be operational.
111 CPLEE Oper Heater On	2.0		This delta will be continuous and will be felt only if automatic control (thermostat) is open at time of command.

TABLE 4-VI.- COMMANDS CAUSING DELTA POWER - CONCLUDED

Command	Delta Power (watts)	Delta Current (mAdc)	Notes
113 CPLEE Dust Cover Eject	4.0		Until squibs have burned.
140 Followed by 152 HFE Heater On	0.5		Command 152 steps HFE heaters through their excitation program, alternately on and off.

NOTE

Electrical demand on +12 Vdc bus required to operate voltage regulation circuit. PCU conversion loss (4-watt dissipation at minimum PCU loading) or shunt regulator dissipation not included. Conversion loss and shunt regulator dissipation variable depending on PCU loading. Refer to Figures 4-4 and 4-5.

TABLE 4-VII.- CENTRAL STATION STEADY STATE POWER DEMANDS ON EACH VOLTAGE BUS FROM THE PCU

SUBSYSTEM	+29 Vdc	+15 Vdc	+12 Vdc	-12 Vdc	-6 Vdc	+5 Vdc	TOTAL	NOTES
XMTR A	6.0 W* 9.0 W*		0.2 W 41.7 mA				Watts 6.5(-10°F) 9.5(+140°F)	CMD 012 selects A XMTR. XMTR A protection: +12 Vdc CB-02. +29 Vdc CB-03 CMD 015 selects B XMTR. XMTR B protection: +12 Vdc CB-04. +29 Vdc CB-05. CMD 013 turns on selected XMTR. CMD 014 turns off selected XMTR. Overload on + 12 Vdc bus (110 to 225 mA) or +29 Vdc bus (560 to 840 mA) causes a switch to other transmitter. When XMTR is commanded off (CMD 014) transmitter heater is automatically turned on. The +12 Vdc switched to XMTR B also energizes the diplexer switch.
XMTR B	6.0 W* 9.0 W*		0.65 W 54 mA				6.65 W 9.65 W	
XMTR HTR	8.4 W 290 mA						8.4 W	
RECEIVER			0.665 W 55.5 mA		0.03 W 5.0 mA		0.695 W	No ground commands to control receiver. Overload on +12 Vdc bus (110 to 225 mA) disconnects +12 Vdc (via CB-01) from receiver and switches in receiver heater. Receiver is turned back on by 12-hour pulse from timer. -6 Vdc on continuously.
RECEIVER HEATER			1.25 W 104 mA				1.25 W	
X OR Y DATA PROCESSOR			0.05 W 4.2 mA			0.45 W 90 mA	0.50 W	CMD 034 turns on "X" processor, "Y" processor off. CMD 035 turns on "Y" processor, "X" processor off. No overload protection for processors. Either "X" or "Y" processor on. No overload protection for analog multiplexer. Analog MUX on continuously.
ANALOG MUX		0.065 W 4.4 mA	0.15 W 12.5 mA	0.12 W 10 mA		1.1 W 220 mA	1.435 W	
COMMAND DECODER			0.325 W 27.1 mA		0.230 W 38.4 mA	0.775 W 155 mA	1.33 W	Command decoder is on continuously with no overload protection. Redundant decoders "A" and "B" addressable from ground.
PDU	0.375 W 12.9 mA	0.075 W 5.0 mA	0.735 W 61.1 mA	0.475 W 39.5 mA	0.008 W 1.3 mA	0.085 W 17 mA	1.753 W	PDU controls distribution of power to the ALSEP subsystems. +12 Vdc, -12 Vdc, and +5 Vdc are for power sequencer logic. +29 Vdc and +5 Vdc are used for relay drivers located in PDU.
DUST DET			0.38 W 31.6 mA	0.16 W 13.2 mA			0.54 W	CMD 027 turns dust detector on. +12 Vdc bus fuse F01 - -12 Vdc bus fuse F02. 250 mA each. CMD 031 turns dust detector off. Dust detector photo-electrical cell temps on continuously.
PCU 1 OR PCU 2			1.5 W				1.5 W	CMD 060 turns on PCU-1, PCU-2 off. CMD 062 turns on PCU-2, PCU-1 off. +12 Vdc required for level sensing circuit and regulator amplifiers. Reserve power <1.5 watts, Exp 4 will go to standby.
PDR #1	7.0 W 240 mA						7.0 W	CMD 017 turns on PDR #1. CMD 021 turns off PDR #1. PDR #1 is located on the CS and is exposed to the Lunar environment.
PDR #2	14.0 W 485 mA						14.0 W	CMD 022 turns on PDR #2. CMD 023 turns off PDR #2. PDR #2 is located on the CS and is exposed to the Lunar environment.
DSS HEATER 3	10.0 W 345 mA						10.0 W	CMD 024 turns DSS HTR 3 on. CMD 025 turns DSS HTR 3 off. When on, heaters are thermostatically controlled by ST-01 (Closed - 10°F, Open 0°F). The four heaters are located on the CS thermal plate.
DSS HEATER 2	5 W 173 mA						5 W	CMD 056 turns DSS Htr 2 on. Protected by F-07 (500 mA). CMD 057 turns DSS Htr 2 off.
DSS HEATER 1	10 W 345 mA						10 W	CMD 055 turns DSS Htr 1 on. Protected by CB-10 (500 mA ±10%). CMD 056 followed by CMD 057 turns DSS Htr 1 and 2 off.

*Transmitter power demand varies with temperature.

TABLE 4-VIII.- RELAY DRIVER FUNCTIONS AND INPUT VOLTAGE REQUIREMENTS

Relay Drivers	Relay	Function	Monitor	CMD	+12 Vdc	Input Voltage (A)	Input Voltage (B)	Input Voltage (C)	+29 Vdc
RD-01	K-01	PCU 1 SEL	AE-5	060	X				
02	K-01	PCU 2 SEL	AE-6	062	X				
03	K-06	EXP 1 OPER SEL	*	036			X		X
04	K-06	EXP 1 STBY SEL	AB-4	037			X	X	
05	K-07	EXP 1 STBY SEL	AB-4	037			X	X	
06	K-07	EXP 1 STBY OFF	*	041			X	X	
07	K-08	EXP 2 OPER SEL	*	042			X		X
08	K-08	EXP 2 STBY SEL	AB-4	043			X	X	
09	K-09	EXP 2 STBY SEL	AB-4	043			X	X	
10	K-09	EXP 2 STBY OFF	*	044			X	X	
11	K-10	EXP 3 OPER SEL	*	045			X		X
12	K-10	EXP 3 STBY SEL	AB-5	046			X	X	
13	K-11	EXP 3 STBY SEL	AB-5	046			X	X	
14	K-11	EXP 3 STBY OFF	*	050			X	X	
15	K-12	EXP 4 OPER SEL	*	052			X		X
16	K-12	EXP 4 STBY SEL	AB-5	053			X	X	
17	K-13	EXP 4 STBY SEL	AB-5	053			X	X	
18	K-13	EXP 4 STBY OFF	*	054			X	X	
19	K-14	DSS HTR 1 SEL	*	055			X		X
20	K-14	DSS HTR 2 SEL	AB-5	056			X	X	
21	K-15	DSS HTR 2 SEL	AB-5	056			X	X	
22	K-15	DSS HTR 2 OFF	*	057			X	X	
23	CB-01	RECEIVER RESET		12 hr pulse			X	X	
24	K-02 K-03	DSS/PROC Y SEL	None	035			X	X	
25	K-02 K-03	DSS/PROC X SEL	None	034			X	X	
26	K-04	XMTR OFF		014		X			X
27	K-04	XMTR ON		013		X			X
28	K-05	XMTR A SEL	AE-17	012			X	X	
29	K-05	XMTR B SEL	AE-18	015			X	X	
30	K-18	DSS HTR 3 ON	*	024		X			X
31	K-18	DSS HTR 3 OFF	*	025		X			X
32	K-16	DISSIP R1 ON	*	017		X			X
33	K-16	DISSIP R1 OFF	*	021		X			X
34	K-17	DISSIP R2 ON	*	022		X			X
35	K-17	DISSIP R2 OFF	*	023		X			X

*Function determined by monitoring PCU 1 shunt current AE-5, or PCU 2 shunt current AE-6.

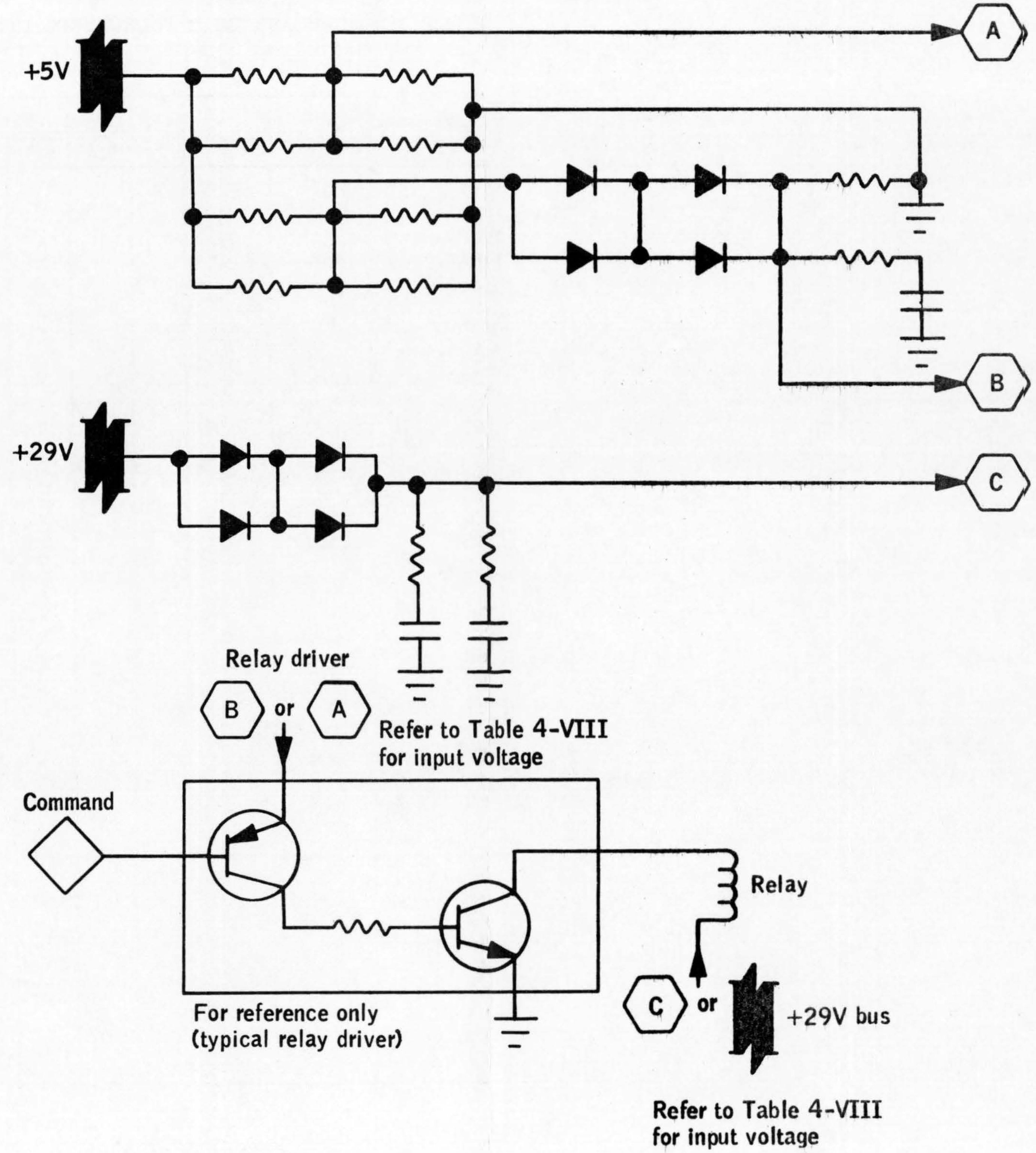
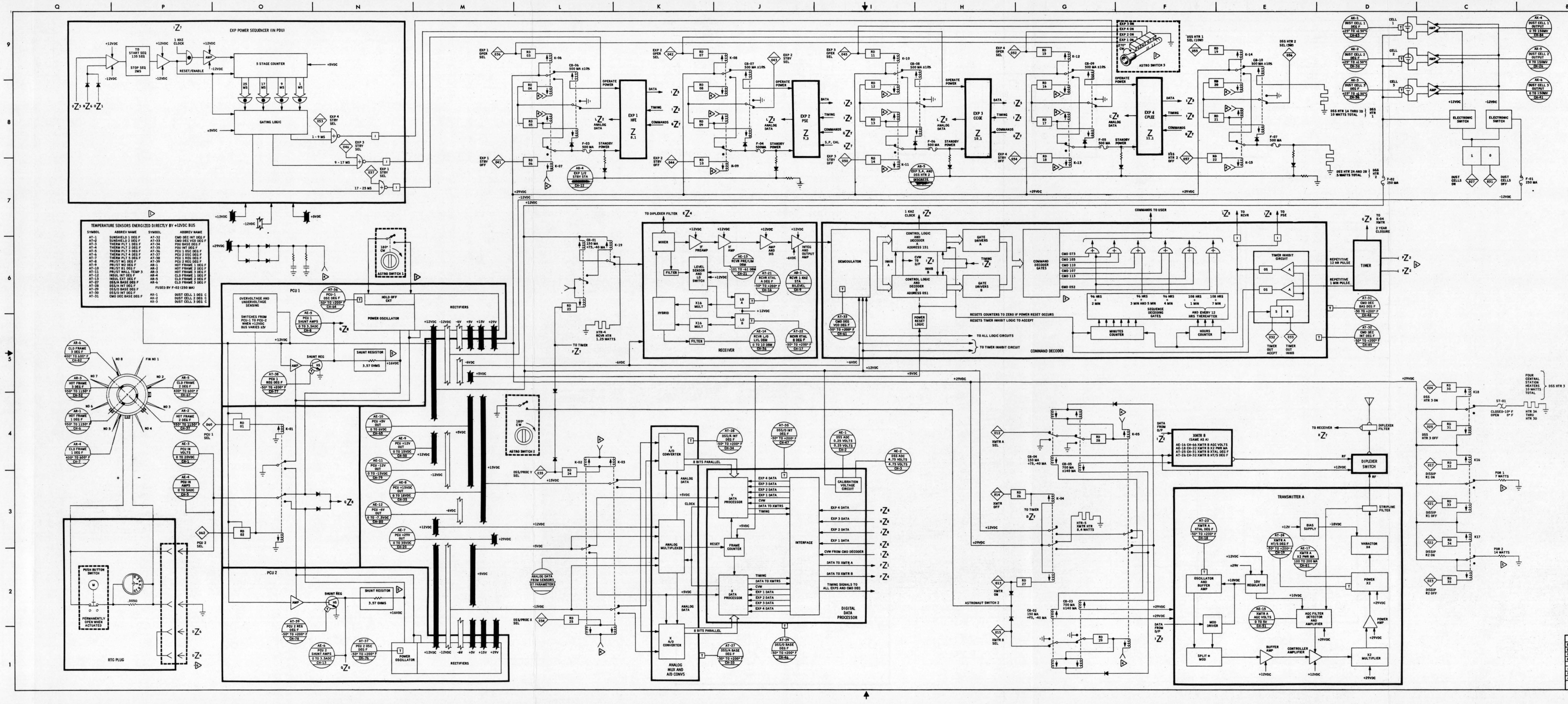


Figure 4-6. - Relay driver voltages.



7. AT DEPLOYMENT, THE HOLDOFF CIRCUIT PREVENTS PCU 1 OPERATION UNTIL THE RTG OPEN CIRCUIT VOLTAGE REACHES 24VDC ±3V. ASTRO SWITCH 1 BYPASSES THE HOLDOFF CIRCUIT, ALLOWING MANUAL TURNON OF PCU 1

6. PLUGGING RTG INTO CENTRAL STATION CAUSES TIMER TO START (PET ZERO)

5. SHUNT RESISTORS, PDR 1 AND PDR 2 LOCATED ON PRIMARY STRUCTURE

4. REFER TO TABLE 4-VIII FOR RELAY DRIVER FUNCTIONS AND INPUT POWER REQUIREMENTS

3. CMD 073 PSE UNCAGE ARM/FIRE
105 SET CCGE SEAL BREAK
110 INITIATE CCGE AUTO OPERATE MODE
107 EXECUTE CCGE SEAL BREAK
113 CPLEE DUST COVER BLOW
052 EXP 4 OPER SEL

2. SINGLE POLE/SINGLE THROW MOMENTARY CONTACT FOUR GANG SWITCH. ASTRONAUT TURNON SEQUENCE

1 EXP 1 (HFE)	3 EXP 4 (CCGE)
2 EXP 2 (PSE)	4 EXP 3 (CPLEE)

1. NOT INCLUDED IN TABLE
AT-21 RCVR XTAL A DEG F MEASURED ONLY WHEN LOCAL OSC A IS OPERATIONAL
AT-22 RCVR XTAL B DEG F MEASURED ONLY WHEN LOCAL OSC B IS OPERATIONAL
AT-23 XMTR A XTAL DEG F MEASURED ONLY WHEN XMTR A IS OPERATIONAL
AT-24 XMTR A HT/S DEG F MEASURED ONLY WHEN XMTR A IS OPERATIONAL
AT-25 XMTR B XTAL DEG F MEASURED ONLY WHEN XMTR B IS OPERATIONAL
AT-26 XMTR B HT/S DEG F MEASURED ONLY WHEN XMTR B IS OPERATIONAL

NOTES: ALL RELAYS, CIRCUIT BREAKERS AND FUSES SHOWN ARE LOCATED IN THE PDU

SIGNATURES	DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION MANNED SPACECRAFT CENTER · HOUSTON, TEXAS
DR Wade Williams	4-7-69	POWER DISTRIBUTION AND FUNCTIONAL BLOCK DIAGRAM
DSGN Bill Cornelius	12-30-69	
QC	12-31-69	
ENGR Joseph F. James	12-31-69	
APP	12-31-69	ALSEP 3 · SIZE J · DWG NO 4.2
FEC	1-2-70	
AUTH	1-2-70	93.5138.25 · PAGE 4-17 · SHEET 1 OF 1

SECTION 5

COMMAND SUBSYSTEM

5.1 SYSTEM DESCRIPTION

The ALSEP Command Subsystem receives real-time commands, decodes the commands, and supplies the commands to applicable users to control prescribed operations.

The delayed command sequencer will generate fixed commands, at predetermined times, under the control of the central station timer, to insure that critical enabling and calibration functions are implemented in the event of failure of the uplink.

The following units make up the ALSEP Command Subsystem:

A. S-band Antenna

B. Diplexer Filter

C. Command Receiver

D. Command Decoder

5.1.1 S-band Antenna

The ALSEP antenna is a modified axial helix designed to receive and to transmit right-hand circular polarized signals at the Apollo S-band frequency.

The antenna has no command requirements, TM measurements, or power requirements.

TABLE 5-I.- ANTENNA OPERATING PARAMETERS

	Antenna Gain	Frequency	Beamwidth	Polarization
Transmit	15.2 db	S-band	27°	Right-Hand
Receive	14.7 db	S-band	27°	Right-Hand

5.1.2 Diplexer Filter

The diplexer is used to couple the received RF from the antenna to the command receiver, and couple the RF signal from the ALSEP transmitter to the antenna.

The diplexer filter has no command requirements, TM measurements, or power requirements.

5.1.3 Command Receiver

A. The command receiver is a narrow-band FM type, incorporating an FM discriminator for carrier phase modulation detection.

TABLE 5-II.- RECEIVER CHARACTERISTICS

1.	Frequency	2119 MHz ± .001%
2.	Dynamic Range	-101 to -61 dbm
3.	IF Bandwidth	275 kHz @ 3 db
4.	Power	695 mW
5.	TM Parameters	5

B. The receiver has redundant local oscillators which are controlled by a level sensor and switch module. When the output power of the local oscillator falls below a given threshold, the switching circuit will switch +12 Vdc to the redundant local oscillator. When power is applied to the receiver, the switching circuit will search between the redundant oscillators until one of the oscillators provides the necessary signal level, at which time the searching between local oscillators will be terminated. The search interval is from 200 to 400 ms. The oscillator in use can be determined by AT 21 (Rcvr XTAL A Deg F) or AT 22 (Rcvr XTAL B Deg F).

C. Receiver Local Oscillator Switchover Point - The receiver local oscillator level, TM measurement AE-14, will normally indicate 5.0 dbm. Local oscillator switchover will occur at approximately 1.0 dbm.

TABLE 5-III.- RECEIVER POWER REQUIREMENTS

Voltage Bus	Watts	DCMA	Circuit Protection
+12 Vdc ± 1%	.665	55.5	CB-01 110 to 225 mA
-6 Vdc ± 1%	.03	5.0	None

NOTE

Receiver overload causes CB-01 to switch on the 1.25 watt (104 mAdc @ +12 Vdc) RECEIVER HEATER. CB-01 is reset by the 12-hour timer pulse.

5.1.4 Command Decoder

The decoder consists of the following sections:

A. Demodulator Section

B. Redundant Digital Decoder Section

C. Delayed Command Sequencer

D. Timer

5.1.4.1 Demodulator section.- The demodulator section accepts the composite audio subcarrier from the command receiver. The composite audio subcarrier is the linear sum of the data and sync subcarriers, where the two-kc data subcarrier is modulated by a 1000 bit per second data stream and the sync signal is a one-kc subcarrier.

The one-kc subcarrier is used to phase-lock a voltage controlled oscillator (VCO) in order to assure command bit synchronization during the decoding process. The detection and extraction of the command bits is accomplished by comparing the two-kc subcarrier with a two-kc synchronized signal produced by the VCO, which is phase-locked by the one-kc subcarrier signal.

5.1.4.2 Digital decoder section.-

A. A redundant digital decoders section is provided. The digital decoders are identical but require different decoder addresses. A command can be executed by either decoder by selecting the proper decoder address. The decoder addresses for ALSEP 1 are the following:

1. ALSEP 3 Decoder A 1101001 (Octal 151)
2. ALSEP 3 Decoder B 0101001 (Octal 051)

The system is unique in that it does not use sub-bit encoding.

The ALSEP command structure consists of 21 bits.

1101001	1000100	MSB 0111011 LSB
7 Bits	7 Bits	7 Bits
Decoder Address	Command Complement	Command

A bit-by-bit comparison is made between the command complement and the command for error protection. A minimum of 20 bits must precede the command to insure phase-lock, and a minimum of 20 bits follow the command to allow for command execution.

Upon receipt of a command, a command verification word is inserted in Word 05 of the TM downlink. The command verification word consists of 10 bits. Seven bits in the downlink word are the command received and one bit, called the parity bit, indicates that the command and command complement did or did not compare.

DA-7	DA-5	DA-6
00	0111011	1
MSB	7 Bits	LSB
2 Bits	Command Received	1 Bit
Filler Bits		Parity

Parity Bit "1": Command and command complement compared, and command was executed.

Parity Bit "0": Command and command complement did not compare, and command was not executed.

B. Normal Decoder Operation - The redundant Decoders A and B receive the command data, timing pulses, and the threshold signal simultaneously. The threshold signal is used to indicate to the decoders that phase-lock has been achieved.

Decoders A and B will search through the command data until one decoder receives a valid address, at which time the other decoder is inhibited. The decoder that received the valid address starts its programer at the count of 29. At a count of 36, the command complement is contained in the decoder shift register. At this time, a bit-by-bit comparison is made against the incoming command. At a programer count of 43, the command is contained in the shift register. If a compare was made, the command is executed for 20 ms, until the programer count is 63. Non-comparison will prevent execution of the command. The command can be downlinked as a command verification word (CVW) only after the count of 63 through 2047.

The seven bits of command information and the one bit that indicates compare or no compare are held in the shift register until a Data Demand Signal from the data processor at Word 46 time is inputted, at which time the 8 bits are shipped serially to the digital processor to be inserted into Word 46 of the PCM downlink. The end of the Data Demand Signal generates a Data End Reset which returns the decoders to the search mode.

C. Command Decoder Reset Capability

1. Power Reset - A separate power reset circuit is provided for Decoder A and B. The purpose of this is to assure that both decoders will start in the search mode when power is applied to ALSEP. The reset circuits will also reset the decoders to the search mode in case of a momentary drop of approximately 3 Vdc on the 5 Vdc Bus. The power reset circuit in Decoder A will reset the timer inhibit circuit in the timer pulse shaping section and allow the command decoder to accept the 12-hour and the one-minute pulses from the timer. If a power reset signal is received during the decoding process of a command, the decoding process will be terminated at that time, and the decoders will return to the search mode. If a power reset is received after the decoding process is complete, the command will be executed, but a CVW will not be received.

2. Demand Override Reset - In the event that the decoders did not receive a Data End Reset signal, the decoder programer will generate a reset signal 1984 ms (programer count 2047) after command execution.

3. Threshold Loss Reset - Loss of phase-lock between the one-kc sync signal that is uplinked and the one-kc signal derived from the eight-kc VCO during the decoding process of the command, will generate a threshold loss reset signal. The decoding process will terminate at this time and the decoders will return to the search mode. If the decoding process has been completed, the command will be executed and a command verification will be received.

5.1.4.3 Delayed command sequencer.- Provisions have been incorporated to automatically generate eight commands to provide a backup feature in the event of an uplink failure.

The delayed command sequencer receives 12-hour timing pulses and 1-minute timing pulses from the timer which advance the "hours" and "minutes" counters (see Drawing 5.1). A power reset will cause the counters to be reset to zero.

Through various combinations of "and" gates connected to these counters, the delayed command sequencer will output the following commands at the times stated. The timer becomes active at PET-zero. PET-zero is defined as the time of RTG plug-in to the central station.

The following commands can be initiated by RTC's or by the delayed command sequencer. The CVW will be available only if the command was by RTC.

A. One-Time Commands	Normal Time of Execution after PET-zero
1. Set CCGE seal break/uprange (CMD 105), fire PSE uncage circuit* (CMD 073), and Blow CPLEE dust cover (CMD 113)	96 hours + 2 minutes
2. Initiate Automatic Range Mode of Op (CMD 110) CCGE.	96 hours + 3 minutes
3. CMD 122 N/A Execute CCGE Seal Break/Downrange (CMD 107)	96 hours + 4 minutes
4. Initiate Automatic Range Mode of Ops (CMD 110) CCGE.	96 hours + 5 minutes

B. Repetitive Commands	Normal Time of Execution after PET-zero
1. CMD 131 N/A	108 hours + 1 minute and every 12 hours thereafter.
2. Restore power to experiment #4 (CPLEE) (CMD 052)	108 hours + 7 minutes and every 12 hours thereafter.

Command Octal 033 inhibits the automatic commands generated by the delayed command sequencer and 12-hour timer.

The 12-hour timer commands are listed below for reference and are not generated by the delayed command sequencer.

C. Repetitive Commands (every 12 hours after PET-zero)

1. Command receiver reset
2. Short period calibrate PSE (same as CMD 065)
3. Uncage PSE*
   a. Arm uncage PSE (at PET-zero +12 hours)
   b. Execute uncage PSE (at PET-zero +24 hours)

5.1.4.4 Timer.- The timer is an electro-mechanical device which produces three separate switching functions: repetitive 1-minute, repetitive 12-hour, and a non-repetitive 2-hour closure. The 1-minute and 12-hour switch closures are used as inputs to the delayed command sequencer. The 12-hour timer function can be observed on AL-7 (PSE CAL STA) and DL-8 (PSE SP DATA). The 2-year switch closure is used to permanently terminate ALSEP transmitter operation. A power reset (Paragraph 5.1.4.2.C.1) will not affect the 2-year switch closure.

The timer mechanism is driven independently of any ALSEP power by means of a zinc-mercuric-oxide cell. Jumper wires in the RTG plug cause the timer to start when the RTG is connected to the central station. This time is defined at package elapsed time (PET) minus zero, and the time is accumulative.

TABLE 5-IV.- CENTRAL STATION TIMER CHARACTERISTICS

1-minute output	±200 ms
12-hour output	±10 min
2-year output	±30 days

Timer starts at PET-zero.

TABLE 5-V.- COMMAND DECODER POWER REQUIREMENTS

Voltage Bus	Watts	mAdc	Protection
+12 Vdc ± 1%	.325	27.1	None
+5 Vdc ± 1%	.775	155	None
-6 Vdc + 1%	.230	38.4	None

*Uncaging of the PSE will normally be accomplished by two successive ground commands 073. However, as a backup, two successive 12-hour timer pulses or one 12-hour timer pulse and the 96-hour 2-minute one-time command pulse will affect uncaging. Arming the uncaging circuit and then placing the PSE to standby will also affect uncaging.

5.2 COMMAND FUNCTIONS

003 ASE HBR ON (ALSEP 4) DATA PROCESSOR

Command 003 disconnects the data processor from the modulator and connects the modulator to the Active Seismic processor which supplies the high bit rate data (10,600 bps). The ASE HBR ON command takes effect at the scheduled end of the 64-word data processor frame which is in progress at the time the mode change command is received. The downlink data is meaningless if this command is executed with no ASE in the flight configuration.

005 ASE HBR OFF (ALSEP 4) DATA PROCESSOR

Command 005 disconnects the ASE processor from the modulator and connects the modulator to the data processor which supplies data at 530 or 1060 bps, depending on the last bit rate mode commanded. The ASE HBR OFF command takes effect at the scheduled end of the 64-word data processor frame which is in progress at the time the mode change command is received. Central station activation or power reset initializes ASE HBR to OFF.

006 NORM BIT RT SEL DATA PROCESSOR

Command 006 causes the data processor to operate at the normal bit rate (1060 bps). This command takes effect at the scheduled end of the 64-word frame which is in progress at the time the mode change command is received. Central station activation or power reset initializes the data processor to NORMAL BIT RATE. Switching bit rates will cause sync loss at ground station.

007 LOW BIT RT SEL DATA PROCESSOR

Command 007 causes the data processor to operate at low bit rate (530 bps). This command takes effect at the scheduled end of the 64-word frame which is in progress at the time the mode change command is received. Switching bit rates will cause sync loss at ground station.

011 NORM BIT RT RST DATA PROCESSOR

Command 011 is a provision for returning the operational data processor (determined by Command 034 or 035) to the normal bit rate from either the high or low bit rate. This command does not reset the analog multiplexer or frame counter. This command takes effect immediately and does not wait until the scheduled end of the 64-word frame.

NOTE

This command may result in sync loss at ground station, hence possible loss or false readout of command verification word.

012 XMTR A SEL POWER DISTRIBUTION UNIT

Command 012 actuates relay K-05, in the PDU, to the position that selects Transmitter A. XMTR A SEL is the lunar surface initial condition. Switching transmitters will cause sync loss at ground station.

013 XMTR ON POWER DISTRIBUTION UNIT

Command 013 actuates relay K-04, in the PDU, which applies +12 Vdc and +29 Vdc to the transmitter selected by Command 012 or 015. This command simultaneously removes +29 Vdc from the 8.4-watt transmitter heater located on the thermal plate.

014 XMTR OFF POWER DISTRIBUTION UNIT

Command 014 actuates relay K-04, in the PDU, to the position that removes +12 Vdc and +29 Vdc from the transmitter selected by Command 012 or 015. This command simultaneously applies +29 Vdc to the 8.4-watt transmitter heater. XMTR OFF is the lunar surface initial condition.

015 XMTR B SEL POWER DISTRIBUTION UNIT

Command 015 actuates relay K-05, in the PDU, to the position that selects Transmitter B. Switching transmitters will cause sync loss at ground station.

017 DISSIP R1 ON POWER DISTRIBUTION UNIT

Command 017 actuates relay K-16, in the PDU, to the position that applies +29 Vdc to a 7-watt power dump resistor and is used to optimize the load on the PCU.

021 DISSIP R1 OFF   POWER DISTRIBUTION UNIT

Command 021 actuates relay K-16, in the PDU, to the position that removes +29 Vdc from the 7-watt power dump resistor.

022 DISSIP R2 ON   POWER DISTRIBUTION UNIT

Command 022 actuates relay K-17, in the PDU, to the position that applies +29 Vdc to a 14-watt power dump resistor and is used to optimize the load on the PCU.

023 DISSIP R2 OFF   POWER DISTRIBUTION UNIT

Command 023 actuates relay K-17, in the PDU, to the position that removes +29 Vdc from the 14-watt power dump resistor.

024 DSS HTR 3 ON   POWER DISTRIBUTION UNIT

Command 024 actuates relay K-18, in the PDU, to the position that applies +29 Vdc to the thermostatically controlled 10-watt heater located on the central station thermal plate. This heater is controlled by thermostat ST-01 to ON below -10°F and OFF above 0°F. This thermal capability for the central station is provided to account for unknown factors in the lunar environment. DSS MAN HTR 3 ON is the lunar surface initial condition.

025 DSS HTR 3 OFF   POWER DISTRIBUTION UNIT

Command 025 actuates relay K-18, in the PDU, to the position that removes the +29 Vdc from the thermostatically controlled 10-watt central station heater.

027 DUST CELLS ON   POWER DISTRIBUTION UNIT

Command 027 is a one-state command that activates the dust detector photo cell amplifiers.

031 DUST CELLS OFF   POWER DISTRIBUTION UNIT

Command 031 is a one-state command that deactivates the dust detector photo cell amplifiers.

032 TIMER OUTPUT ACCPT   COMMAND DECODER

Command 032 enables the 12-hour and the 1-minute timer output pulses, thus allowing automatic commands to be generated by the timer and the delayed command sequencer. This command cancels the effect of Command 033. Central station activation or power reset initializes the TIMER OUTPUT ACCPT.

033 TIMER OUTPUT INHIB   COMMAND DECODER

Command 033 inhibits the 12-hour and the 1-minute timer output pulses which in turn will disable the following automatic commands generated in the delayed command sequencer.

A. One Time Commands	Normal Time of Execution after PET-zero
1. Set CCGE seal break/uprange, fire PSE uncage circuit, and blow CPLEE dust cover	96 hours + 2 minutes
2. Initiate automatic range mode (CCGE)	96 hours + 3 minutes
3. Execute CCGE seal break/down range	96 hours + 4 minutes
4. Same as 2 above.	96 hours + 5 minutes
B. Repetitive Commands	**Normal Time of Execution after PET-zero**
1. This command not used on ALSEP 3	108 hours + 1 minute and every 12 hours thereafter.
2. Restore power to lowest priority experiment (CPLEE)	108 hours + 7 minutes and every 12 hours thereafter.

This command will also disable the following automatic commands generated by the timer:

C. Repetitive Commands (every 12 hours after PET-zero)

1. Command receiver reset
2. Short period calibrate PSE
3. Uncage PSE
   a. Arm uncage PSE (at PET-zero +12 hours)
   b. Execute uncage PSE (at PET-zero + 24 hours)

NOTE

SINCE THIS COMMAND INHIBITS THE RECEIVER RESET, IT IS CONSIDERED HIGHLY CRITICAL.

This command will input level changes to the hours and minutes counters of the delayed command sequencer and advance the counters by 12 hours and 1 minute. This may change the execution times of the automatic commands from the delayed command sequencer and the timer.

This command does not inhibit or affect the two-year transmitter turn-off command generated by the timer.

034 DSS/PROC X SEL POWER DISTRIBUTION UNIT

Command 034 actuates relays K-02 and K-03, in the PDU, that apply operational voltages (+15 Vdc, +5 Vdc, -12 Vdc) to the "X" data processor. It simultaneously removes the above voltages from the "Y" processor. The "X" data processor, upon activation, is initialized to the normal bit rate. DSS/PROC X SEL is the lunar surface initial condition.

NOTE

This command may result in sync loss at ground station, hence possible loss or false readout of command verification word.

035 DSS/PROC Y SEL POWER DISTRIBUTION UNIT

Command 035 actuates relays K-02 and K-03, in the PDU, that apply operational voltages (+15 Vdc, +5 Vdc, -12 Vdc) to "Y" data processor. It simultaneously removes the above voltages from the "X" processor. The "Y" data processor, upon activation, is initialized to the normal bit rate.

NOTE

This command may result in sync loss at ground station, hence possible loss or false readout of command verification word.

036 EXP 1 OPER SEL (HFE) POWER DISTRIBUTION UNIT

Command 036 actuates relay K-06, in the PDU, applying +29 Vdc to the HFE instrument and the heater circuitry in the deployed HFE electronics assembly. It simultaneously removes +29 Vdc from the standby heater in the HFE electronics package.

037 EXP 1 STBY SEL (HFE) POWER DISTRIBUTION UNIT

Command 037 actuates relays K-06 and K-07, in the PDU, applying +29 Vdc to the standby heater in the HFE electronics package. It simultaneously deactivates the HFE by removing +29 Vdc from the instrument. EXP 1 STBY SEL (HFE) is the lunar surface initial condition.

041 EXP 1 STBY OFF (HFE) POWER DISTRIBUTION UNIT

Command 041 actuates relay K-07, in the PDU, to the position that removes +29 Vdc from the HFE heater circuit. If the HFE operating power is on, transmission of this command will have no effect.

042 EXP 2 OPER SEL (PSE) POWER DISTRIBUTION UNIT

Command 042 actuates relay K-08, in the PDU, applying +29 Vdc to the PSE instrument and the heater circuitry in the deployed PSE sensor assembly. It simultaneously removes +29 Vdc from the standby heater in the PSE electronics package in the central station.

043 EXP 2 STBY SEL (PSE) POWER DISTRIBUTION UNIT

Command 043 actuates relays K-08 and K-09, in the PDU, applying +29 Vdc to the standby heater in the PSE electronics package and to the heater in the deployed PSE sensor assembly. It simultaneously deactivates the PSE by removing +29 Vdc from the instrument. EXP 2 STBY SEL (PSE) is the lunar surface initial condition.

044 EXP 2 STBY OFF (PSE) POWER DISTRIBUTION UNIT

Command 044 actuates relay K-09, in the PDU, to the position that removes +29 Vdc from both PSE heater circuits. If the PSE is on, transmission of this command will have no effect.

045 EXP 3 OPER SEL (CCGE) POWER DISTRIBUTION UNIT

Command 045 actuates relay K-10, in the PDU, applying +29 Vdc to activate the CCGE instrument and its operational heater.

046 EXP 3 STBY SEL (CCGE) POWER DISTRIBUTION UNIT

Command 046 actuates relays K-10 and K-11, in the PDU, applying +29 Vdc to the CCGE standby heater. This command simultaneously deactivates the CCGE instrument. EXP 3 STBY SEL (CCGE) is the lunar surface initial condition.

050 EXP 3 STBY OFF (CCGE) POWER DISTRIBUTION UNIT

Command 050 actuates relay K-11, in the PDU, to the position that removes +29 Vdc from the CCGE standby heater. If the CCGE operating power is on, transmission of this command will have no effect.

052 EXP 4 OPER SEL (CPLEE) POWER DISTRIBUTION UNIT

Command 052 actuates relay K-12, in the PDU, applying +29 Vdc to the CPLEE instrument and the CPLEE heater. This command is also generated by the delayed command sequencer (see Command 033).

053 EXP 4 STBY SEL (CPLEE) POWER DISTRIBUTION UNIT

Command 053 actuates relays K-12 and K-13, in the PDU, applying +29 Vdc to the CPLEE heater. It simultaneously deactivates the CPLEE by removing +29 Vdc from the instrument. EXP 4 STBY SEL (CPLEE) is the lunar surface initial condition.

054 EXP 4 STBY OFF (CPLEE) POWER DISTRIBUTION UNIT

Command 054 actuates relay K-13, in the PDU, to the position that removes +29 Vdc from the CPLEE heater. If the CPLEE operating power is on, transmission of this command will have no effect.

055 DSS HTR 1 SEL POWER DISTRIBUTION UNIT

Command 055 actuates relay K-14, in the PDU, to the position that applies +29 Vdc to the 10-watt DSS HTR 1.

056 DSS HTR 2 SEL POWER DISTRIBUTION UNIT

Command 056 actuates relays K-14 and K-15, in the PDU, to the position that applies +29 Vdc to the 5-watt DSS HTR 1.

057 DSS HTR 2 OFF

Command 057 actuates relay K-15, in the PDU, to the powition that removes +29 Vdc from the 5-watt DSS HTR 2. If DSS HTR 1 is ON, this command will have no effect. Initially, DSS HTR 1 and 2 will be OFF.

060 PCU 1 SEL POWER DISTRIBUTION UNIT

Command 060 actuates relay K-01, in the PCU, which applies +16 Vdc from the RTG to PCU 1 and simultaneously de-energizes PCU 2. PCU 1 is preset to be energized at initial lunar activation. Note that there is an automatic switchover feature to PCU 2 in the event the +12 Vdc bus varies more than ± 1 Vdc. Adding or removing electrical loads (via ground commands) on PCU 1 can prevent the +12 Vdc bus from varying out of limits.

NOTE

IN THE EVENT AUTOMATIC SWITCHOVER TO PCU 2 HAS OCCURRED, THIS COMMAND MUST BE FLAGGED AS HIGHLY CRITICAL. THE CAUSE OF THE SWITCHOVER MUST BE DETERMINED BEFORE THIS COMMAND IS EXECUTED.

SWITCHOVER FROM PCU 1 TO PCU 2 MAY GENERATE A POWER RESET SIGNAL TO THE DELAYED COMMAND SEQUENCER COUNTERS, RESETTING THE COUNTERS BACK TO ZERO. PCU SWITCHING WILL CAUSE SYNC LOSS AT GROUND STATION.

062 PCU 2 SEL POWER DISTRIBUTION UNIT

Command 062 actuates relay K-01, in the PCU, which applies +16 Vdc from the RTG to PCU 2 and simultaneously de-energizes PCU 1.

NOTE

AT THE TIME OF LUNAR ACTIVATION PCU 2 IS DE-ENERGIZED, WITH NO MEANS TO DETERMINE ITS CONDITION. FURTHER, NOTE THAT THERE IS NO AUTOMATIC SWITCHOVER FROM PCU 2 TO PCU 1. THIS SITUATION, THEREFORE, MAKES THIS COMMAND HIGHLY CRITICAL. THIS COMMAND SHOULD BE EXECUTED ONLY AFTER DETERMINING THAT PCU 1 IS ON THE VERGE OF FAILING.

SWITCHOVER FROM PCU 2 to PCU 1 MAY GENERATE A POWER RESET SIGNAL TO THE DELAYED COMMAND SEQUENCER COUNTERS, RESETTING THE COUNTERS BACK TO ZERO. PCU SWITCHING WILL CAUSE SYNC LOSS AT GROUND STATION.

063 PSE/XY GAIN CH EXP 2 (PSE)

Command 063 switches different attenuator values into the LPX and LPY amplifier circuits to allow gain control of the long period X- and Y-axes signals. Repeated transmission of the command will cause the attenuators to step through values of 0 db, -10 db, -20 db, and -30 db in a repeating sequence. In addition, this command controls the calibration current of these two axes. PSE activation initializes the attenuators to -30 db.

064 PSE/Z GAIN CH EXP 2 (PSE)

Command 064 switches different attenuator values into the LPZ amplifier circuit to allow gain control of the long period Z-axis signal. Repeated transmission of the command will cause the attenuator to step through values of 0 db, -10 db, -20 db, and -30 db in a repeating sequence. In addition, this command controls the calibration current of this axis. PSE activation initializes the attenuator to -30 db.

065 PSE/SP CAL CH EXP 2 (PSE)

Command 065 activates logic that will apply a current, via the SP calibration attenuator, to the SP calibration coil. The amount of current from the calibration attenuator is determined by Command 067. In addition, the SP calibration is automatically performed every 12 hours by means of the timer unless specifically inhibited by Command 033. This is a sequential ON/OFF command. PSE activation initializes SP calibration to OFF.

066 PSE/LP CAL CH EXP 2 (PSE)

Command 066 activates logic that applies current, via the LP calibration attenuators, to the LP damping coils (all three axes simultaneously). The amount of current from the calibration attenuators is determined by Command 063 and Command 064. This is a sequential ON/OFF command. PSE activation initializes LP calibration to OFF.

067 PSE/SP GAIN CH EXP 2 (PSE)

Command 067 switches different attenuator values into the SPZ amplifier circuit to allow gain control of the SP axis signal. Repeated transmission of the command will cause the attenuator to step through values of 0 db, -10 db, -20 db, and -30 db in a repeating sequence. In addition, this command controls the calibration current of this axis. PSE activation initializes the attenuator to -30 db.

070 LVL MTRX ON/OFF EXP 2 (PSE)

Command 070 activates logic which applies power to the X-axis drive motor. This is a sequential ON/OFF command. PSE activation initializes X motor to OFF. Note that the X motor consumes power in either leveling mode (AUTOMATIC/FORCED) until commanded OFF.

NOTE

Do nct turn on more than one leveling motor at a time. De-energize sensor heater via Command 076 during time any level motor is on.

071 LVL MTRY ON/OFF EXP 2 (PSE)

Command 071 activates logic which applies power to the Y-axis drive motor. This is a sequential ON/OFF command. PSE activation initializes Y motor to OFF. Note that the Y motor consumes power in either leveling mode (AUTOMATIC/FORCED) until commanded OFF.

NOTE

Do not turn on more than one leveling motor at a time. De-energize sensor heater via Command 076 during time any level motor is on.

072 LVL MTRZ ON/OFF EXP 2 (PSE)

Command 072 activates logic which applies power to the Z-axis drive motor. This is a sequential ON/OFF command. PSE activation initializes Z motor to OFF. Note that the Z motor consumes power in either leveling mode (AUTOMATIC/FORCED) until commanded OFF.

NOTE

DO NOT TURN ON Z LEVELING MOTOR WHILE PSE IS CAGED. Do not turn on more than one leveling motor at a time. De-energize sensor heater via command 076 during time any level motor is on.

073 UNCAGE ARM/FIRE EXP 2 (PSE)

A. Command 073 is a two-state command (ARM/FIRE). First transmission will arm the actuator circuit. Second transmission of this command is sent to fire the actuator circuit and uncage all spring mass systems simultaneously. This command is an irreversible function and is necessary to obtain PSE scientific data.

B. The ARM and FIRE commands are also automatically generated by the timer every 12 and 24 hours, respectively, after PET-zero.

C. Conditions to ARM:

   1. First transmission of Command 073.
   2. First 12-hour timer pulse.
   3. 96 hours + 2 minutes pulse from the delayed command sequencer.

D. Conditions to FIRE (after ARM, above):

   1. Next transmission of Command 073.
   2. Next 12-hour timer pulse.
   3. If armed, placing PSE to standby (Command 043 or operational overload).

NOTE

THE UNCAGE CIRCUITRY WILL NOT FUNCTION BELOW 30°F.

074 LVL DIR POS/NEG EXP 2 (PSE)

Command 074 is a two-state command (POS/NEG) which controls the direction of the level motors for LPX, LPY, and LPZ axes when in the forced leveling mode (see Command 103). PSE activation initializes leveling direction to POS.

075 LVL SPEED HI/LO EXP 2 (PSE)

Command 075 is a two-state command (HI/LO) which controls the speed of the leveling motors for LPX, LPY, and LPZ axes when in the forced leveling mode (see Command 103). PSE activation initializes leveling speed to LO.

076 PSE T CTL CH EXP 2 (PSE)

Command 076 is a four-state command that can be sequentially stepped through the following modes to control the heater in the deployed PSE sensor.

A. OFF - +29 Vdc is disconnected from the heater.

B. FORCED - +29 Vdc applied to heater and automatic thermostat control disabled.

C. OFF - +29 Vdc is disconnected from the heater.

D. AUTOMATIC - +29 Vdc applied to heater and automatic thermostat control enabled.

PSE activation initializes thermal control mode to AUTOMATIC.

Note that this command does not control the heater in the PSE electronics package in the central station.

Note that the PSE sensor heater is not controlled by this command when the experiment is in EXP 2 STBY SEL.

101 PSE FILT IN/OUT EXP 2 (PSE)

Command 101 is a two-state command (IN/OUT) which effectively removes the feedback loop filters from the LPX, LPY, and LPZ axes. PSE activation initializes the feedback filter to OUT.

The feedback filter has to be in the following modes for the PSE to operate properly:

A. leveling (all modes) - filter OUT

B. Calibration - filter IN

C. Normal operational mode - filter IN

102 LVL SNSR IN/OUT EXP 2 (PSE)

Command 102 is a two-state command (IN/OUT) which activates logic that enables the coarse level sensors to control the LPX and LPY axes drive motors when an off level condition exists. The coarse level sensors are used only in the automatic leveling mode. PSE activation initializes the coarse level sensor to OUT.

103 PSE LVL MDE A/F EXP 2 (PSE)

Command 103 is a two-state command (AUTOMATIC/FORCED) which controls the leveling mode of LPX, LPY, and LPZ axes. PSE activation initializes the leveling mode to AUTOMATIC.

NOTE

Only one axis motor is to be on at a time.

104 CCGE CAL ENABLE

This command (CG-01) is a one-state command which initiates electrometer calibration immediately and in the existing sensitivity range. Unless Command 110 is transmitted to clear the function (initiated by Command 104), the calibration continues in the same range until the next zero mode calibration (every 30.9 min). After 10 seconds of zero mode calibration, the CCGE reverts to calibration but in the least sensitive (zero) range. When cleared by 110, the automatic mode of CCGE operation applies a full calibration cycle after each zero mode calibration. The cycle consists of stepping through the seven ranges of measurement while applying precision currents to the electrometer. After the automatic cycle, the CCGE reverts to scientific data collection (with automatic range changes) for the next 30.9 minutes. Repeated transmission of Command 104 has no effect.

105 CCGE UPRANGE CH

This command (CG-02) is a one-state command which selects the uprange direction for forced range changes (by Command 106). Repeated transmission of this command has no effect. The uprange direction is toward reduced sensitivity; maximum uprange is range "zero" (10^{-6} amp). After Command 105 is transmitted, unless cleared by Command 110, the next transmission of Command 106 will advance the range one step (uprange) and lock out automatic range changes. Although CCGE seal break (one-time function) is normally executed by the first transmission of Command 107, the toggle may initialize in adverse setting which requires Command 107 for execution.

106 CCGE RANGE STEP/F

This command (CG-03) is a multi-state command which forces the electrometer sensitivity range change one step (in the direction preselected by Command 105 or 107) each time Command 106 is transmitted. Each transmission of Command 106 advances the range one step until the maximum (or minimum) sensitivity is obtained; further transmission has no effect. If Command 105 or 107 is not transmitted before 106 (i.e., they were cleared by Command 110), the CCGE locks in the existing range and repeated transmission of Command 106 will have no effect.

107 CCGE DNRANGE CH

This command (CG-104) is a one-state command which selects the downrange direction for forced range changes (by Command 106). Repeated transmission of this command has no effect. The downrange direction is toward increased sensitivity; maximum downrange is range 6 (10^{-12} amp).

After Command 107 is transmitted, unless cleared by Command 110, the next transmission of Command 106 will advance the range one step (downrange) and lock out automatic range changes. CCGE seal break (one-time function) is normally executed by the first transmission of Command 107; however, the toggle may initialize in adverse setting which requires Command 105 followed by 107 for execution.

110 CCGE RNG MODE/A

This command (CG-05) is a one-state command which clears the functions of all other CCGE commands. It places the CCGE in the normal mode of scientific data collection (instead of calibration) with automatic range changes. It also clears Command 105/107 (uprange/downrange selection). Repeated transmission of Command 110 has no effect. At turn-on, the CCGE initializes in the mode corresponding to Command 110.

NOTE

Every 30.9 minutes of CCGE operation the Auto-Zero cal mode is initiated by the internal programer. This mode is automatic, cannot be inhibited, and takes precedence over all other modes. The zero cycle lasts 2.6 minutes (including a calibration of all ranges) and then returns instrument to normal operation.

111 CPE OPR HTR ON

This command bypasses the thermostat in the CPLEE and turns the operational heater on in manual mode. To restore automatic thermal control the experiment power must be commanded to standby and back to operate. This command has no control over survival (standby) heaters.

112 CPE OPR HTR OFF

This command is used to turn off the operational heater after it has been turned on by Command 111. See Command 111 for restoration of automatic thermal control.

113 CPE CVR GO

This command actuates the guillotine device for removing the CPLEE dust cover.

114 CPE DEF SEQ ON

This command starts the automatic sequence of voltages to the CPLEE deflection plates whenever it has been stopped (by Command 117). Initial turn-on of the experiment is in the automatic sequence mode.

115 CPE DEF STEP

When the sequence has been stopped, this command advances the voltage on the CPLEE deflection plates one step (in the standard sequence) each time it is used. If automatic sequence is on, this command has no effect.

117 CPE DEF SEQ OFF

This command interrupts the automatic sequence of voltages to the CPLEE deflection plates. The voltage then remains constant until advanced by Command 115 or restored to automatic sequence by Command 114.

120 CPE CHAN/HI SEL

This command increases the voltage across the channeltron electron multipliers in both physical analyzers (A and B) to the higher value, 3200 volts, if it is at the lower setting, 2800 volts. If this command is sent twice, without Command 121 between, the second command has no effect. Initial turn-on of the CPLEE is at the 2800-volt setting.

121 CPE CHAN/LO SEL

This command decreases the voltage across the channeltron electron multipliers in both physical analyzers (A and B) to the lower value, 2800 volts, if it is at the higher setting, 3200 volts. If this command is sent twice, without Command 120 between, the second command has no effect. Initial turn-on of the CPLEE is at the 2800-volt setting.

135 HFE MODE/G SEL

This command (C1) is a one-state command. It places the HFE in the normal or gradient mode of operation (Mode 1) such that data is obtained from the gradient sensors and cable thermocouples under the control of the Measurement Sequence Programer. It also turns off the probe heater current supply. At turn-on, the HFE is initialized in this condition.

136 HFE MODE/LK SEL

This command (C2) is a one-state command. It places the HFE in the low conductivity or ring source mode of operation (Mode 2) such that data is obtained from the gradient sensors and cable thermocouples under the control of the Measurement Sequence Programer. It also turns on the probe heater current supply in the low (or ring source) mode allowing heaters to be activated via Command 152.

140 HFE MODE/HK SEL

This command (C3) is a one-state command. It places the HFE in the high conductivity or heat pulse mode of operation (Mode 3) such that data is obtained from the ring (or remote) sensors under the control of the Heater Excitation Programer. It also turns on the probe heater current supply in the high (or heat pulse) mode allowing heaters to be activated by Command 152.

141 HFE SEQ/FUL SEL

This command (C4) is a one-state command. It cancels the effect of measurement Commands 142 through 146 and thereby causes the Measurement Sequence Programer to perform its full 16-state cycle of operation. If transmitted during operation in MODE/HK, this command will cause invalid data. At turn-on, the HFE is initialized in this condition.

142 HFE SEQ/P1 SEL

This command (C5) is a one-state command and alternates with Command 143 to select only one probe for measurement. In MODE/G and MODE/LK it causes the Measurement Sequence Programer to lock the second flip-flop (P_2) in the clear state and bypass that step; that is, act as an eight-state counter if Command 141 was previously executed or as a two-state counter if Command 144, 145, or 146 was previously executed. In MODE/HK this command is meaningless. It is cleared by subsequent execution of Command 141.

143 HFE SEQ/P2 SEL

This command (C6) is a one-state command and alternates with Command 142 to select only one probe for measurement. In MODE/G and MODE/LK it causes the Measurement Sequence Programer to lock the second flip-flop (P_2) in the set state and bypass that step; that is, act as an eight-state counter if Command 141 was previously executed or as a two-state counter if Command 144, 145, or 146 was previously executed. In MODE/HK this command is meaningless. It is cleared by subsequent execution of Command 141.

144 HFE LOAD 1

This command (C7) is a one-state command and is used alone or in combination with either Command 145 or 146 to position and lock the Measurement Sequence Programer's third and fourth flip-flops (P_4P_3). It places these two flip-flops in the clear position (00) and bypasses those steps; thus the MSP acts as a four-state counter if Command 141 was previously executed and as a two-state counter if either Command 142 or 143 was previously executed. In MODE/HK this command must be executed, otherwise the data will be invalid. Subsequent execution (in MODE/G or MODE/LK) of Command 145 or 146 locks P_4P_3 in the 01 or 10 state respectively. All positioning and locking of P_4P_3 is cleared by subsequent execution of Command 141.

145 HFE LOAD 2

This command (C8) is a one-state command and is used in combination with either Command 144 (preceding 145) or Command 146 (preceding or subsequent to 145) to position and lock P_4P_3 (see 144). It sets P_3; therefore 144 followed by 145 places P_4P_3 in the 01 state. In combination with 146, it places P_4P_3 in the 11 state. Depending on whether Command 141 was previously executed or one of Command 142/143, the MSP acts as a four-state or two-state counter. Execution of this command in MODE/HK causes invalid data until Command 144 is executed. It is cleared by subsequent execution of Command 141.

146 HFE LOAD 3

This command (C9) is a one-state command operating essentially the same as Command 145 except that it sets P_4. Therefore, when preceded by 144 it places P_4P_3 in the 10 state.

152 HFE HTR STEPS

This command (C10) is a 16-state command which advances the Heater Excitation Programer ($H_4H_3H_2H_1$) each time the command is executed. In MODE/G the programer advances but there is no other effect since the probe heater current supply is off. In MODE/LK the execution of Command 152 alternates the heater status between on and off, simultaneously stepping through the eight heaters (current supply is on full time, and heater elements are switched in and out of circuit). In MODE/HK the Heater Excitation Programer (advanced by Command 152) also selects the data to be sampled.

NOTE

HFE commands are executed at the ALSEP 90 frame mark; therefore, there must be 54 seconds delta time between transmission of commands to the HFE.

TABLE 5-VI.- PRESET AND LUNAR INITIAL CONDITIONS OF SUBSYSTEMS

Subsystem	Command	Function	Initializes to	Lunar Initial Condition
TM	005	ASE HBR OFF	OFF	
TM	006	NORM BIT RT SEL	NORMAL	
TM	012	XMTR A SEL		XMTR A SELECTED
TM	014	XMTR OFF		XMTR IS OFF
EPS		DISSIP R1		UNDETERMINED
EPS		DISSIP R2		UNDETERMINED
S/T	024	DSS HTR #3 ON		DSS HTR #3 ON
S/T	027	DUST CELLS	ON OR OFF	(RANDOM STATE)
TM	034	DSS/PROC X SEL		DP X SELECTED
HFE	037	EXP 1 STBY SEL		EXP 1 IN STBY
PSE	043	EXP 2 STBY SEL		EXP 2 IN STBY
CCGE	046	EXP 3 STBY SEL		EXP 3 IN STBY
CPLEE	053	EXP 4 STBY SEL		EXP 4 IN STBY
S/T	057	DSS HTR #2 OFF		DSS HTR #2 OFF
EPS	060	PCU 1 SEL		PCU 1 SELECTED
CMD	032	TIMER OUT ACCPT	ACCEPT	
PSE	063	PSE/XY GAIN CH	-30 DB	
PSE	064	PSE/Z GAIN CH	-30 DB	
PSE	065	PSE/SP CAL CH	OFF	
PSE	066	PSE/LP CAL CH	OFF	
PSE	067	PSE/SP GAIN CH	-30 DB	
PSE	070	LVL MTRX ON/OFF	OFF	
PSE	071	LVL MTRY ON/OFF	OFF	
PSE	072	LVL MTRZ ON/OFF	OFF	
PSE	074	LVL DIR POS/NEG	POS	
PSE	075	LVL SPEED HI/LO	LOW	
PSE	076	PSE T CTL CH	AUTO	
PSE	101	PSE FILT IN/OUT	OUT	
PSE	102	LVL SEN IN/OUT	OUT	
PSE	103	PSE LVL MDE A/M	AUTO	
CCGE	110	CCGE RNG MODE/A	AUTO	
CPLEE	053/052	EXP #4 OPER SEL	HTR ON, AUTO MODE	
CPLEE	114	CPE DEF SEQ ON	AUTO DEFL VOLT SEQ ON	
CPLEE	121	CPE CHAN/LO SEL	CHANNELTRON VOLTAGE 2800V	
HFE	135	HFE MODE/G SEL	GRADIENT MODE	
HFE	141	HFE SEQ/FUL SEL	FULL 16 STEP MEAS SEQ	


TO DIPLEXER SWITCH
DIPLEXER FILTER
RF INPUT
CB-01 PROTECTS THE 12VDC APPLIED TO THE RECEIVER AND WILL ACTRATE AT 150 MA +75, -40MA
CB-01
K-19
+12VDC
RD 23
RECEIVER HEATER HTR-4 1.25 WATTS
TIMER
TO ASTRO SWITCH NO 2
RECEIVER
MIXER
IF PREAMP
IF AMP
AMP AND DISCR
INTEG AND OUTPUT AMP
FILTER
LEVEL SENSOR AND L.O. SWITCH
AE-13 RCVR PRE/LIM DBM -101 TO -61 DBM CH-21
AB-1 RCVR 1 KHZ STA BILEVEL CH-9
HYBRID
X16 MULTIPLIER
LOCAL OSCILLATOR A
LOCAL OSCILLATOR B
AT-21 RCVR XTAL A DEG F -50° TO +200° F CH-16
AT-22 RCVR XTAL B DEG F -50° TO +200° F CH-17
AE-14 RCVR L/O LVC DBM 0 TO 10 DBM CH-34
LOCATED IN PDU
DEMODULATOR SECTION
INPUT AMP
DATA Φ DET
INTEGRATOR
DATA FF
THRESHOLD Φ DET
SCHMITT TRIGGER
FF
SYNC Φ DET
LOOP FILTER
8 KHZ VCO
AT-33 CMD DEC VCO DEG F -50° TO +200° F CH-61
NRZ CMD DATA
THRESHOLD
1 KHZ
2 KHZ
4 KHZ
8 KHZ
DECODER B
DECODER A
SHIFT PULSES DSS/D
DATA GATE DSS/D
DATA DEMAND DSS/D
CONTROL LOGIC A
INHIBIT A
INHIBIT B
SHIFT PULSES
CYCLE COUNT
DEMAND OVERRIDE
ADDRESS DETECTOR A
NRZ CMD DATA
ENABLE A
DECODER PROGRAMER A
PARITY SAMPLE PULSE
PARITY DETECTOR A
PARITY LEVEL
SHIFT REGISTER A
7 BITS CMD DATA PARALLEL
CMD EXECUTE
DECODER GATE DRIVERS A
POWER RESET
POWER RESET PULSE FROM A
COMMAND VERIFICATION WORD (63 BIT SERIAL)
AT-32 CMD DEG INT DEG F -50° TO 200° F CH-49
AT-31 CMD DEC BAS DEG F -50° TO +200° F CH-48
CMDS TO DECODER GATES
DECODER GATES
CMD VERIFICATION WORD TO DSS/D
CMDS TO USERS
CMD 113 CPE COVER GO
CMD 073 UNCAGE ARM/FIRE
CMD 105 SET CCGE SEAL BREAK/UPRANGE
CMD 110 CCGE AUTOMATIC RANGING
CMD 107 CCGE SEAL BREAK/DOWN RANGE
CMD 122 NOT USED ON ALSEP NO 3
CMD 131 NOT USED ON ALSEP NO 3
CMD 052 EXP 4 OPER SEL CPLEE (CPE)
1 KHZ TO PDU
96 HRS + 2 MIN
96 HRS + 3 MIN
96 HRS + 5 MIN
96 HRS + 4 MIN
108 HRS + 1 MINUTE
108 HRS + 7 MINITES
AND EVERY 12 HRS THEREAFTER
SEQUENCE DECODING GATES
TO RCVR
TO PSE
MINUTES COUNTER
HOURS COUNTER
TIMER ACCEPT/INHIBIT LOGIC
ONE SHOT MULTI-VIBRATOR
12 HOUR PULSE
1 MINUTE PULSE
TIMER
2 YEAR TIMER OUTPUT
TO K-40 XMTR OFF
POWER RESET PULSE FROM B
POWER RESET PULSE FROM A
TIMER OUT ACCEPT
TIMER OUT INHIBIT
NOTE: REFER TO TABLE 4-VIII FOR RELAY DRIVER FUNCTIONS AND INPUT POWER REQUIREMENTS
SIGNATURES
DATE
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER - HOUSTON, TEXAS
COMMAND SUBSYSTEM
ALSEP 3
J
5.1
PAGE 5-16
SHEET 1 OF 1

SECTION 6

TELEMETRY SUBSYSTEM

6.1 SYSTEM DESCRIPTION

The Telemetry Subsystem consists of central station sensors, experiment sensors, one analog multiplexer, two A/D converters, two digital data processors, two S-band transmitters, one diplexer switch, one diplexer filter, and a common S-band transmit/receive helix antenna.

6.1.1 Sensors (Transducers)

Analog sensors convert such parameters as temperature, voltage, current, and status into 0- to +5-volt signals and input these signals to the 90-channel analog multiplexer as engineering (housekeeping) data to indicate the condition of the central station, RTG, and PSE.

Scientific measurements from the experiment sensors and experiment status, calibration, and temperature data are converted within each experiment to digital data and applied to the X and Y digital data processors at the proper demand time in serial form.

6.1.2 Analog Multiplexer

Analog engineering (housekeeping) data is applied to the 90-channel analog multiplexer. Multiplexer Channels 1 through 15 are redundant. Selection of the redundant channels can be accomplished by ground command, selecting either X or Y data processor (Commands 034 or 035). Channels 16 through 90 are normal channels. The multiplexer is divided into seven groups of 15 column gates each, and the group outputs are further gated through a tier of seven row gates. The channel advance pulse generated in the digital data processor (occurs at the time of the sixty-fourth main frame word) is applied to the analog multiplexer gate sequencers to advance the multiplexer to the next channel after each A/D conversion. The gate sequencers generate a ninetieth-channel output pulse that is used to reset the frame counter located in the digital data processor. The output of the analog multiplexer is buffered by amplifiers at the input to each A/D converter.

6.1.3 A/D Converters

The A/D converters encode the analog signal from the multiplexer into an 8-bit digital word when an encode pulse from the digital data processor occurs (once every digital data processor main frame). The 8-bit digital word is inputted parallel to the digital data processor at Word 33 time of the ALSEP main frame. Selection of A/D converters is accomplished by commands 034 or 035.

6.1.4 Digital Data Processor

Redundant digital data processors (X and Y) are provided. The redundant processors are selectable by Ground Command 034 or 035. The processor that is selected receives data in a parallel form from the A/D converter and in a serial form from the command decoder and experiments. The data is formatted into a serial NRZC format and then encoded into a split-phase signal and applied to the transmitter.

As a backup capability, the data processor provides a low bit rate mode at one-half the normal data rate. The normal or low data rate can be selected by Ground Commands 006 and 007 respectively.

The first three words of the ALSEP main frame are used for the sync code. The bit assignment for the sync word is shown in Figure 6-2. Bits 23 through 29 are provided for channel identification for 1 through 90 channels for correlation of the analog multiplexer data. These bits are derived from a ripple-through counter which is advanced one step whenever Word 1 of the ALSEP main frame occurs and is reset by a ninetieth-frame signal generated by the analog multiplexer. When power is applied to the data processor, these seven bits will be a random count between 0 and 127 and cannot be used to determine the position of the multiplexer until it receives the ninetieth-frame reset signal from the analog multiplexer.

Each of the redundant processors has a power reset circuit. This circuit will reset the processor to the normal mode if there is a momentary drop in the +5 Vdc line.

The data processor will generate and provide all necessary timing signals to the experiments, command decoder, A/D converter, and the 90-channel analog multiplexer (see Table 6-III).

6.1.5 Transmitter

There are two S-band transmitters (A and B) in ALSEP 1, selectable by ground commands. The active transmitter accepts split-phase telemetry data from the data processor, and PM modulates the carrier which is applied to the helix antenna at a one-watt level on a downlink frequency of 2278.5 MHz. Ground Commands are also used to turn the selected transmitter on or off. If the transmitter is commanded OFF, an 8.4-watt heater is simultaneously activated to provide electrical and thermal balance. Overload protection is provided for both transmitters. Circuit breakers associated with the overloaded transmitter will switch operating voltages (+29 Vdc, +12 Vdc) to the other transmitter.

6.1.6 Diplexer Switch

The diplexer switch is utilized to couple the selected transmitter (A or B) output through the diplexer filter to the antenna. The direction of the diplexer switch (thus the selection of transmitter A or B output) is controlled by activating a ferrite device, within the circulator, by a magnetic field from a coil which is energized by +12 Vdc. The +12 Vdc is applied when transmitter B is ON.

TABLE 6-I.- ANALOG MULTIPLEXER A/D CONVERTER CHARACTERISTICS

Analog Multiplexer (Subcommutated)

Input (from sensors or signal conditions)	0 to +5 Vdc
Channels/frame	90 Max
Seconds/frame (normal bit rate)	54.34
Seconds/frame (low bit rate)	108.68
Redundancy	Channels 1 through 15 gates

A/D Converters

Input (from analog mux)	0 to +5 Vdc
Conversion	8 Bits
Data to D/P	Parallel
Time slot in main frame	Word 33
Redundancy	X or Y Converter
Input from +5 to +8 volts	Outputs 255 decimal PCM count
Input from +8 to +12 volts	Outputs ambiguous PCM count (0-255)
Input above +12 volts	Detrimental to analog mux

Either of the two redundant A/D converters are selectable by Ground Command 034 (DSS/PROC X SEL) or 035 (DSS/PROC Y SEL).

TABLE 6-II.- DIGITAL DATA PROCESSOR CHARACTERISTICS

	Low Bit Rate	Normal Bit Rate
Data rate (BPS)	530	1060
Bits/word	10	10
Words/frame	64	64
Frame/second	53/64	1-21/32
Seconds/frame	1.2075	0.6038
Bits/sync word	22	22
Redundancy	X or Y Processors	

Words 1, 2, and 3 are control words. Word 33 of the main frame contains housekeeping data from the analog mux A/D converter. Word 05 contains the command verification word. The two MSB's of Words 33 and 05 are filler bits inserted by the digital data processor. All main frame words are downlinked MSB first.

DA-4 (Bit 10 of Word 3) contains the Data Processor Serial Number.

Frame 3	1 MSB
Frame 4	0
Frame 5	1

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

WORD TOTALS	LEGEND	
3	x	= Control
30	X	= Passive seismic - short period
12	—	= Passive seismic - long period
2	●	= Passive seismic - long period tidal and one temperature
1	HF	= Heat flow
5	CG	= Cold cathode gauge experiment (MSC)
6	CP	= Charged particle lunar environment
1	CV	= Command verification
1	H	= Housekeeping
3	NA	= Not assigned (all zeros shall be transmitted)

Each box contains one ten-bit word
Total bits per frame = 10 X 64 = 640 bits
Bit Rate = 1060 bits/second

Figure 6-1. - ALSEP telemetry frame format.

CONTROL GROUP FORMAT

	ALSEP word no. 1										ALSEP word no. 2										ALSEP word no. 3									
Bit	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	1	1	1	0	0	0	1	0	0	1	0	0	0	0	1	1	1	0	1	1	0	1	F1	F2	F3	F4	F5	F6	F7	M
	Barker code											Complement of Barker code											Frame counter (1, 2 .... 89, 0)							Mode bit

Symbol	Name	ALSEP words	Range	Bits/ sample	Samples/ second
DA-1	Barker Code and complement	1, 2, and bits 1 and 2 of word 3	NA	22	1.67
DA-2	Frame count	Bits 3 to 9 inclusive of word 3	0-127 (frame count reads all zero's on channel 90)	7	1.67
DA-3	Bit rate ID	Bit 10 of word 3			1.67
DA-4	ALSEP ID	Bit 10, LSB, of word 3		3	1.54
DA-5	Received command message	Bits 3 to 9 inclusive of word 5	1 to 127	7	*
DA-6	Command MAP	Bit 10, LSB, of word 5	"0" no parity "1" parity	1	*
DA-7	Filler bits	May be used to determine bit error rate during off line processing. Bits 1 and 2 of word 5			

DA-3 bit rate ID:

Frame	Mode bit	Meaning
1	1	Normal data rate
2	1	low data rate

DA-4 ALSEP ID:

Frame	Mode bit	
3	1 (MSB)	Data processor
4	0	serial number
5	1	ALSEP 3

* One word sample is sent for each command received, other samples are all zeros.

Figure 6-2. - Sync and command verification word format.

TABLE 6-III.- TIMING FROM DIGITAL PROCESSOR/90 CHAN ANALOG MUX

Signals From Data Processor	SIGNAL TO						
	CMD Decoder	PSE	CCGE	CPLEE	HFE	A/D Converter	Analog MUX
Shift Pulse	X	X	X	X	X		
Data Gate	X	X					
Even Frame Mark		X		X			
Frame Mark			X		X		
Data Demand	X	X	X	X	X		
A/D Encode						X	
Advance Pulse							X
90th Frame Mark					X		

TABLE 6-IV.- TIMING AND CONTROL PULSE CHARACTERISTICS

Pulse Type	Duration* (μsec)	Repetition Rate*
Frame	118	Once Per ALSEP Frame
Even Frame Mark	118	Once Every Other Frame
90th Frame Mark	118	Once Every 90th Frame
Data Gate (Word Mark)	118	64, Once Per Each Ten-Bit Word in Frame
Data Demand	9434	Once Per Experiment Word in ALSEP Frame
Shift Pulse	47	640 Pulses Per Frame 1060 Pulses Per Second
Command	20,000	Asynchronous

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

TABLE 6-V.- TELEMETRY SUBSYSTEM POWER REQUIREMENTS AND OVERLOAD PROTECTION

Component	Voltage bus	Watts	mAdc	Circuit protection
Digital Data Processor	+12 Vdc ± 1%	0.05	4.2	None
X or Y	+5 Vdc ± 1%	0.450	90.0	None
Analog Multiplexer	+15 Vdc ± 1%	0.065	4.4	None
and A/D Converter	+12 Vdc ± 1%	0.150	12.5	None
X or Y	+5 Vdc ± 1%	1.10	220.0	None
	-12 Vdc ± 1%	0.12	10.0	None
Transmitter A or B	+29 Vdc ± 1%	8.0	275.0	CB-03 Xmtr A 560 to 840 mA CB-05 Xmtr B 560 to 840 mA
	+12 Vdc ± 1%	0.5	41.7	CB-02 Xmtr A 110-225 mA CB-04 Xmtr B 110-225 mA
Transmitter Heater	+29 Vdc ± 1%	8.4	345.0	None
Diplexer Switch	+12 Vdc ± 1%	0.15	12.5	CB-04 110-225 mA

TABLE 6-VI.- TRANSMITTER CHARACTERISTICS

Frequency	2275.5 MHz
Modulation	PM
Stability (long term)	±0.0025 percent/year
Power output	1 watt minimum
Power input	*6.6 - 9.45 watts
TM parameters	4

*Temperature dependent

TABLE 6-VII.- REDUNDANT ANALOG CHANNELS

The first 15 channels of the analog multiplexer are applied in parallel to redundant gates in the analog multiplexer. Either of these redundant gates can be selected by Ground Command 034 (DSS/PROC X SEL) or 035 (DSS/PROC Y SEL).

Channel	Symbol	Location/Name
1	AE- 3	Converter Input Voltage
2	AE- 1	0.25 Vdc Calibration
3	AE- 2	4.75 Vdc Calibration
4	AT- 3	Thermal Plate Temp 1
5	AE- 4	Converter Input Current
6	AR- 1	RTG Hot Frame 1 Temp
7	AR- 4	RTG Cold Frame 1 Temp
8	AE- 5	Shunt Regulator 1 Current
9	AB- 1	Command Demodulator 1 kc Present
10	AC- 4	DC-DC Converter Voltage (CPLEE)
11	AC- 5	Temperature of Physical Analyser (CPLEE)
12	AB- 4	Power Distribution Exper 1 and 2 Standby
13	AE- 6	Shunt Regulator 2 Current
14	AB- 5	Power Distribution Exper 3, 4, and 5 Standby
15	AT-10	Primary Structure Bottom Temp 1

TABLE 6-VIII.- CHANNEL MEASUREMENT ASSIGNMENTS FOR ANALOG MULTIPLEXER (ALSEP WORD 33)

Channel Number	Symbol	Location/Name
1	AE- 3	Converter Input Voltage
2	AE- 1	0.25 Vdc Calibration
3	AE- 2	4.75 Vdc Calibration
4	AT- 3	Thermal Plate Temp 1
5	AE- 4	Converter Input Current
6	AR- 1	RTG Hot Frame 1 Temp
7	AR- 4	RTG Cold Frame 1 Temp
8	AE- 5	Shunt Regulator 1 Current
9	AB- 1	Command Demodulator 1 kc Present
10	AC- 4	DC-DC Converter Voltage (CPLEE)
11	AC- 5	Temperature of Physical Analyser (CPLEE)
12	AB- 4	Power Distribution Exper 1 and 2 Standby
13	AE- 6	Shunt Regulator 2 Current
14	AB- 5	Power Distribution Exper 3, 4, and 5 Standby
15	AT-10	Primary Structure Bottom Temp 1
16	AT-21	Local Oscillator Crystal A Temp
17	AT-22	Local Oscillator Crystal B Temp
18	AT-23	Transmitter A Crystal Temp
19	AT-24	Transmitter A Heat Sink Temp
20	AE- 7	PCU Output Voltage 1 (29 V)
21	AE-13	Receiver Prelimiting Level
22	AE-18	Transmitter B Power Doubler dc Current
23	AL- 1	LP Amplifier Gain (X and Y)
24	AL- 5	Leveling Mode and Coarse Sensor Mode
25	AC- 1	Switchable P/S Voltage (CPLEE)
26	AX- 5	Dust Cell 2 Output
27	AT- 1	Sunshield Temp 1
28	AT- 4	Thermal Plate Temp 2
29	AH- 1	Supply Voltage #1 (HFE)
30	AX- 2	Dust Cell 2 Temp
31	AT-25	Transmitter B Crystal Temp
32	AT-26	Transmitter B Heat Sink Temp
33	AT-27	Analog DP, Base Temp
34	AT-28	Analog DP, Internal Temp
35	AE- 8	PCU Output Voltage 2 (15 V)
36	AE-14	Receiver Local Oscillator Level
37	AR- 2	RTG Hot Frame 2 Temp
38	AL- 2	LP Amplifier Gain (Z)
39	AL- 6	Thermal Control Status
40	AC- 3	Channeltron P/S #2 (CPLEE)
41	AX- 6	Dust Cell 3 Output
42	AT- 2	Sunshield Temp 2
43	AT- 5	Thermal Plate Temp 3
44	BLANK	
45	AH-2	Supply Voltage #2 (HFE)
46	AT-29	Digital D/P, Base Temp
47	AT-30	Digital D/P, Internal Temp
48	AT-31	Command Decoder Base Temp
49	AT-32	Command Decoder Internal Temp
50	AE- 9	PCU Output Voltage 3 (12 V)
51	AE-15	Transmitter A, AGC Voltage
52	AR- 3	RTG Hot Frame 3 Temp
53	AL- 3	Level Direction and Speed
54	AL- 7	Calibration Status LP and SP
55	AH- 3	Supply Voltage #3 (HFE)
56	AX- 3	Dust Cell 3 Temp
57	AH- 6	Supply Voltage #6 (HFE)
58	AT- 6	Thermal Plate Temp 4
59	AT- 8	Primary Structure Wall Temp 1
60	AT-12	Insulation Inner Temp

NOTE

Channels 1-15 are redundant channels.

TABLE 6-VIII.- CHANNEL MEASUREMENT ASSIGNMENTS FOR ANALOG MULTIPLEXER (ALSEP WORD 33) - Concluded

Channel Number	Symbol	Location/Name
61	AT-33	Command Demodulator, VCO Temp
62	AT-34	Power Distribution, Base Temp
63	AT-35	Power Distribution, Internal Temp
64	AT-36	PCU, Power Oscillator 1 Temp
65	AE-10	PCU Output Voltage 4 (5 V)
66	AE-16	Transmitter B, AGC Voltage
67	AR- 5	RTG Cold Frame 2 Temp
68	AL- 4	SP Amplifier Gain (Z)
69	AL- 8	Uncage Status
70	AG- 1	Gauge Output (CCGE)
71	AT- 7	Thermal Plate Temp 5
72	AT-13	Insulation Outer Temp
73	BLANK	
74	AH- 4	Supply Voltage #4 (HFE)
75	AH- 7	Supply Voltage #7 (HFE)
76	AT-37	PCU, Power Oscillator 2 Temp
77	AT-38	PCU, Regulator 1 Temp
78	AT-39	PCU, Regulator 2 Temp
79	AE-11	PCU Output Voltage 5 (-12 V)
80	AE-12	PCU Output Voltage 6 (-6 V)
81	AE-17	Transmitter A Power Doubler dc Current
82	AR- 6	RTG Cold Frame 3 Temp
83	AX- 1	Dust Cell 1 Temp
84	AX- 4	Dust Cell 1 Output
85	AG- 2	Gauge Range (CCGE)
86	BLANK	
87	AT- 9	Primary Structure Wall Temp 2
88	AT-11	Primary Structure Front Temp 1
89	AC- 2	Channeltron P/S #1 (CPLEE)
90	AC- 6	Temperature of Switchable P/S (CPLEE)

NOTE

Channels 1-15 are redundant channels.

TABLE 6-IX.- EXPERIMENT OFF DOWNLINK STATUS

The observed conditions with experiment operating power OFF, and experiment standby power either OFF or ON, are:

PSE	All "1"s in the digital data words
HFE	All "1"s in the digital data words
CCGE	All "1"s in the digital data words
CPLEE	All "1"s in the digital data words

Central Station Housekeeping

PSE channels (AL-1 through AL-8) either 000 or 001

CCGE channels (AG-1 and AG-2) either 000 or 001

With the experiments in standby ON or OFF, all "1"s are present in the digital data words. Open circuit channels to the analog multiplexer can read anywhere between 000 and 255.

TABLE 6-X.- ALSEP 3 ANALOG CHANNEL USAGE

Symbol	Location/Name	Nominal Operating Limits Low	Nominal Operating Limits High	Nom Oper Value	Redline Limits Low	Redline Limits High
	Structural/Thermal Temperatures (Fahrenheit)					
AT-1	Sunshield Temp 1	-240°	95°	-80°	-300°	+300°
AT-2	Sunshield Temp 2	-240°	95°	-80°	-300°	+300°
AT-3	Thermal Plate Temp 1	0°	140°	83°	-25°	+150°
AT-4	Thermal Plate Temp 2	0°	125°	83°	-25°	+150°
AT-5	Thermal Plate Temp 3	0°	125°	83°	-25°	+150°
AT-6	Thermal Plate Temp 4	0°	125°	83°	-25°	+150°
AT-7	Thermal Plate Temp 5	0°	125°	83°	-25°	+150°
AT-8	Primary Structure Wall Temp 1 (Left)	-210°	236°	0°	-300°	+300°
AT-9	Primary Structure Wall Temp 2 (Right)	-210°	236°	0°	-300°	+300°
AT-10	Primary Structure Bottom Temp 1	-210°	258°	6°	-300°	+300°
AT-11	Primary Structure Wall Temp 3 (Back)	-50°	250°	28°	-300°	+300°
AT-12	Insulation Inner Temp	-20°	157°	64°	-25°	+167°
AT-13	Insulation Outer Temp	-135°	210°	26°	-300°	+300°
	Electronic Temperatures (Fahrenheit)					
AT-21	Local Oscillator Crystal A Temp	-10°	165°	144°	-15°	+170°
AT-22	Local Oscillator Crystal B Temp	0°	125°	75°	-15°	+170°
AT-23	Transmitter A Crystal Temp	-10°	+146°	75°	-15°	+165°
AT-24	Transmitter A Heat Sink Temp	-10°	+146°	75°	-15°	+165°
AT-25	Transmitter B Crystal Temp	-10°	+146°	75°	-15°	+165°
AT-26	Transmitter B Heat Sink Temp	-10°	+146°	75°	-15°	+165°
AT-27	Analog D/P, Base Temp	0°	125°	83°	-25°	+150°
AT-28	Analog D/P, Internal Temp	0°	125°	90°	-15°	+163°
AT-29	Digital D/P, Base Temp	0°	125°	83°	-25°	+150°
AT-30	Digital D/P, Internal Temp	0°	125°	87°	-20°	+158°
AT-31	Command Decoder, Base Temp	0°	125°	83°	-25°	+150°
AT-32	Command Decoder, Internal Temp	0°	125°	86°	-20°	+155°
AT-33	Command Demodulator, VCO Temp	0°	125°	86°	-20°	+155°
AT-34	Power Distribution Unit, Base Temp	0°	140°	83°	-25°	+150°
AT-35	Power Distribution Unit, Internal Temp	10°	150°	100°	-10°	+180°
AT-36	PCU, Power Oscillator 1 Temp	0°	150°	94°	-20°	+172°
AT-37	PCU, Power Oscillator 2 Temp	-10°	165°	94°	-20°	+172°
AT-38	PCU, Regulator 1 Temp	50°	195°	103°	-20°	+210°
AT-39	PCU, Regulator 2 Temp	-10°	195°	103°	-20°	+210°
	Central Station Electrical					
AE-1	0.25 Vdc Calibration	.24V	.26V	.25V	.22V	.28V
AE-2	4.75 Vdc Calibration	4.72V	4.78V	4.75V	4.70V	4.80V
AE-3	Converter Input Voltage	15.4V	16.9V	16.2V	15.0V	17.5V
AE-4	Converter Input Current	3.9A	4.5A	4.2A	3.8A	4.6A
AE-5	Shunt Regulator 1 Current	0.4A	2.7A	1.1A	0.05A	3.18A
AE-6	Shunt Regulator 2 Current	0.4A	2.7A	1.1A	0.1A	3.18A
AE-7	PCU Output Voltage 1 (29 V)	28.8V	29.2V	29.0V	28.59V	29.40V
AE-8	PCU Output Voltage 2 (15 V)	14.9V	15.36V	15.0V	14.8V	15.4V
AE-9	PCU Output Voltage 3 (12 V)	11.9V	12.05V	12.0V	11.85V	12.10V
AE-10	PCU Output Voltage 4 (5 V)	4.9V	5.15V	5.0V	4.85V	5.25V
AE-11	PCU Output Voltage 5 (-12 V)**	-12.35V	-11.9V	-12.0V	-12.4V	-11.8V
AE-12	PCU Output Voltage 6 (-6 V)**	-6.1V	-5.9V	-6.0V	-6.15V	-5.85V
AE-13	Receiver, Prelimiting Level	-92dbm	-84dbm	-88dbm	-101dbm	-61dbm*
AE-14	Receiver, Local Oscillator Level	2.6dbm	7.5dbm	6.1dbm	1.8dbm	7.6dbm*
AE-15	Transmitter A, AGC Voltage	1.47V @-10°F	1.89V @+146°F	1.10V @75°F	0.323V	5.00V
AE-16	Transmitter B, AGC Voltage	1.5V @-10°F	0.95V @+146°F	0.61V @75°F	0.26V	4.17V
AE-17	Transmitter A Power Doubler dc Current	143ma @-10°F	208ma @146°F	162ma @75°F	100ma*	240ma*
AE-18	Transmitter B Power Doubler dc Current	128ma @-10°F	192ma @146°F	157ma @75°F	100ma*	240ma*

*At 77.5°F

**AE-11 and AE-12 valves also vary with changes of PCU output voltage 1 (29V), AE-7.

TABLE 6-X.- ALSEP 3 ANALOG CHANNEL USAGE - Continued

Symbol	Location/Name	Nominal Operating Limits Low	Nominal Operating Limits High	Nom Oper Value	Redline Limits Low	Redline Limits High
	RTG Temperatures (Fahrenheit)					
AR-1	Hot Frame 1 Temp	1000°	1120°	1054°	980°	1136°
AR-2	Hot Frame 2 Temp	1000°	1120°			
AR-3	Hot Frame 3 Temp	1000°	1120°	1107°	980°	1147°
AR-4	Cold Frame 1 Temp	405°	500°	478°	401°	545°
AR-5	Cold Frame 2 Temp	415°	500°	426°	401°	545°
AR-6	Cold Frame 3 Temp	415°	500°			
	Dust Detector					
AX-1	Dust Cell 1 Temp (Fahrenheit)	110°	275°	136°	92°	320°
AX-2	Dust Cell 2 Temp (Fahrenheit)	110°	275°	136°	87°	320°
AX-3	Dust Cell 3 Temp (Fahrenheit)	110°	275°	136°	90°	320°
AX-4	Dust Cell 1 Output	3mV	80mV	52mV	1mV	163mV
AX-5	Dust Cell 2 Output	3mV	80mV	52mV	1mV	163mV
AX-6	Dust Cell 3 Output	3mV	80mV	52mV	1mV	163mV

Symbol	Location/Name	Channel	Operating Limits
	Central Station Discretes		Decimal PCM
AB-1	Command Demodulator 1 kHz Present	9	No modulation 0 to 76, no carrier 128 to 255 Modulation 77 to 127
AB-4	Power Distribution Experiment 1 and 2 Standby	12	Exper 1 / Exper 2 Standby-off Standby-off 1 ± 1 Standby-on Standby-off 72 ± 10 Standby-off Standby-on 131 ± 10 Standby-on Standby-on 192 ± 12
AB-5	Power Distribution Experiment 3, 4 and DSS Heater 2	14	Exper 3 / Exper 4 / DSS HTR 2 Standby-off Standby-off Off 1 ± 1 Standby-off Standby-off On 35 ± 10 Standby-off Standby-on Off 69 ± 10 Standby-off Standby-on On 100 ± 10 Standby-on Standby-off Off 131 ± 10 Standby-on Standby-off On 160 ± 10 Standby-on Standby-on Off 188 ± 10 Standby-on Standby-on On 214 ± 10
	Passive Seismic		
AL-1	LP Amplifier Gain (X and Y)	23	Discrete
AL-2	LP Amplifier Gain (Z)	38	Discrete
AL-3	Level Direction and Speed	53	Discrete
AL-4	SP Amplifier Gain (Z)	68	Discrete
AL-5	Leveling Mode and Coarse Sensor Mode	24	Discrete
AL-6	Thermal Control Status	39	Discrete
AL-7	Calibration Status LP and SP	54	Discrete
AL-8	Uncage Status	69	Discrete

TABLE 6-X.- ALSEP 3 ANALOG CHANNEL USAGE - Concluded

Symbol	Location/Name	Channel	Operating Limits
Heat Flow			
AH-1	Supply Voltage #1	29	4.9 to 5.1 Vdc
AH-2	Supply Voltage #2	45	-4.9 to -5.1 Vdc
AH-3	Supply Voltage #3	55	14.7 to 15.3 Vdc
AH-4	Supply Voltage #4	74	-14.7 to -15.3 Vdc
AH-5	Not Assigned		
AH-6	Low Cond Heater Power Status	57	Discrete
AH-7	High Cond Heater Power Status	75	Discrete
Cold Cathode Gage			
AG-1	Gage Output	70	1.1 to 9 units
AG-2	Gage Range	85	10^{-7} to 10^{-13} amps (7 discrete steps)
Charged Particle			
AC-1	Switchable Power Supply Voltage	25	-3500 to +3500 Vdc (7 discrete steps)
AC-2	Channeltron Power Supply #1	89	} 2800 Vdc ±400 Vdc
AC-3	Channeltron Power Supply #2	40	} or 3200 Vdc ±400 Vdc
AC-4	DC-DC Converter Voltage	10	2.8 to 3.2 Vdc
AC-5	Temperature of Physical Analyser	11	-30° to +80°C
AC-6	Temperature of Switchable P/S	90	-39° to +80°C

TABLE 6-XI.- HEAT FLOW MEASUREMENTS, MODE 1 & 2 GRADIENT AND LOW CONDUCTIVITY

SYMBOL	LOCATION/MEASUREMENT	FRAME	RANGE
DH-1	ΔT_{11} H Temp Grad High Sens	0-7	±2°C
DH-2	ΔT_{12} H Temp Grad High Sens	8-15	±2°C
DH-3	ΔT_{21} H Temp Grad High Sens	90-97	±2°C
DH-4	ΔT_{22} H Temp Grad High Sens	98-105	±2°C
DH-5	ΔT_{11} L Temp Grad Low Sens	180-187	±20°C
DH-6	ΔT_{12} L Temp Grad Low Sens	188-195	±20°C
DH-7	ΔT_{21} L Temp Grad Low Sens	270-277	±20°C
DH-8	ΔT_{22} L Temp Grad Low Sens	278-285	±20°C
DH-9	T_{11} Probe, Ambient Temp	360-367	200 to 250°K
DH-10	T_{12} Probe, Ambient Temp	368-375	200 to 250°K
DH-11	T_{21} Probe, Ambient Temp	450-457	200 to 250°K
DH-12	T_{22} Probe, Ambient Temp	458-465	200 to 250°K
DH-13	Ref T_1, Temp Ref Junction	540-547	-20 to +60°C
* DH-14, 24, 34, 44	TC_1 Group Probe Cable Temp	548-555	90 to 350°K
DH-15	Ref T_2, Temp Ref Junction	630-637	-20 to +60°C
* DH-16, 26, 36, 46	TC_2 Group Probe Cable Temp	638-645	90 to 350°K

*See Table 8-I for these measurements.

TABLE 6-XII.- HEAT FLOW MEASUREMENTS, MODE 3, HIGH CONDUCTIVITY

SYMBOL	LOCATION/MEASUREMENT	FRAME	RANGE	H-BITS	PROBE	BRIDGE	HEATER STATUS
DH-50	Differential Temp	0-7		0000	1	1	Off
DH-51	Ambient Temp	8-15		0000	1	1	Off
DH-52	Differential Temp	0-7		0001	1	1	H_{12} On
DH-53	Ambient Temp	8-15		0001	1	1	H_{12} On
DH-60	Differential Temp	0-7		0010	1	2	Off
DH-61	Ambient Temp	8-15		0010	1	2	Off
DH-62	Differential Temp	0-7		0011	1	2	H_{14} On
DH-63	Ambient Temp	8-15		0011	1	2	H_{14} On
DH-56	Differential Temp	0-7		0100	1	1	Off
DH-57	Ambient Temp	8-15		0100	1	1	Off
DH-58	Differential Temp	0-7		0101	1	1	H_{11} On
DH-59	Ambient Temp	8-15		0101	1	1	H_{11} On
DH-66	Differential Temp	0-7		0110	1	2	Off
DH-67	Ambient Temp	8-15		0110	1	2	Off
DH-68	Differential Temp	0-7		0111	1	2	H_{13} On
DH-69	Ambient Temp	8-15		0111	1	2	H_{13} On
DH-70	Differential Temp	0-7		1000	2	1	Off
DH-71	Ambient Temp	8-15		1000	2	1	Off
DH-72	Differential Temp	0-7		1001	2	1	H_{22} On
DH-73	Ambient Temp	8-15		1001	2	1	H_{22} On
DH-80	Differential Temp	0-7		1010	2	2	Off
DH-81	Ambient Temp	8-15		1010	2	2	Off
DH-82	Differential Temp	0-7		1011	2	2	H_{24} On
DH-83	Ambient Temp	8-15		1011	2	2	H_{24} On
DH-76	Differential Temp	0-7		1100	2	1	Off
DH-77	Ambient Temp	8-15		1100	2	1	Off
DH-78	Differential Temp	0-7		1101	2	1	H_{21} On
DH-79	Ambient Temp	8-15		1101	2	1	H_{21} On
DH-86	Differential Temp	0-7		1110	2	2	Off
DH-87	Ambient Temp	8-15		1110	2	2	Off
DH-88	Differential Temp	0-7		1111	2	2	H_{23} On
DH-89	Ambient Temp	8-15		1111	2	2	H_{23} On

TABLE 6-XIV.- HEAT FLOW MEASUREMENTS, ANALOG

SYMBOL	LOCATION/MEASUREMENT	CHANNEL	RANGE	DECIMAL PCM
AH-1	Supply Voltage #1	29	0 to +5 Volts	
AH-2	Supply Voltage #2	45	0 to -5 Volts	
AH-3	Supply Voltage #3	55	0 to +15 Volts	
AH-4	Supply Voltage #4	74	0 to -15 Volts	
AH-5	Not Assigned			
AH-6	Low Cond Heater Power Status	57	2 to 2.5 Volts On otherwise Off	102-128 Htr On 3-101 Htr Off
AH-7	High Cond Heater Power Status	75	2 to 2.5 Volts On otherwise Off	102-128 Htr On 3-101 Htr Off

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

Notes:

1. It takes two ALSEP main frames to downlink one heat flow word. It takes four heat flow words to obtain one measurement except in Thermocouple Group Probe 1 and 2. In Thermocouple Group Probe 1 and 2 each heat flow word contains a single measurement.
2. Measurement DH-90: M_1, M_2, and M_3 identifies mode.
3. Measurement DH-91:
   P_4, P_3, P_2, and P_1 are measurement identification in gradient mode and low conductivity mode.
4. Measurement DH-92:
   R_2 and R_1 are the binary equivalent of heat flow word and identify the analog parameters (13-bits) that are used in the calculation to derive the engineering units for a measurement number.
5. Measurement DH-93:
   H_4, H_3, H_2, and H_1 identify the conductivity heater status. In the high conductivity mode it identifies the measurement numbers also.
6. Measurement DH-94:
   Filler bits (shown as zeros in above chart).

Figure 6-3. - Heat flow experiment word format.

TABLE 6-XV.- PASSIVE SEISMIC MEASUREMENTS LIST, ALSEP 3

Scientific Measurements

Symbol	Location/Measurement	ALSEP Word	ALSEP Frame	Sensor Range
DL- 1	Long Period X Seismic	9, 25, 41, 57	Every	1 mμ to 10μ
DL- 2	Long Period Y Seismic	11, 27, 43, 59	Every	1 mμ to 10μ
DL- 3	Long Period Z Seismic	13, 29, 45, 61	Every	1 mμ to 10μ
DL- 4	Long Period X Tidal	35	Even	0.01 to 10" (arc)
DL- 5	Long Period Y Tidal	37	Even	0.01 to 10" (arc)
DL- 6	Long Period Z Tidal	35	Odd	8 μgal to 8 mgal
DL- 7	Instrument Temp	37	Odd	107 - 143°F
DL- 8	Short Period Z Seismic	Every Even Word Except 2 and 56	Every	1 mμ to 10μ

Engineering Measurements

8 channels of Engineering Measurements included in ALSEP Word 33

Symbol	Location/Measurement	Analog Channel	Sensor Range		Decimal PCM
AL- 1	LP Ampl Gain (X and Y)	23	0 db	0-0.4V	0-21
			-10db	0.6-1.4	31-72
			-20db	1.6-2.4	82-122
			-30db	2.6-4.0	133-204
AL- 2	LP Ampl Gain (Z)	38	0 db	0-0.4V	0-21
			-10db	0.6-1.4	31-72
			-20db	1.6-2.4	82-122
			-30db	2.6-4.0	133-204
AL- 3	Level Direction and Speed	53	+low	0-0.4V	0-21
			-low	0.6-1.4	31-72
			+high	1.6-2.4	82-122
			-high	2.6-4.0	133-204
AL- 4	SP Ampl Gain (Z)	68	0 db	0-0.4V	0-21
			-10db	0.6-1.4	31-72
			-20db	1.6-2.4	82-122
			-30db	2.6-4.0	133-204
AL- 5	Leveling Mode and Coarse Sensor Mode	24	Automatic, coarse sensor out	0-0.4V	0-21
			Forced, coarse sensor out	0.6-1.4	31-72
			Automatic, coarse sensor in	1.6-2.4	82-122
			Forced, coarse sensor in	2.6-4.0	133-204
AL- 6	Thermal Control	39	Automatic Mode ON	0-0.4V	0-21
			Automatic Mode OFF	0.6-1.4	31-72
			Forced Mode ON	1.6-2.4	82-122
			Forced Mode OFF	2.6-4.0	133-204
AL- 7	Calibration Status LP & SP	54	All ON	0-0.4V	0-21
			LP - ON, SP - OFF	0.6-1.4	31-72
			LP - OFF, SP - ON	1.6-2.4	82-122
			All OFF	2.6-4.0	133-204
AL- 8	Uncage Status	69	Caged 0-0.4V		0-21
			Arm 0.6-1.4		31-72
			Uncage 1.6-2.4		82-122

TABLE 6-XVI.- COLD CATHODE GAGE MEASUREMENTS

SYMBOL	LOCATION/MEASUREMENT	CCGE WORD	ALSEP WORDS	FRAME	RANGE
DG-1	Multiplexer State	All Bits 2^0 & 2^1	15,31,47,56,63	All	0 to 3
DG-2	Automatic Zero State	One, 2^2 Bit	15	All	"0" = Operate "1" Zeroing
DG-3	Calibrate State	One, 2^3 Bit	15	All	"0" = Operate "1" Calibrate
DG-4	Housekeeping Word ID	One, Bits 2^4 & 2^5	15	All	"0" = DG-10 "2" = DG-12 "1" = DG-11 "3" = DG-13
DG-5	Ranging Mode	One, 2^6 Bit	15	All	"1" = Automatic "0" Manual
DG-6	Range	One, Bits 2^7,2^8,2^9	15	All	10^{-6} to 10^{-12} Torr in 7 steps
DG-7	Gage Output	Two	31	All	0 to 255 PCM
DG-8	Gage Temperature	Three	47	All	-300 to +275°F
DG-9	Electronics Pkg Temp	Four	56	All	-50 to +200°F
DG-10	4.5 kilovolt Monitor	Five	63	1	4.2 kV to 4.8 kV
DG-11	+15 Volts	Five	63	2	14.00 to 16.00 Vdc
DG-12	-15 Volts	Five	63	3	-13.90 to -16.75 Vdc
DG-13	+10 Volts	Five	63	4	9.6 to 10.4 Vdc
AG-1	Gage Output		33, Chan 70		Same as DG-7
AG-2	Gage Range		33, Chan 85		10^{-13} - 0.25 to 0.45 Vdc 10^{-12} - 0.60 to 0.80 Vdc 10^{-11} - 0.90 to 1.10 Vdc 10^{-10} - 1.20 to 1.60 Vdc 10^{-9} - 1.50 to 1.90 Vdc 10^{-8} - 1.80 to 2.20 Vdc 10^{-7} - 2.20 to 2.60 Vdc

Flight 3 Only

The CCGE (MSC) interface is designed to replace the SIDE/CCGE without change to the ALSEP system. The experiment uses ALSEP words 15, 31, 47, 56, and 63. The first CCGE (MSC) word contains six experiment state indications; the second CCGE (MSC) words, the cold cathode gauge output; the third, the gauge temperature; the fourth, the CCGE electronics temperature, and the fifth is a subcommutated housekeeping engineering data word. The basic format is shown below:

CCGE/MSC Word	ALSEP Word	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	Remarks
1	15	R_1	R_2	R_3	RM	HKID	HKID	CAL	Zero	1	1	Identification information
2	31	X	X	X	X	X	X	X	X	0	0	Gage output
3	47	X	X	X	X	X	X	X	X	0	1	Gage temperature
4	56	X	X	X	X	X	X	X	X	1	0	Electronics package temperature
5	63	X	X	X	X	X	X	X	X	1	1	Housekeeping engineering data

R - Range
RM - Range mode
HKID - Housekeeping ID
CAL - Calibration state
Zero - Automatic zero state
ID - Multiplexer state

Figure 6-4. - Cold cathode gage experiment (MSC) word format.

Chan	ALSEP words	Det	Analyzer											Frame
1	7	1	A	DC-97	2^{18}	2^{17}	2^{16}	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	Even frame
2	17			2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	Even frame
3	19	2	A	DC-98										Even frame
4	23													Even frame
5	39	3	A	DC-99-1										Even frame
6	55													Even frame
7	7	4	A	DC-99-2										Odd frame
8	17													Odd frame
9	19	5	A											Odd frame
10	23													Odd frame
11	39	6	A	2^{19}	2^{18}	2^{17}	2^{16}	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	Odd frame
12	55			2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	Odd frame

13 ↕ 24 } Repeat format of channels 1 to 12 for analyzer B, Detectors 1 to 6 with the same deflection plate voltage. Channels 1 through 24 are run through for +3500, +350, +35,0, - 3500, -350, -35 and 0 volts each in sequence for a full data cycle

DC-97

Physical analyzer ID
Analyzer A = "1"
B = "0"

DC-98

Polarity of deflection
Voltage ID
Polarity + = "1"
- = "0"

DC-99

Deflection voltage
Level ID

MSB	LSB	Voltage
1	1	3500
1	0	350
0	1	35
0	0	0

Figure 6-5. - CPLEE word format.

TABLE 6-XVII.- CHARGED PARTICLE MEASUREMENTS

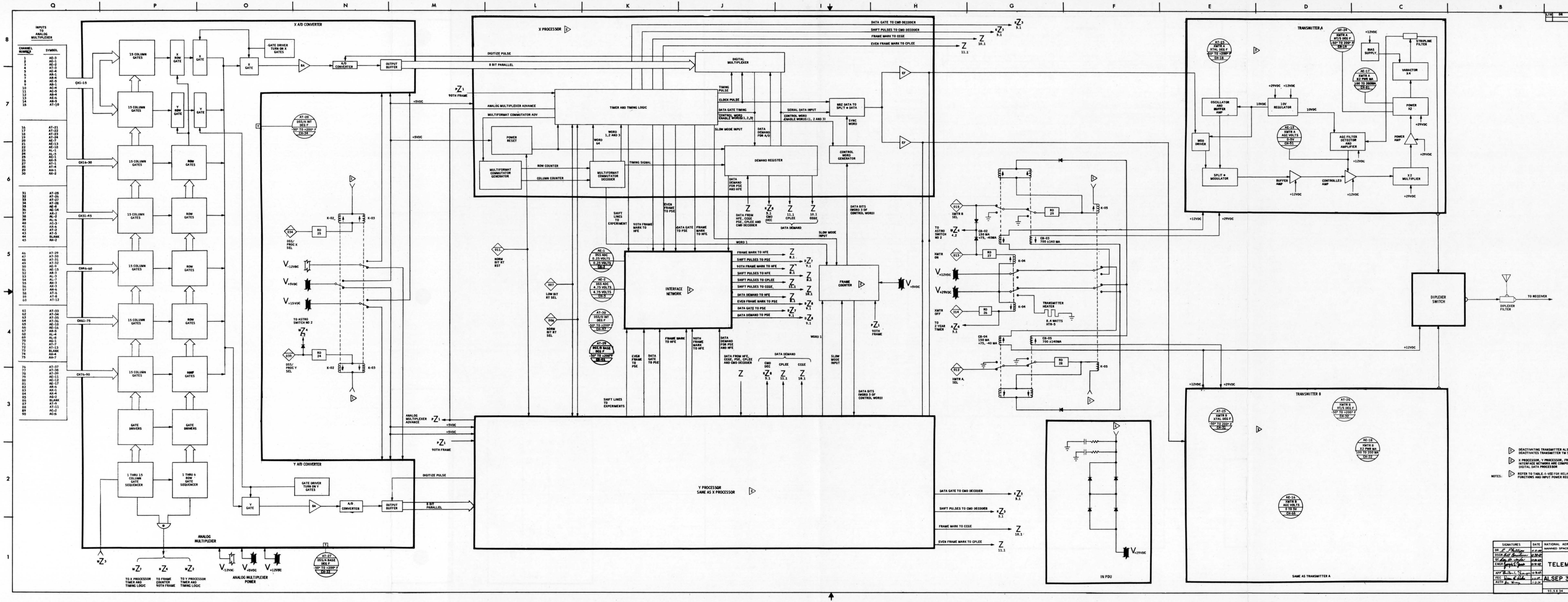
SYMBOL	LOCATION/MEASUREMENT	ALSEP WORDS	CPLEE FRAME
DC-1	Detector 1-A +3500V	7, 17	1
DC-2	Detector 2-A +3500V	19, 23	1
DC-3	Detector 3-A +3500V	39, 55	1
DC-4	Detector 4-A +3500V	7, 17	2
DC-5	Detector 5-A +3500V	19, 23	2
DC-6	Detector 6-A +3500V	39, 55	2
DC-7	Detector 1-B +3500V	7, 17	3
DC-8	Detector 2-B +3500V	19, 23	3
DC-9	Detector 3-B +3500V	39, 55	3
DC-10	Detector 4-B +3500V	7, 17	4
DC-11	Detector 5-B +3500V	19, 23	4
DC-12	Detector 6-B +3500V	39, 55	4
DC-13	Detector 1-A +350V	7, 17	5
DC-14	Detector 2-A +350V	19, 23	5
DC-15	Detector 3-A +350V	39, 55	5
DC-16	Detector 4-A +350V	7, 17	6
DC-17	Detector 5-A +350V	19, 23	6
DC-18	Detector 6-A +350V	39, 55	6
DC-19	Detector 1-B +350V	7, 17	7
DC-20	Detector 2-B +350V	19, 23	7
DC-21	Detector 3-B +350V	39, 55	7
DC-22	Detector 4-B +350V	7, 17	8
DC-23	Detector 5-B +350V	19, 23	8
DC-24	Detector 6-B +350V	39, 55	8
DC-25	Detector 1-A +35V	7, 17	9
DC-26	Detector 2-A +35V	19, 23	9
DC-27	Detector 3-A +35V	39, 55	9
DC-28	Detector 4-A +35V	7, 17	10
DC-29	Detector 5-A +35V	19, 23	10
DC-30	Detector 6-A +35V	39, 55	10
DC-31	Detector 1-B +35V	7, 17	11
DC-32	Detector 2-B +35V	19, 23	11
DC-33	Detector 3-B +35V	39, 55	11
DC-34	Detector 4-B +35V	7, 17	12
DC-35	Detector 5-B +35V	19, 23	12
DC-36	Detector 6-B +35V	39, 55	12
DC-37	Detector 1-A +0V	7, 17	13
DC-38	Detector 2-A +0V	19, 23	13
DC-39	Detector 3-A +0V	39, 55	13
DC-40	Detector 4-A +0V	7, 17	14
DC-41	Detector 5-A +0V	19, 23	14
DC-42	Detector 6-A +0V	39, 55	14
DC-43	Detector 1-B +0V	7, 17	15
DC-44	Detector 2-B +0V	19, 23	15
DC-45	Detector 3-B +0V	39, 55	15
DC-46	Detector 4-B +0V	7, 17	16
DC-47	Detector 5-B +0V	19, 23	16
DC-48	Detector 6-B +0V	39, 55	16
DC-49	Detector 1-A -3500V	7, 17	17
DC-50	Detector 2-A -3500V	19, 23	17
DC-51	Detector 3-A -3500V	39, 55	17
DC-52	Detector 4-A -3500V	7, 17	18
DC-53	Detector 5-A -3500V	19, 23	18
DC-54	Detector 6-A -3500V	39, 55	18
DC-55	Detector 1-B -3500V	7, 17	19
DC-56	Detector 2-B -3500V	19, 23	19
DC-57	Detector 3-B -3500V	39, 55	19
DC-58	Detector 4-B -3500V	7, 17	20
DC-59	Detector 5-B -3500V	19, 23	20
DC-60	Detector 6-B -3500V	39, 55	20

TABLE 6-XVII.- CHARGED PARTICLE MEASUREMENTS - Concluded

SYMBOL	LOCATION/MEASUREMENT	ALSEP WORDS	CPLEE FRAME
DC-61	Detector 1-A -350	7, 17	21
DC-62	Detector 2-A -350	19, 23	21
DC-63	Detector 3-A -350	39, 55	21
DC-64	Detector 4-A -350	7, 17	22
DC-65	Detector 5-A -350	19, 23	22
DC-66	Detector 6-A -350	39, 55	22
DC-67	Detector 1-B -350	7, 17	23
DC-68	Detector 2-B -350	19, 23	23
DC-69	Detector 3-B -350	39, 55	23
DC-70	Detector 4-B -350	7, 17	24
DC-71	Detector 5-B -350	19, 23	24
DC-72	Detector 6-B -350	39, 55	24
DC-73	Detector 1-A -35	7, 17	25
DC-74	Detector 2-A -35	19, 23	25
DC-75	Detector 3-A -35	39, 55	25
DC-76	Detector 4-A -35	7, 17	26
DC-77	Detector 5-A -35	19, 23	26
DC-78	Detector 6-A -35	39, 55	26
DC-79	Detector 1-B -35	7, 17	27
DC-80	Detector 2-B -35	19, 23	27
DC-81	Detector 3-B -35	39, 55	27
DC-82	Detector 4-B -35	7, 17	28
DC-83	Detector 5-B -35	19, 23	28
DC-84	Detector 6-B -35	39, 55	28
DC-85	Detector 1-A -0	7, 17	29
DC-86	Detector 2-A -0	19, 23	29
DC-87	Detector 3-A -0	39, 55	29
DC-88	Detector 4-A -0	7, 17	30
DC-89	Detector 5-A -0	19, 23	30
DC-90	Detector 6-A -0	39, 55	30
DC-91	Detector 1-B -0	7, 17	31
DC-92	Detector 2-B -0	19, 23	31
DC-93	Detector 3-B -0	39, 55	31
DC-94	Detector 4-B -0	7, 17	32
DC-95	Detector 5-B -0	19, 23	32
DC-96	Detector 6-B -0	39, 55	32
DC-97	Physical Analyser ID	7 (Bit #1 Even Fr)	
DC-98	Polarity of Deflection Voltage ID	19 (Bit #1 Even Fr)	
DC-99	Deflection Voltage Level ID	39 (Bit #1 Even Fr) 7 (Bit #1 Odd Fr)	

Analog Measurements

SYMBOL	LOCATION/MEASUREMENT	ALSEP WORD & CHAN	RANGE
AC-1	Switchable P/S Voltage	33 - 25	
AC-2	Channeltron P/S #1	33 - 89	
AC-3	Channeltron P/S #2	33 - 40	
AC-4	DC-DC Converter Voltage	33 - 10	
AC-5	Temperature of Physical Analyser	33 - 11	-30 to +120°C
AC-6	Temperature of Switchable P/S	33 - 90	-30 to +120°C



NOTES:

1. REFER TO TABLE 4-VIII FOR RELAY DRIVER FUNCTIONS AND INPUT POWER REQUIREMENTS
2. X PROCESSOR, Y PROCESSOR, FRAME COUNTER AND INTERFACE NETWORK ARE COMPONENTS OF THE DIGITAL DATA PROCESSOR
3. DEACTIVATING TRANSMITTER ALSO DEACTIVATES TRANSMITTER TM SENSORS

SIGNATURES	DATE
DR L. Phillips	1-2-70
DSGN Bill Bernaltime	12-30-69
QC	12-30-69
ENGR Joseph L. Jones	12-31-69
APP Burton L. Sharpe	12-31-69
FEC	1-2-70
AUTH	1-2-70

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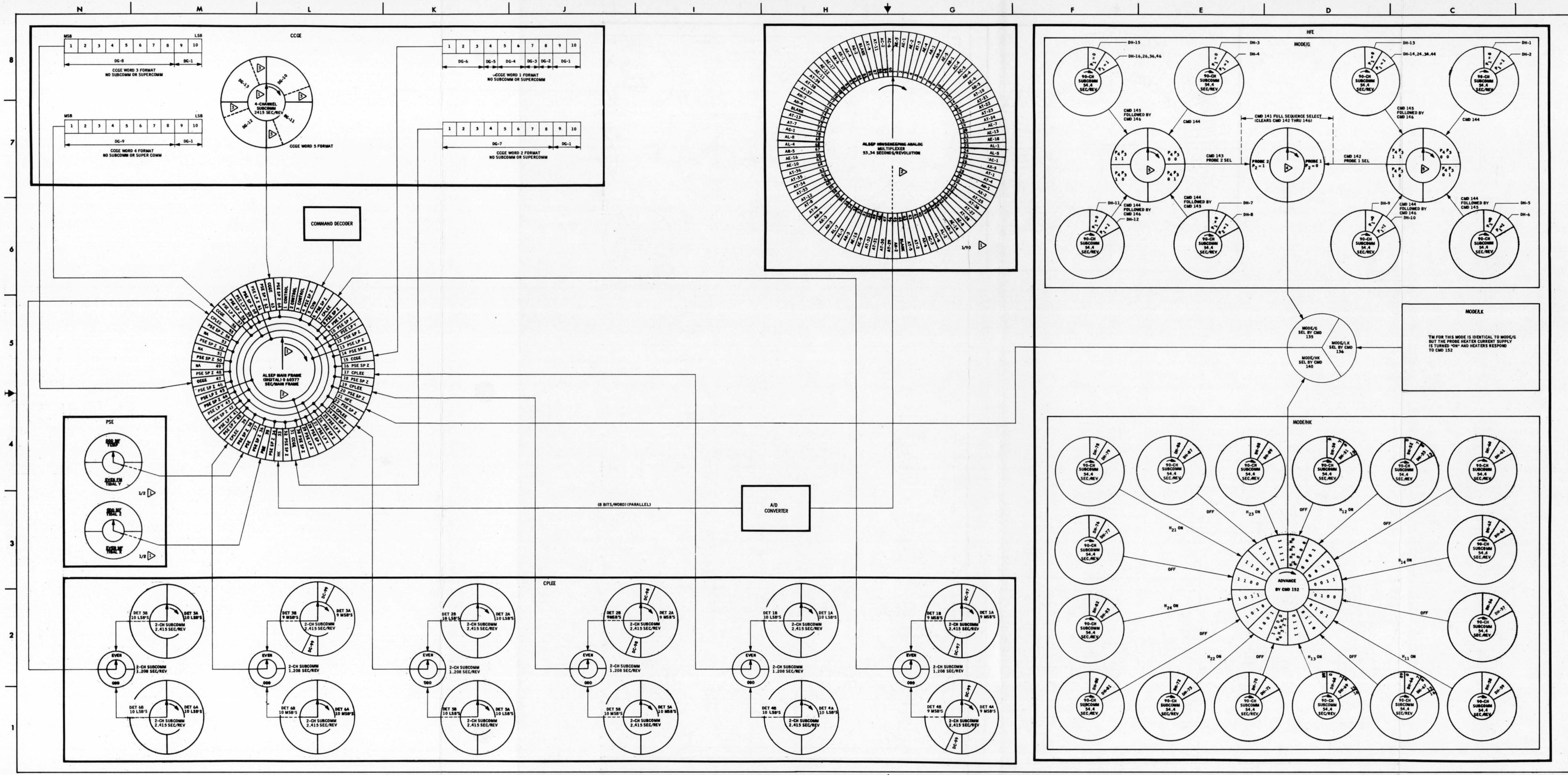
TELEMETRY SUBSYSTEM

ALSEP 3 — DWG NO 6.1

93.5 X 34 — PAGE 6-21 — SHEET 1 OF 1



CMD	CMD	CMD	SUBCOMM STATE P_4	P_3	MEASUREMENT	SUBCOMM RATE SEC/REV
141	144		0	0	DH-1 THRU 4	108.8
142	144		0	0	DH-1 AND 2	54.4
143	144		0	0	DH-3 AND 4	54.4
141	144	145	0	1	DH-5 THRU 8	108.8
142	144	145	0	1	DH-5 AND 6	54.4
143	144	145	0	1	DH-7 AND 8	54.4
141	144	146	1	0	DH-9 THRU 12	108.8
142	144	146	1	0	DH-9 AND 10	54.4
143	144	146	1	0	DH-11 AND 12	54.4
141	145	146	1	1	DH-13 AND 15, 14-44, 16-46	108.8
142	145	146	1	1	DH-13 AND 14, 24, 34, 44	54.4
143	145	146	1	1	DH-15 AND 16, 26, 36, 46	54.4

(5) Table above.

(4) WHEN CMD 141 IS EXECUTED, THE SUBCOMMUTATOR RATE IS 434.712 SEC/REV. (BOTH PROBES ARE SAMPLED). WHEN CMD 142 IS EXECUTED, THE SUBCOMMUTATOR IS LOCKED IN THE "0" STATE (ONLY PROBE 1 IS BEING SAMPLED). WHEN CMD 143 IS EXECUTED, THE SUBCOMMUTATOR IS LOCKED IN THE "1" STATE (ONLY PROBE 2 IS BEING SAMPLED). THE SUBCOMMUTATOR RATE IN EITHER OF THESE TWO STATES IS 217.356 SEC/REV

(3) THE TWO LSB'S OF EACH 10-BIT WORD OF THE 4-CHANNEL SUBCOMM ARE 1D BITS

(2) TIMES ARE FOR NORMAL BIT RATE (1060 SPS)

NOTES: (1) NUMBERS ARE RELATIONS TO ALSEP MAIN FRAME RATE. EXAMPLE: WHEN THE ALSEP MAIN FRAME COMPLETES ONE REVOLUTION ALSEP HOUSEKEEPING ANALOG MUX TURNS 1/90 OF A REVOLUTION

SIGNATURES	DATE
DR [signature]	9-16-69
DSGN [signature]	12-30-69
QC [signature]	12-30-69
ENGR [signature]	12-31-69
APP [signature]	12-31-69
FEC [signature]	1-1-70
AUTH [signature]	1-5-70

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MECHANICAL ANALOGY OF TELEMETRY COMMUTATIONS

ALSEP 3 | SIZE J | DWG NO 6.2

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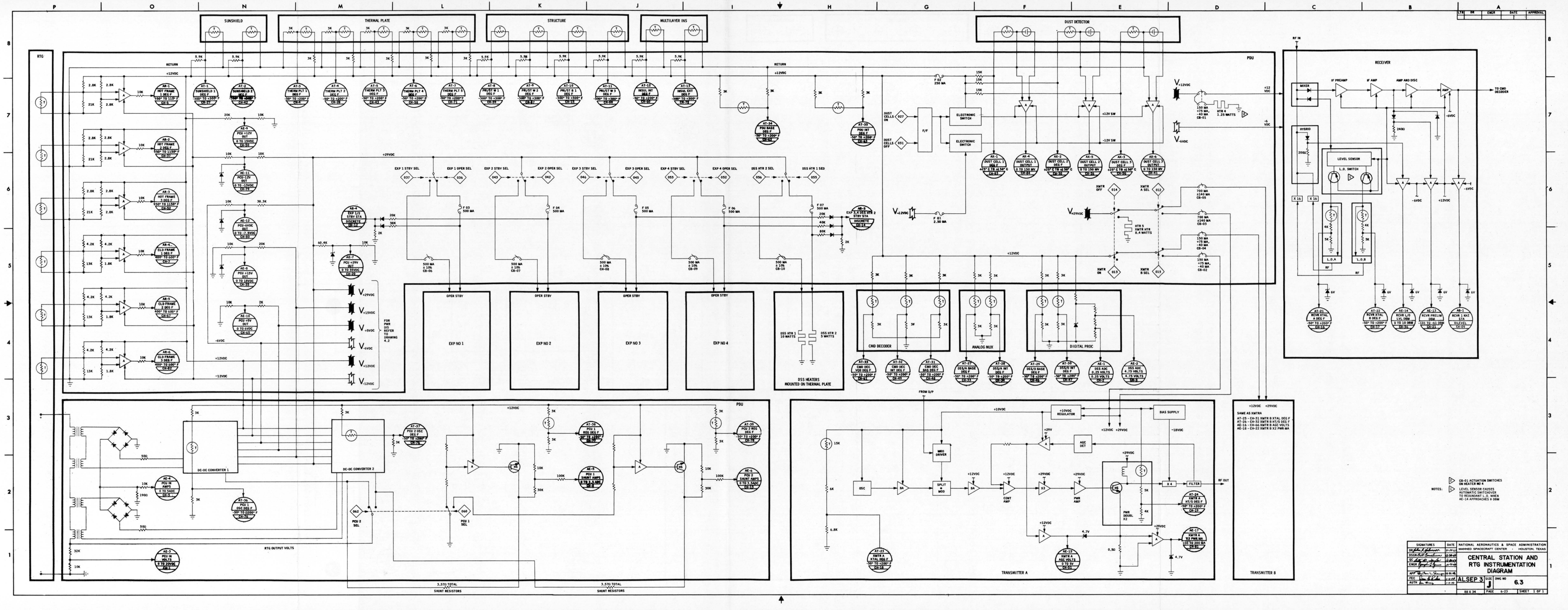
SUNSHIELD
THERMAL PLATE
STRUCTURE
MULTILAYER INS
DUST DETECTOR
RTG
PDU
RECEIVER
MIXER
IF PREAMP
IF AMP
AMP AND DISC
TO CMD DECODER
HYBRID
LEVEL SENSOR
L.O. SWITCH
EXP NO 1
EXP NO 2
EXP NO 3
EXP NO 4
DSS HEATERS MOUNTED ON THERMAL PLATE
CMD DECODER
ANALOG MUX
DIGITAL PROC
DC-DC CONVERTER 1
DC-DC CONVERTER 2
RTG OUTPUT VOLTS
3.57Ω TOTAL SHUNT RESISTORS
TRANSMITTER A
TRANSMITTER B
+12VDC +29VDC
SAME AS XMTRA
AT-25 - CH-31 XMTR B XTAL DEG F
AT-26 - CH-32 XMTR B HT/S DEG F
AE-16 - CH-66 XMTR B AGC VOLTS
AE-18 - CH-22 XMTR B X2 PWR MA
NOTES:
2 CB-01 ACTUATION SWITCHES ON HEATER NO 4
1 LEVEL SENSOR CAUSES AUTOMATIC SWITCHOVER TO REDUNDANT L.O. WHEN AE-14 APPROACHES 0 DBM
SIGNATURES
DATE
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MANNED SPACECRAFT CENTER · HOUSTON, TEXAS
CENTRAL STATION AND RTG INSTRUMENTATION DIAGRAM
ALSEP 3
SIZE J
DWG NO 6.3
88 X 34
PAGE 6-23
SHEET 1 OF 1

SECTION 7

DUST DETECTOR SUBSYSTEM

7.1 SYSTEM DESCRIPTION

The objectives of the dust detector are to obtain data for assessment of dust accretion on the ALSEP and to provide a measure of thermal degradation of thermal surfaces.

Dust accumulation on the surfaces of the three solar cells will reduce the amount of solar illumination detected by the cells. The outputs of the three solar cells are applied to three amplifiers which condition the signals and apply them to three subcommutated analog data channels of the data subsystem.

Temperature at each solar cell, essential to the analysis of cell output data, is monitored by a thermistor to obtain thermal data in relation to dust accretion. The thermistor outputs are applied to three subcommutated analog data channels of the data subsystem.

The expected temperature range of each solar cell will be -300°F to +300°F over a lunar cycle, and the temperature readings will only be usable above +80°F because of calibration difficulties. However, during the lunar night when the dust detector will be turned off, the voltage to the three temperature sensors (AX1, AX2, and AX3) will not be turned off, and the output voltages will be greater than +5V (between +5V and +12V) and will therefore be meaningless. This will occur with temperatures below +80°F and will cause the A-D multiplexer to give an all 1's readout.

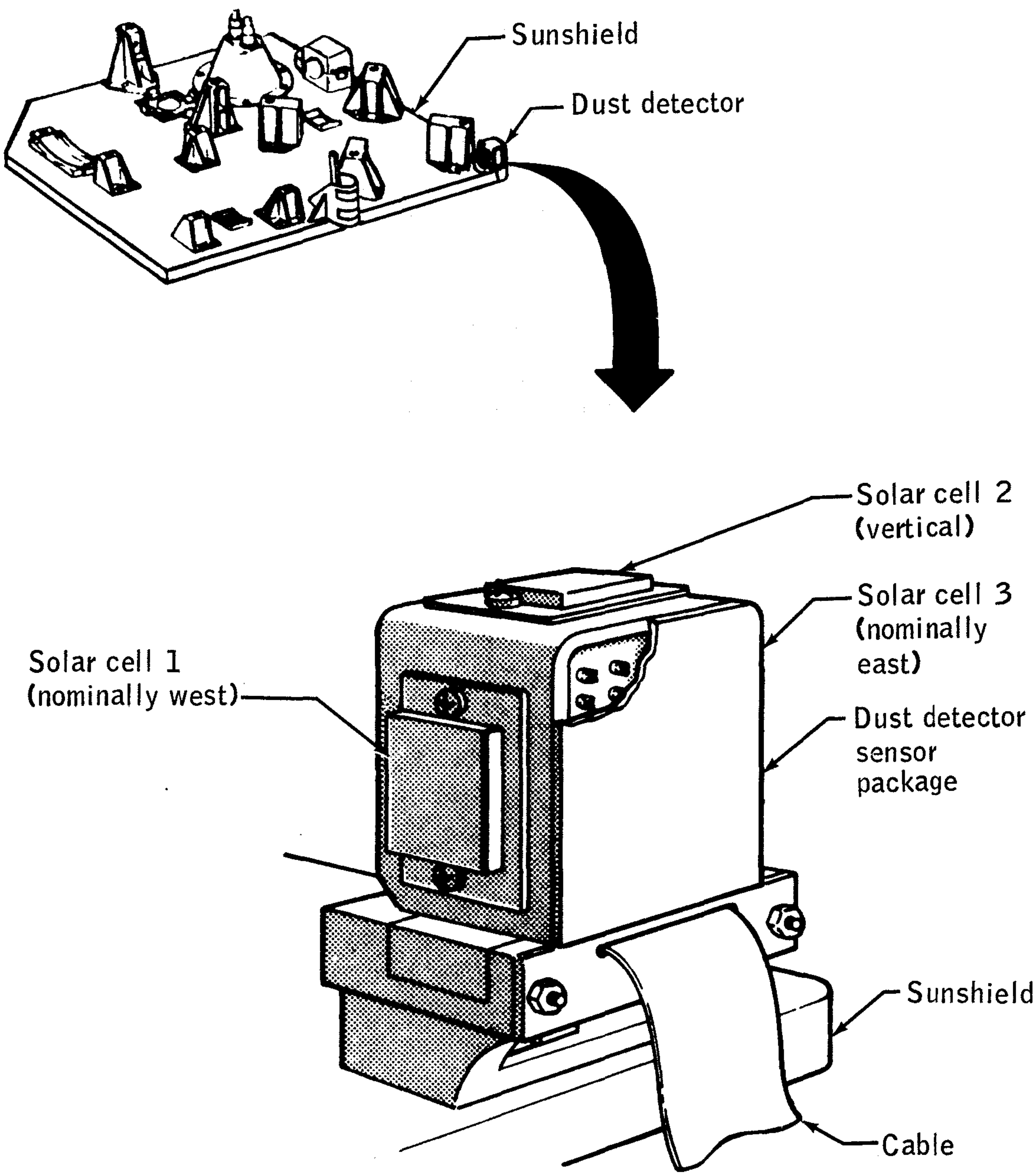
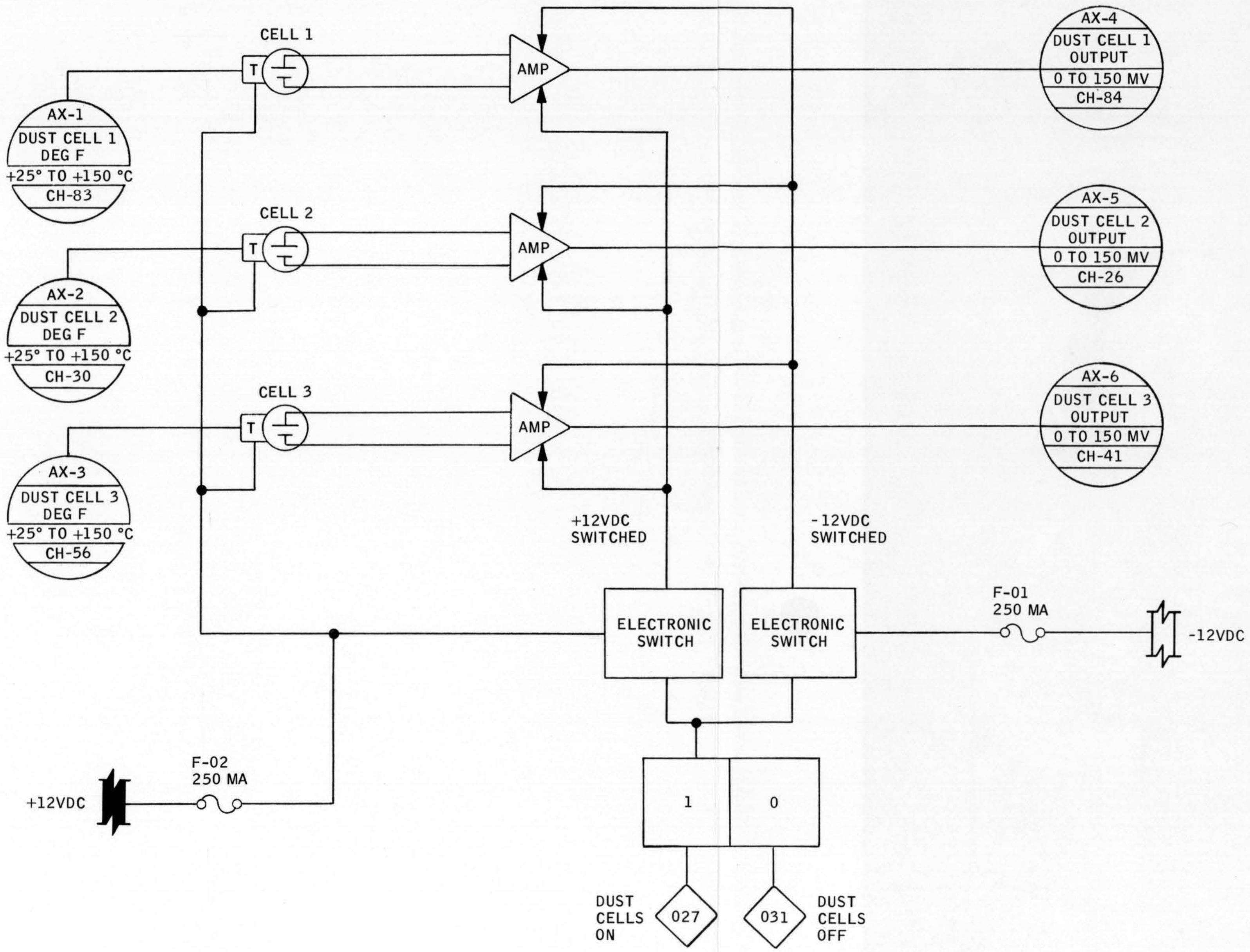


Figure 7-1.- Dust detector.

LTR	DR	ENGR	DATE	APPROVAL



NOTE:

VOLTAGE BUS	POWER	CURRENT	CIRCUIT PROTECTION
-12	160 MW	13.3 MA	F-01 250 MA
+12	380 MW	31.7 MA	F-02 250 MA

A BLOWN FUSE F-01 WILL PERMANENTLY DISABLE THE DUST DETECTOR, RESULTING IN LOSS OF PHOTOELECTRIC CELL VOLTAGE TM PARAMETERS AX-4, AX-5 AND AX-6

A BLOWN FUSE F-02 WILL PERMANENTLY DISABLE THE DUST DETECTOR, RESULTING IN LOSS OF PHOTOELECTRIC CELL VOLTAGE TM PARAMETERS AX-4, AX-5 AND AX-6 AND PHOTOELECTRIC CELL TEMPERATURE TM PARAMETERS AX-1, AX-2 AND AX-3

SIGNATURES	DATE
DR Fred Whitehead Jr.	3-25-69
DSGN Bill Cornelius	12-30-69
QC Betty M. Taylor	12-30-69
ENGR Joseph L. James	12-31-69
APP Burton L. Sharpe	12-31-69
FEC Dean B. Fisher	1-2-70
AUTH Jon Bray	1-2-70

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DUST DETECTOR SCHEMATIC

ALSEP 3	SIZE C	DWG NO 7.1
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SECTION 8

HEAT FLOW EXPERIMENT

8.1 SYSTEM DESCRIPTION

8.1.1 Experiment Objectives

The heat flow experiment (HFE) measures the net outward flux of heat from the moon's interior. Measurement of lunar heat flux will provide:

A. A comparison of the radioactive content of the moon's interior and the earth's mantle.

B. A thermal history of the moon

C. A lunar temperature-versus-depth profile

D. The value of thermal parameters in the first three meters of the moon's crust.

When compared with seismic measurements, data from the HFE experiment will provide information on the composition and physical state of the moon's interior.

8.1.2 Major Components

The major components of the HFE are two sensor probes and an electronics package as shown in Figure 8-1.

8.1.2.1 Sensor probes.- The probes consist of epoxy-fiberglass tubular structures which support and house temperature sensors, heaters, and the associated electrical wiring. Each probe has two sections, each 55 cm (21.6 inches) long, spaced 2 cm (0.8 inches) apart and mechanically connected by a flexible spring. The flexible spring allows the probe assembly to be bent into a U-shape to facilitate packing, stowage, and carry.

There is a gradient heat sensor surrounded by a heater coil at each end of each probe section. Each of these two gradient sensors consists of two resistance elements. These four resistance elements are connected in an electrical bridge circuit. Ring sensors are located 10 cm (4 inches) from each end of each probe section. Each of these two ring sensors has two resistance elements. These four resistance elements are connected into an electrical bridge circuit. Also, four thermocouples are located in the cable of each probe, identified and spaced as follows: number one at the upper end of the probe, numbers two, three and four spaced 25, 45, and 65 inches up the cable from the end of the probe.

8.1.2.2 Electronics package.- The heat flow electronics package contains six printed circuit boards which mount the functional circuits of the experiment. An external cable reel houses the HFE/central station cable and facilitates deployment. A sunshield thermally protects the electronics package from externally generated heat. Two reflectors built into the open ends of this sunshield aid in the radiation of internally generated heat that otherwise might be entrapped under the sunshield. The electronics package is thermally protected by multilayer insulation and thermal control paint.

8.1.3 Deployment

The HFE is deployed with the two sensor probes emplanted in the lunar surface in 3-meter (10-foot) boreholes. These holes are drilled by the astronaut with the Apollo lunar surface drill (ALSD). (Refer to Section 12 for a description of ALSD.) The two probes are connected by two multiple-lead cables to the HFE electronics package which is deployed separately from the ALSEP central station.

8.2 HFE MODES

The HFE performs its measurements in three basic modes of operation: Mode 1 or Mode/G, Mode 2 or Mode/LK, and Mode 3 or Mode/HK.

8.2.1 Mode/G, Normal Gradient Mode

The normal gradient mode is used to monitor the heat flow in and out of the lunar surface crust. Heat from solar radiation flows into the moon during the lunar day and out of the moon during lunar night. This larger heat gradient in the near subsurface of the moon will be monitored and measured in order to differentiate it from the more steady but smaller heat flow outward from the interior of the moon.

8.2.2 Mode/LK, Low Conductivity, and Mode/HK, High Conductivity

Thermal conductivity of the lunar material is measured with the principle of creating a known quantity of heat at a known location by exciting one of the eight probe heaters, and measuring the resultant probe ambient temperature and temperature differentials for a period of time. Because it is not known whether the surrounding material will have a low conductivity (loosely consolidated material) or a high conductivity (solid rock), the capability to measure over a wide range using two modes of operation is incorporated into the HFE design.

8.2.3 Ambient Temperature Measurements

Ambient temperature measurements are made at any gradient bridge or at any one of the thermocouples spaced at four points along each probe cable. In each probe cable, the thermocouples are placed at the top gradient sensor and at distance increments of 25, 45, and 65 inches above the top gradient sensor. The reference junction for the thermocouples is mounted on the HFE electronics package thermal plate.

8.2.3.1 Mode/G.- Normal (gradient) mode initiated by octal command 135 (gradient sensor excitation - no heater excitation). The heat gradients (temperature differentials) and probe ambient temperatures are measured with the gradient sensors and the thermocouples spaced along the two cables connecting the probes to the electronics package. In each deployed probe, the temperature difference between the ends of each of the two sections is measured by the gradient bridge consisting of the gradient sensors positioned at the ends of the probe section. Gradient temperature differentials are measured in both the high sensitivity and low sensitivity ranges.

8.2.3.2 Mode/LK.- Low conductivity mode (ring source) initiated by octal command 136 (gradient sensor excitation - low heater excitation). The probe heater selected by octal command 152 receives low power excitation and dissipates 2 milliwatts of power. The thermal conductivity is determined by measuring the temperature rise of the gradient bridge around which the selected heater is located. The temperature which the heater must reach to dissipate the power input is the measure of thermal conductivity of the surrounding material. The low conductivity measurements are performed in the sequence selected by earth command.

8.2.3.3 Mode/HK.- High conductivity mode (heat pulse) initiated by octal command 140 (ring sensor excitation - high heater excitation). The probe heater selected by octal command 152 receives high power excitation and dissipates 500 milliwatts of power. The thermal conductivity is determined by measuring the temperature rise at the ring bridge nearest the selected heater. The temperature rise per unit of time at the known distance is the measure of thermal conductivity of the surrounding material. The high conductivity measurements are heat gradients in the high sensitivity range and probe ambient temperatures. The bridge used in performing a measurement is determined by the heater selected.

TABLE 8-I.- HFE MEASUREMENT OPTIONS (MODES 1 AND 2)

Location/Name	Cmds and Order (Octal) / Symbol															
		135*	135*	135*	135*	135*	135*	135*	135*	135*	135*	135*	135*	135*	135*	135*
		141					142	142	142	142	142	143	143	143	143	143
		–	144	144	–	144	–	144	144	–	144	–	144	144	–	144
		–	–	145	145	–	–	–	145	145	–	–	–	145	145	–
		–	–	–	146	146	–	–	–	146	146	–	–	–	146	146
Temp grad high sens Temp grad high sens	DH-01 DH-02		Hi only													
Temp grad high sens Temp grad high sens	DH-03 DH-04		Hi only	180 frame rep rate			HFE Seq/P1									
Temp grad low sens Temp grad low sens	DH-05 DH-06	HFE-Seq/Ful		Lo only								HFE Seq/P2				
Temp grad low sens Temp grad low sens	DH-07 DH-08	HFE-Seq/Ful		Lo only												
Probe ambient temp Probe ambient temp	DH-09 DH-10	HFE-Seq/Ful				Amb only		16 out of 90 frames								
Probe ambient temp Probe ambient temp	DH-11 DH-12					Amb only										
Temp ref junction Probe cable temp (1)	**DH-13 ***DH-14,24,34,44				TC & ref			360 frame rep rate			90 frame rep rate					
Temp ref junction Probe cable temp (2)	**DH-15 ***DH-16,26,36,46		720 frame rep rate		TC & ref											

*** Thermocouple group measurement
** DH-13 and DH-15 are identical physical measurements separated in time by approximately 54 seconds
* Command 135 selects Mode 1, Command 136 selects Mode 2

TC_1 Group

Symbol	Data
DH-14	Ref TC-TC_1 (4)
DH-24	TC_1 (4) - TC_1 (1)
DH-34	TC_1 (4) - TC_1 (2)
DH-44	TC_1 (4) - TC_1 (3)

R-Bits

R_2	R_1
0	0
0	1
1	0
1	1

TC_2 Group

Symbol	Data
DH-16	Ref TC-TC_2
DH-26	TC_2 - TC_2 (1)
DH-36	TC_2 - TC_2 (2)
DH-46	TC_2 - TC_2 (3)

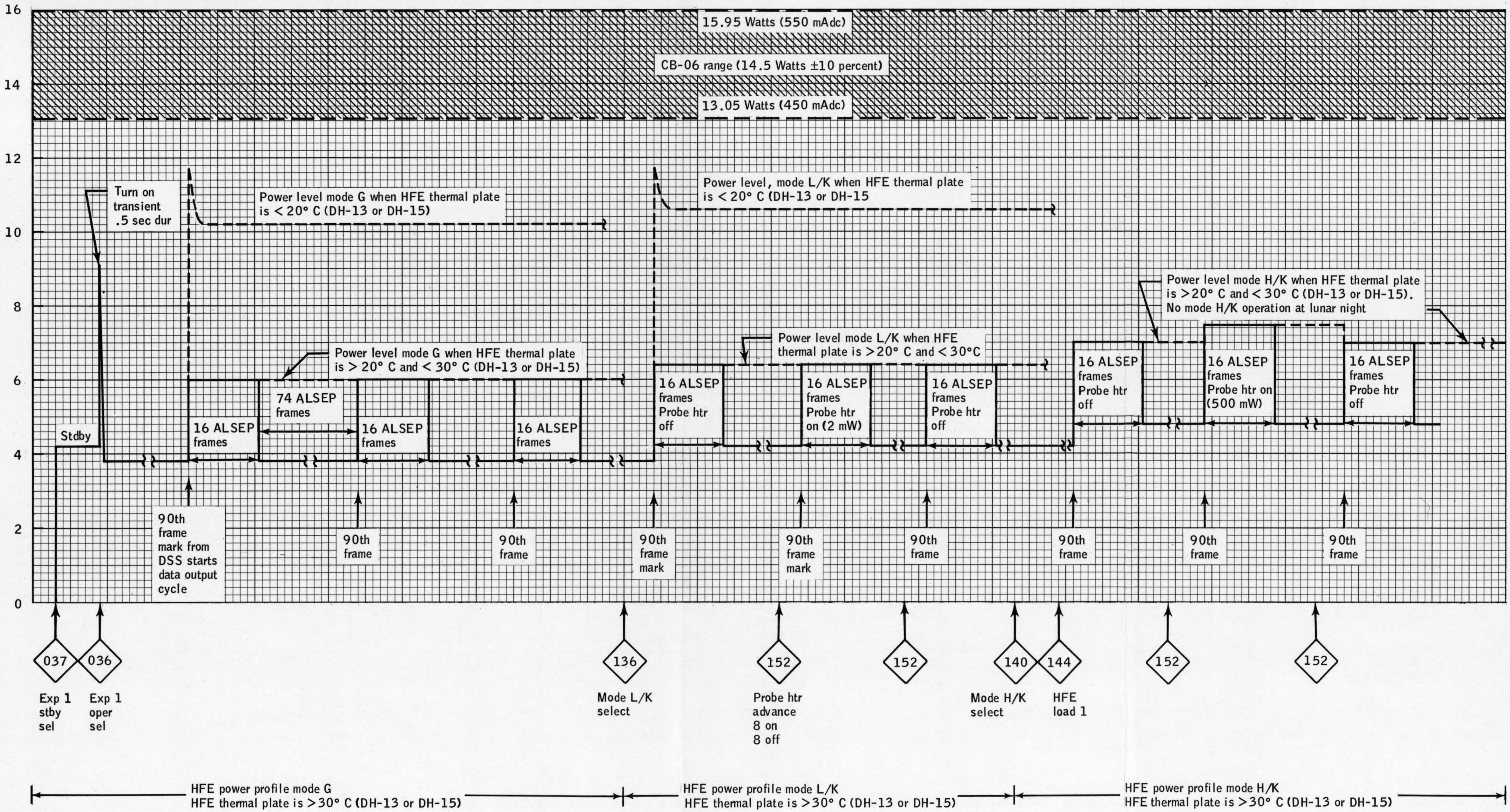

Figure 8-1. - Heat flow experiment power profile.

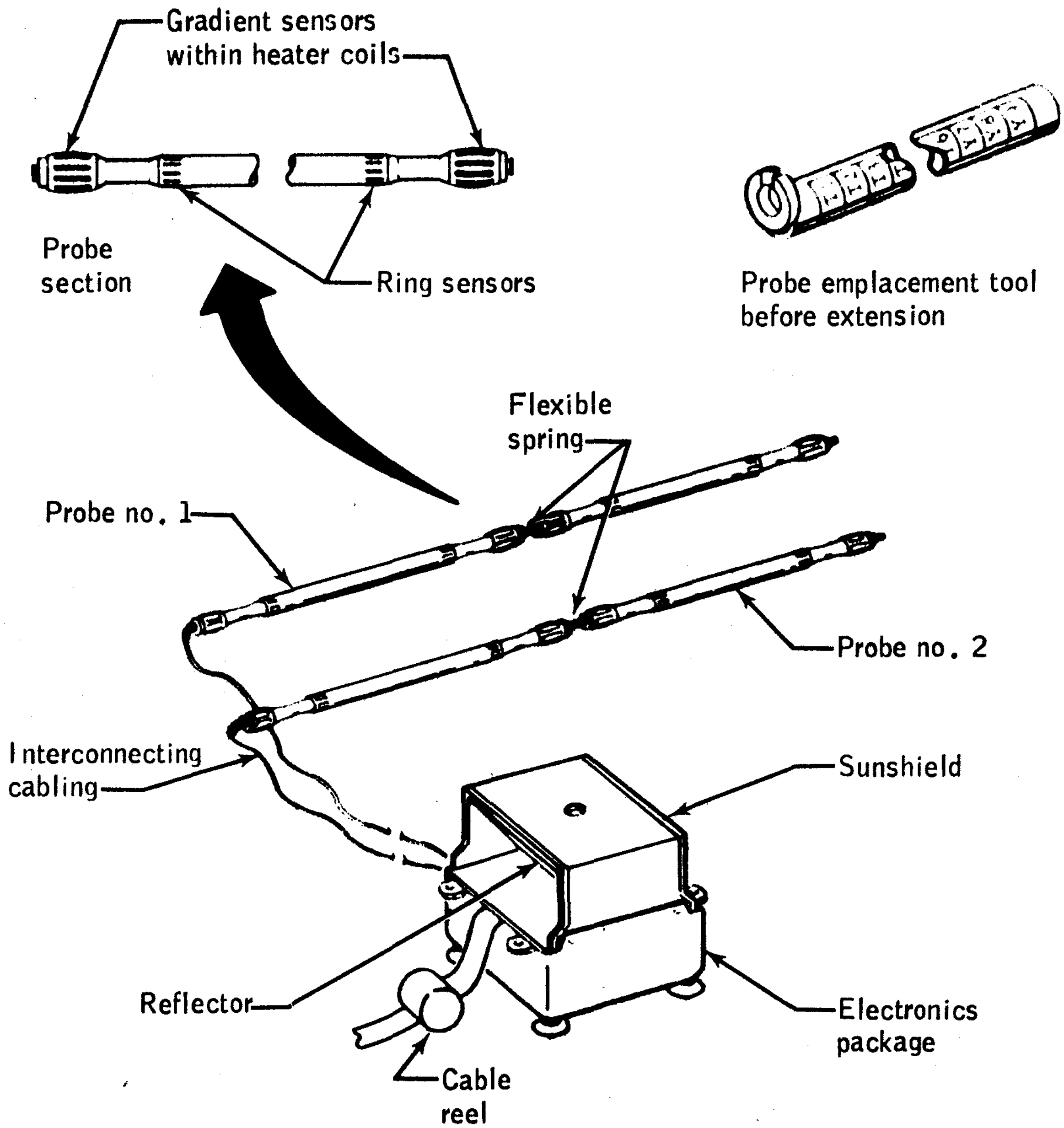

Figure 8-2. - Heat flow experiment.

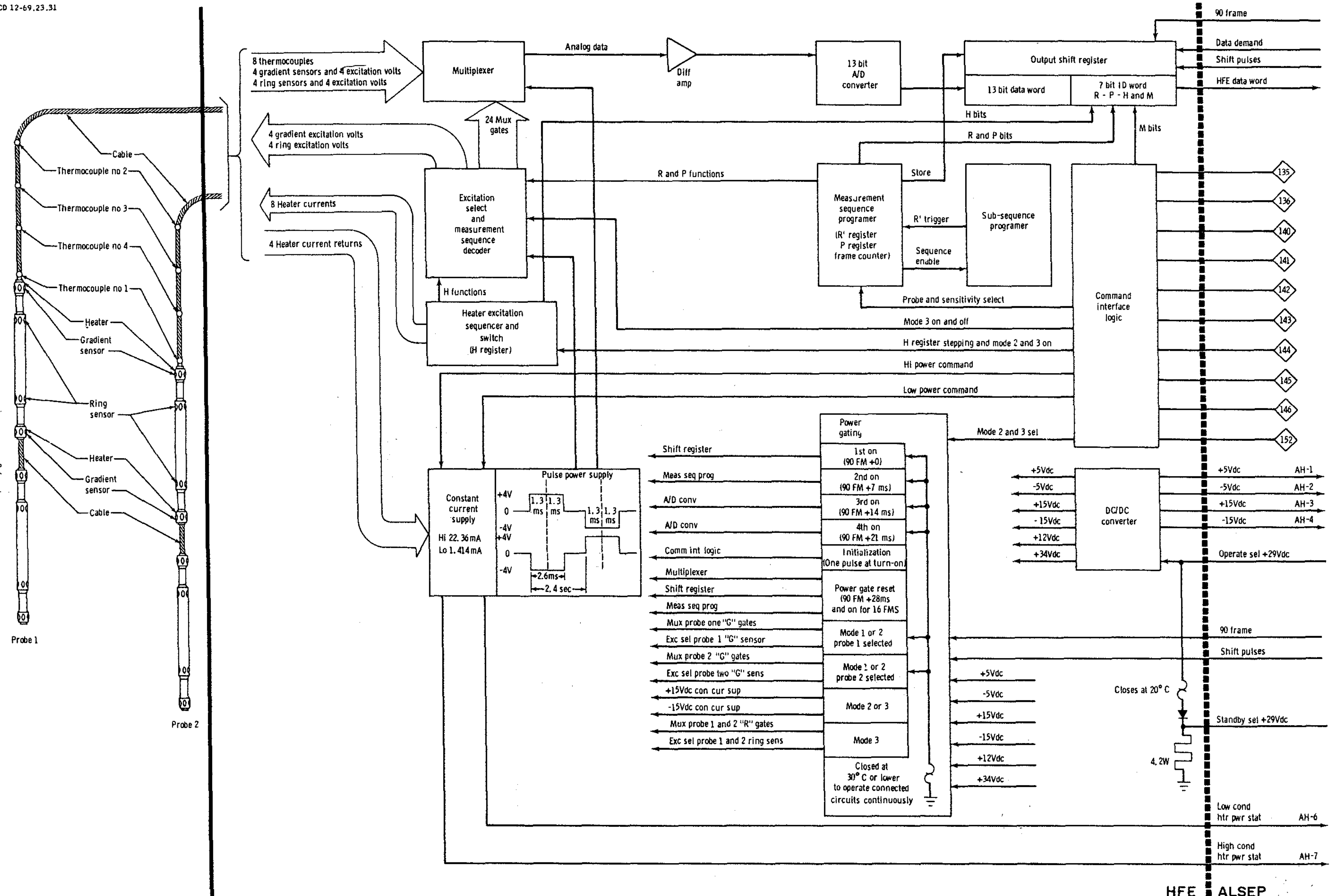

Figure 8-3. - Heat flow block diagram.

Measurement sequences for one section of one probe

ΔTH (modes 1 and 2)

1. Meas 1 + pulse P/S
2. Meas 2 + pulse P/S
3. Meas 1 - pulse P/S
4. Meas 2 - pulse P/S

ΔTL (modes 1 and 2)

1. Meas 3 + pulse P/S
2. Meas 2 + pulse P/S
3. Meas 3 - pulse P/S
4. Meas 2 - pulse P/S

Differential Temp (mode 3)

1. Meas 4 + pulse P/S
2. Meas 5 + pulse P/S
3. Meas 4 - pulse P/S
4. Meas 5 - pulse P/S

Ambient temp (mode 3)

1. Meas 4 + pulse P/S
2. Meas 6 + pulse P/S
3. Meas 4 - pulse P/S
4. Meas 6 - pulse P/S

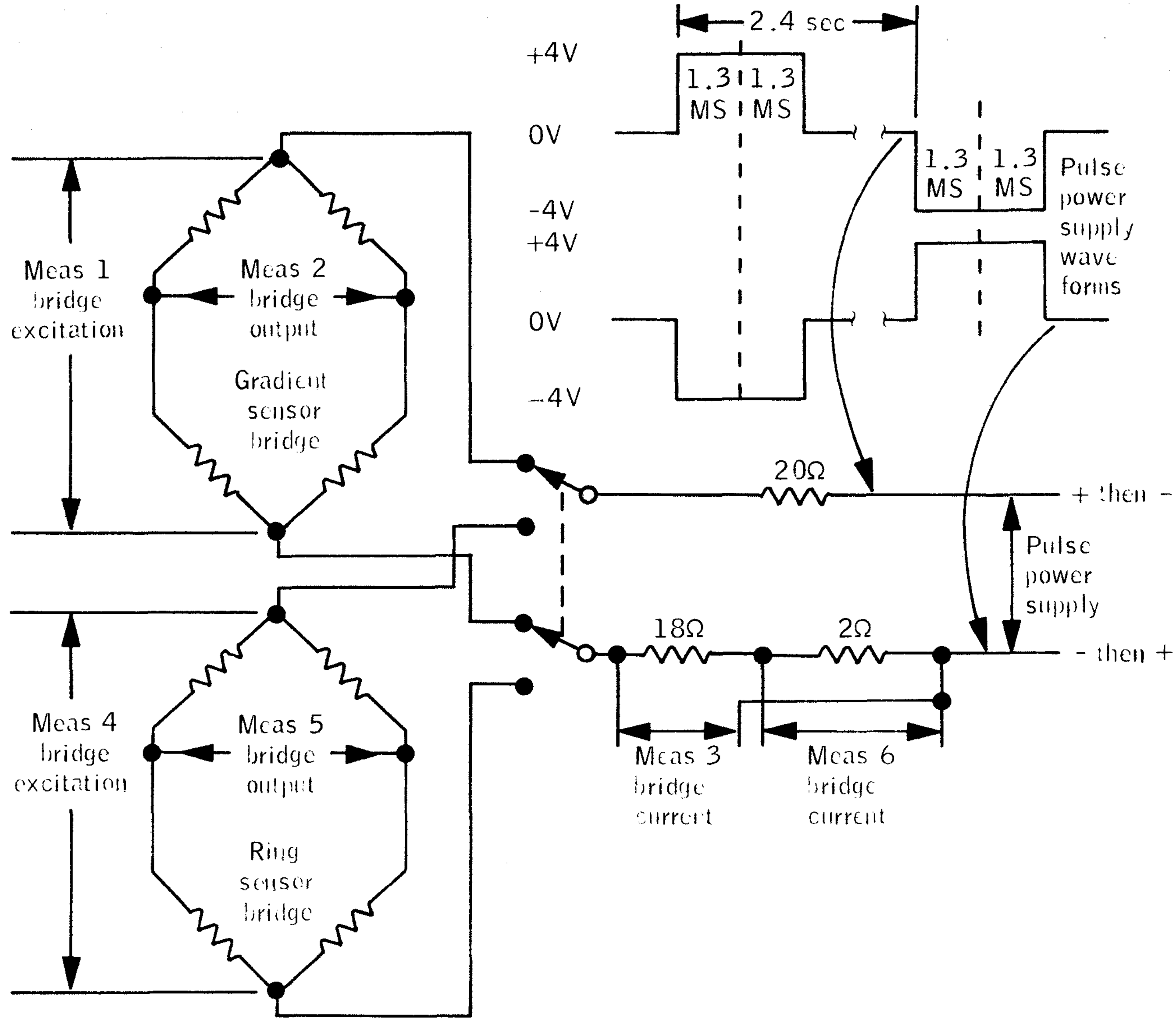

Figure 8-4. - Heat flow probe measurement sequences.

SIGNATURES	DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION MANNED SPACECRAFT CENTER · HOUSTON, TEXAS
DR	6/7/69	HEAT FLOW EXPERIMENT SCHEMATIC
DSGN	6/7/69	
QC	12-31-69	
ENGR	12-31-69	
APP	12-31-69	ALSEP 3 · SIZE J · DWG NO 8.1
FEC	1-2-70	
AUTH	1-2-70	38.25 X 121 · PAGE 8-8 · SHEET 1 OF 1

SECTION 9

PASSIVE SEISMIC EXPERIMENT (SO 31)

9.1 SYSTEM DESCRIPTION

The Passive Seismic Experiment (PSE) provides data on lunar seismic activity and the properties of the lunar interior. The PSE does this by monitoring the long-period, low-frequency and the short-period, high-frequency energy associated with lunar quakes as well as measuring the direction and the distance to the seismic epicenters.

Physically, the PSE consists of two parts, both included in one package. The long-period instrument, which contains three seismometers (one vertical and two horizontal, placed orthogonally to each other), measures long-period, low-frequency seismic energy with a period of 250 to 0.3 seconds. This instrument measures the distance and direction to a seismic quake, as well as the long-term tidal deformations of the moon. The short-period instrument functions as a velocity transducer which measures short-period (5 to .04 seconds), high-frequency (up to 25 cycles per second) seismic energy with very high sensitivity. The instrument consists of a moving-magnet mass built so that a transducer can measure the velocity of the magnet. The displacements and the velocity of these instruments are measured, amplified, and filtered in a series of electronic circuits which produce an output signal to the central station data processor.

When the PSE is deployed by the crew, it must be leveled to within ±5 degrees. Within the instrument case, the seismic elements are mounted on gimbals having leveling motors which can level from an initial tilt as great as 5 degrees. By using a combination of "coarse-level" sensors and the horizontal seismometers, the PSE can be leveled on command to within 3 arc seconds.

TABLE 9-I.- PRESET CONDITIONS

"Preset" is defined as the logic condition initialized by activation of the experiment.

Command	Function	Presets To	Lunar Deployment Condition
037	EXP 1 STBY SEL		EXP IN STBY
063	PSE/XY GAIN CH	-30db	
064	PSE/Z GAIN CH	-30db	
065	PSE/SP CAL CH	OFF	
066	PSE/LP CAL CH	OFF	
067	PSE/SP GAIN CH	-30db	
070	LVL MTRX ON/OFF	OFF	
071	LVL MTRY ON/OFF	OFF	
072	LVL MTRZ ON/OFF	OFF	
073	UNCAGE ARM/FIRE	CAGED	
074	LVL DIR POS/NEG	POS	
075	LVL SPEED HI/LO	LOW	
076	PSE T CTL CH	AUTO ON	
101	PSE FILT IN/OUT	OUT	
102	LVL SNSR IN/OUT	OUT	
103	PSE LVL MDE A/F	AUTO	

The PSE will normally be leveled using the AUTO leveling mode (refer to Table 9-I for the preset conditions) with the forced mode as a backup method. The coarse sensors (utilized only in the X and Y axes) will be commanded IN for the initial leveling sequence. The coarse sensors are effective in the AUTO mode only and provide the X- or Y-axis leveling motor drive signals when there exists an off level condition greater than 8 minutes of arc. At this point the axes' tidal outputs provide the leveling motor drive signals to control leveling to the final level condition.

TABLE 9-II.- LEVELING RATES

	X or Y	Z
FORCED MODE		
High Speed	152 to 305 μrad/sec	20 to 40 mgal/sec
Low Speed	5.1 to 17.7 μrad/sec	.67 to 2.34 mgal/sec
AUTOMATIC MODE		
Coarse Sensor In (off level >8 min of arc)	152 to 305 μrad/sec	No coarse sensor on Z-axis. Use forced mode.
Coarse Sensor Out (tidal output saturated)	3.8 to 7.6 μrad/sec	0.5 to 1.0 mgal/sec
Coarse Sensor Out (tidal data unsaturated)	0 to 3.8 μrad/sec	0 to 1.0 mgal/sec

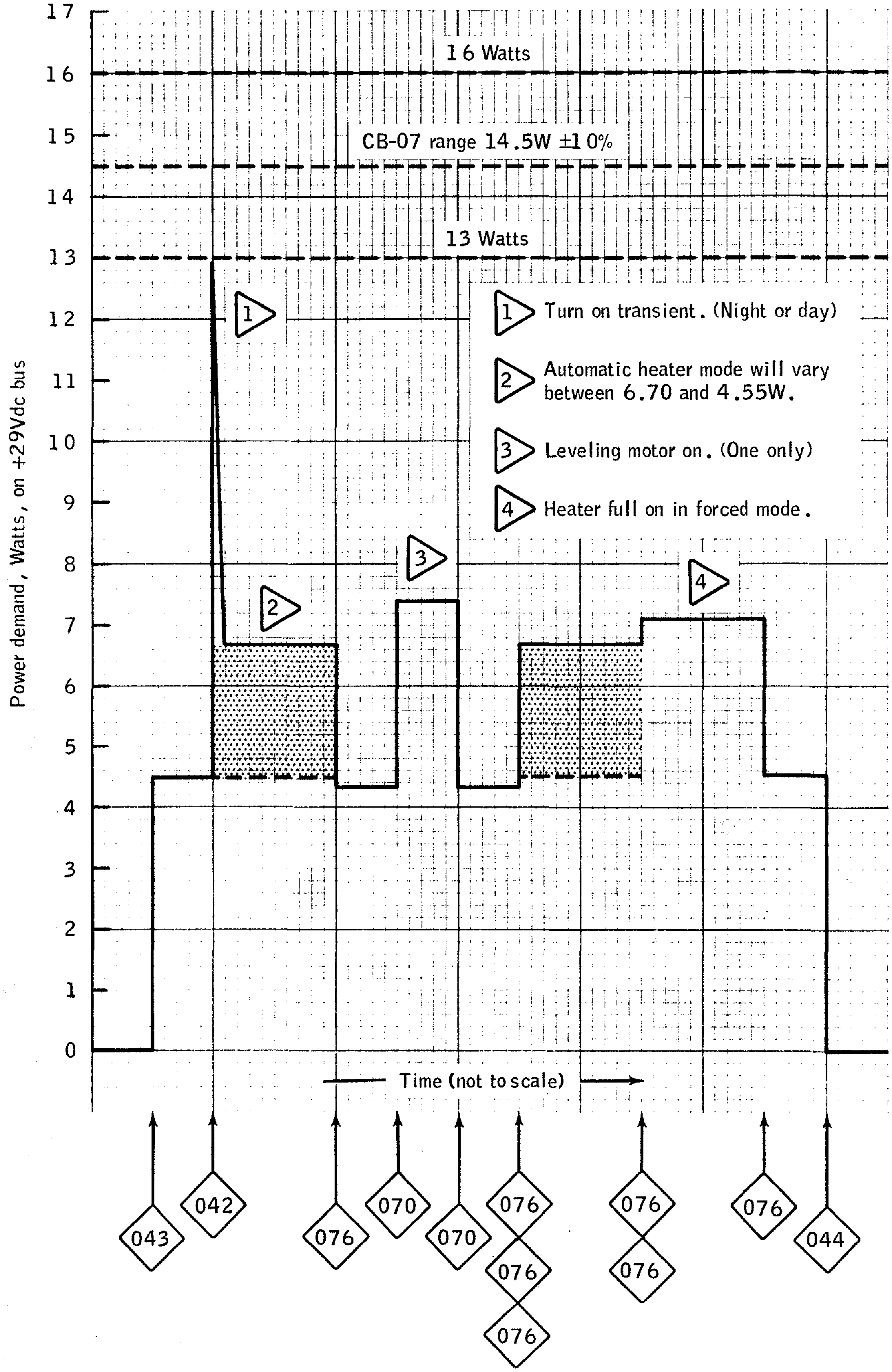

Figure 9-1.- PSE power profile.

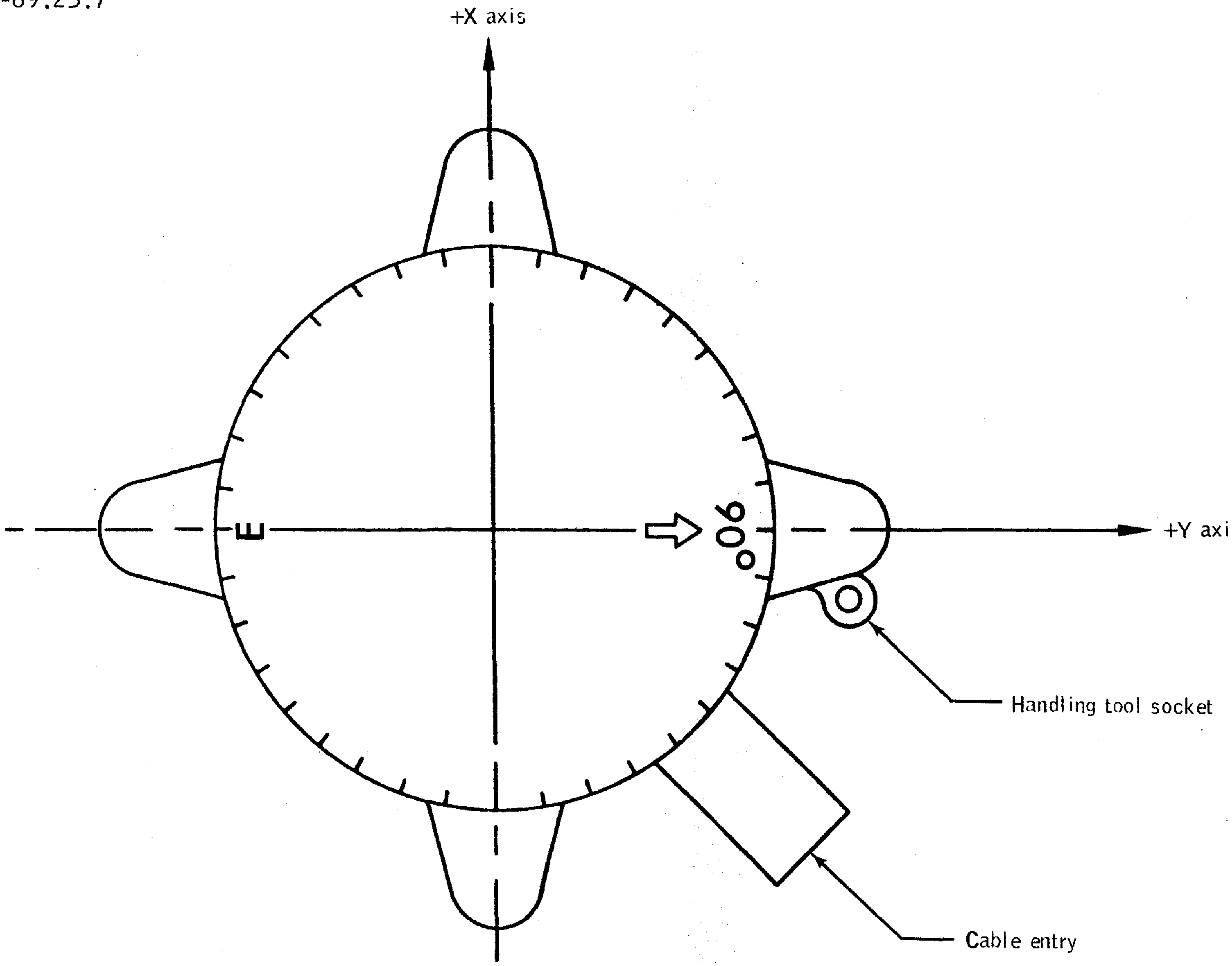

Figure 9-2. - Compass rose orientation.

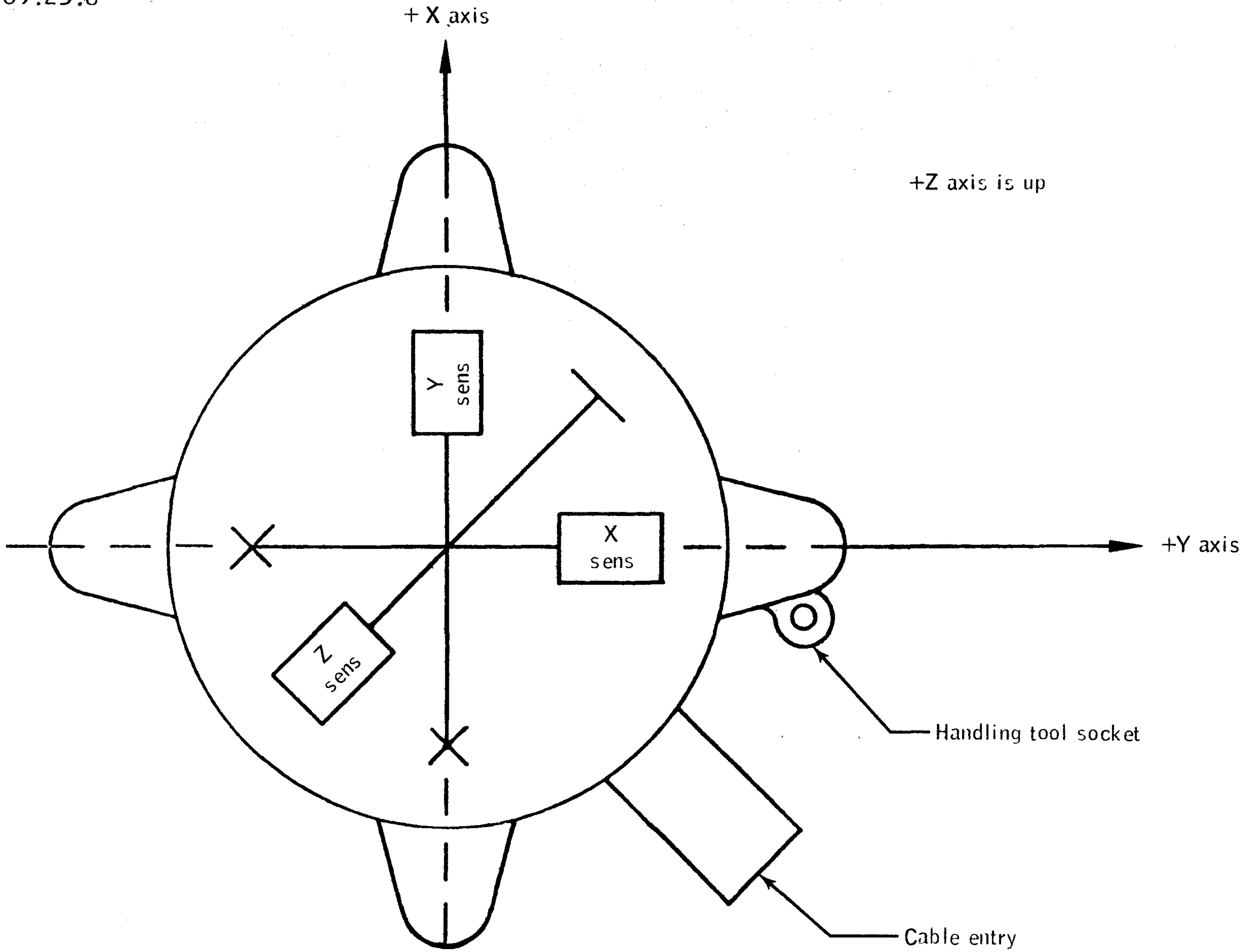

Figure 9-3. - PSE internal axes orientation.


LP HORIZONTAL (X, Y) SENSORS
TOP VIEW
LP VERTICAL (Z) SENSOR
LP X SENSOR
LP Y SENSOR
LP Z SENSOR
SENSOR CABLE
LP X DATA
TIDAL X DATA
X LP CAL
MOTOR DRIVE SIG
COARSE SNSR OUT
COARSE SNSR POWER
LP Y DATA
TIDAL Y DATA
Y LP CAL
LP Z DATA
TIDAL Z DATA
Z LP CAL
SP Z DATA
SP CALIB
UNCAGE CMD
LOW PASS FILTER
BI-DIR PULSE GEN
DIFF AMP
ANALOG MUX
DECODER LOGIC
FRAME POSITION FLIP-FLOPS
A/D CONVERTER
TRANSFER GATES
SHIFT REGISTER
TO CENTRAL STATION DIGITAL DATA PROCESSORS
TO CENTRAL STATION ANALOG MULTIPLEXER
POWER RESET BUS
STANDBY HEATERS
DC/DC CONVERTER
REF POWER SUPPLY
PART OF CMD DECODER
DELAYED CMD SEQUENCER
PART OF PDU
POWER SEQUENCER
EXP 1 STBY OFF
EXP 1 OPER SEL
EXP 1 STBY SEL
UNCAGE ARM/FIRE
"1" = HIGH = +5VDC
"0" = LOW = 0VDC
SIGNATURES
DATE
DR
DSGN
QC
ENGR
APP
FEC
AUTH
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER · HOUSTON, TEXAS
PSE SYSTEM SCHEMATIC
ALSEP 3
SIZE J
DWG NO 9.1
115.5 X 38.25
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SECTION 10

COLD CATHODE GAGE EXPERIMENT

10.1 SYSTEM DESCRIPTION

10.1.1 Experiment Objectives

The cold cathode gage experiment (CCGE) is comprised of the cold cathode ion gage (CCIG) and associated electronics (Figure 10-1). The purpose of the experiment is to measure the density of the lunar atmosphere. The CCGE will determine the density of any lunar ambient atmosphere, including any temporal variations either of a random character or associated with lunar local time or solar activity. In addition, the rate of loss of contaminants left in the landing area by the astronauts and lunar module (LM) will be measured.

10.1.2 Major Components

The cold cathode ion gage and the electronics make up the two basic sub-assemblies of the CCGE. The CCIG performs the required sensing while the electronics develops the scientific and engineering data measurements which are routed to the ALSEP central station data subsystem. The CCIG detects densities corresponding to pressures of 10^{-6} torr to approximately 10^{-12} torr. All numerical parameters are contingent upon known temperatures, anode voltages, and related magnetic/electrostatic field strengths. The normal gage accuracy (including reproducibility) is $\pm$ 30% above 10^{-10} torr and $\pm$ 50% below 10^{-10} torr. At 10^{-10} torr, the starting time for the gage does not exceed 45 minutes at 23°C in total darkness and while operating at rated voltages and related magnetic/electrostatic field strengths. Above 5×10^{-9} torr, the starting time will be instantaneous.

10.1.3 CCGE Operation

The cold cathode gage experiment is designed to sense the particle density of the lunar atmosphere immediately surrounding its deployed position. An electrical current proportional to particle density is produced in the gage. This current is amplified and converted into a 10-bit digital word and transmitted to ALSEP at a prescribed time in the ALSEP telemetry format.

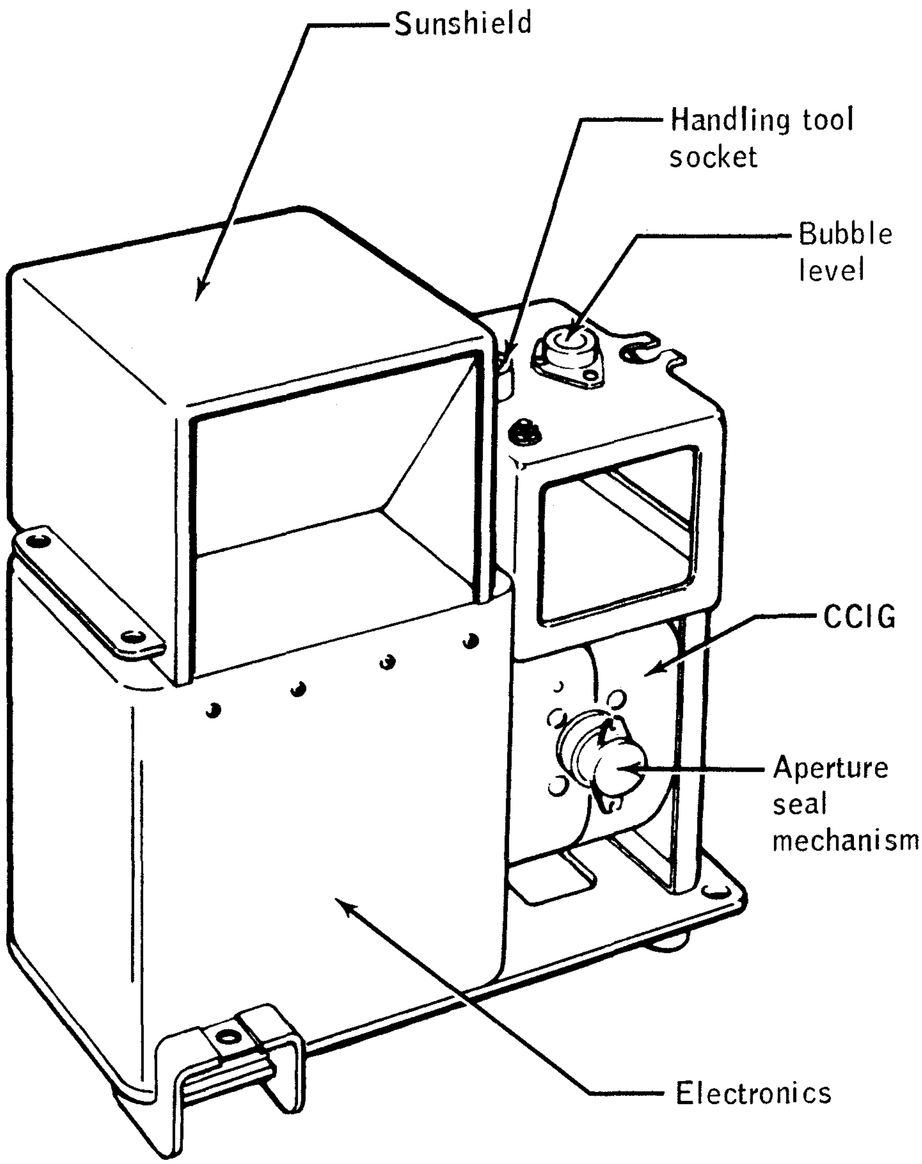


Figure 10-1. - CCGE experiment package.

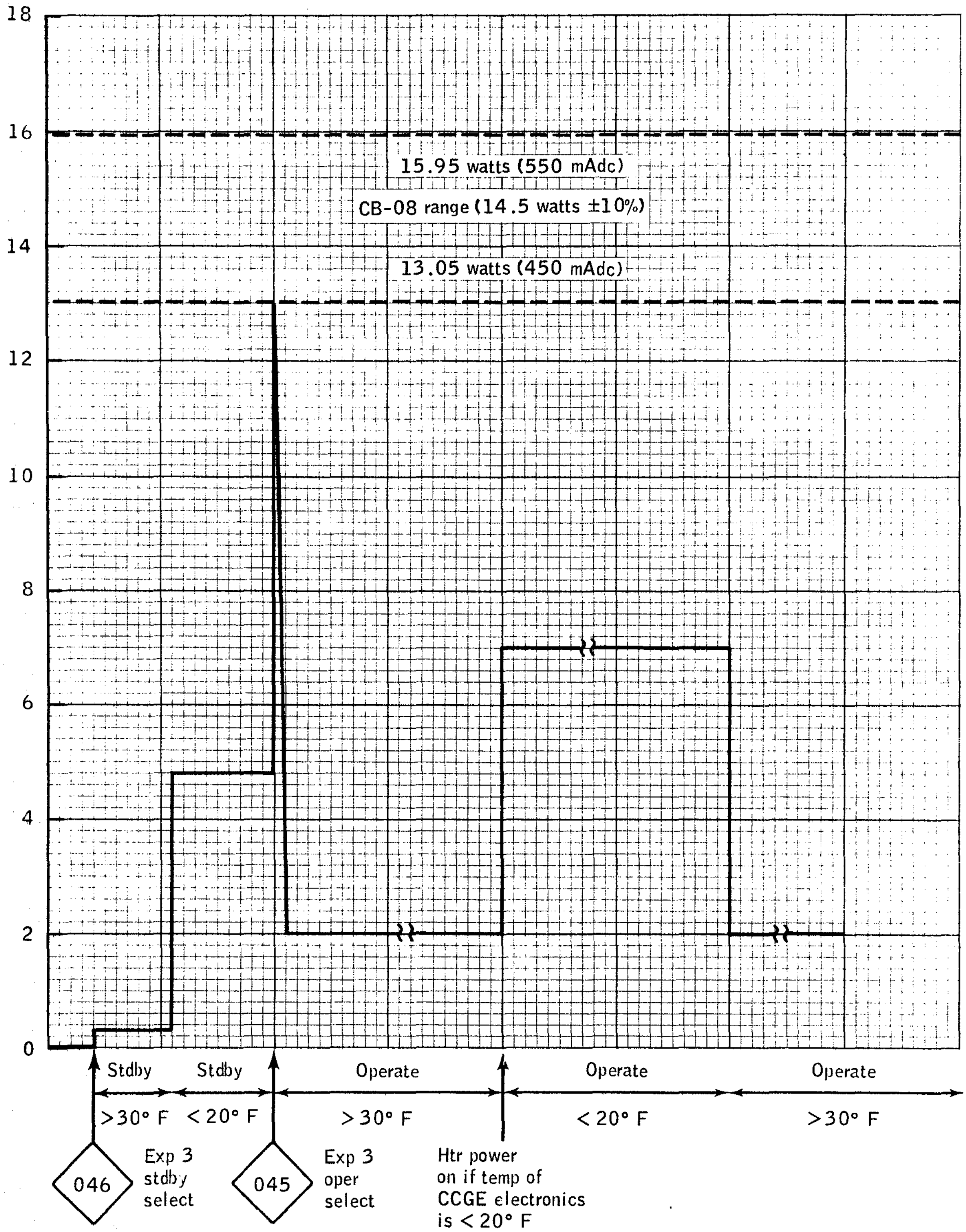


Figure 10-2. - CCGE power profile.

10.2 CCGE FUNCTIONAL DESCRIPTION

10.2.1 Major Functions

The CCGE is divided into four major functional elements: measurement function, timing and control function, command function, and data handling function (Figure 10-3). In addition, a power supply function provides power to all operational circuits and a thermal control function maintains thermal equilibrium of the experiment on the lunar surface.

10.2.2 Measurement Function

The measurement function is accomplished by the cold cathode ion gage (CCIG), the electrometer amplifier, and the gage temperature sensor. The lunar atmospheric particles are detected by the gage and amplified by the electrometer. In the automatic mode, the sensitivity of the electrometer is automatically controlled by the timing and control function. Seven ranges of sensitivity are available.

10.2.3 Timing and Control Function

The timing and control function provides range control signals to the measurement function and timing signals to the data handling function. The range sensitivity stepping of the electrometer amplifier is controlled by the timing and control function when the CCGE is in the automatic ranging mode of operation. The timing and control function also provides calibration timing to the measurement function. The function uses shift, frame-mark, and data-demand pulses from ALSEP to control its internal timing.

10.2.4 Command Function

A break seal command from the command function operates the aperture seal mechanism to remove the seal from the CCIG orifice and expose the CCIG to the lunar atmosphere. The seal is removed by an explosive-actuated piston releasing a spring which normally holds the seal over the aperture.

10.2.5 Thermal Control Function

A package temperature sensor automatically maintains the thermal integrity of the CCGE by controlling the power (on-off) to two heater strips.

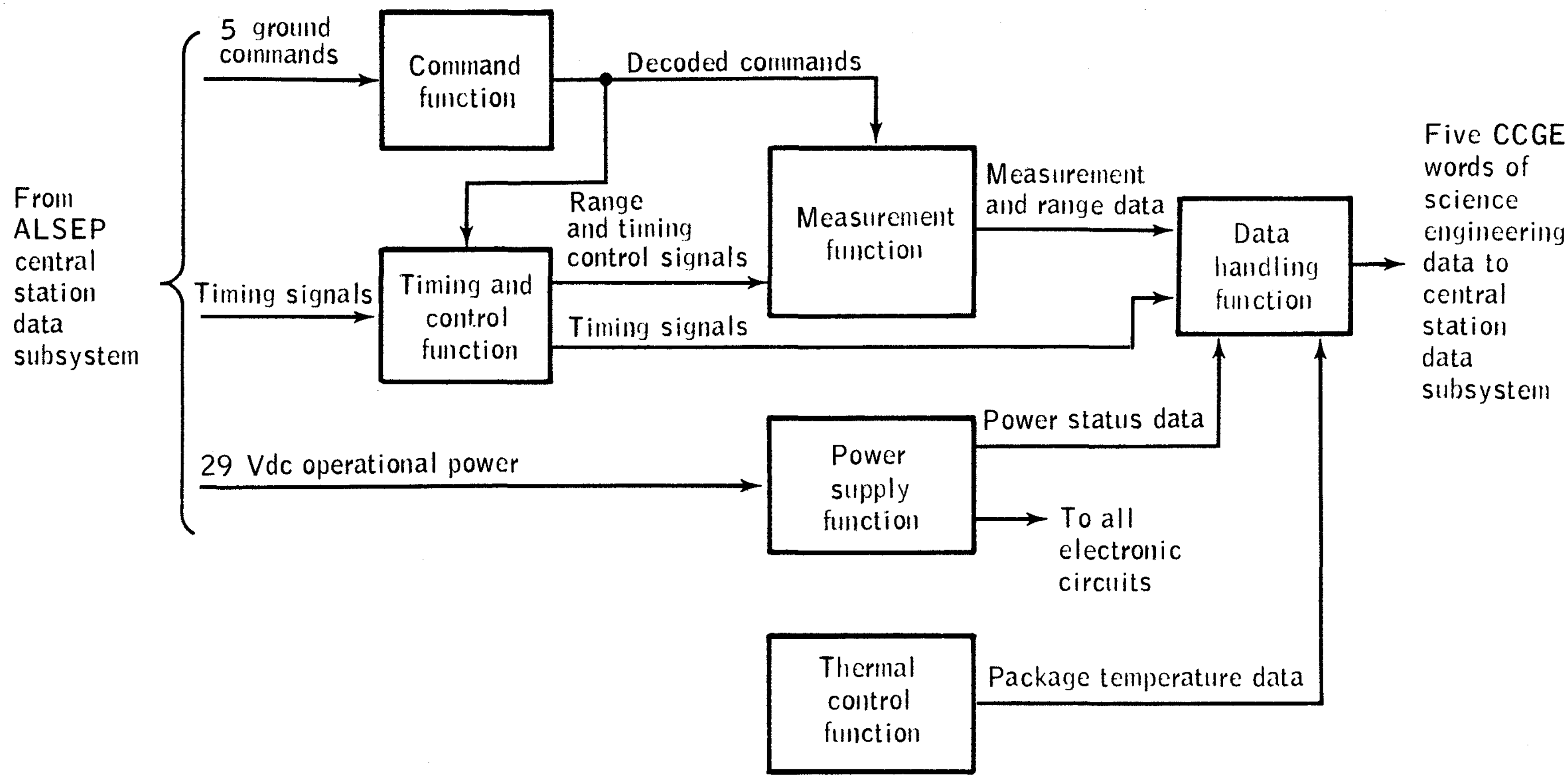


Figure 10-3.- Cold cathode gage experiment, functional block diagram.

To be supplied later.

DWG 10.1 COLD CATHODE GAGE EXPERIMENT SYSTEM SCHEMATIC

SECTION 11

CHARGED PARTICLE LUNAR ENVIRONMENT EXPERIMENT

11.1 SYSTEM DESCRIPTION

11.1.1 Experiment Objectives

The charged particle lunar environment experiment (CPLEE) measures the energy distribution, time variations, and direction of proton and electron fluxes at the lunar surface. The results of these measurements will provide information on a variety of particle phenomena.

11.1.2 Method of Operation

To study these phenomena, the CPLEE measures the energy of protons and electrons separately, and measures each in 18 different energy intervals. The CPLEE is capable of measuring particles with energies ranging from 40 ev to approximately 70 kev with flux levels of about 10^5 to 10^{10} particles per square centimeter/second/steradian. The CPLEE measures particles and, therefore, characteristics of the following solar radiation phenomena:

A. Solar wind electrons and protons (50 ev to 5 kev)
B. Thermalized solar wind electrons and protons (50 ev to 10 kev)
C. Magnetospheric tail particles (50 ev to 70 kev)
D. Low-energy solar cosmic rays (10 ev to 70 kev).

11.1.3 Major Components

The basic instrument of the CPLEE used to perform these measurements consists of two detector packages (analyzers) oriented in different directions for minimum exposure to the ecliptic path of the sun. Each detector package has six particle detectors. Five of these detectors provide information about particle energy distribution, while the sixth detector provides high sensitivity at low particle fluxes. Particles entering the detector package are deflected by an electrical field into one of the six detectors, depending on the energy and polarity of the particles. The CPLEE also includes electronics for recording the particle counts and providing data to the data subsystem.

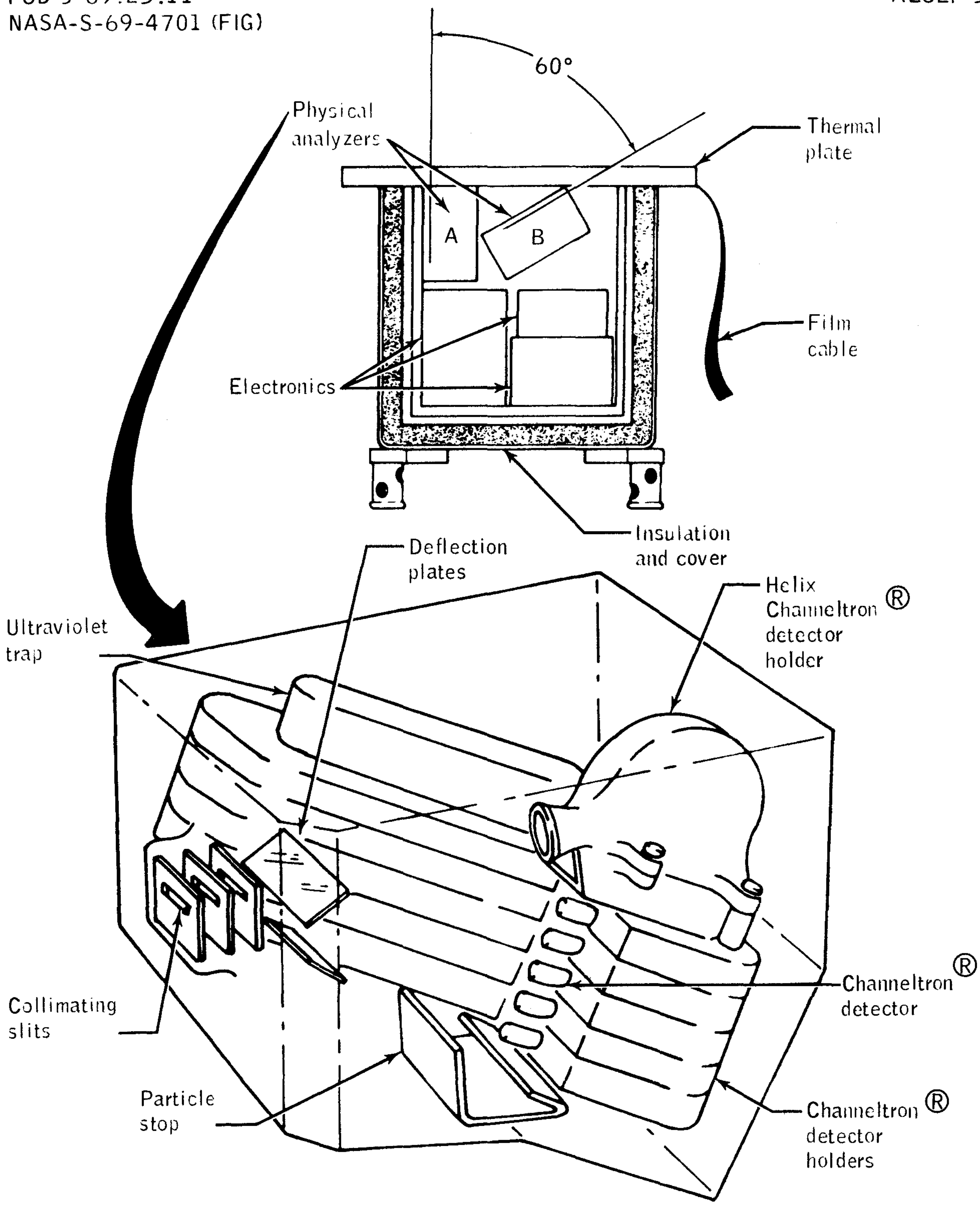
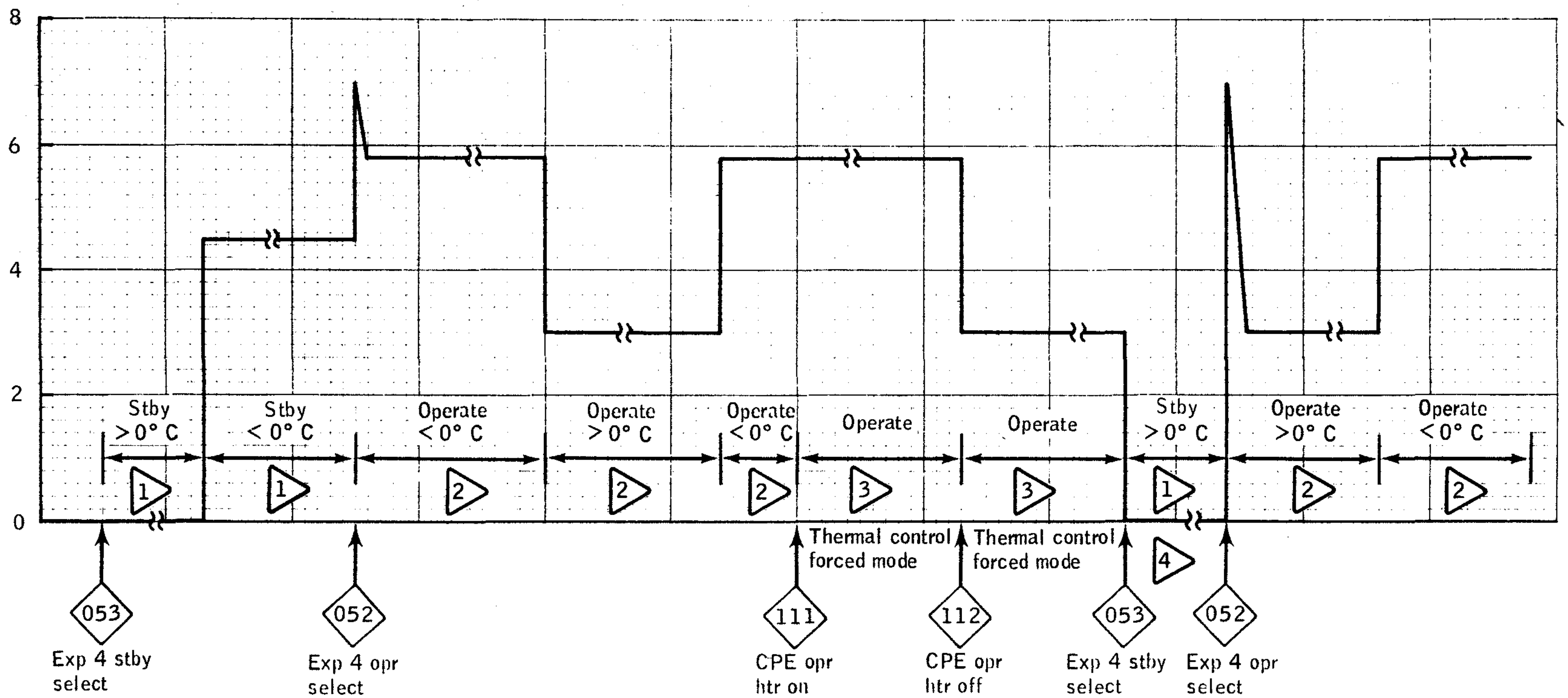


Figure 11-1. - CPLEE experiment.



1. CPE stby htr's are thermostatically controlled 0° C ± 10° C
2. At turnon CPE opr htr's are preset to thermostat control mode. 0° C ± 10° C
3. CPE opr htr's can be grnd commanded to a forced thermal control mode.
4. To return CPE to the auto thermal control mode, it is necessary to interrupt the 29V power. This is done by commanding CPE to stby (053) then back to operate (052)

Figure 11-2. - CPLEE power profile.

11.2 CPLEE FUNCTIONAL DESCRIPTION

11.2.1 Major Functions

The CPLEE has six major functions:

A. Charged particle detection

B. Particle discrimination and programing

C. Data handling

D. Power supply

E. Self-test

F. Environmental control.

11.2.2 Measurement Functions

The polarity and energy content of charged particles are measured in a programed sequence. These data are reported to data handling which converts them in a programed sequence to digital format compatible with the ALSEP telemetry frame. These digital data are stored until requested by the data subsystem for downlink transmission to earth.

11.2.3 Power Supply

The power supply provides high voltage to the deflection plates in the sensing function as programed high voltage to the twelve detectors in both physical analyzers, and low voltage to all the CPLEE electronic circuits.

11.2.4 Calibration

The CPLEE contains two provisions to self-test its own operation:

A. Beta radiation source for end-to-end testing before dust cover removal

B. Test oscillator for checking amplifiers and data processing electronics.

11.2.5 Environmental Control

Environmental control features include a dust cover, dust cover removal, and thermal control.

11.2.6 Command Function

Besides operational power commands (on-off-standby) the CPLEE responds to eight functional ground commands. Only one of these is absolutely necessary to its operation. This command is Dust Cover Removal. The other commands serve to increase the versatility of the unit. See Section 5 for an explanation of each command.

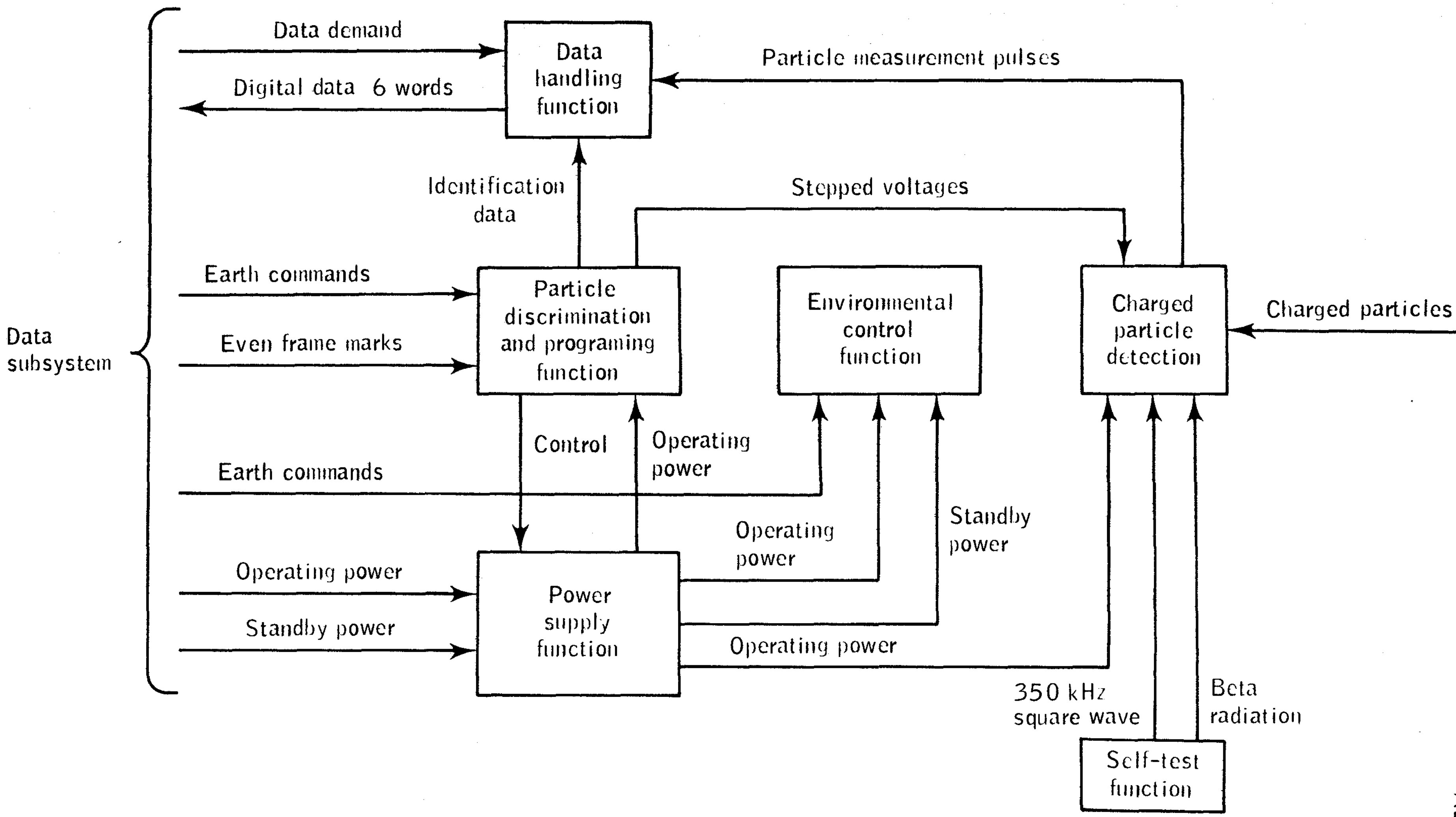


Figure 11-3. - CPLEE, functional block diagram.

VERTICAL ANALYZER A
COLLIMATING PLATES
DEFLECTION PLATES
HELIX
DETECTOR 1A OUTPUT
TO PREAMPS
60° ANALYZER "B"
COLLIMATING PLATES
DEFLECTION PLATES
CHANNELTRONS
+2.8 KVDC OR +3.2 KVDC
20 BIT COUNTER
20 BIT SHIFT REGISTER
ANALYZER INHIBIT
CAL OSC 550 KHZ
OSC ENABLE
OSC
TRANSFORMER
VOLTAGE MULTIPLIER AND FILTER
2.8 OR 3.2 KVDC
LOW VOLTAGE POWER SUPPLY
OPERATIONAL HEATERS
STANDBY HTRS
1.7 WATTS
2.8 WATTS
SERIAL DATA TO DIGITAL DATA PROC
DEMAND PULSE FROM DIGITAL DATA PROC
EVEN FRAME MARK FROM DIGITAL DATA PROC
SHIFT PULSES FROM DIGITAL DATA PROC
BUFFERED EVEN FRAME MARKS
BUFFERED SHIFT PULSES
TRANSFER COUNTER TO SHIFT REGISTER (GATED SHIFT PULSES)
ANALYZER SEQUENCING (GATED SHIFT PULSE)
ADVANCE DEFLECTION POWER SUPPLY
TOGGLE PROGRAMMER
RESET
POWER RESET
+3500 VOLT POWER SUPPLY
-3500 VOLT POWER SUPPLY
350 VOLT POWER SUPPLY
35 VOLT POWER SUPPLY
DUST COVER REMOVAL CIRCUIT
4 WATT TOTAL
TO AMPLEX MULTIPLEXER
CPLEE
ALSEP
CPE DEF STEP
CPE DEF STEP OFF
CPE DEF SEQ ON
CPE CHAN/HI SEL
CPE CHAN/LO SEL
CPE CVR GO
EXP 4 STBY SEL
EXP 4 OPER SEL
EXP 4 STBY OFF
EXPERIMENT POWER SEQUENCER
GATING LOGIC
DELAYED COMMAND SEQUENCER
COMMAND = 5V, INACTIVE STATE
COMMAND = 0V, ACTIVE STATE FOR 20 MSECS
LOGIC SHOWN IS NEGATIVE NOR
COMMON RELAY OPERATING VOLTAGE NETWORK SEE TABLE 4-VIII
CPLEE IS DESIGNED TO SURVIVE A TEMPERATURE RANGE OF -17° C TO +52° C WHILE IN AN OPERATIONAL MODE
CPLEE IS DESIGNED TO SURVIVE A TEMPERATURE RANGE OF -30°C TO +80° C WHILE IN A STANDBY MODE
WHERE SUPPLY VOLTAGES TO FUNCTIONAL BLOCKS ARE NOT SHOWN, +3VDC CAN BE ASSUMED
POWER RESET (CPLEE TURNON) INITIALIZES TO AUTOMATIC DEFLECTION VOLTAGE SEQUENCING, CHANNELTRON LOW SELECT AND THERMOSTATIC HEATER CONTROL
SYMBOL
OUTPUT
INPUT
NOTES:
THE ONLY METHOD TO RETURN THE CPLEE OPERATIONAL HEATERS TO THERMOSTATIC CONTROL IS TO COMMAND CPLEE TO STBY SEL (CMD 053) THEN RETURN TO OPER SEL (CMD 052)
SIGNATURES
DATE
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER · HOUSTON, TEXAS
CPLEE SYSTEMS SCHEMATIC
ALSEP 3
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SECTION 12

APOLLO LUNAR SURFACE DRILL

12.1 SYSTEM DESCRIPTION

12.1.1 Objectives

The Apollo lunar surface drill (ALSD) is used to provide a means for an astronaut to implant heat flow temperature probes below the lunar surface and to collect subsurface core material.

12.1.2 Drilling Principle

The drilling device which will be employed to produce the lunar subsurface holes is a hand-held, battery-powered, rotary-percussion drill. The rotary-percussion drilling principle was selected for this application for the following reasons:

A. The axial bit pressure and rotary torque requirements for efficient drilling are considerably less than that required for rotary drilling.

B. The drill bit operating temperatures are sufficiently low to preclude the requirement for a drill bit coolant such as air or water.

C. The tungsten-carbide bit cutters will drill with reasonable efficiency in the presence of a small dust layer in the bottom of the hole, a factor which is inherent with a mechanical cuttings transport system.

12.1.3 Operational Parameters

The ALSD is inherently capable of core drilling a 1.032-inch diameter hole in dense basalt (22,000 psi compressive strength) at a maximum rate of 2.5 inches per minute, or 43% porosity vesicular basalt at a maximum rate of 6 to 8 inches per minute, with an optimum applied axial bit pressure of 60 pounds. Under actual lunar surface drilling conditions, the maximum drilling penetration rate is degraded in proportion to the hole depth and available axial bit pressure which can be manually applied by the astronaut. For a hole depth of 1.5 meters and nominal astronaut applied axial bit pressure of 10 to 12 pounds, the dense and vesicular basalt penetration rates are reduced to 1 and 5 inches per minute respectively. Penetration rates in conglomerate or pumice type materials vary from 30 to 120 inches per minute.

12.1.4 Drilling Operation

Implanting the temperature probes requires drilling two holes to a maximum depth of 3 meters. The holes are cased to prevent cave-in and to facilitate insertion of the probes. Subsurface core material resulting from the drilling operation of the first hole will be removed from the drill string and discarded. The subsurface core material resulting from the second hole will be retained in the drill string and returned to earth in the sample return container.

12.1.5 Deployment

The ALSD is designed as a totally integrated system which interfaces with the ALSEP pallet located in the LM during transit from earth to the moon's surface. The drill and associated assemblies can be removed as a single package from the ALSEP pallet and transported by the astronaut to the selected drilling site for subsequent assembly and operation. (See Figure 12-1.)

FCD 7-69.23.14
NASA-S-69-4703 (FIG)

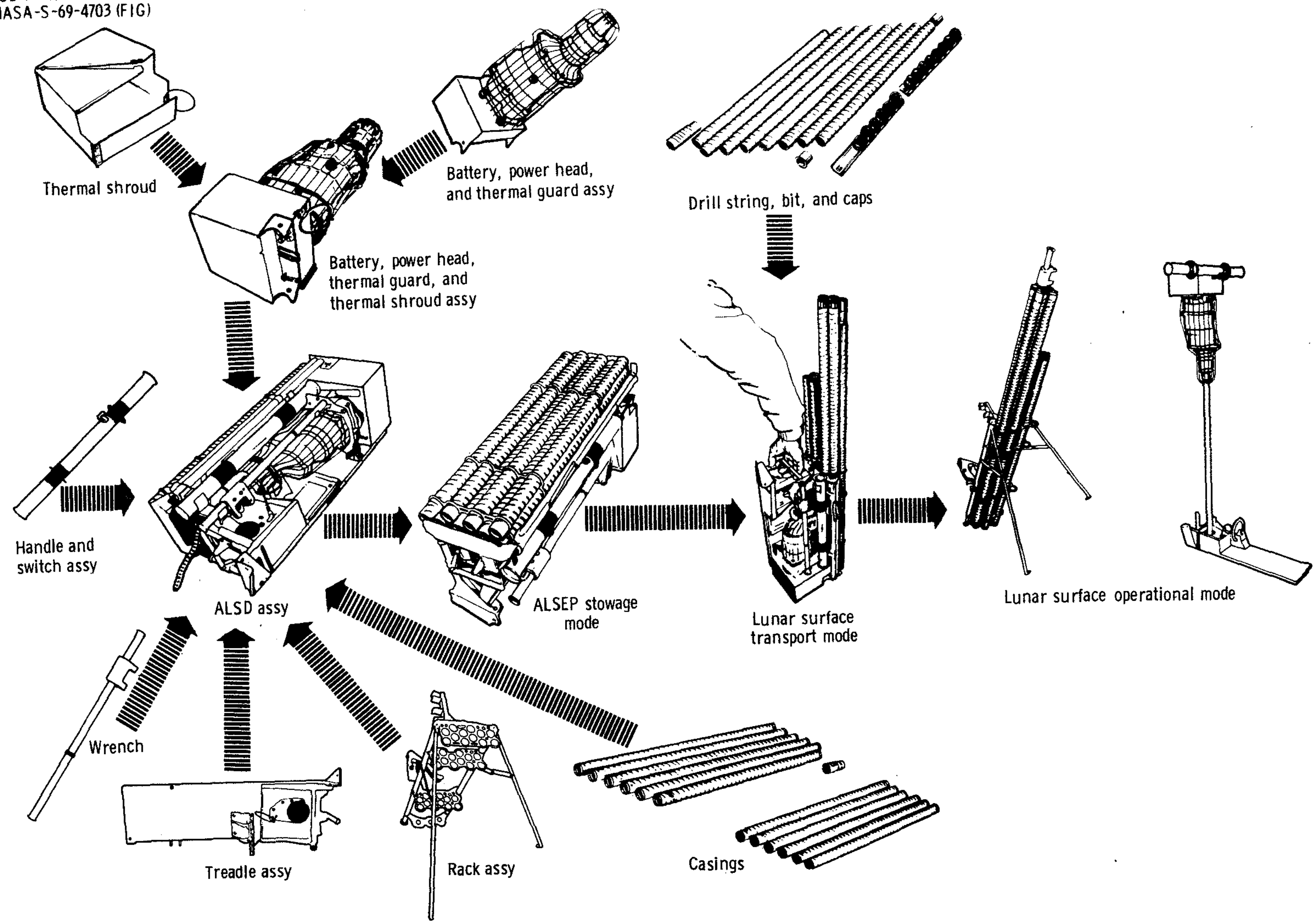


Figure 12-1. - ALSD assembly, stowage, and lunar operating sequence.

12.2 ALSD PHYSICAL DESCRIPTION

12.2.1 Major Elements

The ALSD is a hand-held battery-powered, rotary percussion drill consisting of four major elements: a battery pack, power head, drill string, and accessory group (Figure 12-1). Table 12-I provides leading particulars of the Apollo lunar surface drill.

12.2.2 Battery Pack

The battery pack provides the power necessary for the lunar surface drilling mission. The battery pack comprises a battery case, battery cells, power switch, thermal shroud, and handle assembly.

12.2.2.1 Battery case.- The battery case is a magnesium alloy enclosure with a pressure relief valve, electrical receptacle, and power switch. Integral with the case are brackets for securing the case to the power head and the portable handle assembly. The external surface of the case is coated for a high ratio of thermal emissivity-to-absorptivity to control the battery temperature profile during lunar surface operation. The case material shields the active circuit elements and conductors to contain potential electromagnetic interference.

12.2.2.2 Battery cells.- The battery has 16 individual cells and operates at a nominal output of 23 $\pm$ 1 volts dc at 18.75 amperes for 40 minutes. Each cell is constructed with a silver oxide primary and zinc secondary encased in a high temperature plastic. The battery cells are activated by filling each cell with an electrolyte during the prelaunch operations.

12.2.2.3 Power switch.- The power switch is a single-pole, single-throw, heavy-duty microswitch with a push-to-activate mechanism. The switch portion of the assembly is contained by the battery case with the push-to-activate mechanism protruding through the case for external operation.

12.2.2.4 Thermal shroud.- The thermal shroud, fabricated predominately from aluminum alloy sheeting, provides battery temperature compensation during temporary lunar stowage under the combined effects of minimum temperature (20 degrees F) and low sun angles (7 to 22 degrees) above the lunar horizon. The shroud will be removed from the ALSD at sun angles higher than 22 degrees above the horizon. Under all sun angle conditions, the shroud will be removed when the ALSD is used to perform the drilling mission. Removal is performed by pulling a release lanyard. The thermal shroud will always be installed on the battery case during the translunar portion of the mission and at specified sun angles when the ALSD is undergoing temporary lunar stowage.

12.2.2.5 Handle assembly.- The handle assembly provides the astronaut with a means of manual restraint and ALSD motor control. The handle assembly comprises the handle and the switch actuator assembly. The handle enables the astronaut to provide the rotary restraint and axial force required for drilling. The switch actuator assembly contains the fail-safe controls for operating the power head motor. The handle assembly is attached to the battery case by fixed and spring-loaded lock pins.

12.2.3 Power Head

The power head is self-contained within a housing which interfaces with the battery and drill string. The power head comprises a housing, motor armature, power train, clutch assembly, percussor, shock absorber, output spindle, pressurization system, and a thermal guard shield.

12.2.3.1 Housing.- The housing consists predominantly of three magnesium alloy castings mated together by externally sealed flanges threaded for socket head screws. The internal surfaces of the castings are impregnated with a polyester resin sealant to prevent leakage through the walls.

12.2.3.2 Motor armature.- The motor armature is a nominal 0.4 horsepower, brush-commutated, direct-current device employing as its field a permanent magnet. The armature is wound with copper wire protected by high temperature insulation. The motor possesses a peak efficiency of approximately 70% when operating at its nominal 9,300 rpm at an input voltage and current of 23 volts dc and 18.75 amperes, respectively. A reduction gear couples the output shaft of the motor armature to the power train.

12.2.3.3 Power train.- The power train consists of reduction gears which provide the proper rotational speeds for the percussor cam gear and output drive spindle of 2270 blows per minute and 280 revolutions per minute, respectively.

12.2.3.4 Clutch assembly.- The clutch assembly consists of a metal disc emplaced between two bronze discs. Friction between the discs is maintained by a preloaded spring. The clutch assembly is in series with the power train behind the final output drive gear. The clutch assembly limits the reactive torque load to a level which can be safely controlled by the astronaut.

12.2.3.5 Percussor.- The percussor converts the uniform rotary output motion of the power train into pulsating, high energy, short duration, linear impact blows which are delivered to the output spindle. This action is accomplished by a rotating cam riding against a spring-loaded cam follower which is an integral part of the percussor.

12.2.3.6 Shock absorber.- The shock absorber consists of a telescoping, titanium tube element (internal to and concentric with the percussor spring) restrained by the center housing. When the end of the shock absorber is impacted by the percussor hammer, the titanium tube elements extend under tension thus dissipating the percussor energy into heat.

12.2.3.7 Output spindle.- The output spindle contains a female double lead thread, one revolution per inch pitch, which mates interchangeably with any drill string extension tube and hole casing adapter. Visual rotation indicators are painted on the output spindle to serve as a positive means of determining drill string rotation.

12.2.3.8 Pressurization system.- The pressurization system maintains pressure integrity within the power head housing through the use of eight static seals, one linear bellows dynamic seal, and two rotary dynamic seals. The static seals are employed between the three housing sections, fron end section, and the various components such as the connector, pressure relief valve, and lubrication ports. The lubricated dynamic seals are employed with the output spindle. Internal pressure of the power head is controlled by a 10 ($\pm$ 1) psi relief valve.

12.2.3.9 Thermal guard shield.- The thermal guard shield consists of a wire cage mounted to the external surface of the power head. The shield is used to prevent damage to the astronaut's suit when accidentally brushing against the power head which may have a temperature exceeding +250°F.

12.2.4 Drill String

The drill string provides the cutting capability required for coring the hole in any lunar surface material which may be encountered ranging in hardness from dense basalt to unconsolidated conglomerate. The drill string is comprised of a core bit and eight extension tubes.

12.2.4.1 Core bit.- The core bit is composed of five tungsten-carbide tips which are brazed into a steel body and functions to provide the rock cutting capability of the drill string. Four helical flutes are machined into the outer diameter of the bit body. The flutes, or ramps, transport the rock cuttings from the face of the cutting tips upward to the double flute system of the extension tubes and subsequently to the surface. Coupling of the core bit to the extension tubes is accomplished by double acme-type male threads machined into the extension tubes and core bit.

12.2.4.2 Extension tubes.- The eight extension tubes provide the mechanical coupling to transmit the rotary-percussive energy from the power head output spindle to the core bit. During normal drilling operations, the extension tubes are added in groups of two as the depth of the hole increases until the full depth of three meters is attained.

12.2.5 ALSD Accessory Group

The accessory group comprises extension tube caps, hole casings, hole casing adapter, rack assembly, treadle assembly, and a wrench.

12.2.5.1 Extension tube caps.- The extension tube caps are fabricated from teflon and are installed on each end of the extension tubes after completion of second hole drilling. The caps prevent loss of core material from within the extensions during stowage in the sample return container (SRC) for the earth return flight.

12.2.5.2 Hole casings.- Hole casings are employed by the astronaut on the lunar surface when the hole is drilled in unconsolidated material which tends to cave in after retraction of the drill string. Twelve hole casing sections are required for the two 3-meter holes. The casings are fabricated from continuous filament, glass fabric, epoxy laminated tubes. The casings are assembled in groups of two and power driven into the pre-drilled hole with the power head. The first casing of each assembly incorporates a closed tip on its forward end which prevents entry of core material during the emplacement process. The continuous 0.875 inch inside diameter of the emplaced hole casing permits rapid insertion of the HFE probe.

12.2.5.3 Hole casing adapter.- The hole casing adapter, made of titanium with one end that mates with the hole casings and the other end mating with the power head, is used to sequentially couple the double sections to the power head during the casing emplacement process.

12.2.5.4 Rack assembly.- The rack assembly is made of magnesium alloy and provides basic restraint for the twelve hole casings, wrench, and handle assembly within the ALSD assembly stowage mode during the outbound translunar phase of the mission. On the lunar surface, the rack is deployed into a tripod configuration which provides vertical stowage for the core bit, extension tubes, and hole casings.

12.2.5.5 Treadle assembly.- The treadle assembly is primarily aluminum alloy sheeting and provides structural restraint for the rack assembly and battery power head assembly during outbound mission stowage on the ALSEP subpackage. On the lunar surface, the treadle assembly drill string locking feature is used in conjunction with the wrench for uncoupling extension tube joints during phases of the drilling operation.

12.2.5.6 Wrench.- The wrench is a multi-purpose tool employed to perform four functions:

A. To decouple emplaced extension tubes in conjunction with the treadle assembly.
B. To aid in retracting the emplaced drill string after completion of hole drilling.
C. To assist in removing core material from the extension tubes.
D. To aid in retrieving objects from surface level (e.g., extension tubes, treadle assembly).

TABLE 12-I.- ALSD LEADING PARTICULARS

Characteristic	Value
Battery Assembly	
Silver-zinc cells	16 cells
Open circuit voltage	29.6 ± 0.5 Vdc
Operating voltage	23.0 ± 1 Vdc
Nominal operating current	18.75 amperes
Nominal power capacity	300 watt-hours
Activated storage life	30 days
Recharge capability	3 cycles
Dry storage life	2 years
Electrolyte	40% potassium hydroxide
Cell pressure	8 ± 3 psig
ECS (case) pressure	5 ± 0.5 psig
Weight	7.24 pounds
Power Head	
Motor	
Operating voltage	23.0 ± 1 Vdc
Load speed	9300 rpm
Load current	18.75 amperes
Efficiency	70%
Percussor	
Blow rate	2270 bpm
Energy per blow	39 inch-pounds
Spring energy	240 pounds/inch
Effective hammer weight	0.661 pounds
Hammer velocity	213 inches/second
Power Train	
Motor-to-cam ratio	4.1
Motor-to-drive shaft ratio	33.1
Drive shaft speed	280 rpm
Blows per bit revolution	8.1
Weight	8.37 pounds
Drill String Assembly	
Integrated length	126 inches
Extension tube length	16.75 inches
Drill bit	
Cutting diameter	1.032 inch
Body outside diameter	1.00 inch
Body inside diameter	0.802 inch
Length	2.5 inches
Number of carbide cutters	5
Inside cutting (core) diameter	0.572 inch
Weight	3.49 pounds
Hole Casing Sleeve (12)	
Wall Thickness	0.025 inch
Length	22 inches
Nominal diameter	1.0 inch

12.3 ALSD FUNCTIONAL DESCRIPTION

12.3.1 Battery/Power Head Operation

12.3.1.1 Battery to power train.- Power is supplied from the 16-cell silver oxide-zinc battery to the power head motor (Figure 12-2) at 23 Vdc. The nominal speed of the motor armature is 9300 rpm. A reduction gear couples the output shaft of the motor to the power train which consists of the necessary reduction gears to provide the desired rotary motion and percussive action: 280 rpm at 2,270 blows per minute at the output shaft.

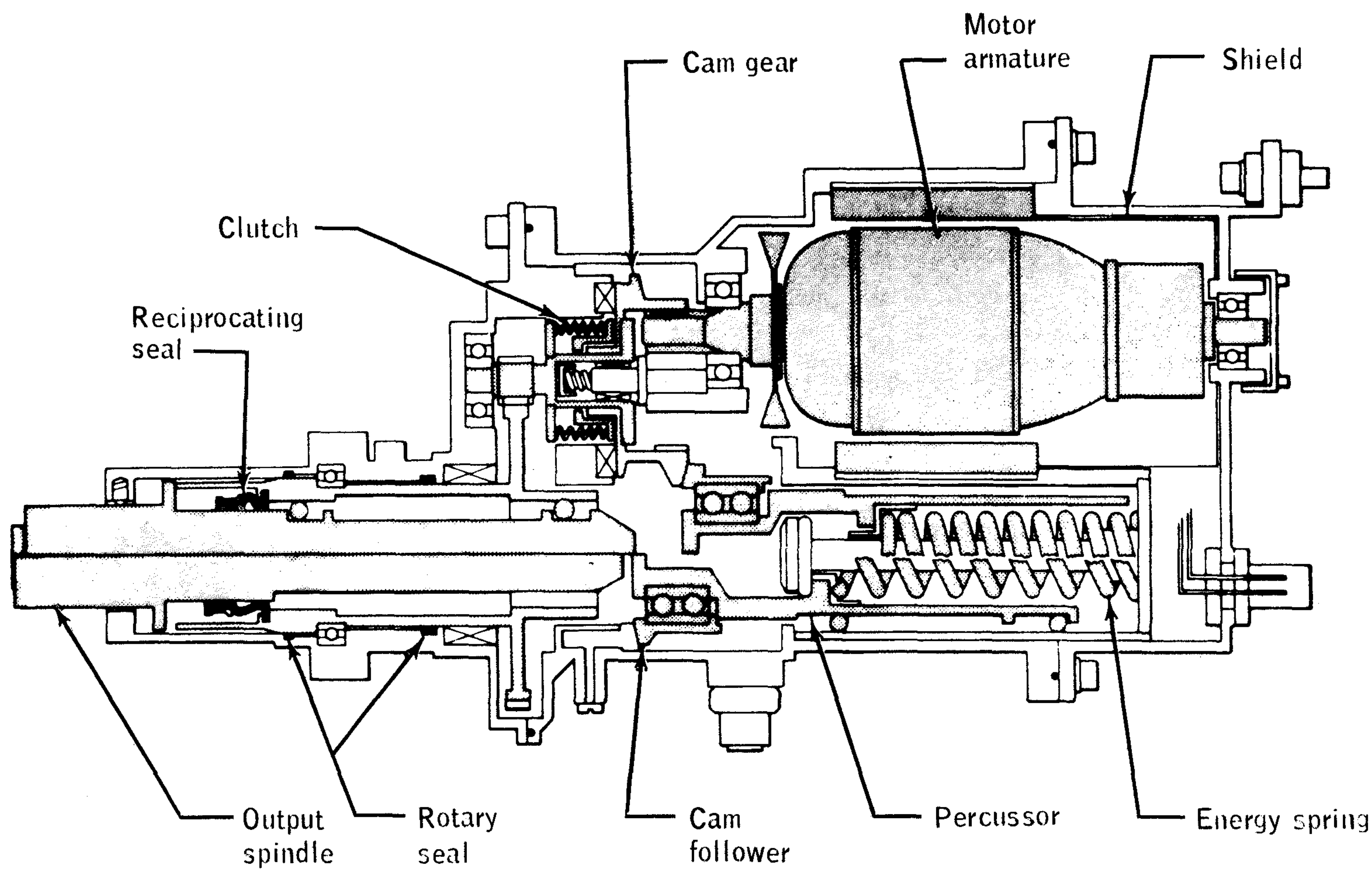
12.3.1.2 Power train to percussor.- The interface between the power train and the percussor is provided by the clutch. The clutch limits the torque load to a level which can be safely controlled by the astronaut. (The clutch is designed for a nominal slip value of 20 foot-pounds.)

12.3.1.3 Percussor to drill string.- The percussor converts the uniform rotary output motion of the power train into pulsating, high-energy, short-duration, linear-impact blows to the output shaft of the power head. The impact action is accomplished by a rotating cam against a cam follower which also serves as the hammer. As the cam rotates, the follower raises, cocking a spring. The spring, by virtue of the cam shape, releases its kinetic energy rapidly thereby accelerating the hammer toward a transition section. This transition section, or power head shaft, serves as the anvil for the hammer and as the receiver for the rotary motion output of the power train.

12.3.2 Drill String Operation

12.3.2.1 Drilling.- The rotary-percussive energy at the output of the power head is coupled to the core bit by the drill string. The drill string operates through the treadle assembly which employs a locking mechanism insuring positive energy coupling to the core bit. The core bit delivers the rotary-percussive energy to the rock. The percussive element of the input energy fractures the rock by exceeding its compressive strength under each cutting tip. The rotary element of the input energy repositions the cutting tips for subsequent rock fracturing and provides the means for transporting the rock cuttings upward to the surface via the helical transport flutes.

12.3.2.2 Core storage.- The drill string stores the core material cuttings. After the second hole is completed, the drill string is dissassembled, capped, and installed into the sample return container (SRC) for eventual return to earth of lunar core material samples.



Note: Percussor and spindle shown in both fully retracted and fully extended positions.

Figure 12-2. - ALSD, power head, simplified cutaway view.

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