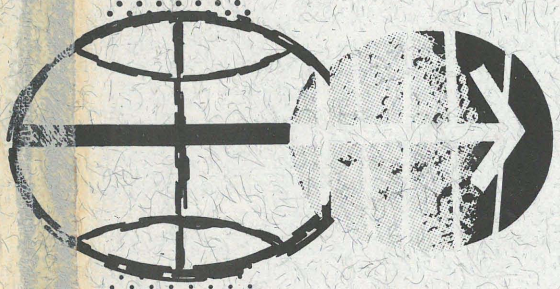
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Apollo Lunar Surface Experiments Package

ALSEP Training Handout
Apollo 16 Crew Briefing

November 1971

Contract NAS9-5829



MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

Apollo Lunar Surface Experiments Package

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BSR 3238

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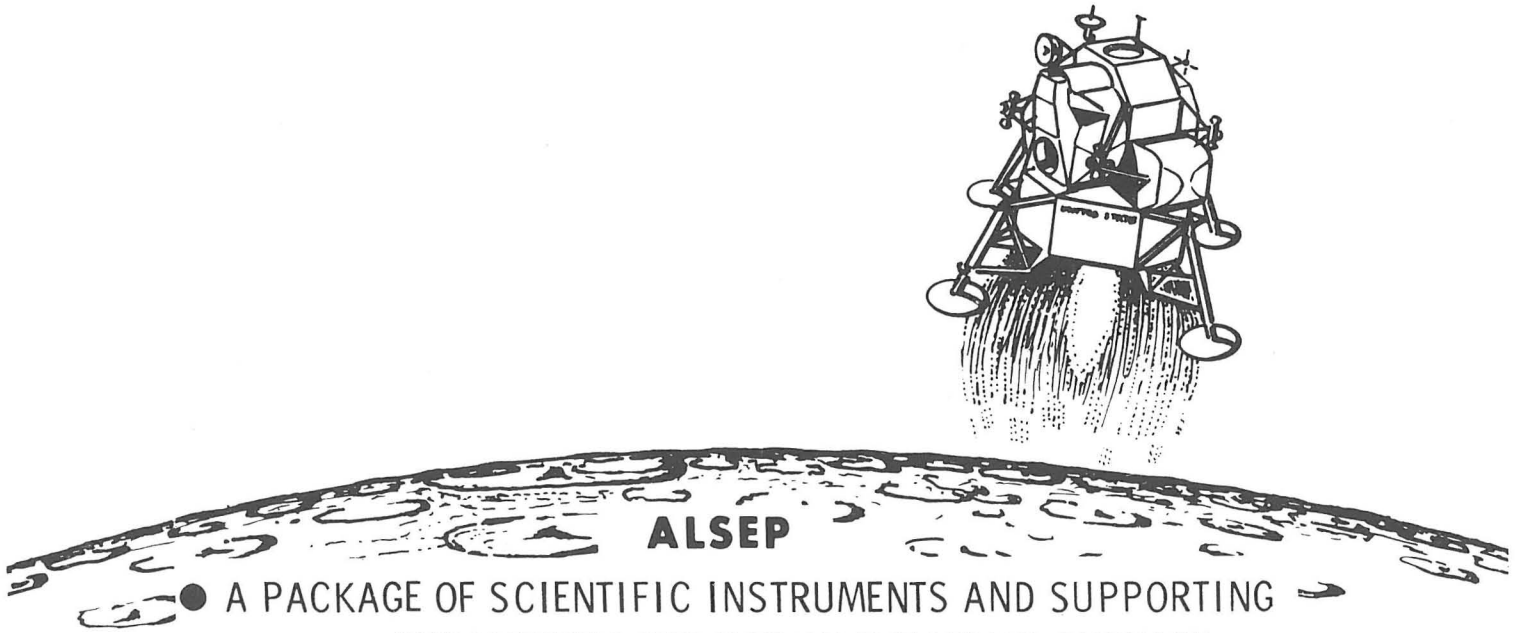
APOLLO LUNAR SURFACE EXPERIMENTS PACKAGE



- A PACKAGE OF SCIENTIFIC INSTRUMENTS AND SUPPORTING SUBSYSTEMS FOR USE ON THE LUNAR SURFACE
- CARRIED ON APOLLO, DEPLOYED BY ASTRONAUT
- ONE YEAR CONTINUOUS OPERATION (2 YEAR MAXIMUM)

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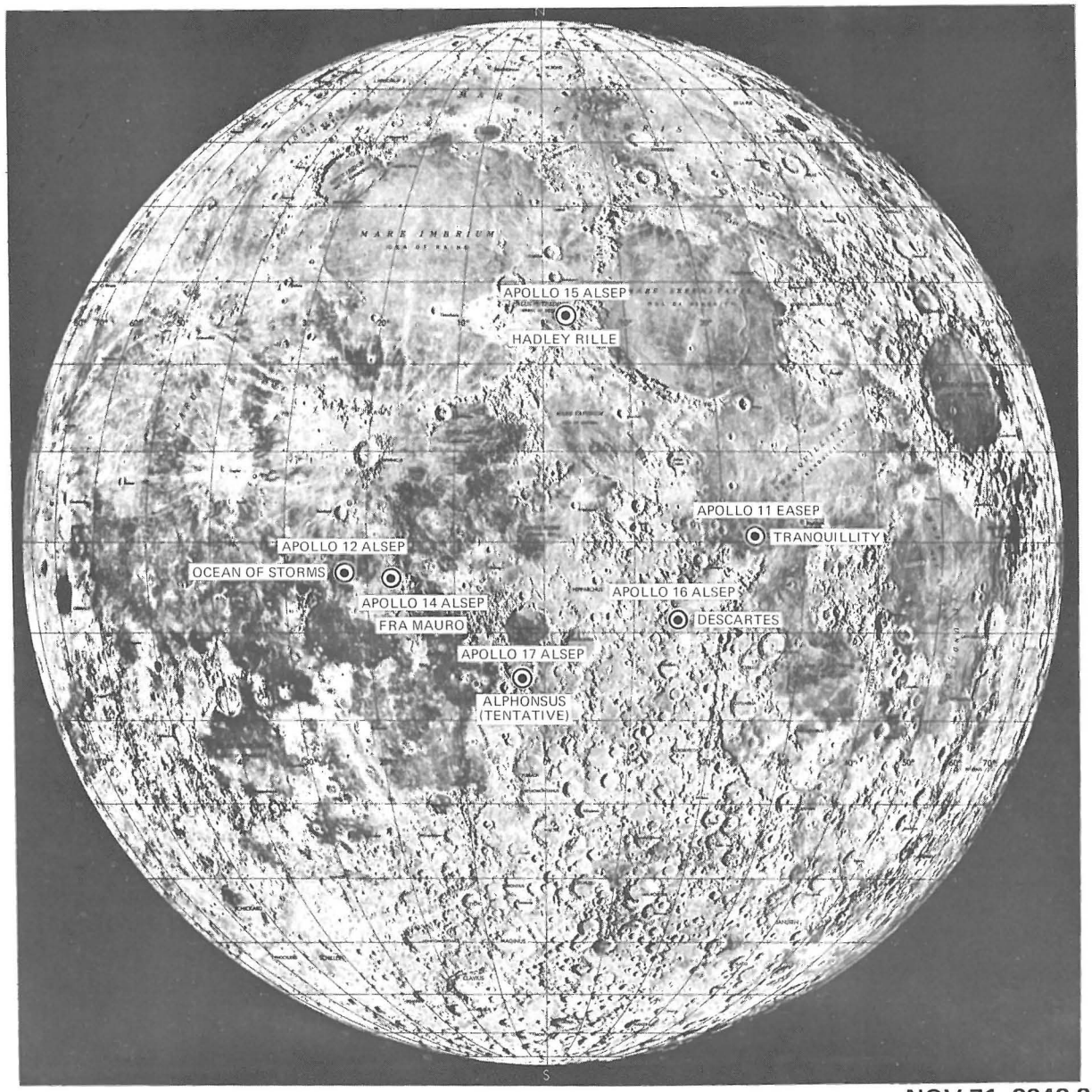
ALSEP LOCATIONS ON MOON



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MISSION ASSIGNMENTS

ALSEP EXPERIMENT	APOLLO / LOCATION	11 23.4°E 0.7°N	12 23.5°W 3.0°S	13	14 17.5°W 3.7°S	15 3.7°E 26.1°N	16 15.5°E 8.9°S	17 *4.1°W 13.9°S
PASSIVE SEISMIC EXPERIMENT		●	●	●	●	●	●	
ACTIVE SEISMIC EXPERIMENT					●		●	
SUPRATHERMAL ION DETECTOR			●		●	●		
COLD-CATHODE ION GAGE			●	●	●	●		
SOLAR WIND SPECTROMETER			●			●		
CHARGED-PARTICLE EXPERIMENT				●	●			
LUNAR SURFACE MAGNETOMETER			●			●	●	
HEAT FLOW EXPERIMENT				●		●	●	
LASER-RANGING RETRO-REFLECTOR		●			●	●		

SECOND GENERATION

*TENTATIVE

CREW INTERFACE

WITH ARRAY D ALSEP OPERATIONS

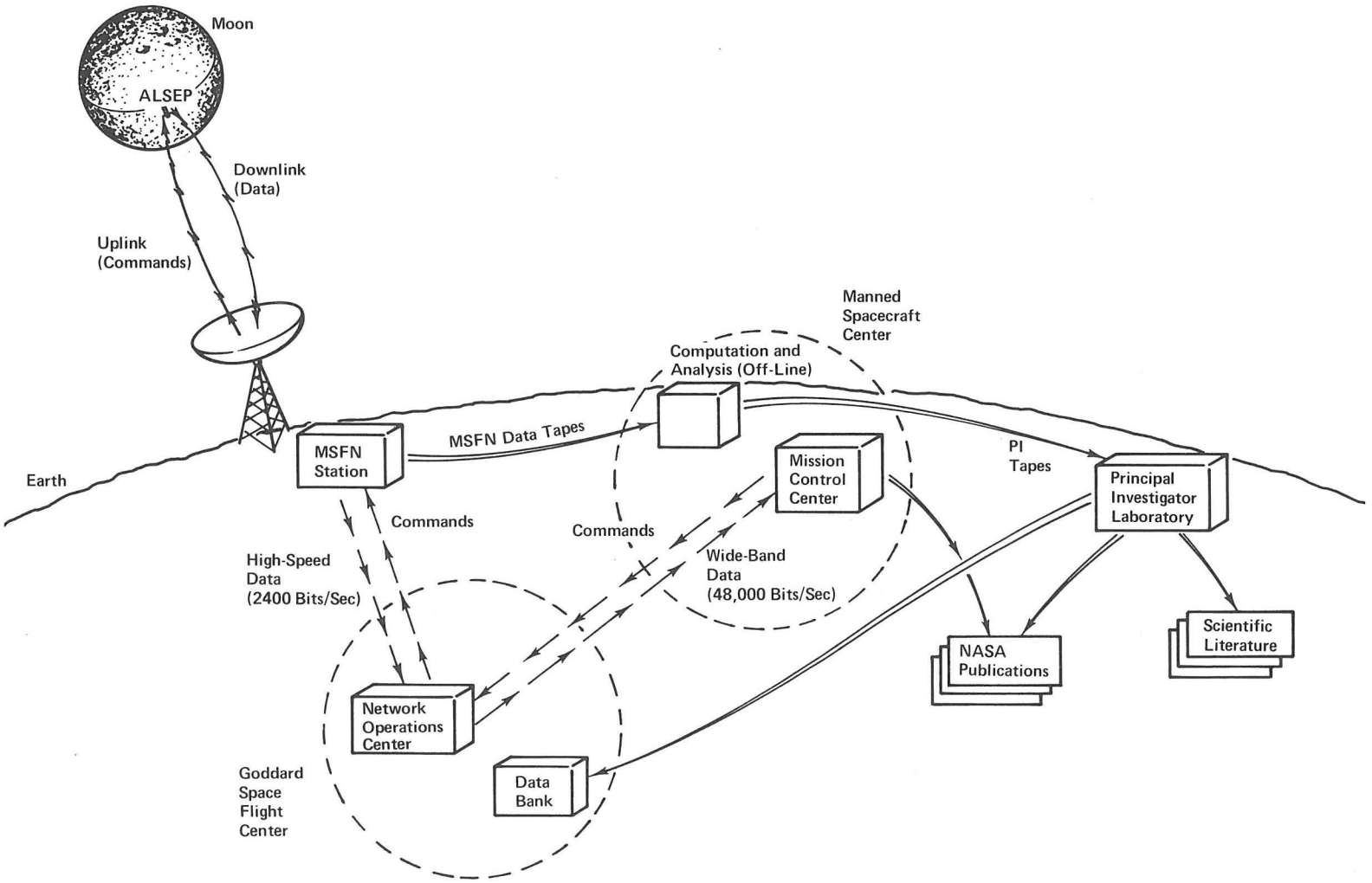
- EARTH/MOON COMMUNICATIONS

- ALSEP ANTENNA POINTING CONSTRAINTS

- OPERATIONAL EFFECTS OF ASTRO SWITCH 5

NOV 71 8948.5

EARTH-MOON COMMUNICATIONS



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ANTENNA POINTING CONSTRAINTS

LUNAR LIBRATION: AN APPARENT WOBBLING MOTION AS VIEWED FROM THE EARTH; CAUSES EQUIVALENT EARTH MOTION IN LUNAR COORDINATES

PRINCIPAL EFFECTS:

± 7.5° LUNAR LONGITUDE DUE TO:

CONSTANT ANGULAR RATE OF MOON ABOUT ITS AXIS

VARIABLE ANGULAR RATE IN ELLIPTICAL ORBIT AROUND EARTH

± 6.5° LUNAR LATITUDE DUE TO:

INCLINATION OF MOON'S ROTATION AXIS TO ITS ORBITAL PLANE

SECONDARY EFFECTS:

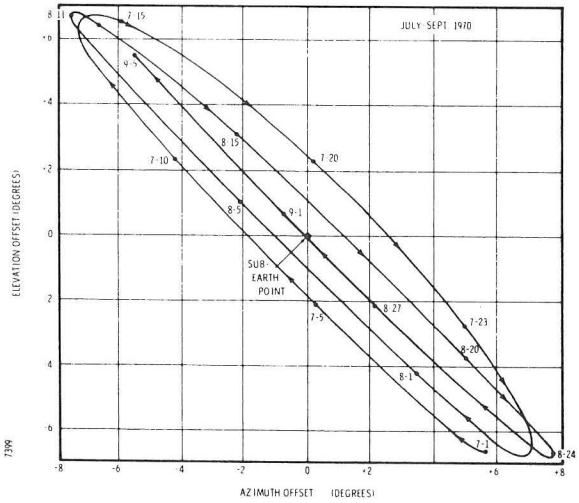
NON-SPHERICAL EARTH & MOON

SOLAR PERTURBATIONS

GYROSCOPE & PENDULUM COUPLING

COMBINED EFFECTS: PATTERN CHANGES MONTHLY & YEARLY

ALSEP ANTENNA: 22° BEAM WIDTH DOWN 4.2 db AIMED AT MEAN CENTER OF PATTERN



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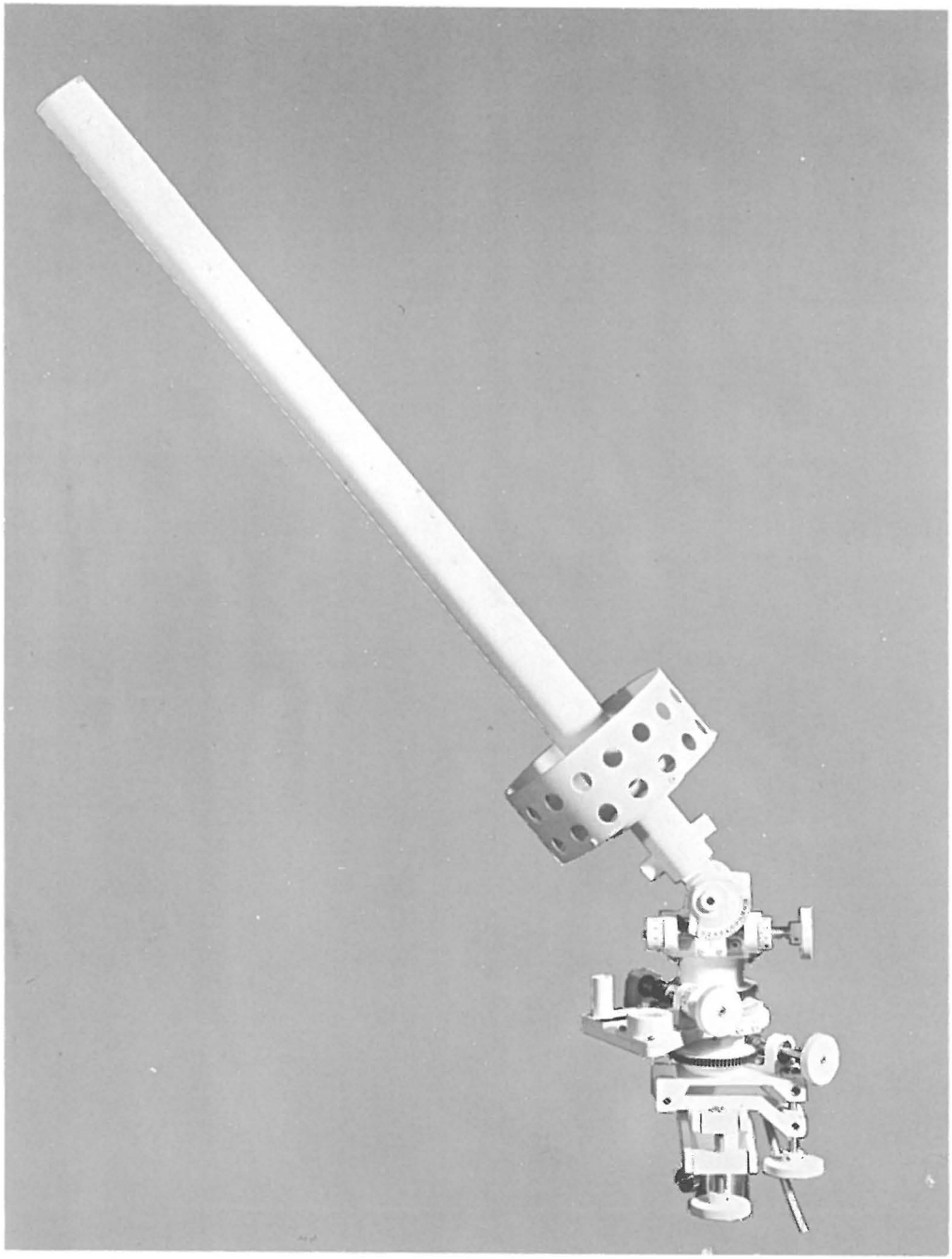

ANTENNA AND AIMING MECHANISM

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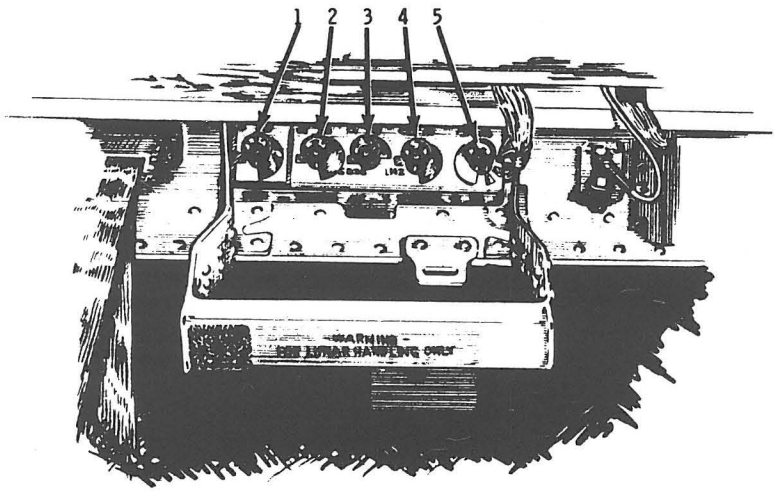
ASTRONAUT SWITCHES



SWITCH NUMBER	INITIAL POSITION	ASTRONAUT	FUNCTION
1	SEE NOTE 1 CCW ORANGE CRESCENT TO RIGHT	ROTATE 180° CW (COVER RECTANGLE)	DISABLES THE HOLD OFF CIRCUIT MUST BE OPERATED BY THE ASTRONAUT
2	CCW ORANGE CRESCENT TO RIGHT	ROTATE 180° CW (COVER RECTANGLE)	BACKUP ONLY * SELECT XMTR B "ON" * SELECT DATA PROCESSOR Y "ON"
3	CCW ORANGE FLAG TO UPPER RIGHT	ROTATE 270° CW (ORANGE FLAG TO UPPER LEFT	BACKUP ONLY SEQUENTIALLY ACTIVATES EXPS IN 1, 4, 3 ORDER TO OPER SELECT
4	CCW ORANGE CRESCENT TO RIGHT	ROTATE 180° CW (COVER RECTANGLE)	BACKUP ONLY * ACTIVATE ASE OPER SELECT * SWITCH DATA PROCESSOR TO ASE HBR ON
5	CW UNPAINTED CRESCENT TO LEFT	ROTATE 180° CCW COVER ALL FOUR TRIANGULAR SHAPES	MUST BE CCW TO OPERATE ASE (SEE NOTE 2) * ACTIVATE ASE STBY SELECT * SWITCH DATA PROCESSOR TO ASE HBR OFF * 1. CLOSE ASE 29V OPER LINE IN CCW POSITION * 2. OPEN ASE 29V OPER LINE IN CW POSITION

NOTE: 1. SWITCH 1 IS ENCLOSED BY ORANGE PAINT
2. SEQUENCE REQUIRED TO PLACE ASE IN OPERATE: ROTATE S5 FULL CCW; EITHER REQUEST ASE GND CMDS OR ROTATE S4 IN EITHER DIRECTION.

CREW INTERFACE

WITH ARRAY D ALSEP ENGINEERING FUNCTIONS

- CONSTRUCTING THE LUNAR LABORATORY

- ALSEP POWER SUPPLY
  - POWER SOURCE
  - POWER CONNECTION
  - POWER TURN-ON

- ALSEP COMMUNICATION CENTER
  - CONFIGURATION
  - THERMAL CONSTRAINTS
  - CONTINGENCY CONTROL SWITCHES

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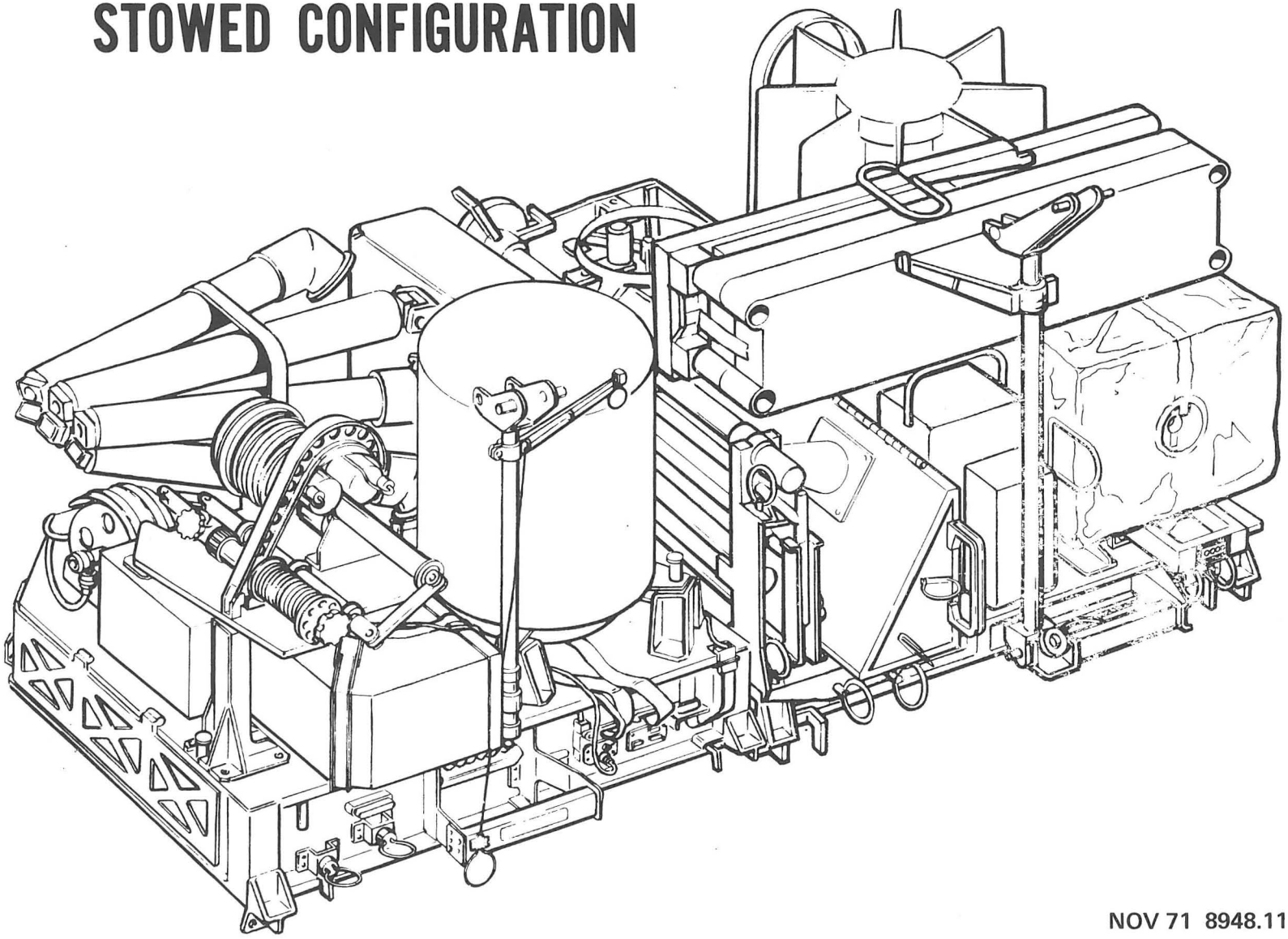
ALSEP ARRAY D

STOWED CONFIGURATION



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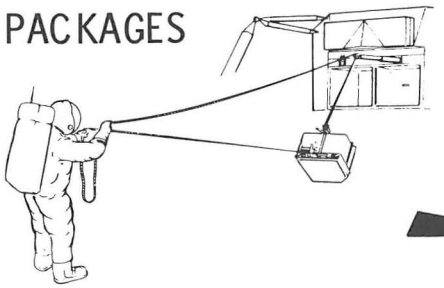
LUNAR SURFACE ACTIVITY

ALSEP DEPLOYMENT TASKS ASSOCIATED WITH LM

REMOVE PACKAGES



FUEL GENERATOR

PREPARE FOR TRAVERSE

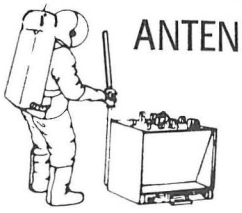
DEPLOYMENT DUST COVERS NOT SHOWN

TRAVERSE

ALSEP DEPLOYMENT TASKS AT EXPERIMENT SITE

DEPLOY CENTRAL STATION

DEPLOY ANTENNA



DEPLOY EXPERIMENTS

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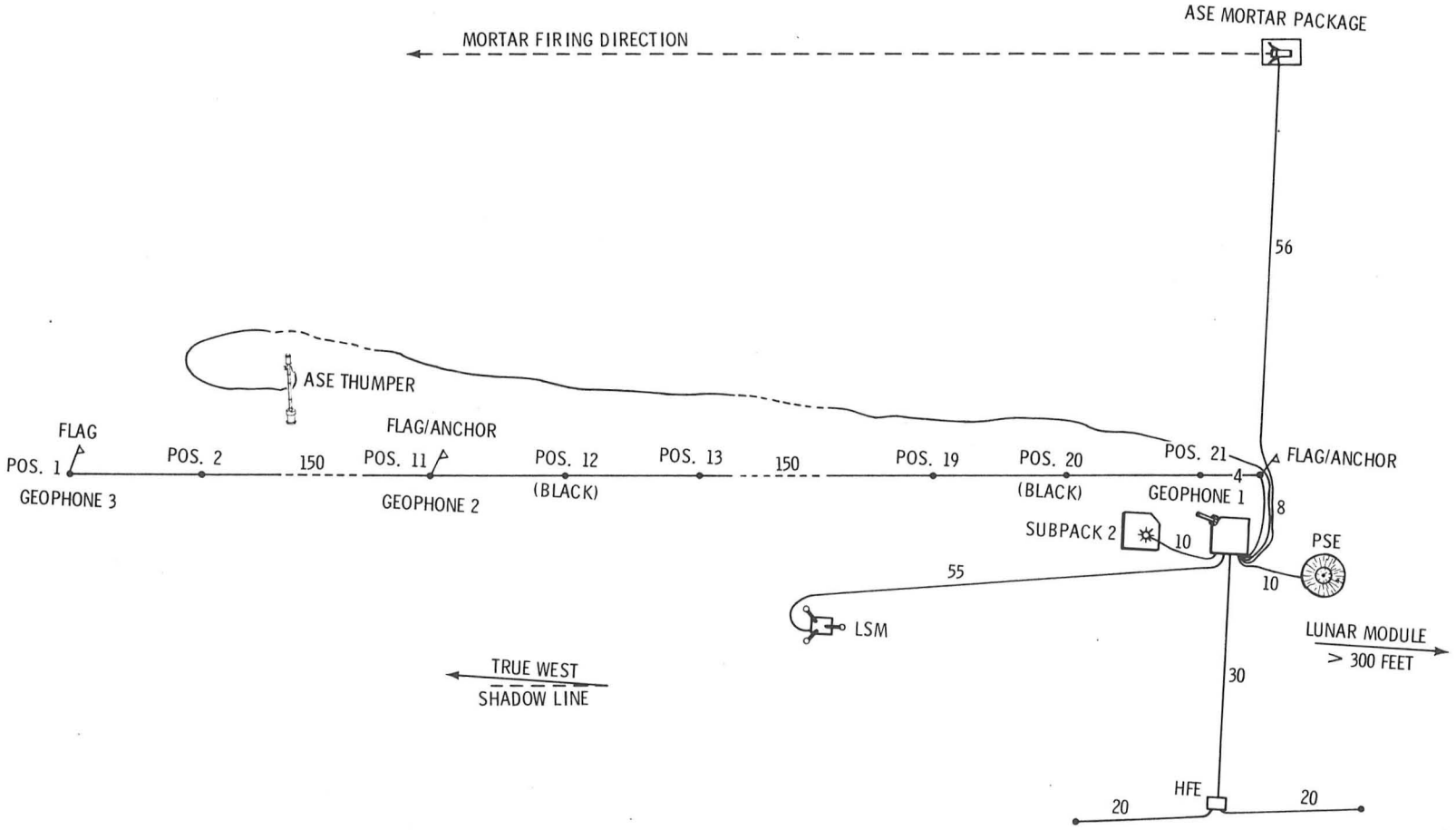
ARRAY D GENERAL DEPLOYMENT CONFIGURATION



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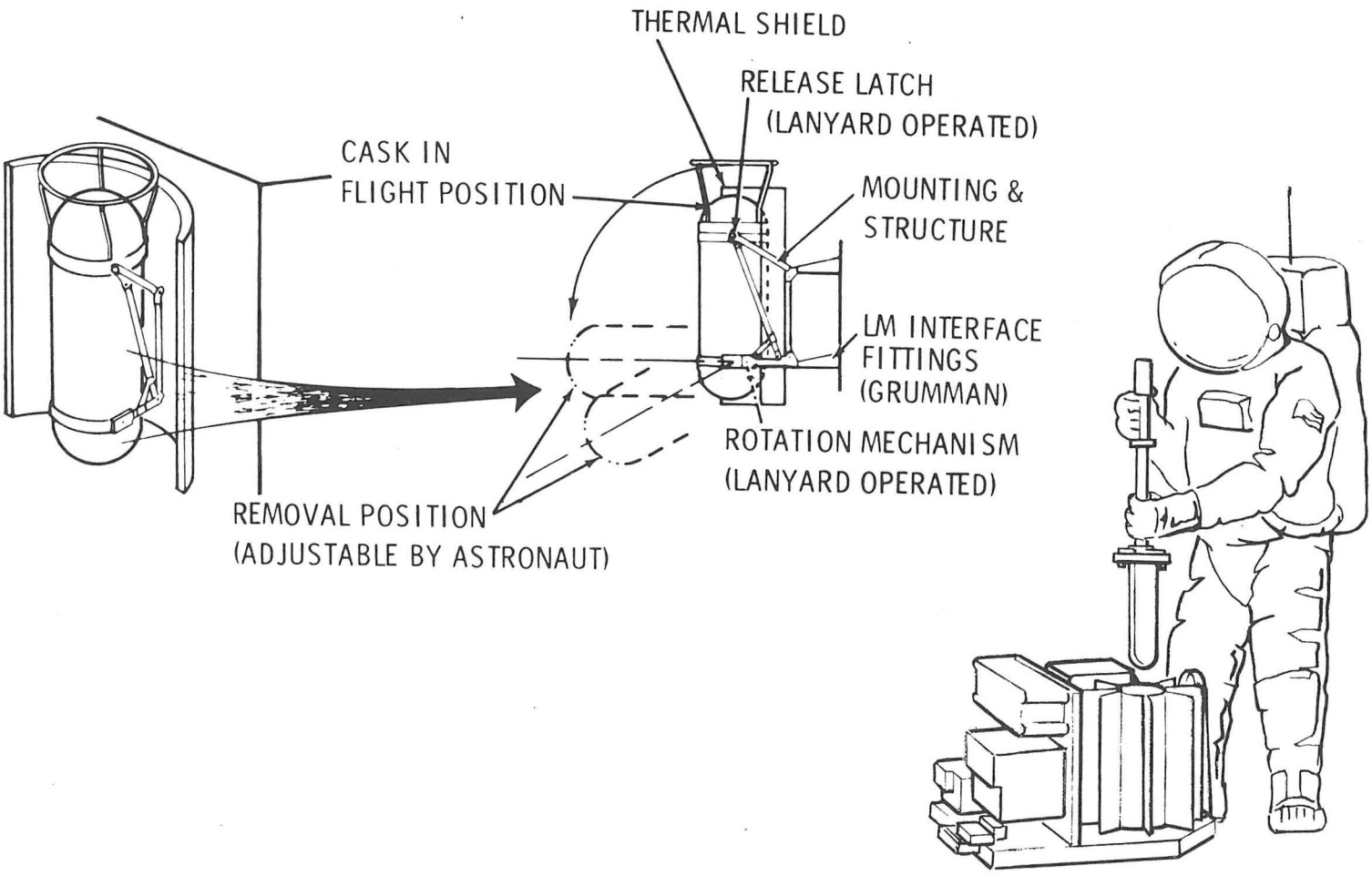
RTG FUELING



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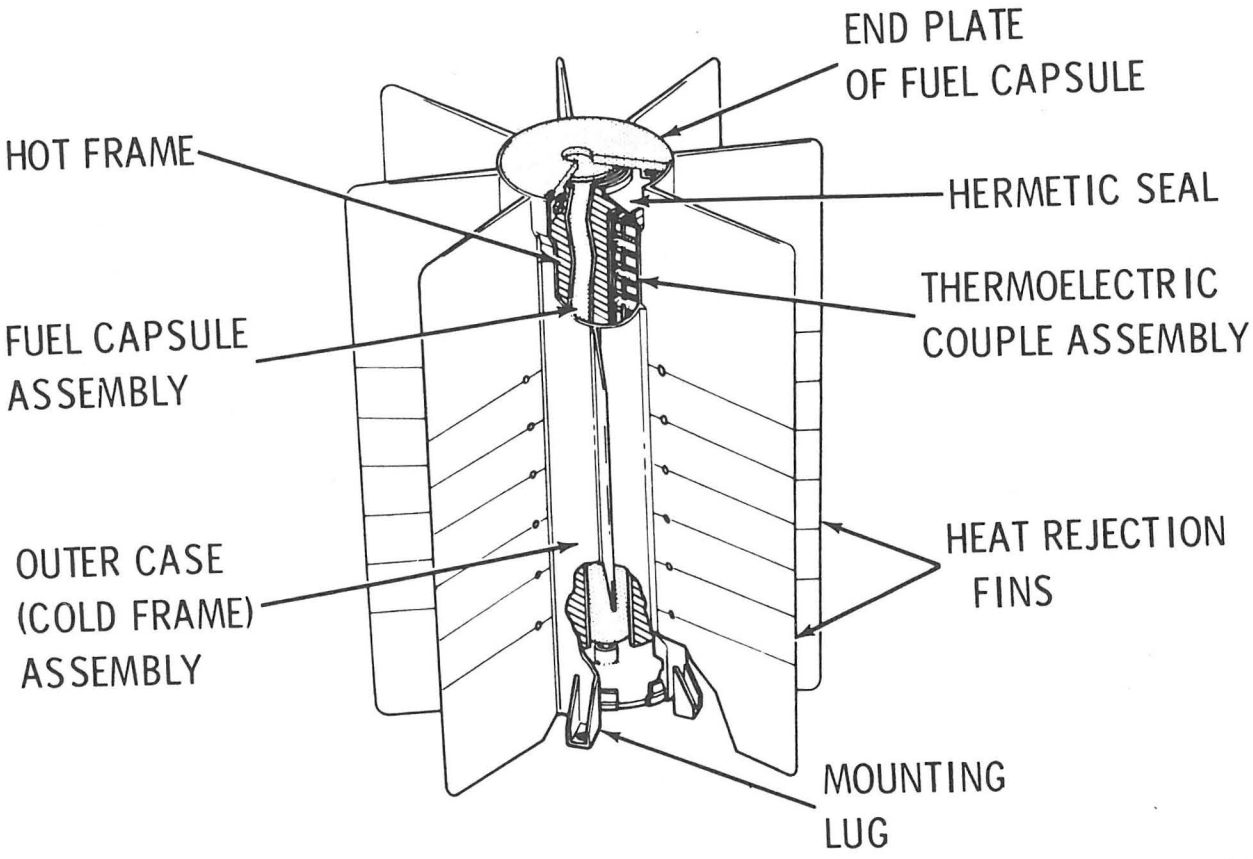
RTG CUTAWAY



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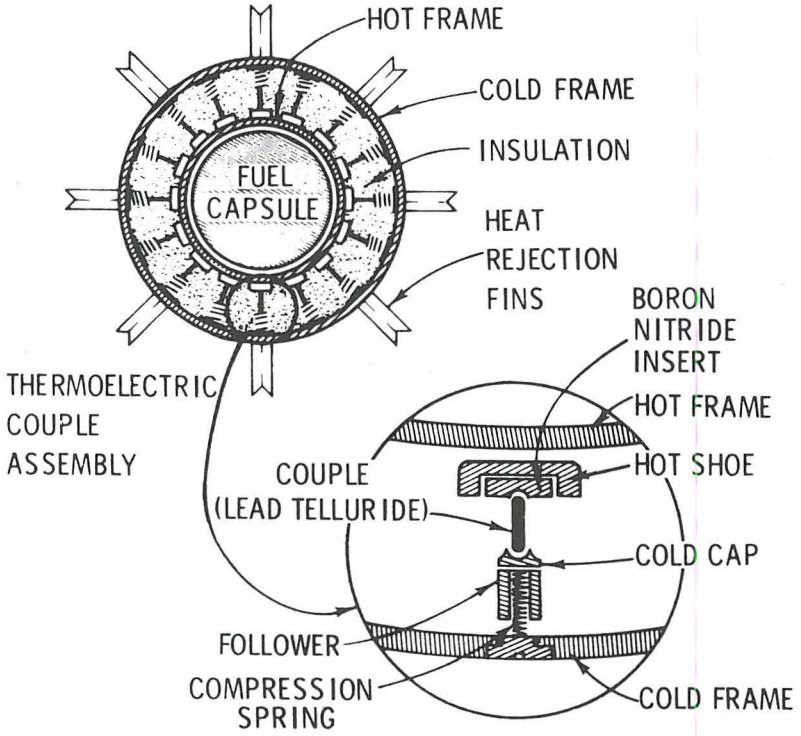
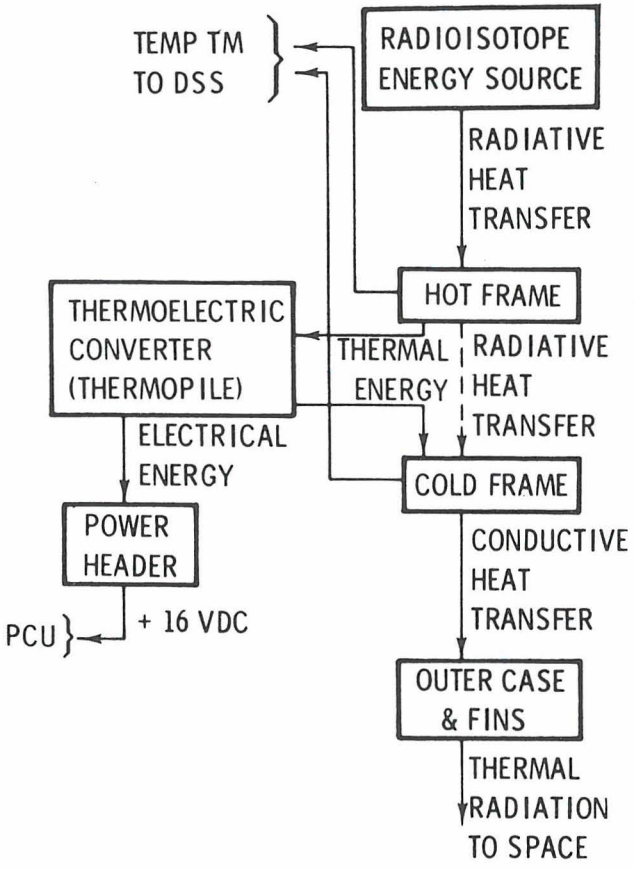
POWER GENERATING FUNCTION





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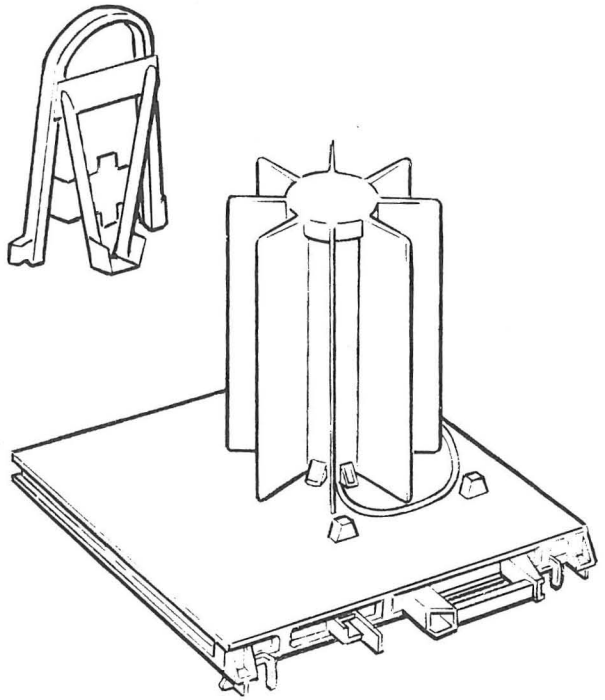
RTG CABLE



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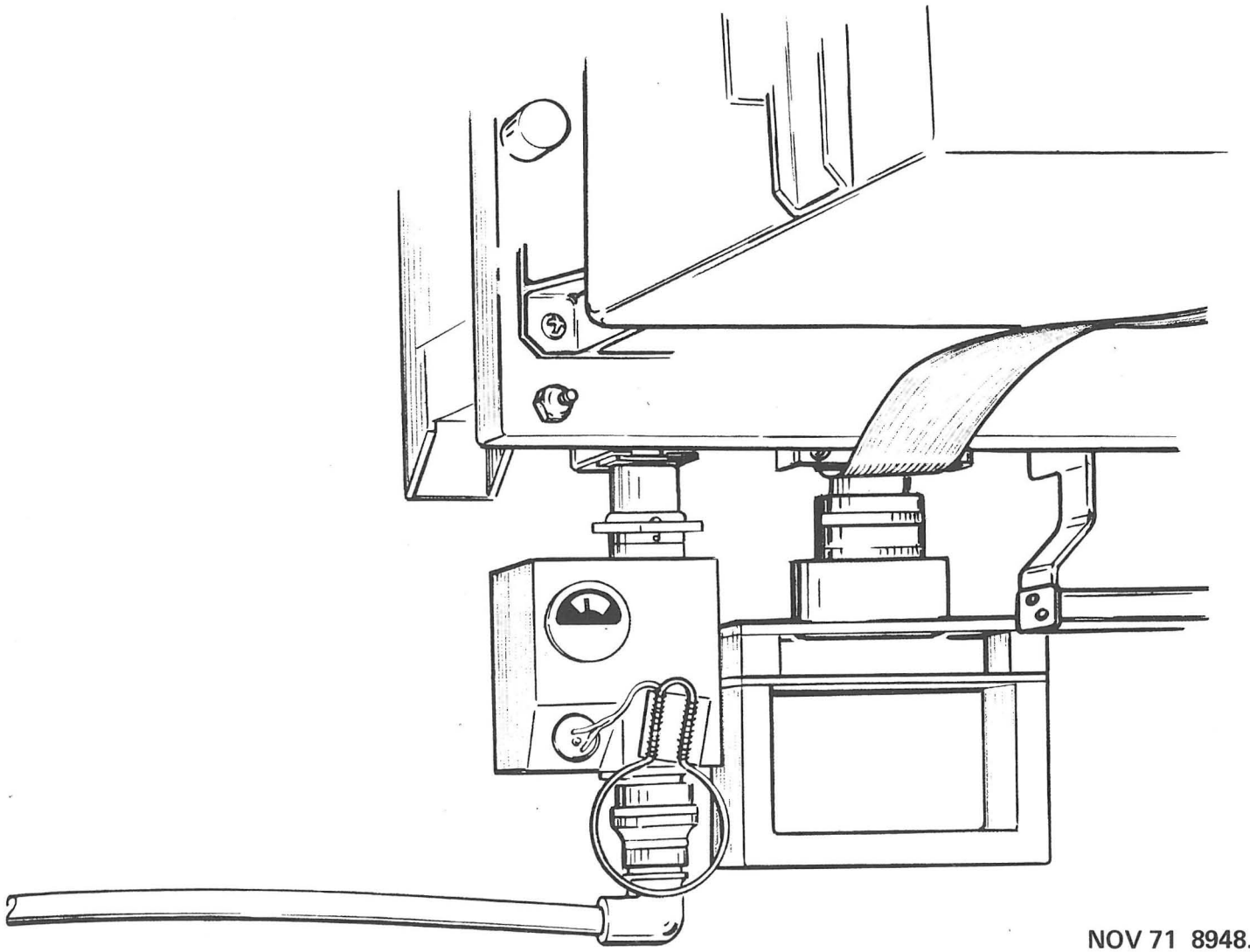
RTG CABLE CONNECTION



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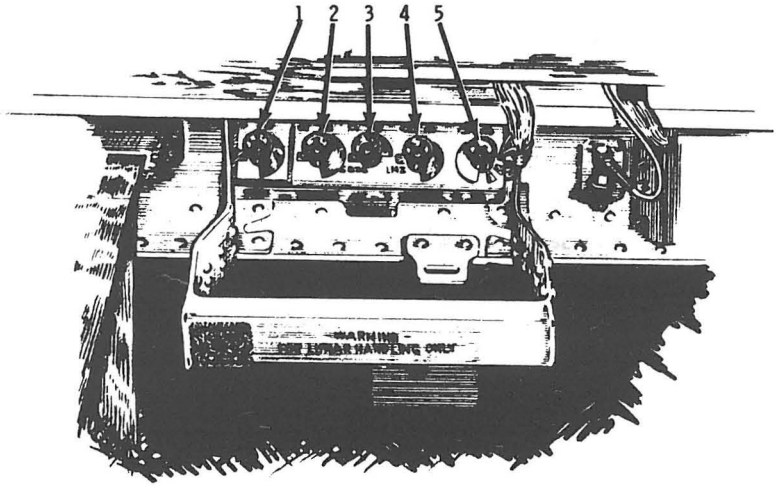
ASTRO SWITCHES



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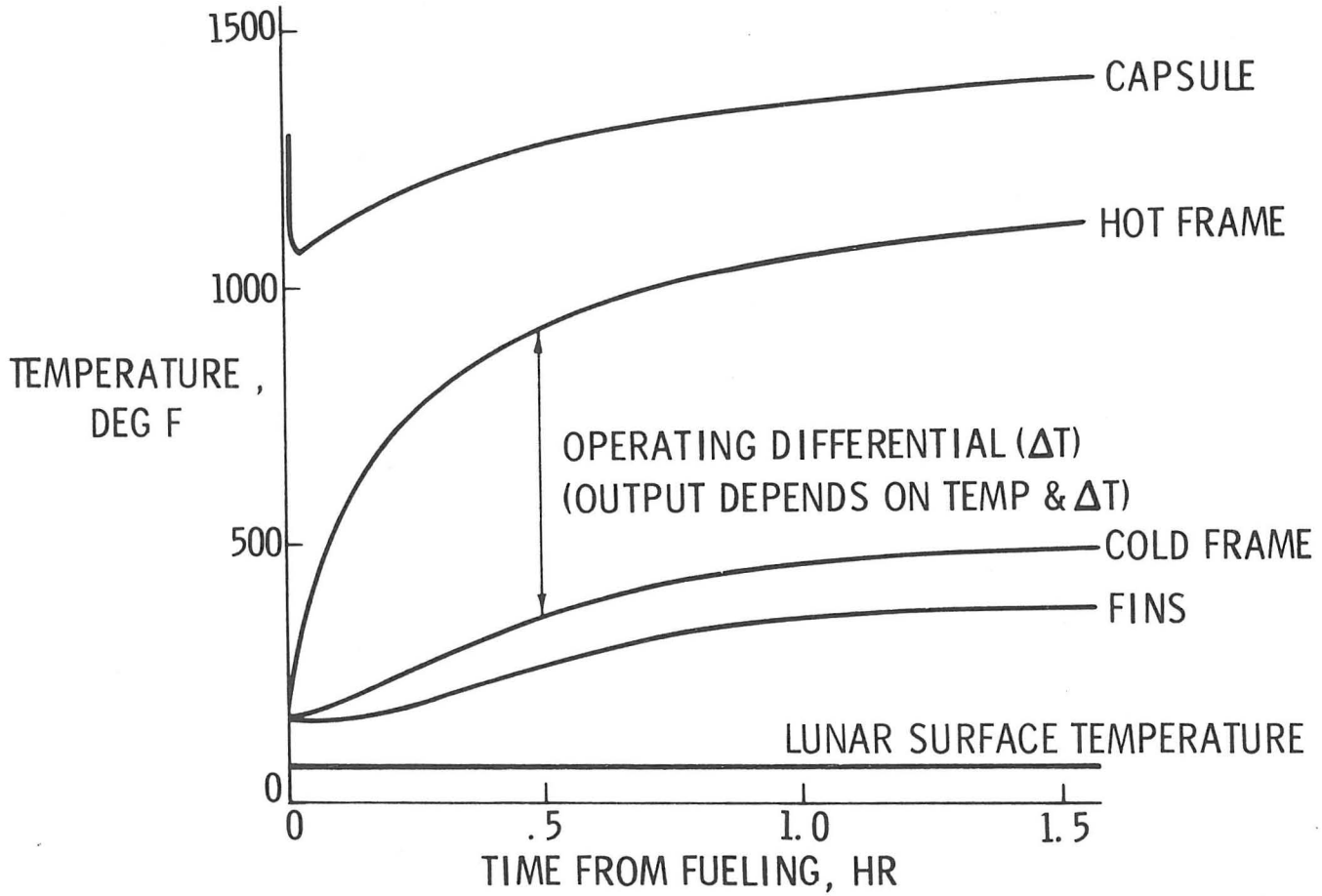
RTG WARM-UP CYCLE



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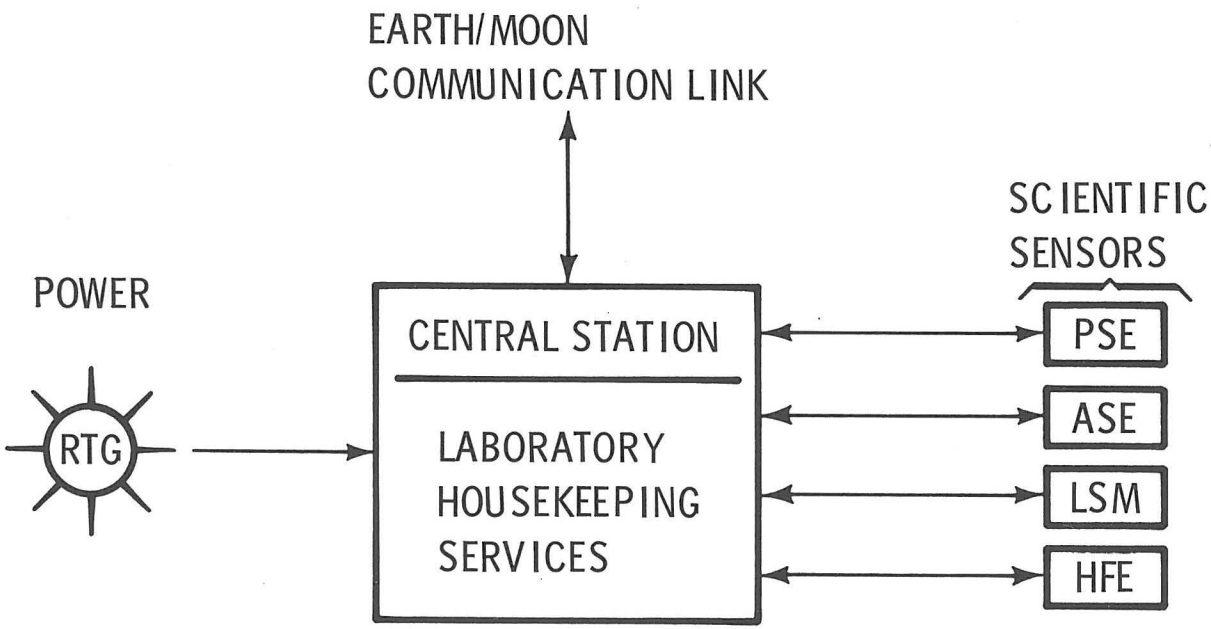
ALSEP COMMUNICATION CENTER



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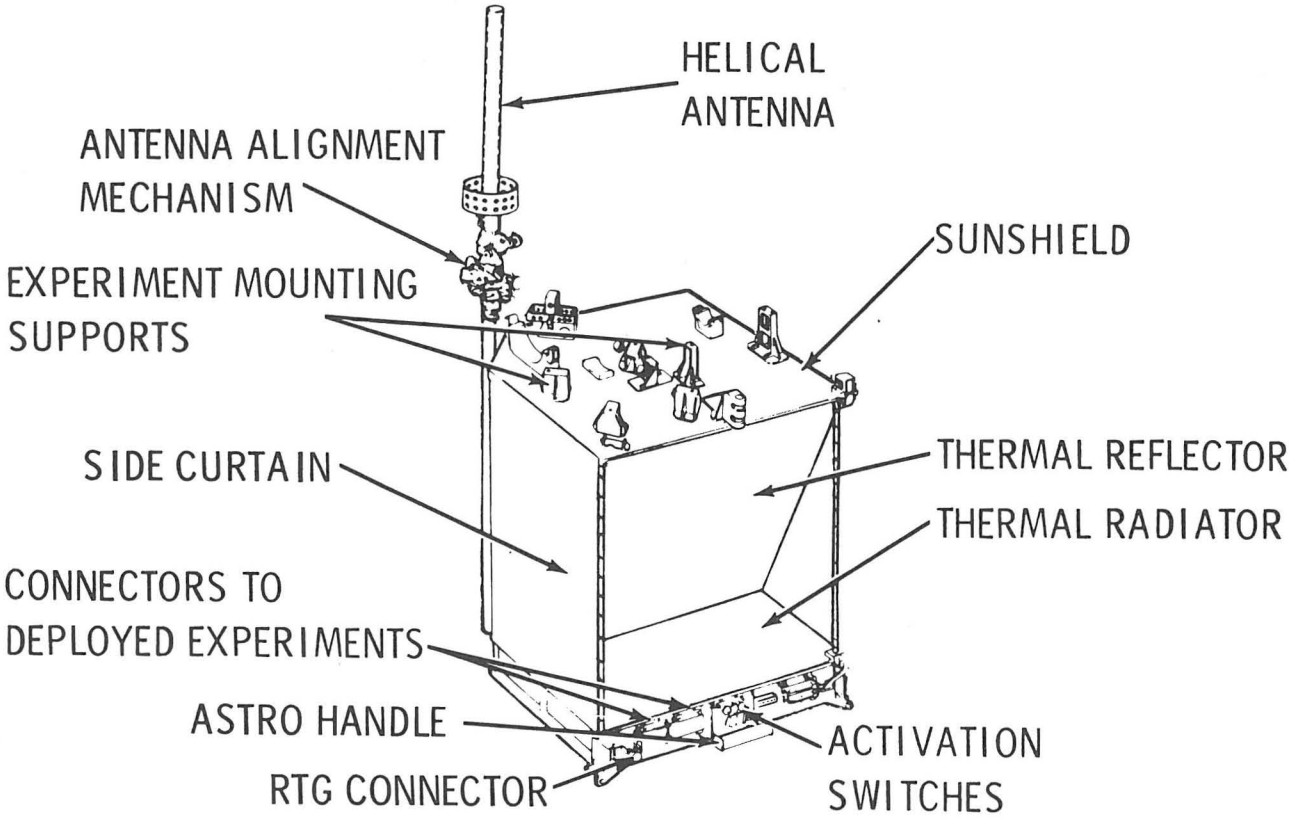
CENTRAL STATION DEPLOYED CONFIGURATION



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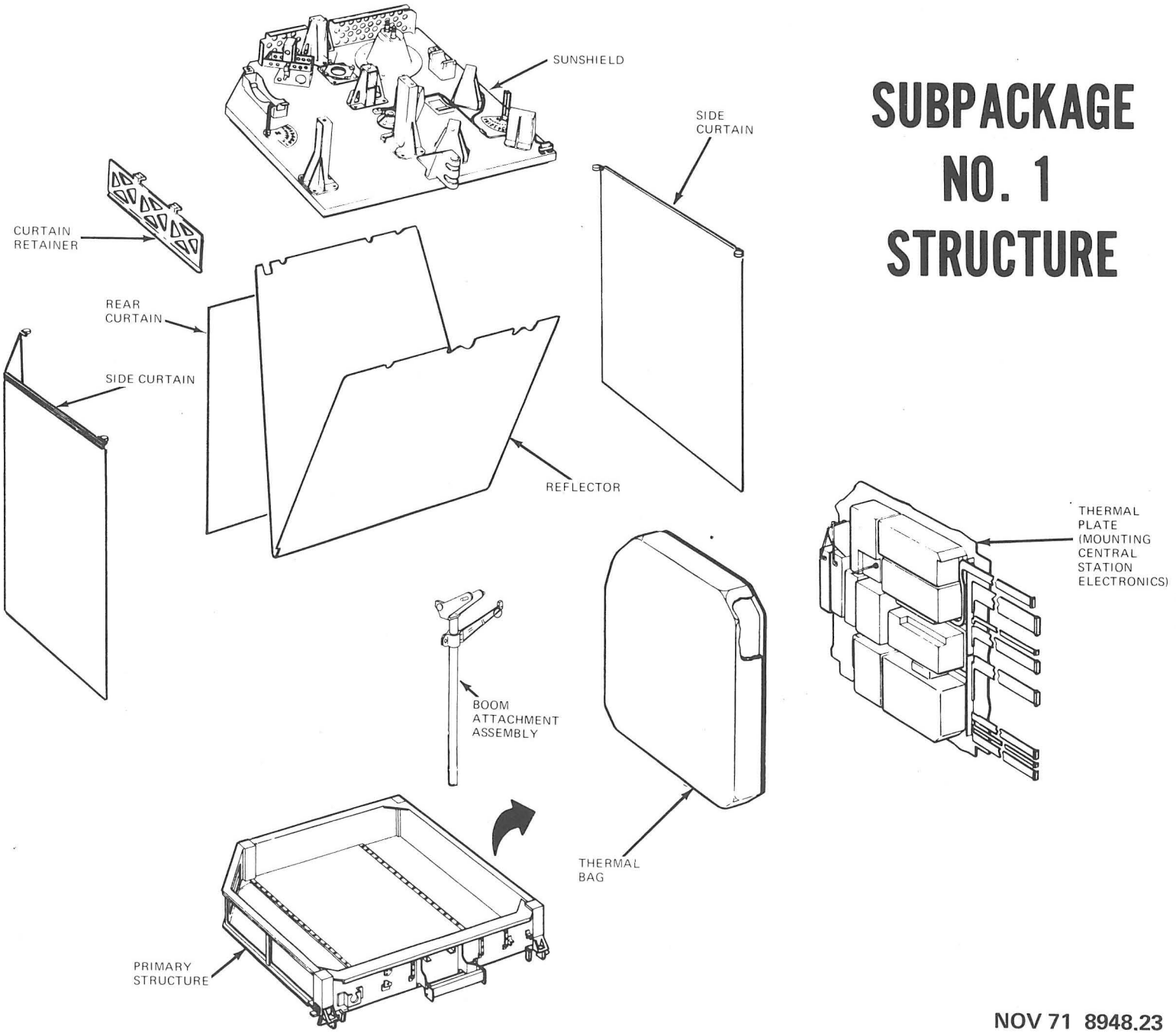
SUBPACKAGE NO. 1 STRUCTURE



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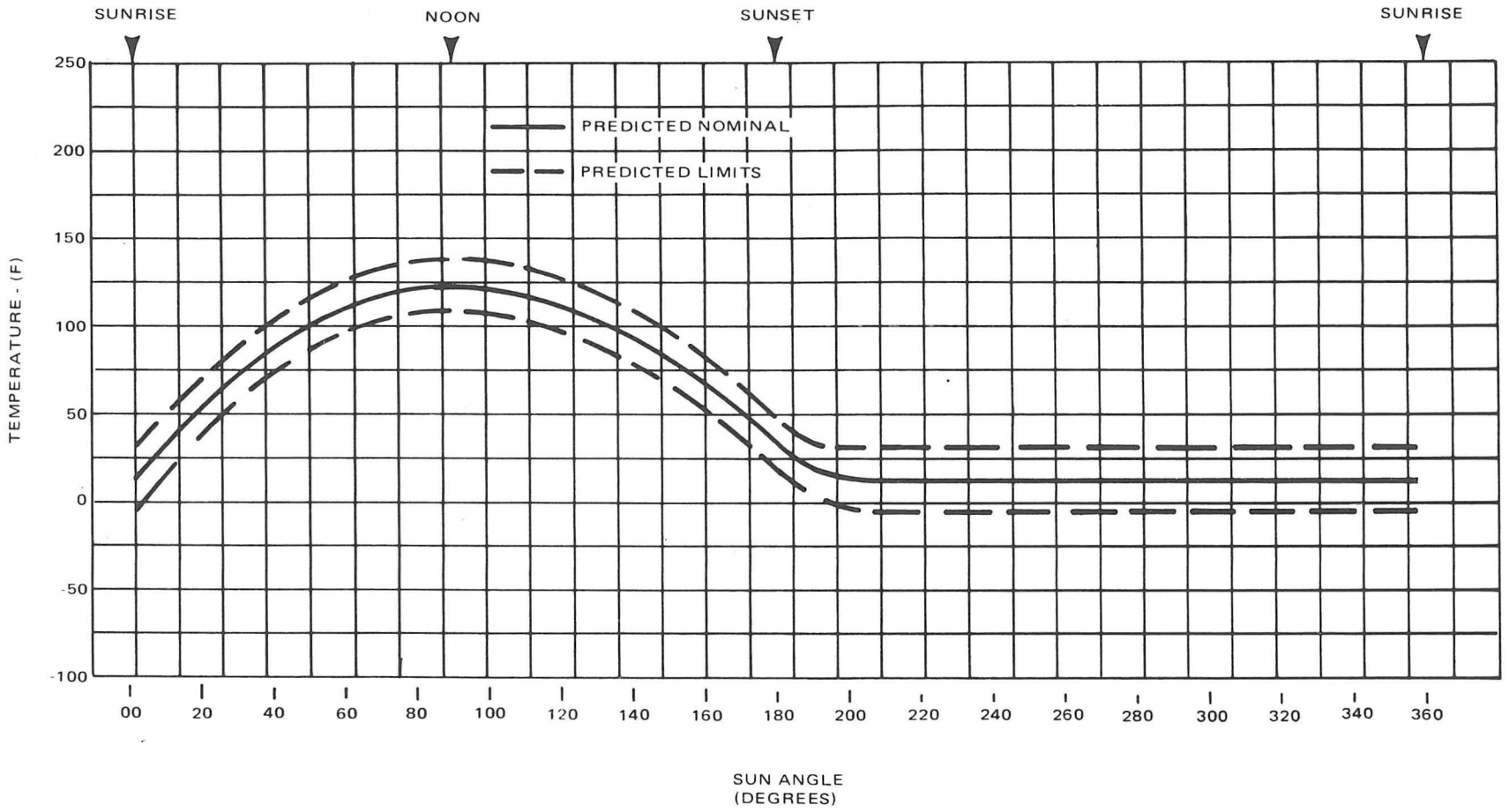
PREDICTED TEMPERATURE OF ELECTRONICS



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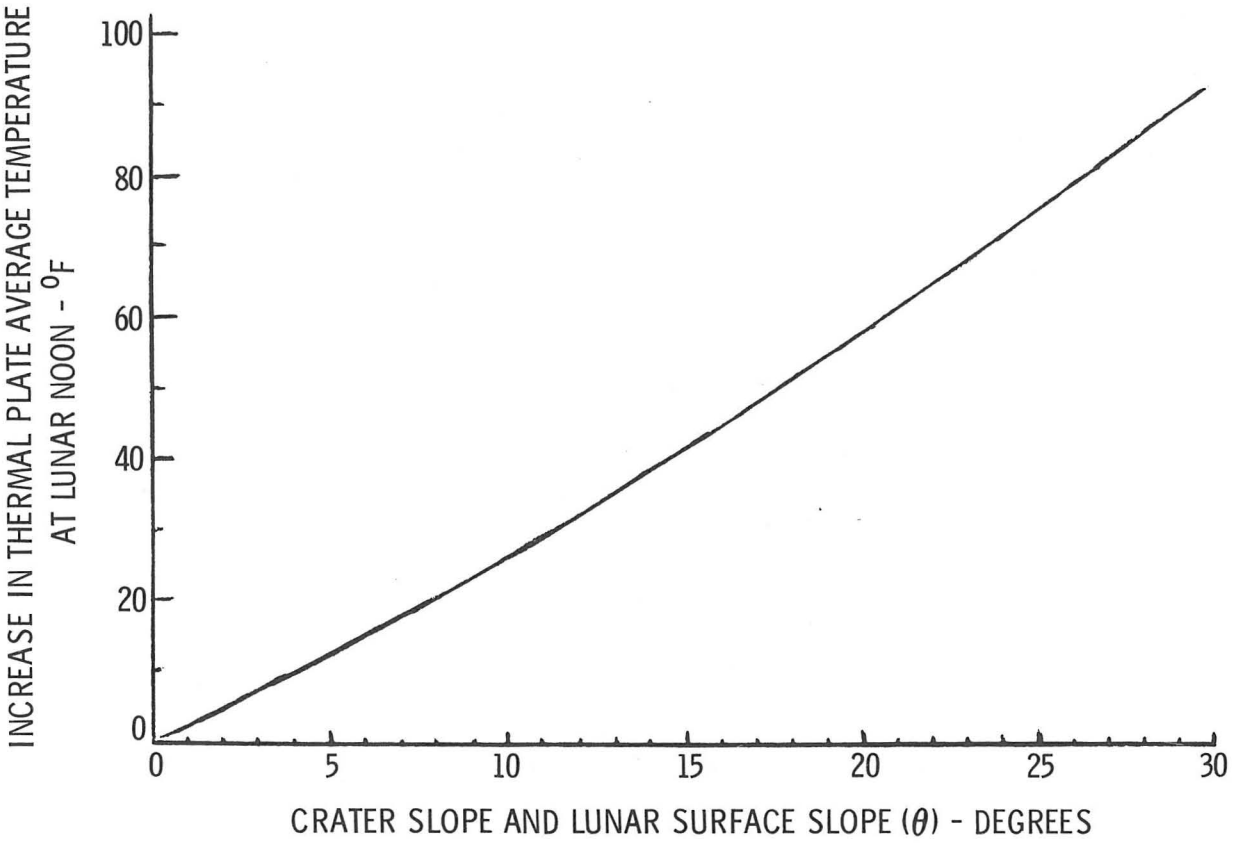
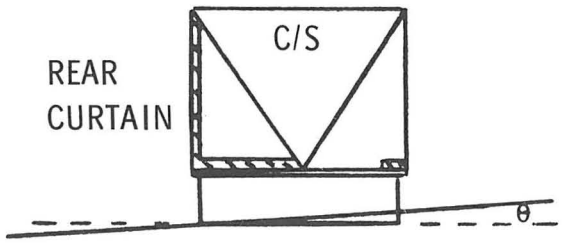
EFFECT OF SURFACE SLOPE ON ELECTRONICS TEMPERATURES





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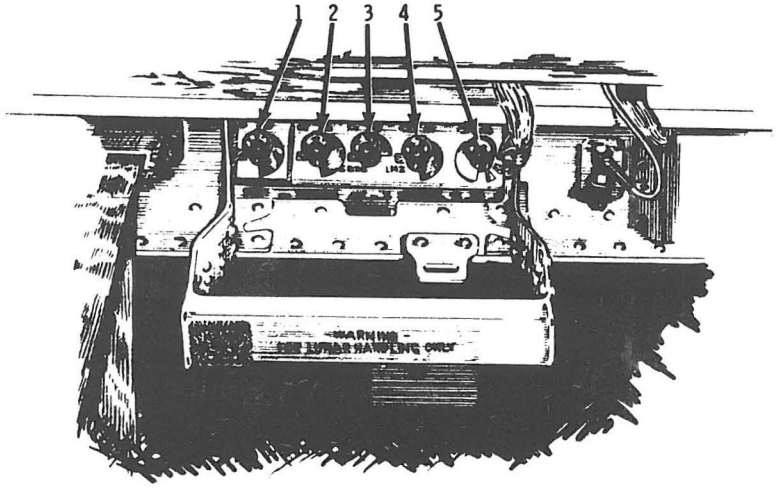
ASTRO SWITCHES



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CREW INTERFACE

WITH ARRAY D ALSEP SCIENCE SENSORS

- PASSIVE SEISMIC EXPERIMENT
- ACTIVE SEISMIC EXPERIMENT
- LUNAR SURFACE MAGNETOMETER
- HEAT FLOW EXPERIMENT

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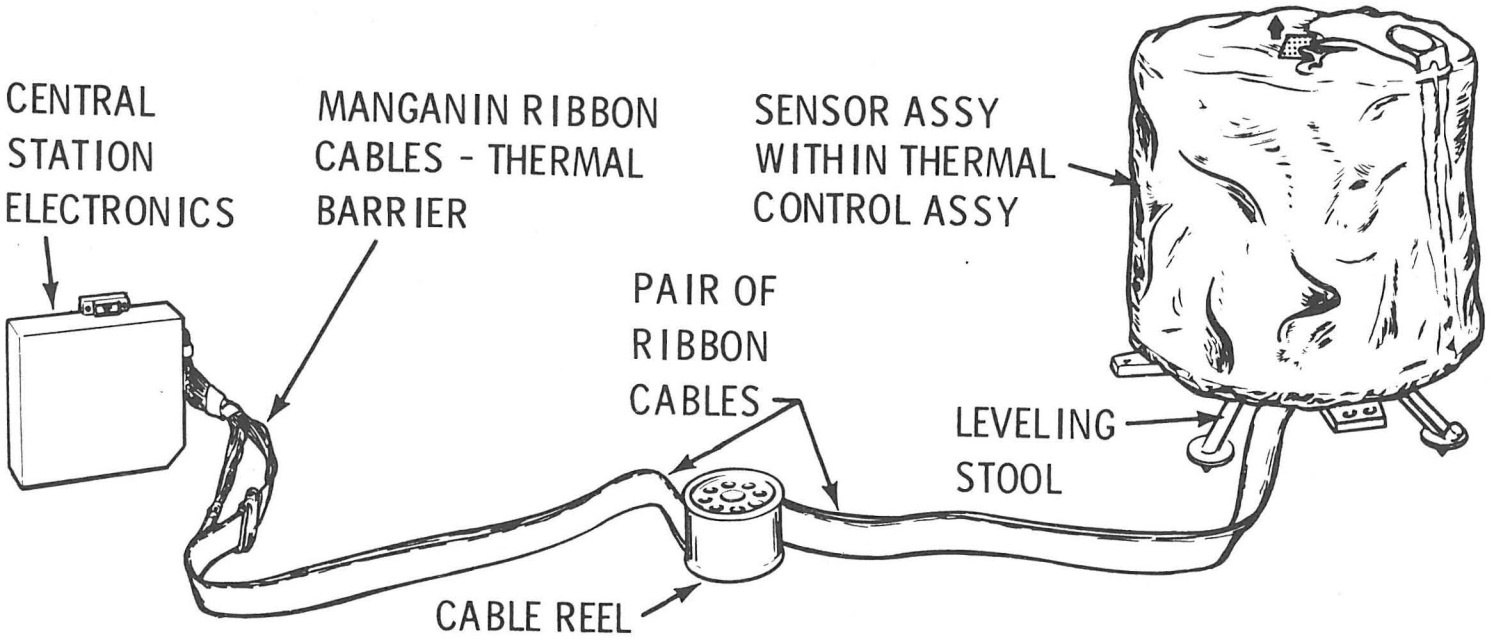
PASSIVE SEISMIC EXPERIMENT



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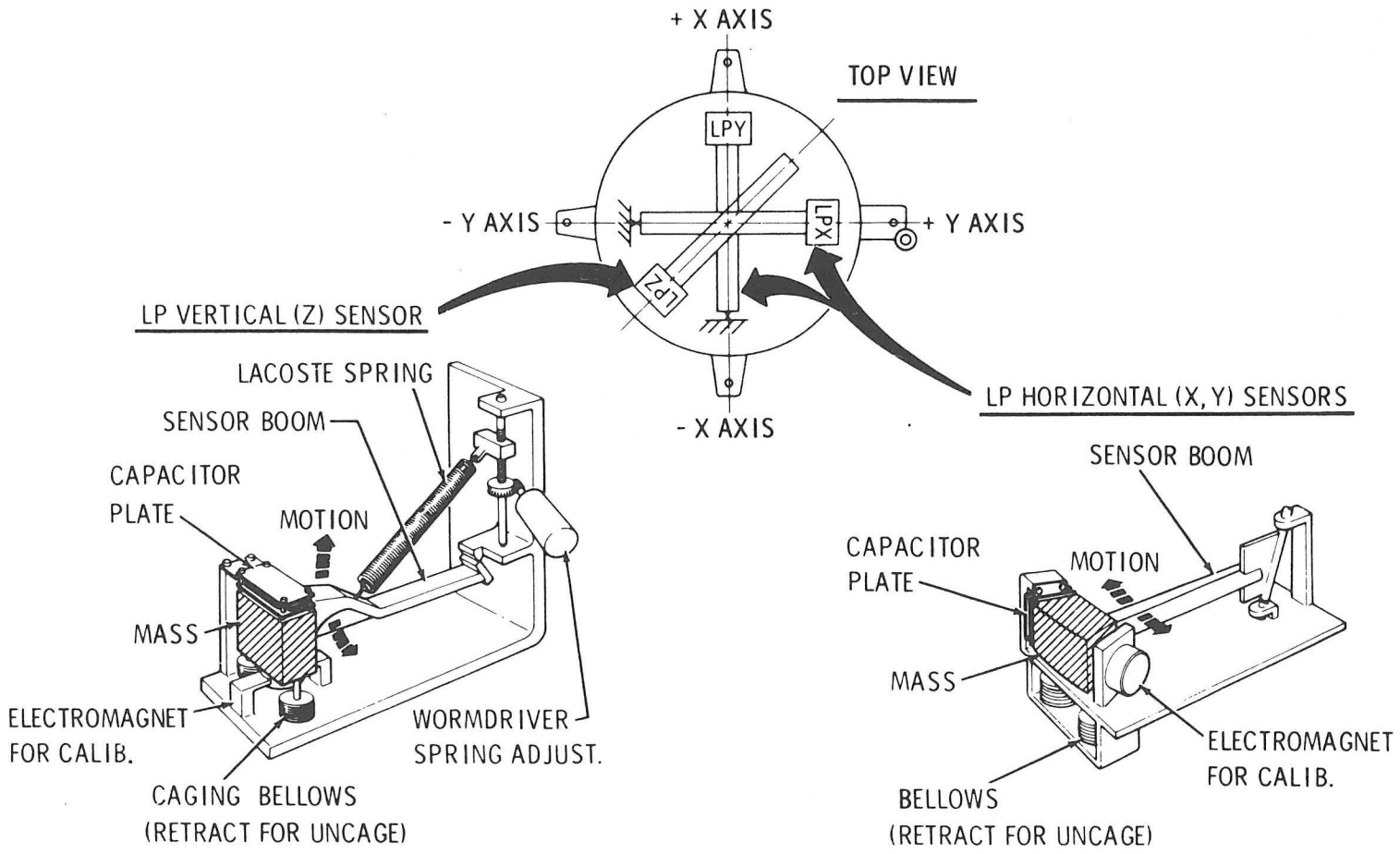
INSTRUMENT DETAILS



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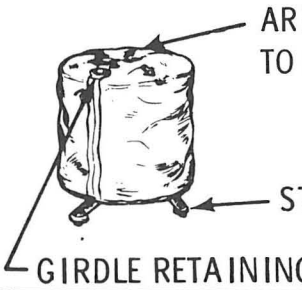
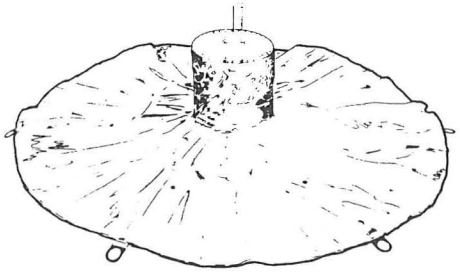
PSE EMPLACEMENT CRITERIA

PARAMETER	REQUIREMENT	PRIORITY	INDICATOR	COMMENTS
DISTANCE FROM SUBPACKAGE 1	9 ±1 FT	1	10 FT CABLE	15 FT SEPARATION REQUIREMENT FROM RTG FOR THERMAL REASONS
DIRECTION FROM SUBPACKAGE 1	EAST	1	EYEBALL	OUT OF FIELD OF VIEW OF CENTRAL STATION RADIATOR
SITE SELECTION	"QUIET" LOCATION	1	EYEBALL	FREE FROM LOOSE RUBBLE ***
ROUGH ALIGN	±20° OF E-W	2	ARROW**	BEFORE OPENING SHROUD
LEVEL, WRT INDICATOR	±5° OF HORIZONTAL	1	BUBBLE LEVEL	INTERACTS WITH ALIGNMENT; INSTRUMENT FINE-LEVELS INTERNALLY
READOUT OF ALIGNMENT WRT SHADOW	±5°	1	FULL ROSE	AFTER OPENING SHROUD
EXPERIMENT INTERRELATION	*NO LESS THAN 10 FT FROM OTHER SUBSYSTEMS TO MINIMIZE PICKUP OF STRAY VIBRATIONS.			
SPECIAL REQUIREMENTS	**ARROW NOMINALLY POINTS EAST ALTHOUGH SCIENTIFIC OUTPUT DEPENDS ONLY ON KNOWING FINAL ALIGNMENT. FINAL READING IS ACCOMPLISHED WITH ASSISTANCE OF AZIMUTH GNOMON MOUNTED ON TOP OF THERMAL SHROUD. ***PACK SURFACE MATERIAL AND GOUGE HOLE TO PREVENT CONTACT BETWEEN SENSOR AND SURFACE.			

PSE ALIGNMENT MARKINGS

PHASE	CONFIGURATION	TASK	MARKING
INITIAL	CYLINDRICAL SENSOR ASSY INSIDE THERMAL CASE, ENCLOSED IN THERMAL SHROUD WITH GIRDLE OVER SHROUD	ROUGH ALIGN VIA ARROW ON TOP OF GIRDLE	
FINAL	SHROUD OPENED & ASSY LEVELED	READOUT VIA SHADOWS WRT COMPASS MARKINGS ON TOP	

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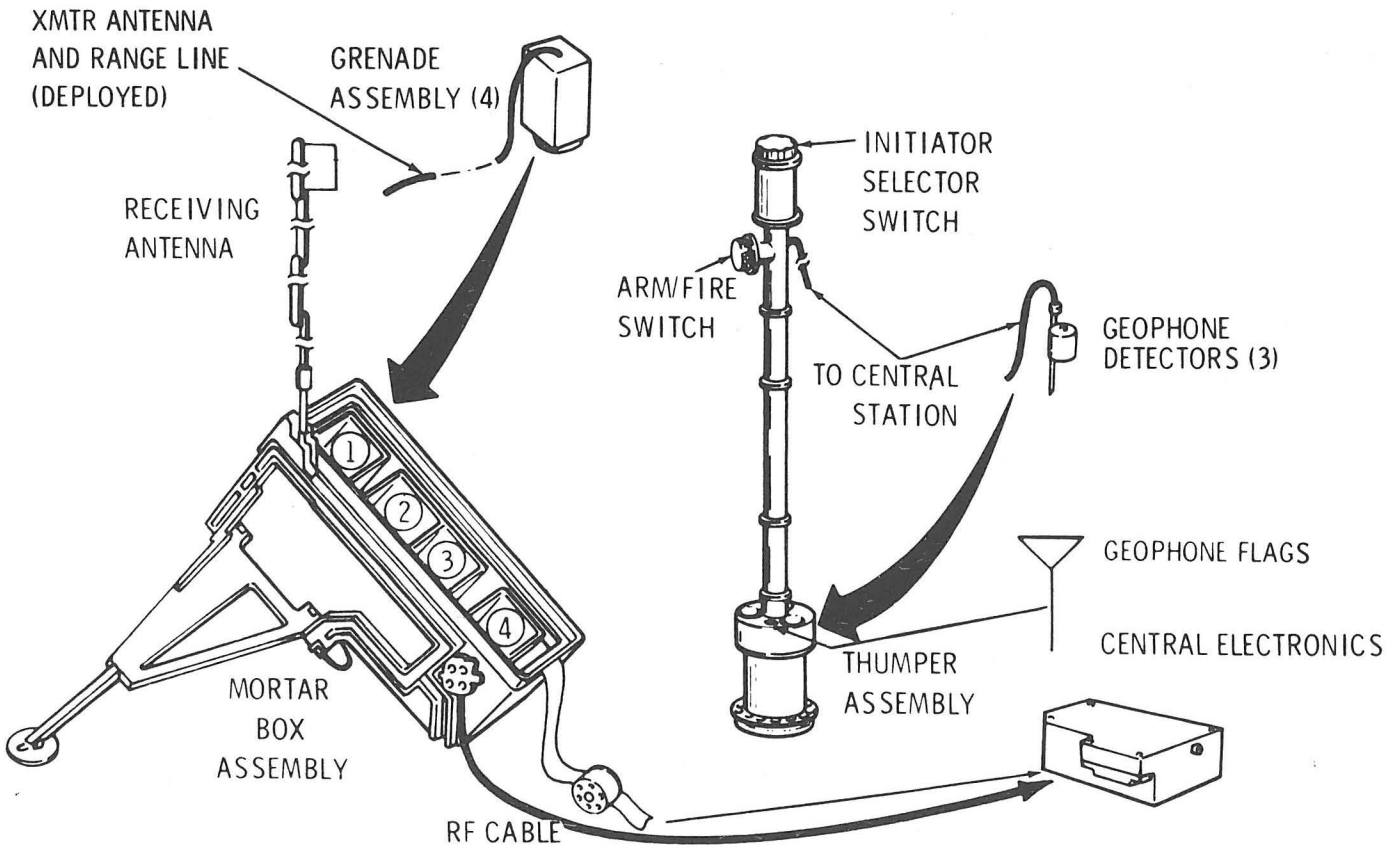
ACTIVE SEISMIC EXPERIMENT SUBSYSTEM



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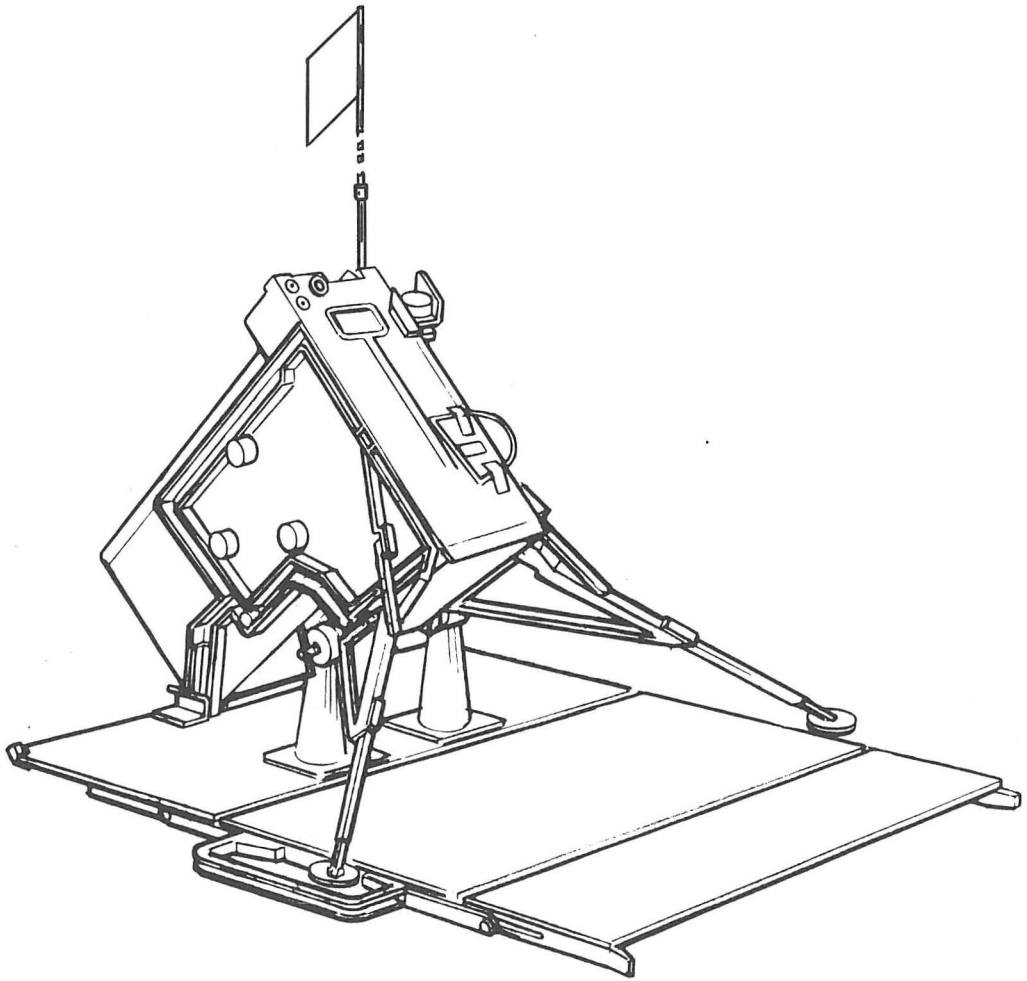
ASE MORTAR PACKAGE DEPLOYED CONFIGURATION



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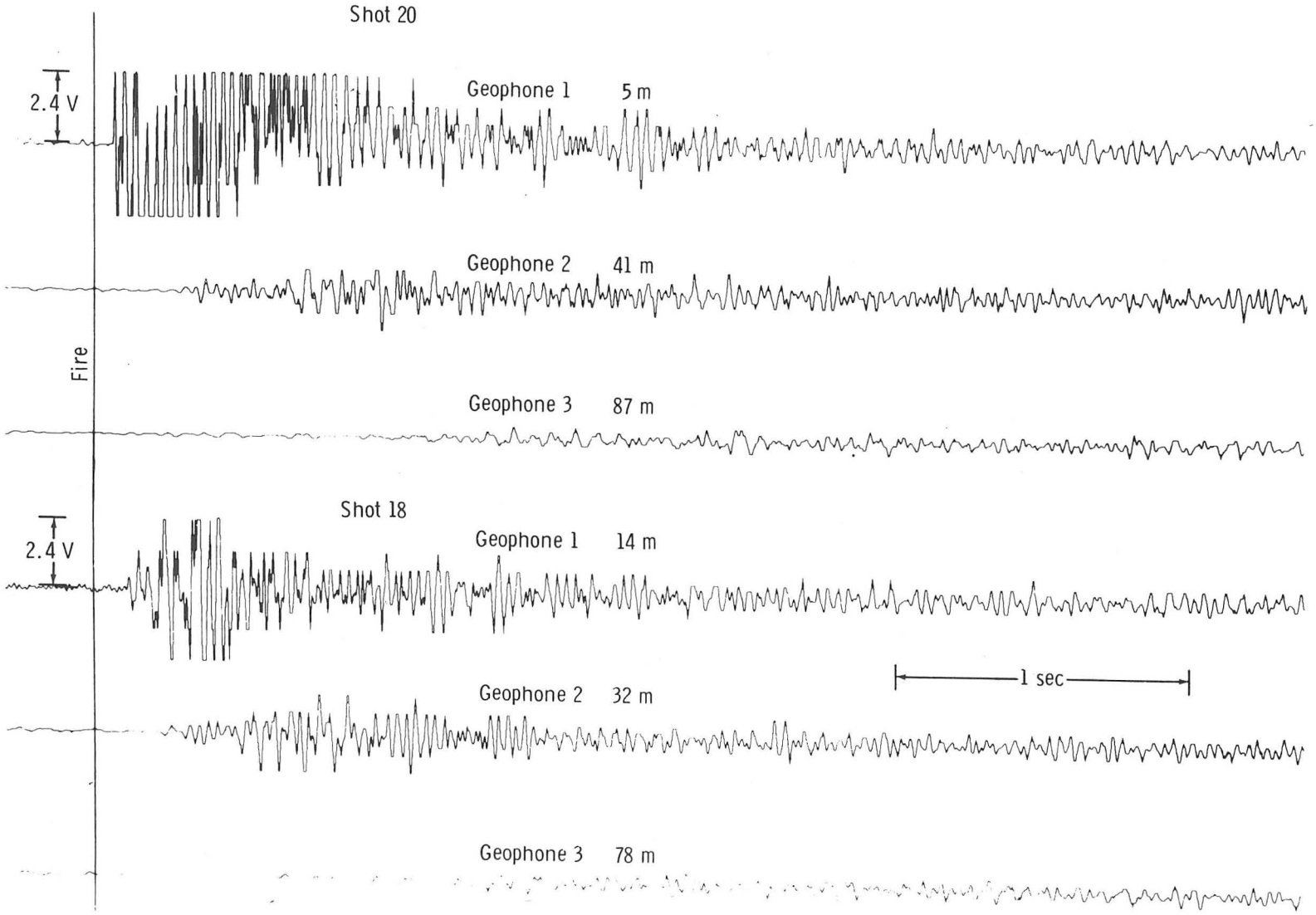
SEISMIC SIGNALS PRODUCED BY APOLLO 14 THUMPER FIRINGS



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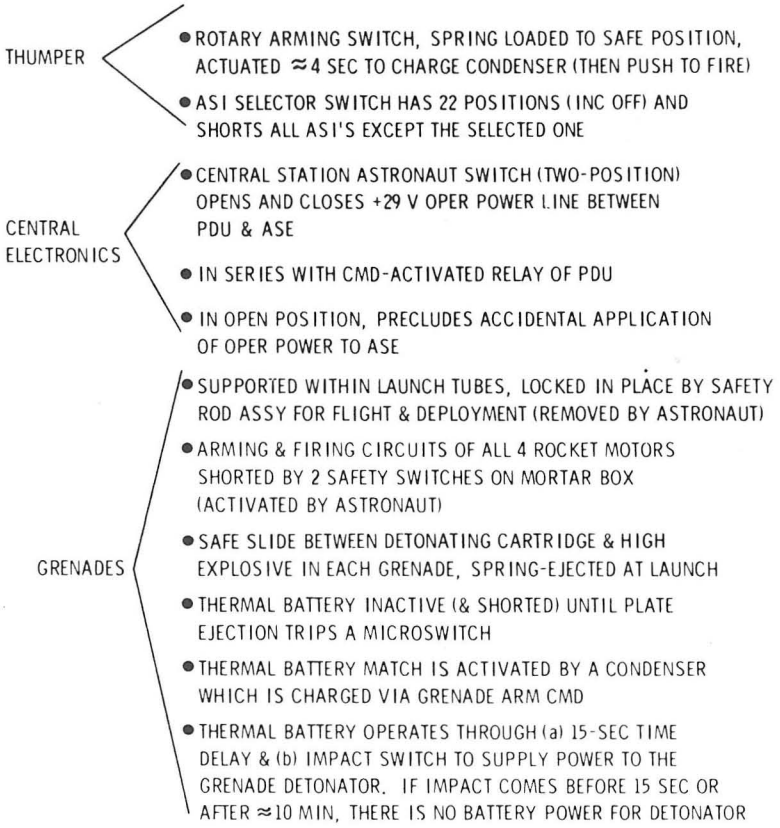
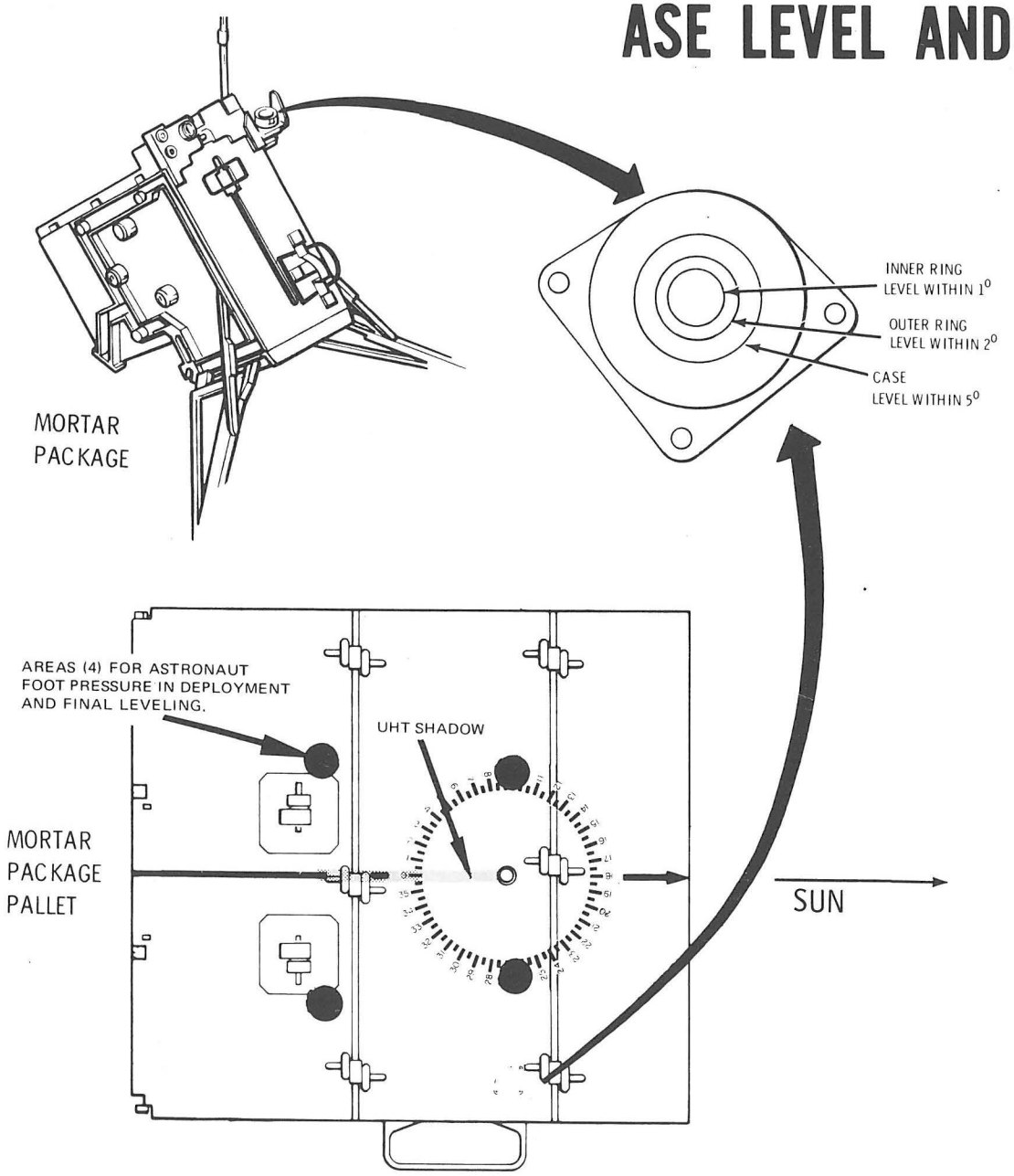
ASE SAFETY FEATURES



ASE LEVEL AND ALIGNMENT INDICATORS



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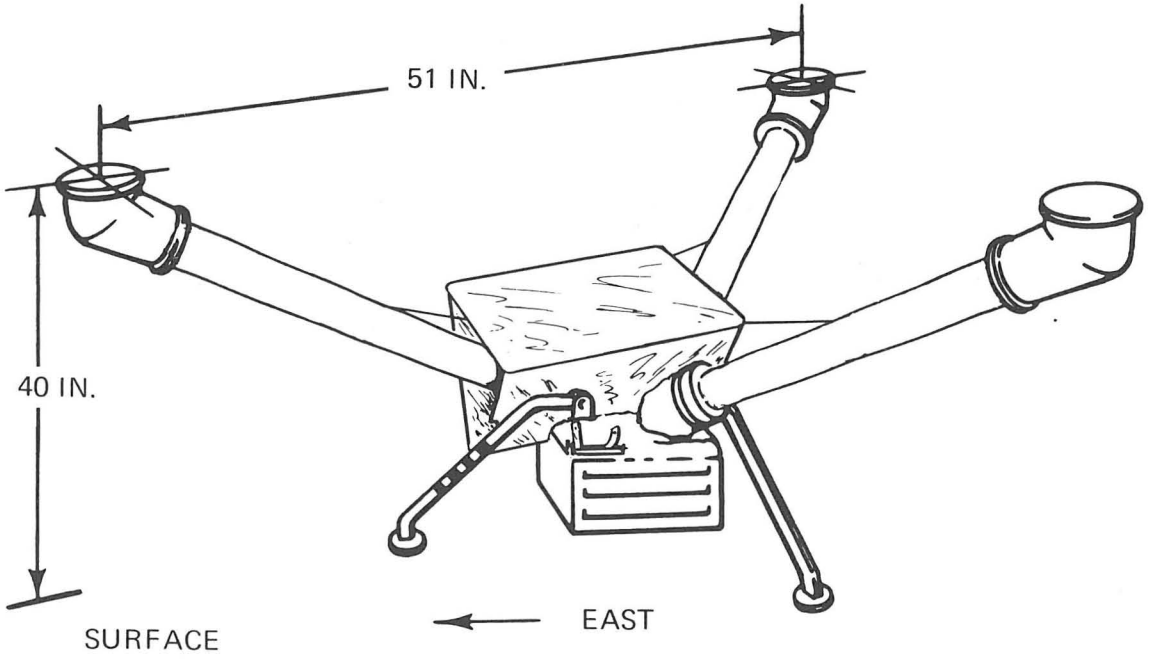
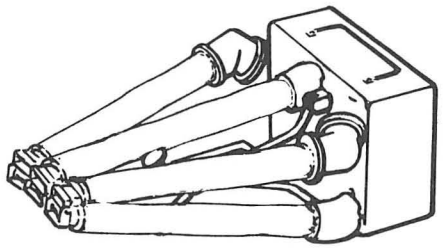
LUNAR SURFACE MAGNETOMETER EXPERIMENT SUBSYSTEM



DEPLOYED



FOLDED

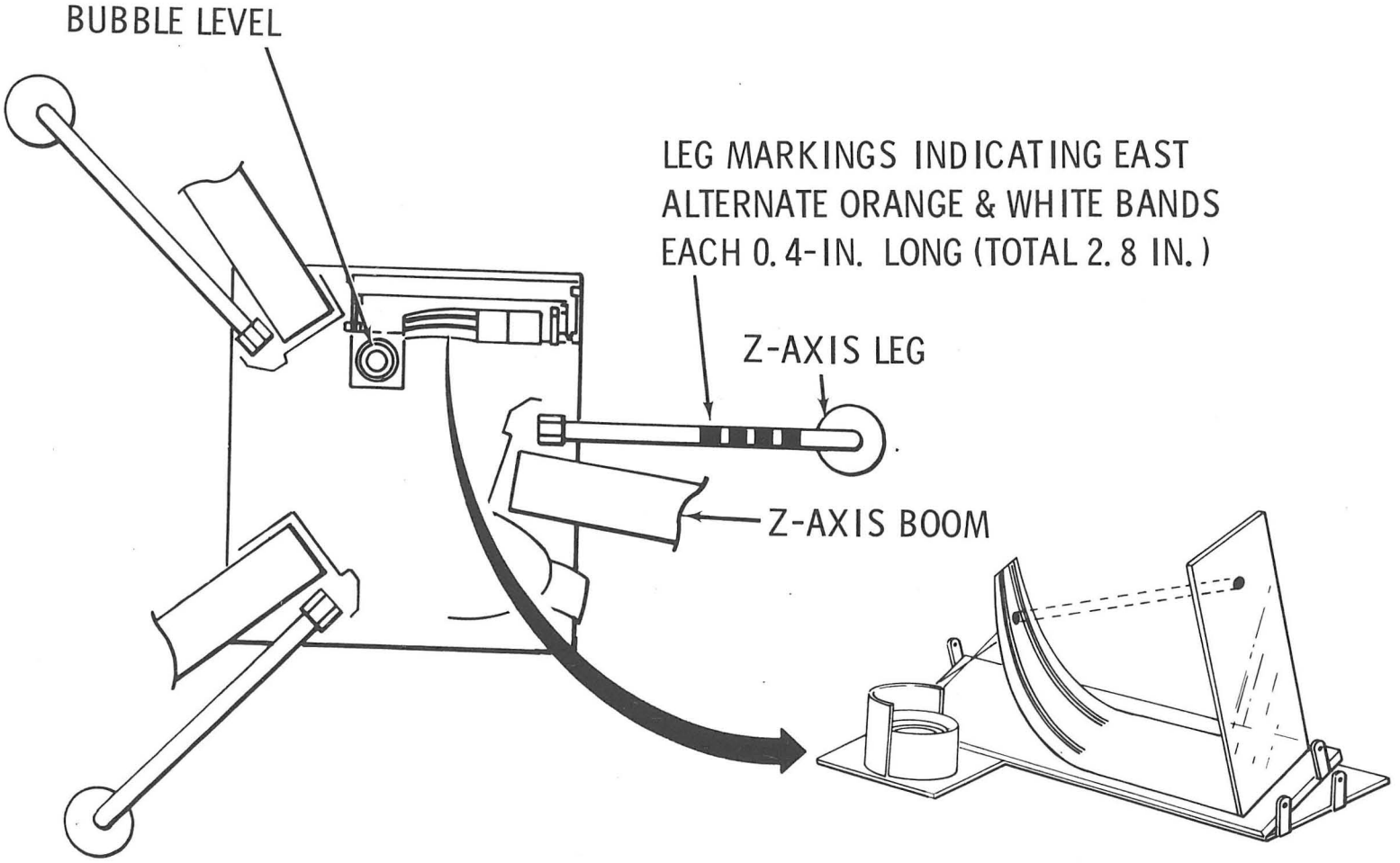
APR 71 8948.37

LSM EMPLACEMENT CRITERIA

PARAMETER	REQUIREMENT	PRIORITY	INDICATOR	COMMENTS
DISTANCE FROM SUBPACKAGE 1	50 ±5 FT	2	55 FT CABLE	MINIMIZE MAGNETIC EFFECTS
DIRECTION FROM SUBPACKAGE 1	WEST	2	EYEBALL	
SITE SELECTION	AVOID RUBBLE	3	EYEBALL	FOR MAXIMUM STABILITY
LEVEL, WRT INDICATOR	± 3° OF HORIZ	1	BUBBLE LEVEL	TM OF INTERNAL LEVEL SENSOR
ALIGN, WRT SHADOW	± 3^0 OF E-W	1	SHADOWGRAPH	COLOR-CODED LEG POINTS E*
READOUT OF ALIGNMENT, WRT SHADOW	± 1^0	1	SHADOWGRAPH	NEEDED FOR SCIENTIFIC DATA INTERPRETATION; THERMAL LESS CRITICAL**
EXPERIMENT INTERRELATION	MUST BE AT LEAST 35 FT FROM HFE PROBE			
SPECIAL REQUIREMENTS	*COULD BE ROTATED 180^0 AND MEET THERMAL CRITERIA; HOWEVER, SHADOWGRAPH IS NOT REVERSIBLE **RADIATORS ON ELECTRONICS REQUIRE E-W ALIGNMENT ±3^0.			

NOV 71 8948.38

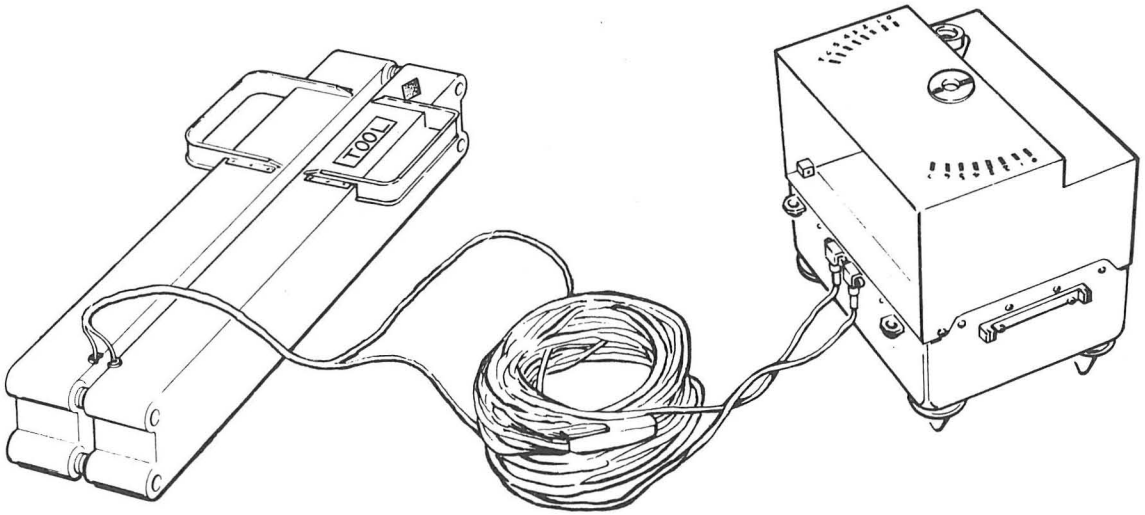
LSM LEVELING AND ALIGNMENT



SHADOWGRAPH (SUN COMPASS)
ON TOP OF EGFU

NOV 71 8948.39

HEAT FLOW EXPERIMENT

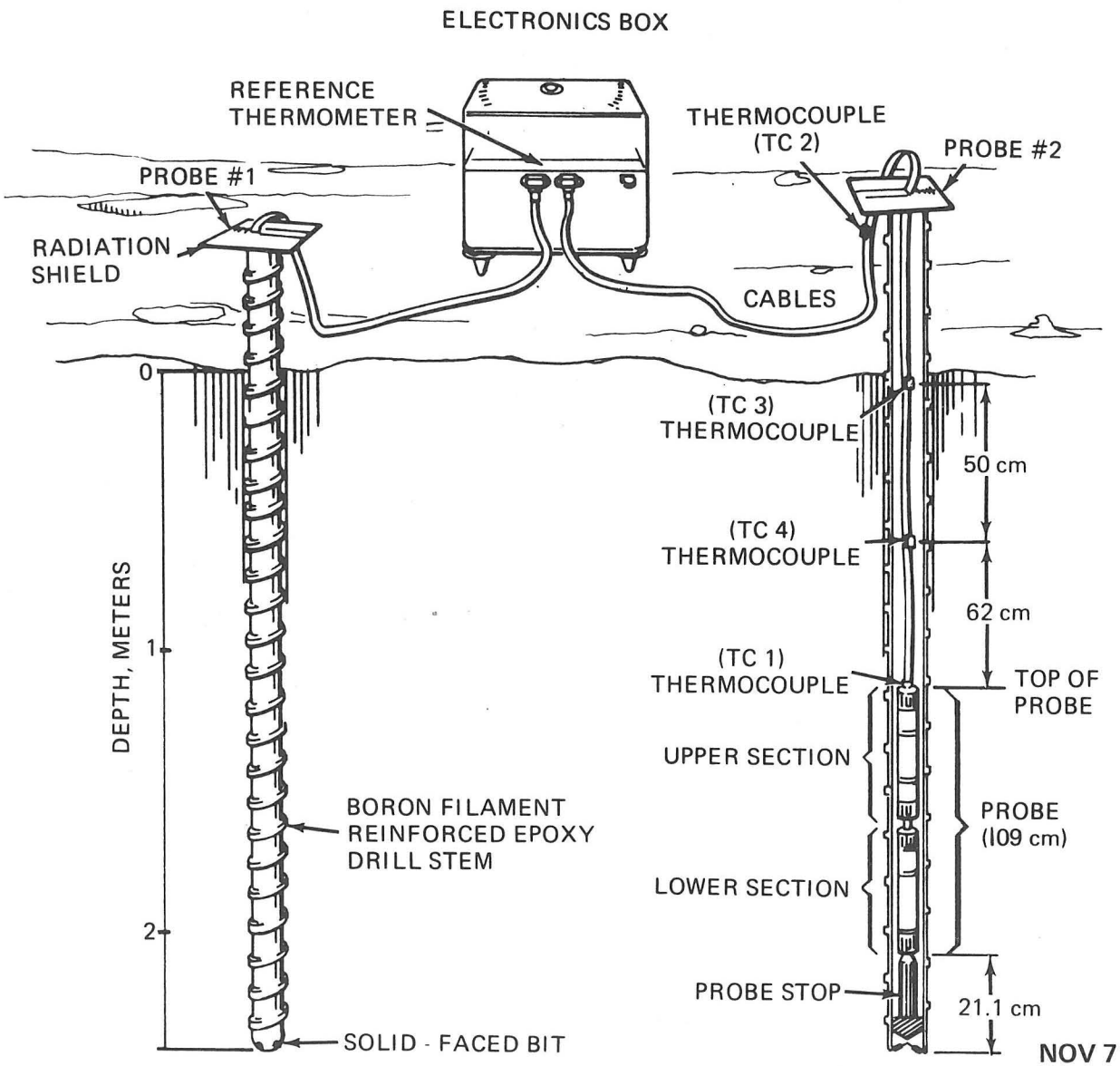


PROBE CARRYING PACKAGE
(CONTAINS 2 PROBES &
EMPLACEMENT TOOL)

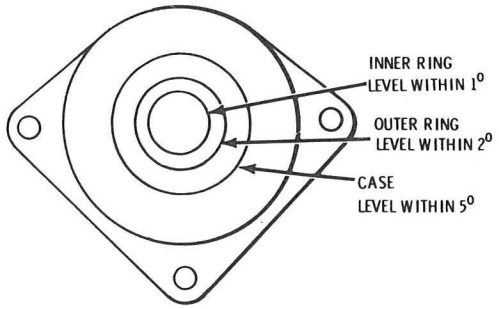
ELECTRONICS
PACKAGE

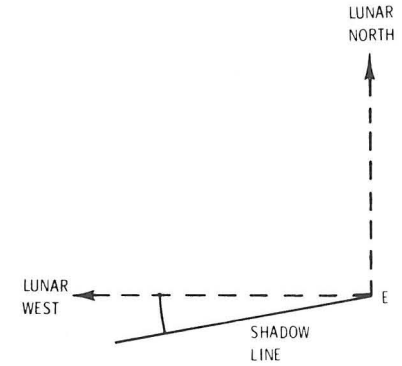
NOV 71 8948.40

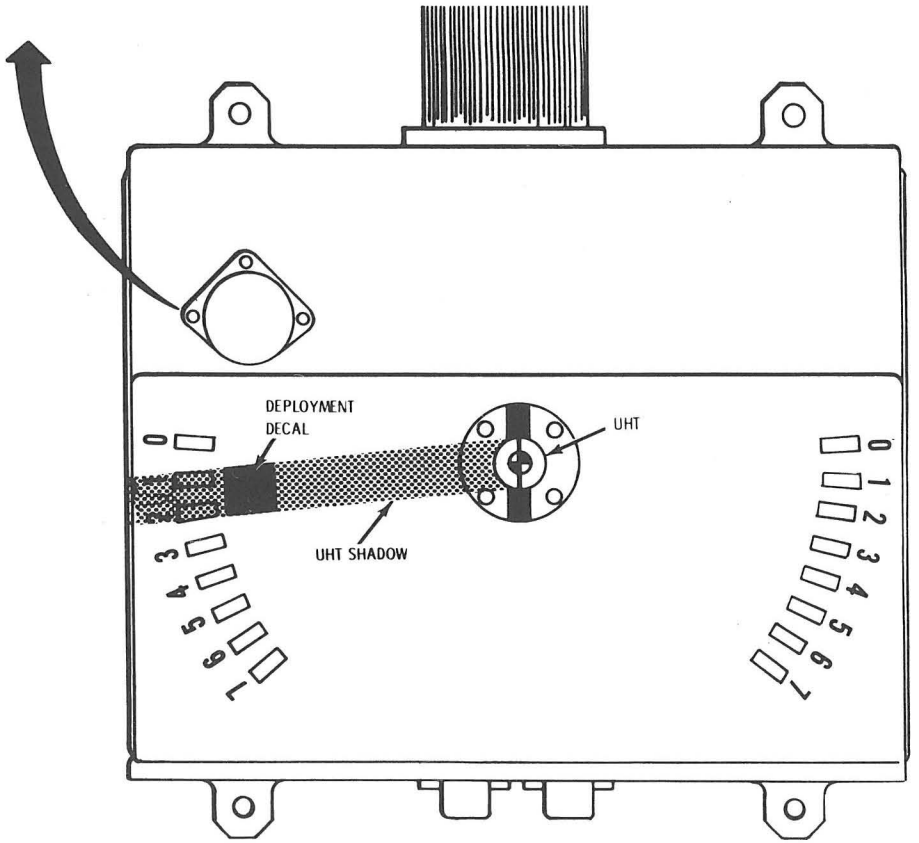
HFE DEPLOYED CONFIGURATION



HFE LEVEL AND ALIGNMENT INDICATORS







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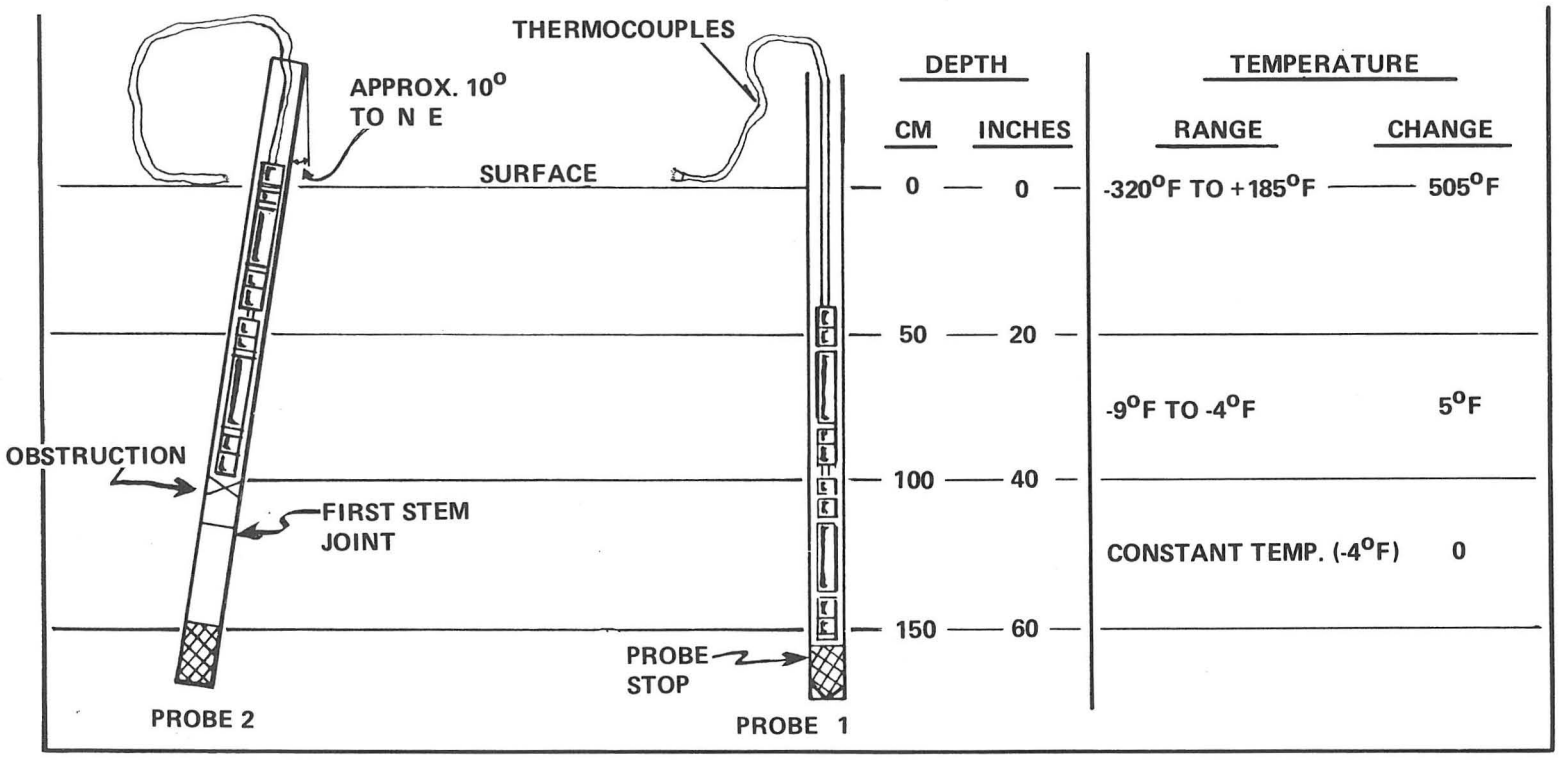
HFE EMPLACEMENT CRITERIA

	PARAMETER	REQUIREMENT	PRIORITY	INDICATOR	COMMENTS
ELECTRONICS PACKAGE	DISTANCE FROM SUBPACKAGE 1	29 ± 1 ft (30 ft CABLE)	2	PACED OFF	TO OBTAIN PROBE SEPARATION FROM RTG*
	DIRECTION FROM SUBPACKAGE 1	SOUTH	2	EYEBALL	GREATER THAN 80° FROM RTG
	LEVEL	±5° OF HORIZ.	2	BUBBLE LEVEL	INTERACTS WITH ALIGNMENT
	ALIGN WRT SHADOW	± 5° OF SHADOW LINE	2	UHT SHADOW, SUN COMPASS, DECAL	THERMAL REQ FOR SUN SHIELD SHADOWS TO ALIGN WITH PLATE EDGES
PROBES (2)	DISTANCE FROM ELECTRONICS	17 ± 1 ft (20 ft CABLE TO HOLE)	1	PACED OFF (CABLE MARKED FOR DEPTH)	TO OBTAIN 30 ft SEPARATION BETWEEN PROBES (REQUIREMENT)
	DIRECTION FROM ELECTRONICS	PROBE 1 WEST; PROBE 2 EAST	1	EYEBALL	PROBE AND RTG SEPARATION* AVOID SHADOWS FROM ALL SUBSYSTEMS **
	VERTICAL ALIGNMENT	WITHIN ± 15°	2	EYEBALL	OBJECTIVE FOR DRILLING
EXPERIMENT INTERRELATION		*SEPARATION DISTANCE FROM RTG: 40 ft MINIMUM. **EACH PROBE SHOULD BE AT LEAST 17 FEET FROM ALL OTHER EQUIPMENT AND PACKAGING DEBRIS.			
SPECIAL REQUIREMENTS		AVOID MAJOR DISTURBANCES (TRAMPLING, ETC.) AND SHADOWS IN 17 FT CIRCLE AROUND PROBE.			

HFE PROBE EMPLACEMENT ON APOLLO 15



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OPERATING EXPERIENCE

NOV 71 8948.45

TWO YEARS OF ALSEP OPERATION

	APOLLO 11	APOLLO 12	APOLLO 14	APOLLO 15
DEPLOYMENT DATE	JULY '69	NOV '69	FEB '71	JULY '71
NO. OF EXPERIMENTS	2	5	6	7
PRESENTLY OPERATING	NO	YES	YES	YES
OPERATING TIME (DAYS)*	71	725	282	106
LUNATIONS	5	25	10	4

EACH ALSEP PROVIDES 9 MILLION MEASUREMENTS PER DAY

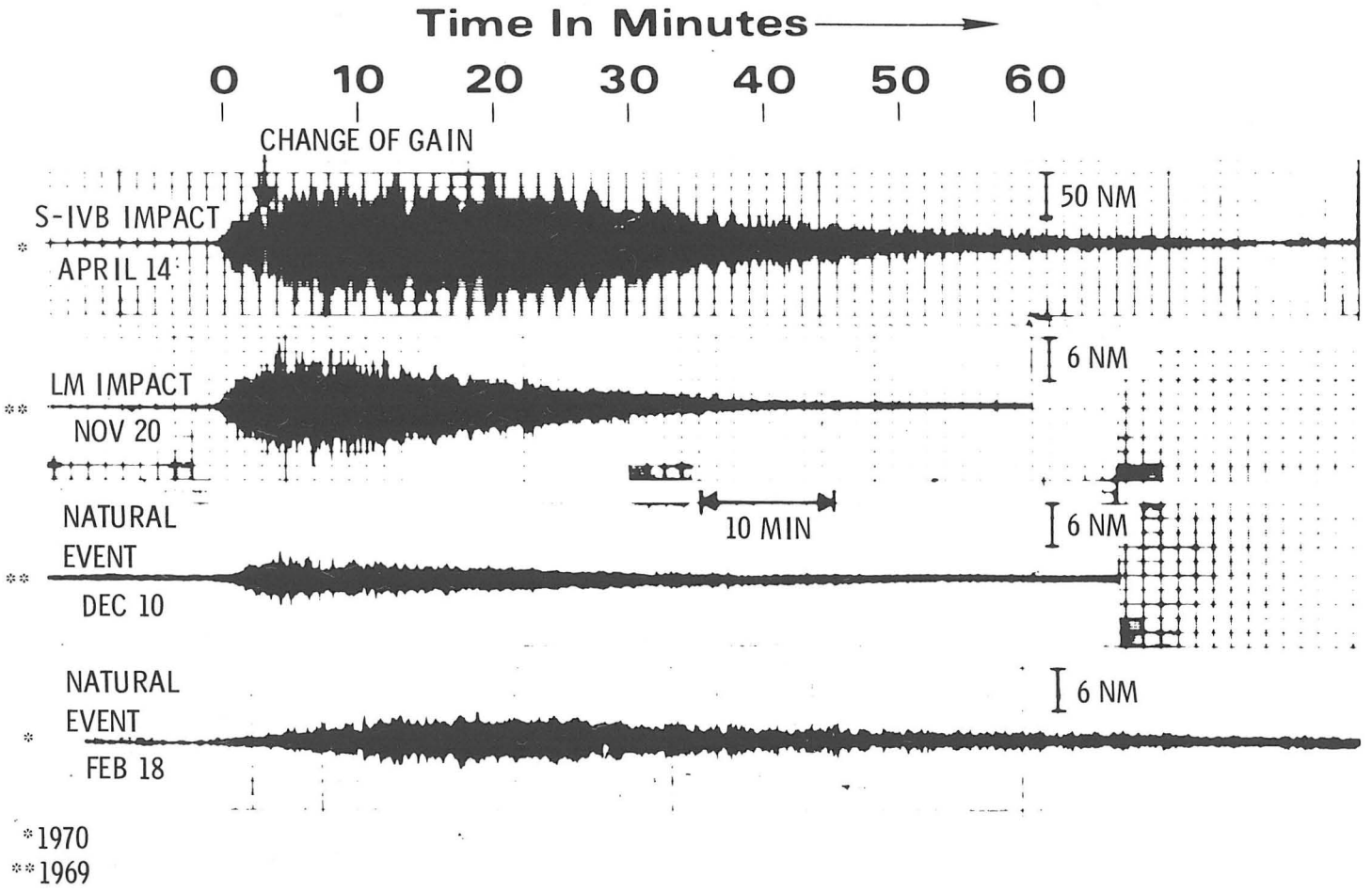
*AS OF 14 NOV 1971

NOV 71 8948.46

SCIENTIFIC ACHIEVEMENTS (PSE)

- PASSIVE SEISMIC EXPERIMENT (PSE)
  - LUNAR OUTER STRUCTURE IS ROCK CLUMPS, BUT THERE IS A CRUST AND MANTLE (LIKE EARTH) WITH CRUST THICKNESS OF 55 TO 70 KM
  - 2-5 MOONQUAKES PER MONTH – USUALLY NEAR PERIGEE – AT DEPTHS OF 800 KM
  - DAILY METEOROID IMPACTS
  - UNEXPECTED STRONG "RINGING" FROM MAN-MADE IMPACTS

TYPICAL SEISMIC DATA



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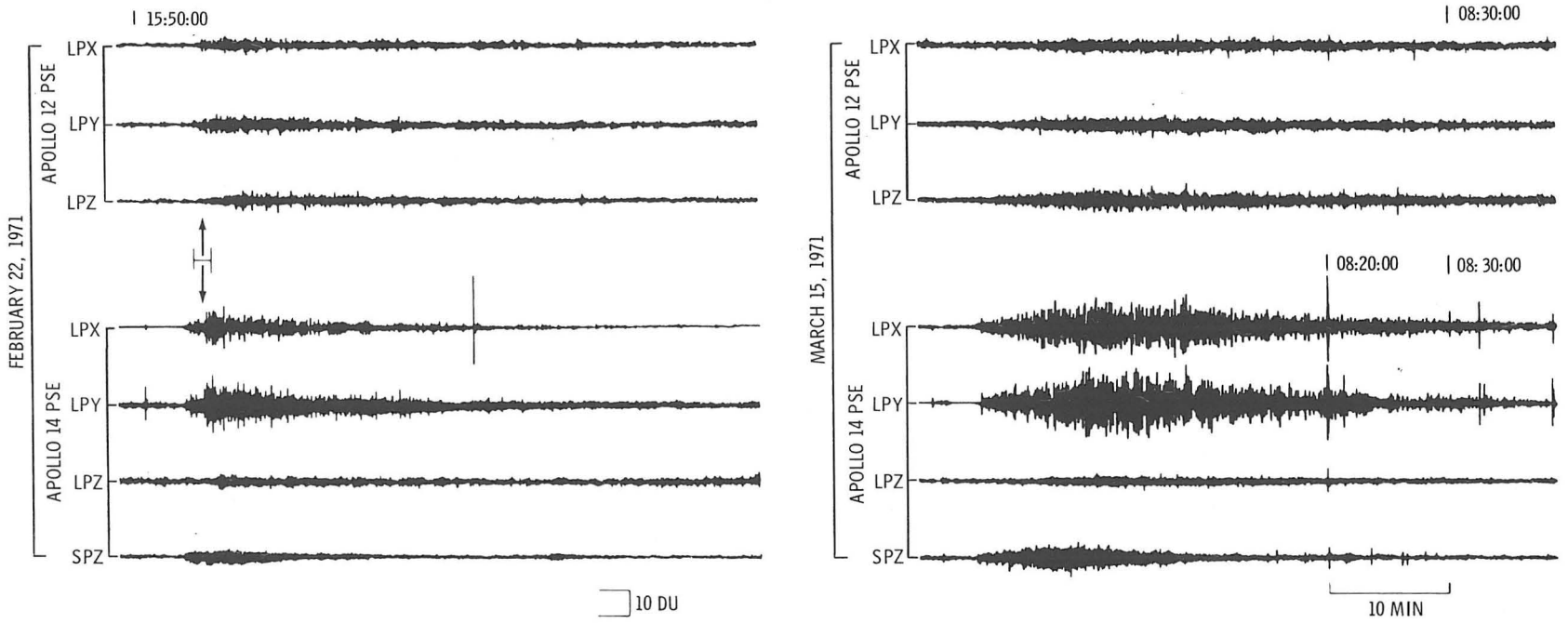
MOONQUAKE AND METEOROID IMPACT



NOV 71 8948.49

SCIENTIFIC ACHIEVEMENTS (SIDE AND CCIG)

- SUPRATHERMAL ION DETECTOR EXPERIMENT (SIDE)
  - DETECTS SOLAR STORMS AND MAN-MADE IMPACTS, AS EXPECTED
  - ONE GAS CLOUD, BELIEVED TO BE CORRELATED WITH MOONQUAKE ON 7 MARCH 1971, SHOWS EVIDENCE OF WATER
  - UNEXPECTED ION CONCENTRATIONS AT LUNAR SUNRISE AND SUNSET, AND IN GEOMAGNETIC TAIL TRANSITION REGION (FLOWING DOWNSTREAM WITH SOLAR WIND)
- COLD CATHODE ION GAGE (CCIG)
  - NEUTRAL PARTICLE CONCENTRATION VARIES FROM 10^7 ATOMS/CC DURING DAY TO 2×10^5 ATOMS/CC AT NIGHT
  - FREQUENT TRANSIENT INCREASES
  - TRANSIENTS UP TO 2×10^7 WITHIN TWO MINUTES OF SUNRISE

SCIENTIFIC ACHIEVEMENTS (SWS AND LSM)

- SOLAR WIND SPECTROMETER (SWS)
  - BASIC BEHAVIOR OF SOLAR WIND

    SAME AS FREE-SPACE OUTSIDE EARTH'S MAGNETIC TAIL

    SLIGHTLY PERTURBED IN GEOMAGNETIC TRANSITION REGION

    DOES NOT PENETRATE TO CENTER OF TAIL
  - SWS UNEXPECTEDLY DETECTED GAS CLOUD FROM APOLLO 13 S-IVB IMPACT
- LUNAR SURFACE MAGNETOMETER (LSM)
  - 38 GAMMA STEADY FIELD AT APOLLO 12 SITE; 6 GAMMA AT APOLLO 15 SITE
  - TEMPORAL CORRELATION WITH MAGNETOMETER ON EXPLORER 35 ORBITER INDICATES ELECTRICAL CURRENTS DEEP WITHIN MOON
  - CORRESPONDING TEMPERATURE PROFILE ESTIMATES:

    810^{0}K IN SHELL AT 0.6 LUNAR RADIUS

    1240^{0}K AT CORE (3000^{0} TO 5000^{0}K AT CORE OF EARTH)

SCIENTIFIC ACHIEVEMENTS (ASE AND CPLEE)

- ACTIVE SEISMIC EXPERIMENT (ASE)
  - 104 METER/SEC SEISMIC VELOCITY AGREES WITH PSE DATA
  - 8.5 METER SURFACE LAYER (REGOLITH) AT APOLLO 14 SITE

- CHARGED PARTICLE LUNAR ENVIRONMENT EXPERIMENT (CPLEE)
  - DETECTS LARGE CHANGES IN SOLAR WIND FLUX
  - LOW ENERGY PHOTO-ELECTRONS DETECTED DURING LUNAR DAY
  - UNEXPECTED DETECTION OF ELECTRONS WITH TERRESTRIAL AURORAE BAND ENERGIES IN MAGNETOSPHERIC TAIL

SCIENTIFIC ACHIEVEMENTS (HFE AND LRRR)

- HEAT FLOW EXPERIMENT (HFE)
  - LIMITED PENETRATION HAS NOT COMPROMISED ACHIEVEMENT OF SCIENTIFIC OBJECTIVES
  - PROBE DATA INDICATE SURFACE LAYER IS IDEAL THERMAL BLANKET

NIGHT SURFACE TEMP	$76^{\circ}K$ ($-320^{\circ}F$)
DAY SURFACE TEMP	$358^{\circ}K$ ($+185^{\circ}F$)
SUBSURFACE AT 1.5 M VIRTUALLY CONSTANT AT	$253^{\circ}K$ ($-4^{\circ}F$)

  - HEAT FLOW APPROX 3.3×10^{-6} WATT/CM^2 (1/2 THAT OF EARTH)
  - CONDUCTIVITY AT 1.0 TO 1.5M DEPTH IS BETWEEN 1.4 AND 2.5×10^{-4} WATT/CM-$^{\circ}K$ (7 TO 10 TIMES GREATER THAN AT SURFACE)
  - DATA SUPPORT MAGNETOMETER FINDINGS
- LASER-RANGING RETRO-REFLECTOR (LRRR)
  - PRELIMINARY RESULTS FROM THREE REFLECTORS INDICATE LARGE-SCALE LUNAR SURFACE "WARPING"

FUTURE ALSEP MISSIONS

APOLLO 16

COMPLETION OF MEASUREMENT NETWORKS: –

INSTRUMENT	NETWORK COMPLEMENT
PASSIVE SEISMOMETER	4*
ACTIVE SEISMOMETER	2*
IONOSPHERE DETECTOR	3
ATMOSPHERE DETECTOR	2
SOLAR WIND SPECTROMETER	2
MAGNETOMETER	3*
HEAT FLOW PROBE	3*
LASER REFLECTOR	3

APOLLO 17

SECOND GENERATION OF SCIENTIFIC MEASUREMENT: –

- SEISMIC PROFILING
- ATMOSPHERIC SPECTRUM ANALYSIS
- METEORITE & EJECTA DETECTION
- GRAVITY FIELD SENSING
- THERMAL CONDUCTIVITY MEASUREMENT

*APOLLO 16 INSTRUMENT