ALSEP DESIGN SUMMARY

Presentation Material

BSR-2900

17 - 20 March 1970

NASA/MSC - Bendix
Aerospace Systems Division

Sec
1
2
3 PSE
4 ASE
5
6
7

Bendix Aerospace Systems Division

Section 1

Alsep System Description

ALSEP SYSTEM SUMMARY

REQUIREMENTS AND CONSTRAINTS

SYSTEM DESCRIPTION

- ARRAY A DESCRIPTION
- MISSION PROFILE
- ARRAY B DESCRIPTION
- ARRAY C DESCRIPTION
- ARRAY D DESCRIPTION

EASEP DESCRIPTION

7759-5100

LANDING SITE:

LATITUDE: ±5° / LONGITUDE: ±45°	APOLLO 11-13	LATITUDE: ±45° / LONGITUDE: ±45° PLUS MARIUS HILLS	APOLLO 14 & LATER

ASTRONAUT TASKS

- SIMPLE AND SAFE DEPLOYMENT SEQUENCE
- MAXIMUM DEPLOYMENT TIME FLIGHT 1 - 90 MINUTES

MSFN/MCC COMPATIBILITY

MULTIPLE OPERATION

- SIMULTANEOUS OPERATION OF THREE ALSEPS

POWER

- SNAP-27 RTG - 63 WATTS AT ONE YEAR

7759-5102

SYSTEM REQUIREMENTS AND CONSTRAINTS

LIFETIME: ONE YEAR

LAUNCH VEHICLE:

- INTERNAL (SEQ BAYS)
  - VOLUME: 15 CUBIC FEET
  - WEIGHT: 215 POUNDS
  - THERMAL: 20°F TO 160°F DURING FLIGHT
- EXTERNAL (FUEL CASK)
  - WEIGHT: 65 POUNDS
  - THERMAL: $<$ 100 BTU/HR INPUT TO LM
- ENVIRONMENTAL
  - VIBRATION - LAUNCH, BOOST, AND LUNAR DESCENT

LUNAR SURFACE

- TEMPERATURE: -300°F TO +250°F
- VACUUM: $<10^{-12}$ TORR
- DUSTY MOON

7759-5101

1-1A

ALSEP FLIGHT ASSIGNMENTS

APOLLO 11	EASEP
APOLLO 12	ARRAY A
APOLLO 13	ARRAY B
APOLLO 14	ARRAY C
APOLLO 15	ARRAY A-2
APOLLO 16	ARRAY D

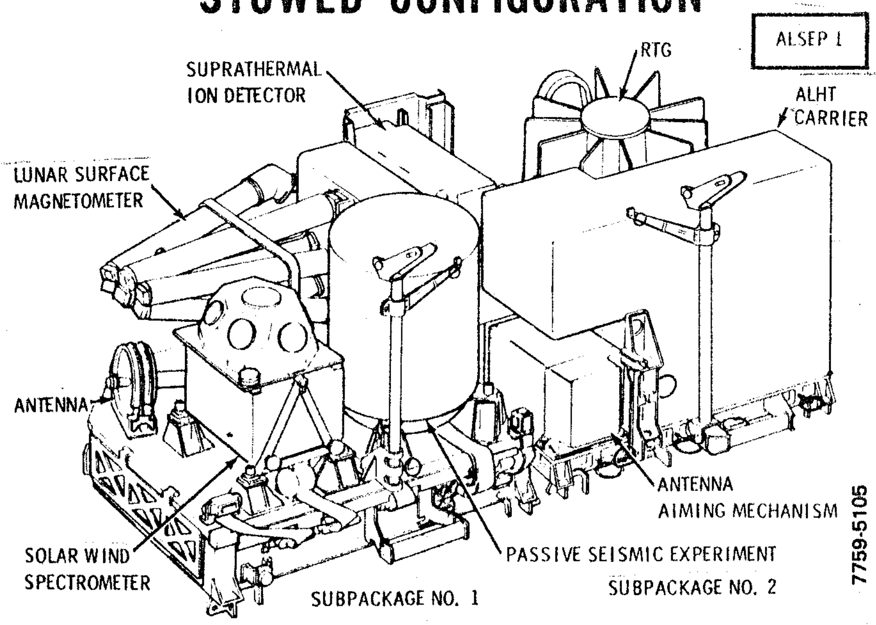
7759-5103

ARRAY A

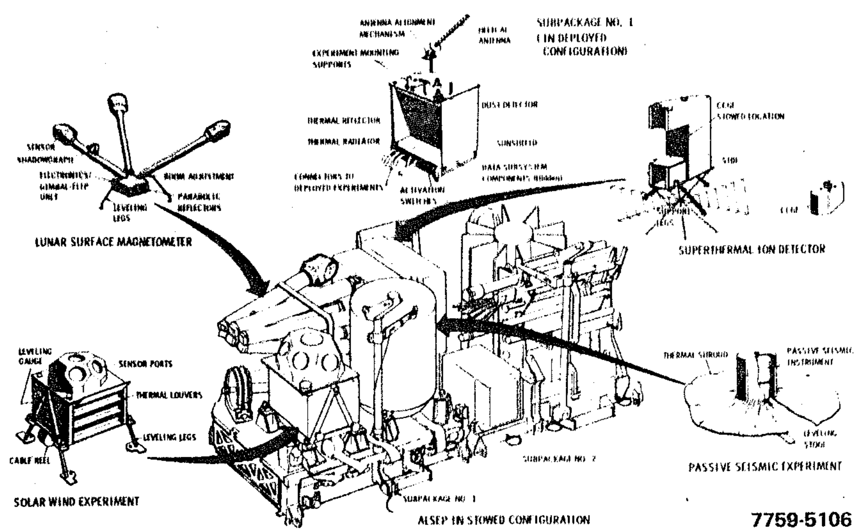
CONFIGURATION DESCRIPTION

7759-5104

STOWED CONFIGURATION

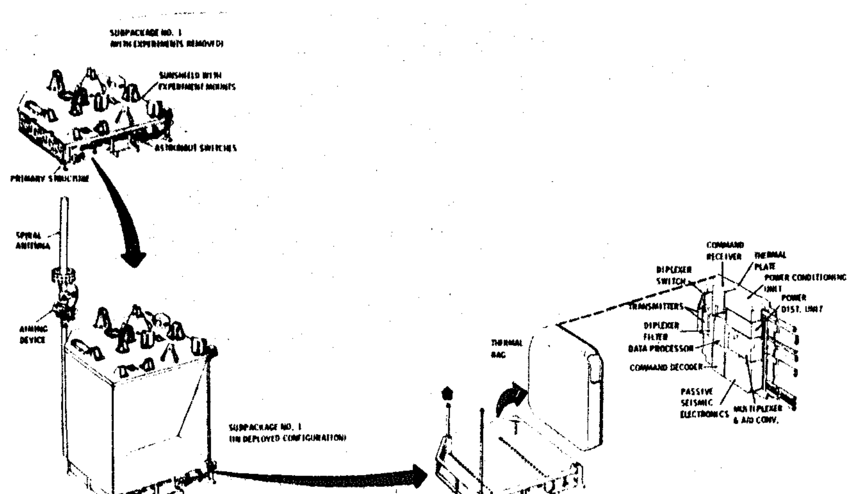


ALSEP IN STOWED CONFIGURATION



7759-5106

ALSEP CENTRAL STATION



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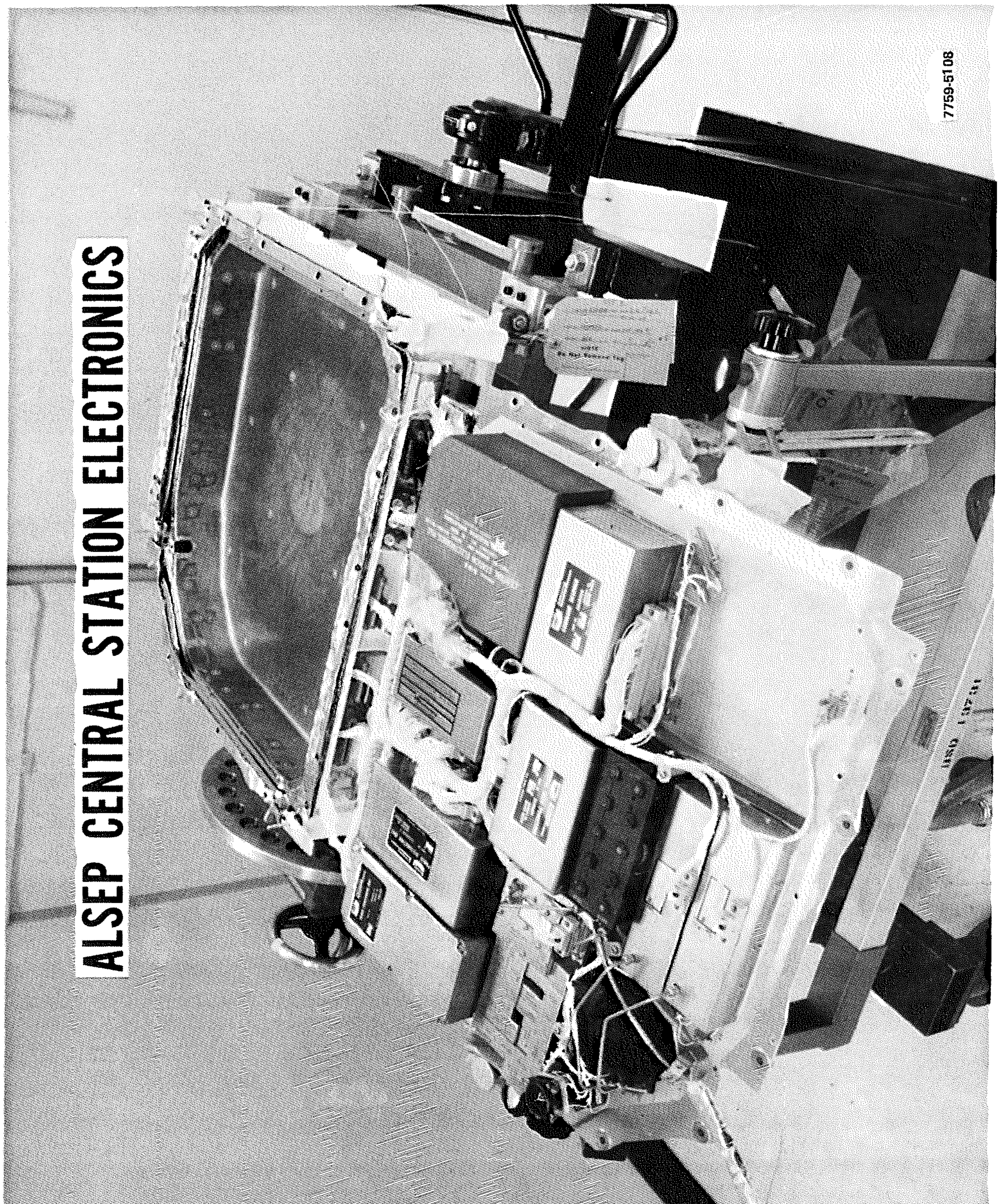
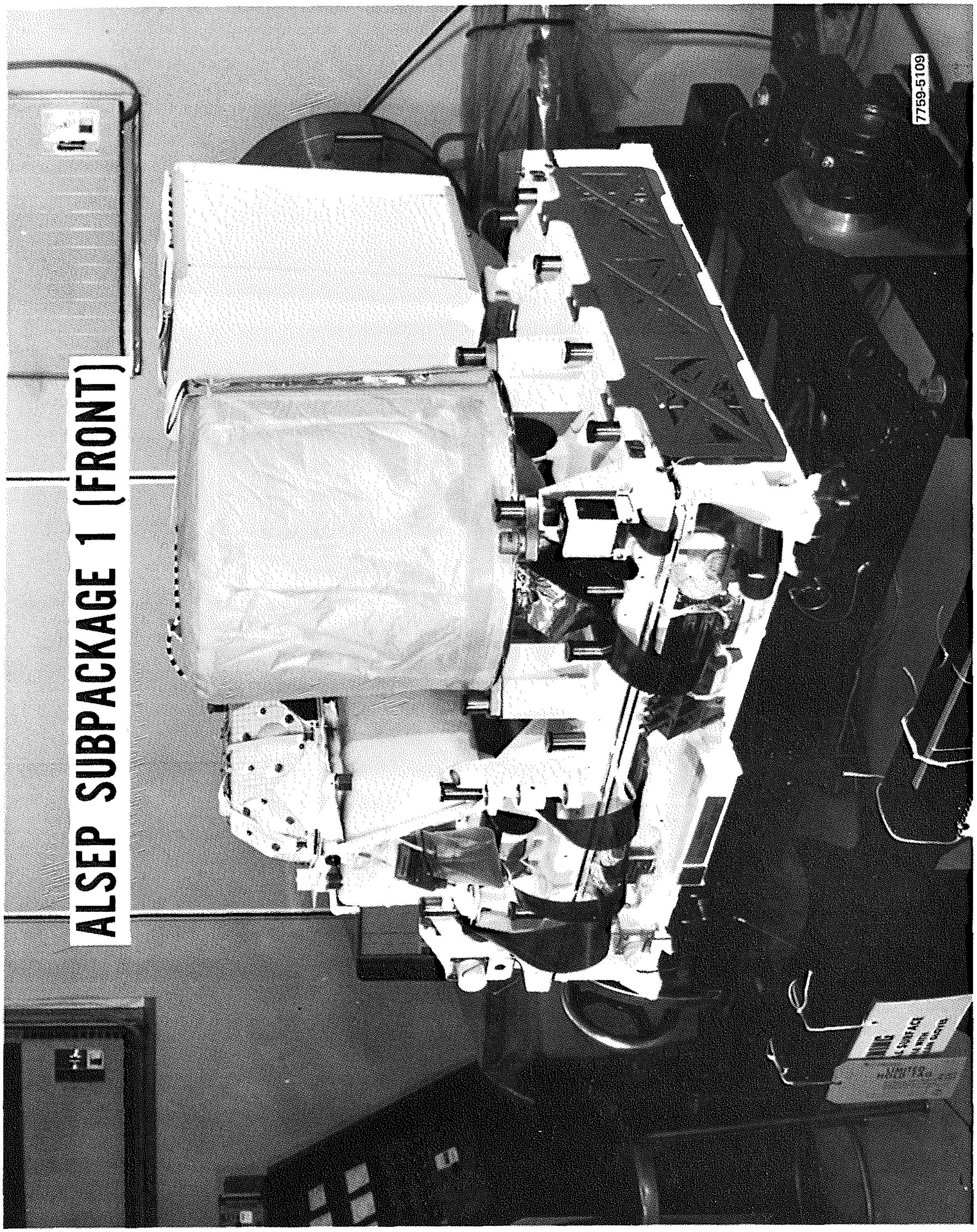
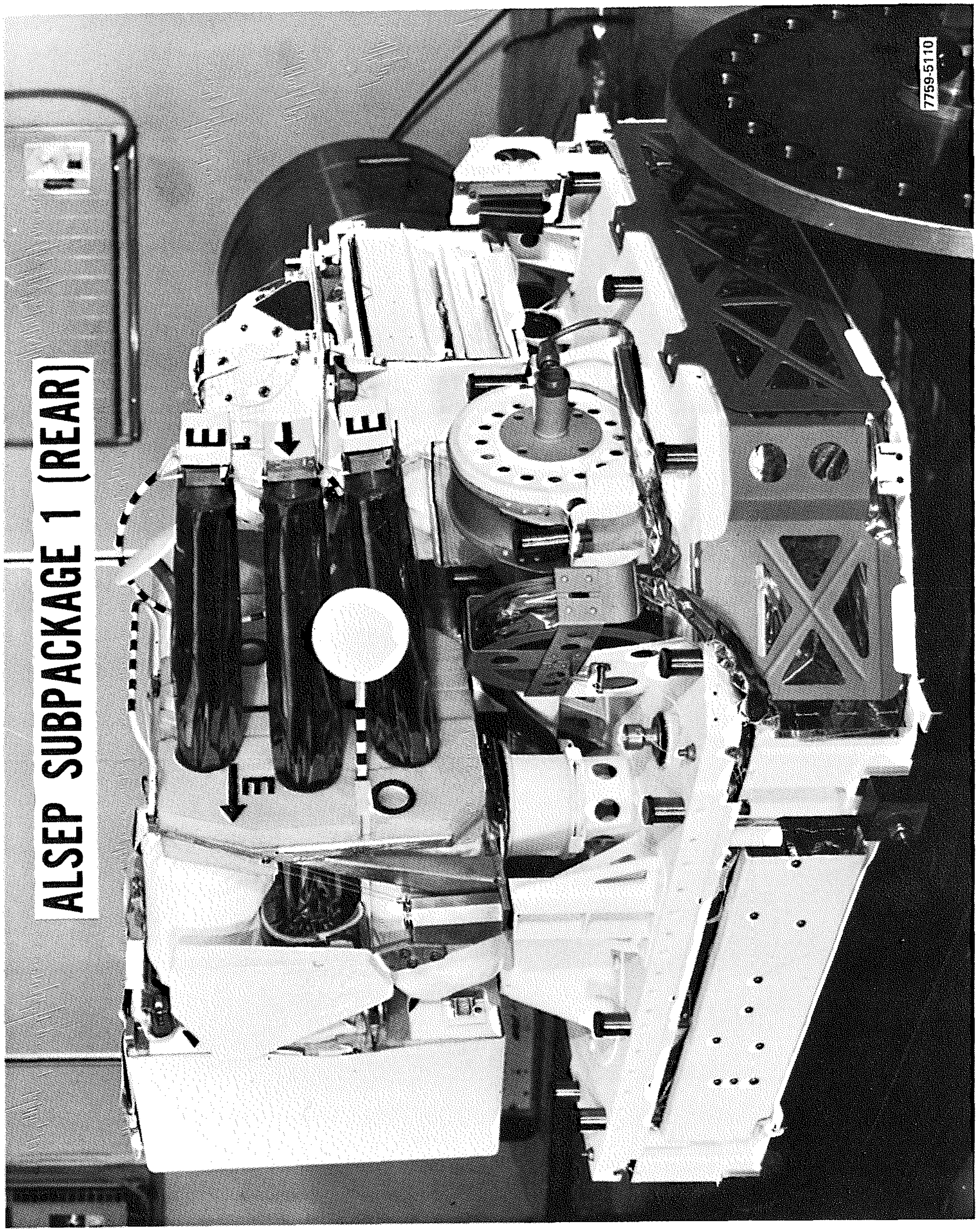
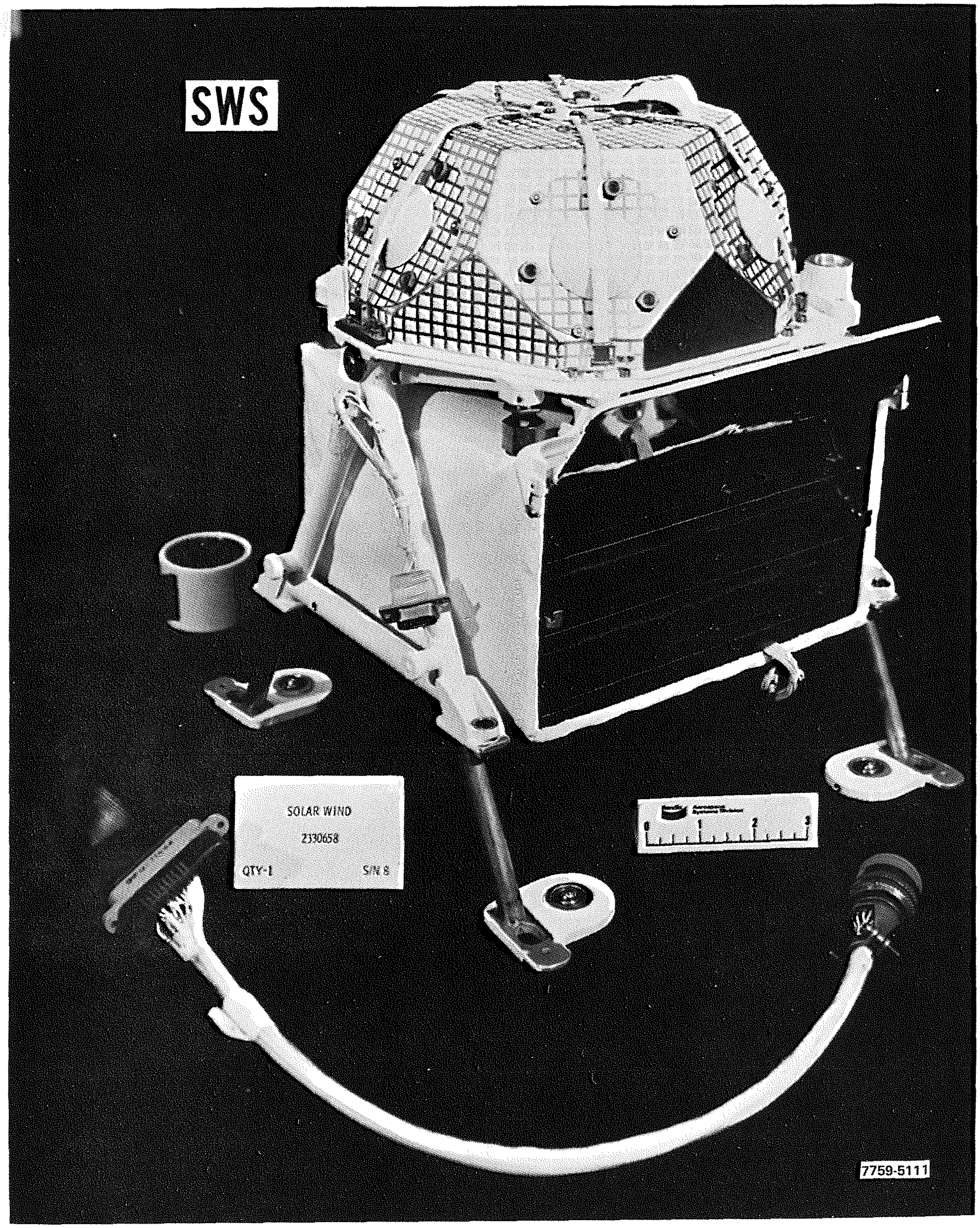
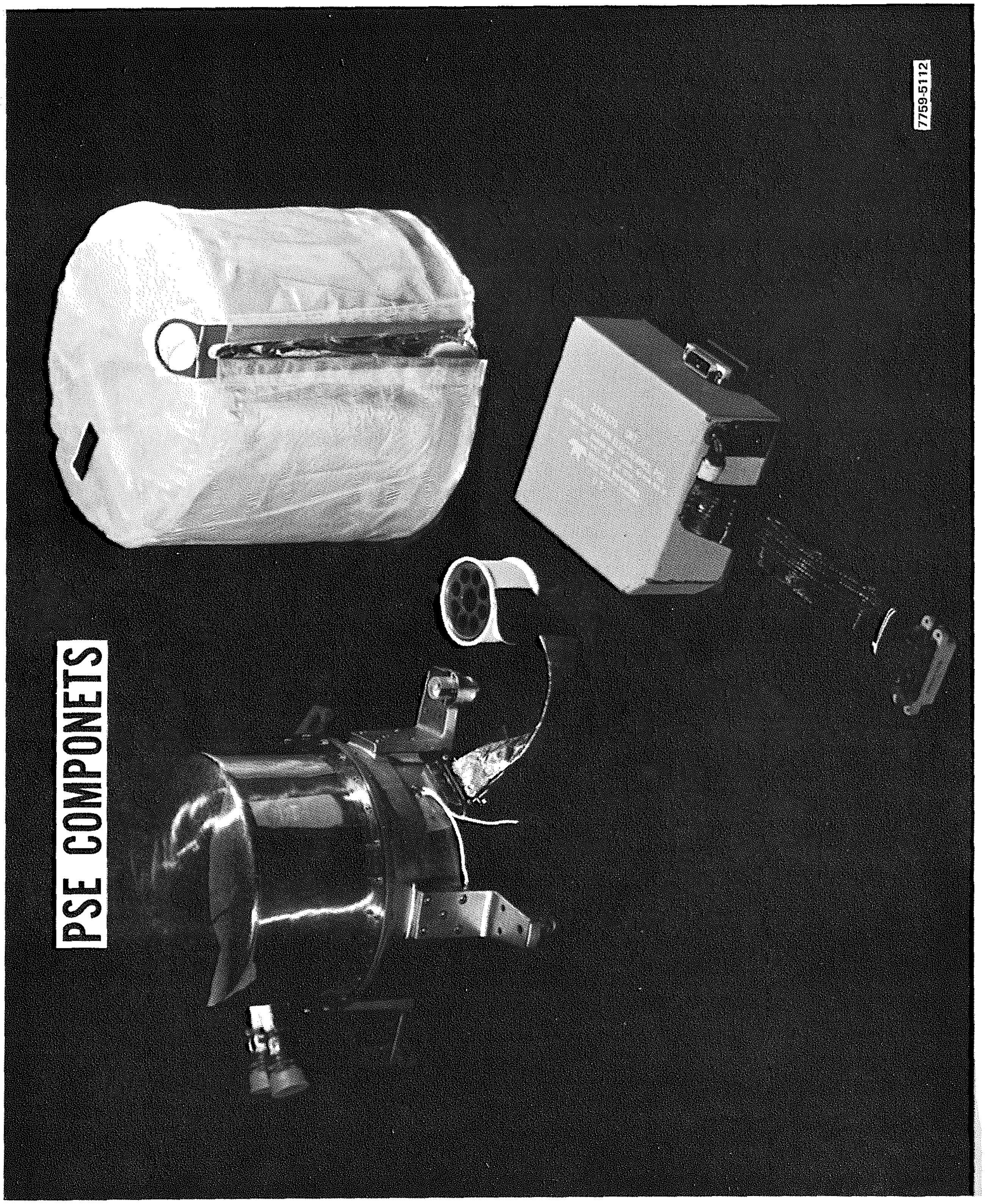

ALSEP CENTRAL STATION ELECTRONICS
7759-5108


ALSEP SUBPACKAGE 1 (FRONT)
7759-5109


ALSEP SUBPACKAGE 1 (REAR)
7759-5110


SWS
SOLAR WIND
2330658
QTY-1
S/N 8
7759-5111


PSE COMPONETS
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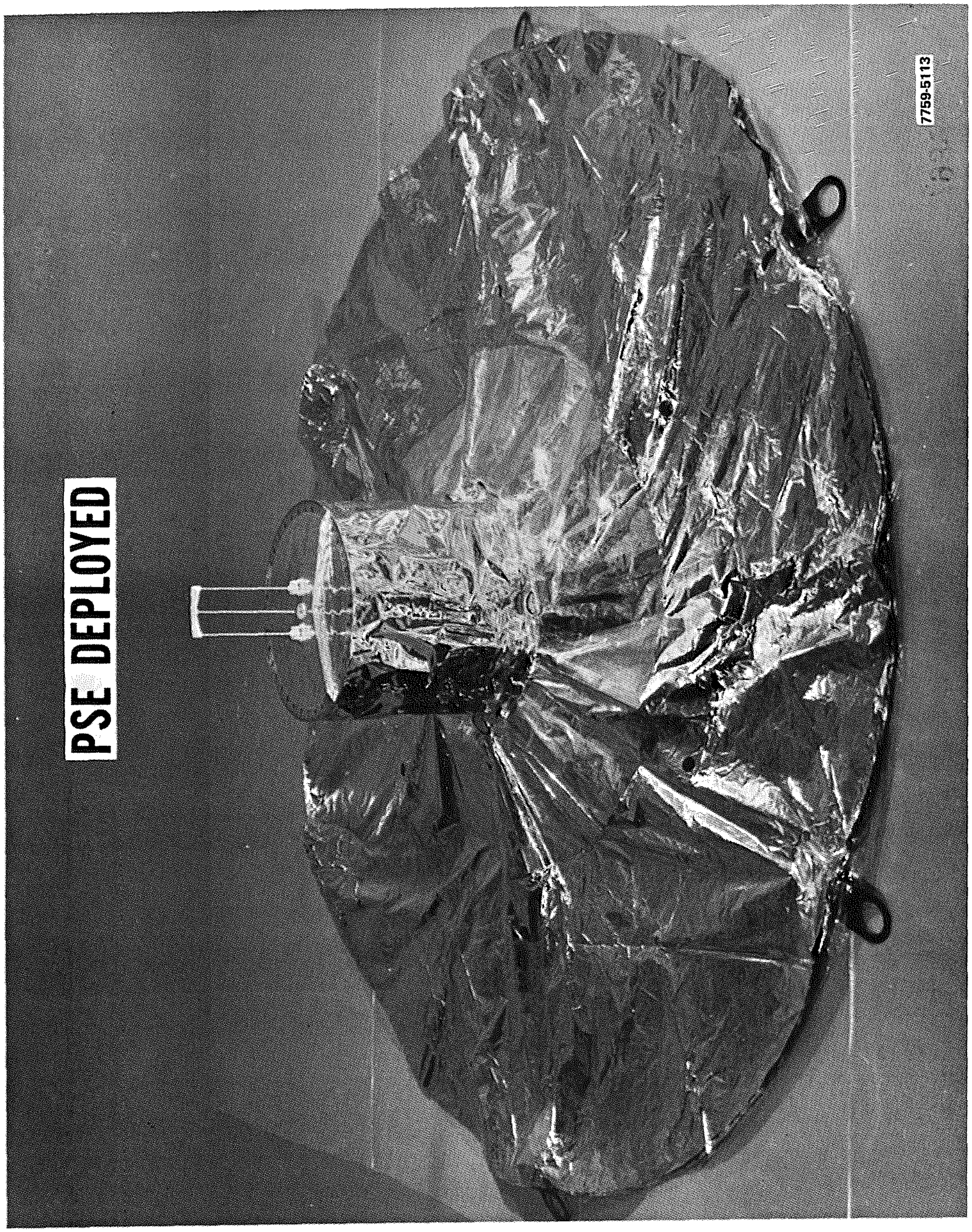
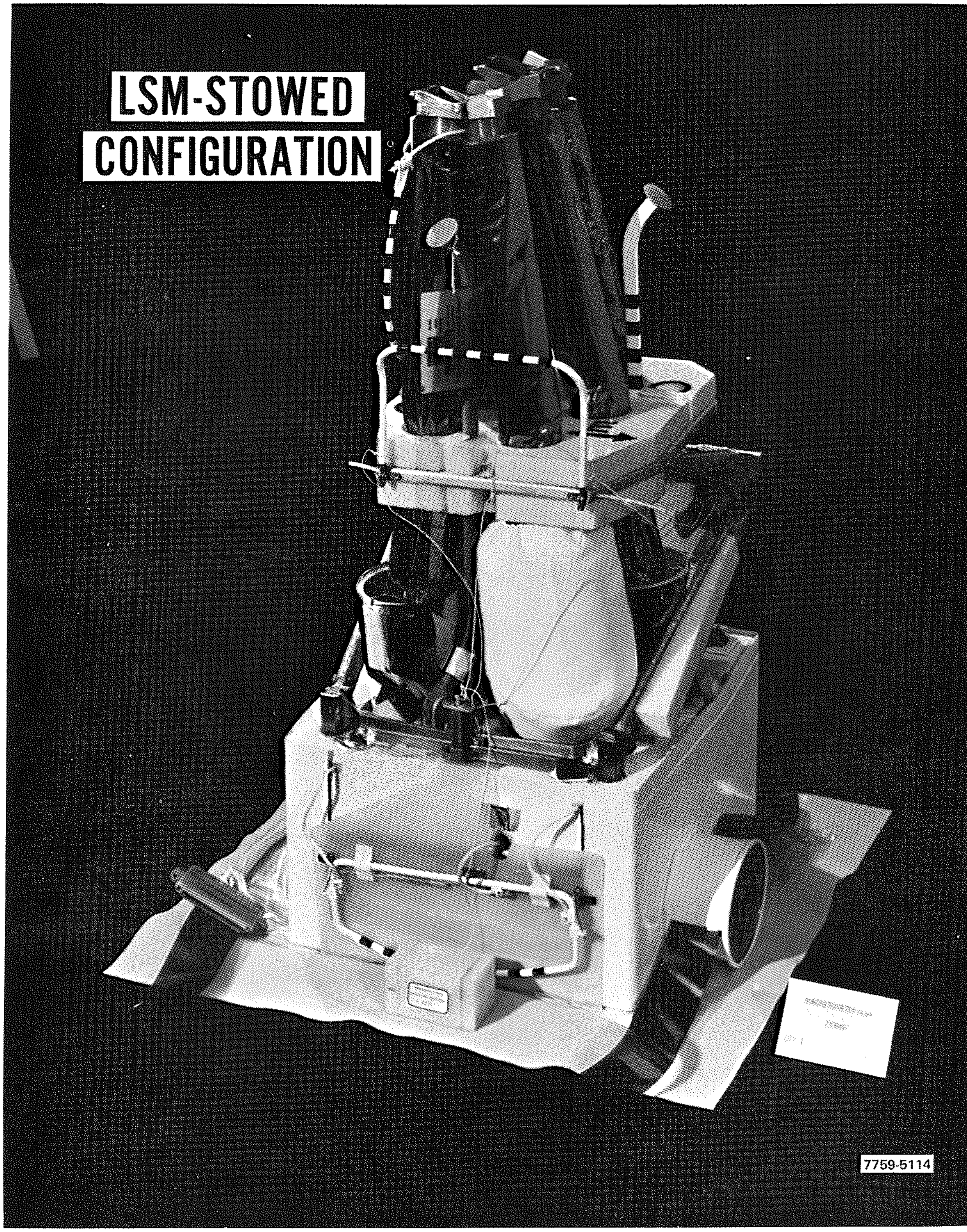
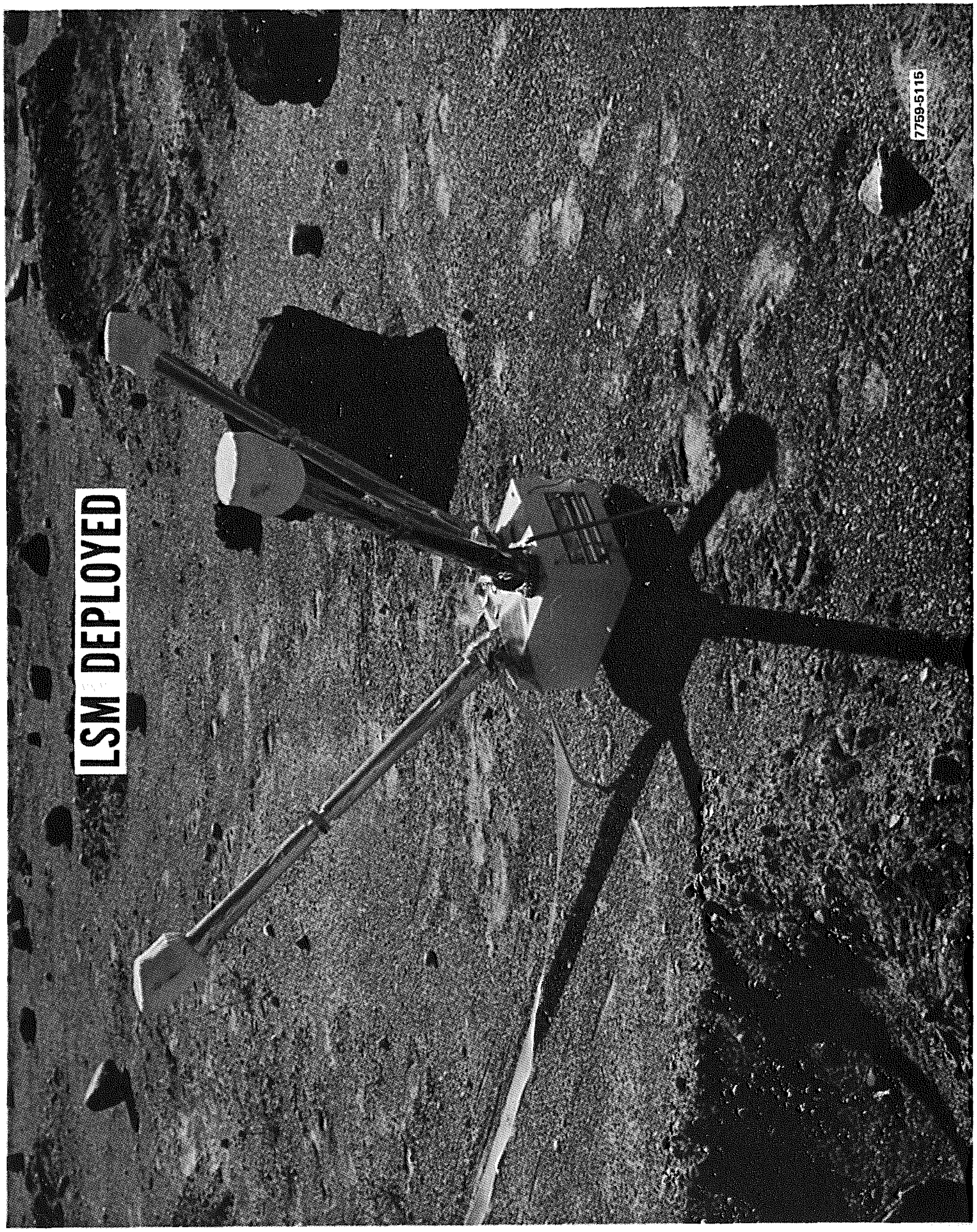

PSE DEPLOYED
7759-5113


LSM-STOWED
CONFIGURATION
7759-5114


LSM DEPLOYED
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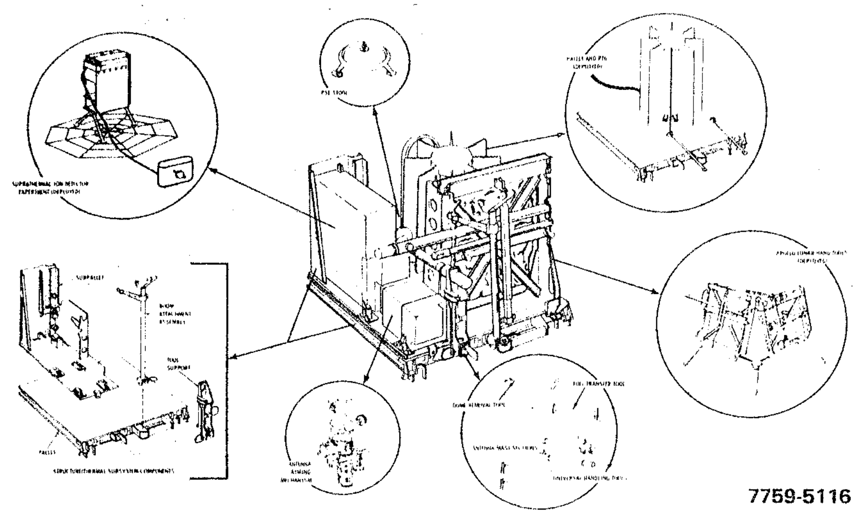

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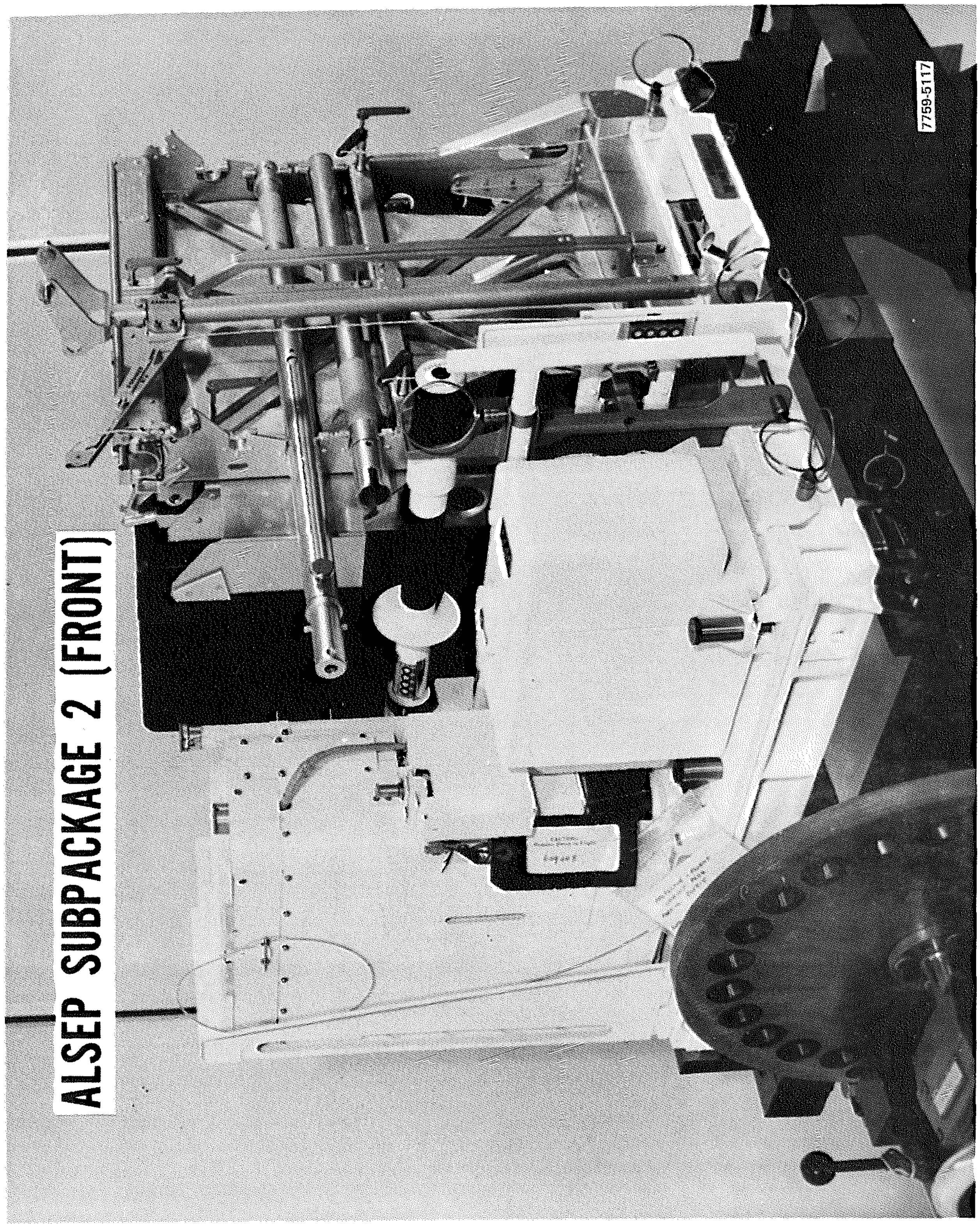
ALSEP SUBPACKAGE 2 (FRONT)
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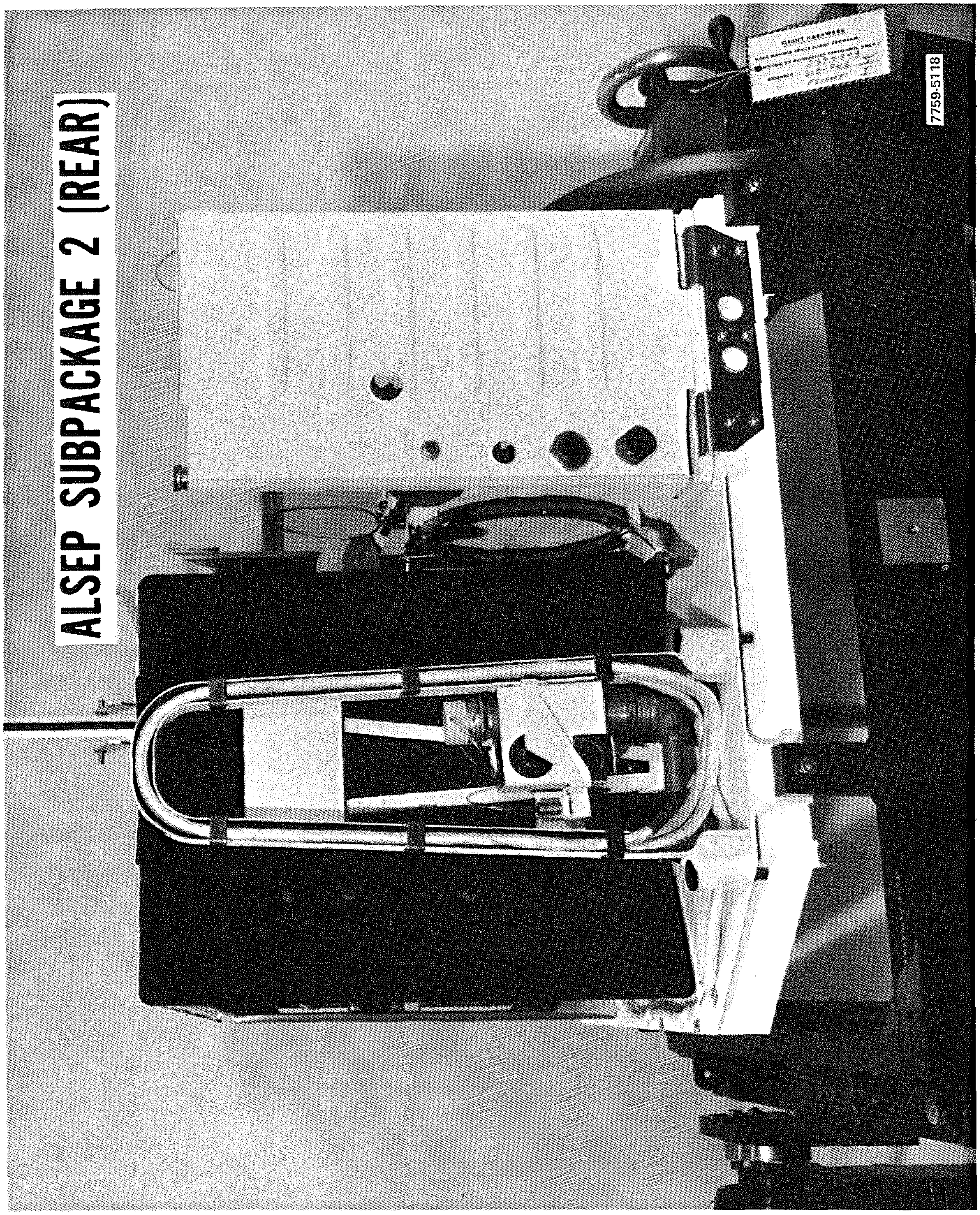
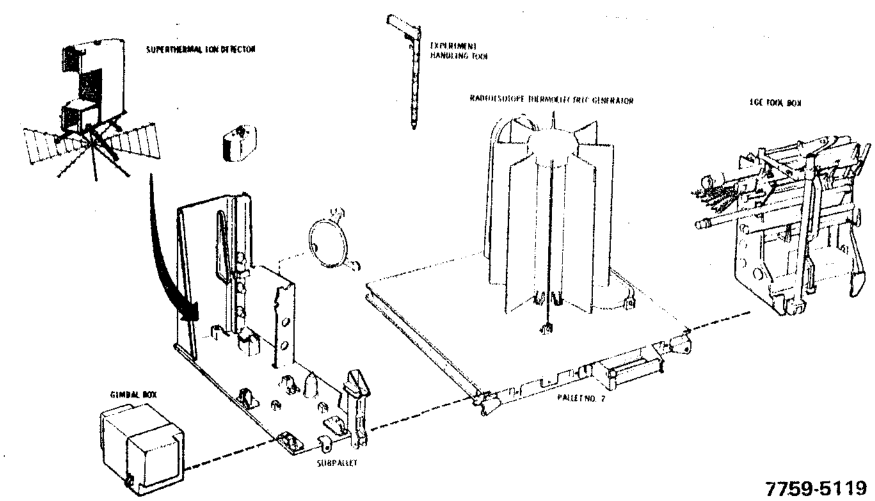

ALSEP SUBPACKAGE 2 (REAR)
7759-5118

SUBPACKAGE NO. 2



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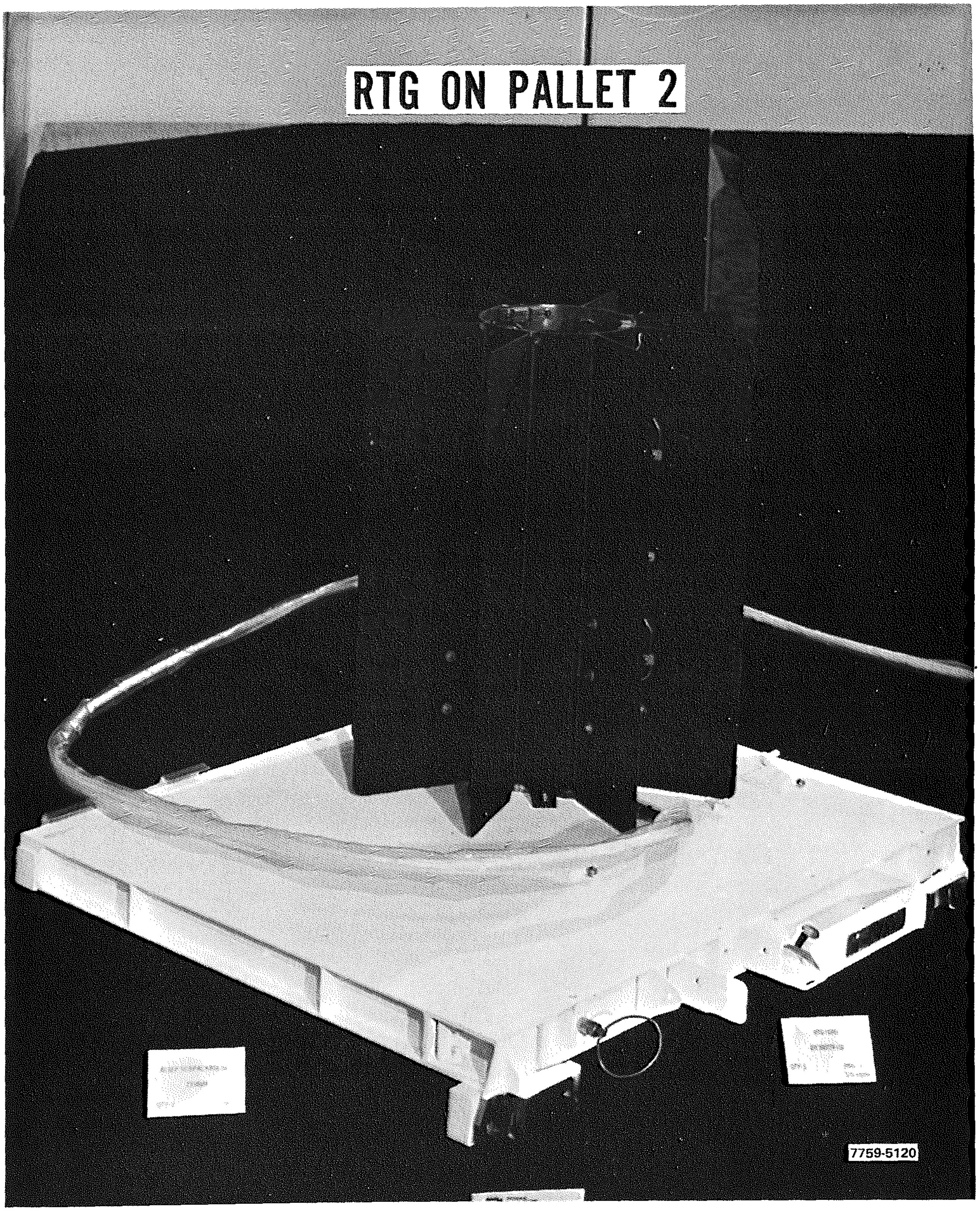
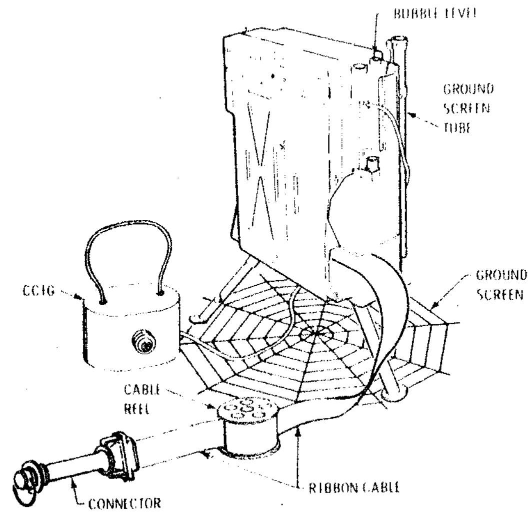

RTG ON PALLET 2
7759-5120

SIDE



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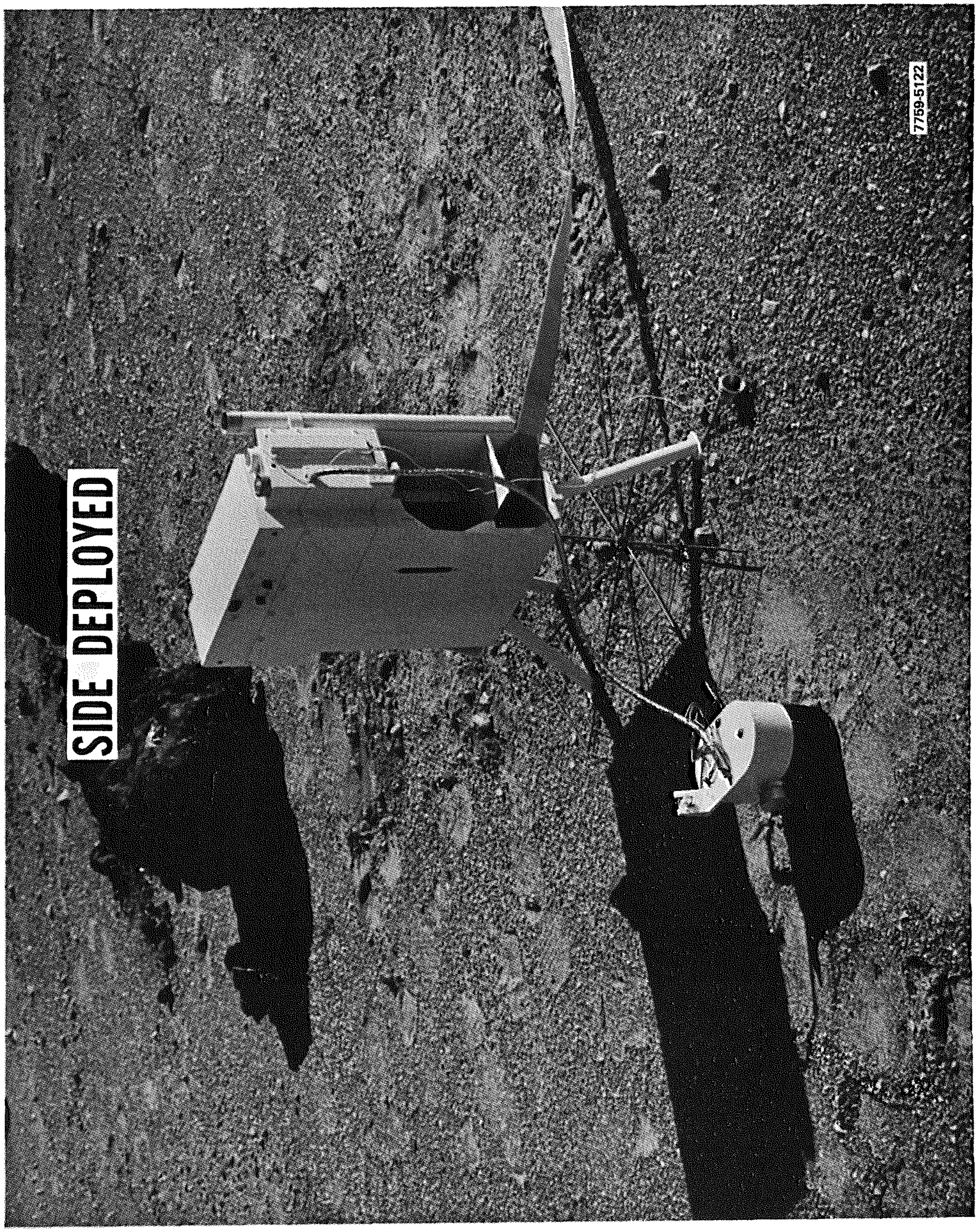
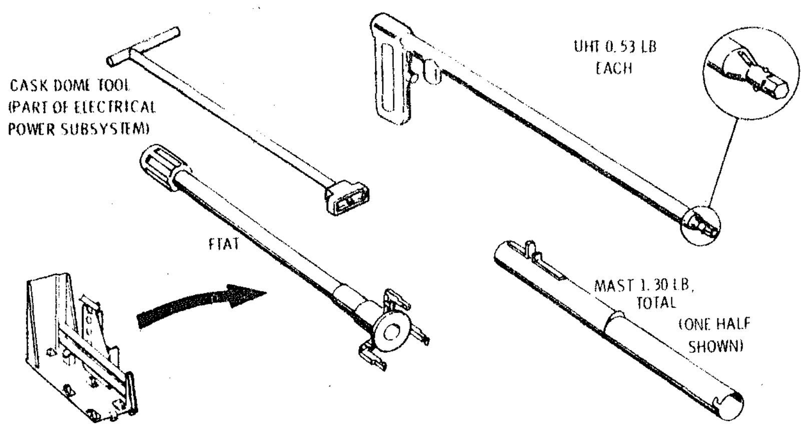

SIDE DEPLOYED
7759-5122

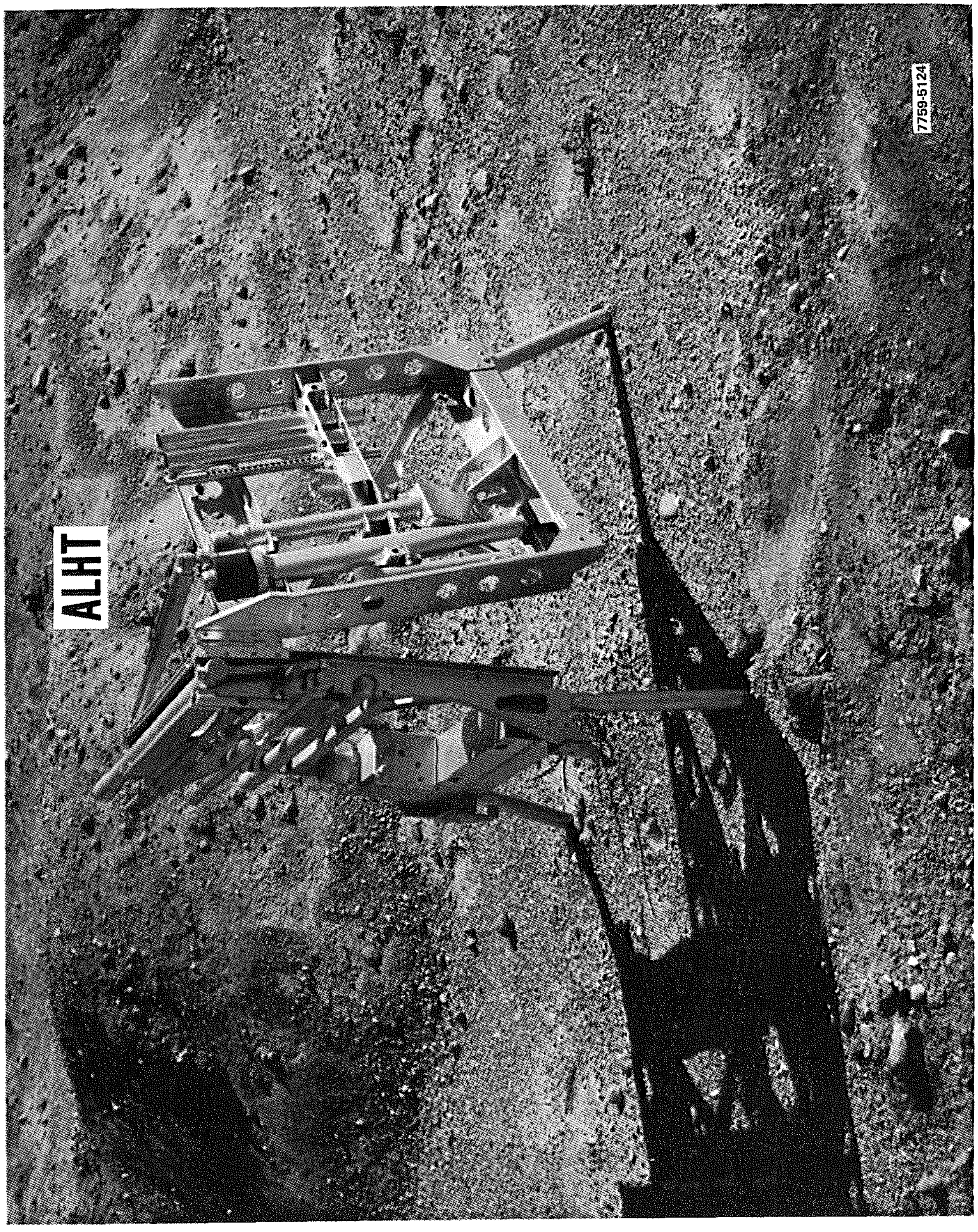
SPECIAL TOOLS

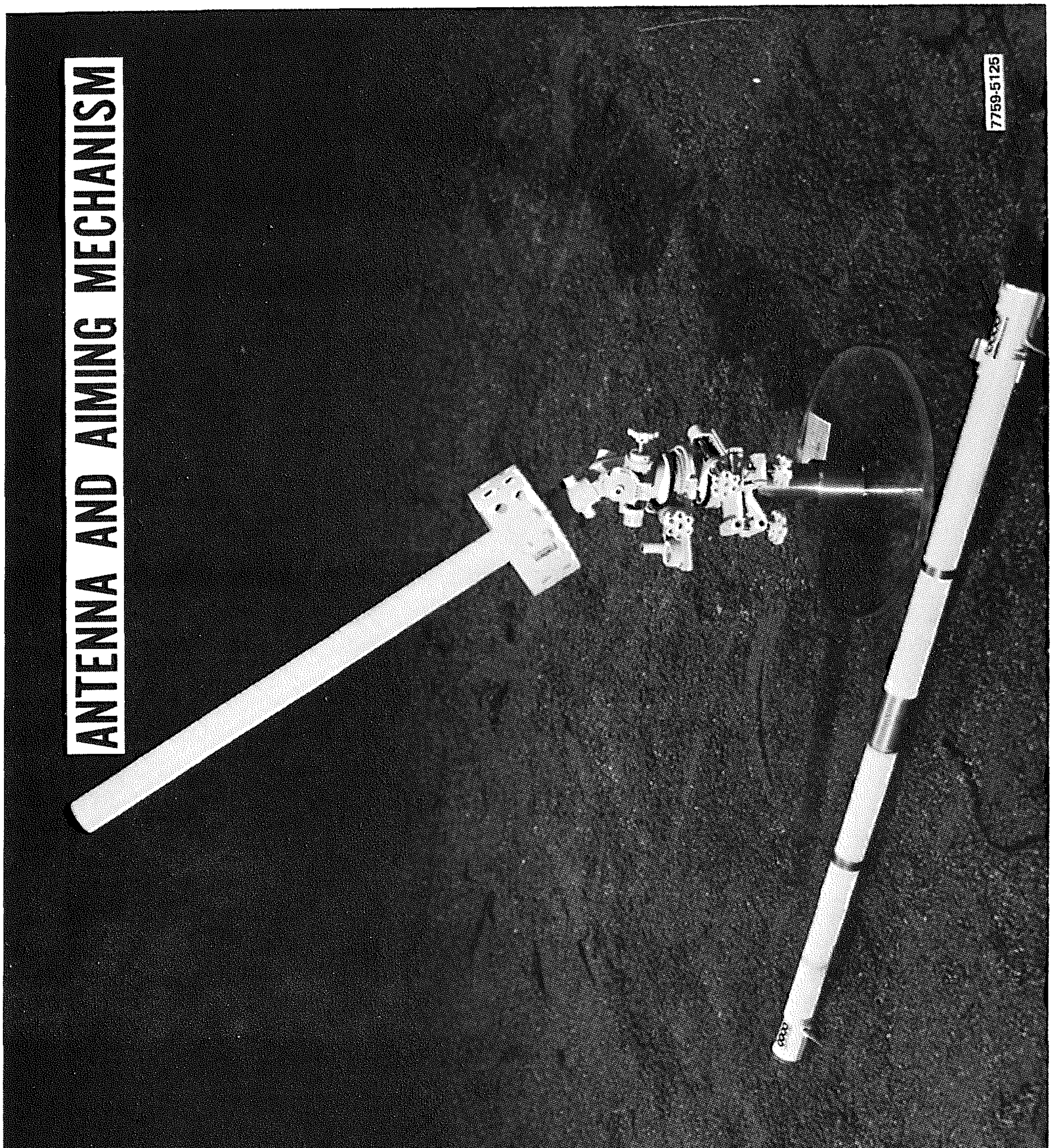


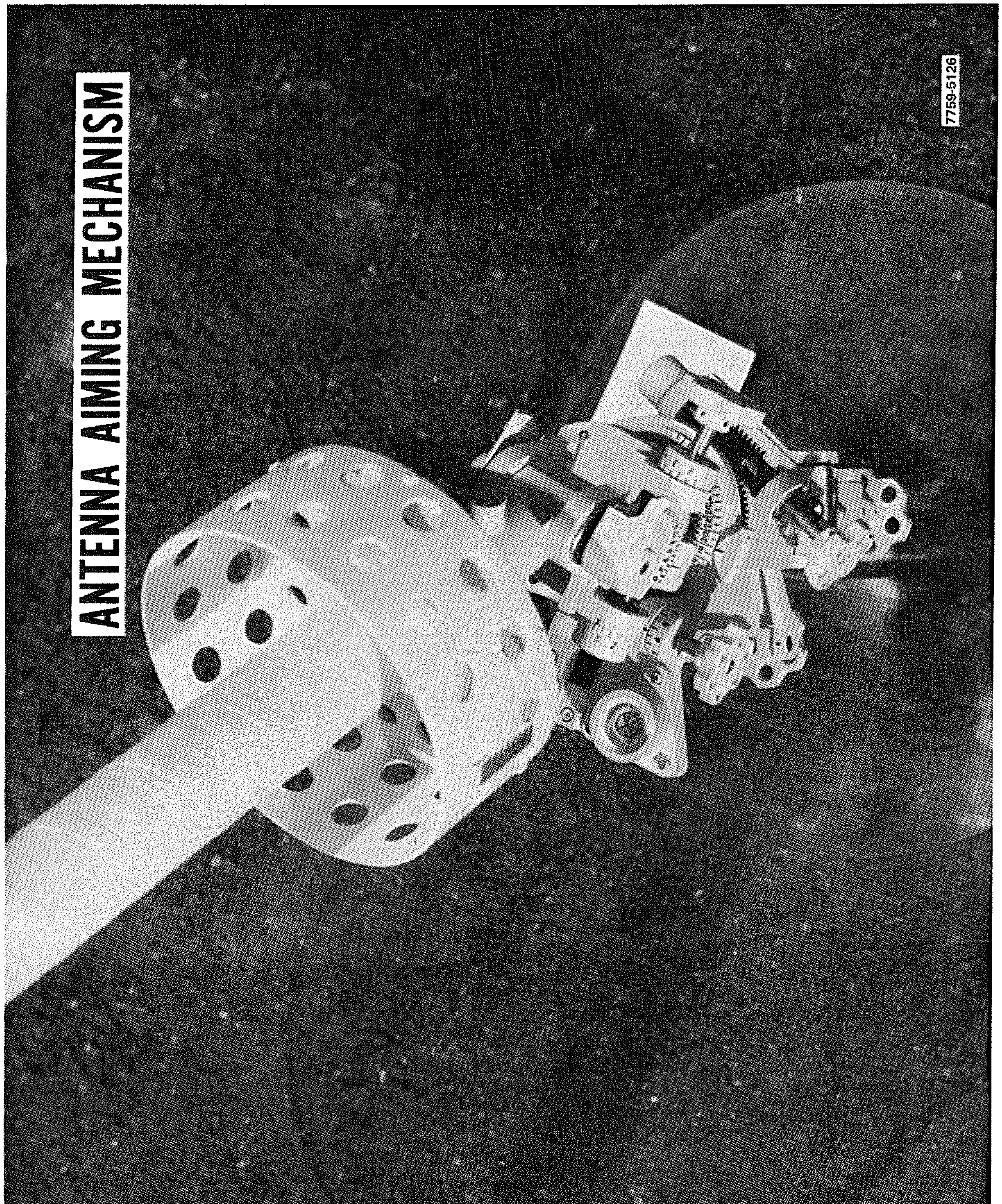
ALL WEIGHTS ARE EARTH LB

14.6 LB FUEL CASK MOUNT & INSULATION, PART OF STRUCTURE/THERMAL SUBSYSTEM, COVERED UNDER ELECTRICAL POWER SUBSYSTEM

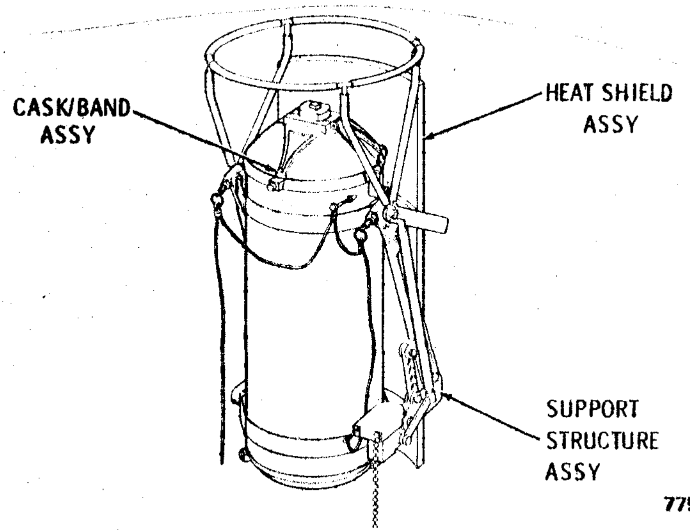
7759-5123


ALHT
7759-5124


ANTENNA AND AIMING MECHANISM
7759-5125

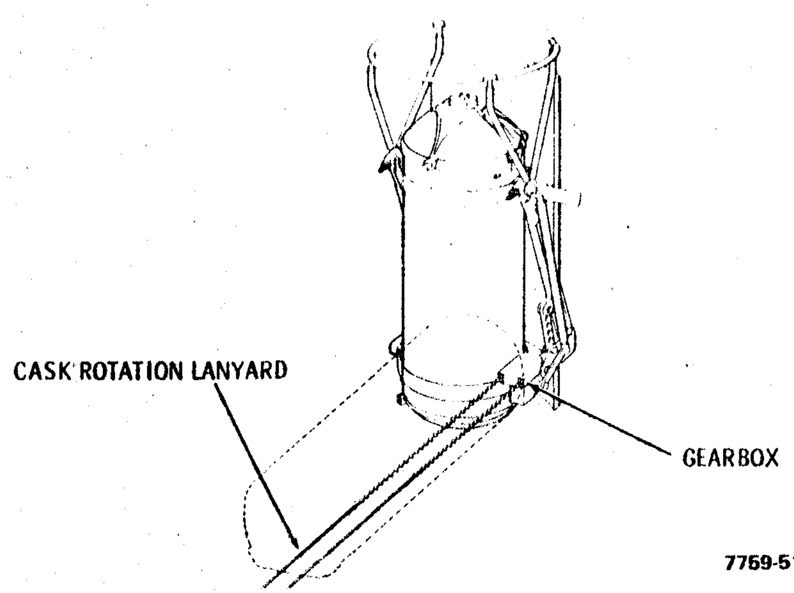

ANTENNA AIMING MECHANISM
7759-5126

FUEL CASK SUPPORT ASSEMBLY



7759-5127

CASK ROTATION DETAILS



7759-5128


FUEL CASK ASSEMBLY
7759-5129

ALSEP MISSION PROFILE

7759-5130A

PRELAUNCH PHASE ARRAY A

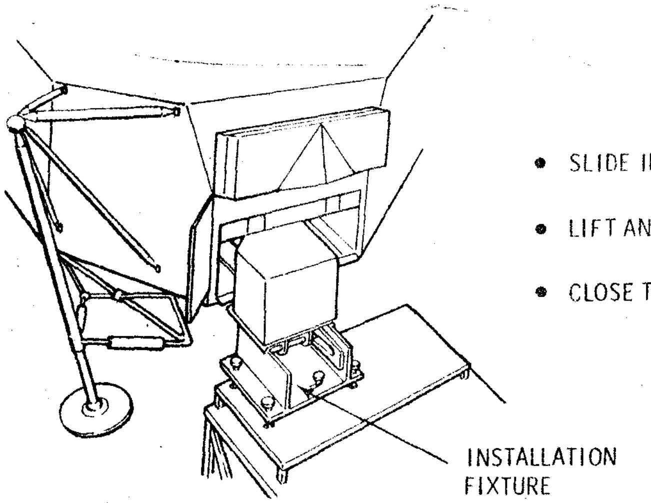
KSC ALSEP INTEGRATION

INSTALLATION IN LUNAR MODULE

RTG CASK LOADING

7759-5130B

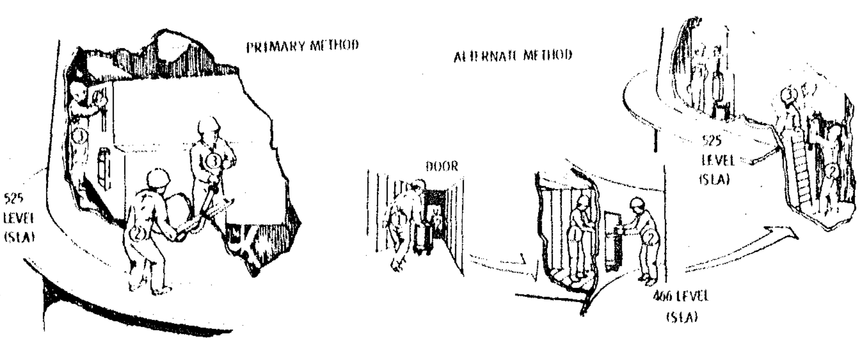
INSTALLATION IN LUNAR MODULE



- SLIDE IN
- LIFT AND INSERT PIP PINS
- CLOSE THERMAL DOOR

7759-5131

RTG CASK LOADING



7759-5132

ALSEP DEPLOYMENT TIMELINE

- **KEY TO MISSION PLANNING**
- THIS TIMELINE IS FOR REFERENCE ONLY - THE FINAL TIMELINE WILL CONFORM TO THE FLIGHT PLAN
- ALSEP 1 TIMELINE, 2-MAN EVA

LEGEND:

———— EVENT LINE

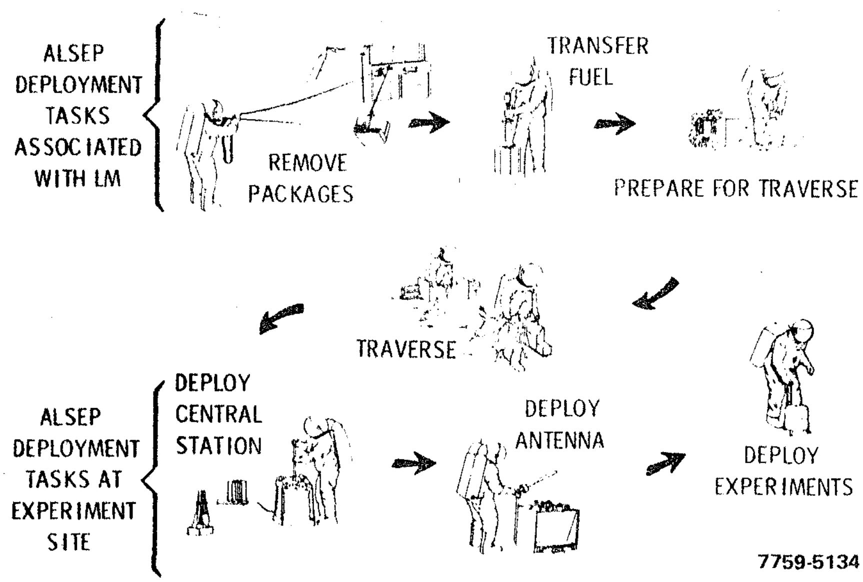
TEAM ACTIVITY. BOTH EVA CREWMEN REQUIRED TO ACCOMPLISH A GIVEN TASK

COUPLED ACTIVITY. BOTH CREW MEMBERS ARE WORKING ON RELATED TASKS AND ARE IN VOICE COMM WITH EACH OTHER. VISUAL CONTACT BETWEEN CREWMEN IS HIGHLY DESIRABLE BUT NOT MANDATORY

UNCOUPLED ACTIVITY. CREW MEMBERS WORKING ON UNRELATED TASKS AND PROCEEDING INDEPENDENTLY

7759-5133

LUNAR SURFACE ACTIVITY

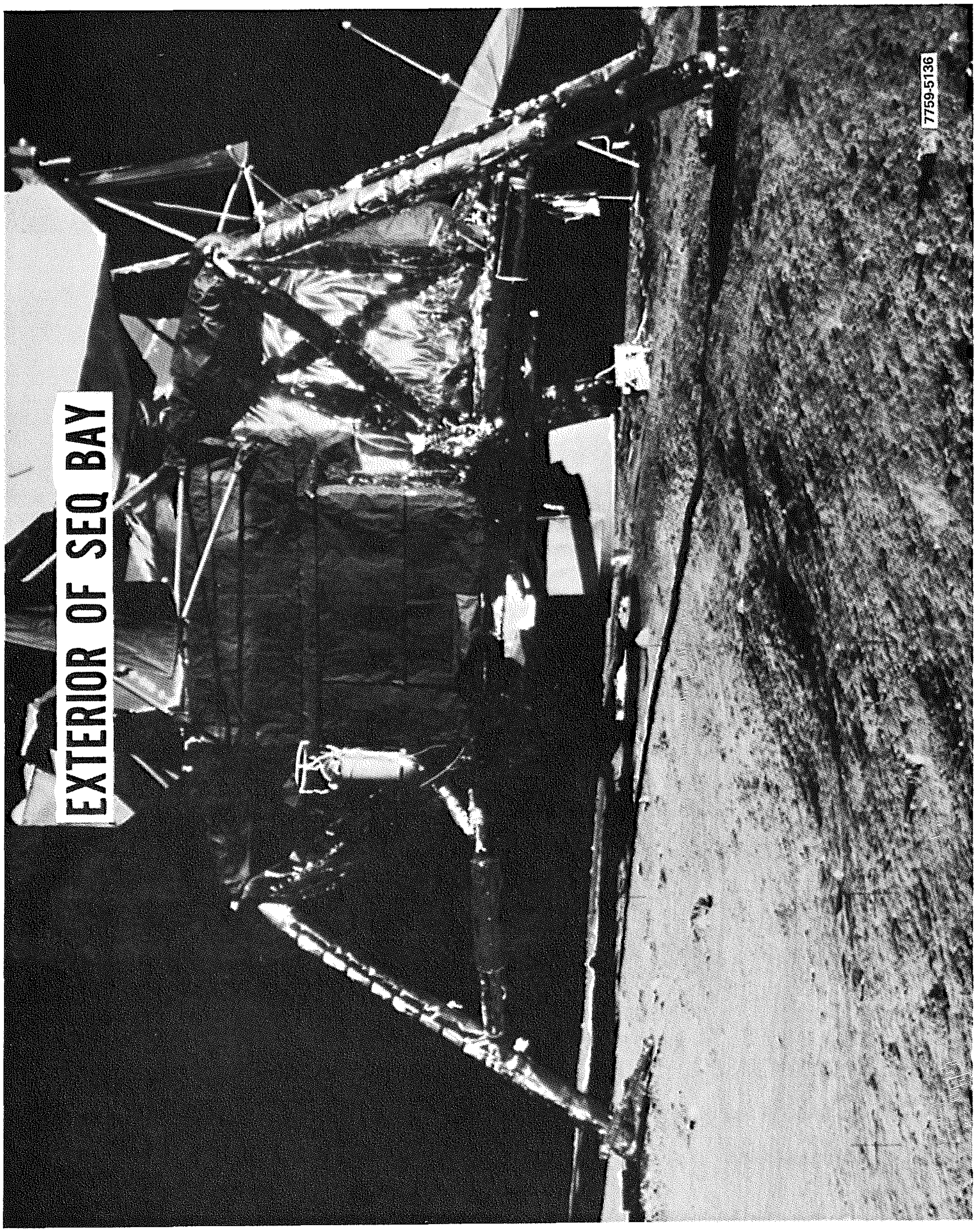


7759-5134

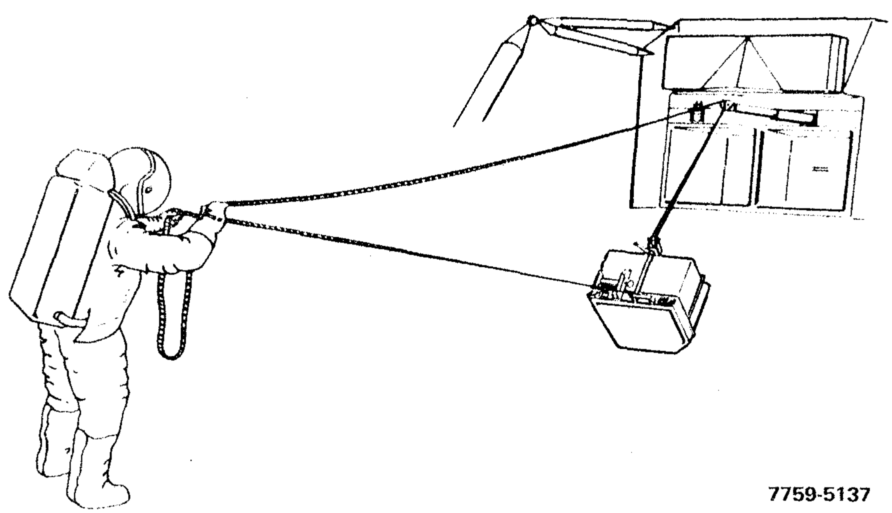
ACTIVITY TIMELINE (CONT.)

MIN SEC	COMMANDER ACTIVITY	LM PILOT ACTIVITY	MCC & REMARKS
00:00	REMOVE PKG #1 (54 SEC)	MONITOR FOR SAFETY	
00:54		REPORT PKG #1 OUT	ACK & LOG
00:55	RELOCATE PKG #1 (15 SEC)		(REMOVE PACKAGES)
	MONITOR FOR SAFETY	REMOVE PKG #2 (53 SEC)	
02:02	REPORT PKG #2 OUT		ACK & LOG
02:03	MONITOR FOR SAFETY	RELOCATE PKG #2 (11 SEC)	
	RESTOW BOOMS (30 SEC)	REMOVE ALHT (42 SEC)	
TENTATIVE	CLOSE SEQ BAY DOOR (01 MIN)		
		REMOVE & DEPLOY ALSEP TOOLS (01 MIN 30 SEC)	
	OBTAIN & STOW GEOLOGICAL TOOLS (42 SEC)		
04:26	REPORT READY FOR FUEL TRANSFER		ACK & LOG

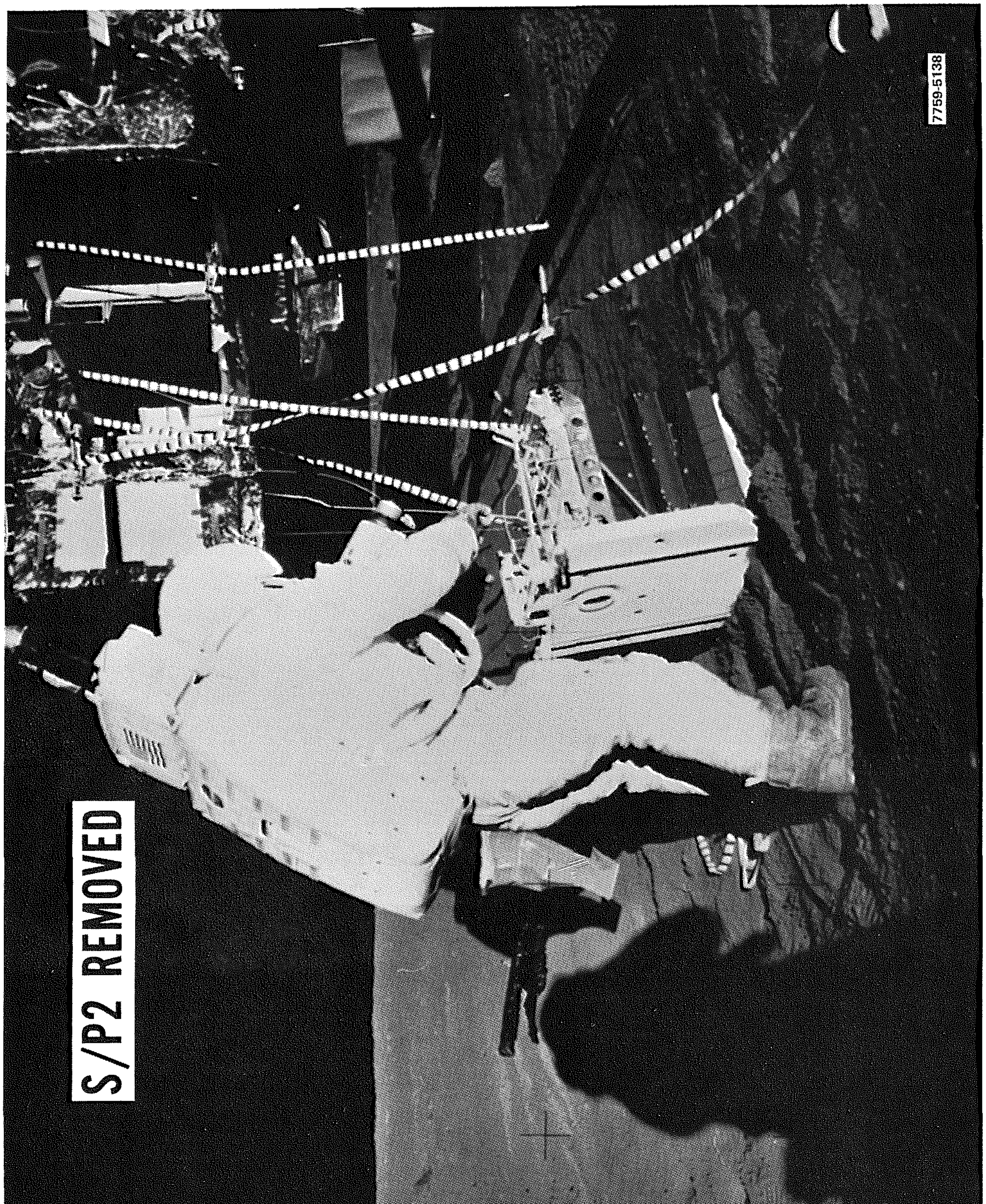
7759-5135


EXTERIOR OF SEQ BAY
7759-5136

REMOVE PACKAGES



7759-5137

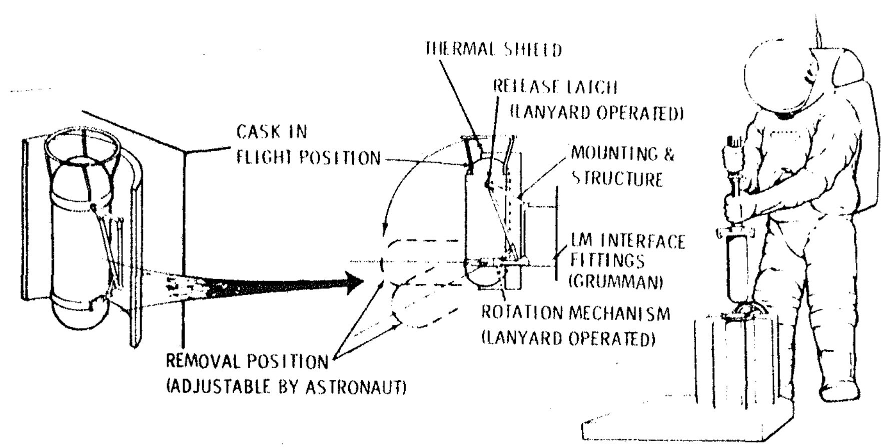

S/P2 REMOVED
7759-5138

ACTIVITY TIMELINE (CONT.)

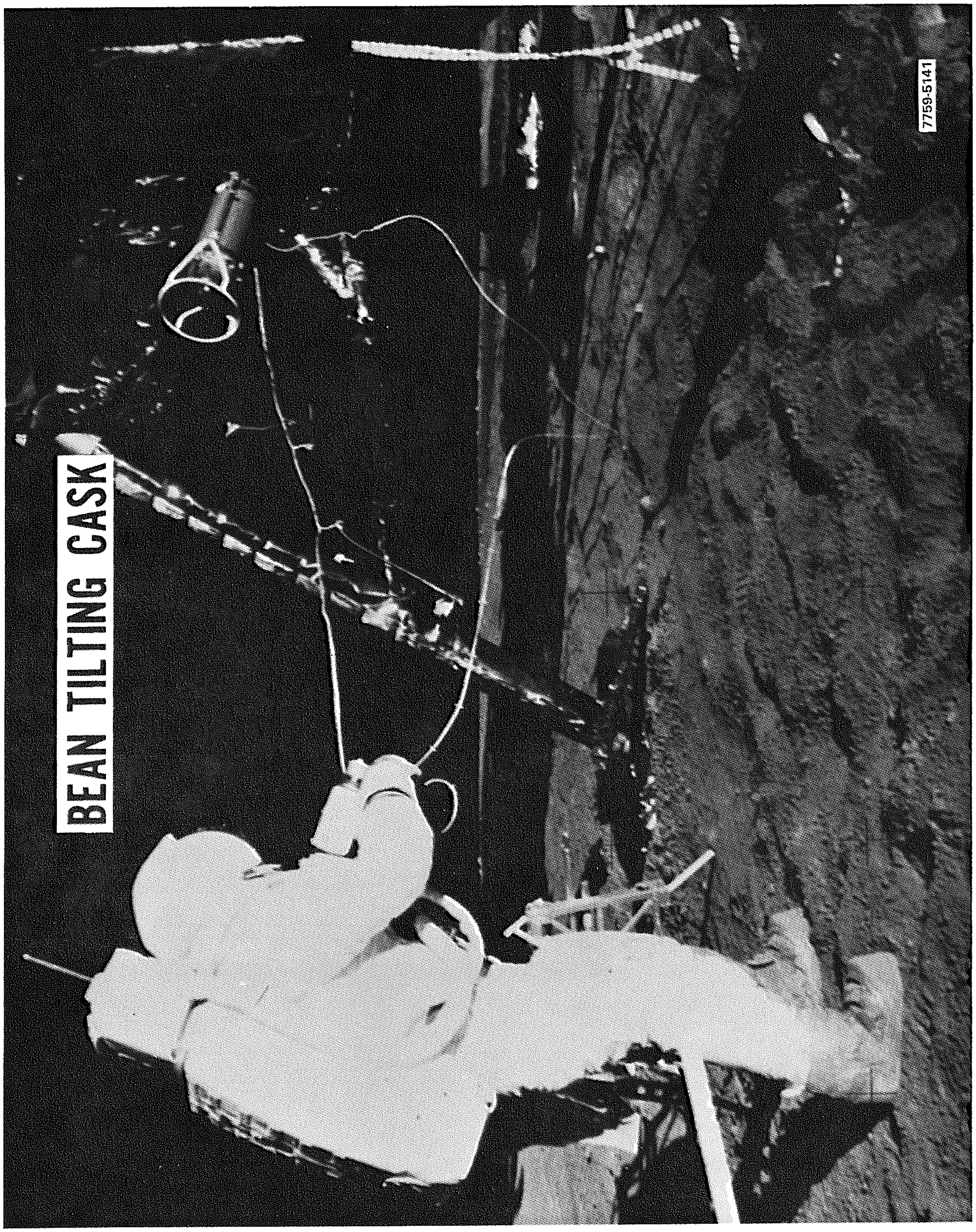
MIN : SEC	COMMANDER ACTIVITY	LM PILOT ACTIVITY	MCC & REMARKS
TENTATIVE 07:24	CONTINUE STOWING GEOLOGICAL TOOLS MONITOR FOR SAFETY & SUPPLY TOOLS REPORT: RTG FUELED	ROTATE PKG #2 UPRIGHT & REMOVE SUBPALLET (40 SEC) ROTATE FUEL CASK (43 SEC) REMOVE CASK DOME (26 SEC) TRANSFER FUEL CAPSULE (01 MIN 08 SEC)	(TRANSFER FUEL) ACK & LOG
07:25 07:52	RETRIEVE SUBPALLET (16 SEC) REPORT: START OF TRAVERSE	ASSEMBLE BARBELL CONFIGURATION (27 SEC)	(PREPARE FOR TRAVERSE) ACK & LOG
07:53 13:45	CARRY SUBPALLET & ALHT LEAD TRAVERSE PICK ROUTE REST AS NECESSARY (5 MIN 52 SEC) REPORT: TRAVERSE COMPLETE	CARRY BARBELL REST AS NECESSARY (5 MIN 52 SEC)	(TRAVERSE) ACK & LOG

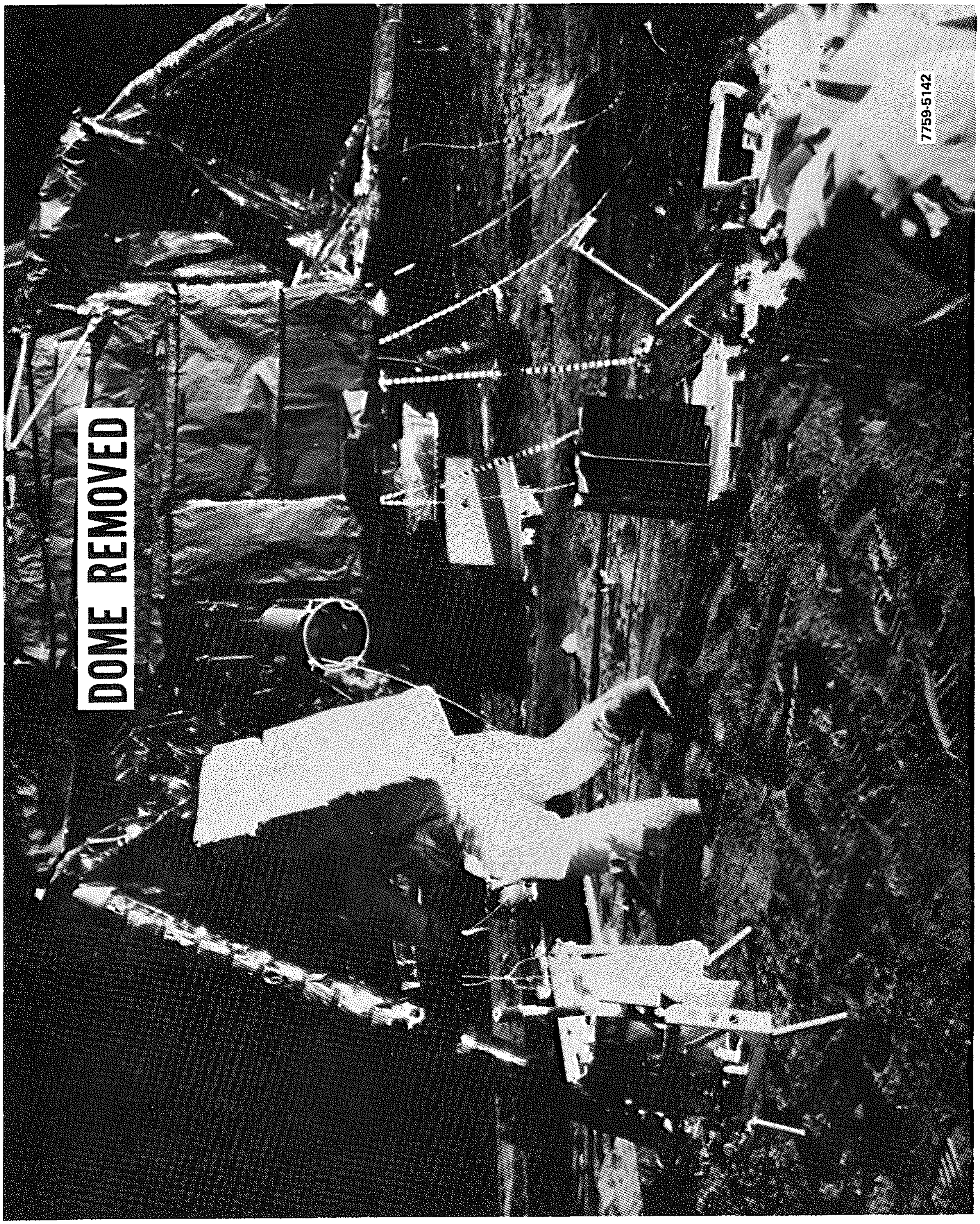
7759-5139

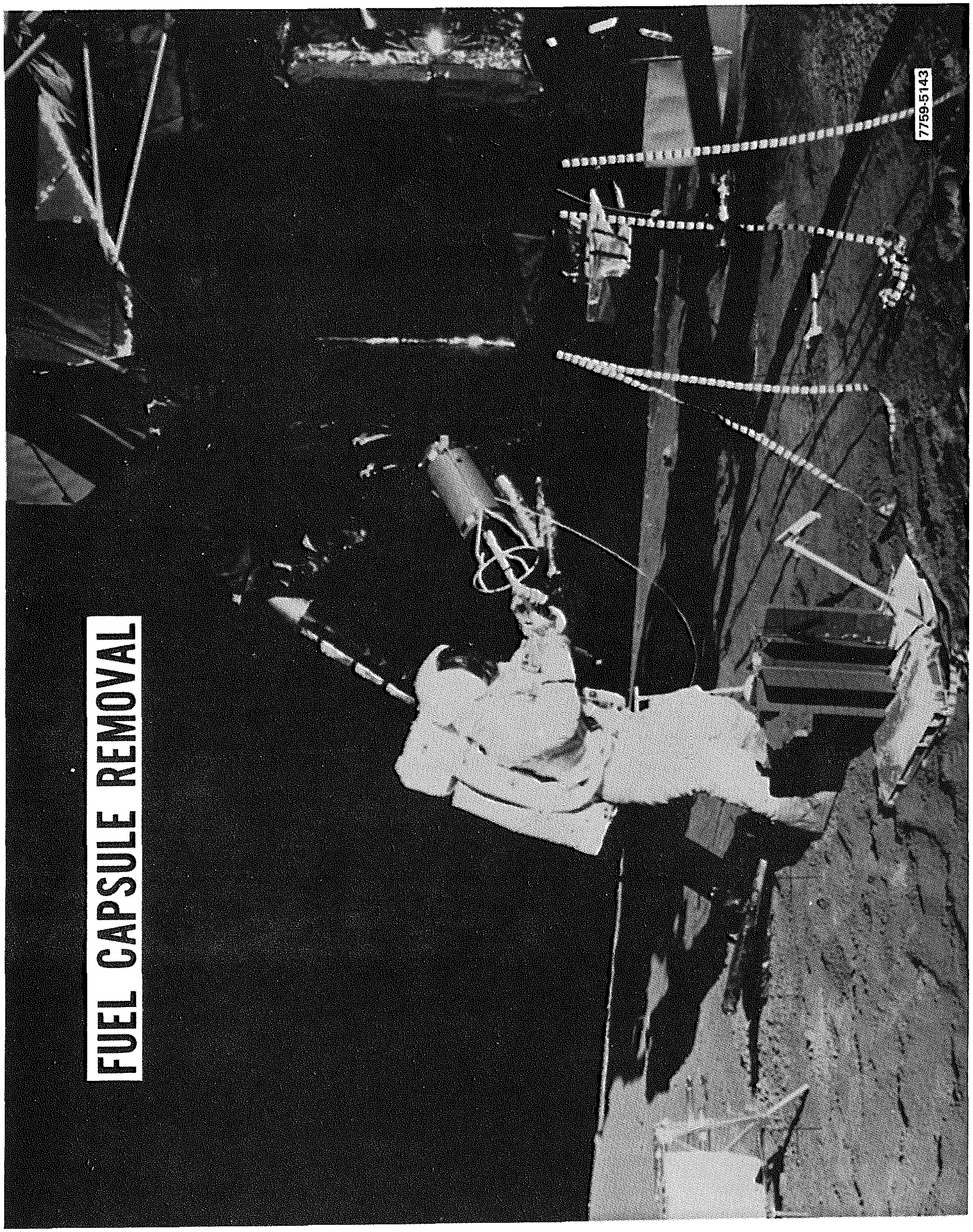
RTG FUELING



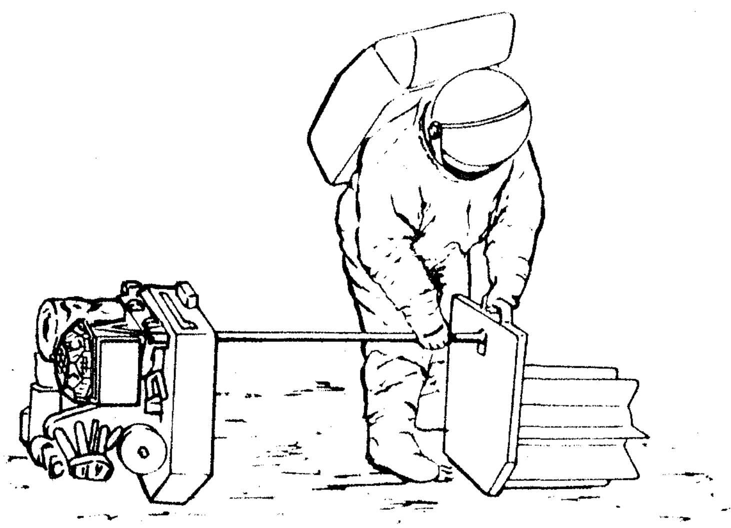
7759-5140


BEAN TILTING CASK
7759-5141


DOME REMOVED
7759-5142


FUEL CAPSULE REMOVAL
7759-5143

PREPARE FOR TRAVERSE



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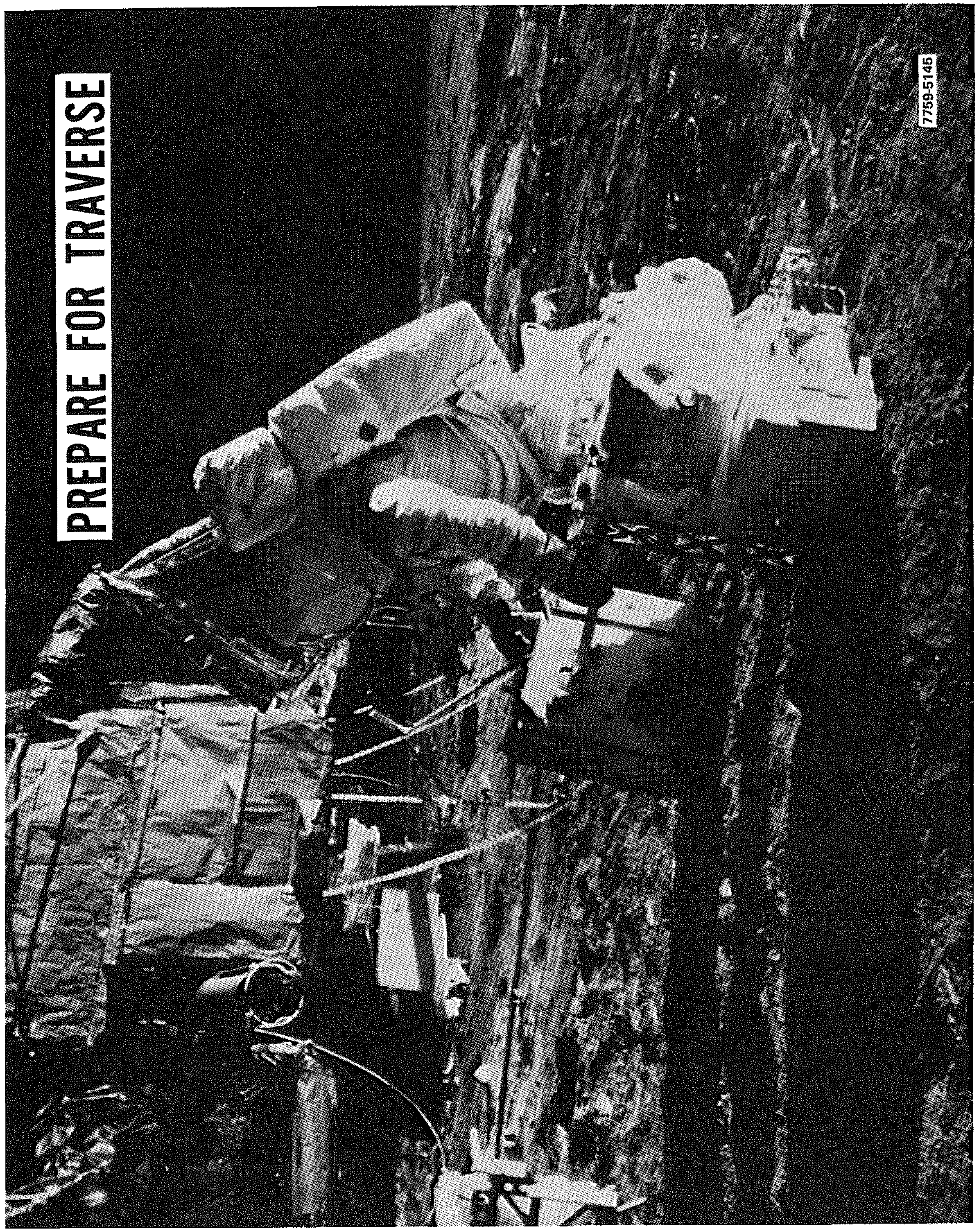
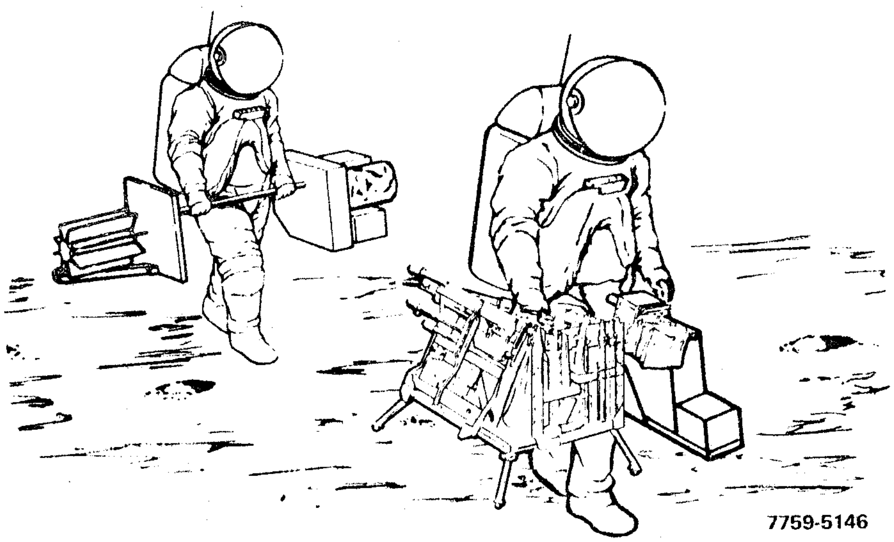

PREPARE FOR TRAVERSE
7759-5145

TRAVERSE



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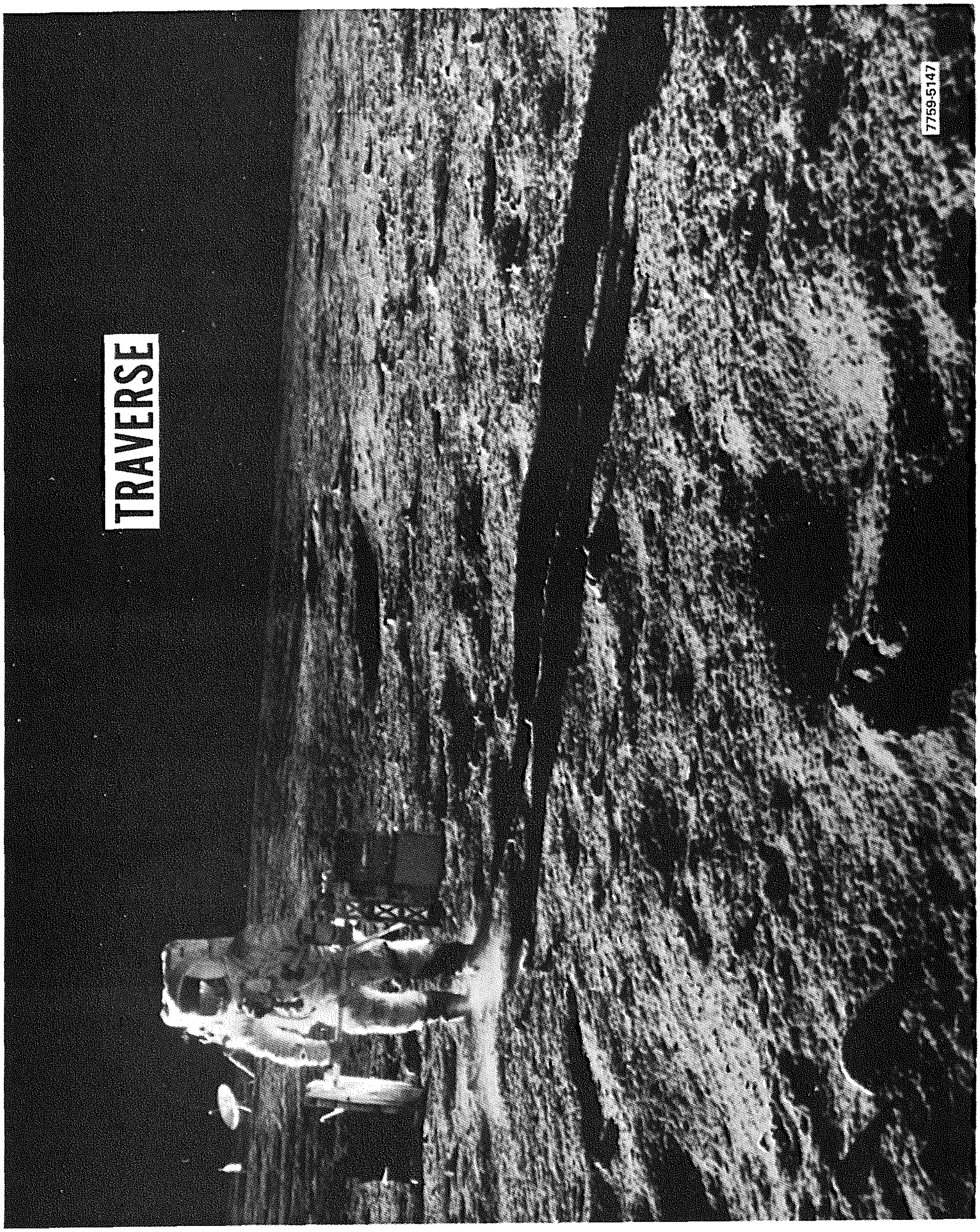
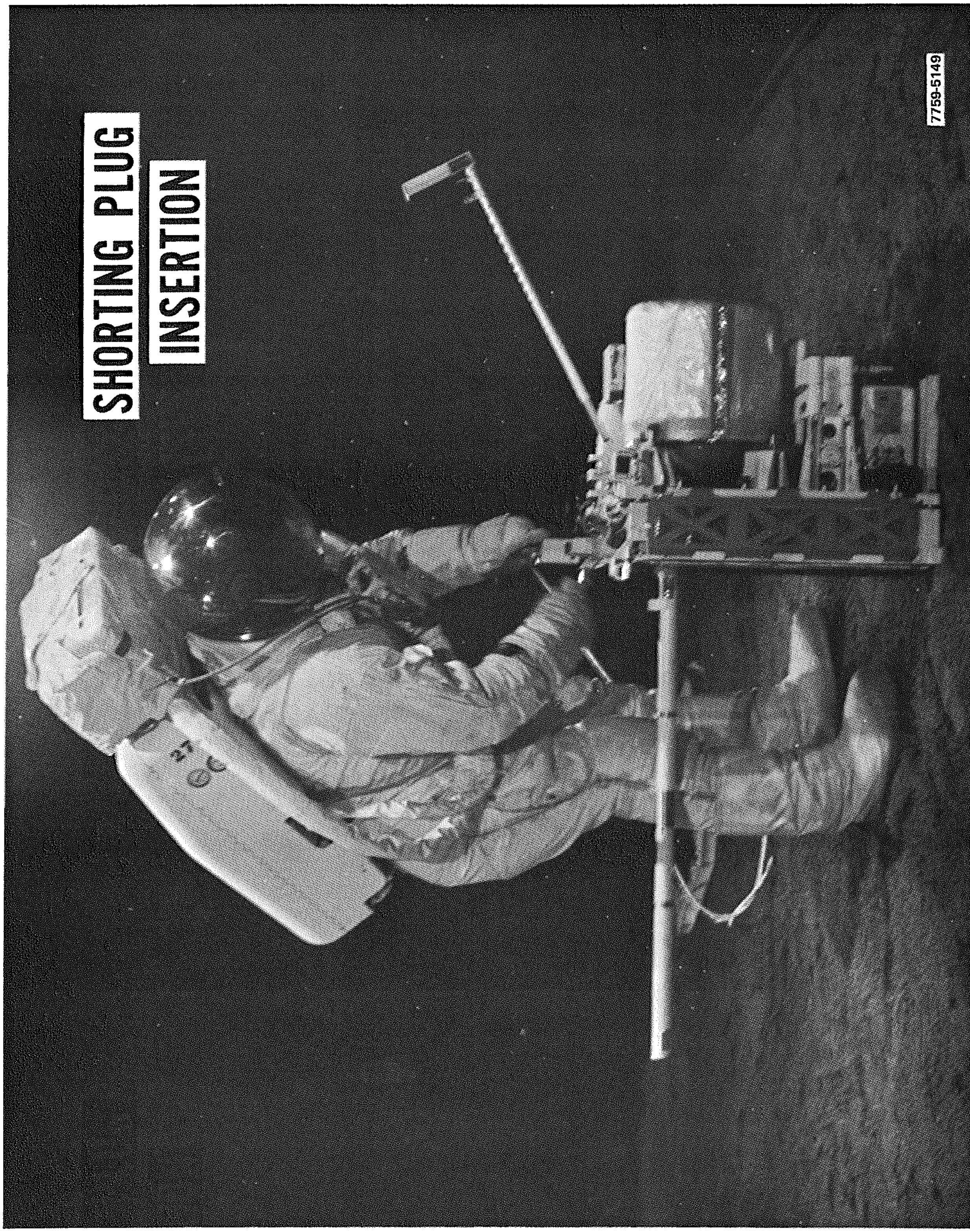
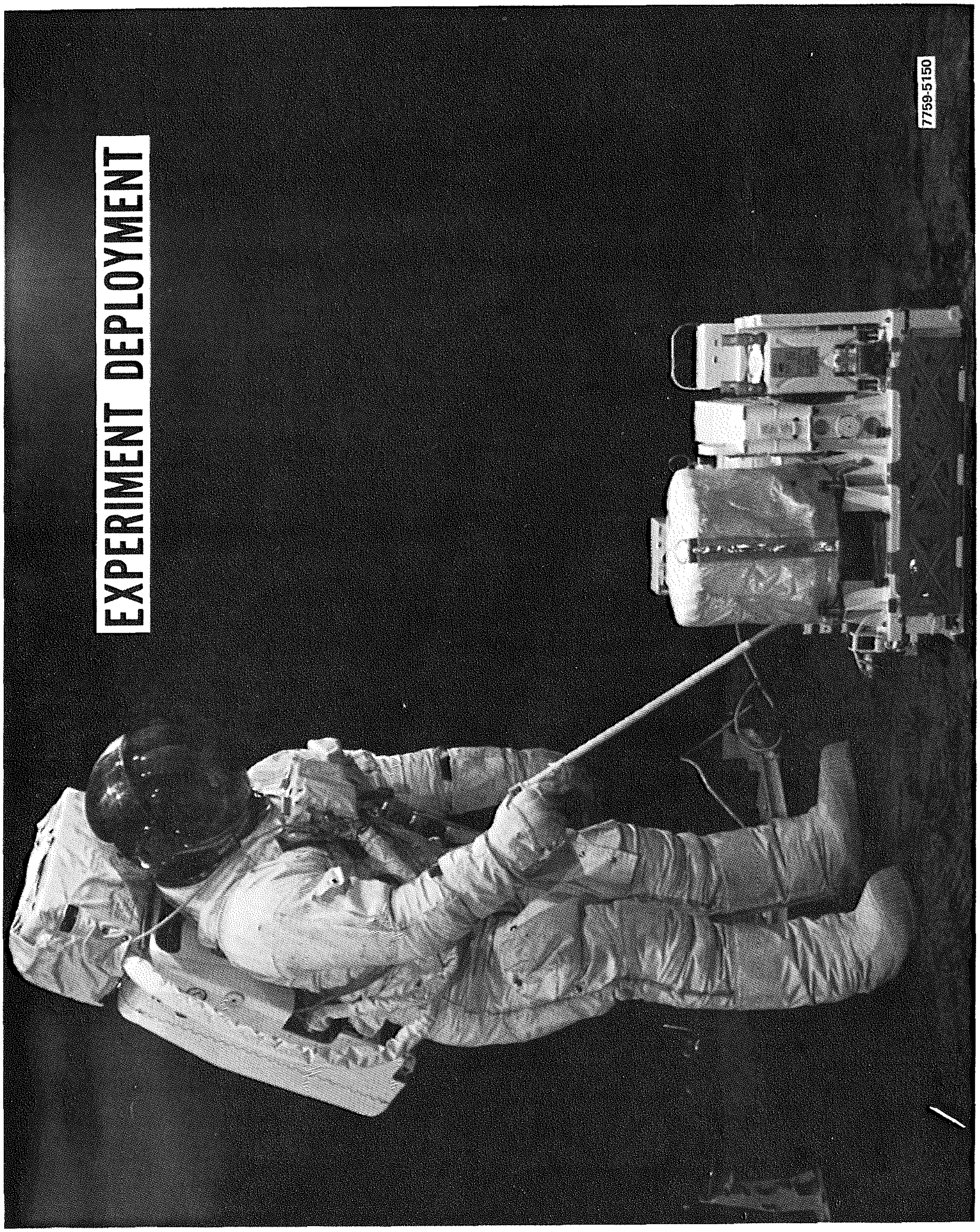

TRAVERSE
7759-5147

ACTIVITY TIMELINE (CONT.)

MIN : SEC	COMMANDER ACTIVITY	LM PILOT ACTIVITY	MCC & REMARKS
13:46 TENTATIVE 15:12	TEMPORARILY EMPLACE SUBPALLET & ALHT (14 SEC) ROTATE PKG #2 (9 SEC) DEPLOY PKG #2 (01 MIN 3 SEC) REPORT: AMMETER READING	DEPLOY MAST/PKG #1 (22 SEC) MONITOR FOR SAFETY	(DEPLOY CENTRAL STATION) ACK & LOG PET-ZERO
15:13 16:13	CONNECT RTG TO CENT STA (02 SEC) DISCONNECT & STOW MAST (58 SEC)	REMOVE SIDE/CCIG & CONNECT CABLE (41 SEC) ACTIVATE RTG SW (2 SEC) REPORT: RTG SW ON	ACK & LOG
16:14 16:28	ROTATE PKG #1 (14 SEC)	DEPLOY PSE STOOL (18 SEC)	

7759-5148


SHORTING PLUG
INSERTION
7759-5149


EXPERIMENT DEPLOYMENT
7759-5150

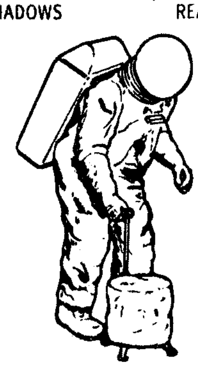
ACTIVITY TIMELINE
(CONT.)

MIN : SEC	COMMANDER ACTIVITY	LM PILOT ACTIVITY	MCC & REMARKS
16:29	RELEASE SWS (32 SEC)		
	RELEASE PSE (32 SEC)	DEPLOY SWS (01 MIN 22 SEC)	
	REMOVE LSM (54 SEC)	REPORT: ALIGNMENT COMPLETE	ACK
		DEPLOY PSE (01 MIN 05 SEC)	(DEPLOY CENTRAL STATION)
TENTATIVE	RELEASE SUNSHIELD (03 MIN)	REPORT: ALIGNMENT VALUES	ACK (DEPLOY EXPER)
		DEPLOY LSM (02 MIN 34 SEC)	
	DEPLOY SUNSHIELD (53 SEC)	REPORT: ALIGNMENT VALUES	ACK (DEPLOY ANTENNA)
	ASSEMBLE ANTENNA (02 MIN 06 SEC)	DEPLOY SIDE/CCIG (03 MIN 42 SEC)	
	CONFIRM: AZ/EL SETTING (02 MIN 07 SEC)		GIVE: AZ/EL SETTING
	ACTUATE SW-1 REQUEST: XMTR ON IF ALSEP DOES NOT RESPOND ACTUATE SW-2 AND SW-3	OBTAIN METRIC PHOTOGRAPHS OF DEPLOYED ALSEP	
			COMMAND: XMTR ON REPORT: TM STATUS
28:00	REPORT: SW POSITIONS		ACK & LOG
TBD	RETURN TO LM	RETURN TO LM	

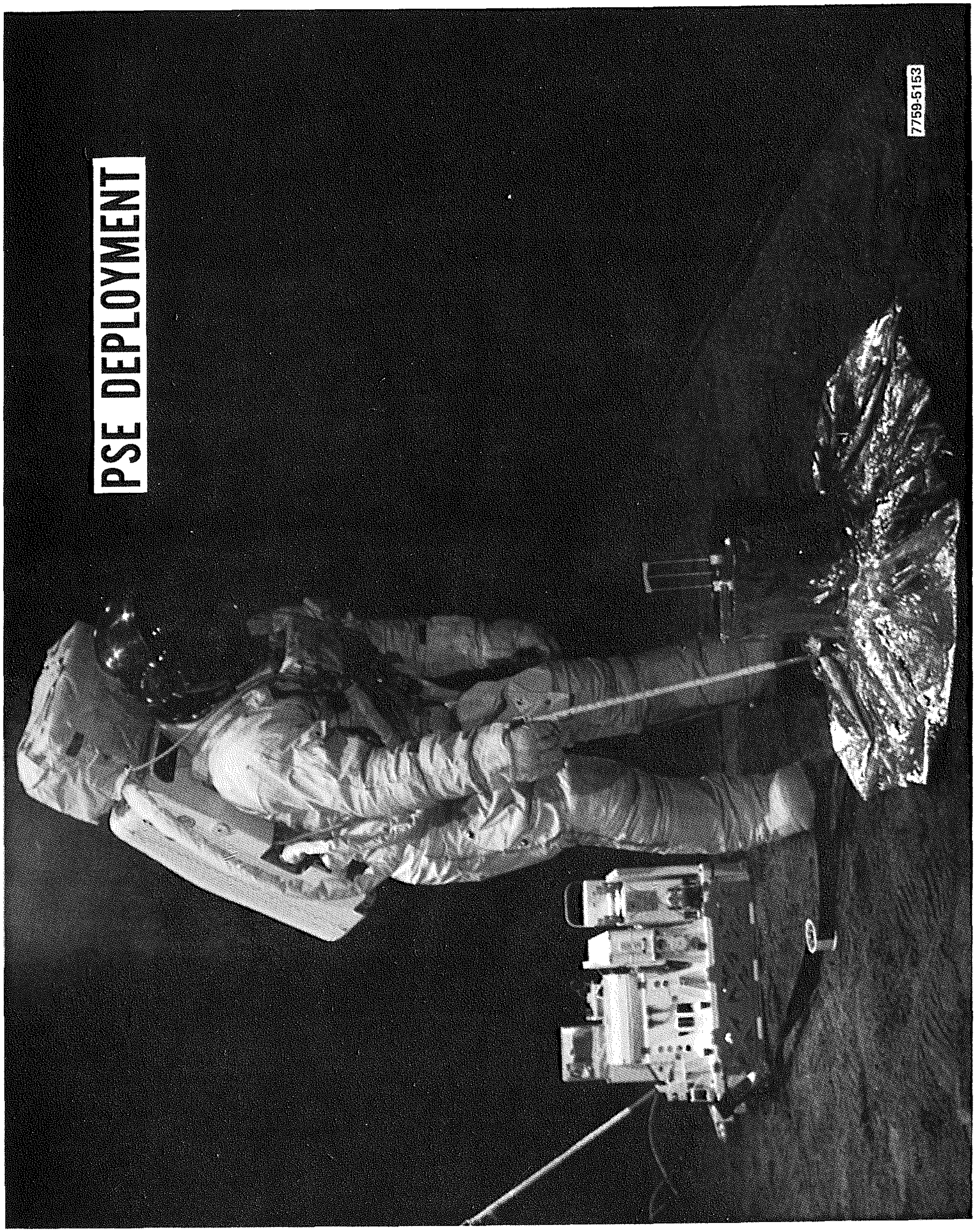
7759-5151

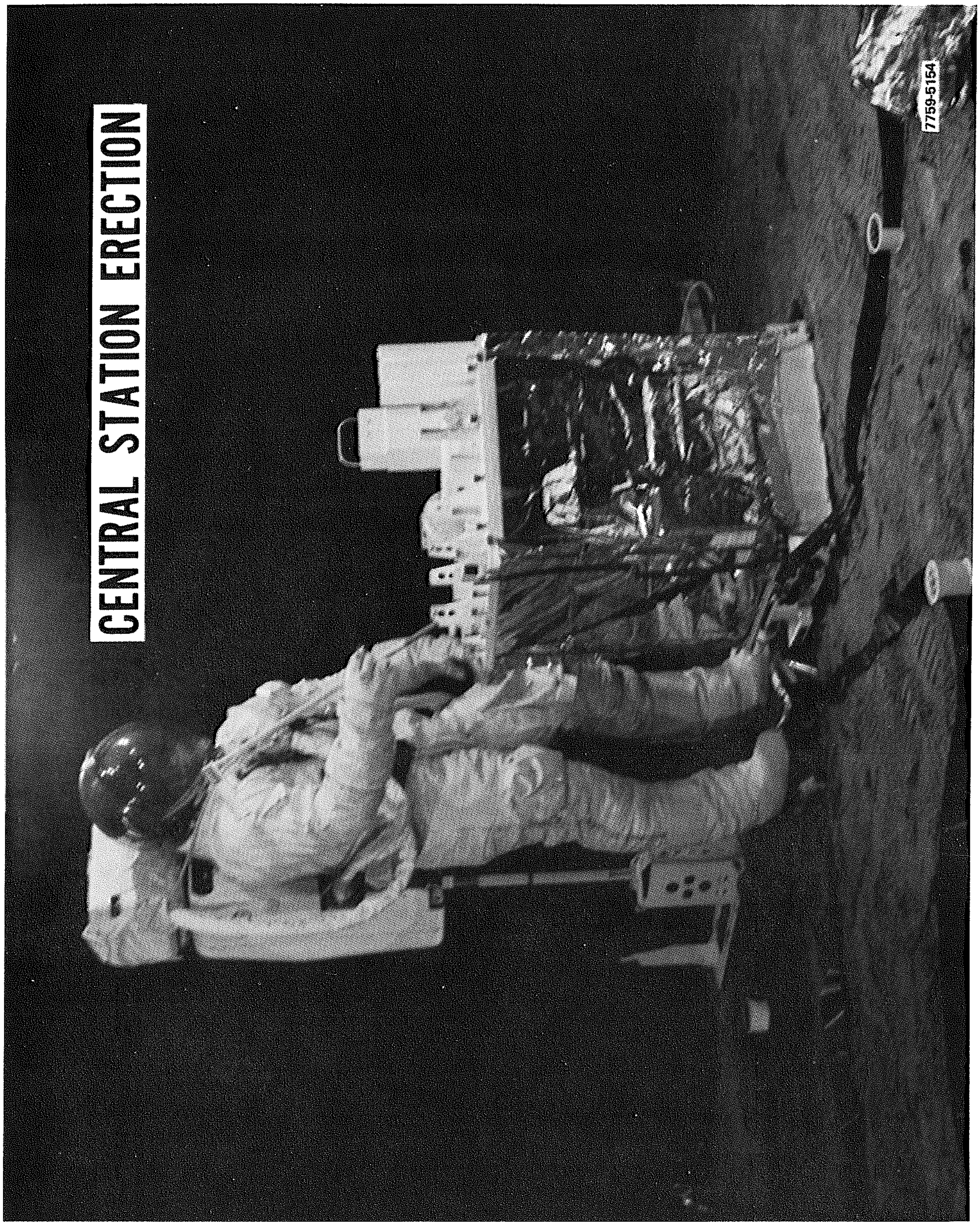
DEPLOY EXPERIMENTS

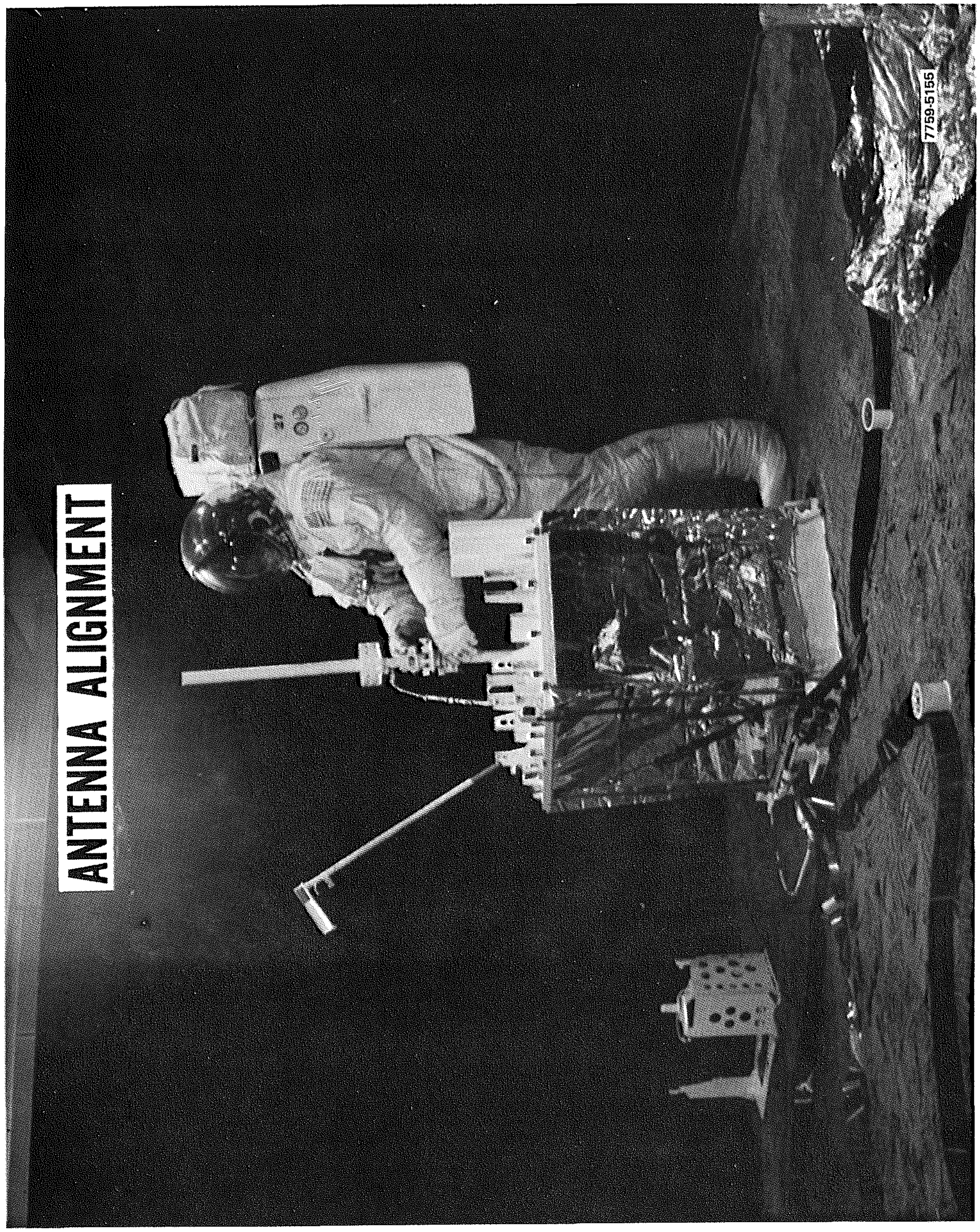
SWS	PSE	LSM	SIDE
CARRY 13 FT EXTEND LEVELING LEGS PLACE ON SURFACE (PARTIALLY SELF-LEVELING) ALIGN BY SHADOWS	CARRY 10 FT REMOVE GIRDLE PLACE ON STOOL UNFOLD SHROUD LEVEL BY BALL INDICATOR READ ALIGNMENT BY GNOMON SHADOW	CARRY 50 FT DEPLOY SUPPORT LEGS PLACE ON SURFACE UNFOLD SENSOR ARMS REMOVE PRA COVERS LEVEL BY BUBBLE ALIGN BY SHADOWGRAPH READ SHADOWGRAPH ALIGNMENT	CARRY 55 FT PLACE ON SURFACE DEPLOY GROUND SCREEN RELEASE CCIG EMPLACE SIDE ON GROUND SCREEN EMPLACE CCIG LEVEL BY BUBBLE ALIGN BY SHADOWS

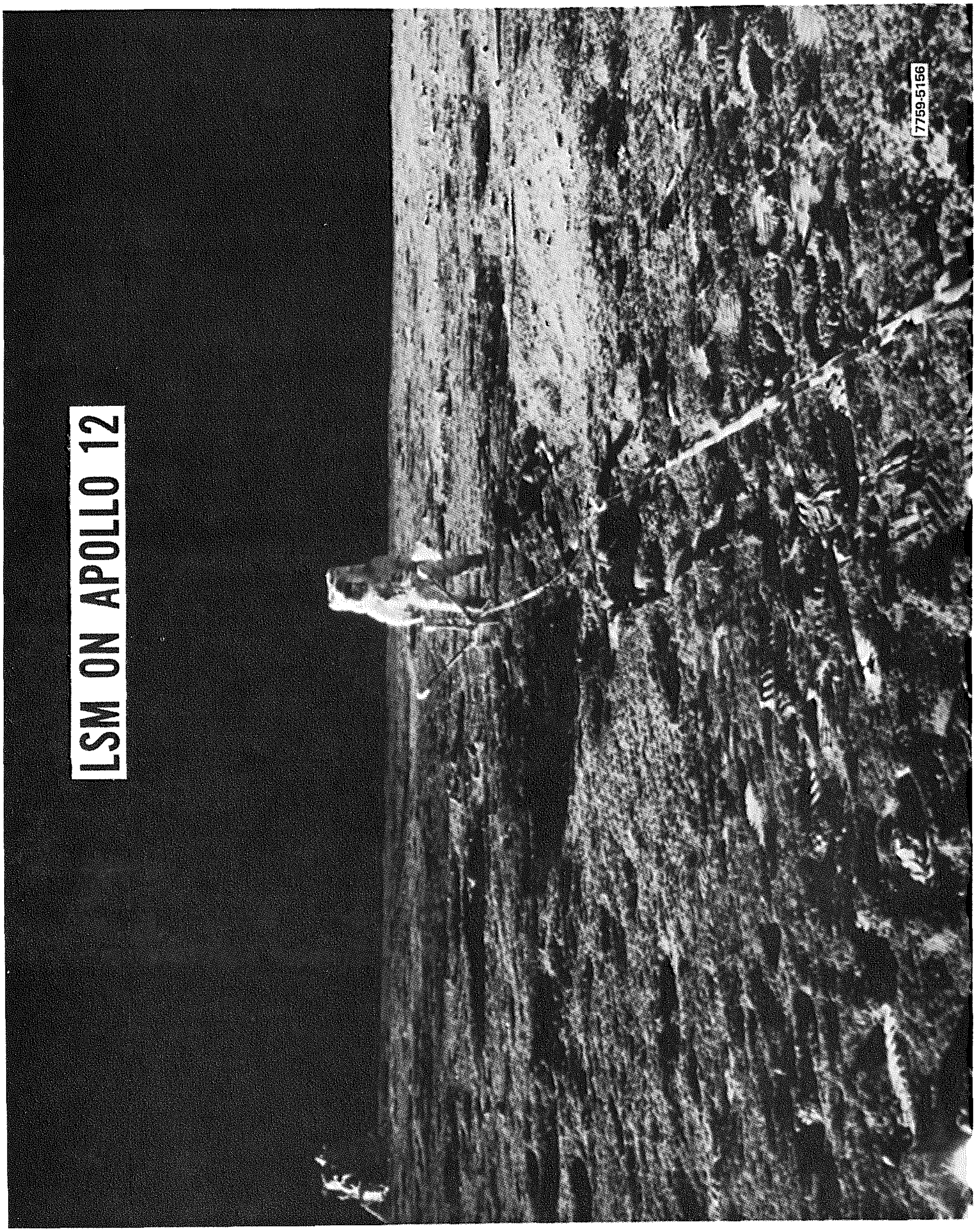


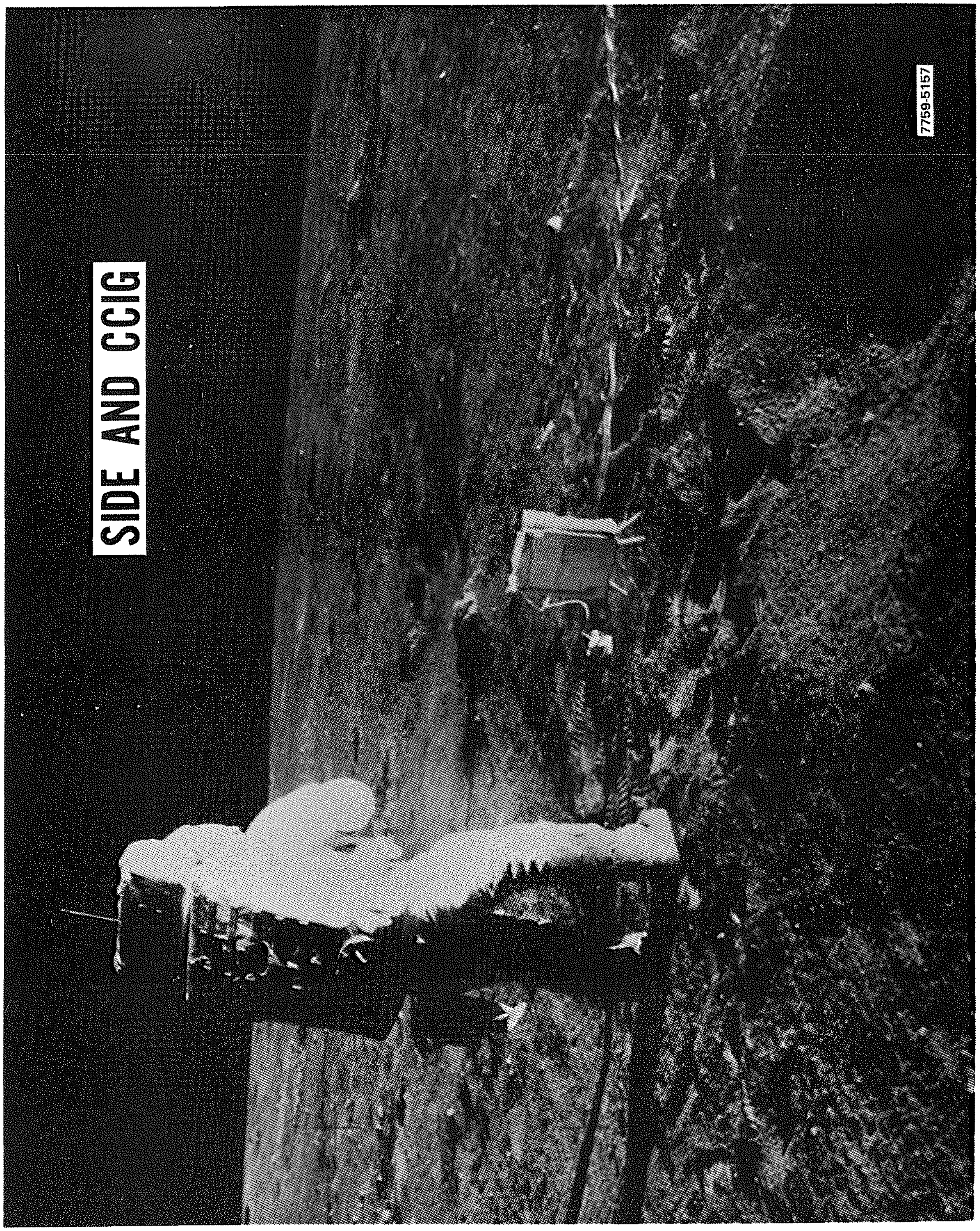
7759-5152

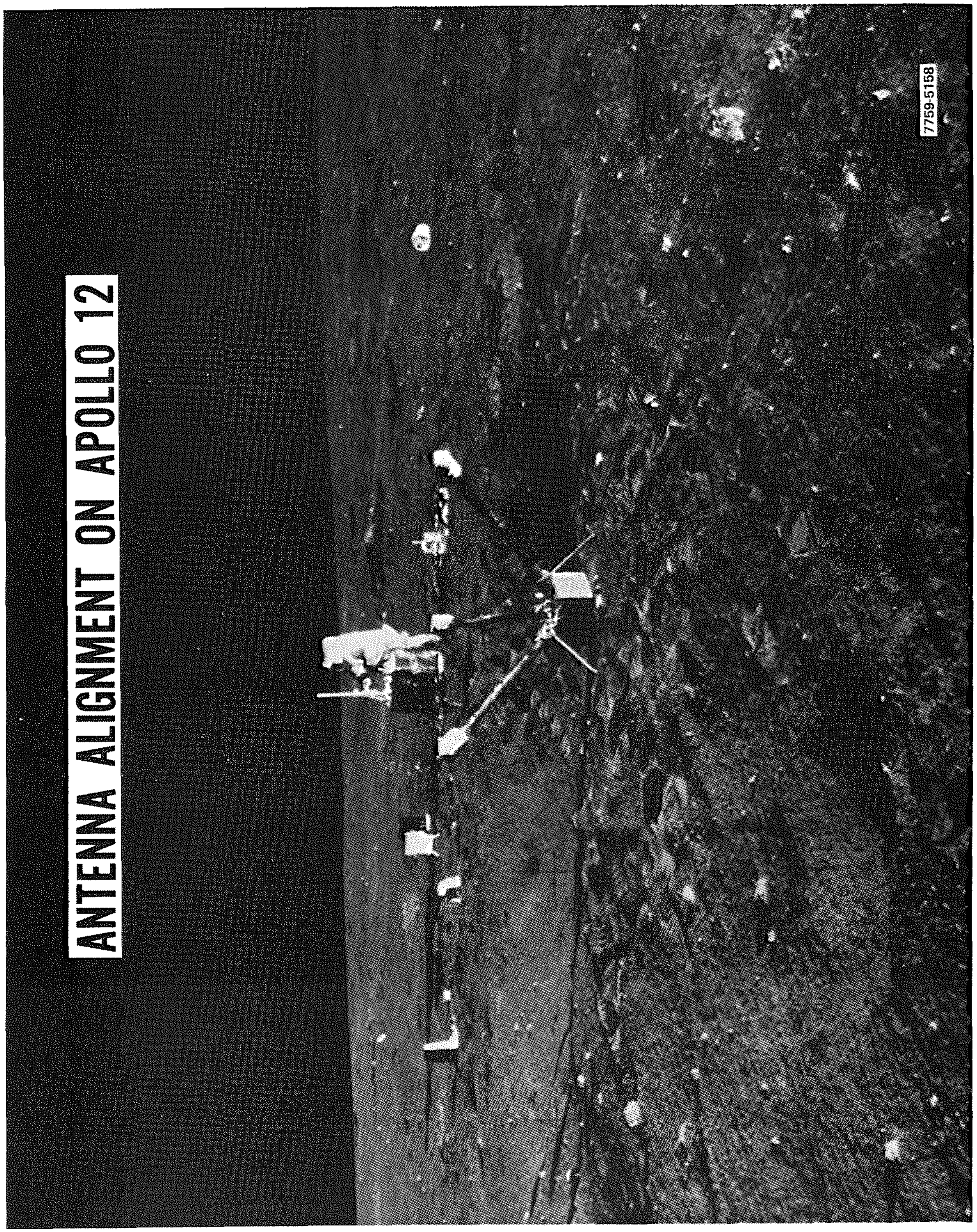

PSE DEPLOYMENT
7759-5153


CENTRAL STATION ERECTION
7759-5154


ANTENNA ALIGNMENT
7759-5155


LSM ON APOLLO 12
7759-5156


SIDE AND CCIG
7759-5157

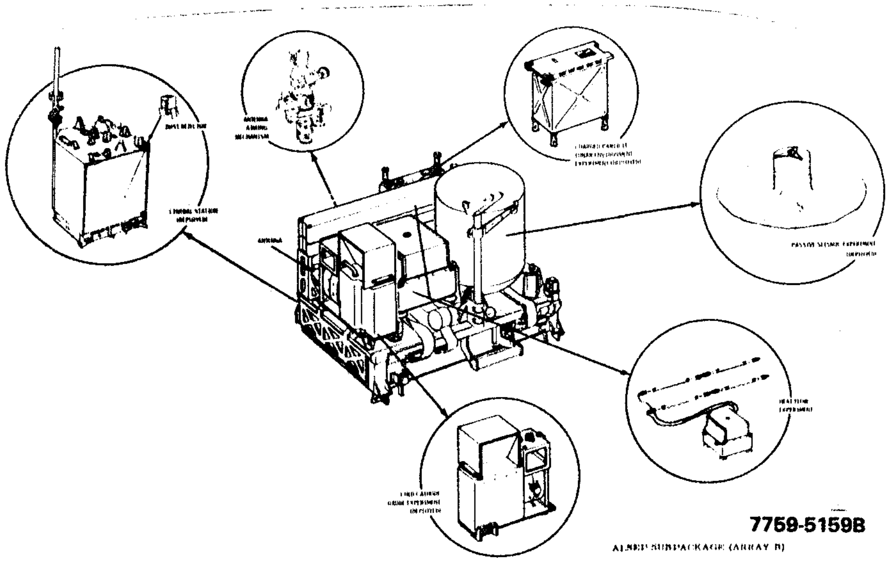

ANTENNA ALIGNMENT ON APOLLO 12
7759-5158

ARRAY B

CONFIGURATION DESCRIPTION

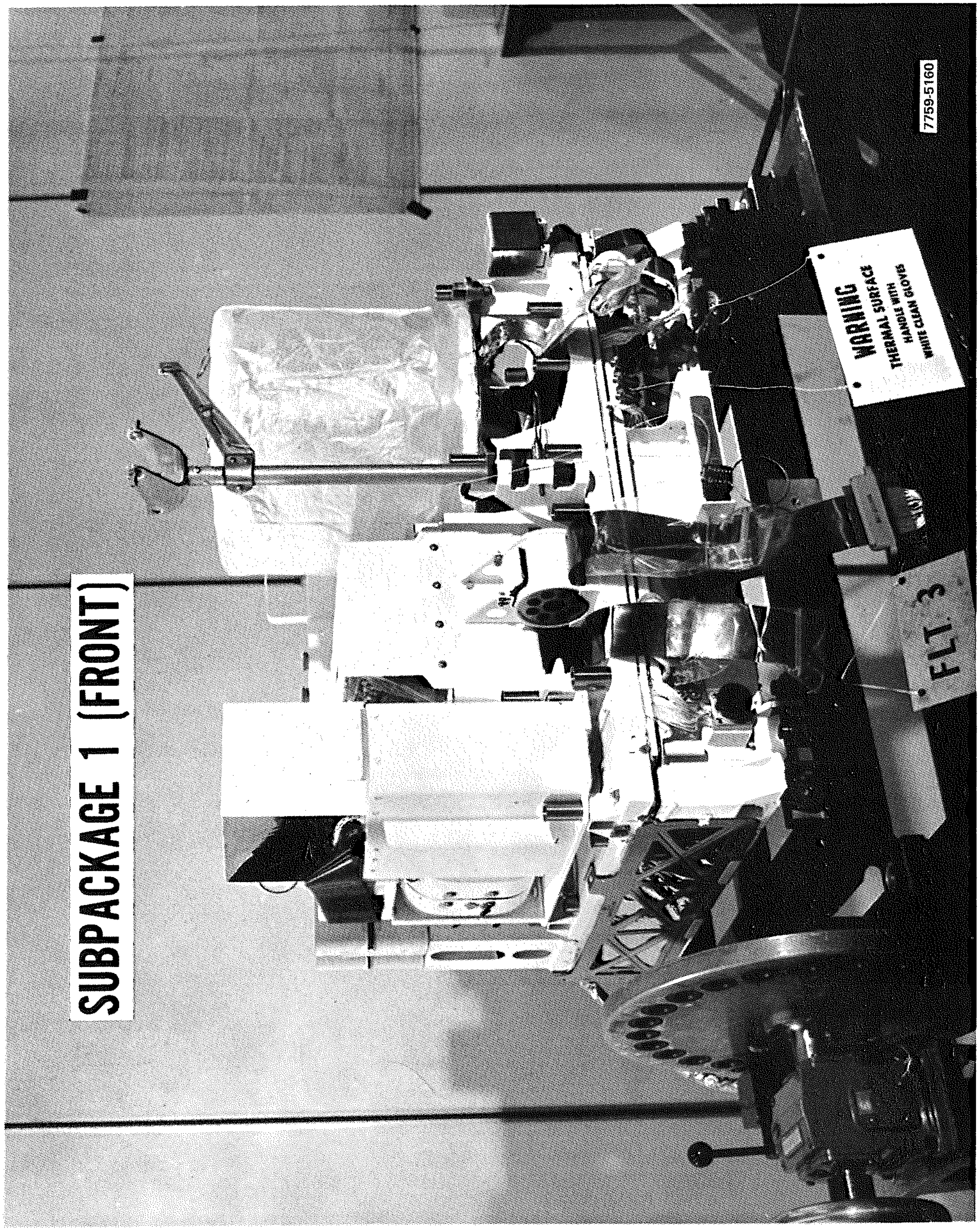
7759-5159A

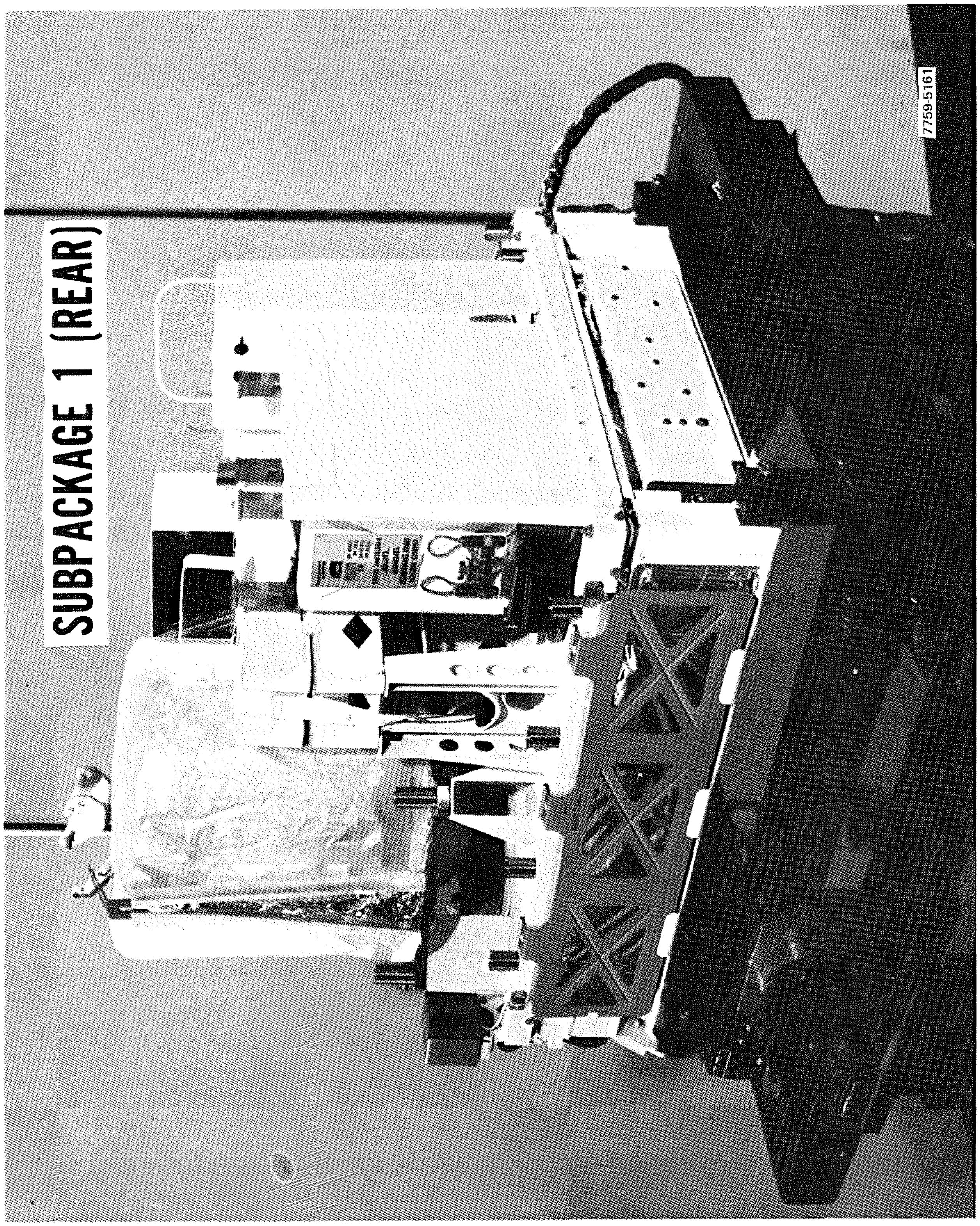
ALSEP SUBPACKAGE (ARRAY B)

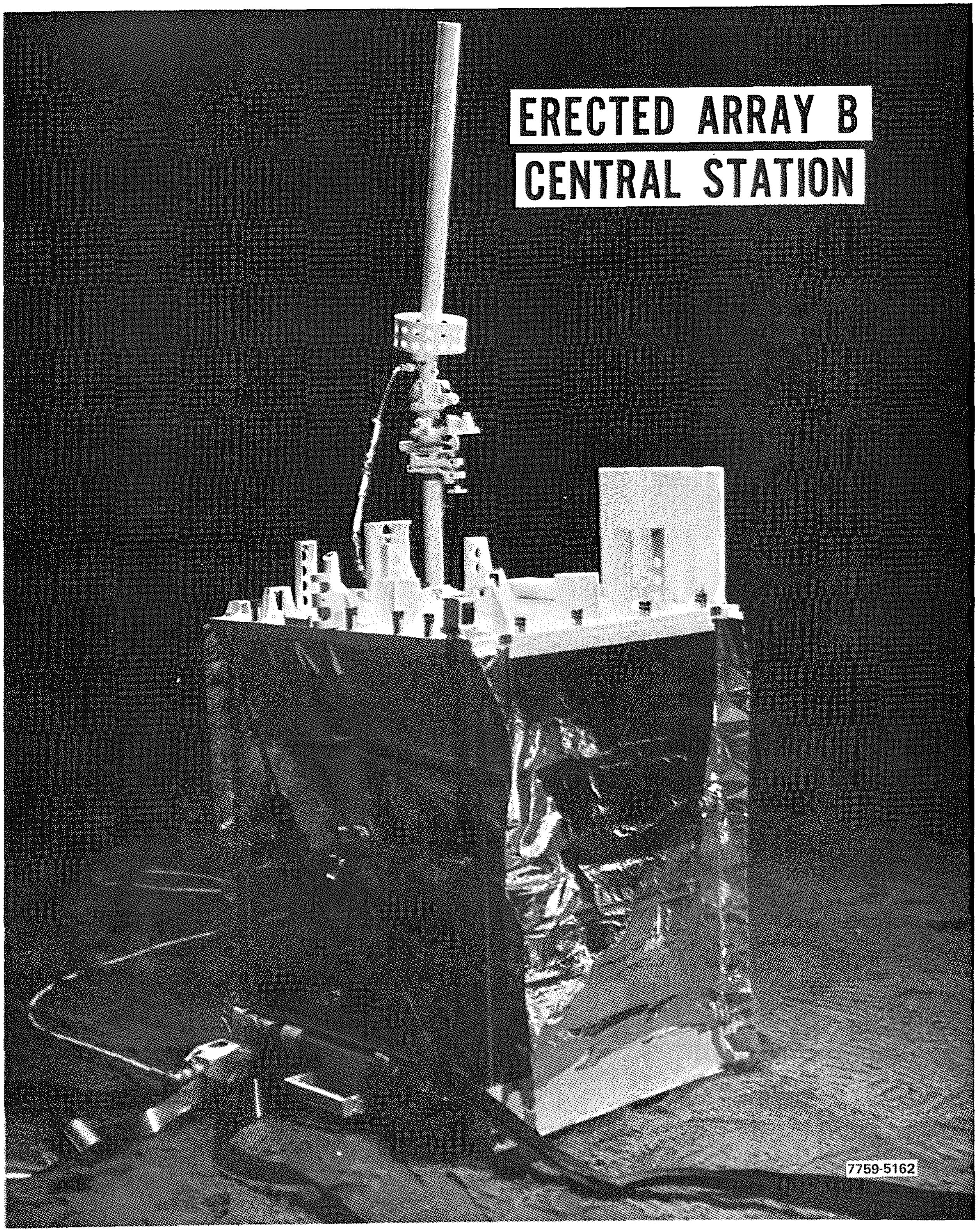


7759-5159B

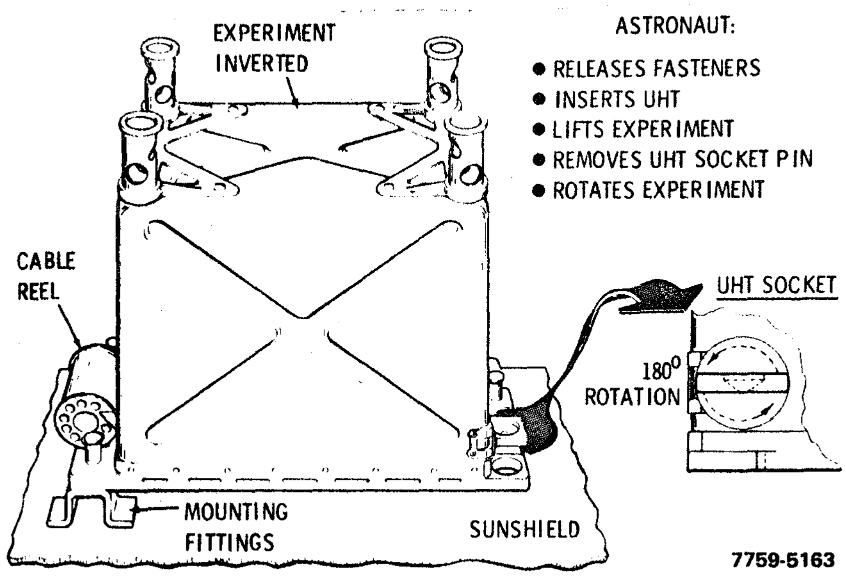
ALSEP SUBPACKAGE (ARRAY B)

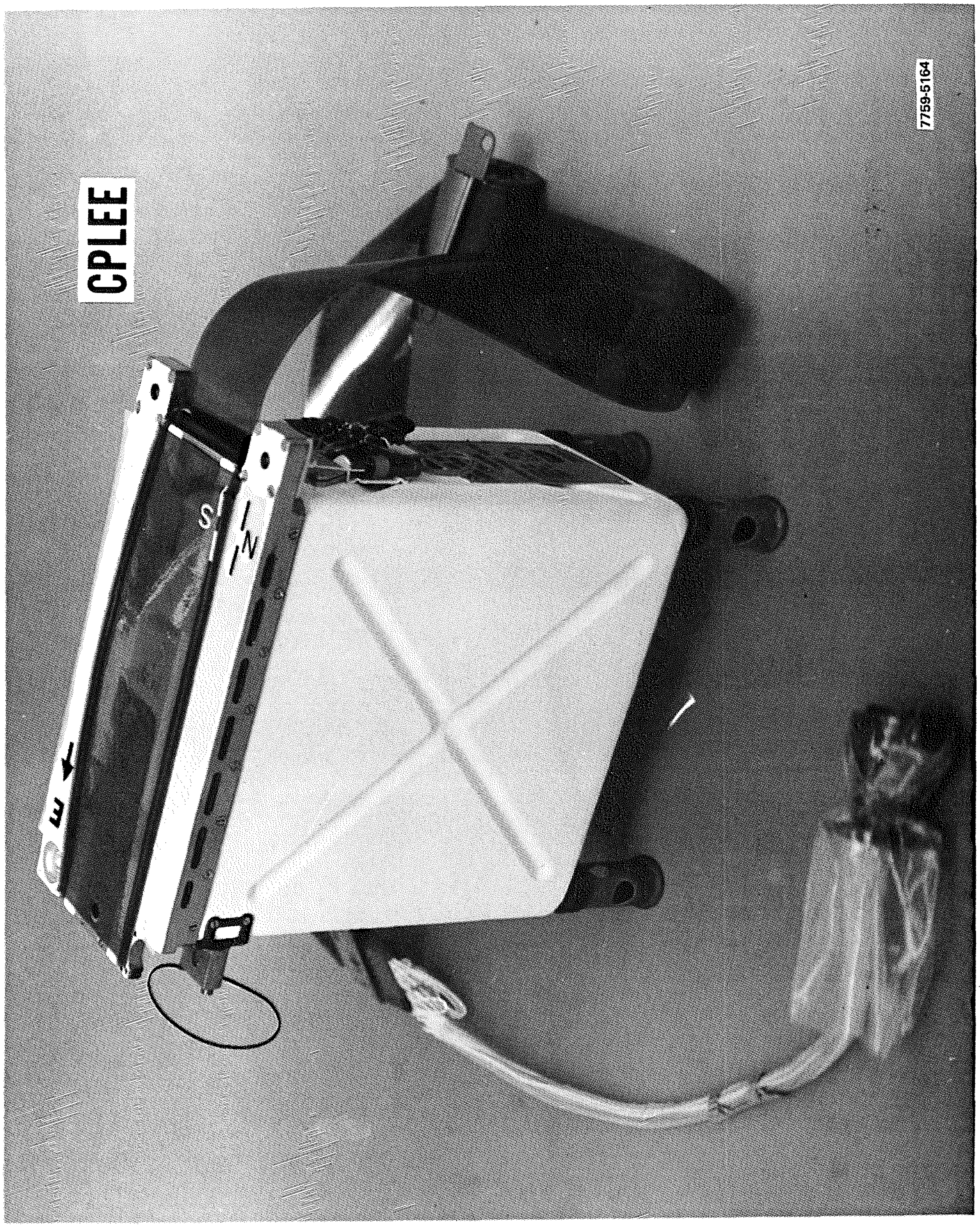

SUBPACKAGE 1 (FRONT)
WARNING
THERMAL SURFACE
HANDLE WITH
WHITE CLEAN GLOVES
FLT 3
7759-5160

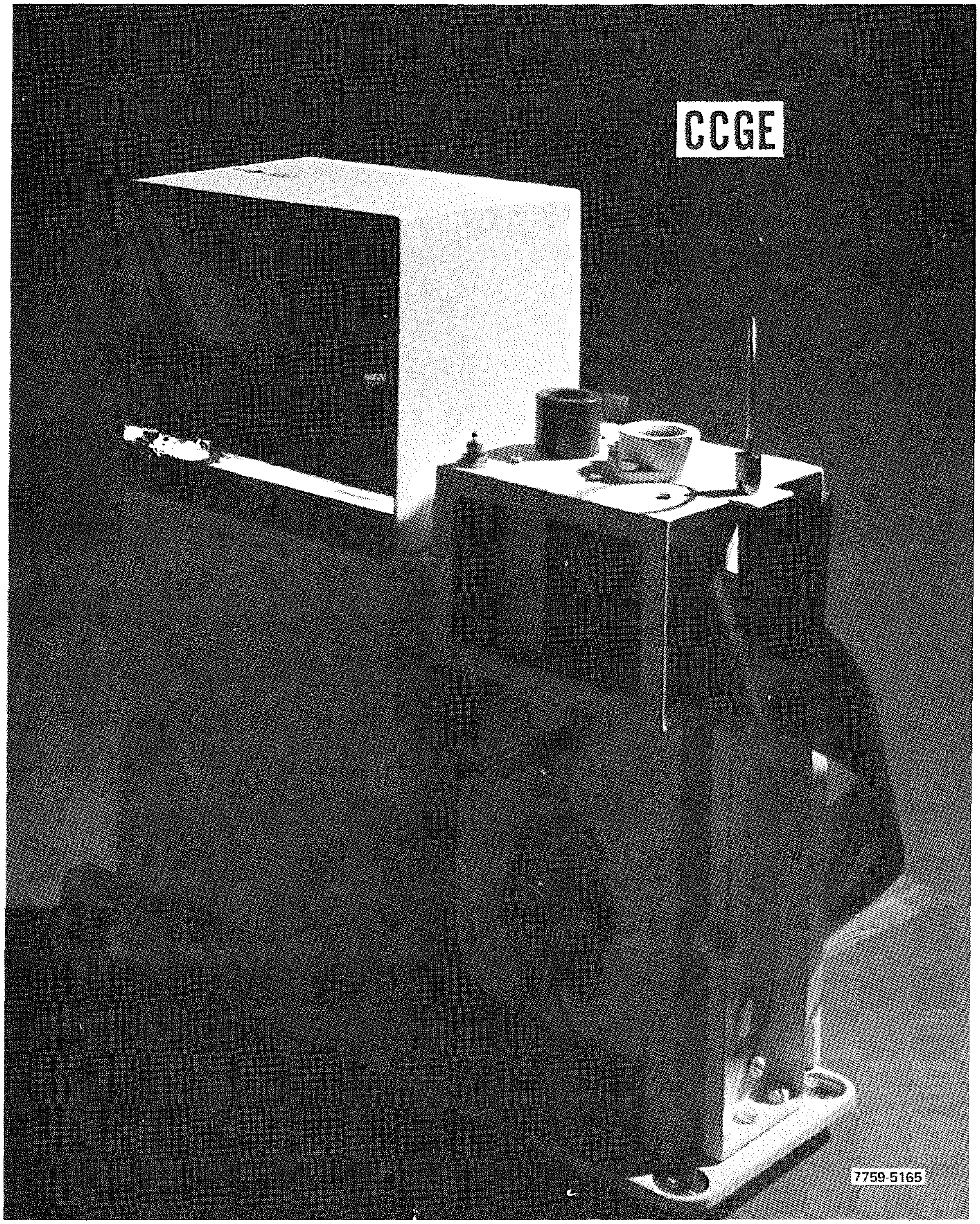

SUBPACKAGE 1 (REAR)
7759-5161

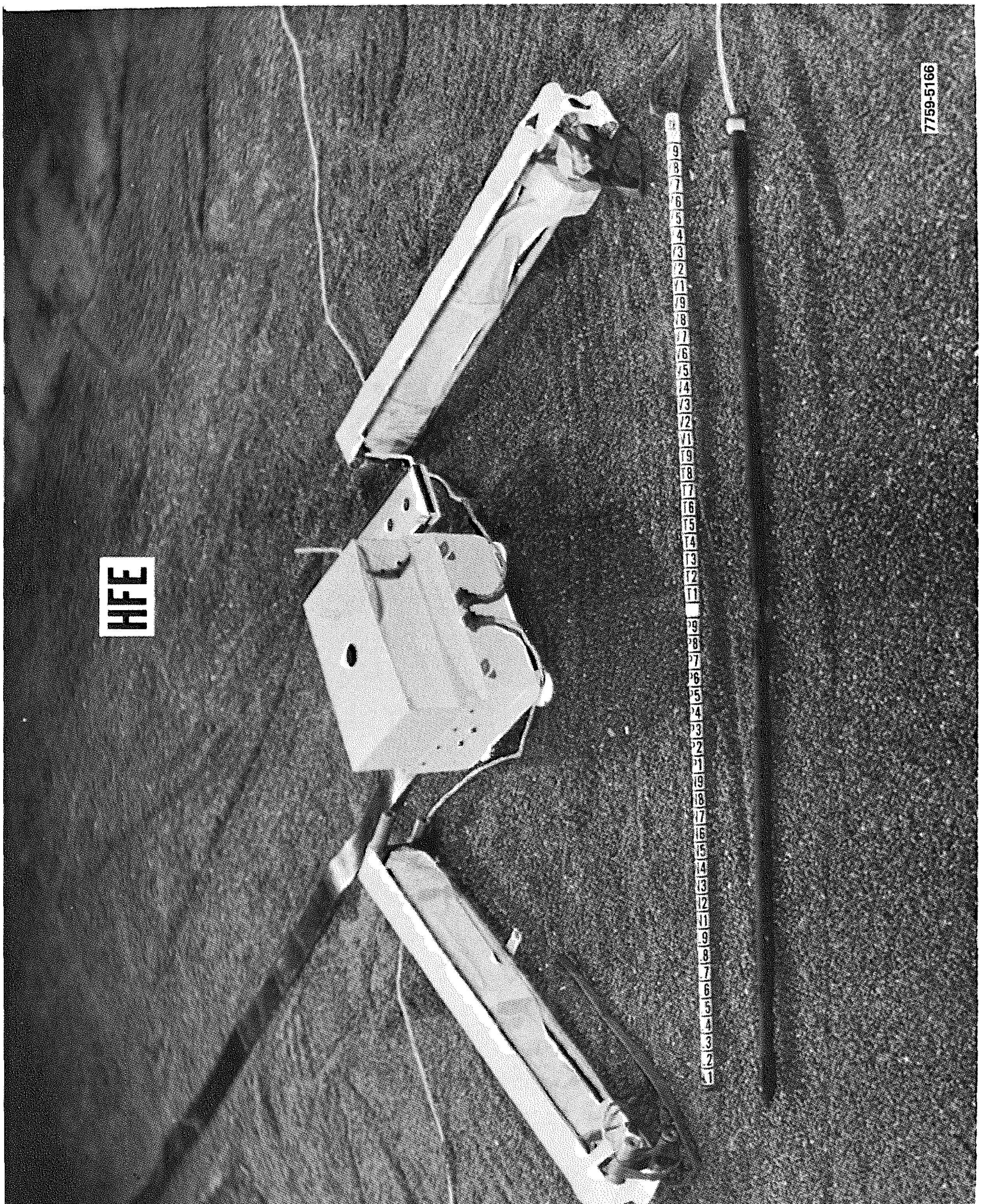

ERECTED ARRAY B
CENTRAL STATION
7759-5162

CPLEE REMOVAL

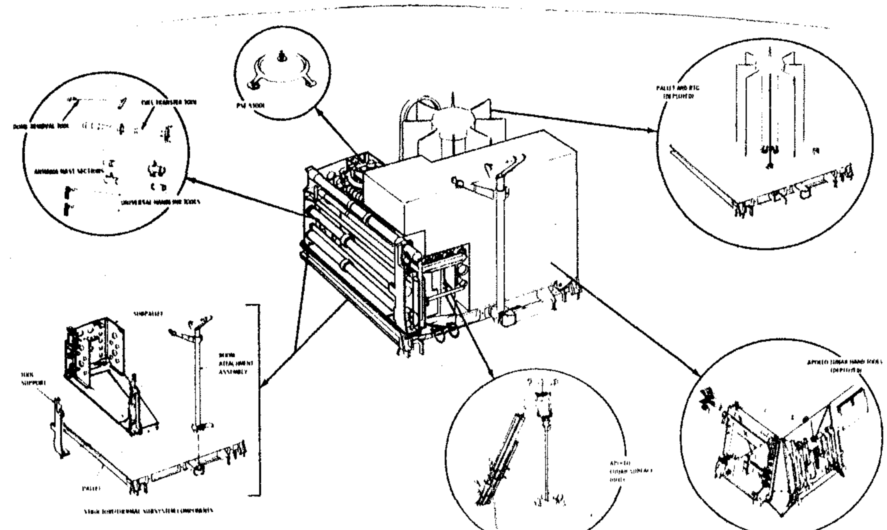



CPLEE
7759-5164

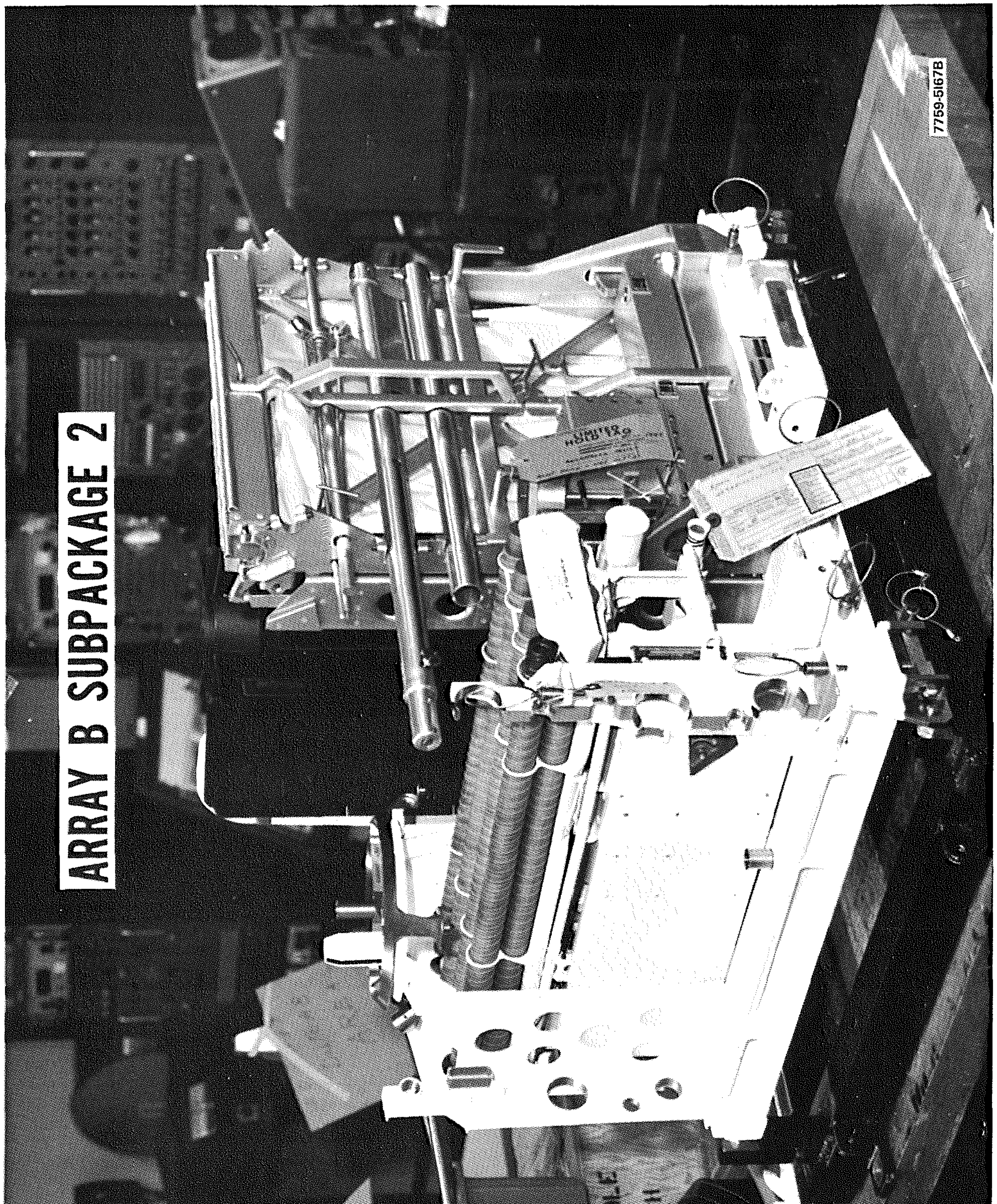

CCGE
7759-5165

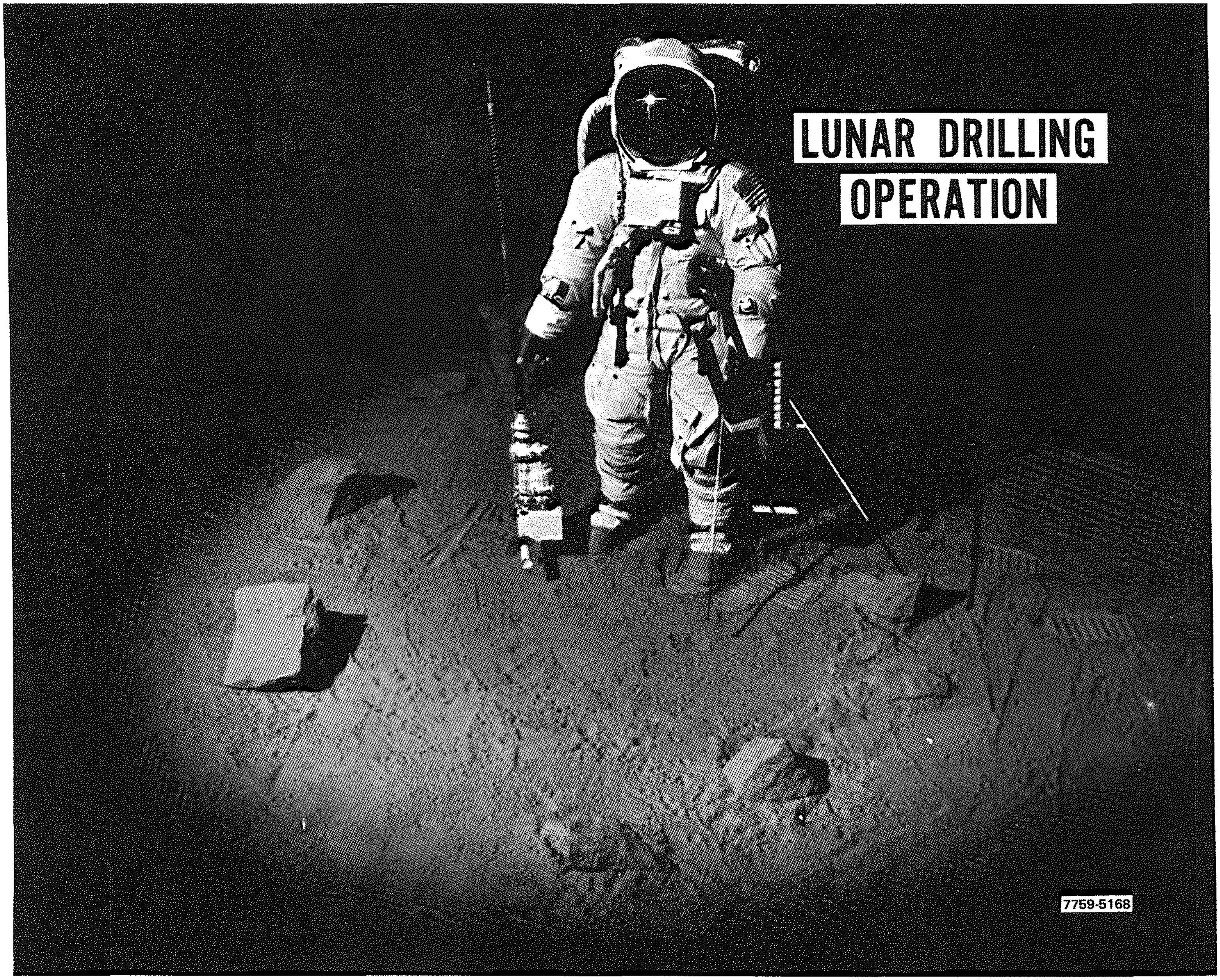

HFE
7759-5166

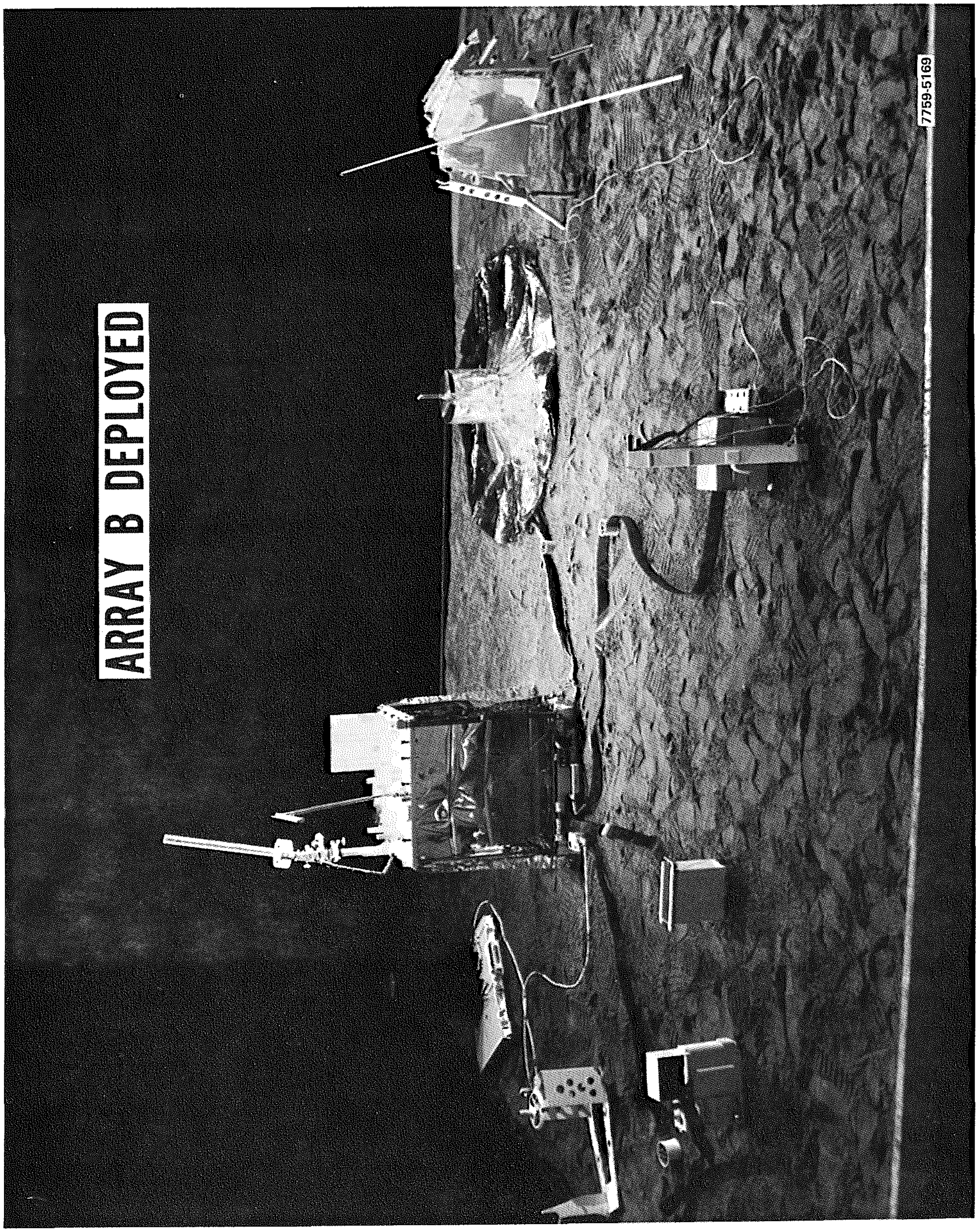
ARRAY B SUBPACKAGE 2



7759-5167A


ARRAY B SUBPACKAGE 2
7759-5167B


LUNAR DRILLING
OPERATION
7759-5168


ARRAY B DEPLOYED
7759-5169

MISSION PROFILE
UNIQUE TO ARRAY B

PRELAUNCH PHASE

SAME AS ARRAY A PLUS ALSD INSTALLATION (RECHARGED BATTERY) AT F-12 HOURS

LUNAR SURFACE ACTIVITY

CPLEE DEPLOYMENT

HFE DEPLOYMENT

CCGE DEPLOYMENT

DRILLING OPERATIONS

7759-5170

ARRAY C

CONFIGURATION DESCRIPTION

7759-5171A

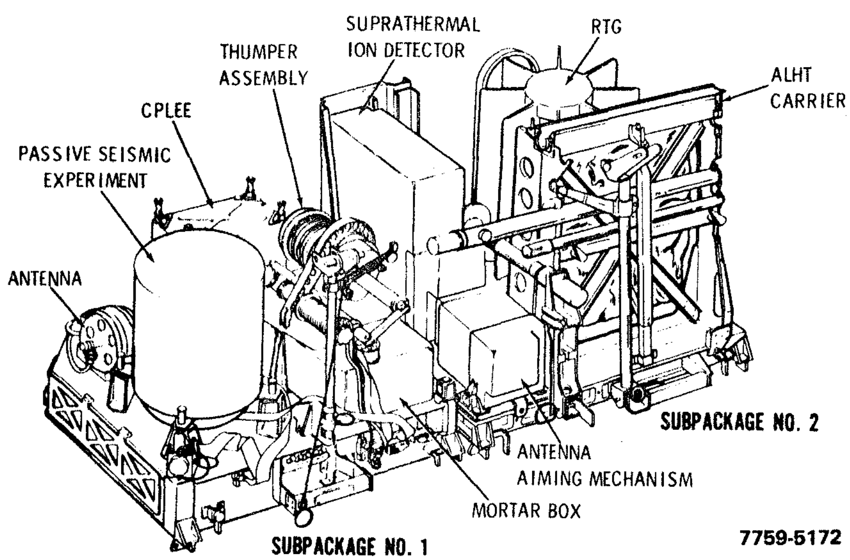
LANDING SITES

		LONGITUDE	LATITUDE
APOLLO 11	SEA OF TRANQUILITY	34 E	3 N
APOLLO 12	OCEAN OF STORMS	42 W	3 S
APOLLO 13	FRA MAURO	17 W	4 S
APOLLO 14	LITTROW	29 E	22 N
APOLLO 15	DAVEY RILLE	6 W	11 S
APOLLO 16	MARIUS HILLS	56.5 W	14.5 N
APOLLO 17	DECARTE	16 E	10 S
APOLLO 18	COPERNICUS	20 W	10 N
APOLLO 19	HADLEY APENNINES	2 E	25 N

7759-5171B

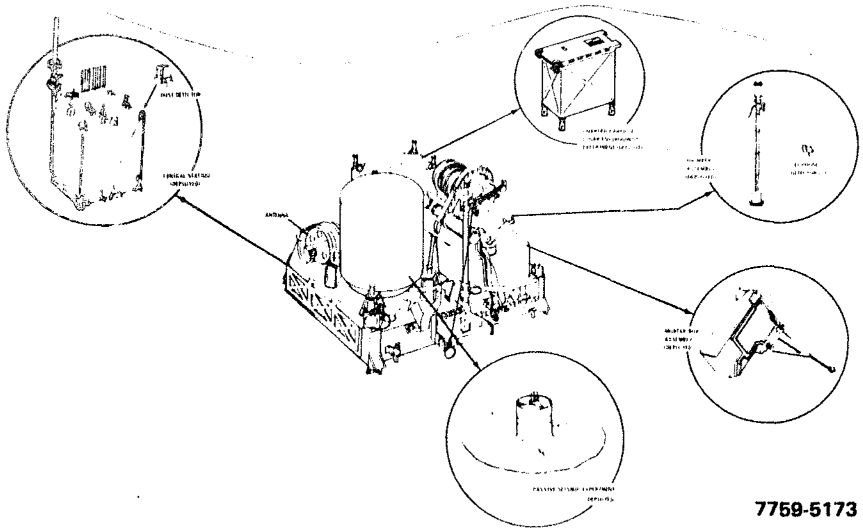
STOWED CONFIGURATION

ALSEP 4



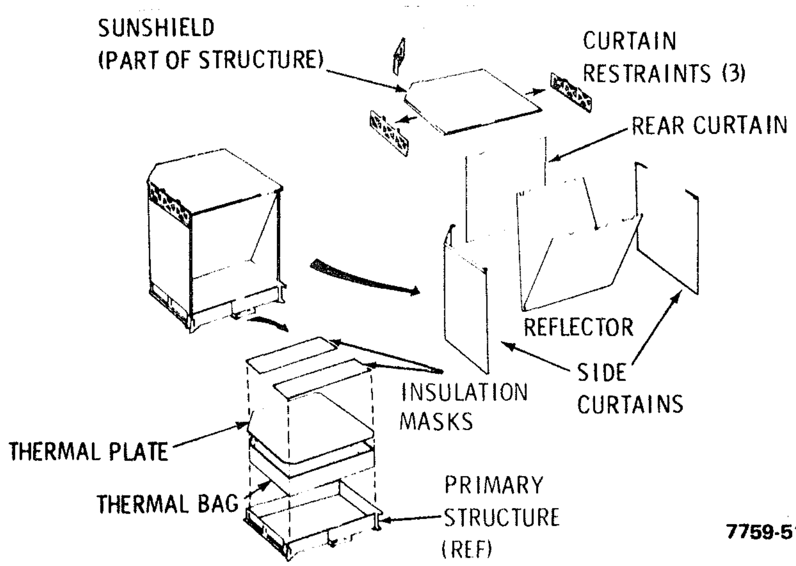
7759-5172

ALSEP SUBPACKAGE NO. 1

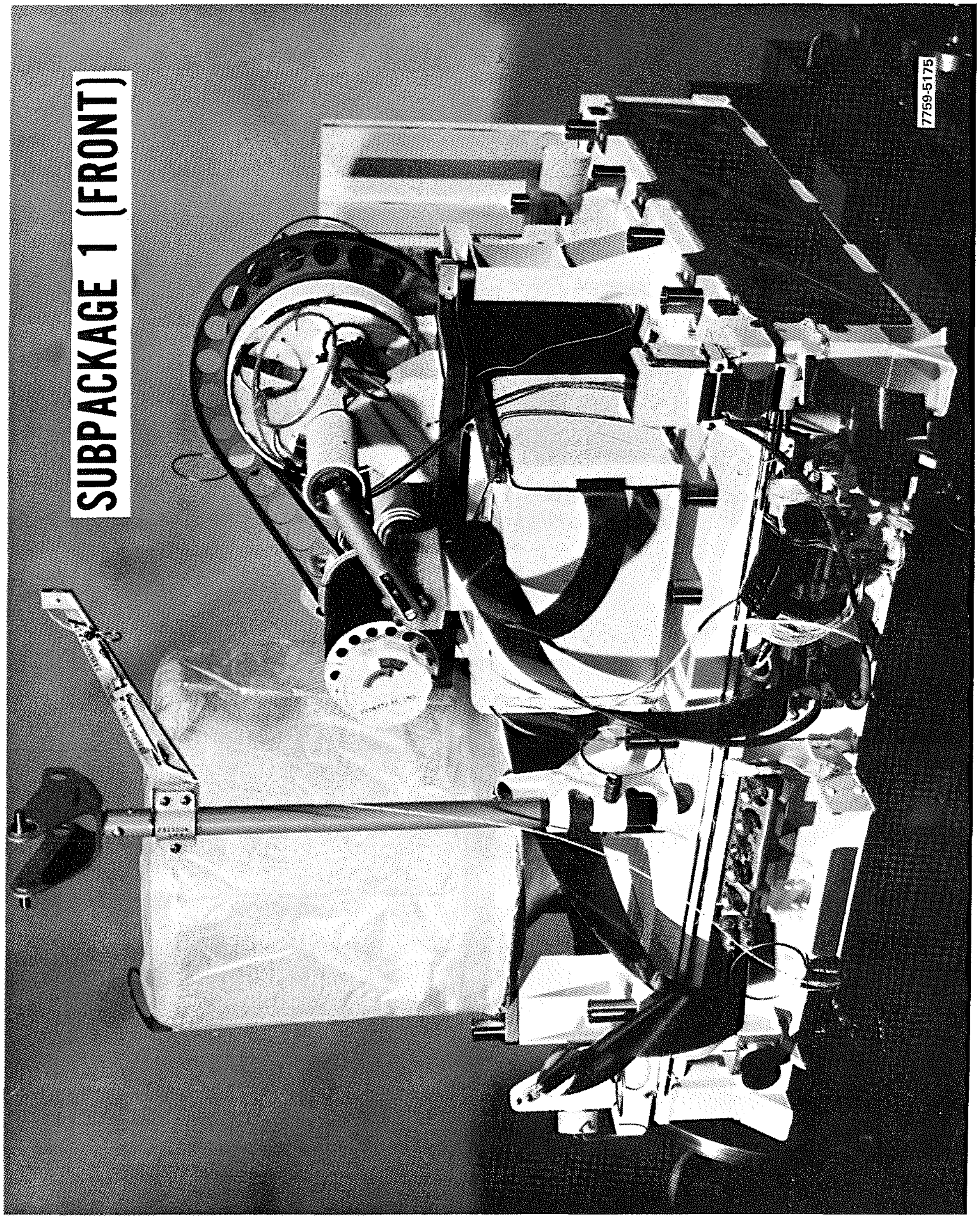


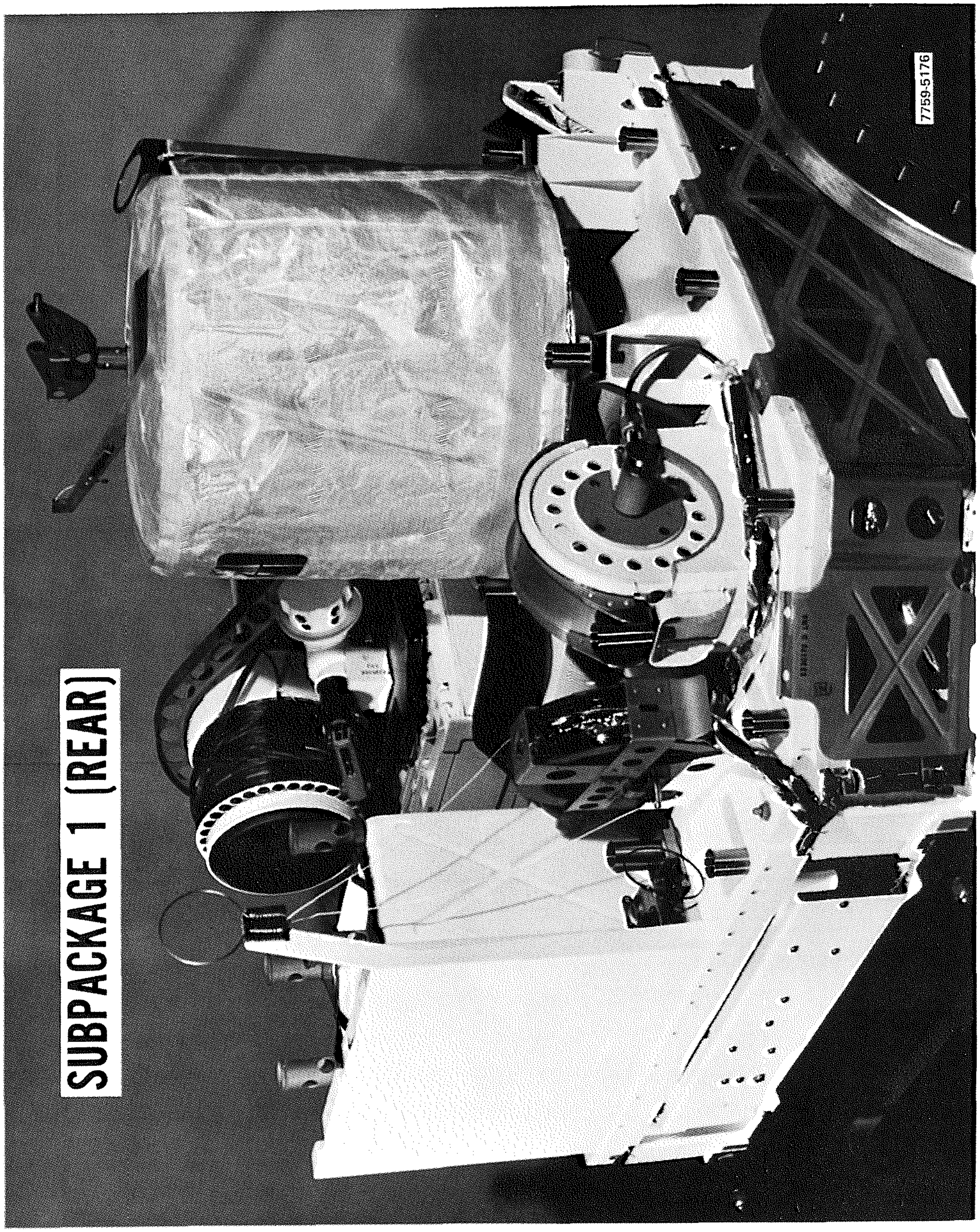
7759-5173

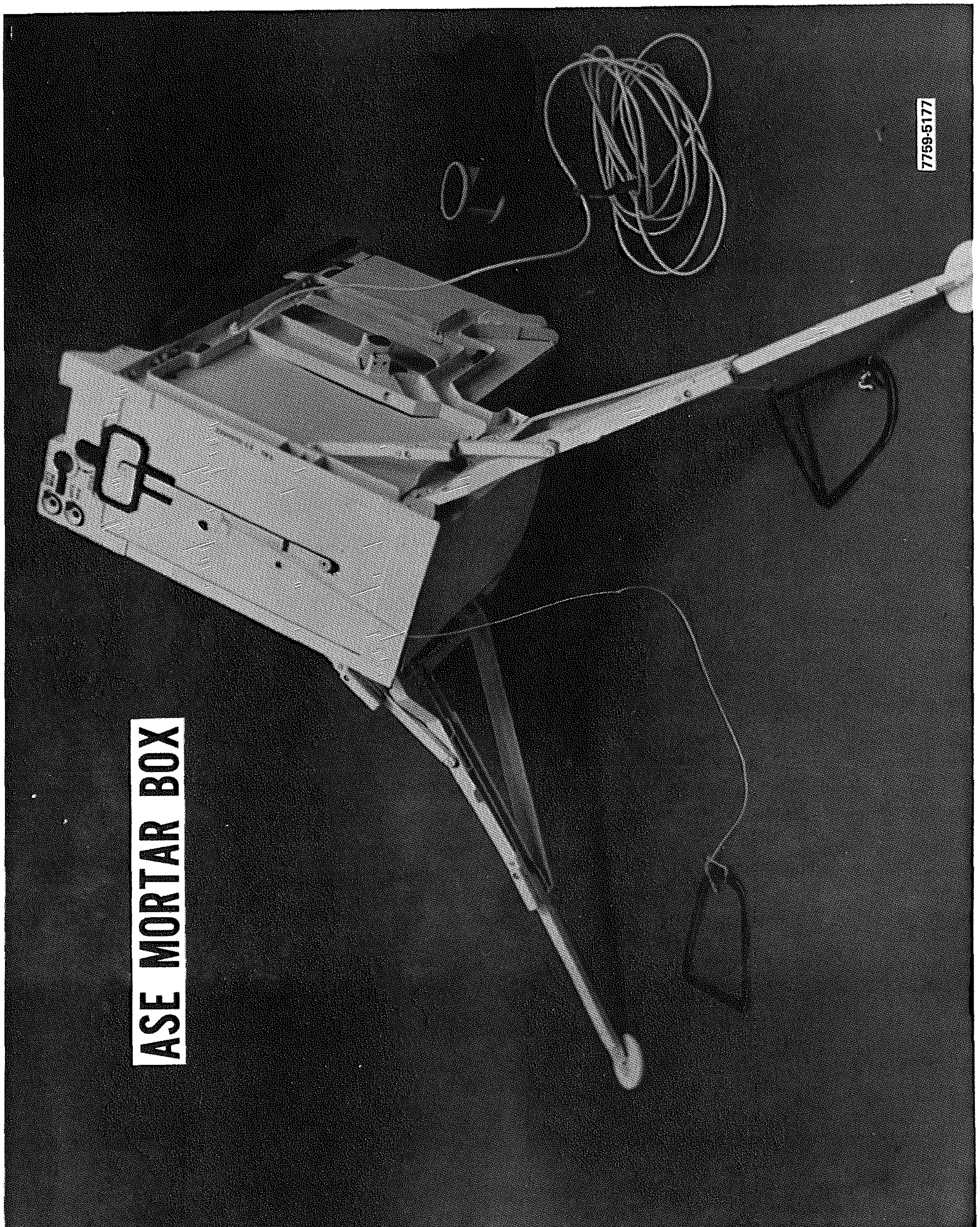
THERMAL MODS FOR ARRAY C

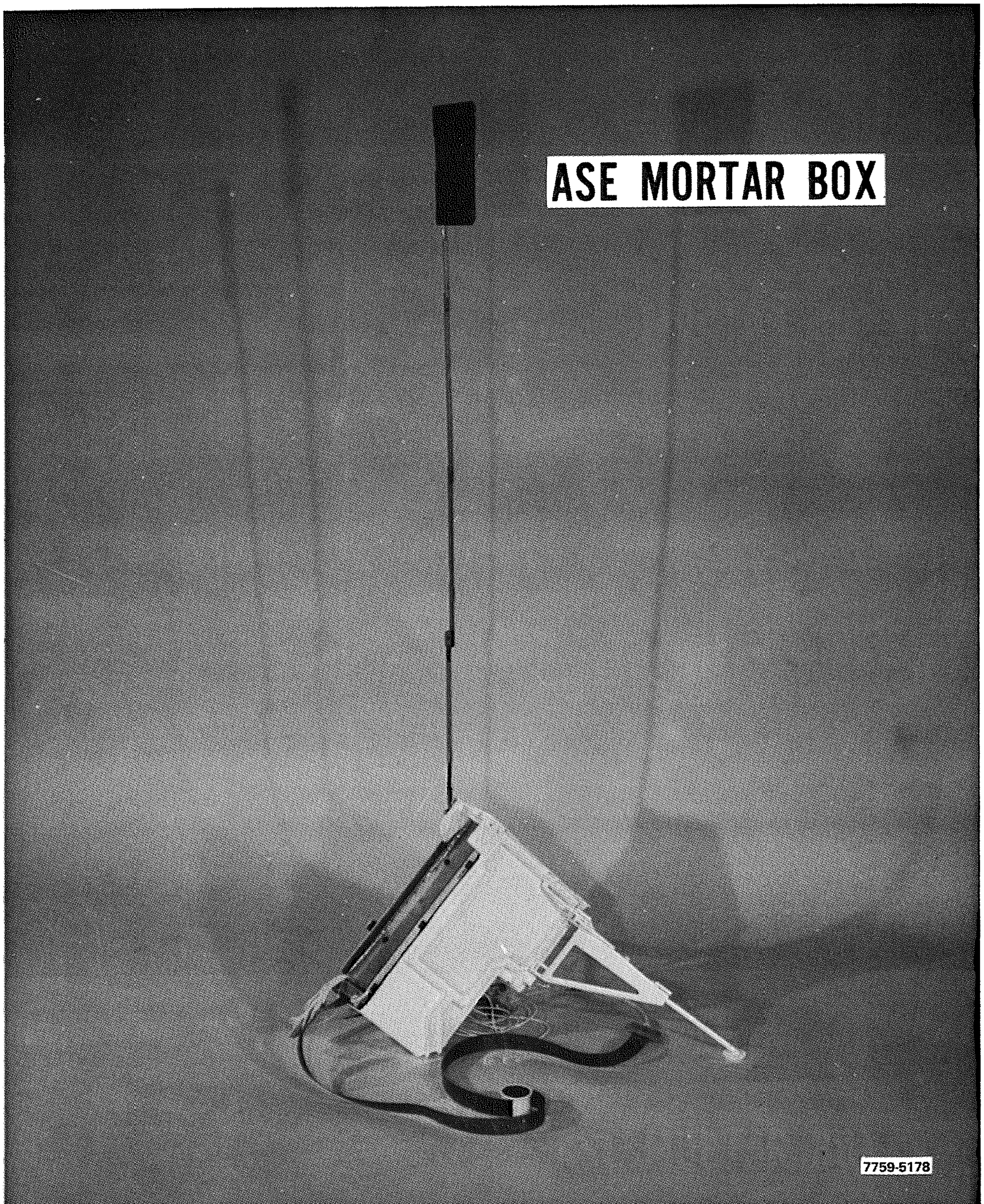


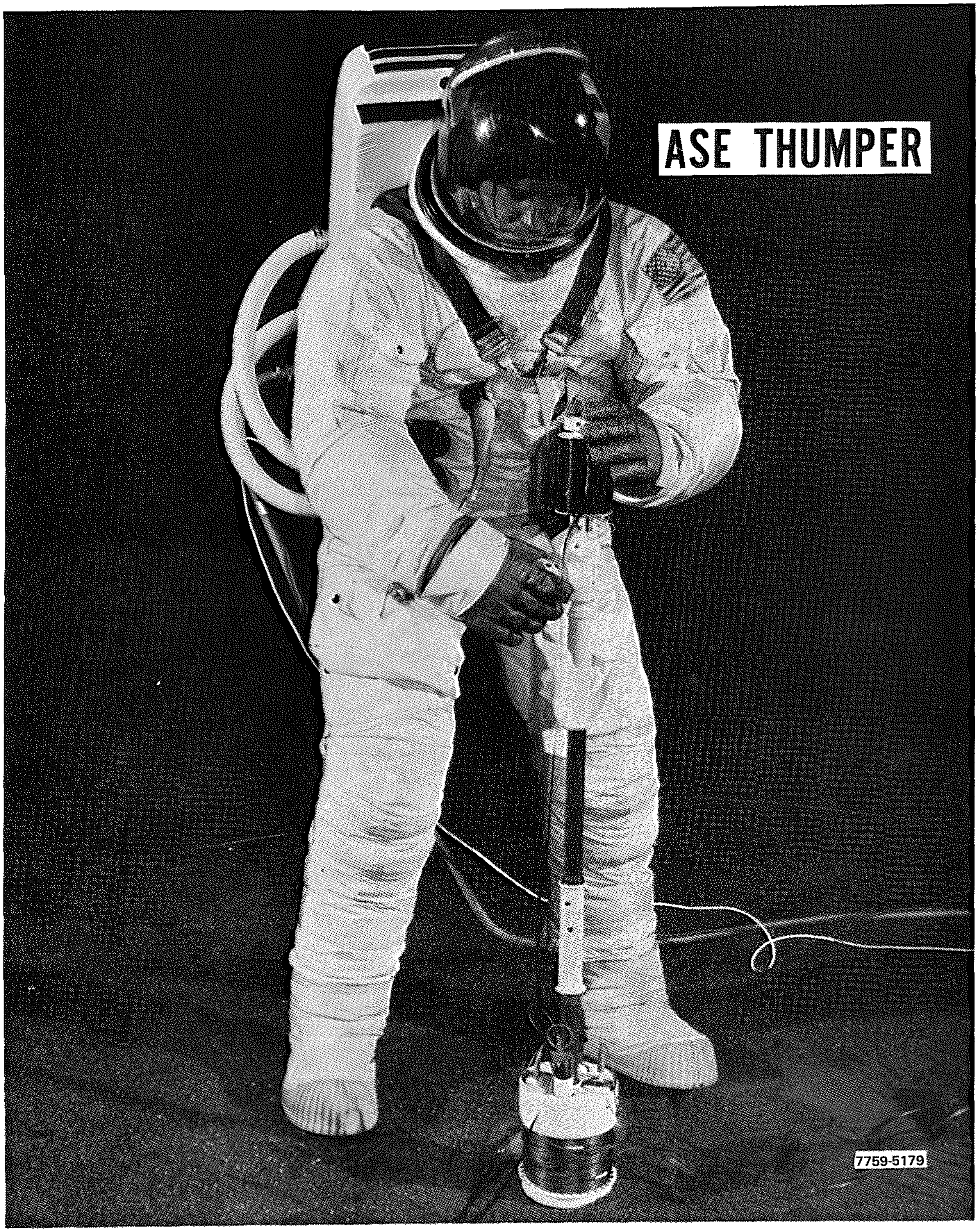
7759-5174


SUBPACKAGE 1 (FRONT)
7759-5175

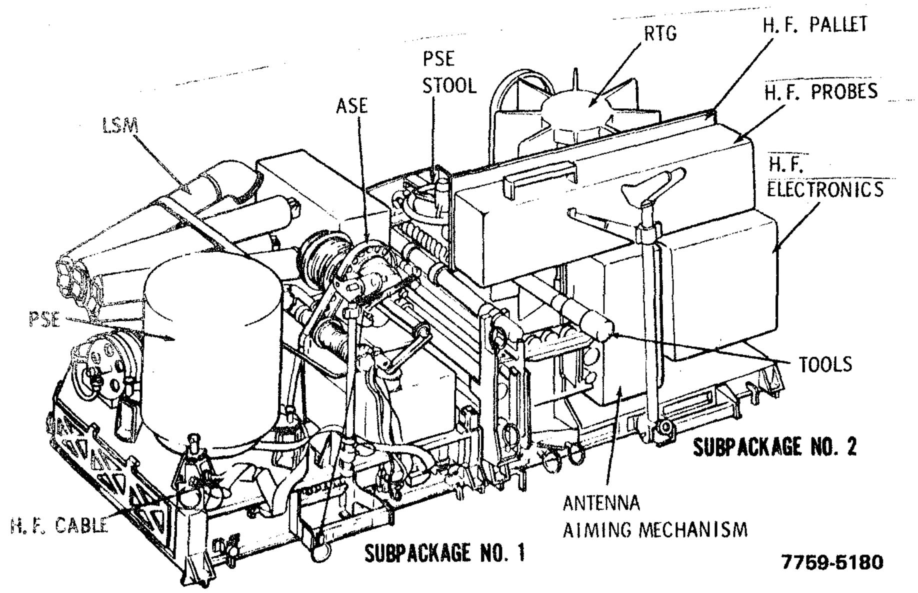

SUBPACKAGE 1 (REAR)
7759-5176


ASE MORTAR BOX
7759-5177


ASE MORTAR BOX
7759-5178


ASE THUMPER
7759-5179

ALSEP ARRAY "D"



7759-5180

EASEP

CONFIGURATION DESCRIPTION

7759-5181A

EASEP/ALSEP HISTORY AND PLAN

JUNE 1965 - WOODS HOLE CONFERENCE ESTABLISHED SCIENTIFIC GOALS

JULY 1965 - FALMOUT CONFERENCE SCREENED SCIENTIFIC PROPOSALS

APOLLO LUNAR SURFACE EXPERIMENTS PACKAGE(ALSEP)		EARLY APOLLO SCIENTIFIC EXPERIMENT PAPLOAD (EASEP)	
AUG 1965	- NASA STARTED PRELIMINARY DESIGNS (THREE CONTRACTORS)	OCT 1968	- START OF EASEP DEVELOPMENT USING PARTS OF SECOND ALSEP PLUS NEW EQUIPMENT
MARCH 1966	- START OF DEVELOPMENT PROGRAM TO BUILD FOUR FLIGHT ARTICLES (BENDIX PRIME CONTRACTOR)	THIS SIMPLIFIED PACKAGE WILL ALLOW THE ASTRONAUTS TO CONCENTRATE ON MAKING A SAFE LUNAR TRIP AND WILL PRODUCE IMPORTANT SCIENTIFIC DATA LONG AFTER THE FLIGHT	
JULY 1968	- DELIVERY OF FIRST FLIGHT ARTICLE		
OCT 1968	- DELIVERY OF SECOND FLIGHT ARTICLE		

PLANNED MISSION ASSIGNMENTS

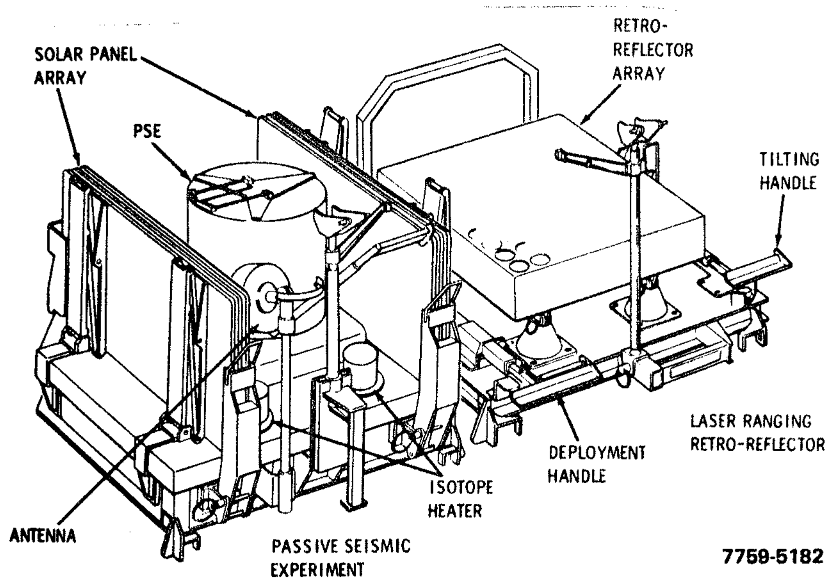
APOLLO 11: EASEP

APOLLO 12: ALSEP A
APOLLO 13: ALSEP B
APOLLO 14: ALSEP C

(CONTAIN 8 DIFFERENT EXPERIMENTS IN SETS OF 4/FLIGHT)

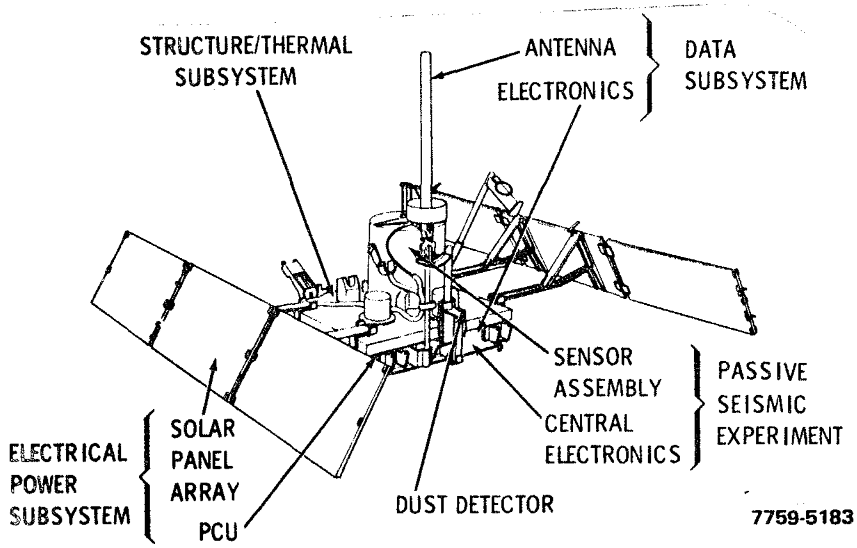
7759-5181B

EASEP STOWED CONFIGURATION

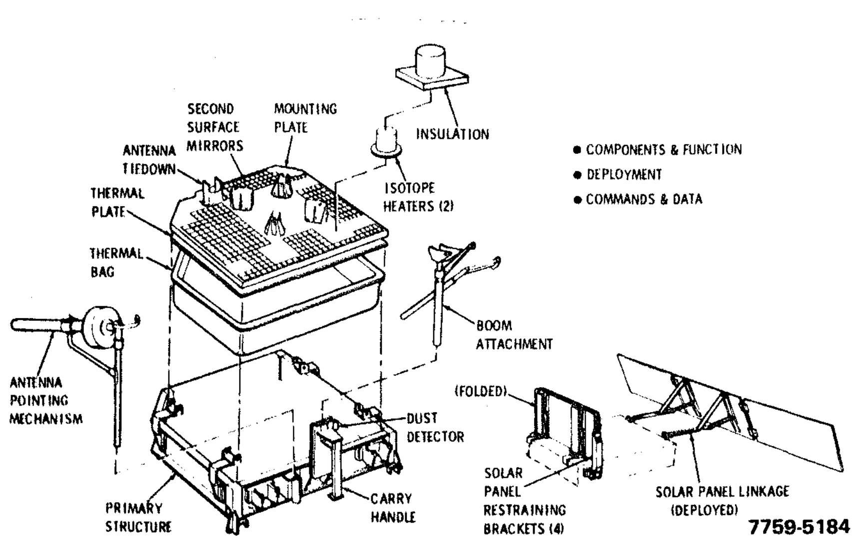


7759-5182

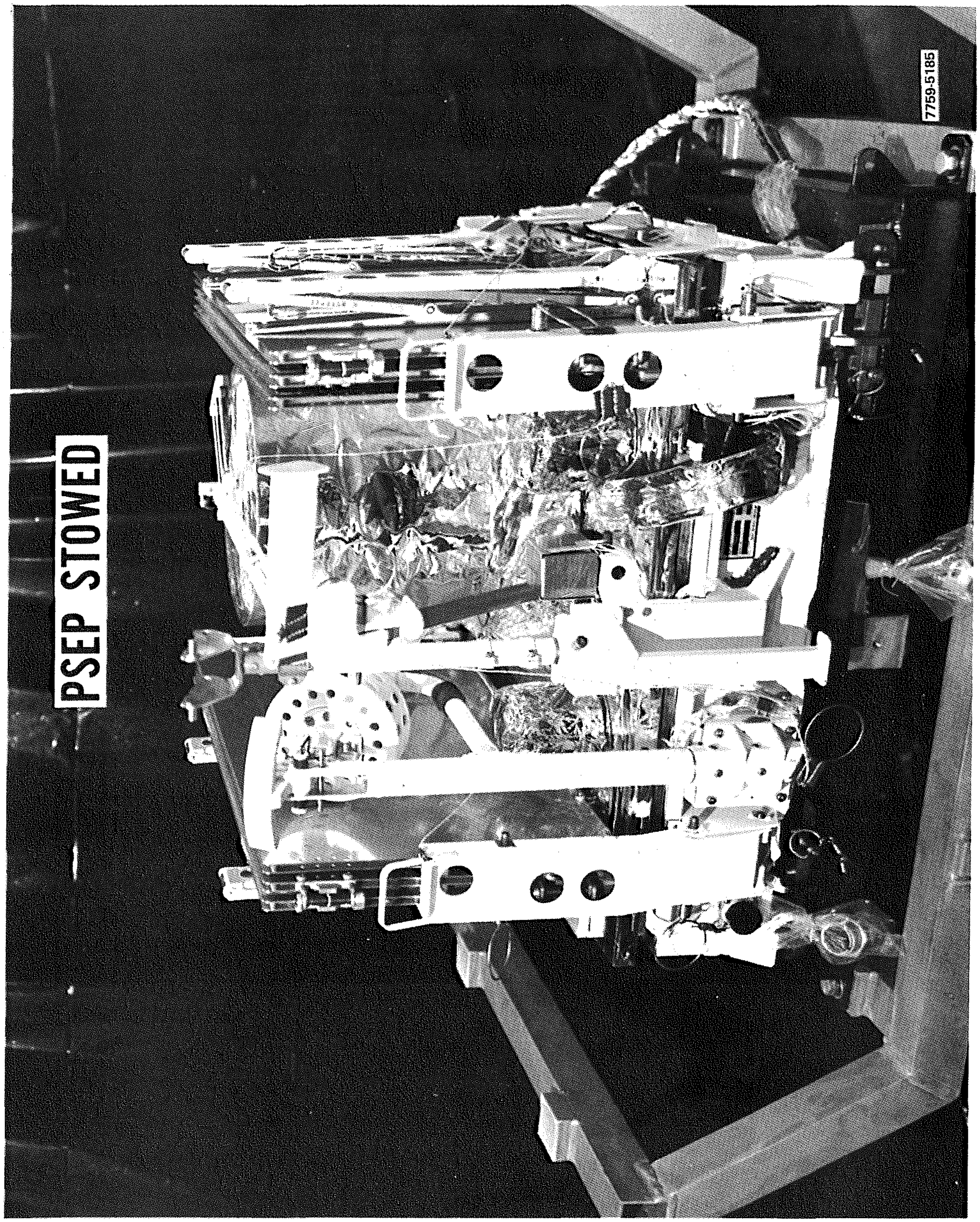
PSEP SUBSYSTEMS

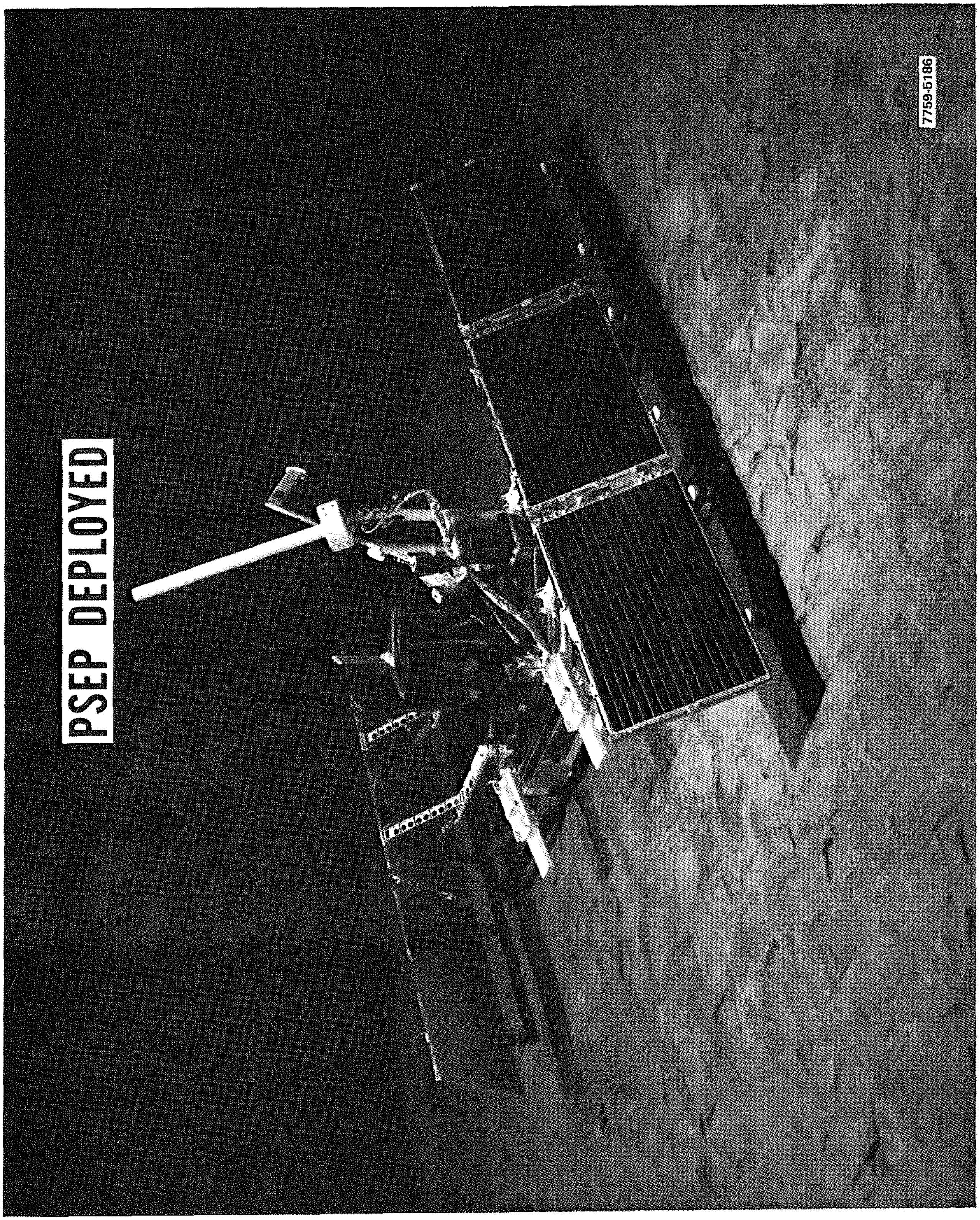


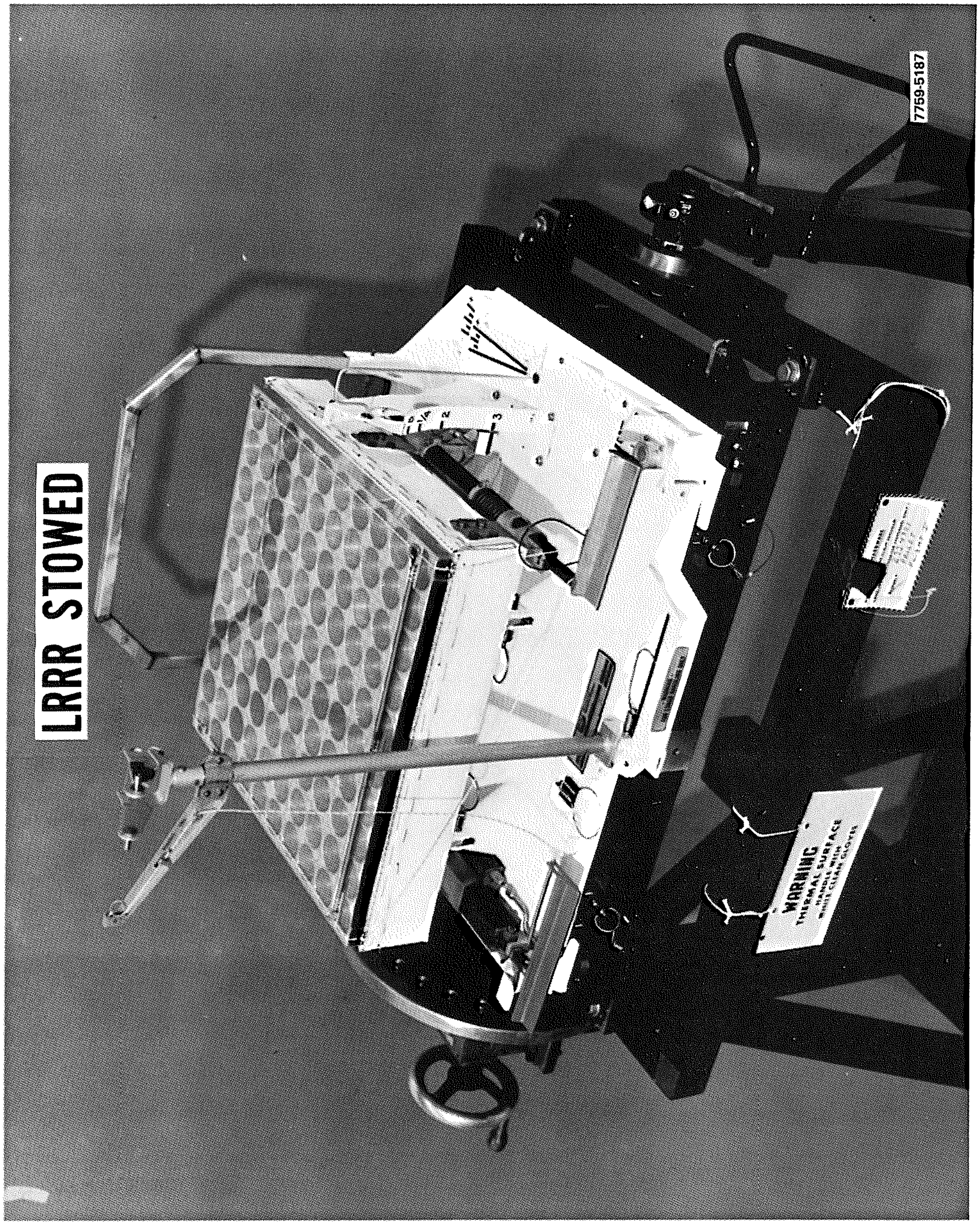
PSEP STRUCTURE/THERMAL SUBSYSTEM

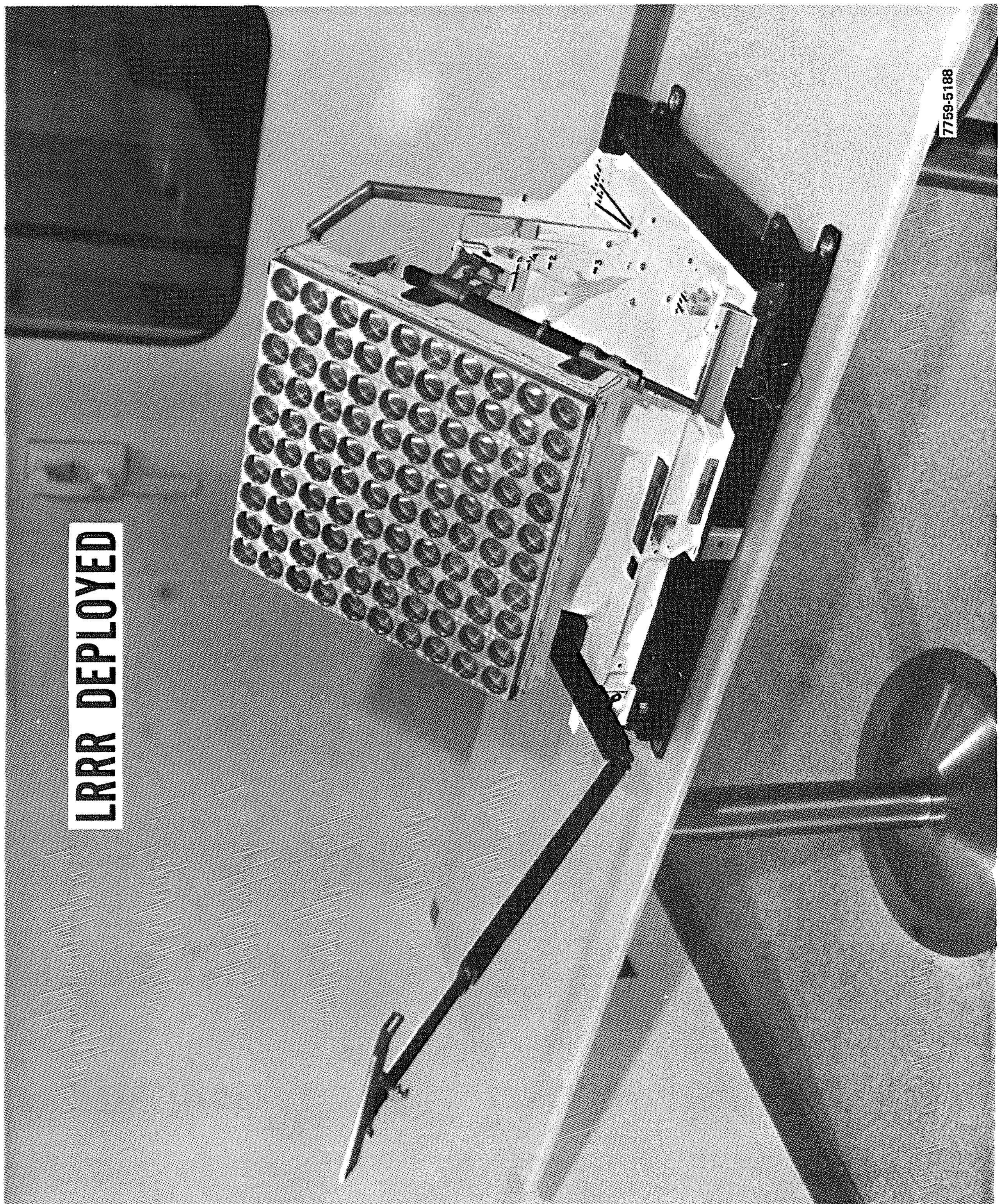


- COMPONENTS & FUNCTION
- DEPLOYMENT
- COMMANDS & DATA

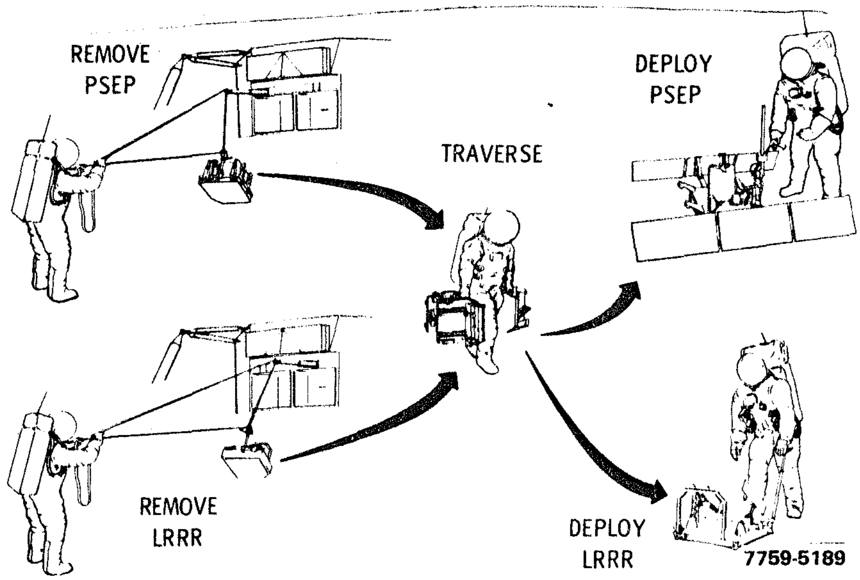

PSEP STOWED
7759-5185

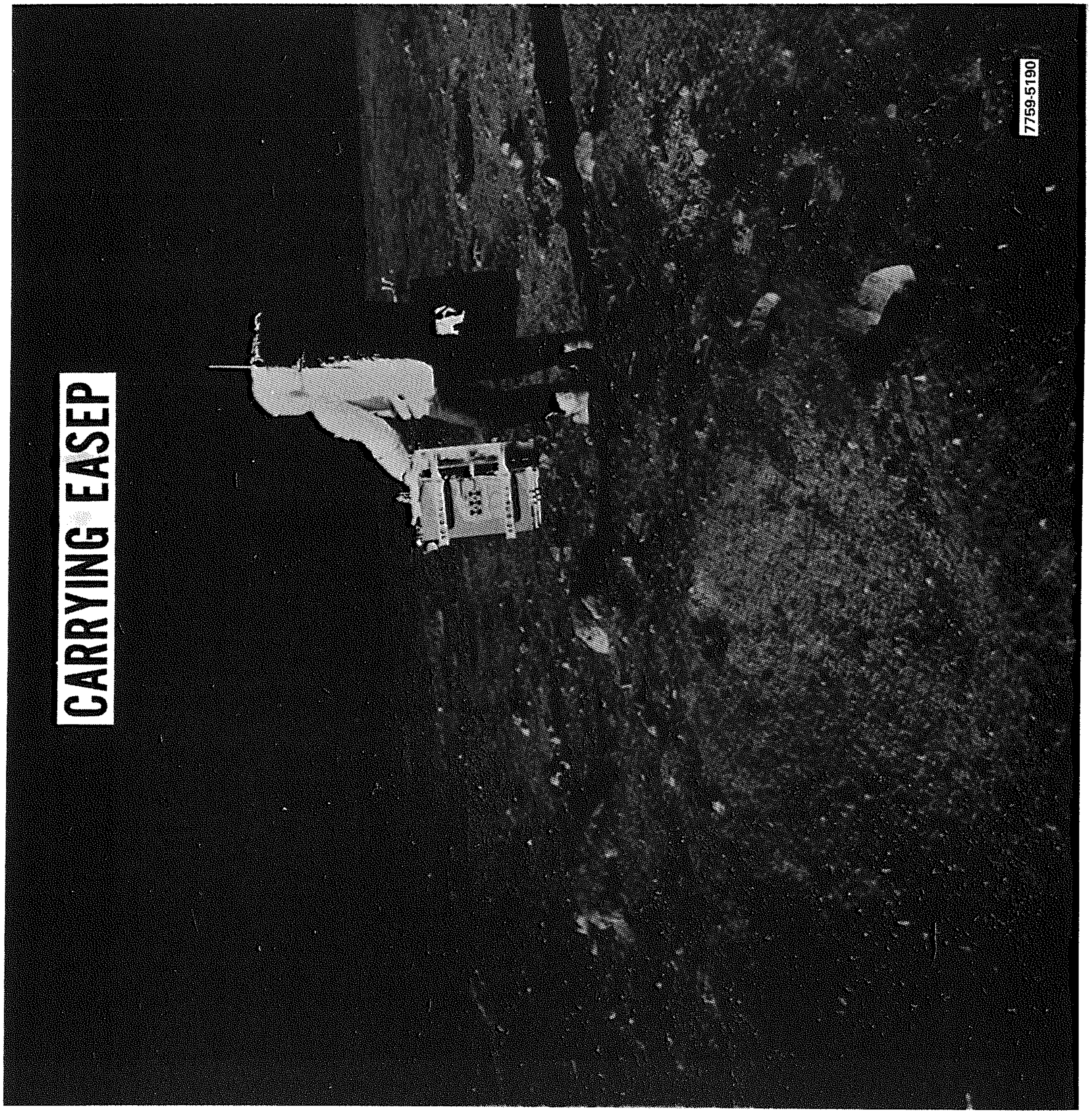

PSEP DEPLOYED
7759-5186

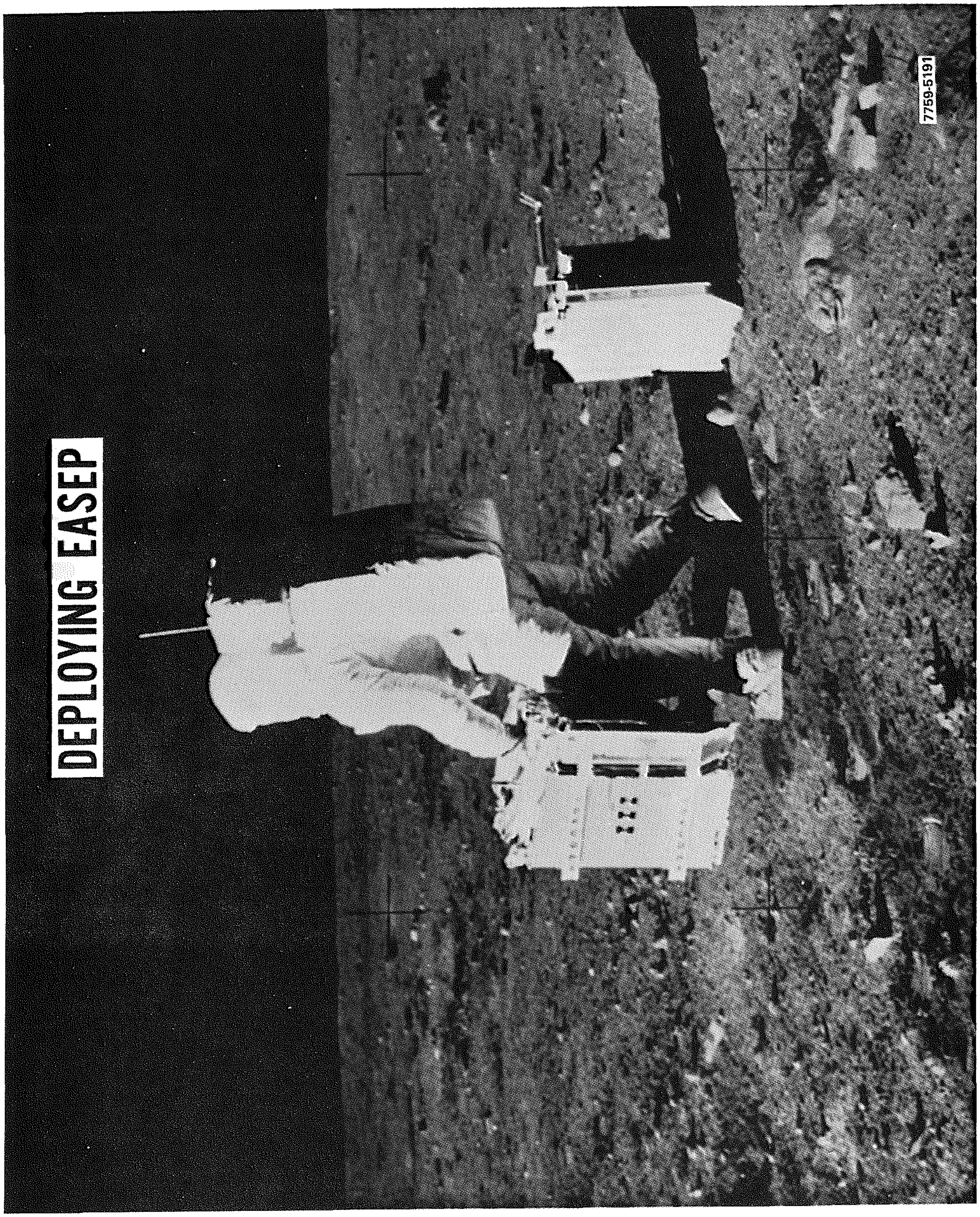

LRRR STOWED
7759-5187
WARNING
THERMAL SURFACE

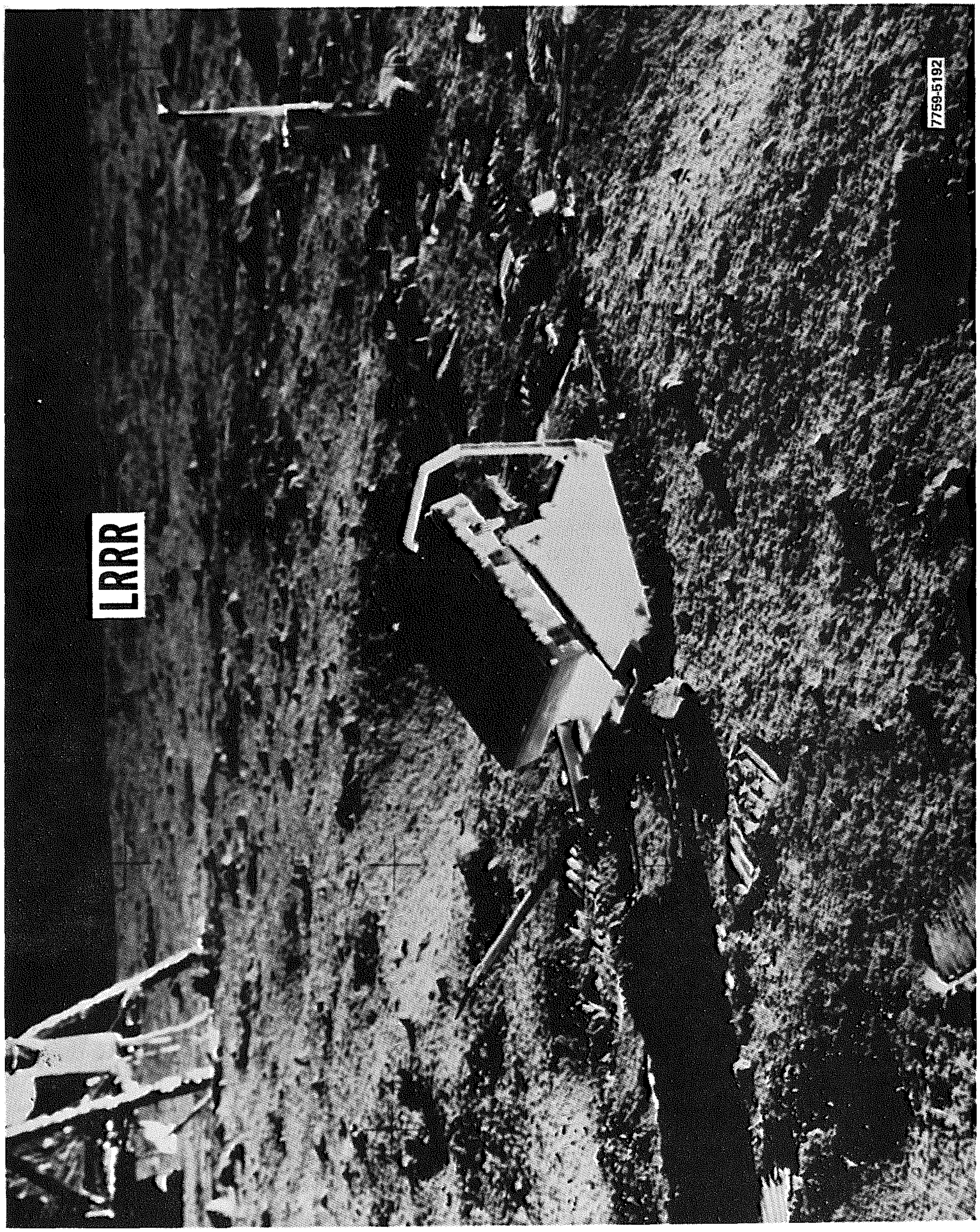

LRRR DEPLOYED
7759-5188

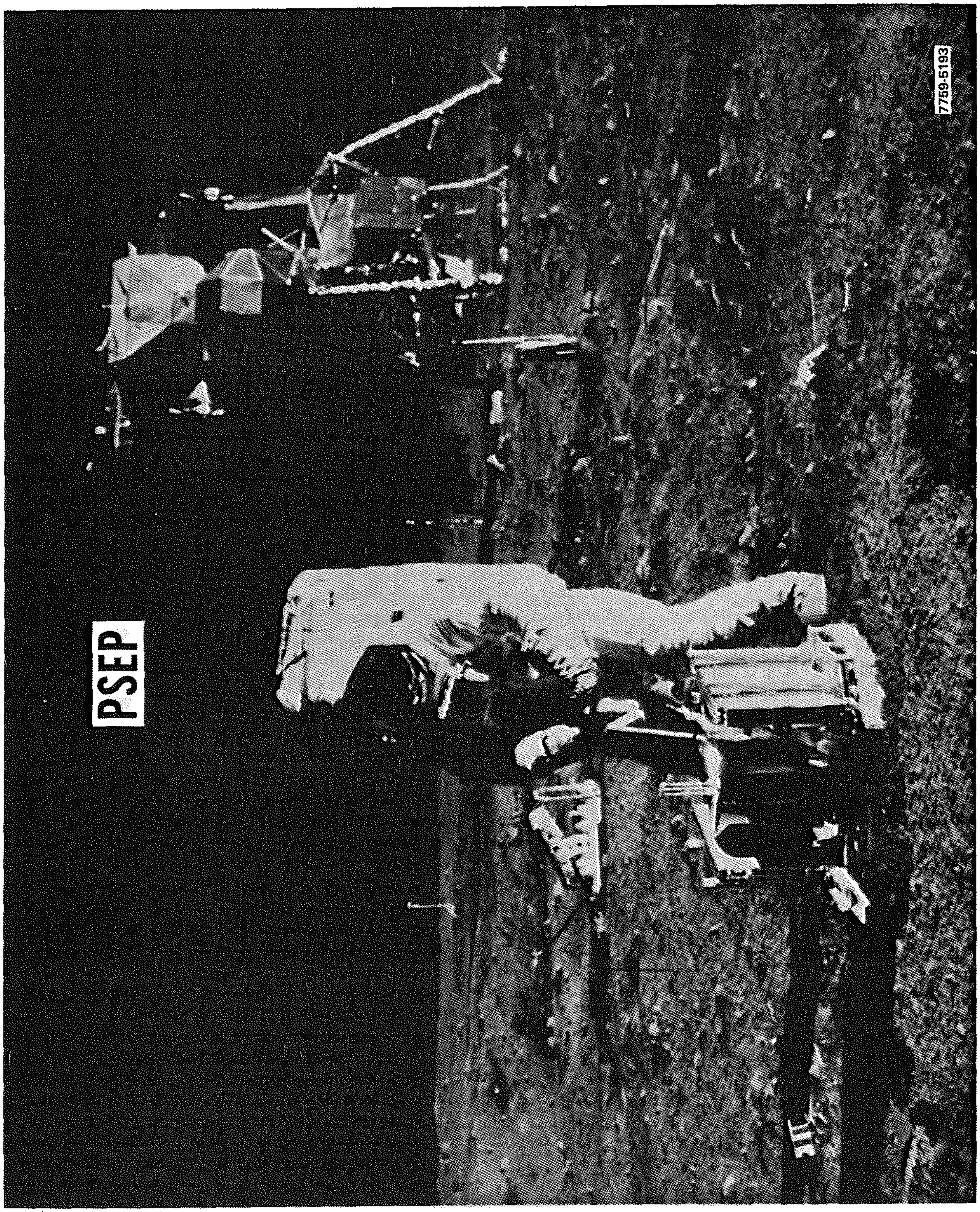
LUNAR SURFACE PHASE

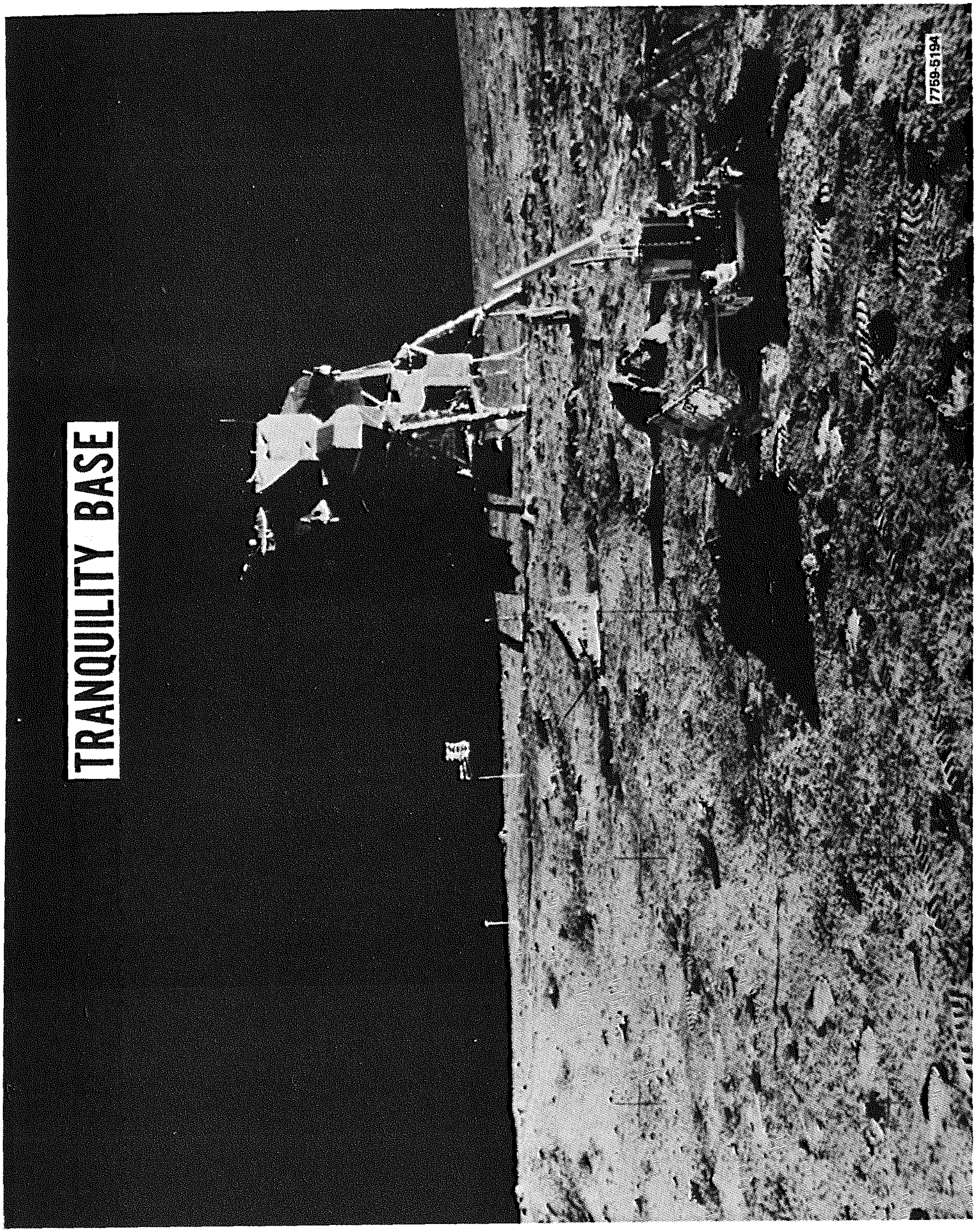



CARRYING EASEP
7759-5190


DEPLOYING EASEP
7759-5191


LRRR
7759-5192


PSEP
7759-5193


TRANQUILITY BASE
7759-5194

ALSEP FLIGHT 1 RELIABILITY

SUBSYSTEM	RELIABILITY GOAL	CURRENT RELIABILITY PREDICTION
POWER	0.9900	0.9819
DATA	0.9642	0.8766
STRUCTURAL/THERMAL	0.9997	0.9926
PASSIVE SEISMIC	0.9900	0.9322
MAGNETOMETER	0.9900	0.7644*
SOLAR WIND	0.9900	0.8543*
SIDE/CCGE	0.9900	0.6803*

*GFE PREDICTIONS FURNISHED BY NASA.

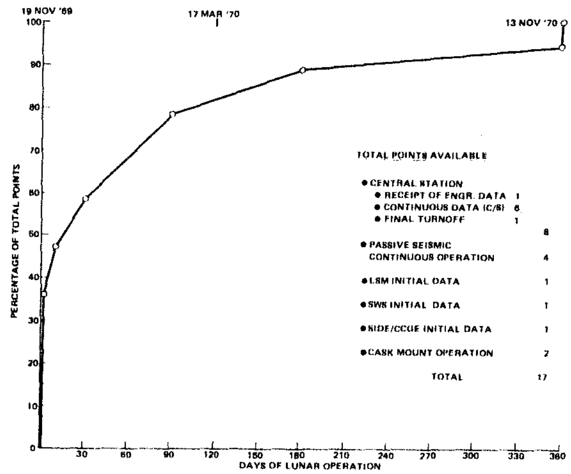
7759-5195

ALSEP FLIGHT 1
SUBSYSTEM FIGURE OF MERIT

SUBSYSTEM	PROBABILITY OF SUCCESS 12 MONTH OPERATION	FIGURE OF MERIT 12 MONTH OPERATION
ELECTRICAL POWER SUBSYSTEM	0.98194	0.98907
DATA SUBSYSTEM	0.87662	0.937333
STRUCTURAL THERMAL	0.99256	0.994623
PASSIVE SEISMIC EXPERIMENT	0.9322	0.965811
LUNAR SURFACE MAGNETOMETER EXPERIMENT	0.7644	0.876814
SOLAR WIND EXPERIMENT	0.8543	0.925255
SIDE/CCGE	0.6803	0.829915

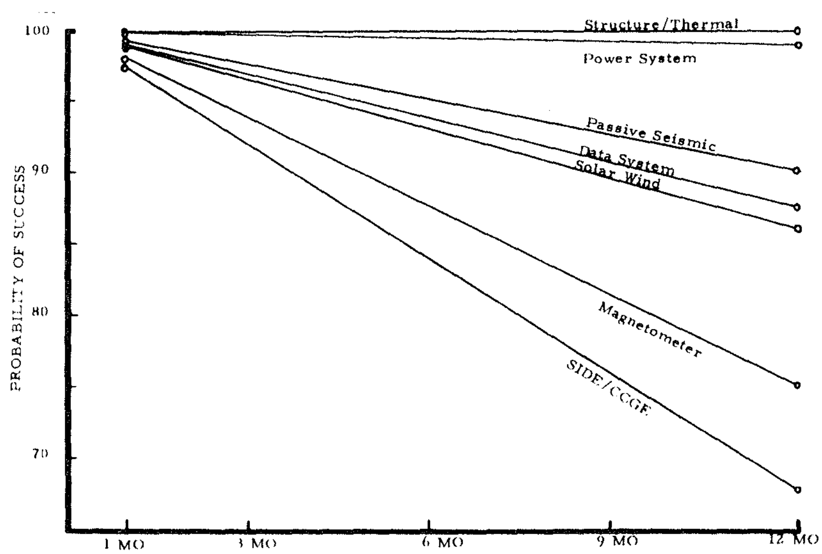
7759-5196

ALSEP ARRAY A (FLT 1)
LUNAR PERFORMANCE INCENTIVES



7759-5198

ALSEP FLIGHT 1 PROBABILITY OF SUCCESSFULLY OBTAINING SCIENTIFIC DATA ON EARTH



7759-5197

Section 2

Alsep Power System

RTG/ASTRONAUT INTERFACE

CONSTRAINT	RESOLUTION
THERMAL: • NO SUIT CONTACT WITH SURFACES MORE THAN 250°F • MINIMIZE HEAT LOAD ON SUIT COOLING EQUIP	• THERMAL BARRIER (SMALL DOOR) PROTECTION WHILE AT SEQ BAY • LANYARDS FOR CASK ROTATION & DOME LOCK • TOOL FOR DOME REMOVAL • TOOL FOR FUEL TRANSFER, CASK TO GENERATOR • SUBPACKAGE 2 CARRY PLACES RTG AWAY FROM SUIT
NUCLEAR: • NO HAZARDOUS DOSE	• PU 238 IS α EMITTER • α PARTICLES ARE ENTIRELY ABSORBED IN HEAT GENERATION • ONLY SECONDARY TYPES (γ & NEUTRONS) GET OUT • LOW EXTERNAL FIELD, VERY LOW DOSE LEVEL
ELECTRICAL: • NO EXPOSED CHARGED CONTACTS	• RTG CABLE HAS SHORTING SWITCH IN CONNECTOR • ASTRONAUT READS AMMETER, REMOVES DUST COVERS, ENGAGES CONNECTOR, & ACTIVATES SWITCH

OPERATIONS

PREPARE CASK FOR TRANSFER, 2 MIN; TRANSFER FUEL CAPSULE CASK TO GENERATOR, 1 MIN; DEPLOY SUBPACKAGE 2, UNREEL CABLE & MAKE CONNECTION, 2 MIN (ALL TIMES ARE APPROX)

7759-5819

FUEL CASK DESIGN CONSTRAINTS

CASK & CAPSULE DESIGN	SYSTEM REQUIREMENT	SYSTEM DESIGN
	. ENVELOPE RESTRICTIONS	. DESIGN LIMITED BY SLA WITHDRAWAL ENVELOPE
. CLASSICAL AERODYNAMIC SHAPE	. DIFFICULTY TO GRASP	. BASKET DESIGN WITH ADJUSTABLE BANDS
	. NO METALLIC PROTRUSIONS OR ATTACHMENTS	
	. NO INDENTATIONS	
. GRAPHITE MATERIAL	. LOW COEFFICIENT OF THERMAL EXPANSION (1.0×10^{-6})	. ADJUSTABLE BANDS
	. WEIGHT - 42 lb	. INCREASED STRUCTURAL MEMBERS (SIZE AND NUMBER)
		. SAME GAEC INTERFACE
	. NEGLIGIBLE LOAD CARRYING CAPABILITY.	. ALLOWABLE LOAD PATHS TO LM AND LOAD POINTS OF CASK WERE ACCOMMODATED BY BASKET DESIGN, LONGITUDINAL STRUCTURAL MEMBERS AND ADDITION OF LINKAGE IN VERTICAL PLANE.

7759-6200

ICS DEPLOYMENT REQUIREMENTS

TASK	MAX FORCE
TRUNNION RELEASE	20 LB
SPLINE RELEASE	20 LB
TILT FUNCTION	
LOWER AND RAISE	20 LB
DRT ENGAGEMENT	20 LB
DOME REMOVAL	80 IN - LB
CAPSULE REMOVAL	20 IN - LB

7759-6208

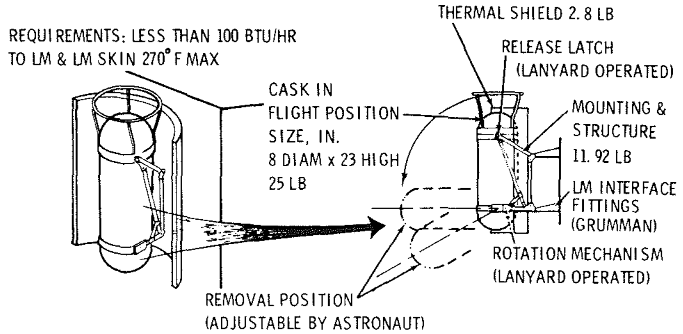
ALSEP/CASK/LM INTERFACE SPECIFICATION REQUIREMENTS VERSUS QUALIFICATION TEST RESULTS

		INTERFACE SPECIFICATION	SPECIFICATION REQUIREMENT	TEST RESULTS
1.	MAXIMUM FUEL CASK SURFACE TEMPERATURE	BXA/GE	$\leq$ 835°F	830°F
2.	MAXIMUM FUEL CASK CIRCUMFERENTIAL TEMP GRADIENT	BXA/GE	$\leq$ 150°F	105°F
3.	MAXIMUM HEAT LEAK TO LM	BXA/GAEC	$\leq$ 100 BTU/HR	33 BTU/HR
4.	MAXIMUM LM SKIN SURFACE TEMPERATURE (EXCEPT ASTRONAUT THERMAL DOOR)	BXA/GAEC	$\leq$ 270°F	258°F
5.	ASTRONAUT THERMAL DOOR TEMPERATURE	BXA/GAEC	$\leq$ 450°F	432°F
6.	MAXIMUM CASK THERMAL SHIELD TEMPERATURE	BXA	$\leq$ 600°F	598°F
7.	MINIMUM AVERAGE FUEL CASK SURFACE TEMPERATURE DURING CASK COOLING	BXA/GE	$\geq$ 125°F	161°F
8.	MAXIMUM AVERAGE FUEL CASK SURFACE TEMPERATURE DURING CASK COOLING	BXA/MSC	$\leq$ 350°F	194°F TO 287°F*
9.	ASTRONAUT PROTECTION GUARD	BXA/MSC	$\leq$ 250°F	105°F

*FOR FLOW RATE RANGE BETWEEN 15 TO 35 LB/MIN

7759-6209

FUEL CASK AND MOUNTING



SUMMARY OF EARTH WT

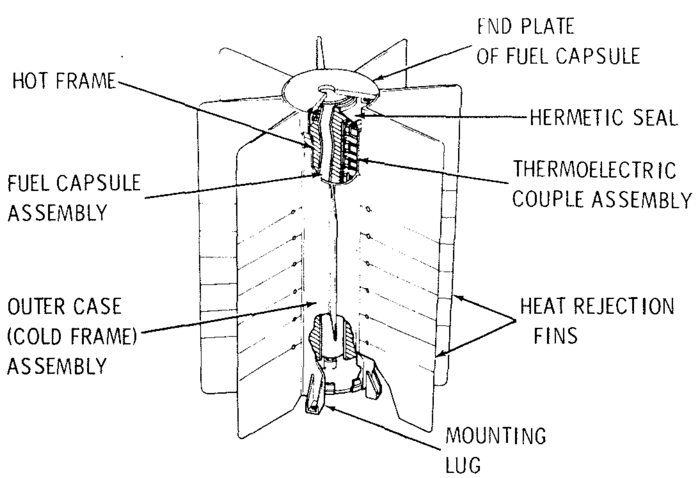
POWER SUBSYSTEM	STRUCTURE/THERMAL SUBSYSTEM	
CASK 25.0 LB NOT INC 15.0 LB FUEL CAPSULE	THERMAL SHIELD	2.80 LB
	MTG & STRUCTURE	11.92
	MISC (ASTRO PROTECT)	5.28
	TOTAL	20.0 LB

OPERATIONS

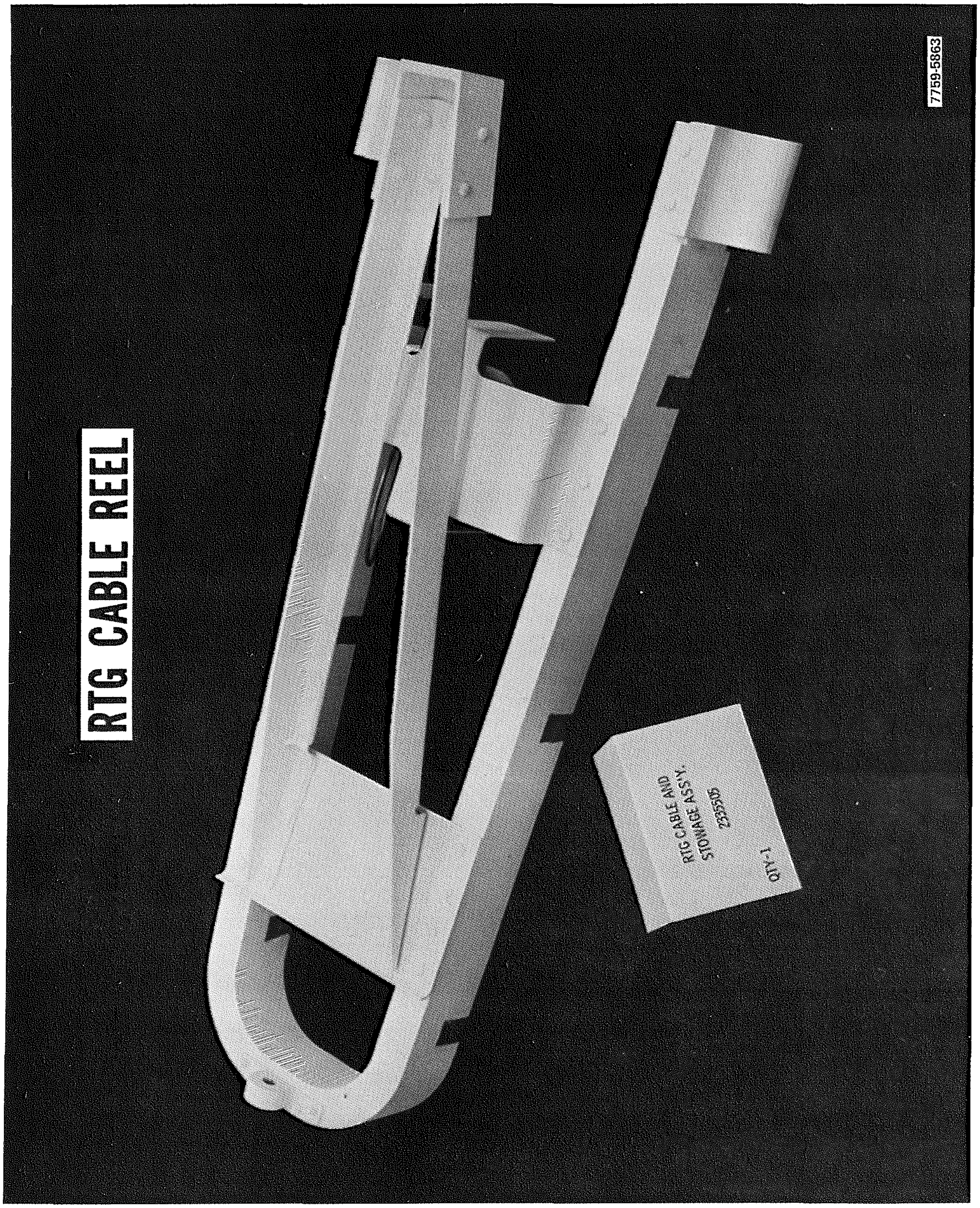
RELEASE LATCHES AND DOME LOCK, ROTATE CASK, UNSCREW CASK DOME (DOME REMOVAL TOOL), TRANSFER FUEL CAPSULE (FUEL TRANSFER TOOL) APPROX TIME 3 MIN, INC IN PRE-TRAVERSE TOTAL

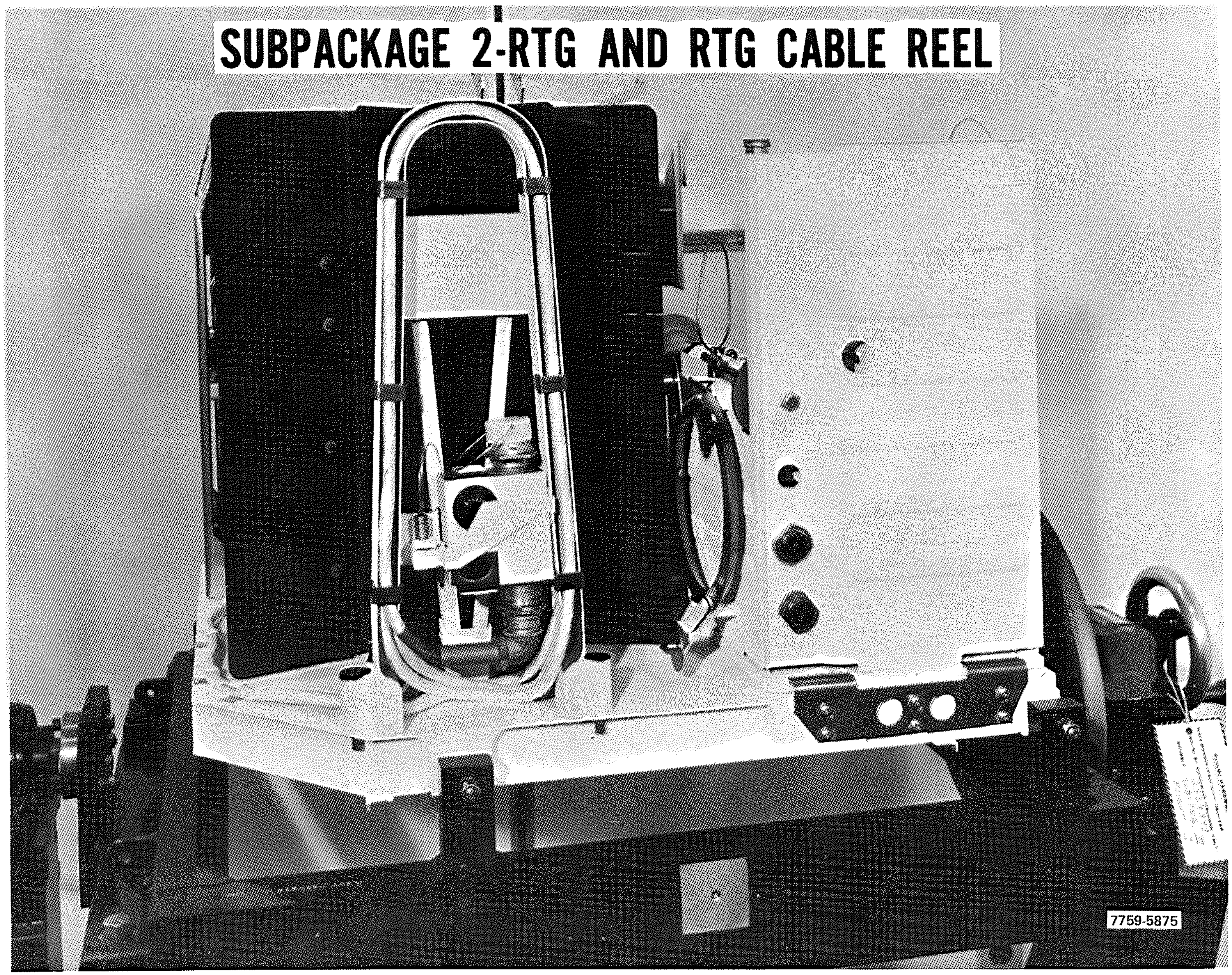
7759-5820

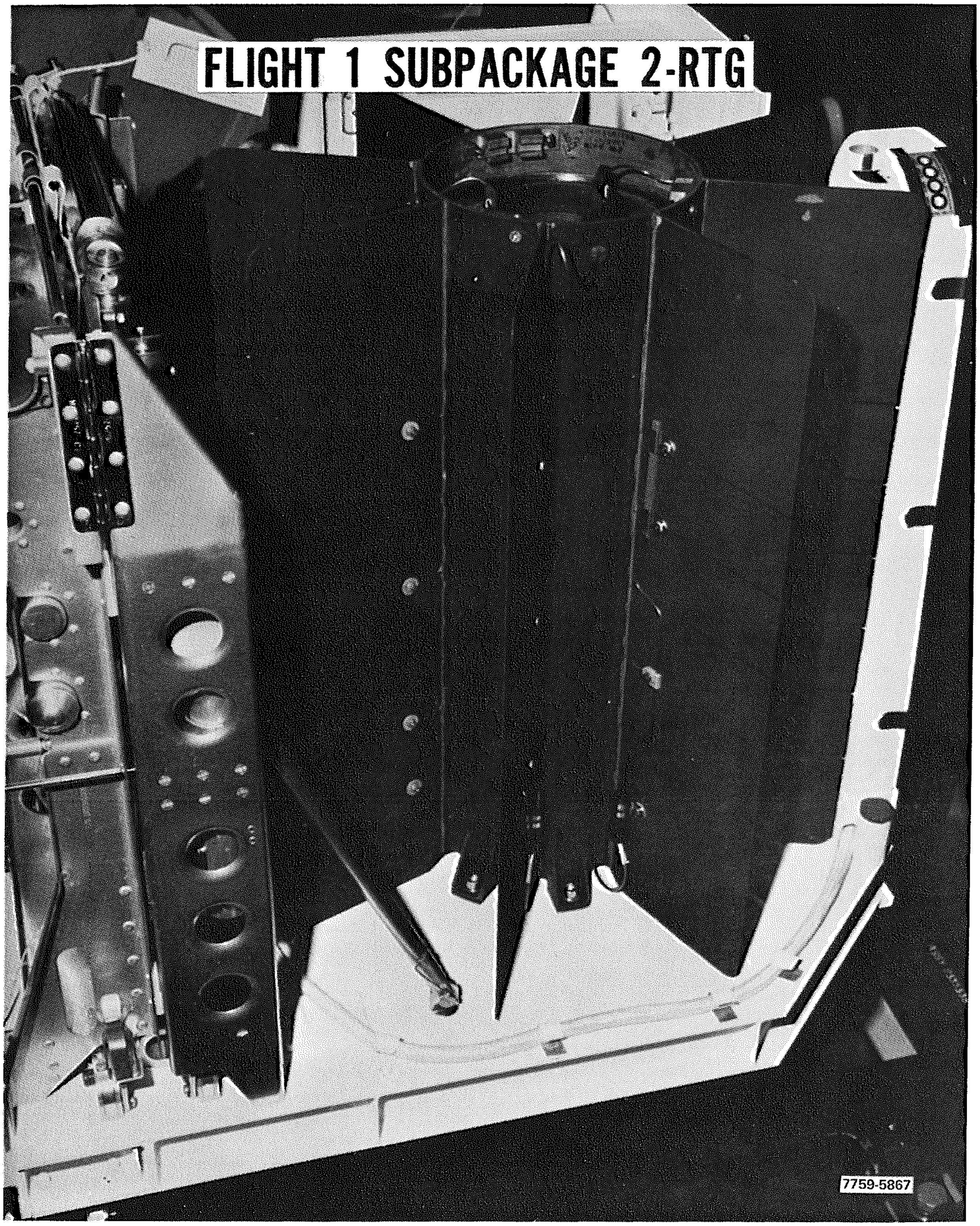
RTG CUTAWAY



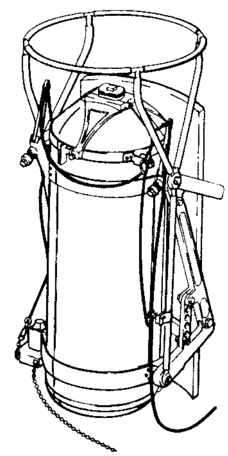
7759-5821


RTG CABLE REEL
7759-5863
RTG CABLE AND
STOWAGE ASS'Y.
2335505
QTY-1


SUBPACKAGE 2-RTG AND RTG CABLE REEL
7759-5875

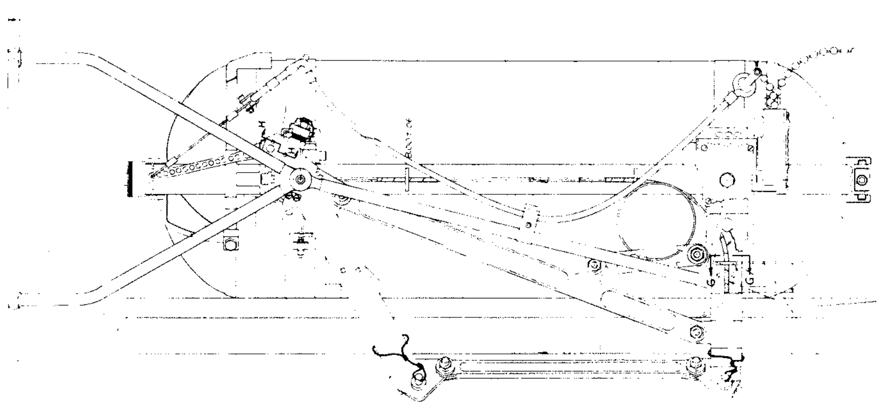

FLIGHT 1 SUBPACKAGE 2-RTG
7759-5867

FUEL CASK STRUCTURE ASSEMBLY



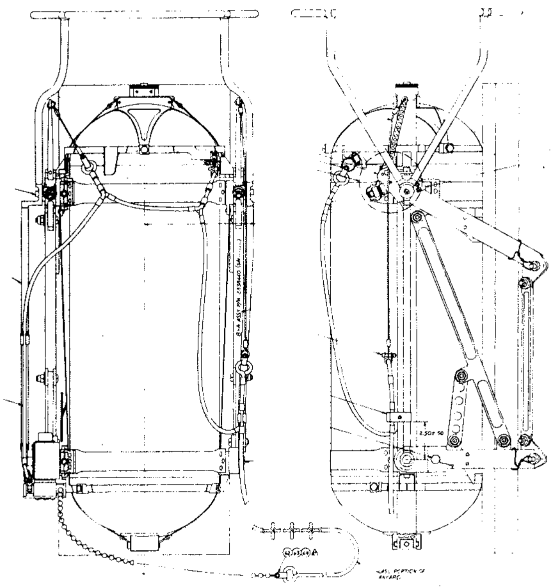
7759-5807

ALSEP CASK ASSEMBLY (ACA) SIDE VIEW



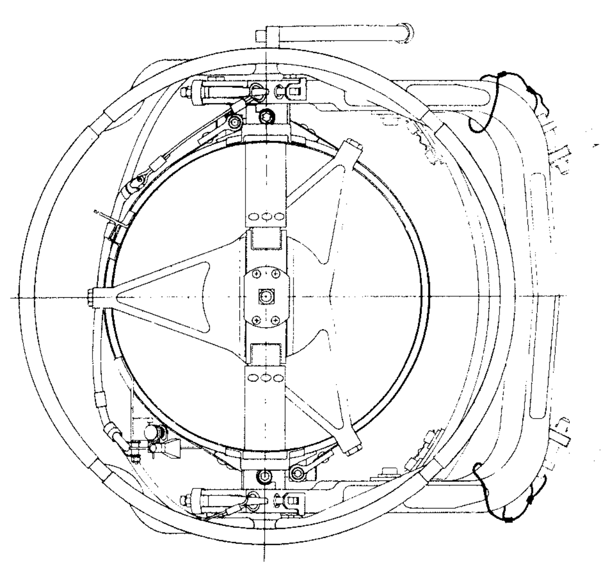
7759-6210

ACA SIDE AND FRONT VIEW



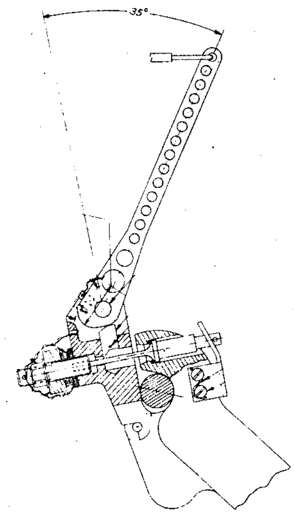
7759-6212

ACA PLAN VIEW



7759-6211

TRUNNION RELEASE MECHANISM



7759-6214

TEST SEQUENCE

1. PROTO MODEL

   VIBRATION
   THERMAL VACUUM
   TILT TEST

2. D2 MODELS (QUAL & FLIGHT)

   WEIGHT & C.G.
   VIBRATION

3. QUALIFICATION MODEL

   ACCEPTANCE TESTING

      WEIGHT & C.G.
      VIBRATION
      TILT TEST

7759-6201

TEST SEQUENCE (CONT')

3. QUALIFICATION MODEL (CONT')

   QUALIFICATION TESTING

   ON-PAD COOLING SIMULATION
   THERMAL VAC
   LAUNCH AND BOOST VIBRATION
   LUNAR DECENT VIBRATION & SHOCK
   FUNCTIONAL TILT TEST

4. FLIGHT MODELS

   WEIGHT & C.G.
   VIBRATION
   TILT TEST

7759-6202

ACCEPTANCE TEST PROGRAM OUTLINE

FLIGHT 1		COMPLETION DATE
1.	RECEIVING INSPECTION	20 DECEMBER 1968
2.	ALIGNMENT AND ASSEMBLY	31 JANUARY 1969
3.	WEIGHT AND C.G. MEASUREMENTS	4 FEBRUARY 1969
4.	LAUNCH VIBRATION	6 FEBRUARY 1969
5.	FUNCTIONAL TILT TEST, NO. 1	6 FEBRUARY 1969
6.	INSPECTION	10 FEBRUARY 1969
7.	FUNCTIONAL TILT TEST, NO. 2	4 JUNE 1969

7759-6203

ACCEPTANCE TEST
PROGRAM OUTLINE (CONT')

FLIGHT 1 BU

1.	RECEIVING INSPECTION	24 FEBRUARY 1969
2.	ALIGNMENT AND ASSEMBLY	26 FEBRUARY 1969
3.	WEIGHT AND C.G. MEASUREMENTS	27 FEBRUARY 1969
4.	LAUNCH VIBRATION	5 MARCH 1969
5.	FUNCTIONAL TILT TEST, NO. 1	5 MARCH 1969
6.	INSPECTION	6 MARCH 1969
7.	FUNCTIONAL TILT TEST, NO. 2	9 JUNE 1969

7759-6204

ACCEPTANCE TEST
PROGRAM OUTLINE (CONT')

FLIGHT 2

1.	RECEIVING INSPECTION	1 APRIL 1969
2.	ALIGNMENT AND ASSEMBLY	4 APRIL 1969
3.	LAUNCH VIBRATION	8 APRIL 1969
4.	FUNCTIONAL TILT TEST, NO. 1	8 APRIL 1969
5.	INSPECTION	10 APRIL 1969
6.	WEIGHT AND C.G. MEASUREMENTS	10 APRIL 1969
7.	FUNCTIONAL TILT TEST, NO. 2	11 JUNE 1969

7759-6205

ACCEPTANCE TEST PROGRAM OUTLINE (CONT')

FLIGHT 3

1.	RECEIVING INSPECTION	9 APRIL 1969
2.	ALIGNMENT AND ASSEMBLY	11 APRIL 1969
3.	LAUNCH VIBRATION	15 APRIL 1969
4.	FUNCTIONAL TILT TEST, NO. 1	15 APRIL 1969
5.	INSPECTION	16 APRIL 1969
6.	WEIGHT AND C.G. MEASUREMENTS	21 APRIL 1969
7.	FUNCTIONAL TILT TEST, NO. 2	17 JUNE 1969

7759-6206

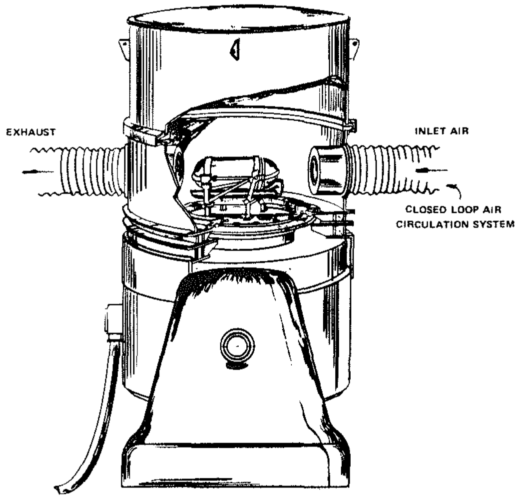
ACCEPTANCE TEST PROGRAM OUTLINE (CONT')

FLIGHT 4

1.	RECEIVING INSPECTION	22 APRIL 1969
2.	ALIGNMENT AND ASSEMBLY	23 APRIL 1969
3.	LAUNCH VIBRATION	24 APRIL 1969
4.	FUNCTIONAL TILT TEST, NO. 1	25 APRIL 1969
5.	INSPECTION	29 APRIL 1969
6.	WEIGHT AND C.G. MEASUREMENTS	29 APRIL 1969
7.	FUNCTIONAL TILT TEST, NO. 2	17 JUNE 1969

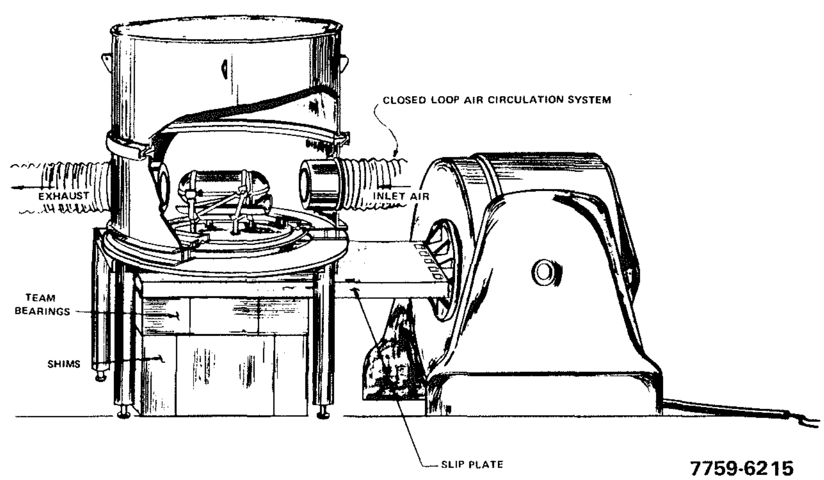
7759-6207

VIBRATION SAFETY ENCLOSURE Z AXIS



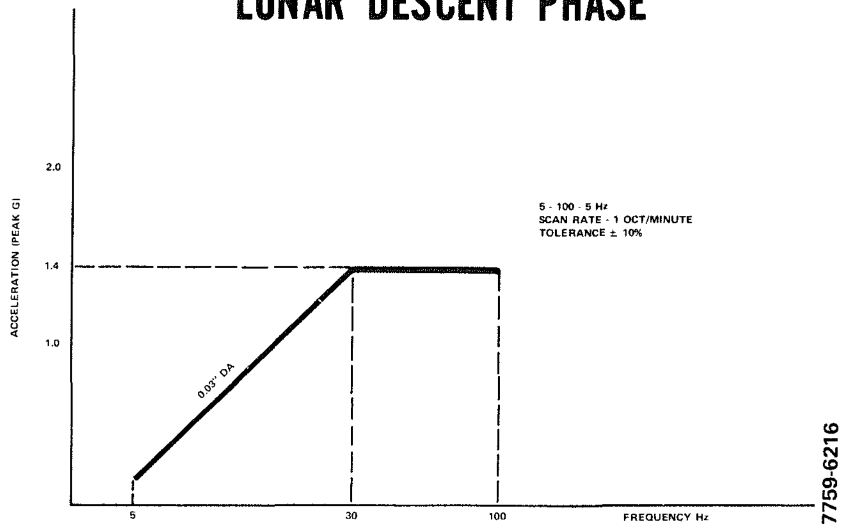
7759-6213

VIBRATION SAFETY ENCLOSURE X AND Y AXIS

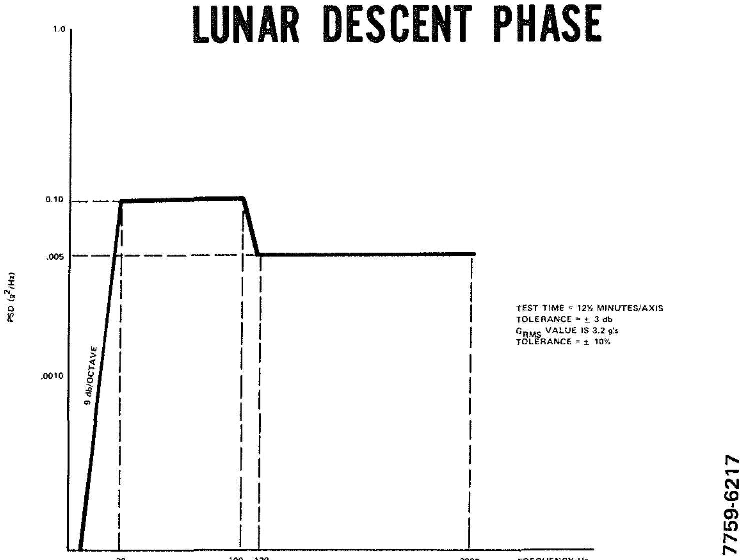


7759-6215

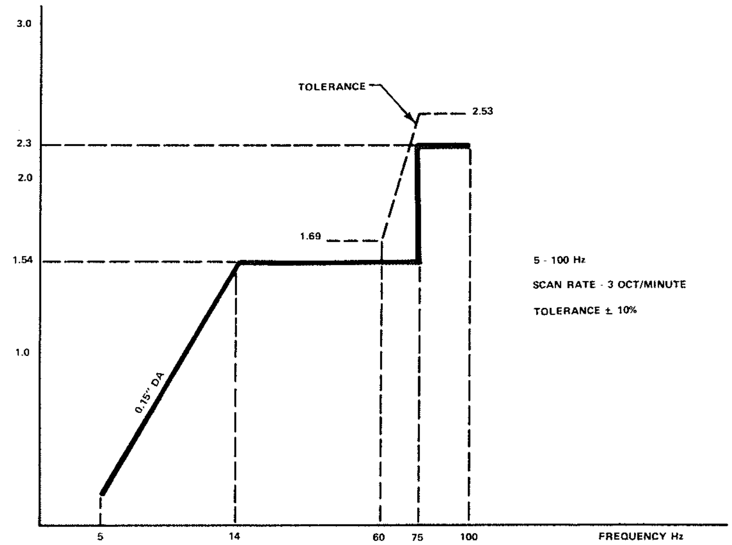
ACA QUAL LEVEL SINE WAVE VIBRATION LUNAR DESCENT PHASE



ACA QUAL LEVEL RANDOM VIBRATION LUNAR DESCENT PHASE

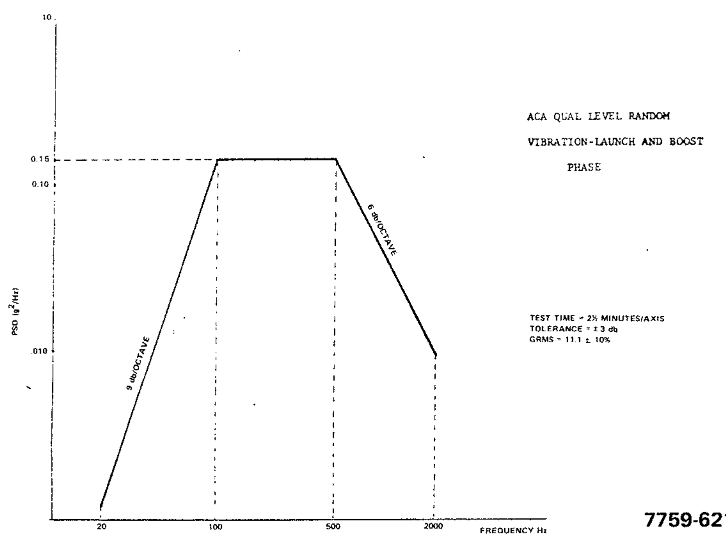


ACA FLIGHT LEVEL SINE WAVE VIBRATION



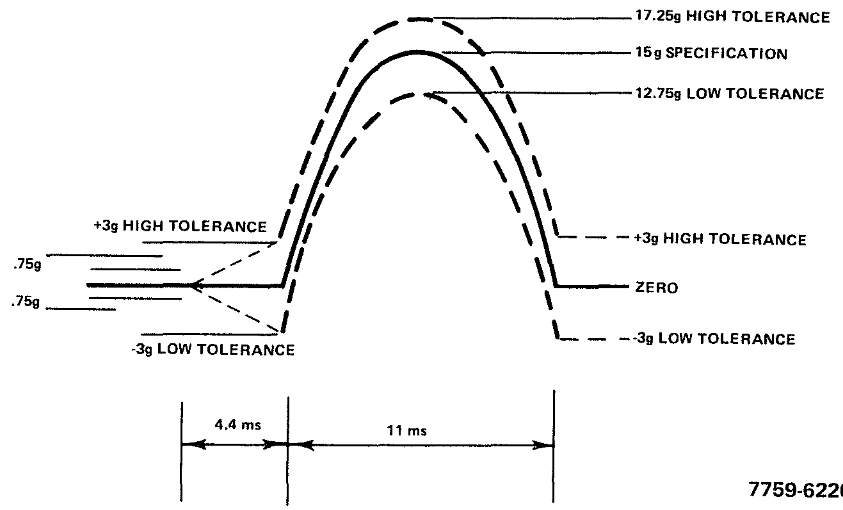
7759-6218

ACA QUAL LEVEL RANDOM VIBRATION-LAUNCH AND BOOST PHASE



7759-6219

HALF SINE SHOCK PULSE CONFIGURATION AND ITS TOLERANCE LIMITS (+X, ±Y, ±Z DIRECTION)



7759-6220

(ACA) INTERFACE THERMAL SPECIFICATION REQUIREMENTS VS. QUALIFICATION TEST RESULTS

	REQUIREMENT	SPECIFICATION	ITEM	MAXIMUM SPECIFICATION VALUE	TEST RESULTS
1.	FUEL CASK SURFACE TEMP	BXA/GE	CASK	$\leq$835°F	830°F
2.	FUEL CASK CIRCUMFERENTIAL TEMP GRADIENT	BXA/GE	CASK	$\leq$150°F	105°F
3.	HEAT LEAK TO LM	BXA/GAEC	LM	<100 BTU/HR	33 BTU/HR
4.	LM SKIN SURFACE TEMP	BXA/GAEC	LM	$\leq$270°F	258°F
5.	ASTRONAUT THERMAL DOOR TEMP	BXA/GAEC	LM	$\leq$450°F	432°F
6.	ACA THERMAL SHIELD TEMP	BXA	ACA	$\leq$600°F	598°F
7.	MINIMUM AVERAGE FUEL CASK SURFACE TEMP DURING CASK COOLING	BXA/GE	CASK COOLING	$\geq$125°F	161°F
8.	FUEL CASK SURFACE TEMP DURING CASK COOLING	BXA/MSC	CASK COOLING	$\leq$350°F	195°F
9.	ASTRONAUT PROTECTION GUARD	BXA/MSC	CREW	$\leq$250°F	105°F

7759-5916

ALSEP CASK ASSEMBLY
THERMAL QUALIFICATIONS TEST PROGRAM

PRELAUNCH CASK COOLING

- 10 FLOW TESTS
- FLOW RATES 15 TO 35 LB/MIN
- PURGE TEMPERATURE 80 TO 130^{o}F
- NOZZLE PRESSURE .12 TO .64 PSI

EARTH ORBIT WITH SLA ON AND MAX SOLAR HEATING

- SLA TEMP 250^{o}F
- CHAMBER PRESSURE 1 X 10^{-6} TORR
- CRYOWALL -300^{o}F
- 10-HOUR T/V TEST

7759-6221

ACA THERMAL QUALIFICATION TEST PROGRAM (CONT')

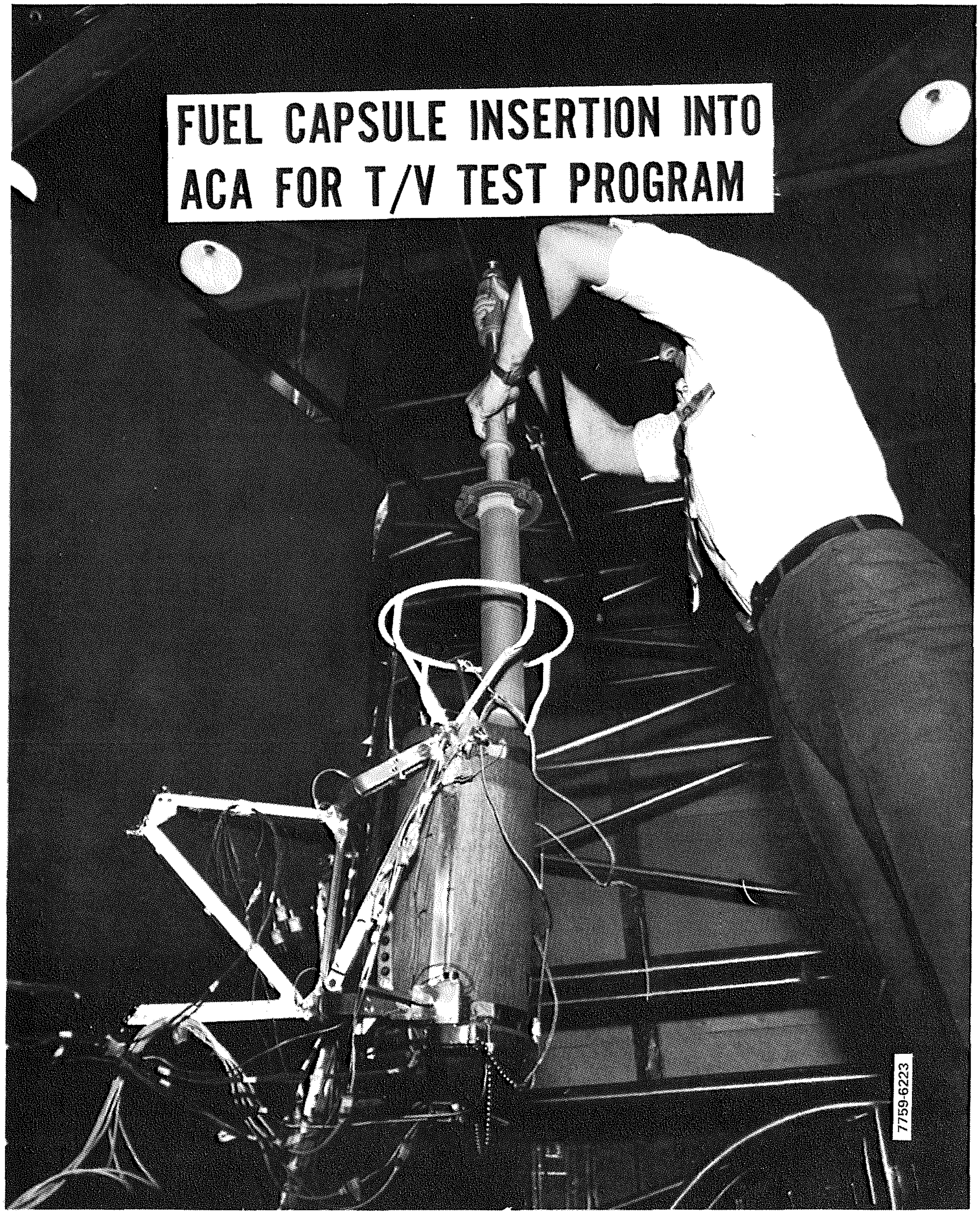
TRANSLUNAR FLIGHT WITH SLA OFF AND MAX SOLAR HEATING

- SOLAR INPUT 130 WATTS/FT^2
- CHAMBER PRESSURE 1 X 10^{-6} TORR
- CRYOWALL -300 ^{o}F
- 36-HR T/V TEST

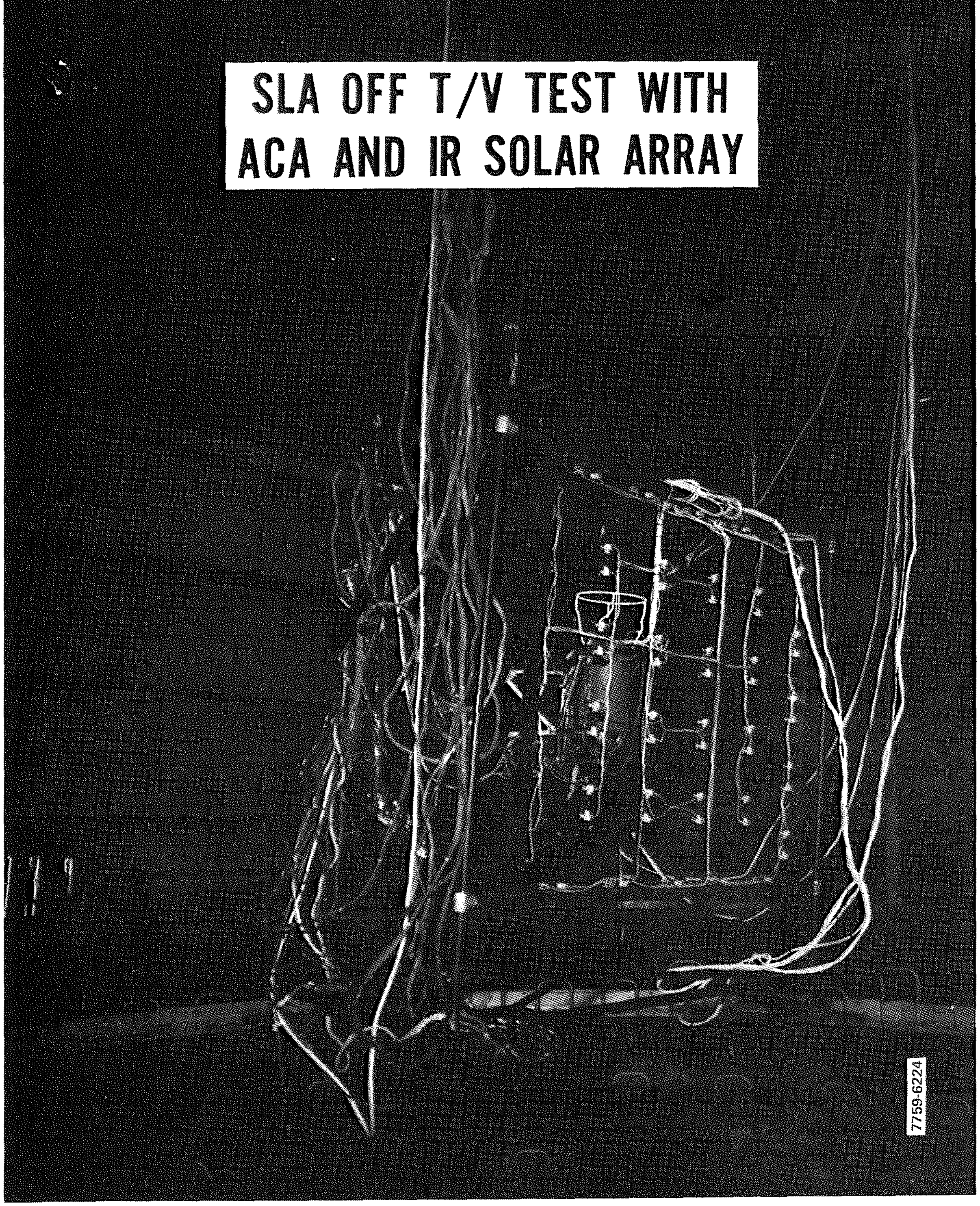
TRANSLUNAR FLIGHT WITH SLA OFF AND NO SOLAR HEATING

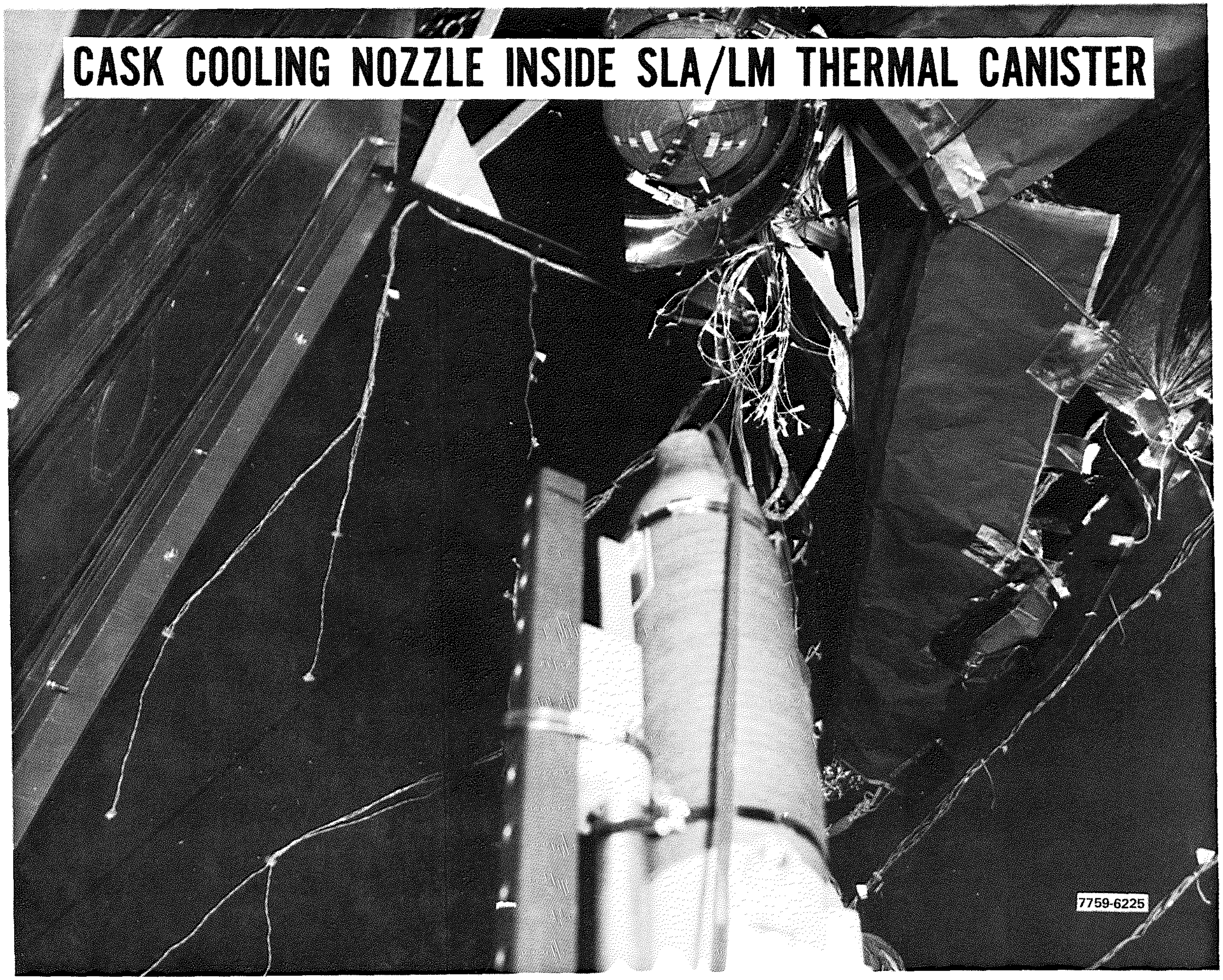
- NO SOLAR INPUT
- CHAMBER PRESSURE 1 X 10^{-6} TORR
- CRYOWALL -300^{o}F
- 36-HR T/V TEST

7759-6222

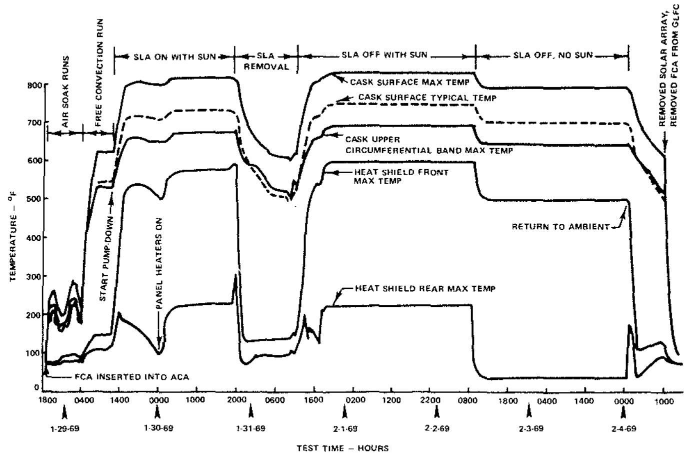


FUEL CAPSULE INSERTION INTO
ACA FOR T/V TEST PROGRAM
7759-6223


SLA OFF T/V TEST WITH
ACA AND IR SOLAR ARRAY
7759-6224


CASK COOLING NOZZLE INSIDE SLA/LM THERMAL CANISTER
7759-6225

SUMMARY OF AIR SOAK AND THERMAL/VACUUM RESULTS



7759-6226

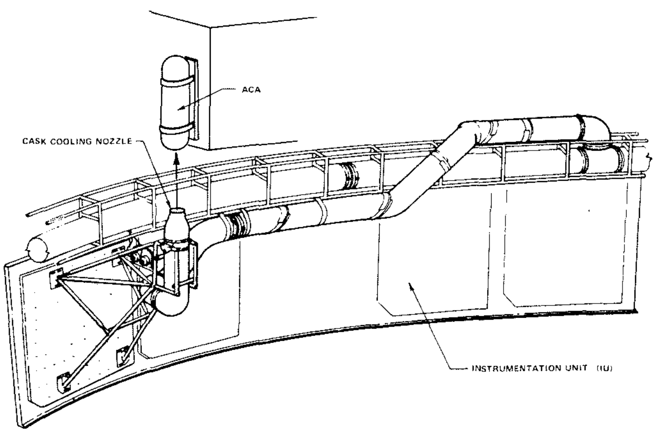
SUMMARY OF ALSEP CASK ASSEMBLY MAXIMUM TEMPERATURES DURING PRELAUNCH FLIGHT AND LUNAR DEPLOYMENT,°F

		PRELAUNCH	FLIGHT	DEPLOYMENT
1.	CASK SURFACE	200°* ± 40°*	830°	820°
2.	CASK DOMES	160°	600°	590°
3.	CAPSULE SURFACE	1250°	1400°	1400°
4.	CIRCUMFERENCIAL BANDS	200° ± 40°*	750°	730°
5.	THERMAL SHIELD, FRONT	95°	600°	580°
6.	THERMAL SHIELD, REAR	80°	230°	225°
7.	LM THERMAL DOOR	80°	430°	420°
8.	ACA ASTRONAUT GUARD	90°	105°	105°

*VARIATION DUE TO CASK COOLING FLOWRATE RANGE.

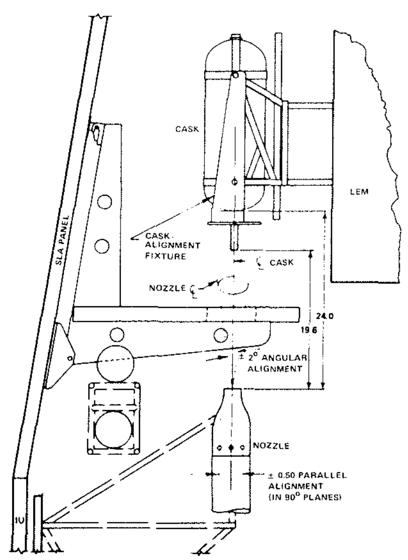
7759-6227

ALSEP CASK COOLING CONFIGURATION



7759-6228

CASK COOLING INTERFACE



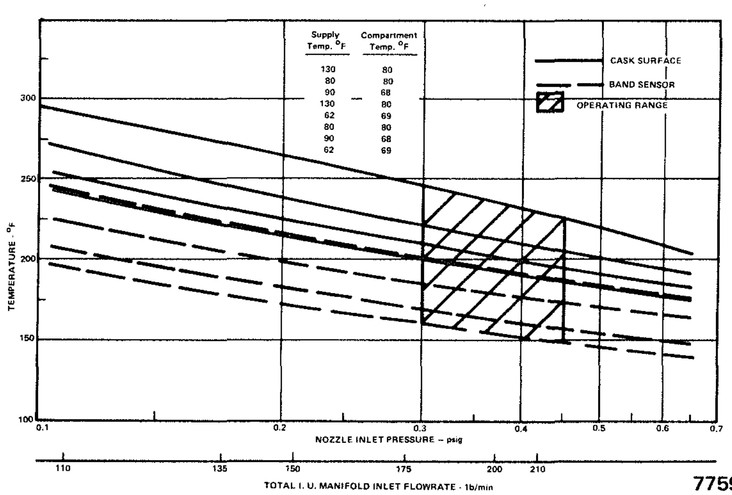
7759-6229

ACA PRELAUNCH COOLING REQUIREMENTS COMPARED TO APOLLO 12 PERFORMANCE RESULTS

REQUIREMENT	SPECIFICATION	APOLLO 12 RESULTS
CASK SURFACE TEMPERATURE, °F	<350	185 TO 200
ACA SENSOR TEMPERATURE, °F	< 300	150 TO 165
I.U. FLOWRATE (MIN), LB/MIN	180	210
I.U. INLET TEMPERATURE, °F	55 TO 130	60 TO 120
CASK COOLING NOZZLE PRESSURE, PSI	0.30	0.42
CASK COOLING NOZZLE FLOWRATE, LB/MIN	18.2	28

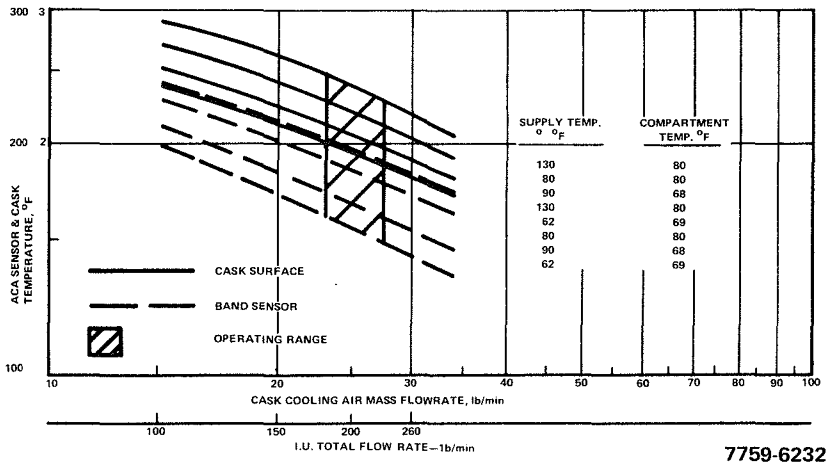
7759-6230

ACA TEMPERATURES DURING PRELAUNCH CASK COOLING



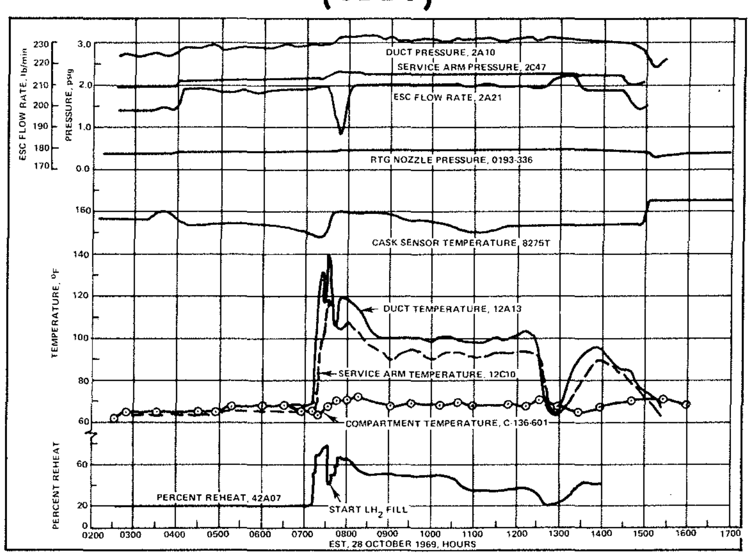
7759-6231

ACA TEMPERATURES FOR PREDICTED CASK COOLING I.U. OPERATING RANGE



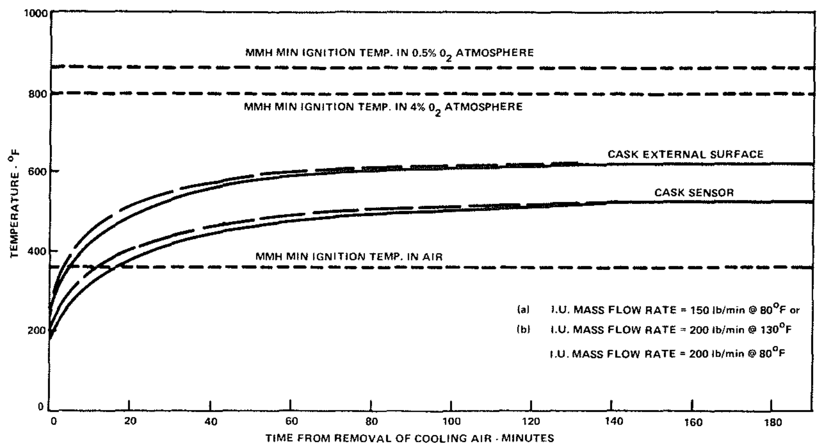
7759-6232

APOLLO 12 ACA CASK COOLING PERFORMANCE (CDDT)



7759-6233

ACA TRANSIENT TEMPERATURE RISE AFTER REMOVAL OF AIR FLOW



7759-6234

SUBPACKAGE 2 THERMAL INTERFACE REQUIREMENTS AND CONSTRAINTS

- PASSIVE THERMAL DESIGN AND INTEGRATION
- NONOPERATING TEMPERATURES IN LM 0 TO 160°F
- RTG THERMAL DISSIPATION 1500 WATTS
- RTG COLD FRAME TEMPERATURE 400° TO 500°F
- HEAT LEAK FROM RTG TO PALLET 20 TO 80 WATTS
- RTG BLOCKAGE BY ALSEP EQUIPMENT <4%
- PALLET 2 LUNAR OPERATIONAL TEMPERATURES -300° TO 450°F
- MAXIMUM CREW TOUCH TEMPERATURE 250°F

7759-6235

SUMMARY OF SUBPACKAGE 2 KEY THERMAL CONTROL DESIGN FEATURES

- PALLET
  - FLEXIBLE, LOW THERMAL CONDUCTANCE MOUNT
  - THIN HONEYCOMB ALUMINUM SKINS
  - HIGH TEMP., LOW α/ϵ = (.2/.9) Z-93 WHITE COATING
  - CLEAN PALLET UPPER SURFACE AFTER DEPLOYMENT
- SUBPALLET
  - REMOVABLE SUBPALLET WITH EQUIPMENT
  - WHITE COATING ON EXTERNAL SURFACE
  - MINIMUM CREW TASKS NEAR RTG DURING WARM UP
- CREW TOOLS (DRT, FTT AND UHT)
  - DURABLE LOW α/ϵ 3M 401 WHITE COATINGS ON TOOLS
  - MINIMUM CROSS SECTION AREA, MAXIMUM LENGTH ON TOOLS
- RTG
  - REFLECTIVE GOLD FINISH ON FTT FACING CAPSULE END PLATE
  - HIGH TEMPERATURE IRON TITANITE COATING (.85/.85)
- ANTENNA, HOUSING, CARRY BAR, CABLE REEL AND MISC. EQUIPMENT
  - DURABLE 3 M WHITE THERMAL COATING

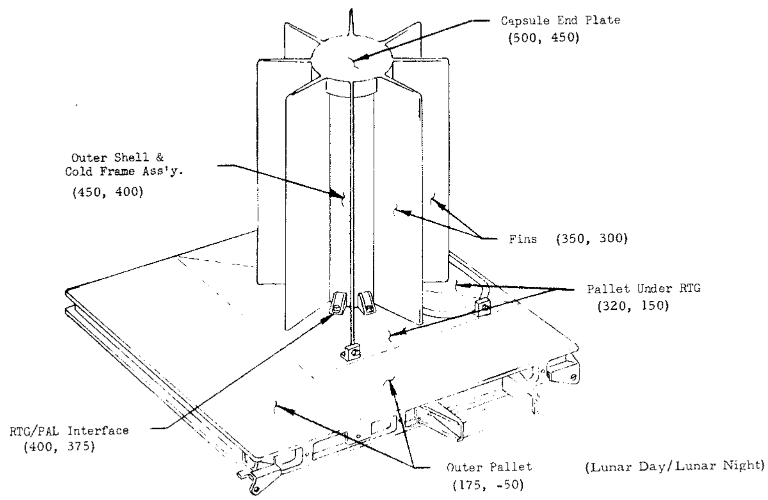
7759-6236

SUMMARY OF RADIATIVE PROPERTIES OF SURFACES ON SUBPACKAGE NO. 2 THERMAL MODELS

	Surface Description	α	ϵ	Comments
1.	Pallet Assembly No. 1 (top/bottom)	.2	.9	Z-93 White Paint
2.	Apollo Lunar Hand Tool (ALHT)	.25	.85	Sulfuric Anodized
3.	Antenna Gimbal Box	.25	.85	3M401 White Paint
4.	Fuel Cask Handling Tool (FHT)	.25	.85	3M401 White Paint
5.	Cask Dome Removal Tool (CDRT)	.25	.85	3M401 White Paint
6.	Carry Bars	.25	.85	3M401 White Paint
7.	RTG Cable Reel	.25	.85	3M401 White Paint
8.	Universal Handling Tool (UHT)	.25	.85	3M401 White Paint
9.	RTG Surfaces	.85	.85	Iron Titinate
10.	Subpallet	.2	.9	3M401 White Paint
11.	Suprathermal Ion Detector Experiment (SIDE)	.25	.85	S-13G White Paint

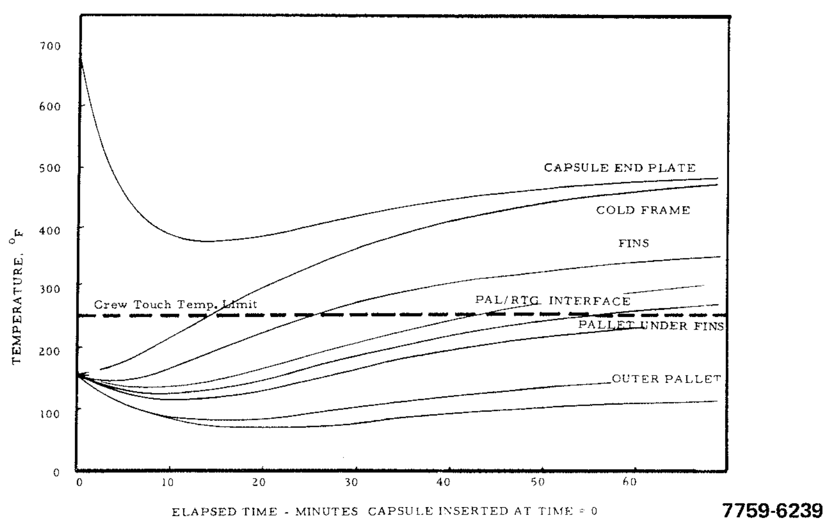
7759-6237

RTG AND PALLET 2 LUNAR OPERATING TEMPERATURES



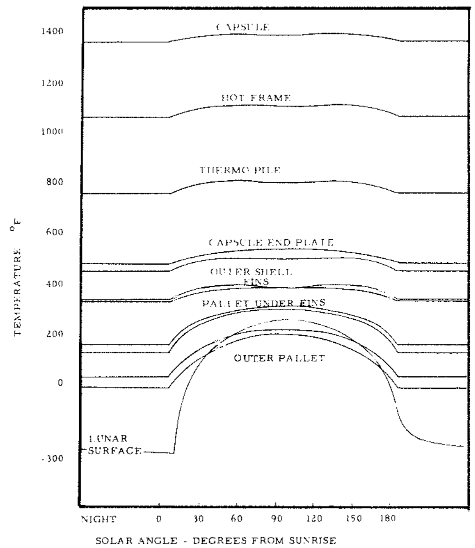
7759-6238

RTG/SUBPACKAGE TEMPERATURE HISTORIES DURING DEPLOYMENT



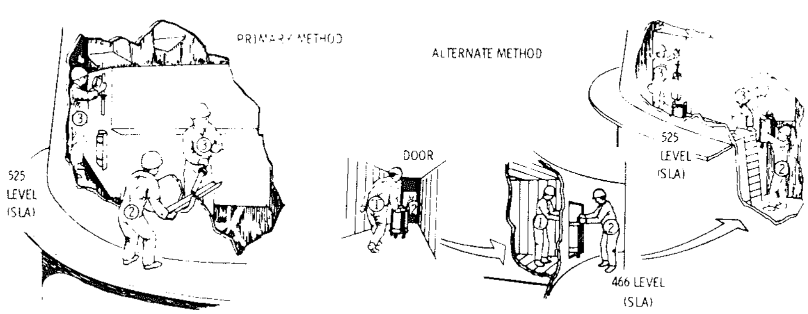
7759-6239

RTG AND PALLET TEMPERATURES DURING COMPLETE LUNATION

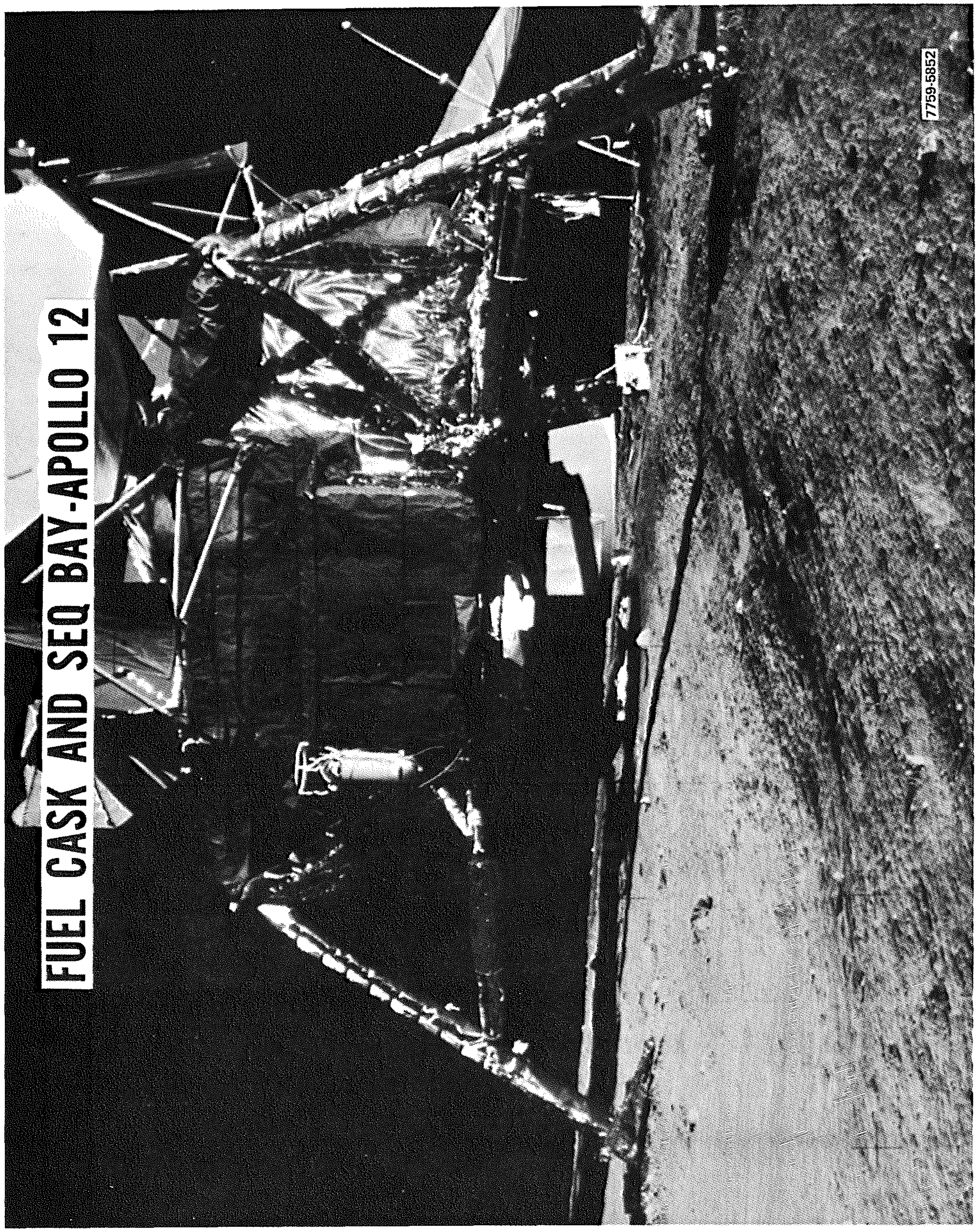


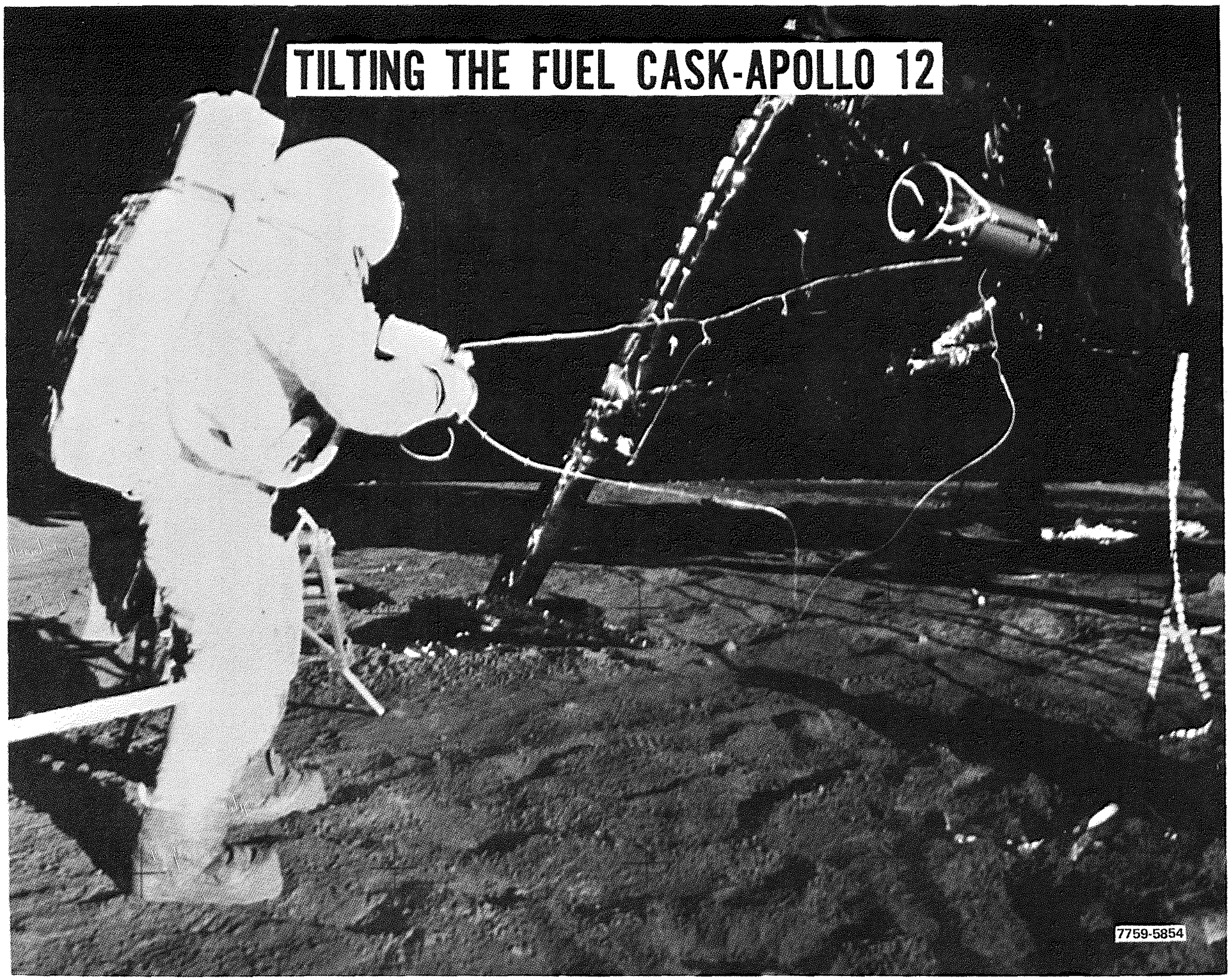
7759-6240

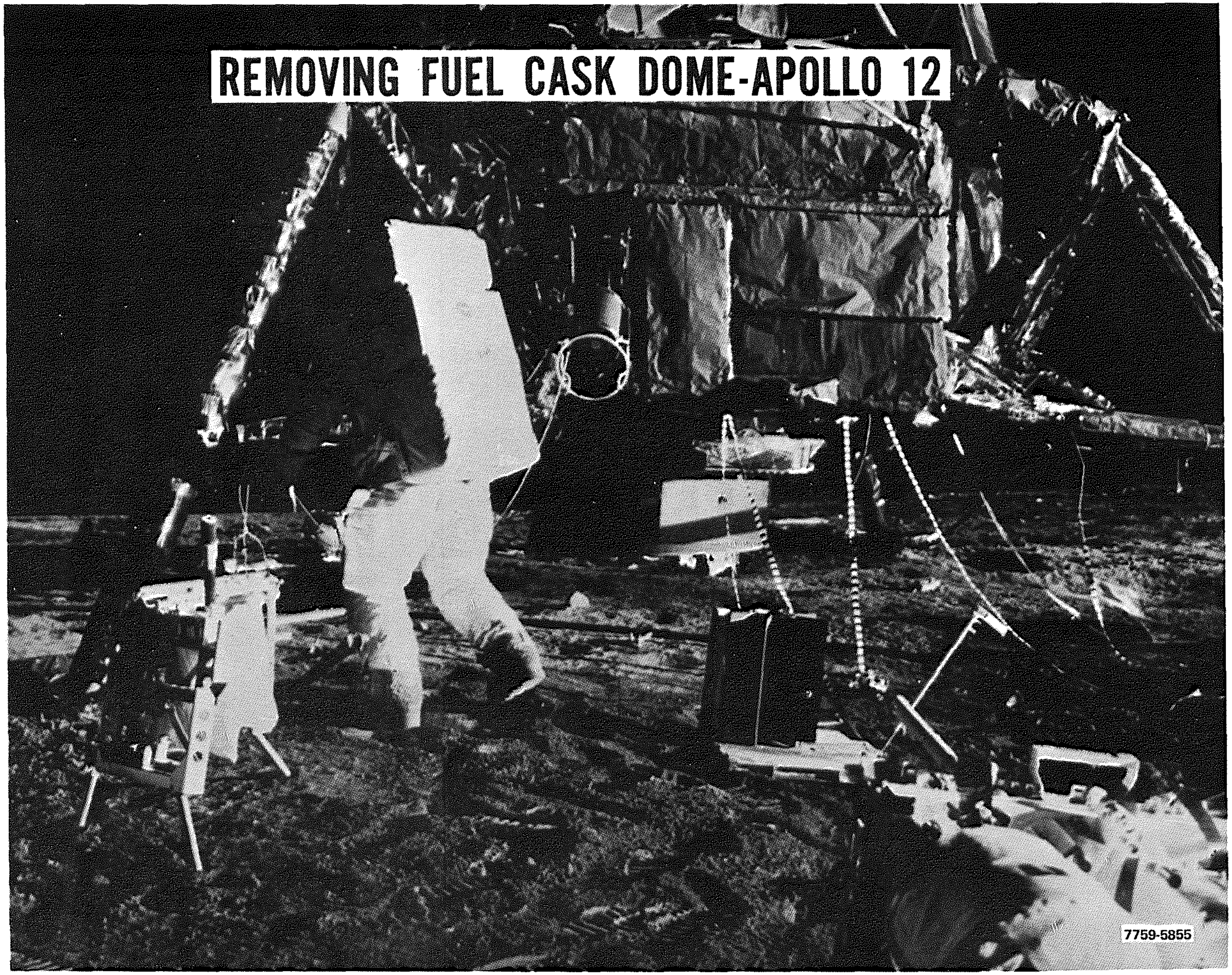
RTG CASK LOADING

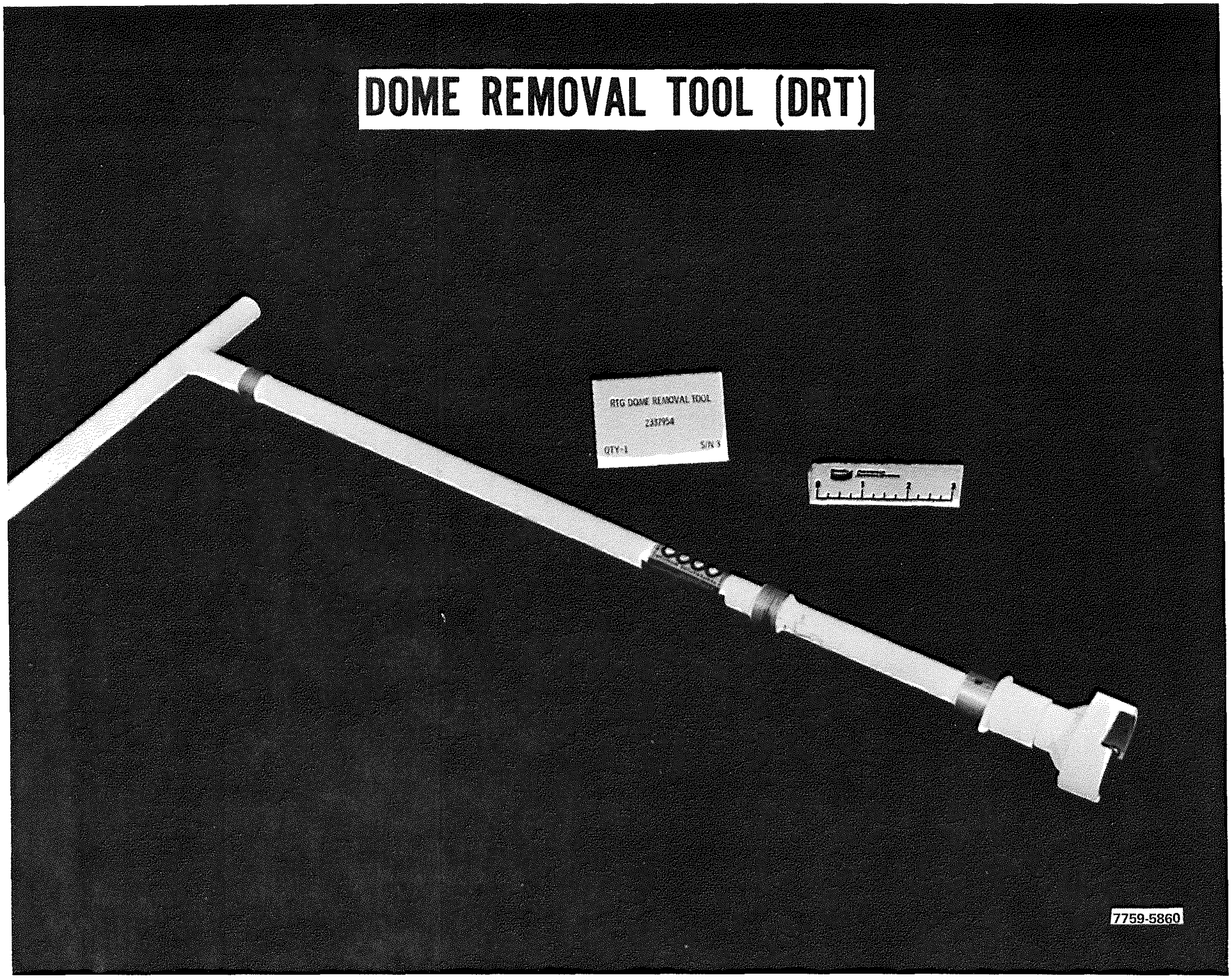


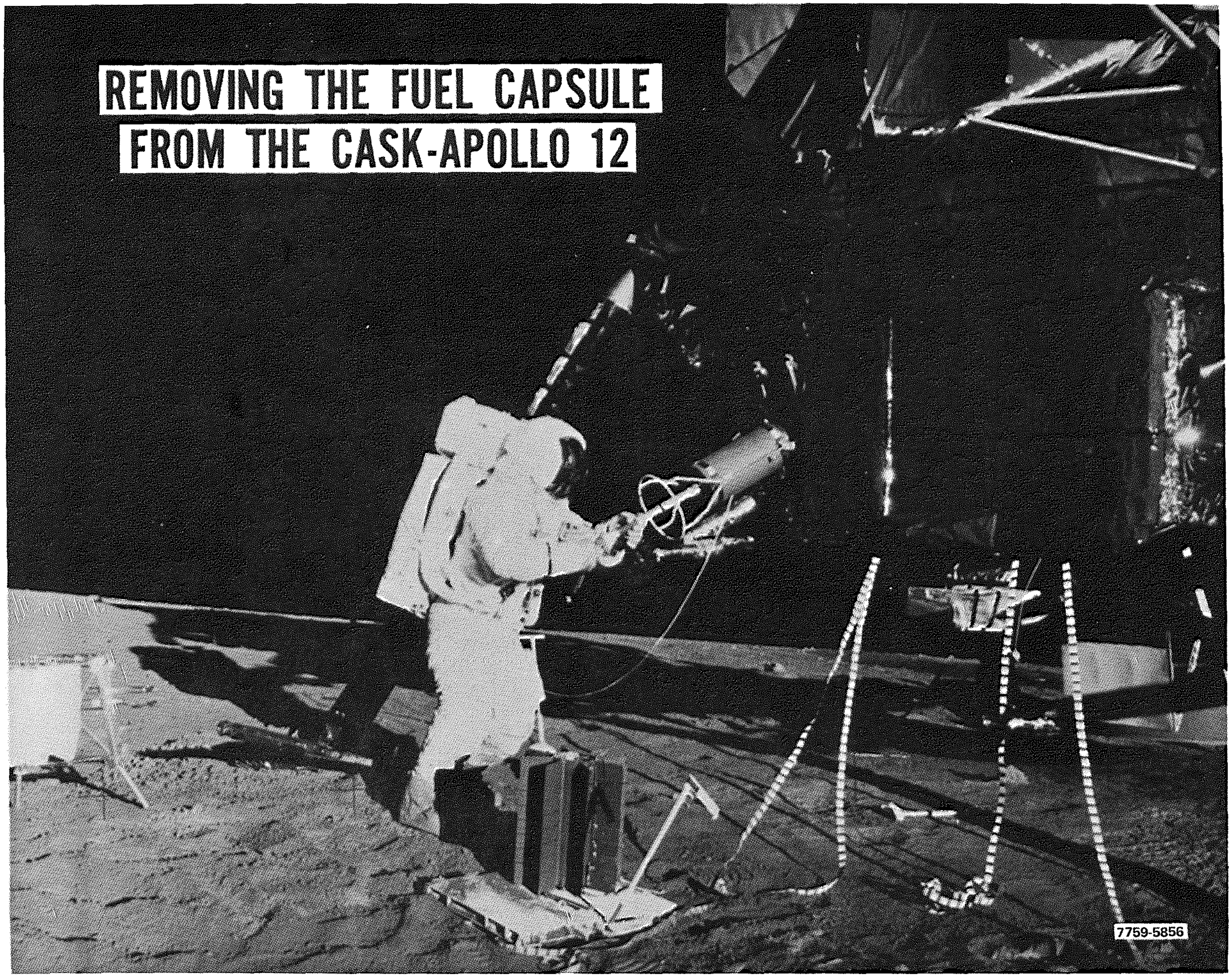
7759-5850


FUEL CASK AND SEQ BAY-APOLLO 12
7759-5852


TILTING THE FUEL CASK-APOLLO 12
7759-5854


REMOVING FUEL CASK DOME-APOLLO 12
7759-5855

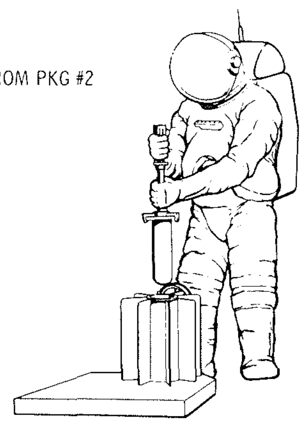

DOME REMOVAL TOOL (DRT)
RTG DOME REMOVAL TOOL
2337954
QTY-1
S/N 3
7759-5860



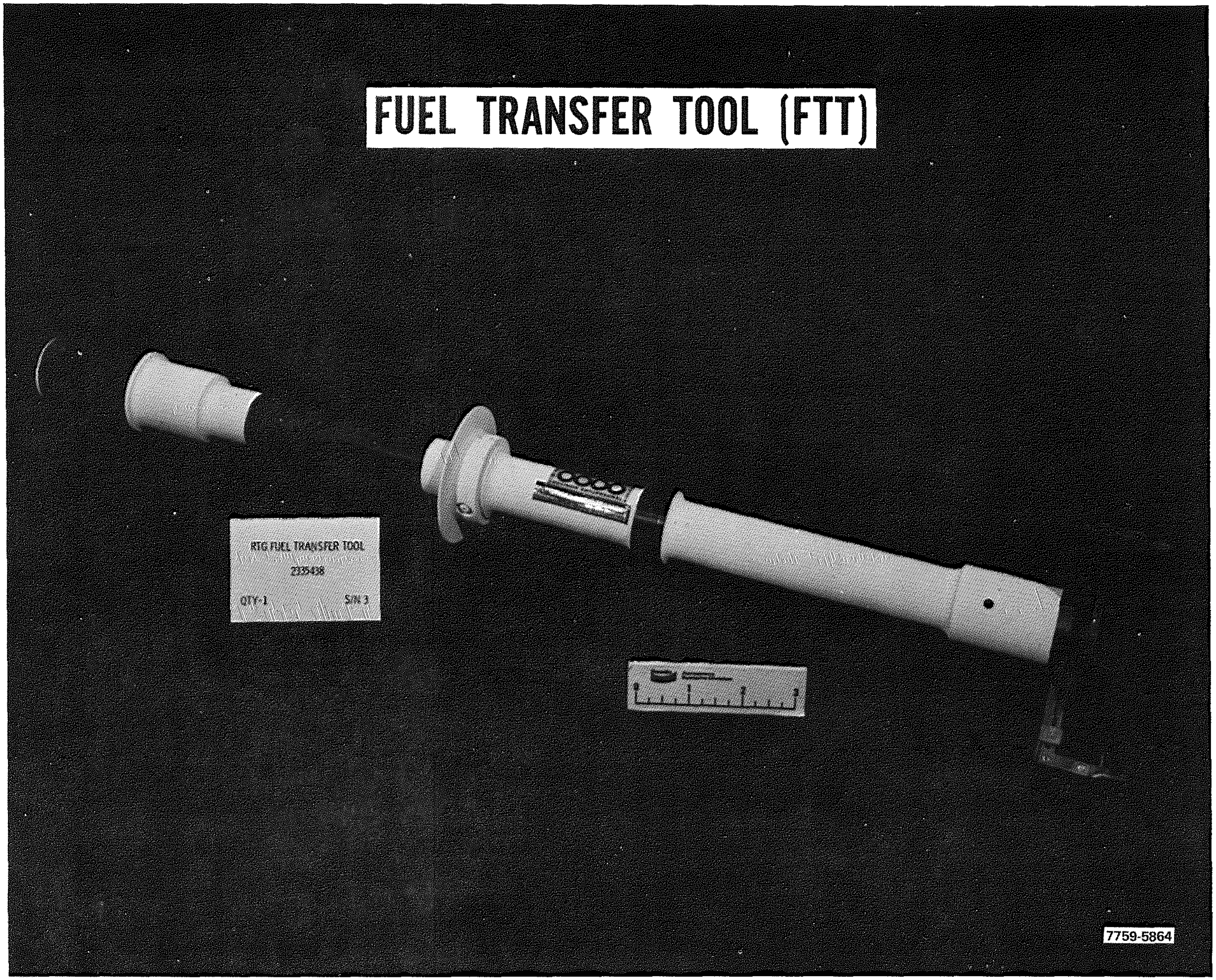
REMOVING THE FUEL CAPSULE
FROM THE CASK-APOLLO 12

TRANSFER FUEL

- ROTATE PKG #2 & REMOVE SUBPALLET
  - USE UHT TO ROTATE PKG #2 UPRIGHT
  - RELEASE BOYD BOLTS, REMOVE SUBPALLET FROM PKG #2
- ROTATE FUEL CASK FOR FUEL TRANSFER
  - RETRIEVE CASK LANYARD
  - ROTATE LEVERS
  - PULL SPLINE
  - ROTATE CASK TO DESIRED ANGLE
- REMOVE CASK DOME USING DRT
- TRANSFER FUEL CAPSULE
  - ENGAGE FTT WITH CAPSULE
  - LOCK TOOL TO CAPSULE TO RELEASE FROM CASK
  - WITHDRAW CAPSULE
  - LOWER INTO RTG
  - RELEASE TOOL FROM CAPSULE TO LOCK IN RTG



7759-5837


FUEL TRANSFER TOOL (FTT)
RTG FUEL TRANSFER TOOL
2335438
QTY-1
S/N 3
7759-5864

Section 3

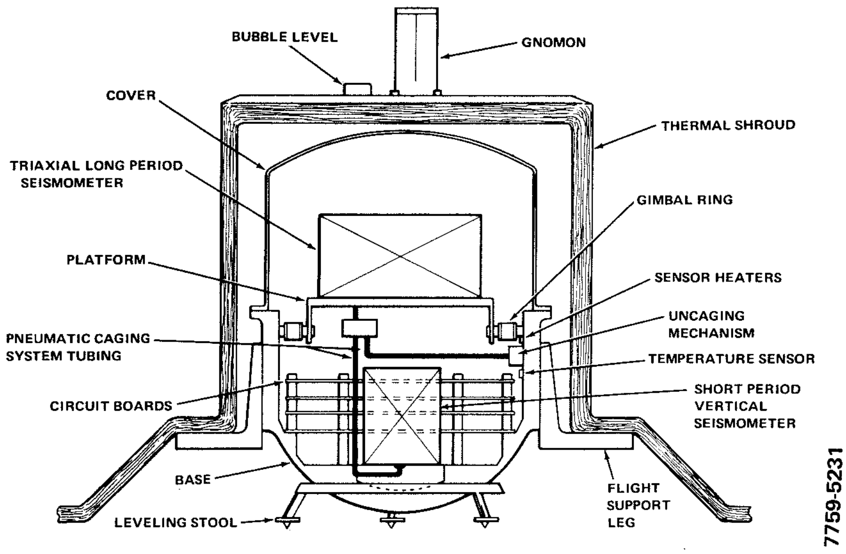
Passive Seismic Experiment

DR. GARY LATHAM WILL PRESENT THE FOLLOWING SLIDES:

- MEASUREMENTS LIST
- LPZ - SCHEMATIC DIAGRAM OF FEEDBACK-CONTROLLED SEISMOMETER
- LPZ MODEL - PHOTO
- PICTORIAL REPRESENTATION OF FINE LEVELING SYSTEM
- SPZ MODEL
- PICTORIAL REPRESENTATION OF CAGING CONCEPT
- COMPARISON SEISMOGRAMS
- EARTH TIDES
- PROBLEM AREAS
- NOMINAL RESPONSE VS. MODIFIED RESPONSE FOR LP SEISMOMETERS
- SEISMIC DISTURBANCES DURING ECLIPSE
- DOME CONCEPT FOR THERMAL SHROUD
- ASTROSEISMS - SIGNAL FROM ARMSTRONG ON LADDER
- LM ASCENT SIGNAL
- MAP SHOWING LM IMPACT AND ALSEP LOCATIONS
- SEISMOGRAMS SHOWING LM IMPACT SIGNAL AND TWO NATURAL EVENTS
- TIDES AND TEMPERATURES FROM ECLIPSE

THESE WILL BE PUBLISHED AS ADDENDUM I IN THE FINAL COMPILED EDITION OF BSR-2900.

SENSOR/SHROUD ARRANGEMENT



DEPLOYMENT TASKS

REMOVE LEVELING STOOL FROM SUBPACK 2

DEPLOY STOOL AT 9 $\pm$ 1 FT E OR W OF C/S

REMOVE SENSOR FROM SUBPACK 1

PLACE SENSOR ON STOOL, ROUGH ALIGN (GIRDLE ARROW)

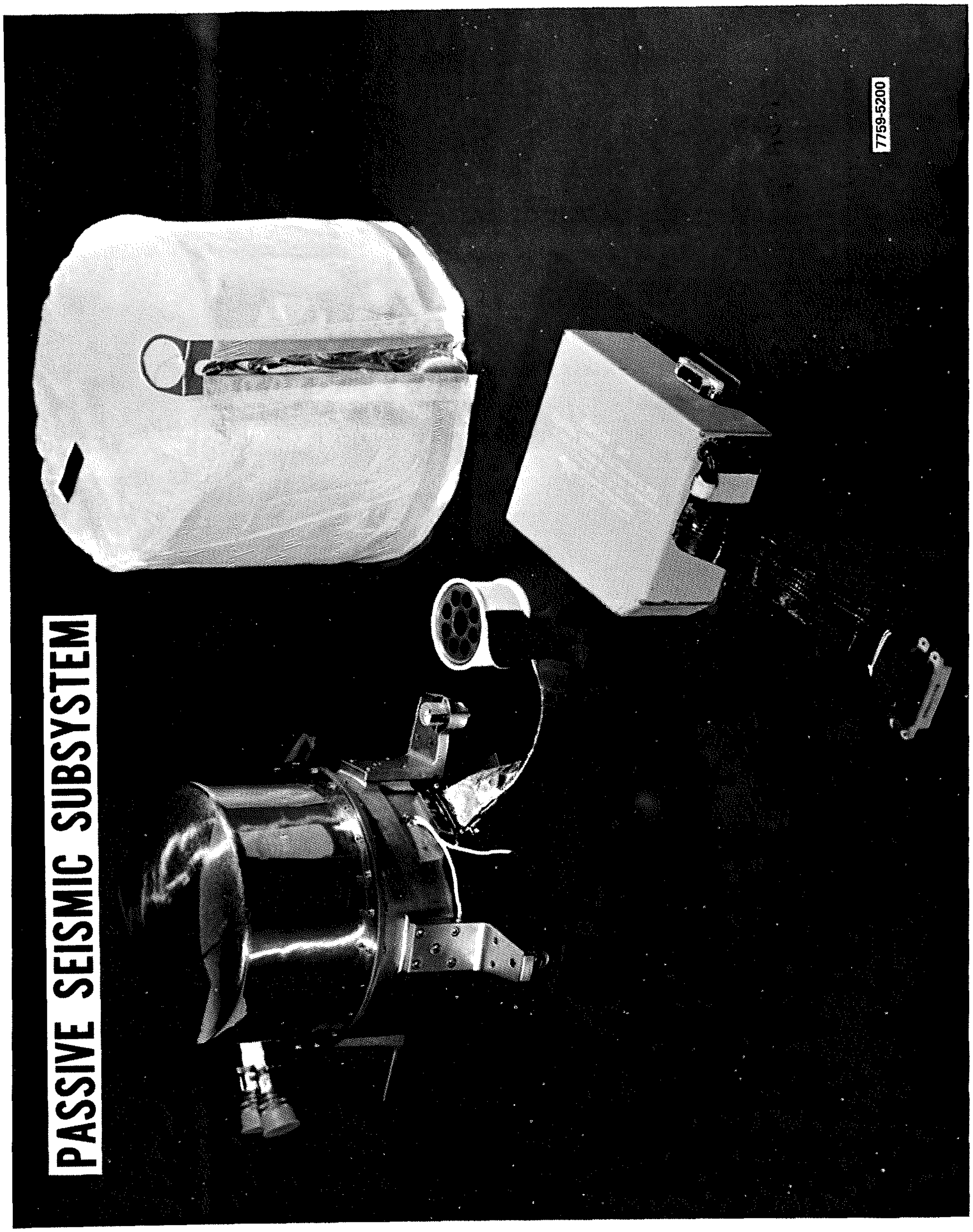
REMOVE SHROUD GIRDLE PIN AND GIRDLE

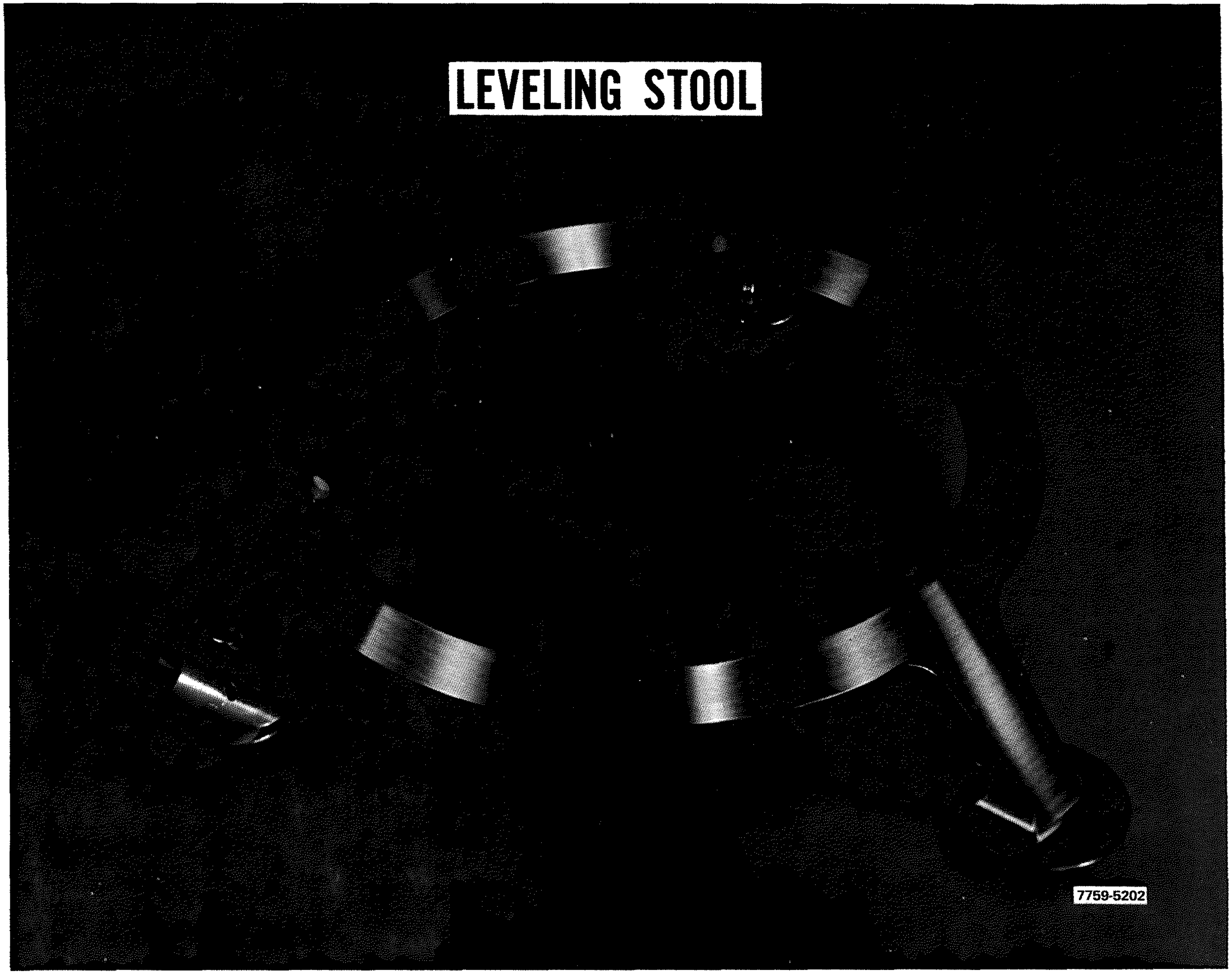
DEPLOY SHROUD SKIRT

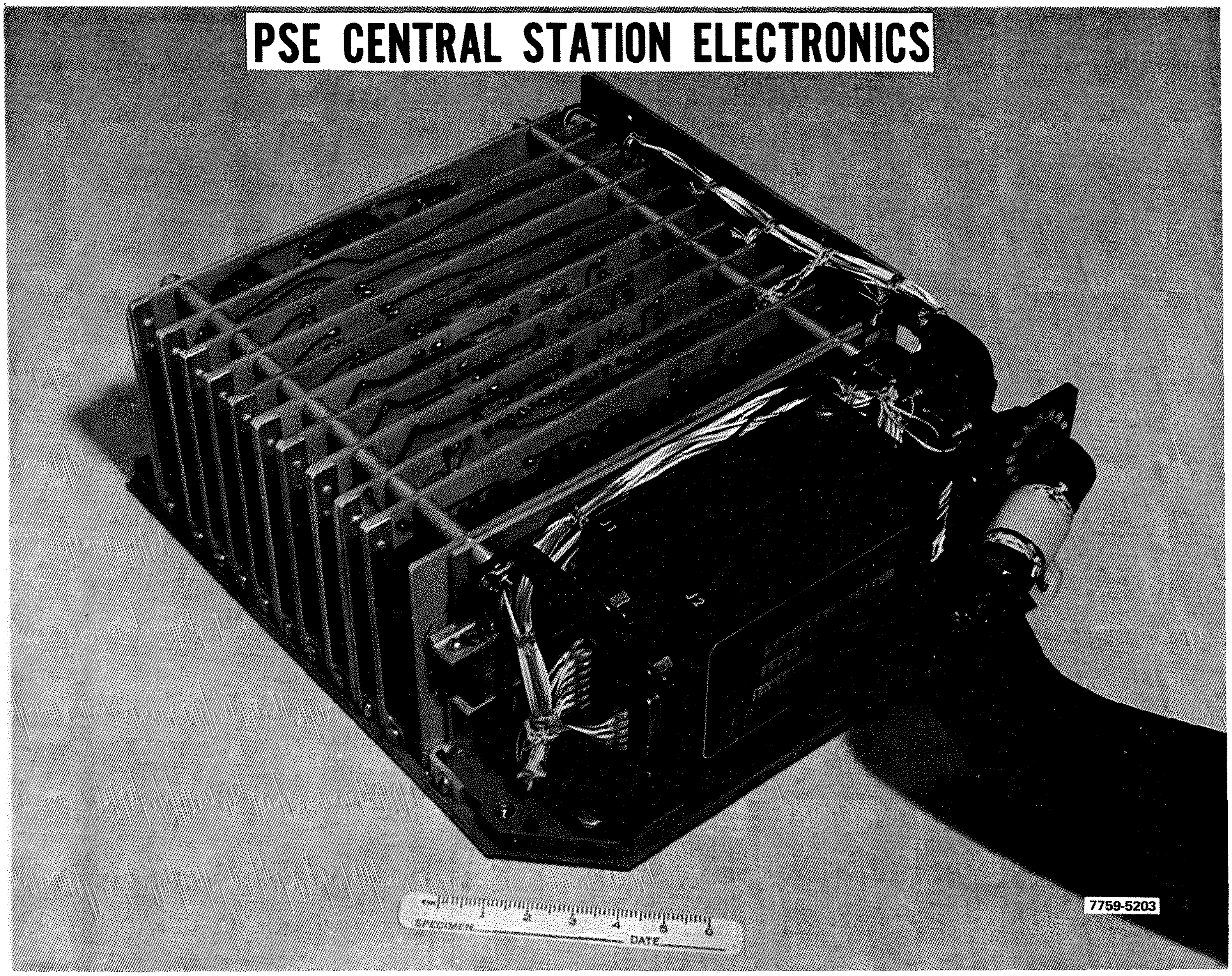
LEVEL SENSOR TO $\pm 5^{\circ}$ (BUBBLE LEVEL)

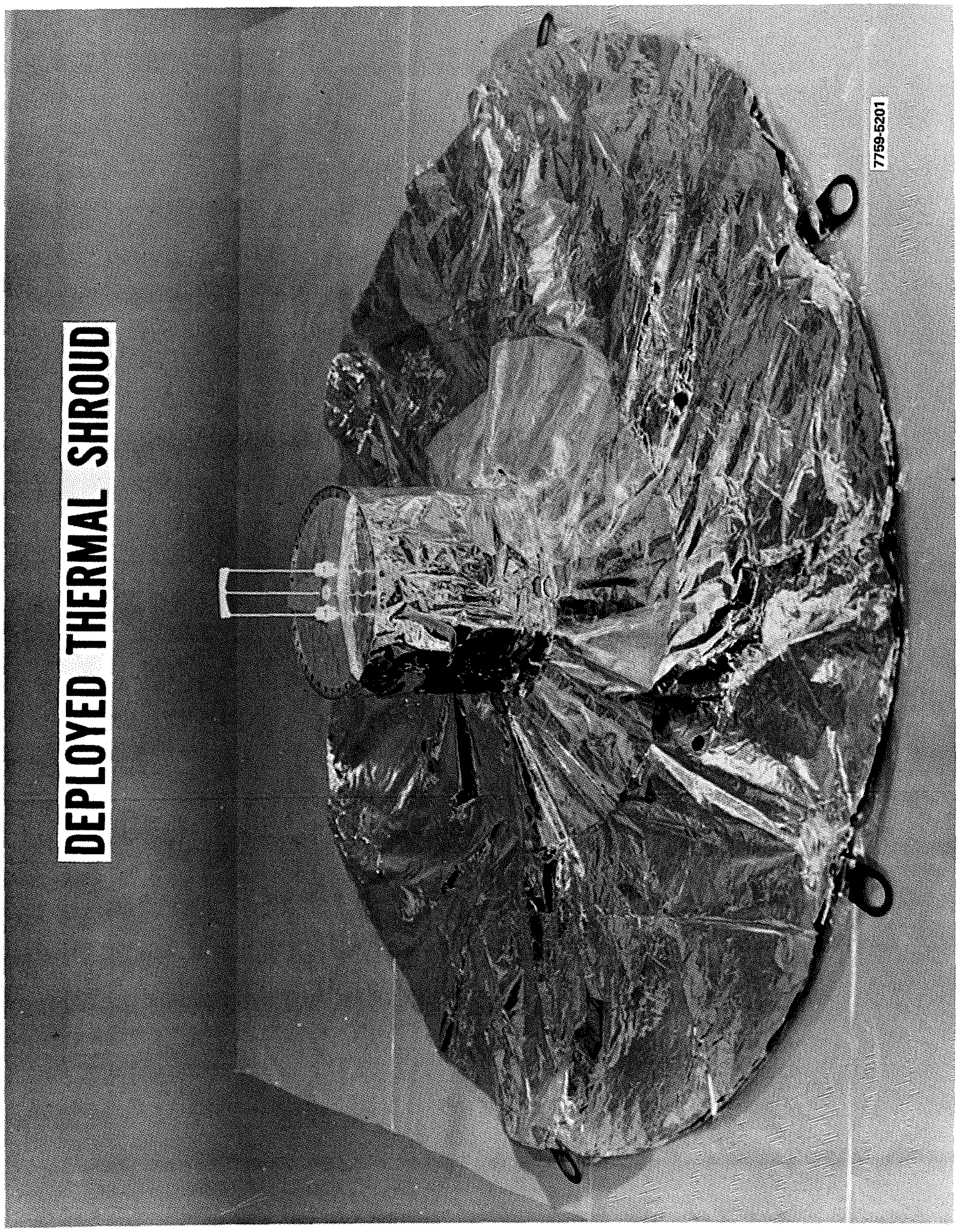
READ ALIGNMENT ANGLE (GNOMON SHADOW ON COMPASS ROSE)

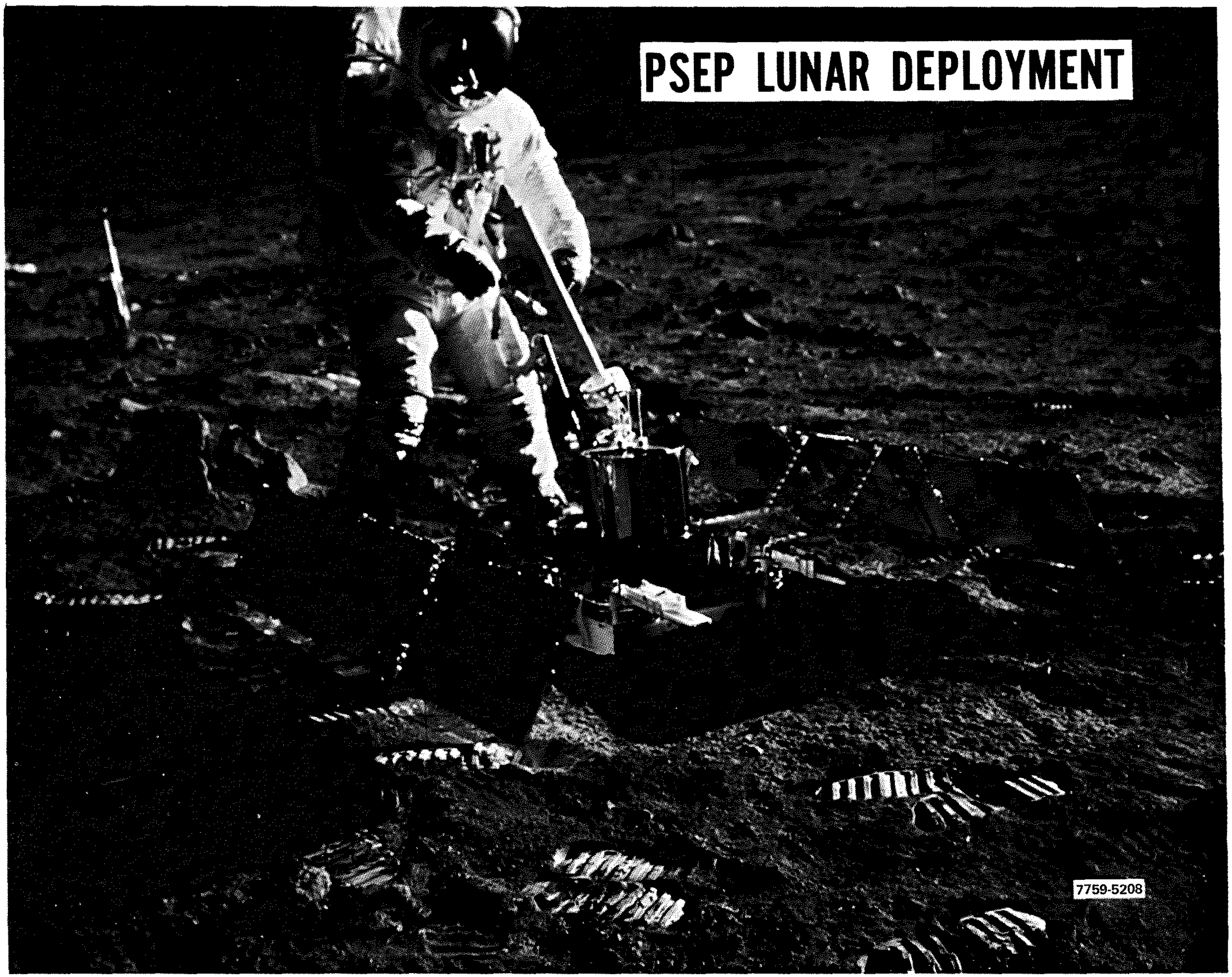
7759 - 5222


PASSIVE SEISMIC SUBSYSTEM
7759-5200

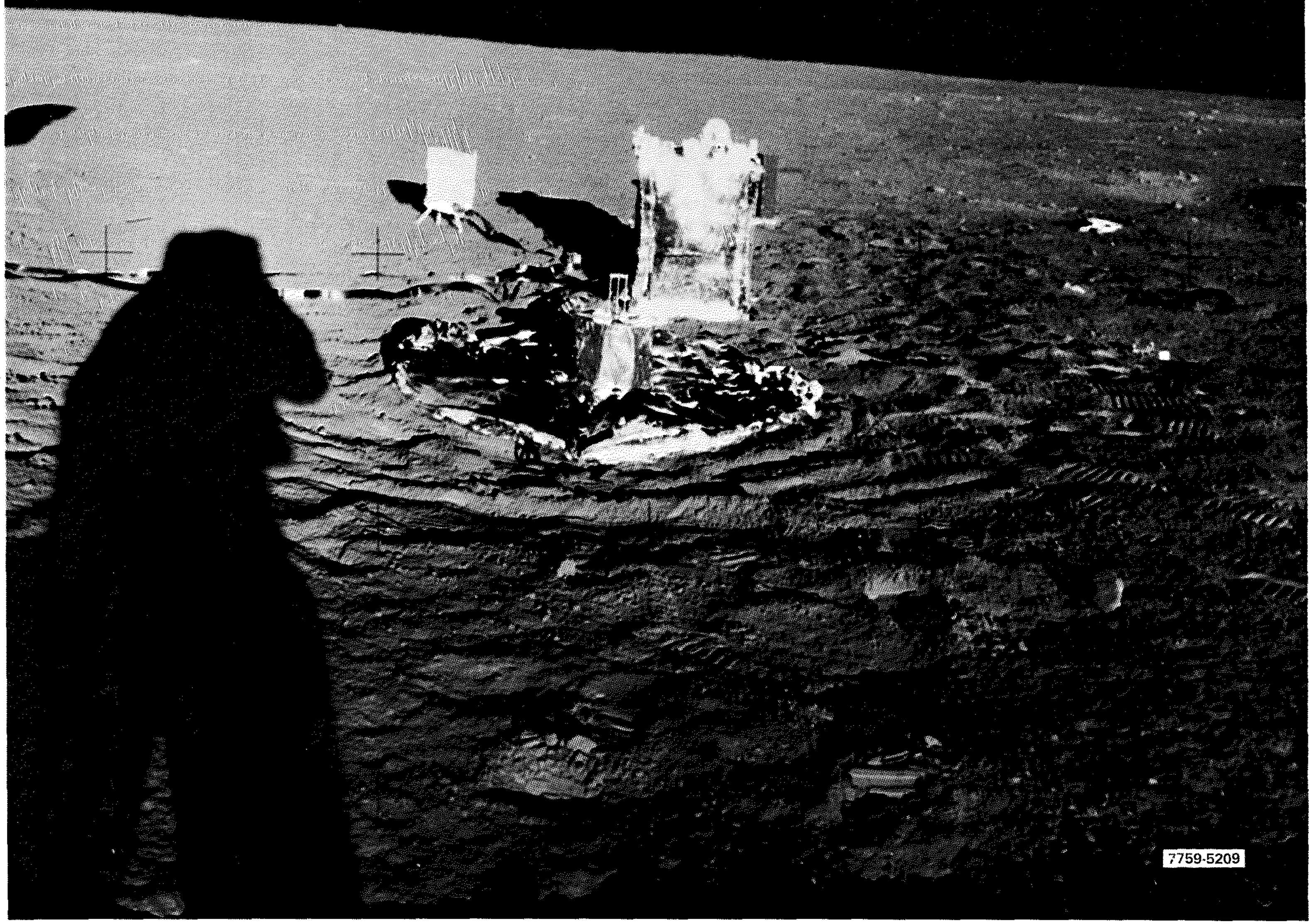

LEVELING STOOL
7759-5202


PSE CENTRAL STATION ELECTRONICS
J1
J2
SPECIMEN
DATE
7759-5203


DEPLOYED THERMAL SHROUD
7759-5201


PSEP LUNAR DEPLOYMENT
7759-5208

PASSIVE SEISMIC EXPERIMENT DEPLOYED-APOLLO 12



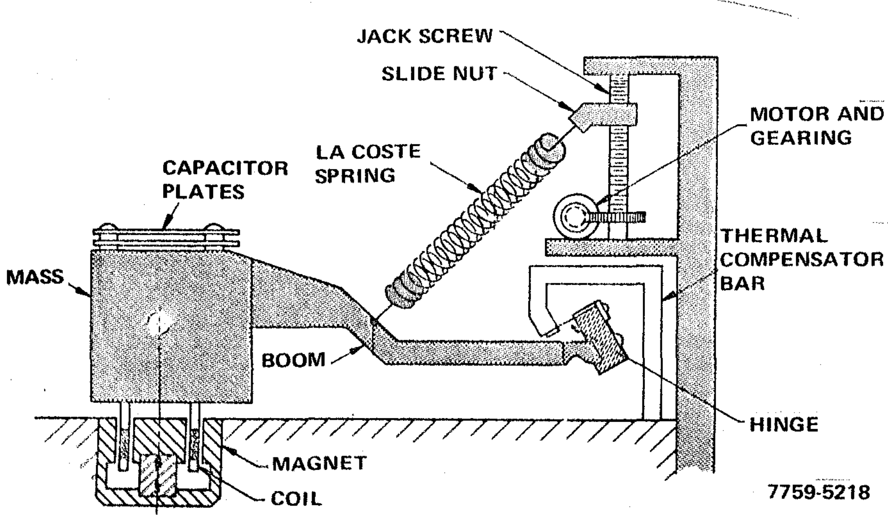

PSE SHROUD DEPLOYED-APOLLO 12
7759-5210

PHYSICAL PARAMETERS

WEIGHT	SENSOR	18.4 LB	
	SHROUD	2.9	
	CSE	4.2	
	STOOL	0.3	25.8 LB
DIMENSIONS	SENSOR	11.1 X 9.1 DIA INCHES	
	SHROUD	15 X 11 DIA	
	CSE	7.25 X 6.50 X 2.75	
	STOOL	2.3 X 11 DIA	
POWER	STANDBY	3.5 WATTS	
	FUNCTIONAL	4.2	
	THERM CONT	2.8 (MAX)	
	LEVELING	3.0 (PER AXIS)	

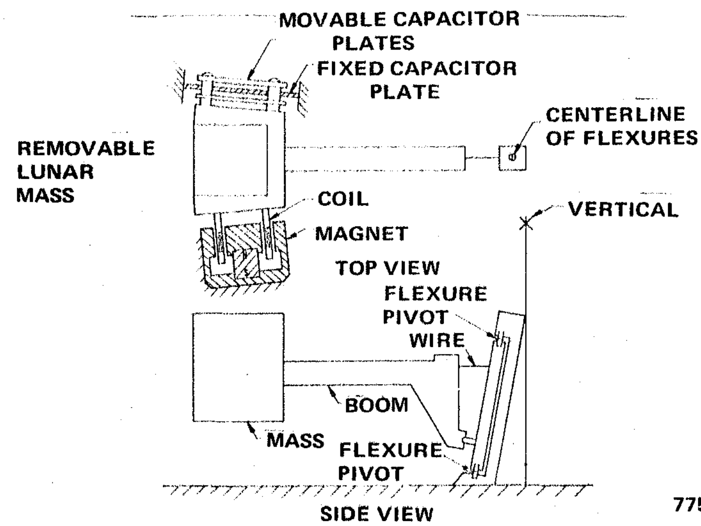
7759-5232

VERTICAL SEISMOMETER



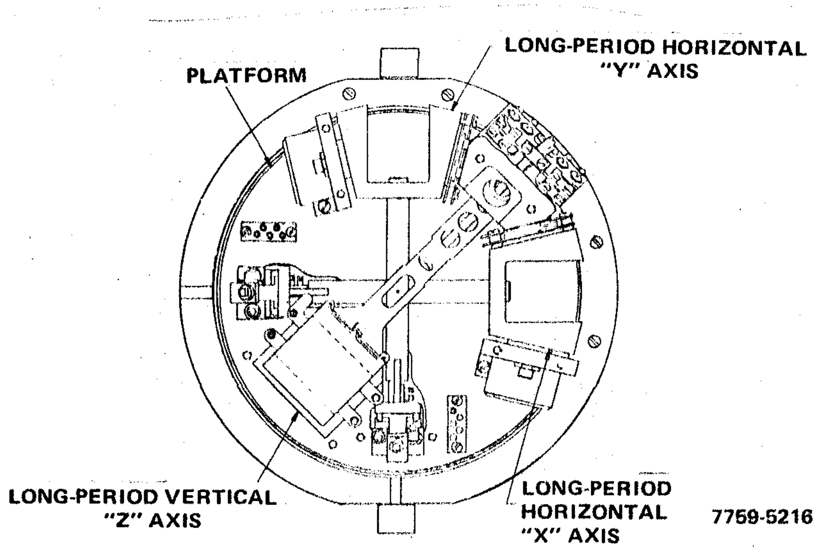
7759-5218

HORIZONTAL SEISMOMETER

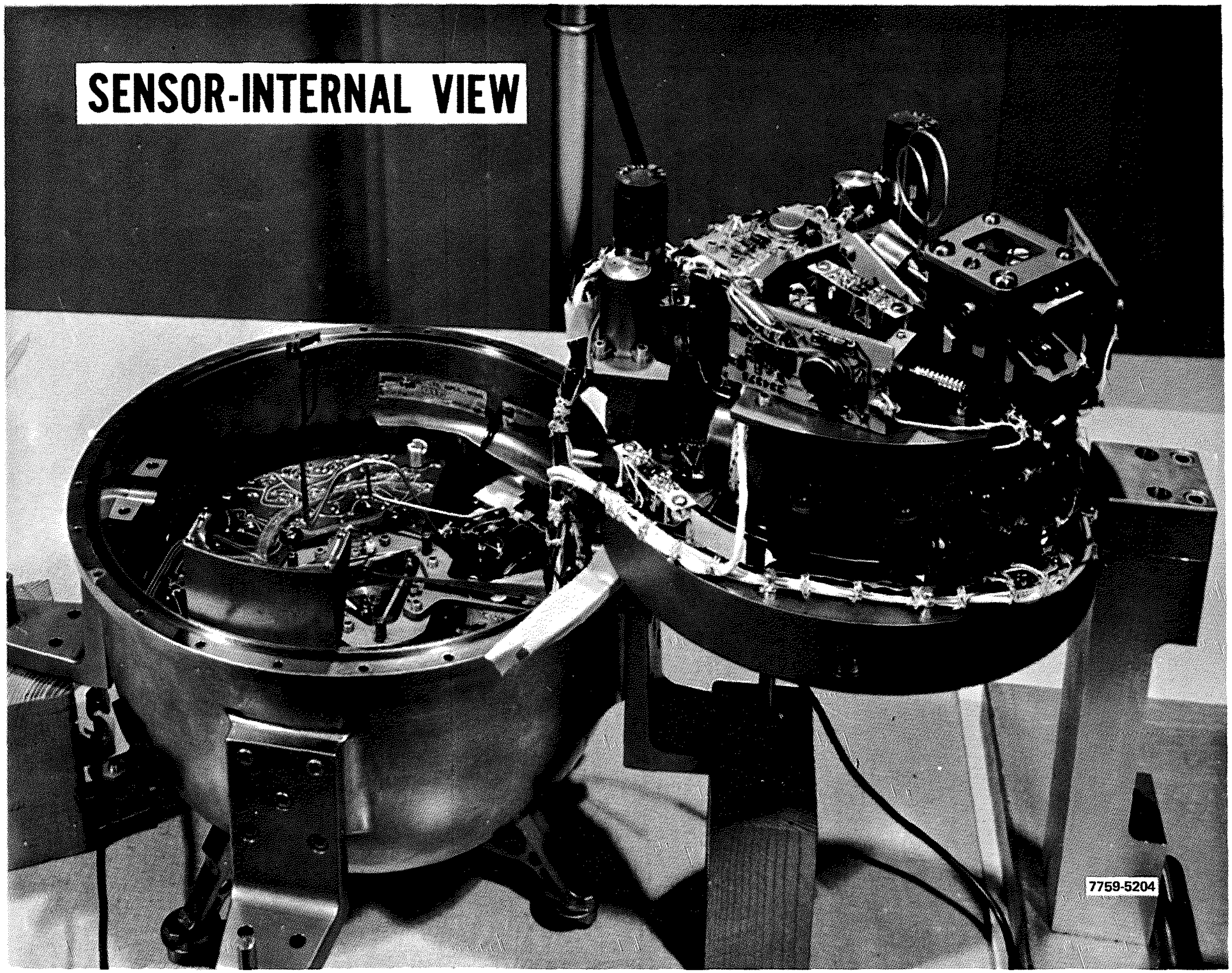


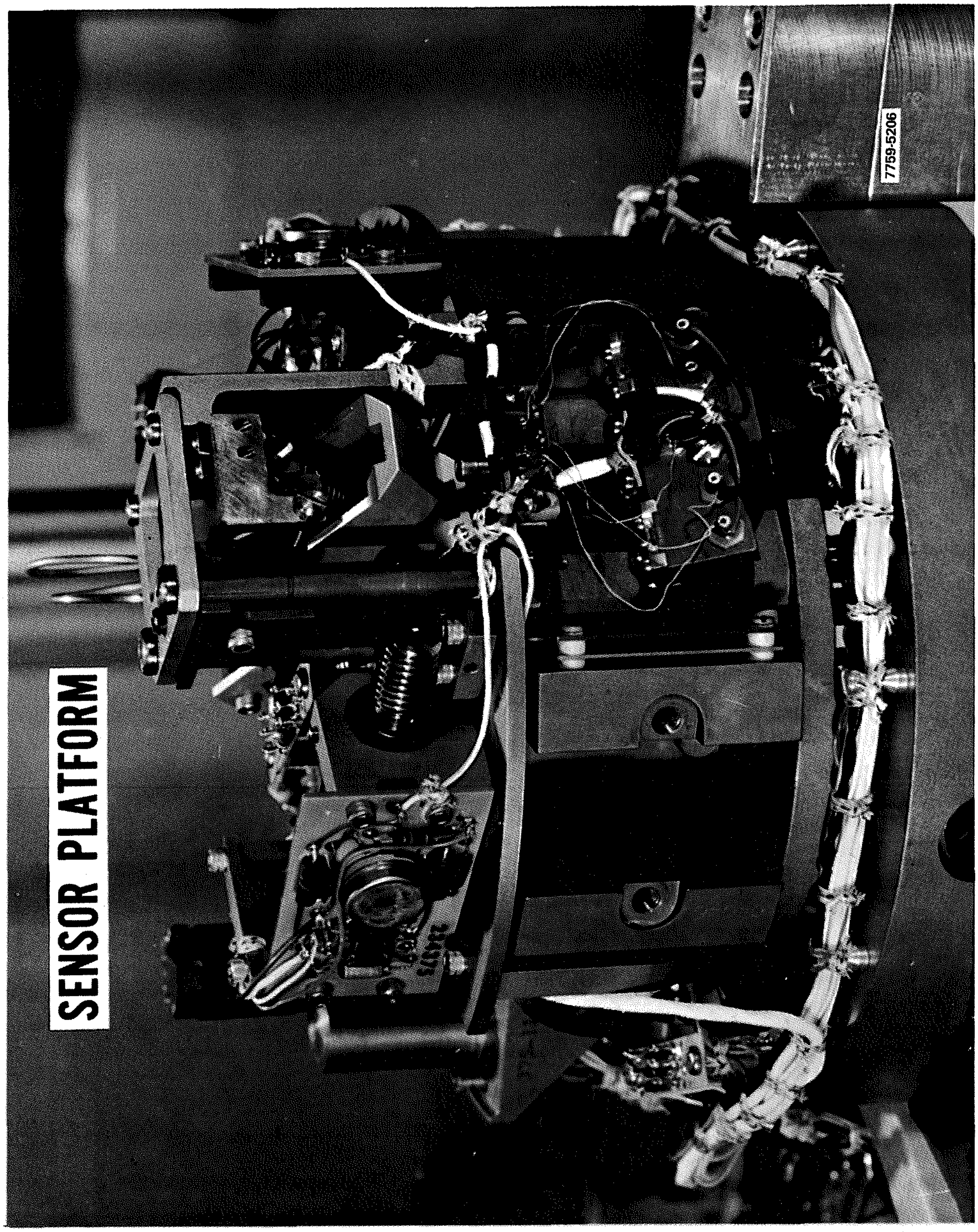
7759-5217

LONG-PERIOD SEISMOMETERS

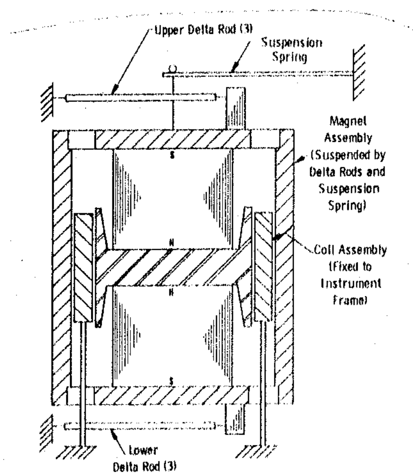


7759-5216


SENSOR-INTERNAL VIEW
7759-5204


SENSOR PLATFORM
7759-5206

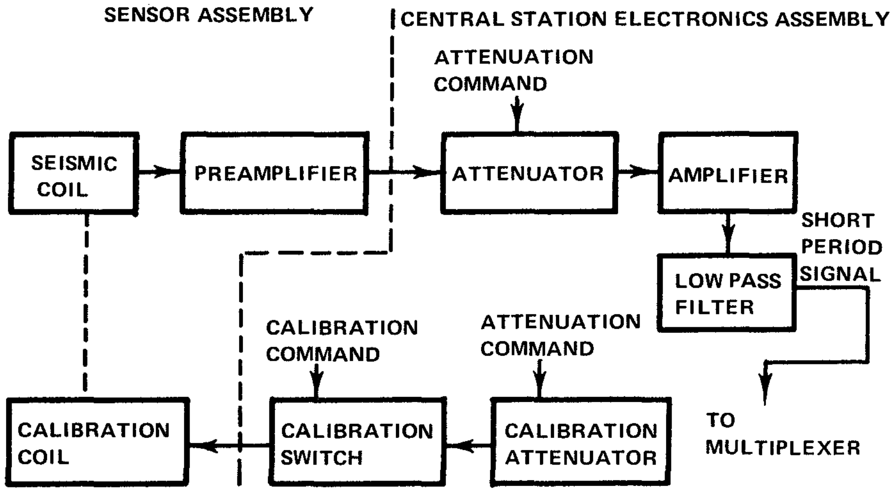
SHORT-PERIOD SEISMOMETER



7759-5215

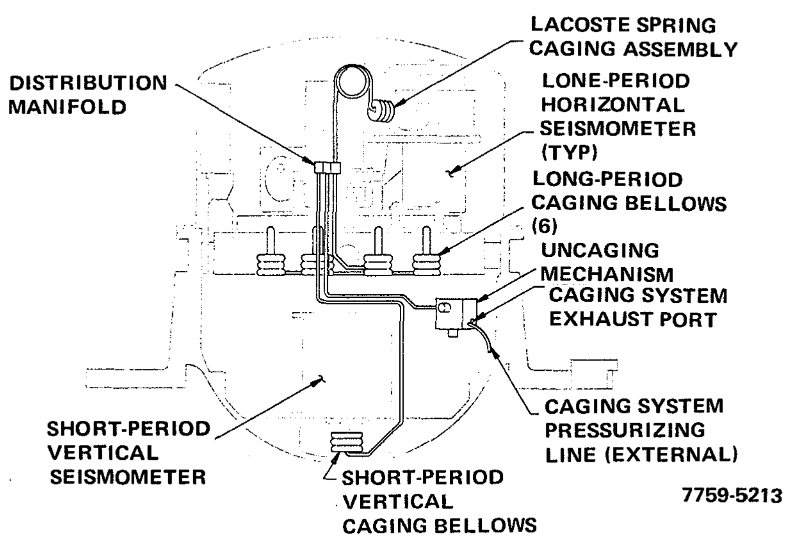

SENSOR BASE
7759-5205

BLOCK DIAGRAM, SP SENSOR



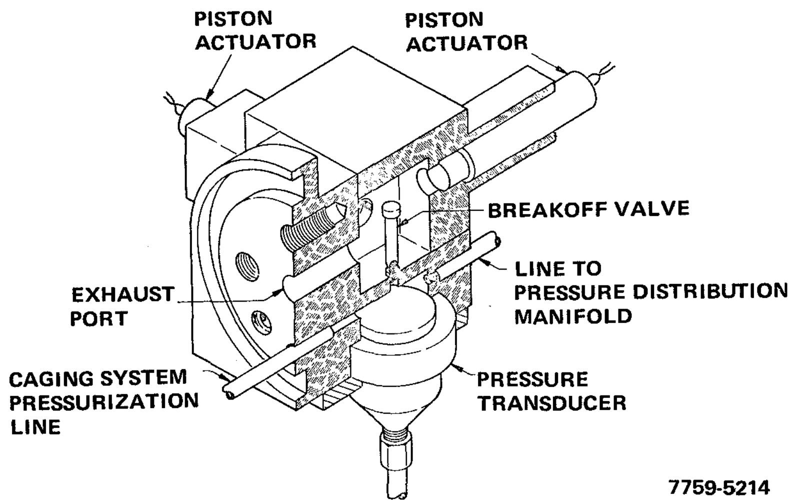
7759-5224

CAGING SYSTEM SCHEMATIC



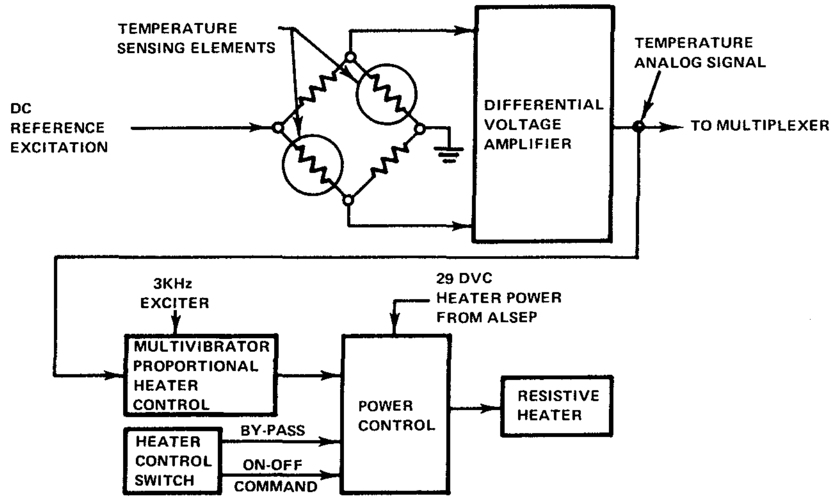
7759-5213

UNCAGING MECHANISM



7759-5214

BLOCK DIAGRAM, TEMPERATURE CONTROL



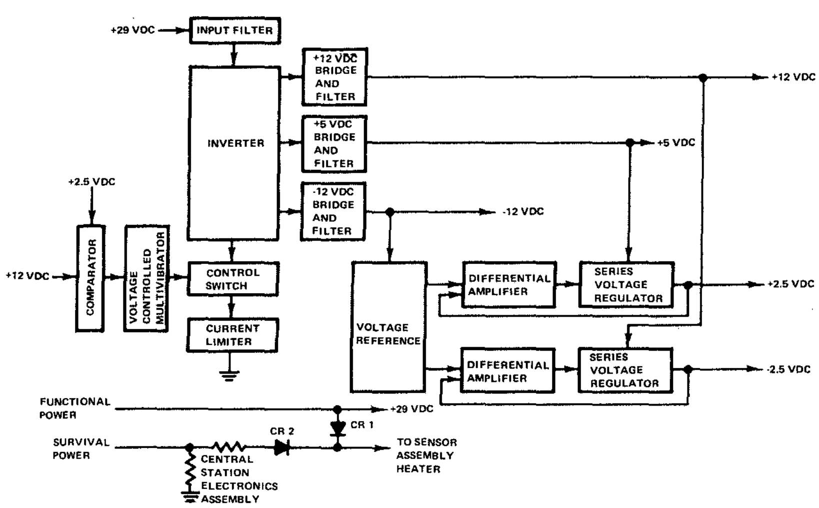
7759-5225

COMMAND FUNCTIONS

GAIN CHANGE LPX, LPY:	0, -10, -20, -30 DB
GAIN CHANGE LPZ:	0, -10, -20, -30 DB
GAIN CHANGE SPZ:	0, -10, -20, -30 DB
CALIBRATION LP:	ON, OFF
CALIBRATION SP:	ON, OFF
FEEDBACK FILTER:	IN, OUT
COARSE SENSOR:	IN, OUT
LEVELING MODE:	AUTO, COMMAND
LEVELING SPEED:	LOW, HIGH
LEVELING DIRECTION:	PLUS, MINUS
LEVELING POWER, X MTR:	ON, OFF
LEVELING POWER, Y MTR:	ON, OFF
LEVELING POWER, Z MTR:	ON, OFF
THERMAL CONTROL MODE:	OFF, AUTO, ON
UNCAGE:	CAGE, ARM, UNCAGE

7759-5220

BLOCK DIAGRAM, POWER CIRCUITS



7759-5223

DATA OUTPUT

SCIENCE CHANNELS: 43 WORDS PER FRAME

SP SENSOR	–	29 WORDS PER FRAME
LPX SENSOR	–	4 WORDS PER FRAME
LPY SENSOR	–	4 WORDS PER FRAME
LPZ SENSOR	–	4 WORDS PER FRAME
LPX TIDAL	–	1 WORD PER 2 FRAMES
LPY TIDAL	–	1 WORD PER 2 FRAMES
LPZ TIDAL	–	1 WORD PER 2 FRAMES
TEMPERATURE	–	1 WORD PER 2 FRAMES

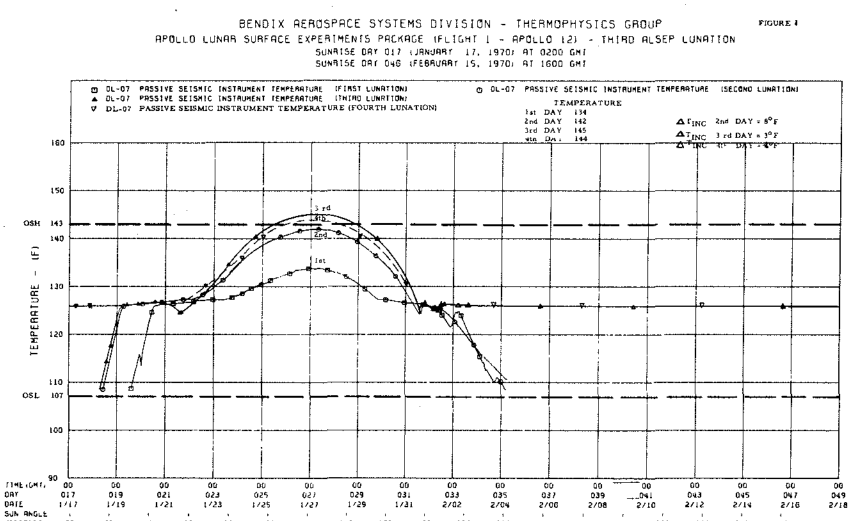
ENGINEERING DATA: 8 WORDS PER 54 SEC

FRAME LENGTH: 64 WORDS

WORD LENGTH: 10 BITS

FRAME RATE: 1 FRAME/0.604 SEC

7759-5221



7759-5236

3-18

THERMAL ANOMALY AND POSSIBLE NOISE PROBLEM

THERMAL ANOMALY

– INSTRUMENT SPECIFICATION: 126 ± 18F, DESIGN GOAL ± 4F

– LUNAR TEMPERATURE

LUNAR TEMPERATURE	NOON TEMP	NIGHT TEMP
FIRST DAY	134 F	75 F*
SECOND DAY	142 F	75 F*
THIRD DAY	145 F*	126 F**
FOURTH DAY	144 F	126 F**

POSSIBLE NOISE PROBLEM

– CONSIDERABLE INSTRUMENT TILT WAS RECORDED AT SUNSET AND SUNRISE

– MAY BE CAUSED BY SHROUD PULLING

SCIENCE CONSIDERATIONS

– THE TEMP VARIATION OF LESS THAN ± 2°F IS REQUIRED TO OBTAIN FULL TIDE DATA

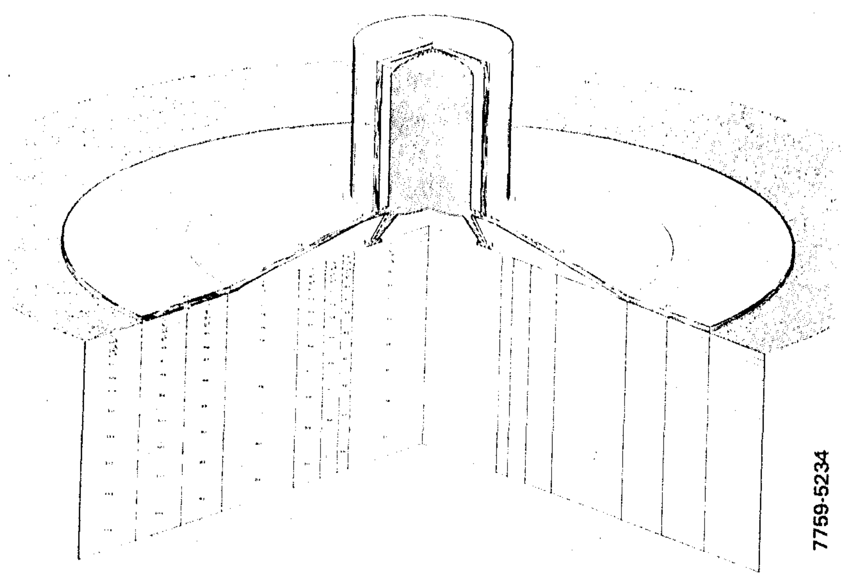
– THE INSTRUMENT TILT RECORDED AT SUNSET AND SUNRISE MAY BE NATURAL LUNAR EVENT: THIS CAN'T BE VARIFIED UNLESS POSSIBLE SHROUD PROBLEM IS ELIMINATED

– SEISMIC DATA IS INTERRUPTED BY REPEATED LEVELING DUE TO OUT-OF-SPECIFICATION VARIATION

* ESTIMATED
** WITH LEVELING MOTOR ON

7759-5233

PSE AND LUNAR SUBSURFACE THERMAL MODEL



7759-5234

APOLLO 12 PSE THERMAL STUDY RESULTS

MAX LUNAR DAY TEMP INCREASED FOR FIRST THREE LUNAR DAYS FROM 134° to 145°F

IMPROPER DEPLOYMENT OF PSE SKIRT ATTRIBUTED TO ELECTROSTATIC CHARGE BETWEEN LUNAR SURFACE AND MYLAR MATERIAL

SHROUD THERMAL CONDUCTIVITY IS HIGHER THAN SPECIFIED VALUE

SPECIFIED 2.5×10^{-5} BTU/HR-FT-F

ACTUAL 7.5×10^{-4} BTU/HR-FT-F

EXTERNAL SURFACE OF SKIRT DAMAGED BY LM EXHAUST OR DETERIORATED IN LUNAR ENVIRONMENT

MYLAR SHIRT $(\alpha/\epsilon)_{NOM} \approx .15/.37$

ACT $\approx .37/.37$

TEFLON SHROUD $(\alpha/\epsilon)_{NOM} \approx .2/.73$

ACT $\approx .73/.73$ (EAST SIDE FACING LM ONLY)

7759-5245

MODIFICATION - APOLLO 13 SHROUD

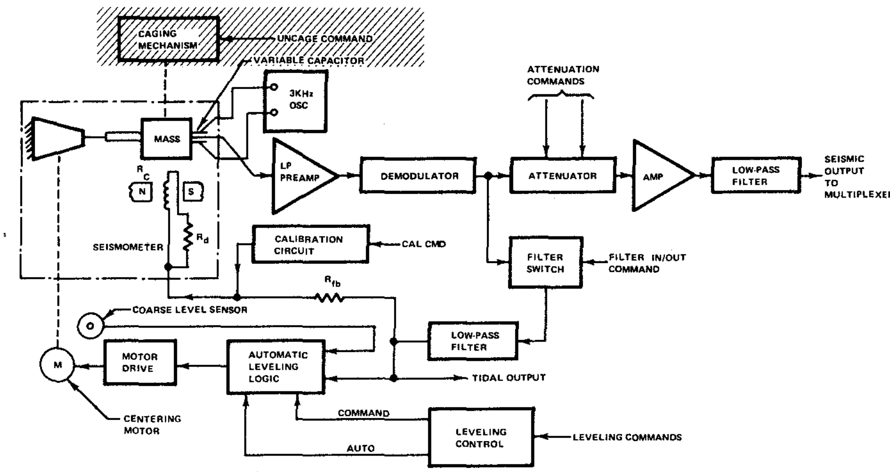
- PROVIDE ONE LAYER OF TEFLON TO IMPROVE THERMAL PERFORMANCE AND MINIMIZE TERMINATOR NOISE PROBLEM
- INCORPORATE WEIGHTS TO INSURE PROPER DEPLOYMENT
- SEW SKIRT AND ADD BUTTONS TO IMPROVE DEPLOYMENT

THERMAL MODIFICATION COMPARISON

MODEL	TEMPERATURE RANGE °F DAY	NIGHT
APOLLO 12	145	75
APOLLO 13	126	95 ± 15

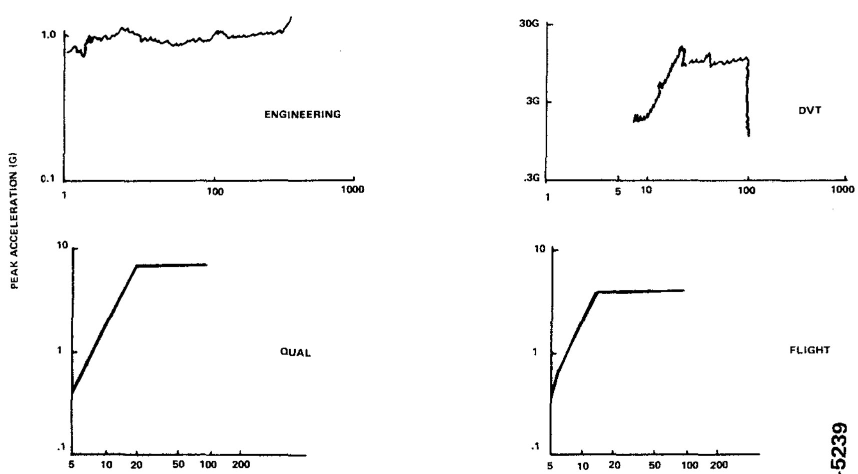
7759 - 5235

BLOCK DIAGRAM, TYPICAL LP SENSOR



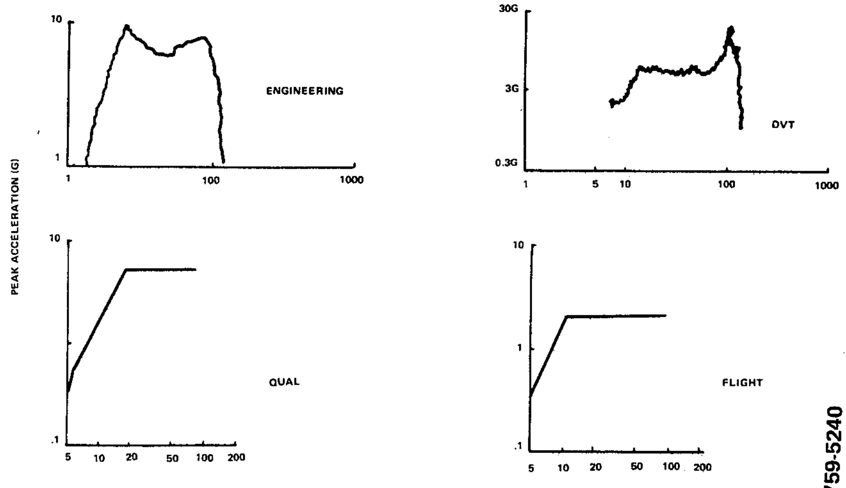
7759-5226

SINE X–AXIS



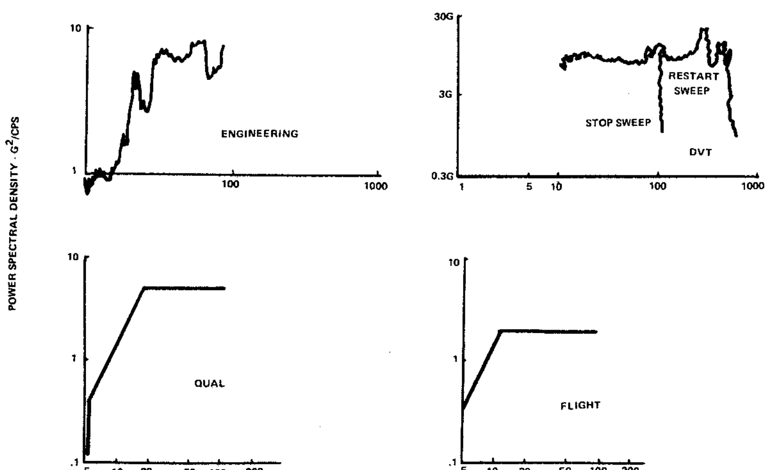
7759-5239

SINE Y-AXIS



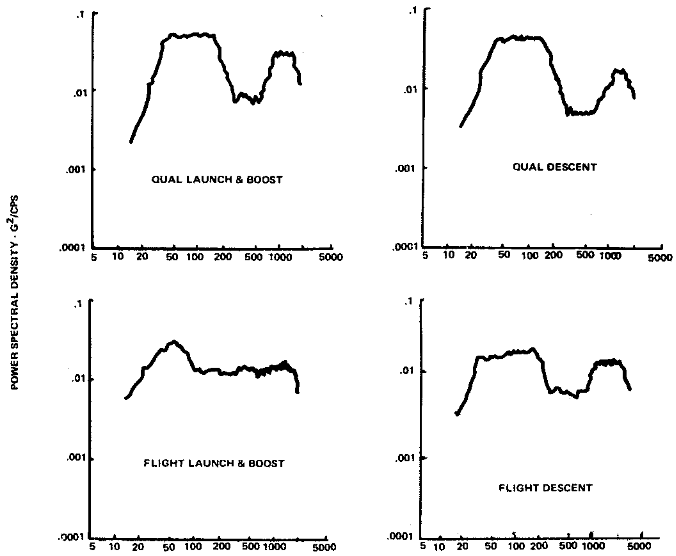
7759-5240

SINE Z-AXIS



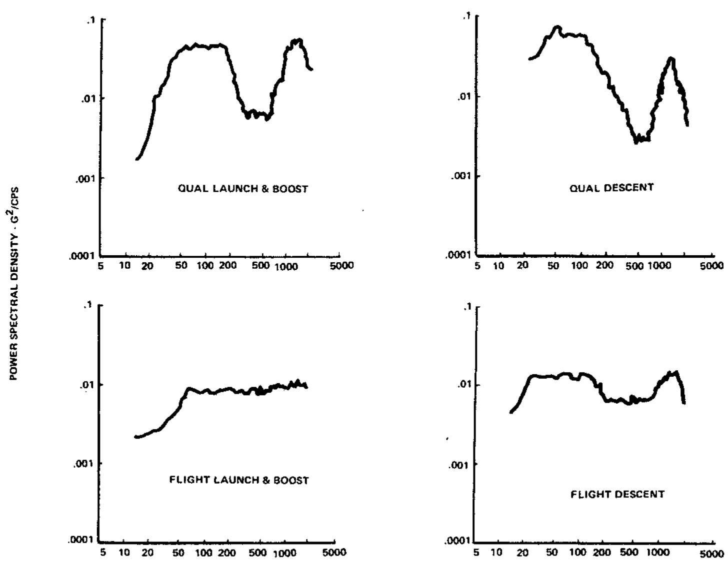
7759-5241

RANDOM X-AXIS



7759-5242

RANDOM Y-AXIS



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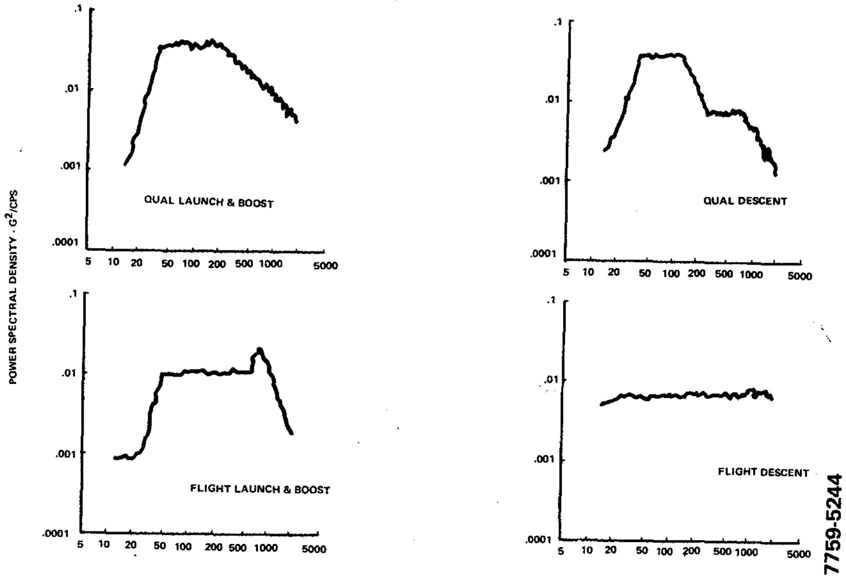
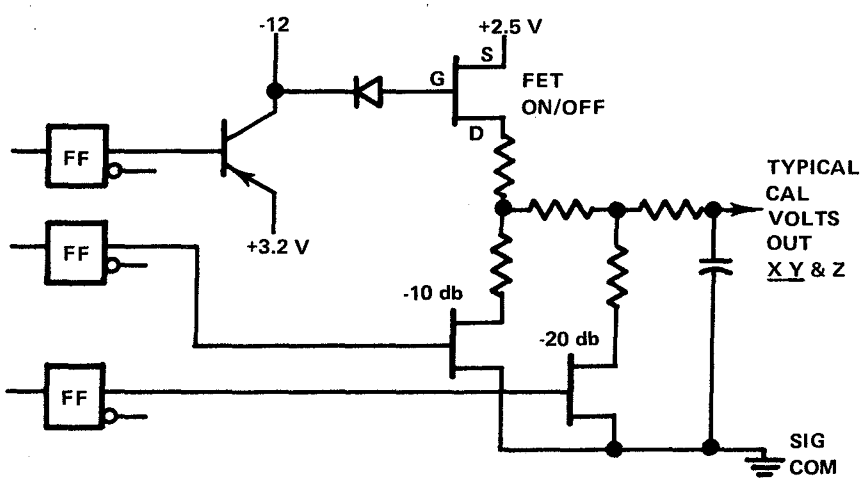
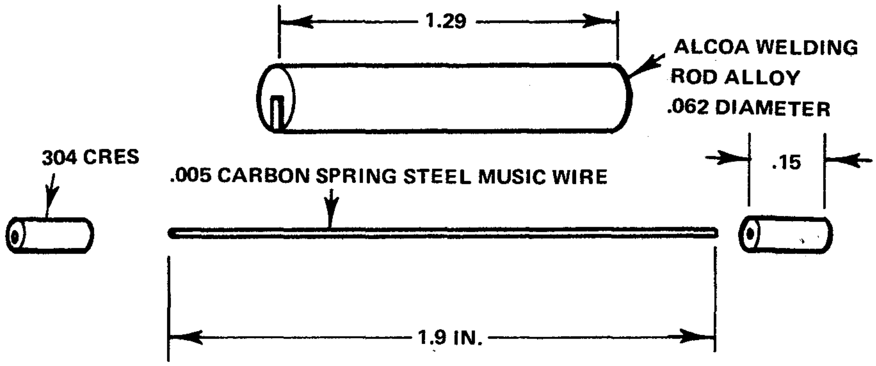
RANDOM Z-AXIS



TYPICAL CALIBRATION VOLTAGE CONTROL CIRCUIT



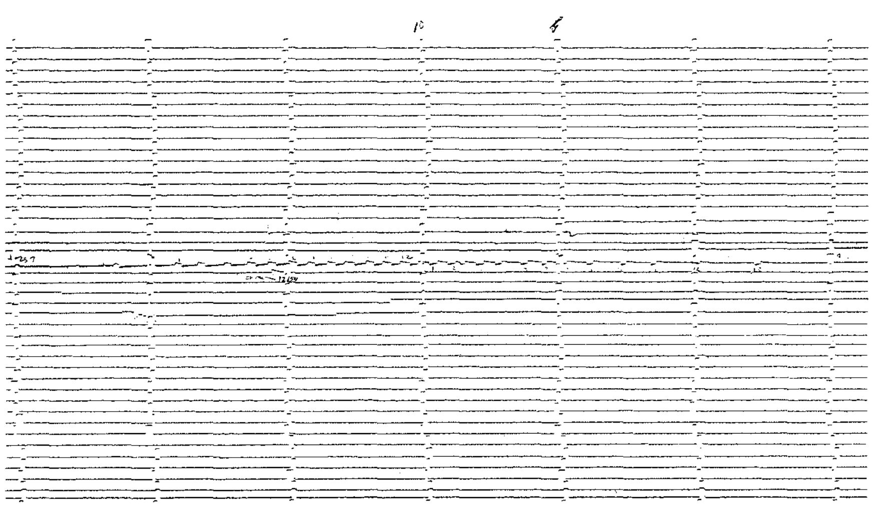
DELTA ROD



ALL PIECES SWAGED

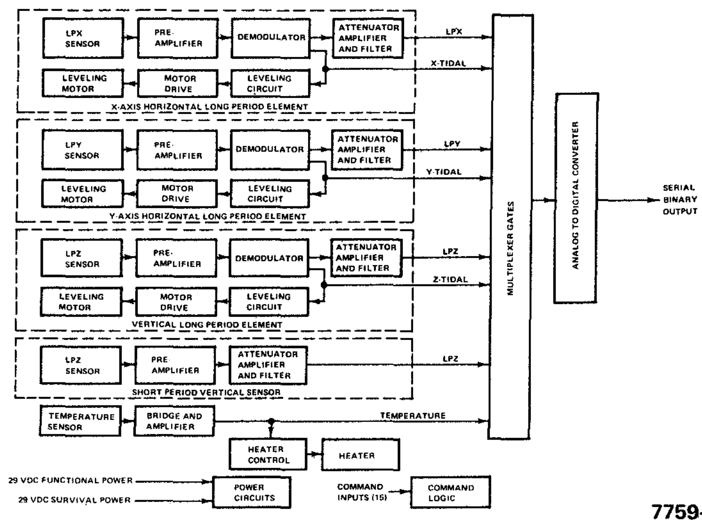
7759-5230

APOLLO 12 SHORT-PERIOD NOISE PULSES



7759-5238

PSE SIMPLIFIED BLOCK DIAGRAM



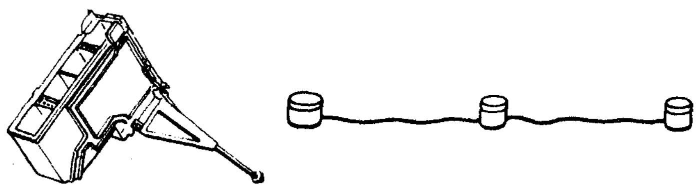
7759-5228

Section 4

Active Seismic Experiment

ACTIVE SEISMIC
NASA No. S033

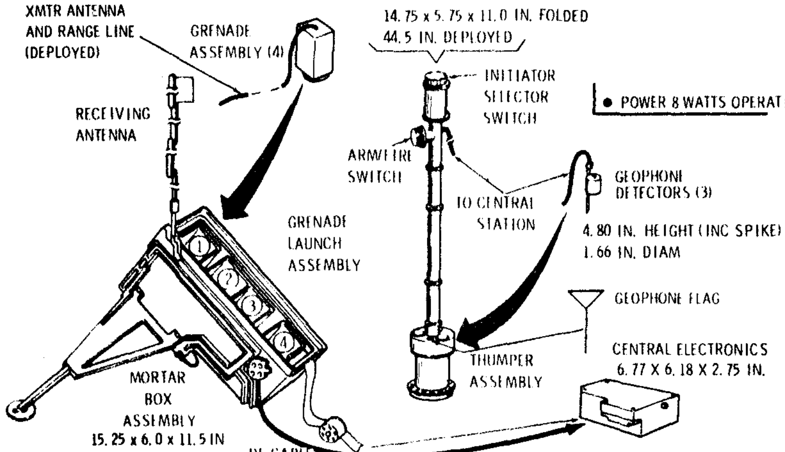
OBJECTIVE: PHYSICAL PROPERTIES TO SHALLOW DEPTHS, FORMATION PROCESSES
MEASUREMENT: ARTIFICIAL SEISMIC WAVE VELOCITY, FREQUENCY, & ATTENUATION
EQUIPMENT: ENERGY SOURCES (THUMPER & GRENADES), DETECTION EQUIPMENT (GEOPHONES & AMPLIFIERS)



7759-5630

ACTIVE SEISMIC EXPERIMENT SUBSYSTEM

• POWER 8 WATTS OPERATING



7759-5636

4-1

ASE MODES OF OPERATION

THUMPER MODE: APPROX 7 MIN (PLUS SET UP) WHILE ASTRONAUT IS ON SURFACE. USES SMALL SEISMIC SOURCES RELATIVELY CLOSE TO GEOPHONES.

LISTENING (PASSIVE) MODE: 15 MINUTES, ONCE PER WEEK (AVERAGE). DETECTS TECTONIC DISTURBANCES OR METEOROID IMPACTS TO EVALUATE SYSTEM STATUS, PARTICULARLY LUNAR SURFACE NOISE LEVEL (WHICH MAY BE A FUNCTION OF AMBIENT TEMPERATURE), AND ASSIST IN SELECTING OPTIMUM TIME FOR MORTAR MODE.

MORTAR OR GRENADE MODE: APPROX 1 HR NEAR END OF ALSEP MISSION. USES RELATIVELY LARGE SEISMIC SOURCES AT RANGES UP TO 5000 FT.

NOTE: ALL MODES REQUIRE 85-FT MSFN ANTENNA BUT, WITH THE EXCEPTION OF THE THUMPER MODE, CAN BE SCHEDULED FOR MOST CONVENIENT GROUND OPERATIONS.

7759-5663

ASE GENERAL FEATURES

PURPOSE:
- MONITOR NATURAL LUNAR SEISMIC ACTIVITY
- GENERATE & MONITOR ARTIFICIAL SEISMIC ENERGY

IN THE RANGE FROM 3 TO 250 Hz

GENERATE (SOURCES):
- EXPLOSIVE DEVICES

THUMPER ASI's (21)
- ACTUATED NEAR MARKED POSITIONS ON GEOPHONE CABLE

MORTAR GRENADES (4)
- RANGE, FT 500 1000 3000 5000
- CHARGE PROPORTIONAL TO RANGE

MONITOR (DETECTORS):
- GEOPHONES (3) WITH LOG COMPRESSION AMPLIFIERS

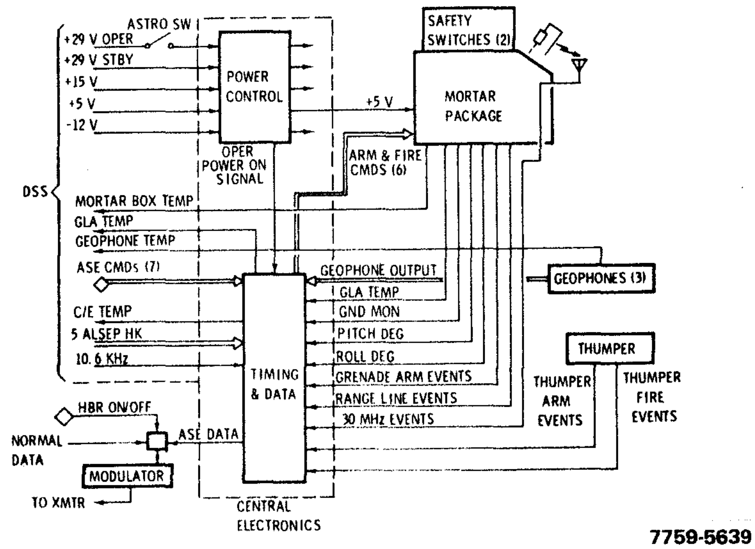
BY VARYING THE MAGNITUDE & LOCATION OF SOURCES WITH RESPECT TO DETECTORS
- OBTAIN PENETRATION OF WAVES TO ≃ 500 FT
- THUS INVESTIGATE VELOCITY THROUGH SEVERAL LAYERS OF SUBSURFACE MATERIAL

- ACCURATE DETERMINATION OF SHOT TIME AND RANGE IS FUNDAMENTAL FOR ANALYSIS OF GEOPHONE DATA

	SHOT TIME	RANGE
THUMPER	PRESSURE SW SIGNAL	ASTRONAUT LOCATION
GRENADES	XMTR OFF SIGNAL	TRAJECTORY CALCULATIONS

7759-5637

ASE FUNCTIONAL DIAGRAM



7759-5639

ACTIVE SEISMIC CHARACTERISTICS

KEY FEATURES

HIGH BIT RATE (10.6 KBPS) OF ASE REQUIRES 85-FT MSFN ANTENNA (ON REQUEST)

EXPLOSIVES HAVE SAFE/ARM PROTECTION FEATURES

GRENADES LAUNCHED TO 500, 1000, 3000 & 5000 FT RANGE FROM GEOPHONES

CHARGE EQUIVALENT TO 150 MILLIGRAM TNT IN THUMPER AND UP TO 1.0 LB TNT IN GRENADE

IMPACT POINT OF GRENADES DETERMINED BY LAUNCH ANGLE, INITIAL LAUNCH VELOCITY, & IMPACT TIME

INDIVIDUAL HEATER FOR MORTAR BOX, "THERMOSTATICALLY" CONTROLLED ELECTRONICALLY

7759-5633

ACTIVE SEISMIC CHARACTERISTICS

OPERATIONS	
DEPLOYMENT & THUMPER	POST DEPLOYMENT
• EMPLACE MORTAR PACKAGE • PLACE GEOPHONES AT 10, 160 & 310 FT FROM CENTRAL STATION • ACTIVATE THUMPER EVERY 15 FT • REMOVE SAFETY RELEASE ASSEMBLY AND ACTUATE SAFE/ARM SWITCHES ON MORTAR BOX APPROX TIME, 20 MIN	• GROUND OPERATIONS DURING DEPLOYMENT/THUMPER REQUIRING TURN-ON, GEOPHONE CALIBRATE, & TURN-OFF • LATER, MONITOR 15 MIN PER WEEK • NEAR YEAR-END, TURN ON & CALIBRATE GEOPHONES, ARM & FIRE GRENADES • OTHER COMMANDS AS NECESSARY

7759-5632

ASE DEPLOYMENT SEQUENCE

1. VERIFY THAT CENTRAL STATION ASTRONAUT SWITCH (S-5) IS IN OPEN POSITION
2. REMOVE THUMPER & PLACE IN TEMPORARY LOCATION
3. REMOVE MORTAR BOX & PLACE 10 FT FROM CENTRAL STATION IN OPPOSITE DIRECTION TO THAT SELECTED FOR GEOPHONES
4. ALIGN TO FIRE AWAY FROM GEOPHONES & ERECT ASE RECEIVING ANTENNA (INC FLAG)
5. ERECT CENTRAL STATION SUNSHIELD & ANTENNA
6. AFTER ALSEP COMMUNICATIONS HAVE BEEN ESTABLISHED & SWITCHED TO ASE HBR, PLACE CENTRAL STATION ASTRONAUT SWITCH IN CLOSED POSITION
7. UNFOLD THUMPER & WALK OUT IN SELECTED DIRECTION PLACING GEOPHONES AT 10, 160, & WALK OUT IN SELECTED DIRECTION PLACING GEOPHONES AT 10, 160, & 310 FT FROM CENTRAL STATION & IN LINE $\pm 3^0$ USING FLAG ON MORTAR BOX (PLUS FLAG PLACED AT 160- FT GEOPHONE LOCATION) AS REFERENCE.

7759-5660

ASE DEPLOYMENT SEQUENCE (CONT')

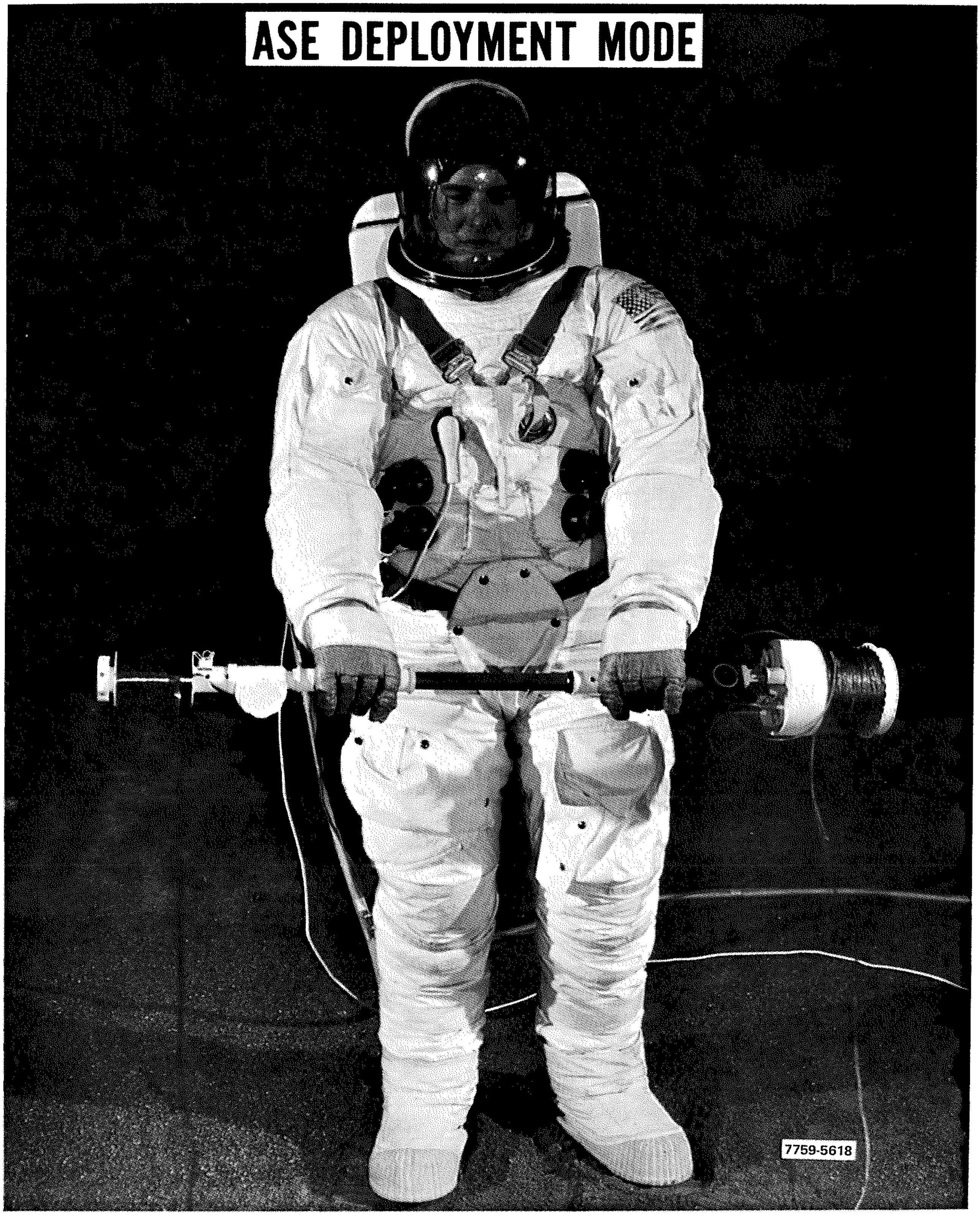
8. RETURN ALONG GEOPHONE CABLE ACTUATING THUMPER AT 15-FT INTERVALS AS INDICATED BY CABLE MARKINGS
9. PLACE CENTRAL STATION ASTRONAUT SWITCH IN OPEN POSITION
10. REMOVE GRENADE RETAINING ROD ASSY FROM MORTAR BOX
11. ACTUATE MORTAR BOX SAFETY SWITCHES (2) REMOVING SHORTS FROM GRENADE ARM/FIRE CIRCUITS
12. PLACE CENTRAL STATION ASTRONAUT SWITCH IN CLOSED POSITION

7759-5661

ASE EMPLACEMENT CRITERIA

	PARAMETER	REQUIREMENT	PRIORITY	INDICATOR	COMMENTS
MORTAR PKG	SITE SELECTION	LEVEL (UPRANGE & DOWNRANGE)	1	EYEBALL	SELECTION MUST CONSIDER BOTH GRENADE IMPACT & GEOPHONE AREAS
	DISTANCE FROM SUBPACKAGE 1	DEPENDS ON SITE/ SCIENTIFIC CONSTRAINTS			
	DIRECTION FROM SUBPACKAGE 1	130 ± 8° FROM LM *	2	EYEBALL	122° FOR 300 FT PLSS CONSTRAINT 138° FOR 200 FT LM SEPARATION
	LEVEL	± 10° OF HORIZONTAL	1	EYEBALL	INTERNAL LEVEL SENSORS
	ALIGN	± 3° FROM ASSUMED GEOPHONES DEPLOYMENT LINE	1	EYEBALL	FIRES AWAY FROM LM & GEOPHONES
GEOPHONES	DISTANCE FROM SUBPACKAGE 1	12 ± 2 FT TO 1ST 150 ± 1.5 FT 1ST TO 2ND 300 ± 3 FT 1ST TO 3RD	1	314 FT CABLE	GEOPHONES SET LATERALLY FROM CABLE ON 3-FT PIGTAILS
	DIRECTION FROM SUBPACKAGE 1		2	EYEBALL	OPPOSITE MORTAR PACKAGE
	LEVEL GEOPHONE	± 7° OF HORIZONTAL	2	EYEBALL	GEOPHONE RESPONSE REQUIREMENT
	ALIGN CABLE	± 3° FROM STRAIGHT	1	FLAGS **	VARIATION OF 2ND GEOPHONE FROM LINE BETWEEN 1ST & 3RD
SPECIAL REQUIREMENTS		30° FROM N S LINE OF SUBPACKAGE 1 TO AVOID FIELD OF VIEW OF CENTRAL STATION RADIATOR. **2 FLAGS: MORTAR BOX AND 2ND GEOPHONE (USED FOR ALIGNMENT) ANTENNA MOUNTED ON MORTAR BOX (OMNI DIRECTIONAL).			
EXPERIMENT INTERRELATION		*GEOPHONES AT LEAST 10 FT FROM RTG AND SUBPACKAGE 1			

7759-5662


ASE DEPLOYMENT MODE
7759-5618


ASE MPA DEPLOYMENT
7759-5616

ASE THERMAL CONTROL

MECHANICAL

(MORTAR PACKAGE)

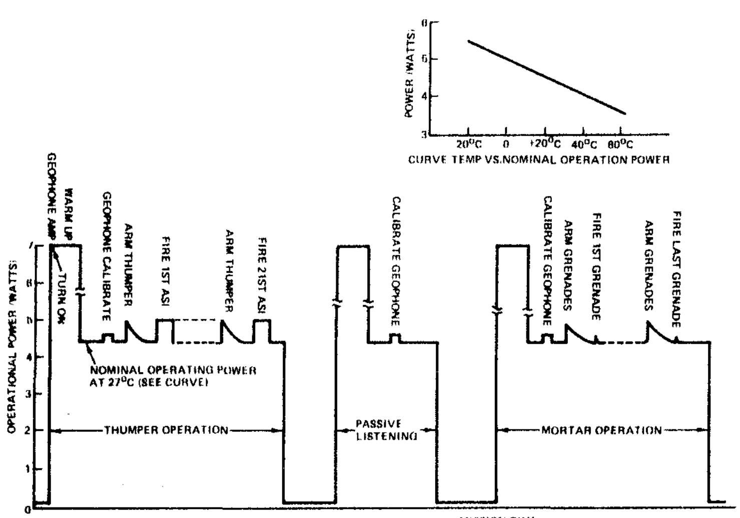
- 0.5-IN. MULTILAYER ALUMINIZED MYLAR ON SIDES & BOTTOM
- THIN ALUMINIZED MYLAR SUNSHIELD OVER TOP
- GRENADES LAUNCHED THROUGH SUNSHIELD
- ROCKET BLAST DISINTEGRATES MYLAR INSULATION REDUCING RECOIL EFFECT ON BOX STABILITY
- THERMAL PAINT TO MAINTAIN TEMP. 85 C

ELECTRICAL

- MORTAR PACKAGE
  - ELECTRONIC SENSOR/CONTROL CIRCUIT OPERATES SERIES/PARALLEL HEATER ARRAY TO MAINTAIN TEMP ABOVE -60° C
  - PROPORTIONAL CONTROL, DISSIPATION IS A FUNCTION OF TEMPERATURE
  - CIRCUIT ACTIVATED ONLY IN STBY POWER MODE AT 0 F.
- CENTRAL ELECTRONICS IS CONTROLLED BY CENTRAL STATION ENVIRONMENT
- THUMPER HAS NO HEATER

7759-5657

ASE OPERATIONAL POWER PROFILE



7759-5658

ASE SAFETY FEATURES

THUMPER
- ROTARY ARMING SWITCH, SPRING LOADED TO SAFE POSITION, ACTUATED ≈4 SEC TO CHARGE CONDENSER (THEN PUSH TO FIRE)
- ASI SELECTOR SWITCH HAS 22 POSITIONS (INC OFF) AND SHORTS ALL ASI'S EXCEPT THE SELECTED ONE

CENTRAL ELECTRONICS
- CENTRAL STATION ASTRONAUT SWITCH (TWO-POSITION) OPENS AND CLOSES +29 V OPER POWER LINE BETWEEN PDU & ASE
- IN SERIES WITH CMD-ACTIVATED RELAY OF PDU
- IN OPEN POSITION, PRECLUDES ACCIDENTAL APPLICATION OF OPER POWER TO ASE

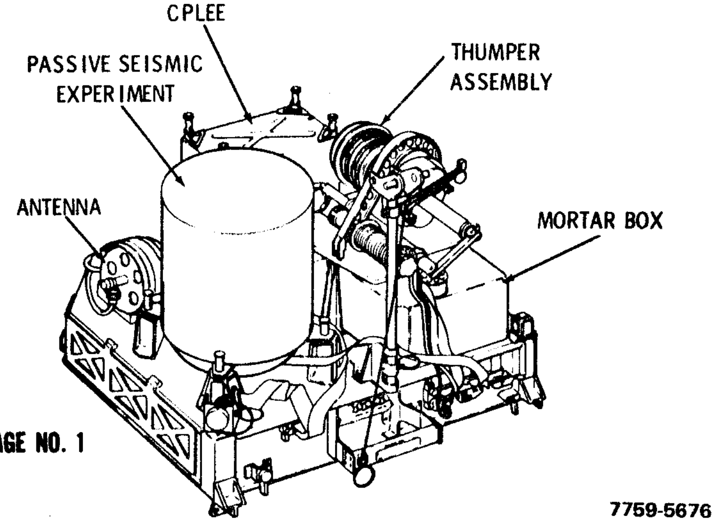
7759-5659A

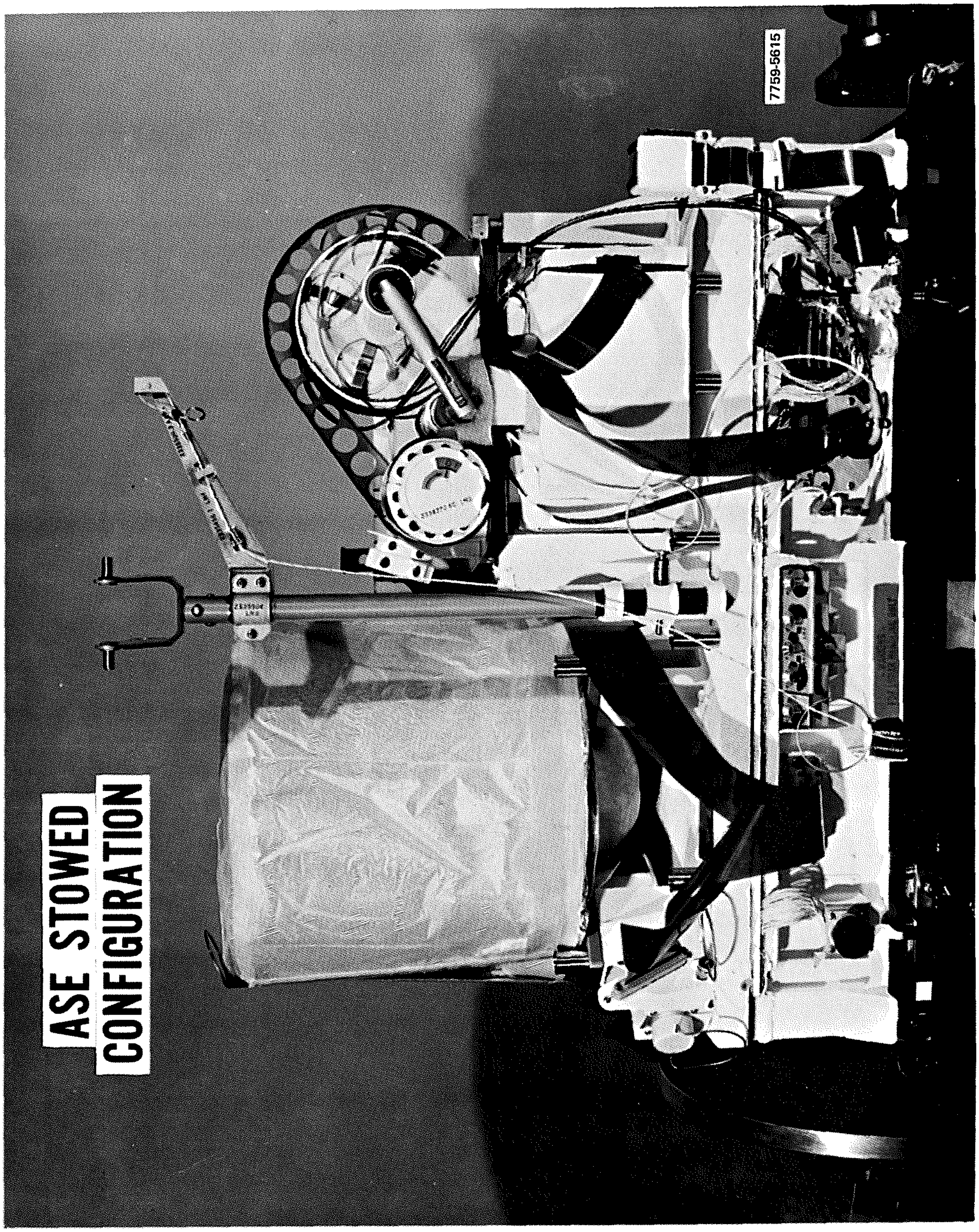
ASE SAFETY FEATURES (CONT')

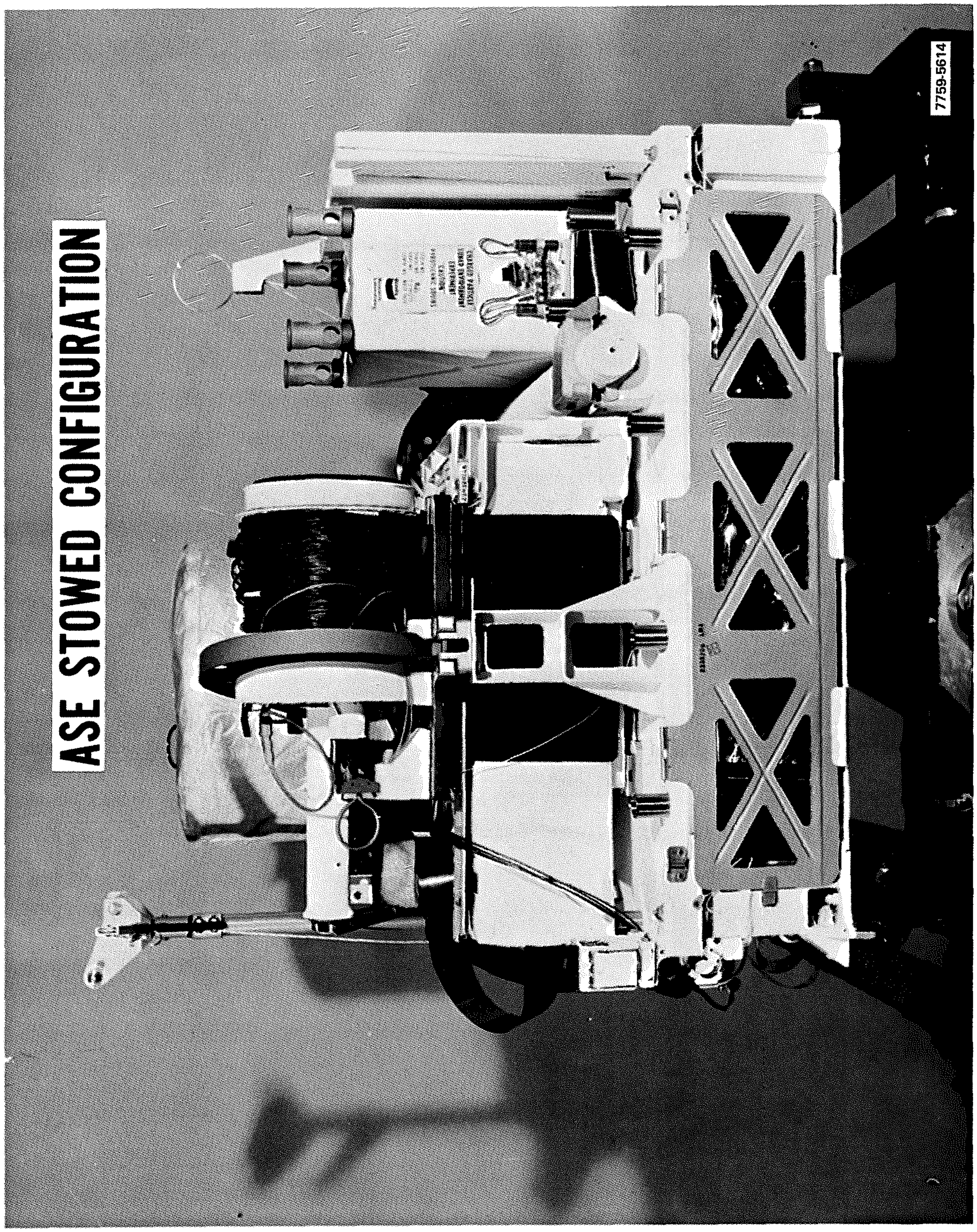
GRENADES
- SUPPORTED WITHIN LAUNCH TUBES, LOCKED IN PLACE BY SAFETY ROD ASSY FOR FLIGHT & DEPLOYMENT (REMOVED BY ASTRONAUT)
- ARMING & FIRING CIRCUITS OF ALL 4 ROCKET MOTORS SHORTED BY 2 SAFETY SWITCHES ON MORTAR BOX (ACTIVATED BY ASTRONAUT)
- SAFE SLIDE BETWEEN DETONATING CARTRIDGE & HIGH EXPLOSIVE IN EACH GRENADE, SPRING-EJECTED AT LAUNCH
- THERMAL BATTERY INACTIVE (& SHORTED) UNTIL PLATE EJECTION TRIPS A MICROSWITCH
- THERMAL BATTERY MATCH IS ACTIVATED BY A CONDENSER WHICH IS CHARGED VIA GRENADE ARM CMD
- THERMAL BATTERY SUPPLIES POWER TO GRENADE DETONATOR THROUGH A 8-10 SEC. TIME DELAY AND AN IMPACT SWITCH. IF IMPACT COMES BEFORE 10 SEC. OR AFTER ≈ 10 MIN., THERE IS NO BATTERY POWER FOR DETONATOR.

7759-5659B

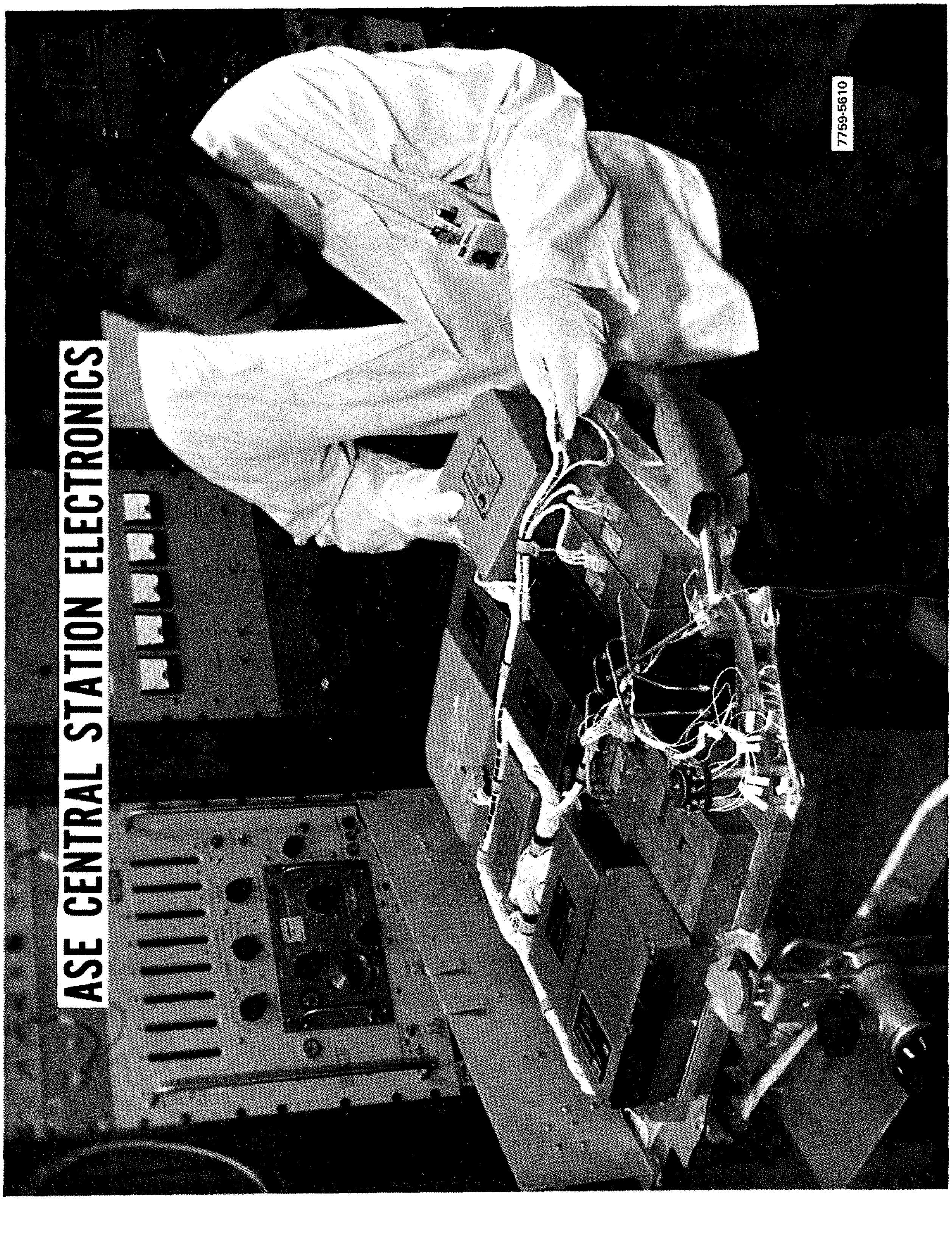
ACTIVE SEISMIC EXPERIMENT REMOVAL




ASE STOWED
CONFIGURATION
7759-5615


ASE STOWED CONFIGURATION
7759-5614


ASE THUMPER/
GEOPHONE STOWED
7759-5613

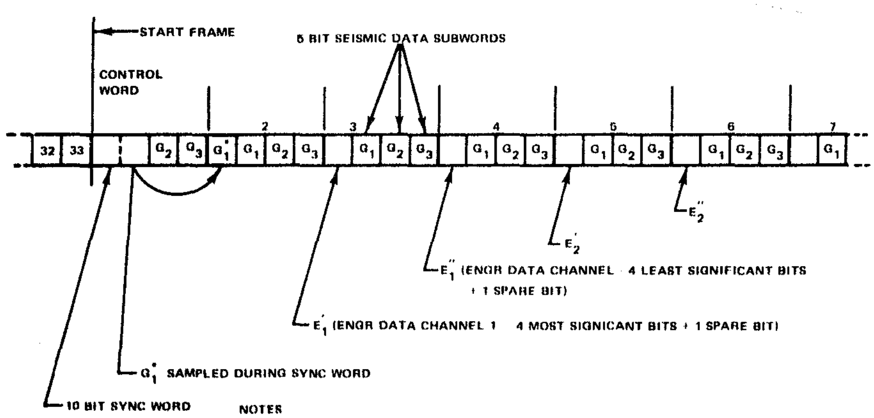

ASE CENTRAL STATION ELECTRONICS
7759-5610

ASE DATA FORMAT

- CONSISTS OF 32 – 20-BIT WORDS AT 10.6 KB RATE
- UNIFORM TIME SAMPLING OF GEOPHONES PROVIDED BY DIVINDING EACH WORD INTO 4 SUBWORDS OF 5 BITS EACH
- 1ST SUBWORD USED FOR HOUSEKEEPING OR ENGINEERING TYPE DATA
- 2ND, 3RD AND 4TH SUBWORDS ARE GEOPHONE NO. 1, GEOPHONE NO. 2 AND GEOPHONE NO. 3 DATA READOUTS
- 10-BIT FRAME SYNCRONIZATION PROVIDED IN FIRST WORD BY STORING GEOPHONE NO. 1 READOUT DURING SYNCHRONIZATION TRANSMISSION AND READING OUT IN 1ST SUBWORD OF 2ND WORD

7759-5679

ASE FRAME DESCRIPTION (PART I)



NOTES
1) G_1, G_2, G_3 GEOPHONE SEISMIC DATA FROM 3 GEOPHONES
2) EACH ENGINEERING DATA READOUT TO 8 BITS ACCURACY USING THE 1ST SUBWORD OF 2 WORDS IN SEQUENCE $E_n' + E_n'' = E_n$ for n = 1 TO 13

7759-5680

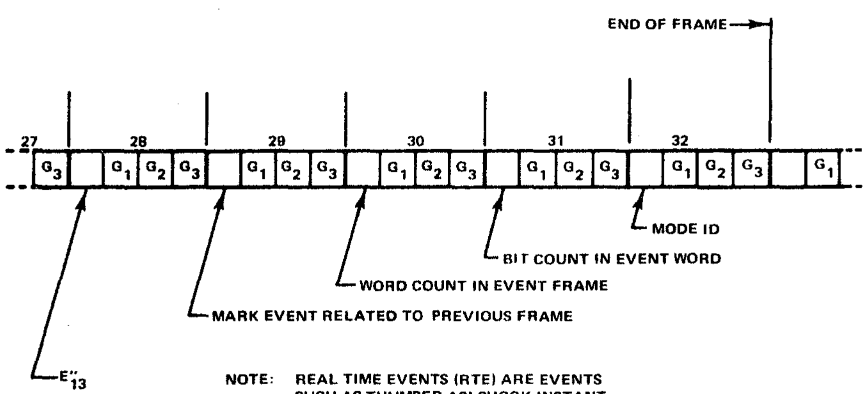
4-15

ENGINEERING WORDS

FORMAT REF	WORD NO'S	ALSEP SYMBOL	DESCRIPTION
E_1	3, 4	AR-4	RTG COLD FRAME TEMP NO. 1
E_2	5, 6	DS-7	PITCH ANGLE
E_3	7, 8	DS-5	MORTAR BOX GRD MONITOR
E_4	9, 10	DS-6	ROLL ANGLE
E_5	11, 12	–	SPARE
E_6	13, 14	AS-3	GLA TEMP
E_7	15, 16	DS-8	GEOPHONE CALIBRATION PULSE
E_8	17, 18	DS-11	A/D CALIBRATION 3.75 V (NOM)
E_9	19, 20	DS-10	A/D CALIBRATION 1.25 V (NOM)
E_{10}	21, 22	AS-1	CENTRAL ELECTRONICS TEMP
E_{11}	23, 24	AE-3	RTG OUTPUT VOLTAGE
E_{12}	25, 26	AE-4	RTG OUTPUT CURRENT
E_{13}	27, 28	AR-1	RTG HOT FRAME TEMP NO. 1

7759-5681

ASE FRAME DESCRIPTION (PART II)

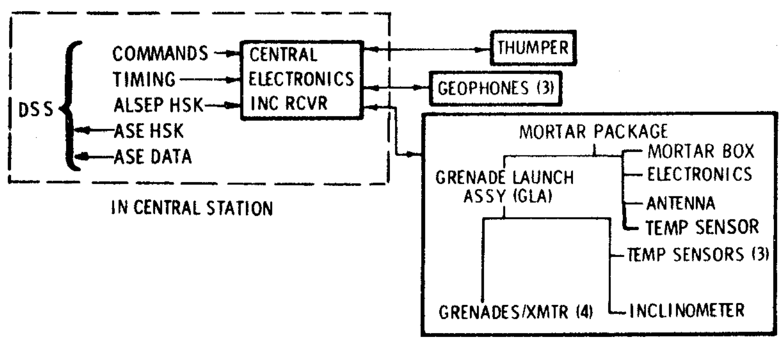


NOTE: REAL TIME EVENTS (RTE) ARE EVENTS SUCH AS THUMPER ASI SHOCK INSTANT OR GRENADE IMPACT & EXPLOSION INSTANT

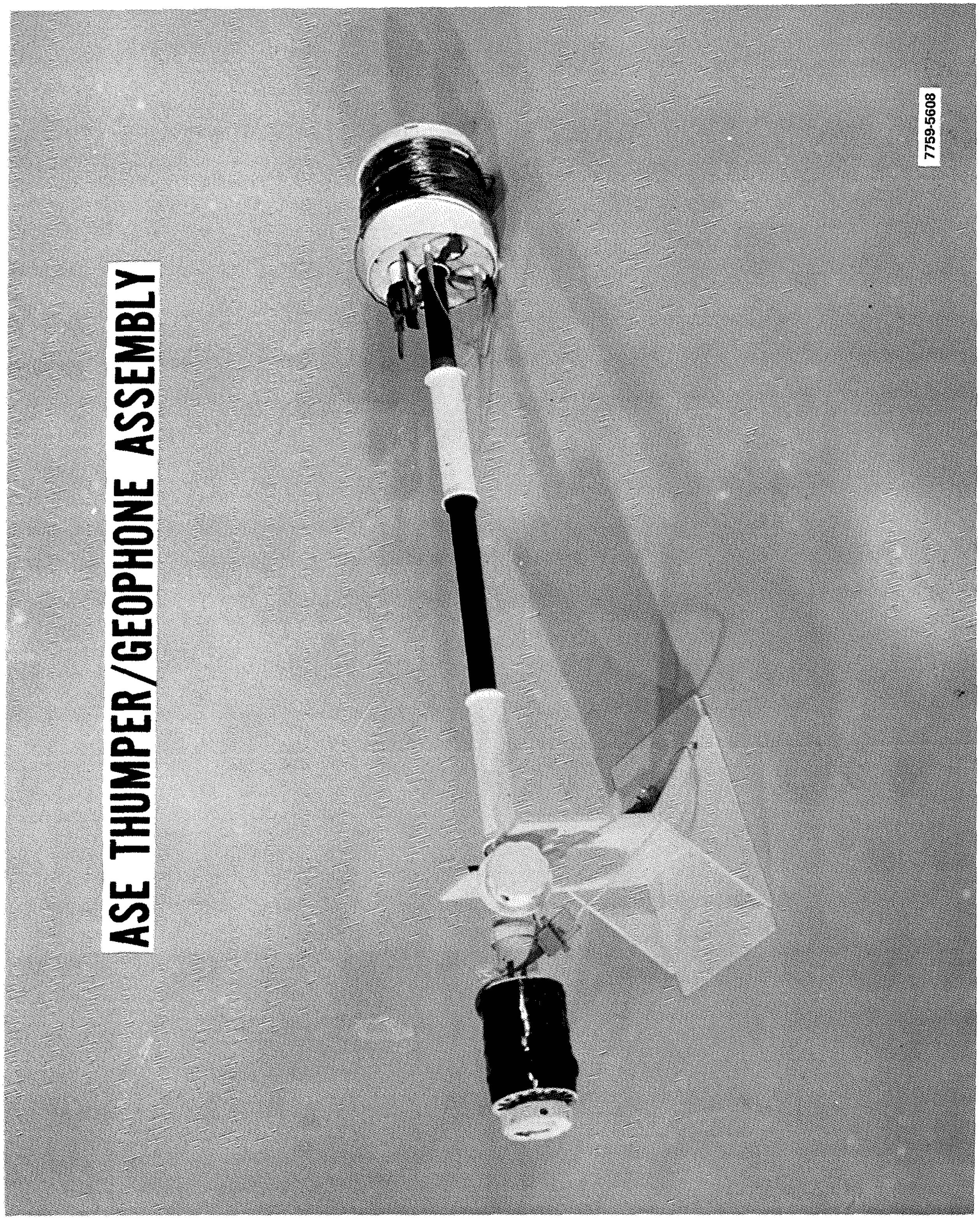
7759-5682

ACTIVE SEISMIC CHARACTERISTICS

COMPONENTS



7759-5631


ASE THUMPER/GEOPHONE ASSEMBLY
7759-5608

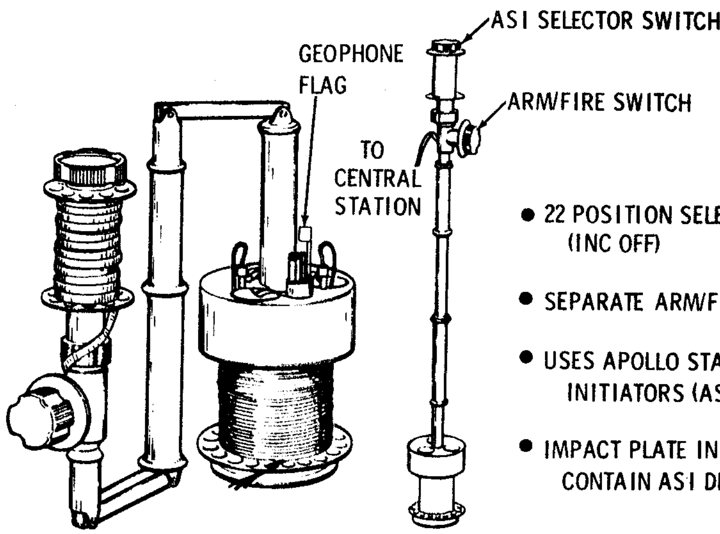
ASE THUMPER FEATURES

• INITIATOR (ASI) MOUNTING PLATE & BASE PLATE	INSIDE LOWER END	
• ARM/FIRE & ASI SELECTOR SWITCHES	ON UPPER END	
• FLAT, 4-CONDUCTOR CABLE TO CENTRAL ELECTRONICS	ON UPPER SPLIT REEL	UNWOUND DURING DEPLOYMENT
• 3 GEOPHONES WITH CABLES	ON LOWER INTEGRAL REEL	UNWOUND DURING DEPLOYMENT

- **GEOPHONE FLAG STOWED ON THUMPER**
- PRESSURE SWITCH ON ASI MOUNTING PLATE DETECTS TIME OF SEISMIC EXPLOSION
- GEOPHONE FLAG DEPLOYED ON LUNAR SURFACE AT 150 FT TO AID IN GEOPHONE CABLE ALIGNMENT
- GEOPHONES AND CABLES STOWED ON THUMPER UNTIL DEPLOYED

7759-5641

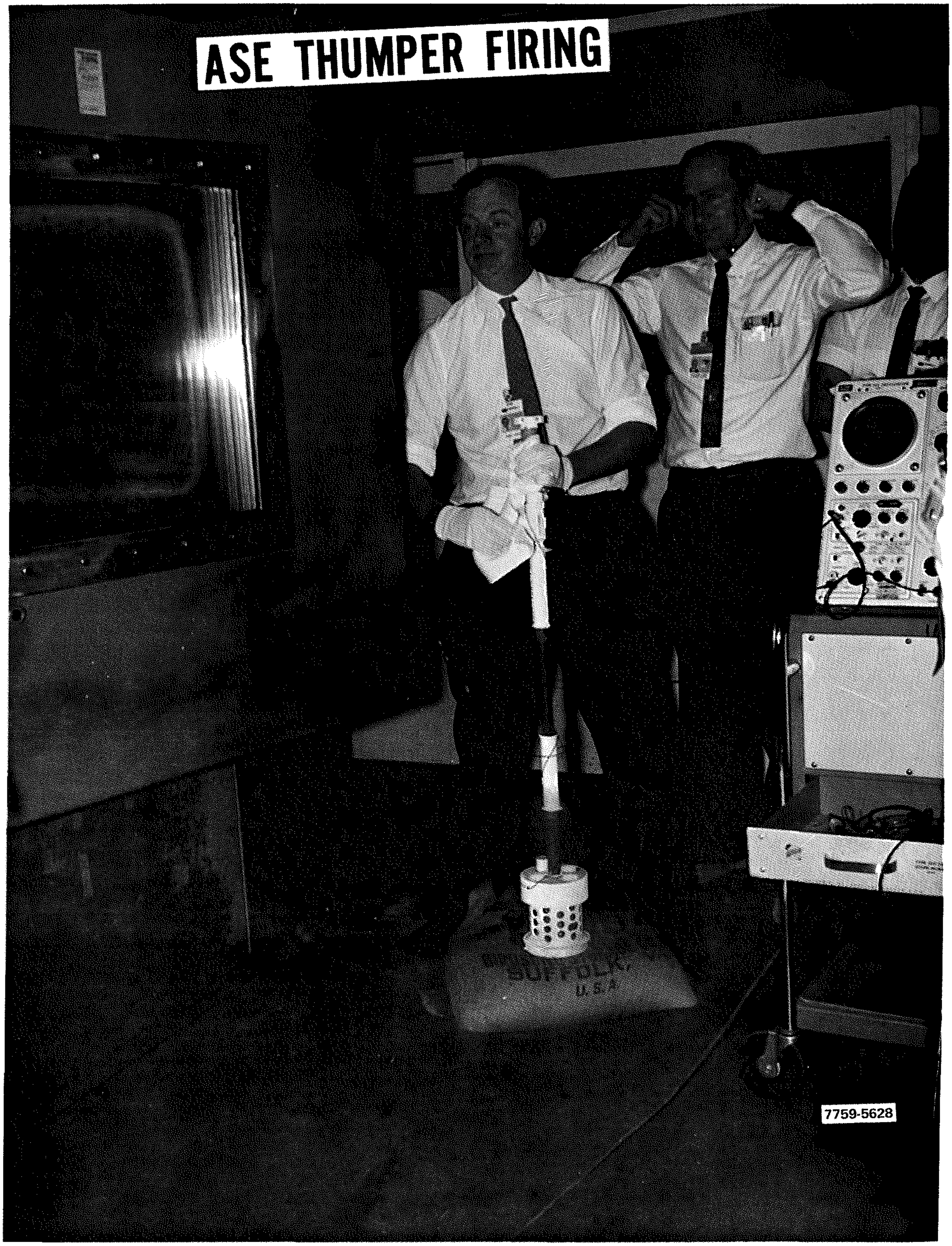
THUMPER CHARACTERISTICS



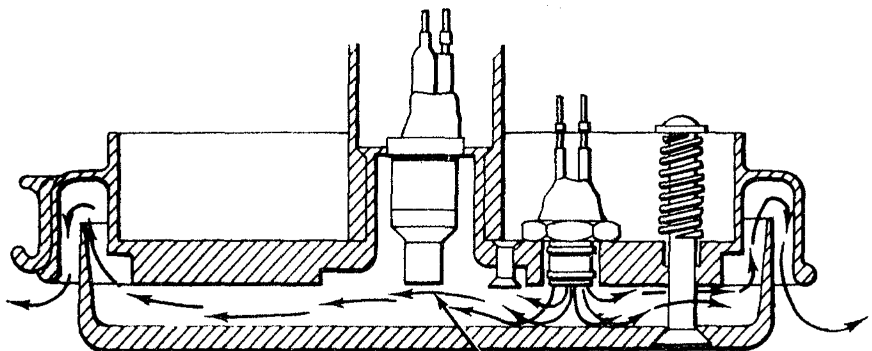
FOLDED EXTENDED

- 22 POSITION SELECTOR SWITCH (INC OFF)
- SEPARATE ARM/FIRE SWITCH
- USES APOLLO STANDARD INITIATORS (ASIs)
- IMPACT PLATE IN LOWER END TO CONTAIN ASI DEBRIS

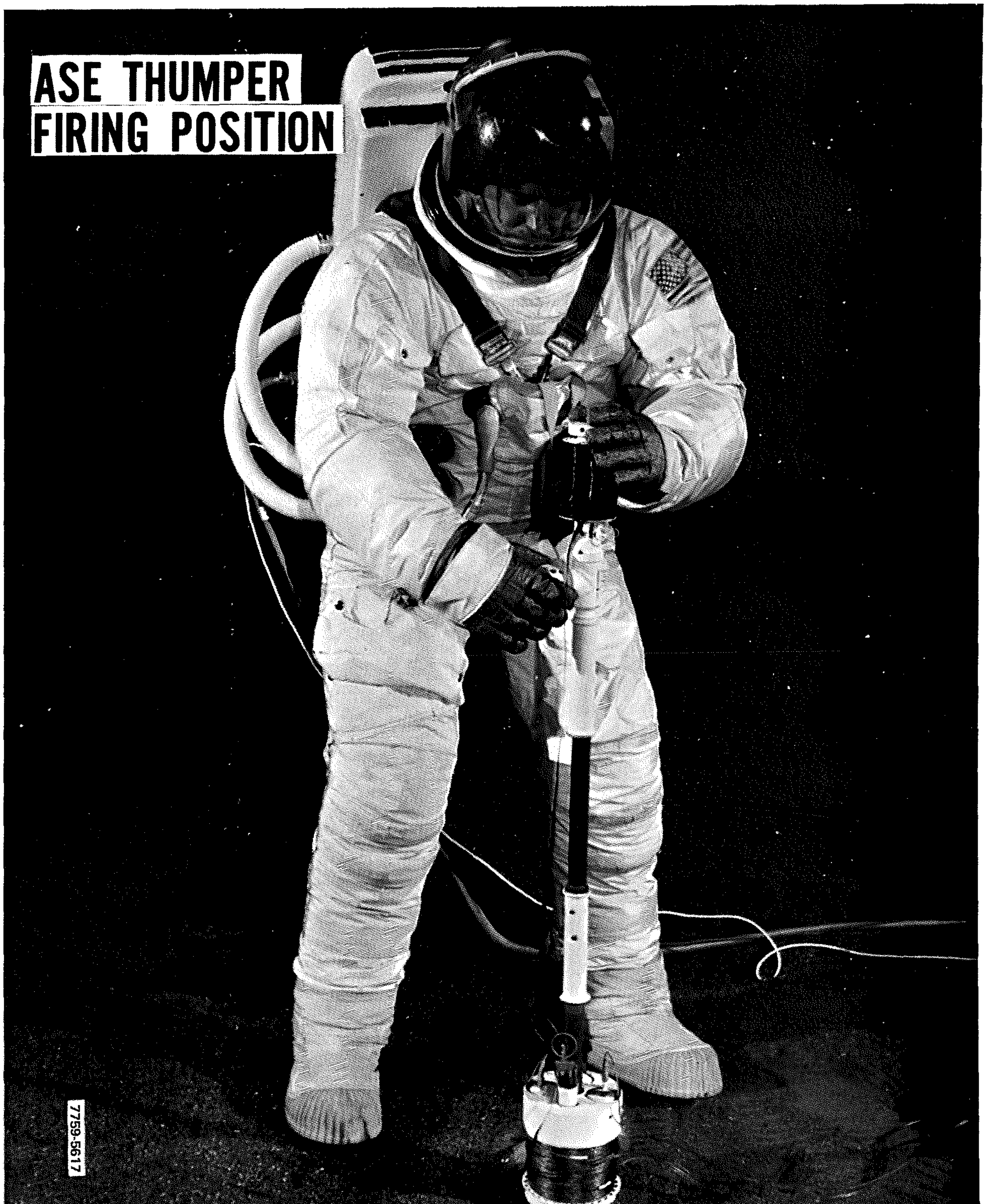
7759-5638


ASE THUMPER FIRING
SUFFOLK
U.S.A.
7759-5628

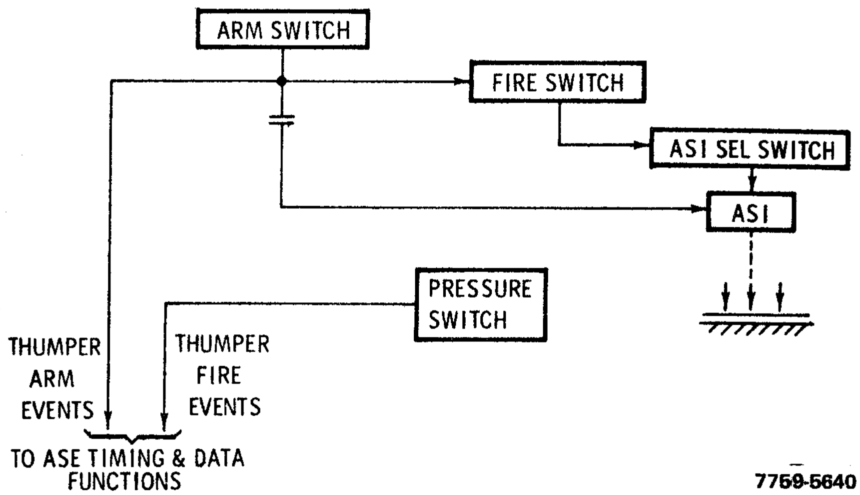
THUMPER BASE SECTION OPERATING



7759-5683


ASE THUMPER
FIRING POSITION
7759-5617

ASE THUMPER FUNCTION



7759-5640

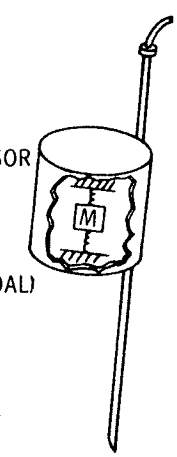
ASE DETECTION SYSTEM

GEOPHONE (SENSORS)
- TYPE: ELECTROMAGNETIC
- NATURAL FREQUENCY: 7.5 CPS
- SENSITIVITY: 250 VOLT/METER/SEC
- WEIGHT: 6 OZ EACH SENSOR

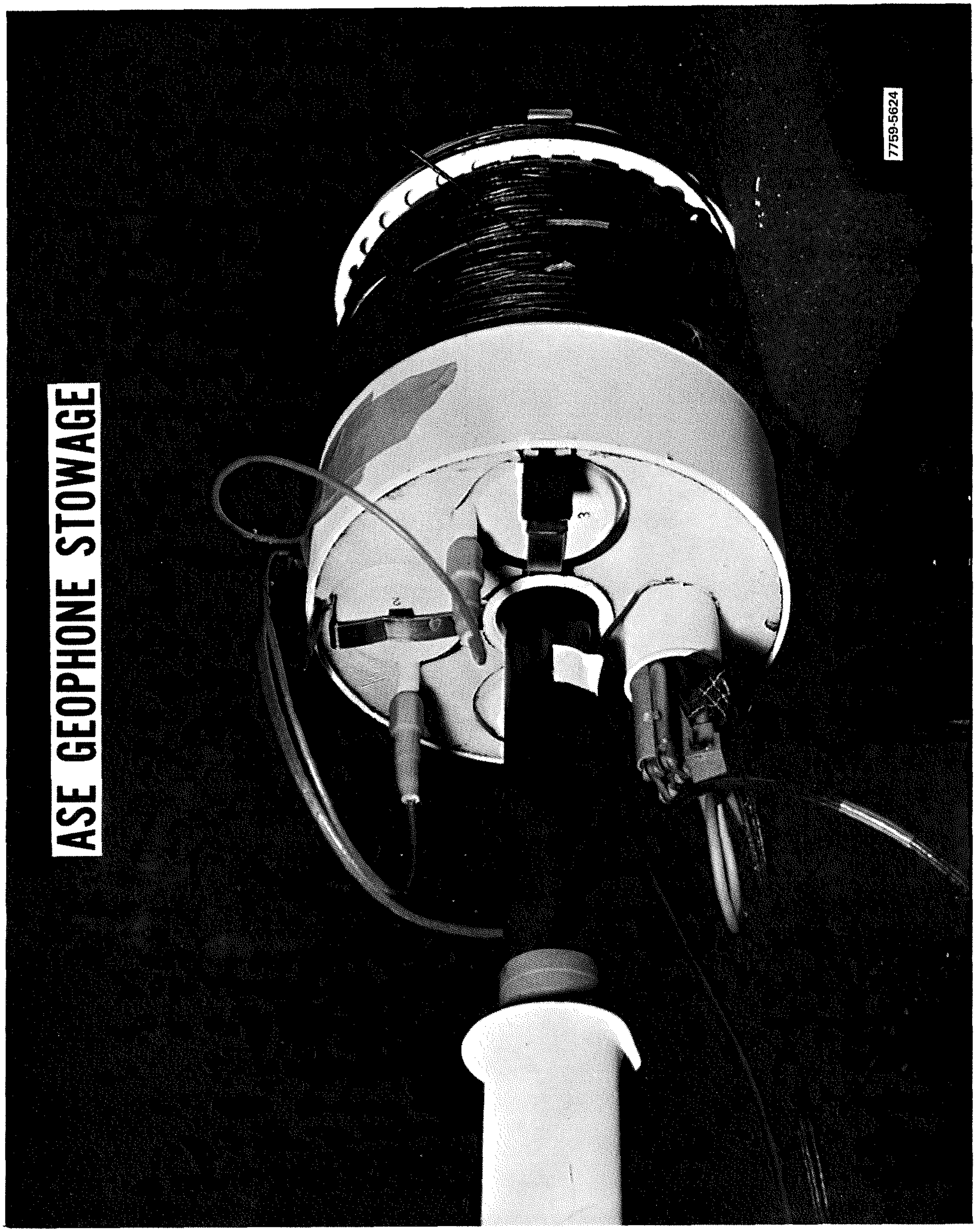
AMPLIFIER
- 3 CHANNELS EACH WITH PREAMP, FILTER AND LOG COMPRESSOR
- 80 DB DYNAMIC RANGE LOG COMPRESSED TO 40 DB
- LOG COMPRESSOR TEMPERATURE CONTROLLED

GEOPHONE & AMPLIFIER
- SENSITIVITY: 5 mμ PEAK DISPLACEMENT AT 10 Hz (1 mμ GOAL) AT A SIGNAL TO NOISE RATIO OF 18 db
- BANDWIDTH: 3 TO 250 Hz WITH RESPECT TO VELOCITY

BASIC DATA WORD
- 5-BIT WORD FOR EACH SENSOR READING AT 500 SAMPLES/SEC (EACH CHANNEL)

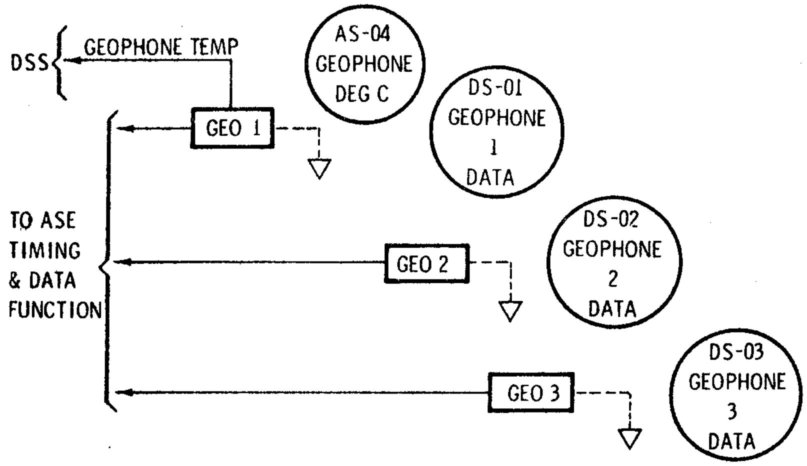


7759-5635



ASE GEOPHONE STOWAGE

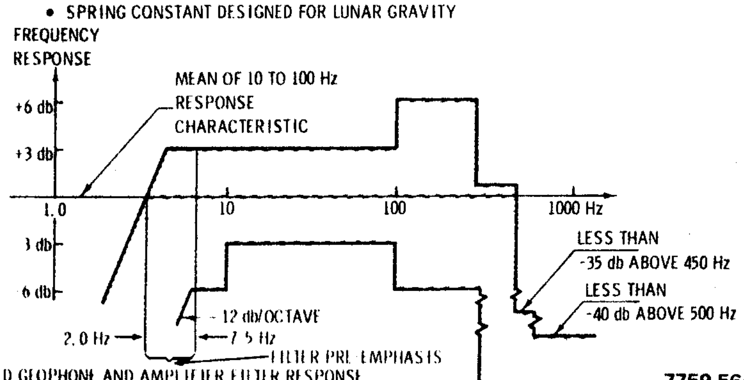
ASE GEOPHONE FUNCTION



7759-5642

ASE GEOPHONE FEATURES

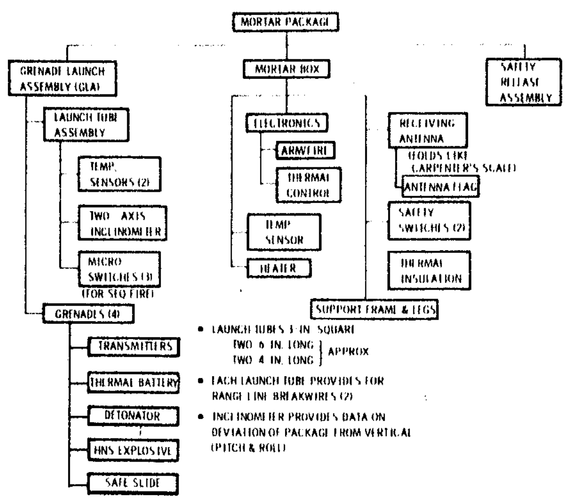
- ELECTROMAGNETIC TRANSDUCERS (VELOCITY SENSOR) (OUTPUT TO SEPARATE LOG COMPRESSION AMPLIFIERS)
- IMPLANTED IN SURFACE BY SPIKE
- TEMPERATURE SENSOR IN ONE GEOPHONE
- 7.5 CPS NATURAL FREQUENCY
- SPRING CONSTANT DESIGNED FOR LUNAR GRAVITY



COMBINED GEOPHONE AND AMPLIFIER FILTER RESPONSE
(BEFORE LOG COMPRESSION)

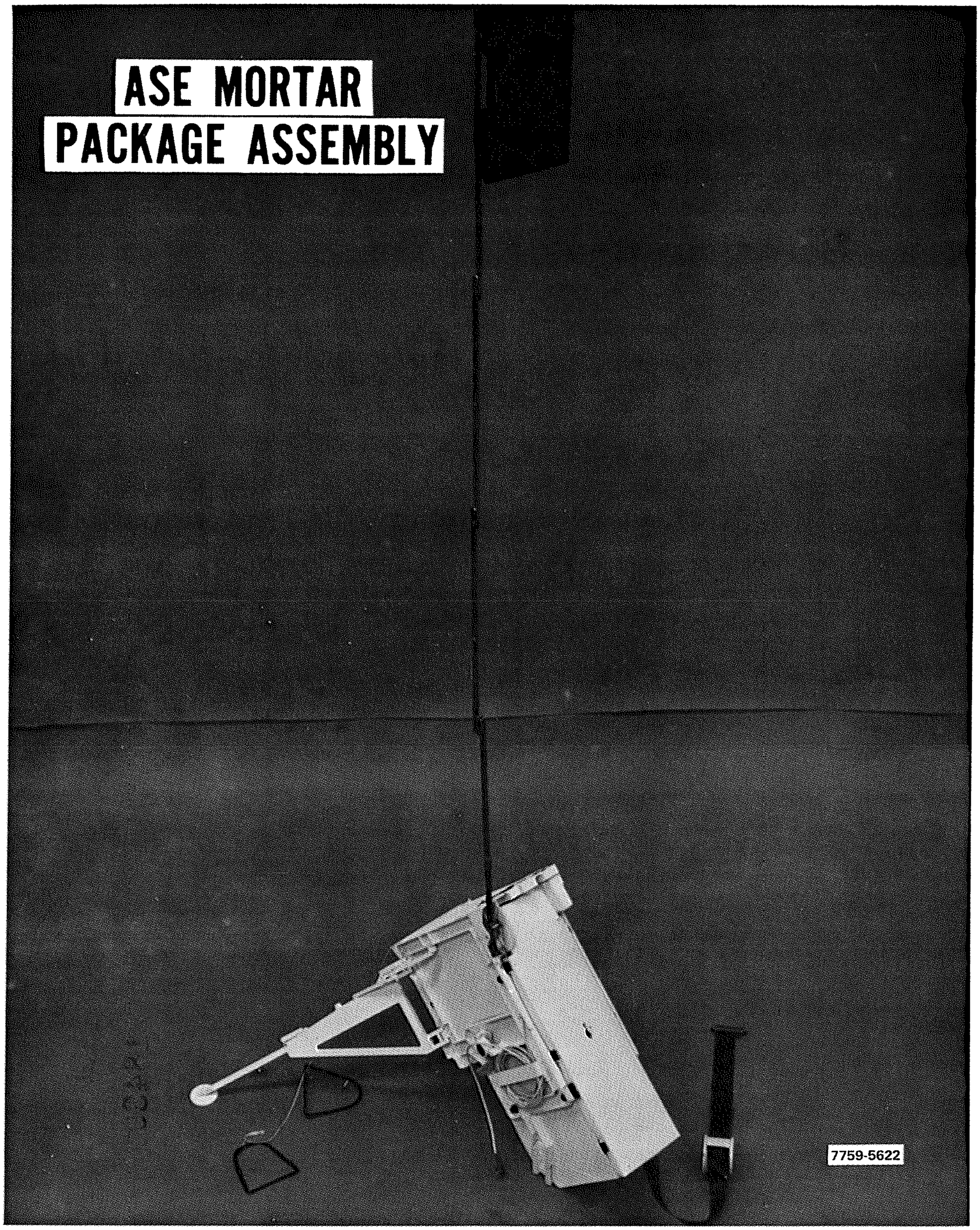
7759-5643

ASE MORTAR PACKAGE COMPONENTS

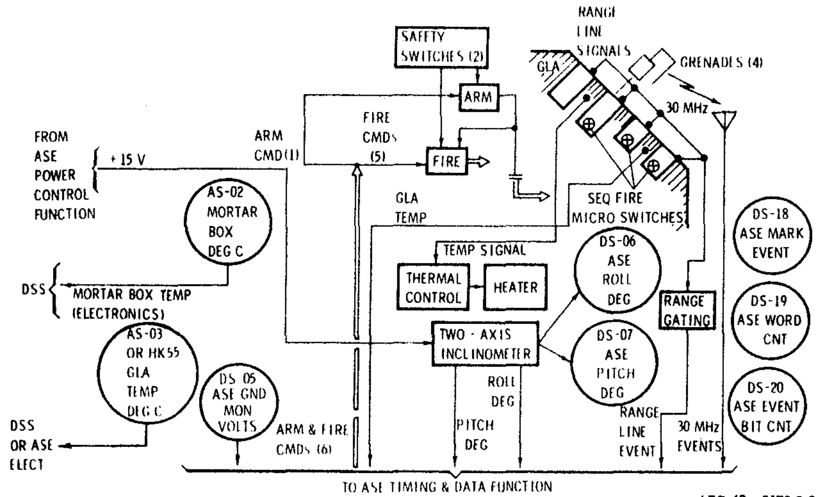


- LAUNCH TUBES 3 IN. SQUARE
  TWO 6 IN. LONG } APPROX
  TWO 4 IN. LONG }
- EACH LAUNCH TUBE PROVIDES FOR RANGE LINE BREAKWIRES (2)
- INCLINOMETER PROVIDES DATA ON DEVIATION OF PACKAGE FROM VERTICAL (PITCH & ROLL)

7759-5645


ASE MORTAR
PACKAGE ASSEMBLY
7759-5622

ASE MORTAR PACKAGE FUNCTION



APR 69 5178.9.8

7759-5644

ASE GRENADE RANGING CONCEPT

CONCEPT

- BALLISTIC TRAJECTORY OF GRENADE IS CALCULATED FROM ITS INITIAL DIRECTION & TIME OF FLIGHT:
  - DIRECTION (45° ANGLE OF MORTAR CORRECTED BY INCLINOMETER ROLL & PITCH)
  - TIME-OF-FLIGHT FROM LAUNCH (FIRST RANGE LINE SIGNAL) TO IMPACT (XMTR OFF)
- CONFIDENCE IS ENHANCED BY KNOWING INITIAL LAUNCH VELOCITY (BASED ON TIME BETWEEN RANGE LINE EVENTS FOR 10-IN. & 25-FT + 10-IN. TRAVEL)

7759-5649

ASE GRENADE RANGING

MECHANIZATION

- RANGE LINE: A THIN STRANDED CABLE WOUND AROUND THE OUTSIDE OF LAUNCH TUBE & CONNECTED AT ONE END TO GRENADE (30 MHz TRANSMITTING ANTENNA)
- BREAKWIRES (2): EACH A SINGLE LOOP OF FINE COPPER WIRE ARRANGED TO BE SEVERED WHEN RANGE LINE REACHES 10-IN. & 25-FT + 10-IN. POINTS
- INCLINOMETER: MEASURES DEVIATIONS AROUND TWO AXES
  - PITCH: INCREASE OR DECREASE IN THE 45° LAUNCH ANGLE
  - ROLL: ROTATION AROUND A HORIZONTAL AXIS PERPENDICULAR TO THE PITCH AXIS

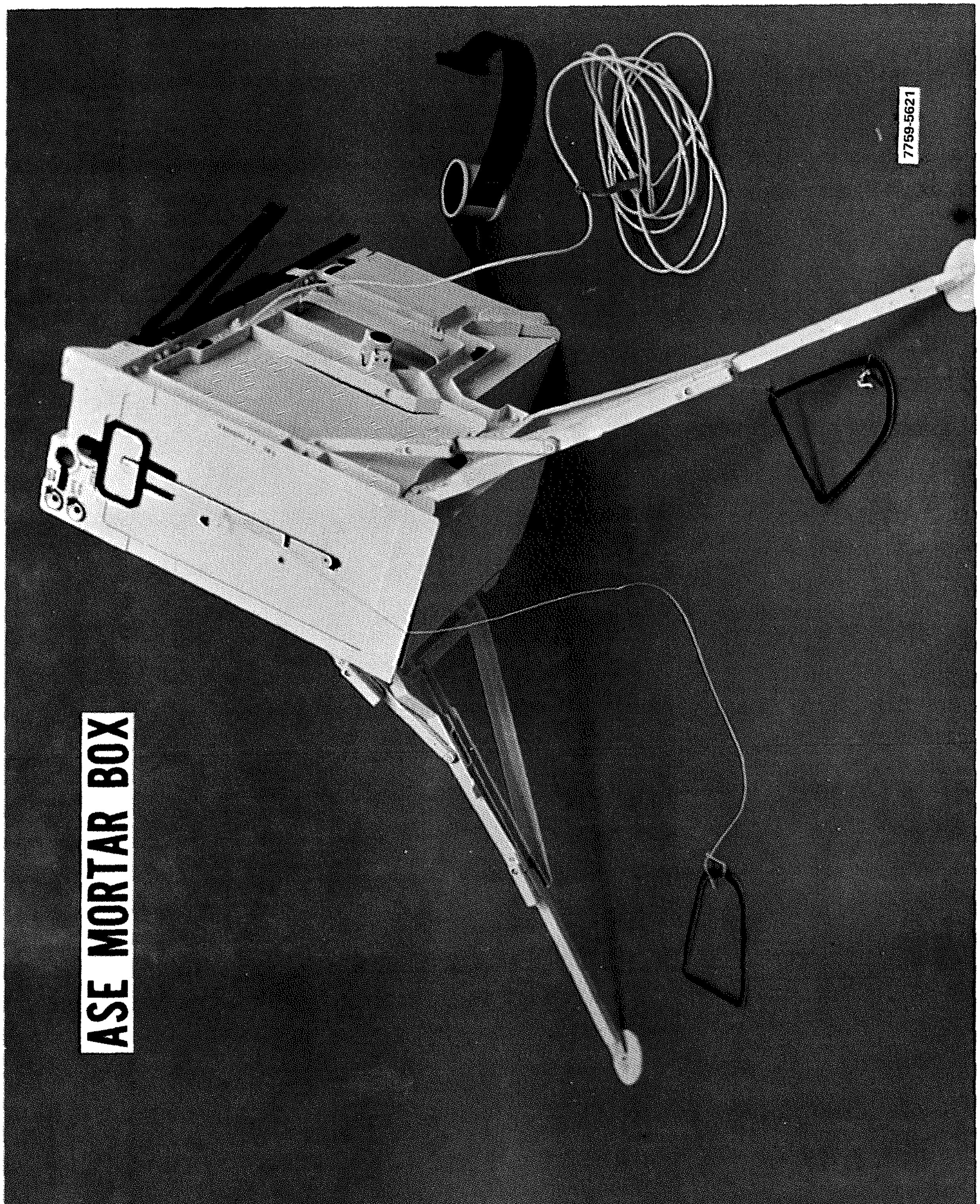
7759-5650

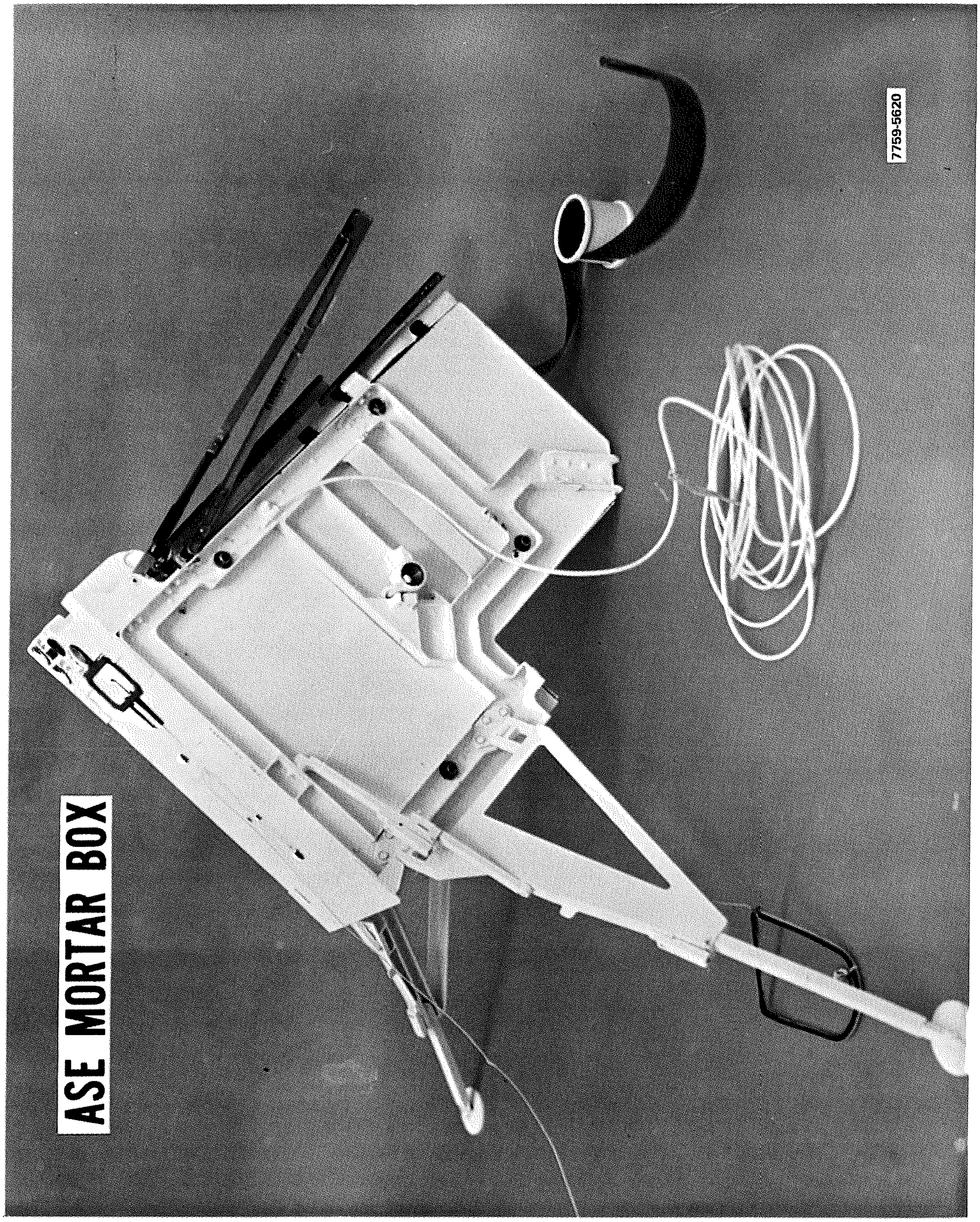
ASE GRENADE RANGING

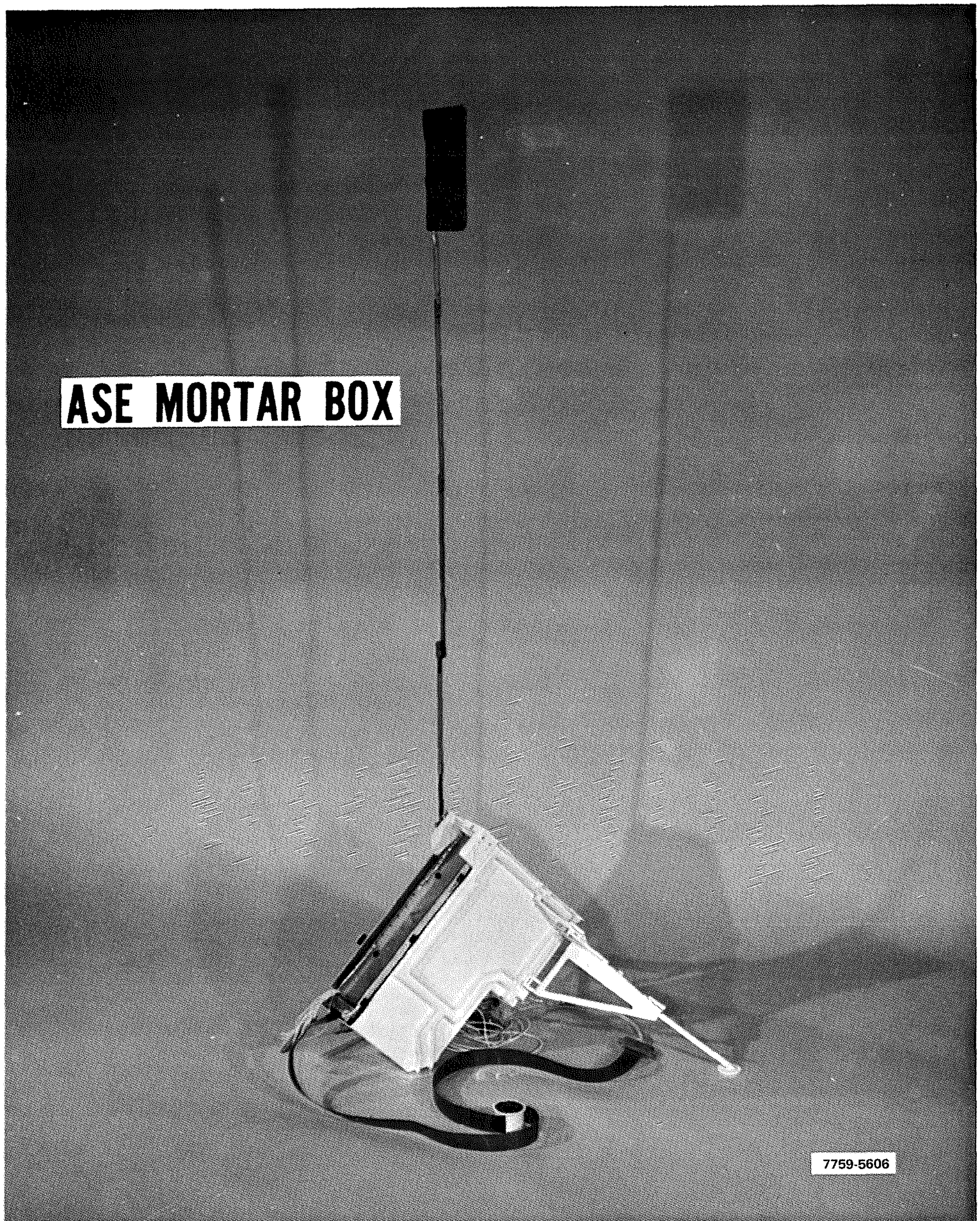
IMPLICATIONS

- INCLINOMETER DATA IS AVAILABLE IN CASE MORTAR PACKAGE SHIFTS DURING EACH FIRING
- PACKAGE STABILITY ENHANCED BY "BLOWOUT" REAR CLOSURE & THRUST TERMINATION BEFORE GRENADE LEAVES TUBE
- SEQUENTIAL FIRING ORDER (2,4,3,1), ALSO USED FOR STANDARD FIRING, OPTIMIZES PACKAGE STABILITY
- NOTE THAT ARM CMD MUST BE SENT 4 TIMES (SEQUENTIAL & STANDARD CONDENSERS ARE CHARGED & DISCHARGED SIMULTANEOUSLY); ALSO, SEQUENTIAL FIRE ACTUATES ONE GRENADE EACH TIME SENT

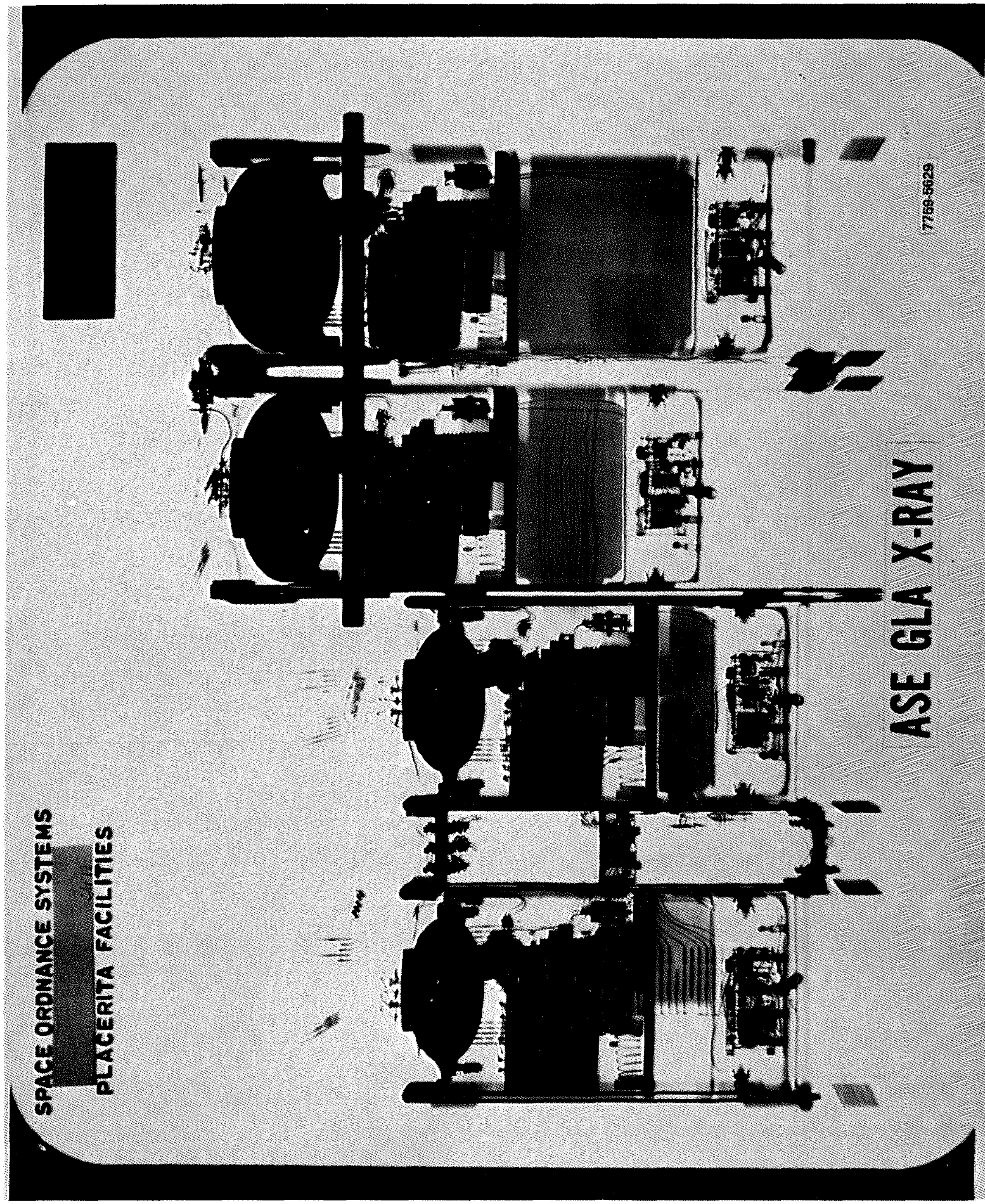
7759-5651


ASE MORTAR BOX
7759-5621


ASE MORTAR BOX
7759-5620


ASE MORTAR BOX
7759-5606

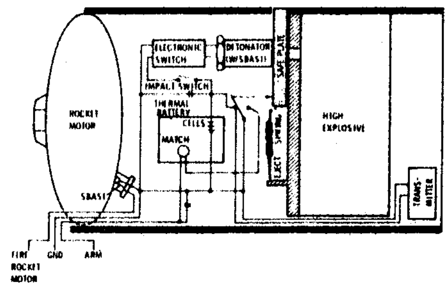
ASE GRENADE LAUNCH ASSEMBLY (GLA)


SPACE ORDNANCE SYSTEMS
PLACERITA FACILITIES
ASE GLA X-RAY
7759-5629

ASE GRENADE CHARACTERISTICS

DESCRIPTION

- CASING SIZE:
  - 2.7 IN. SQUARE } APPROX
  - 4 TO 6 IN. LONG }
- CASING CONTAINS:
  - SOLID FUEL ROCKET MOTOR
  - SAFE SLIDE
  - HIGH EXPLOSIVE CHARGE
  - IGNITION & DETONATION DEVICES
  - THERMAL BATTERY
  - 30 MHz XMTR CONNECTED TO TRAILING WIRE ANTENNA (FUNCTIONS AS RANGE LINE)
- GRENADES DIFFER ONLY IN AMOUNT OF PROPELLANT & HIGH EXPLOSIVE



7759-5646

ASE GRENADE CHARACTERISTICS

OPERATION

- GRENADE ARM CMD APPLIES PULSE TO ROCKET MOTOR ARMING CIRCUIT CHARGING CONDENSER IN MORTAR BOX AND CHARGES MATCH CONDENSER IN GRENADE)
- GRENADE FIRE CMD DISCHARGES CONDENSER THROUGH ASI IGNITING ROCKET MOTOR
- WHEN GRENADE LEAVES TUBE:
  - SPRING EJECTED SAFE SLIDE ENABLES DETONATOR
  - SLIDE EJECTION ACTIVATES MICROSWITCH IN GRENADE
  - MICROSWITCH DISCHARGES CONDENSER ACROSS MATCH ACTIVATING THERMAL BATTERY

7759-5647

ASE GRENADE CHARACTERISTICS

OPERATION (CONT)

- BATTERY PROVIDES INTERNAL POWER FOR:
  - 30 MHz XMTR
  - CHARGING DETONATOR CONDENSER
- EVENT MARK FOR:
  - BREAKWIRE (10-IN. & 25-FT + 10-IN. TRAVEL)
- AT IMPACT, AN OMNIDIRECTIONAL IMPACT SWITCH DISCHARGES CONDENSER THROUGH DETONATOR SETTING OFF HIGH EXPLOSIVE
- EXPLOSION DESTROYS BATTERY AND TRANSMITTER TERMINATING RF TRANSMISSION
- EVENT MARK FOR XMTR OFF

7759-5648


GRENADE COMPONENTS
7759-5600


GRENADE COMPONENTS
7759-5601

ASE CENTRAL ELECTRONICS FEATURES

TIMING AND DATA

- TEMP SENSING

  INTERNAL TEMPERATURE MONITORED IN BASIC ALSEP DATA AS WELL AS ASE DATA STREAM

- LOG COMPRESSION AMPLIFIERS

  LOW-NOISE, PROVIDE WIDE DYNAMIC RANGE
  PRE-EMPHASIS TO INCREASE LOW FREQ GEOPHONE RESPONSE

- GEOPHONE CALIBRATION
  - DRIVER (PULSE STRETCHER) CONVERTS COMMAND INTO 1-SEC EXCITATION PULSE APPLIED VIA AMPLIFIERS
  - ELECTRICALLY DRIVES GEOPHONES FOR MEASUREMENT OF RESONANT FREQUENCY, GENERATOR CONSTANT, & DAMPING COEFFICIENT
  - COMPARE TO PREFLIGHT DATA (RELATIVE CALIBRATION)
  - PULSE VOLTAGE SAMPLED IN ASE DATA

7759-5652

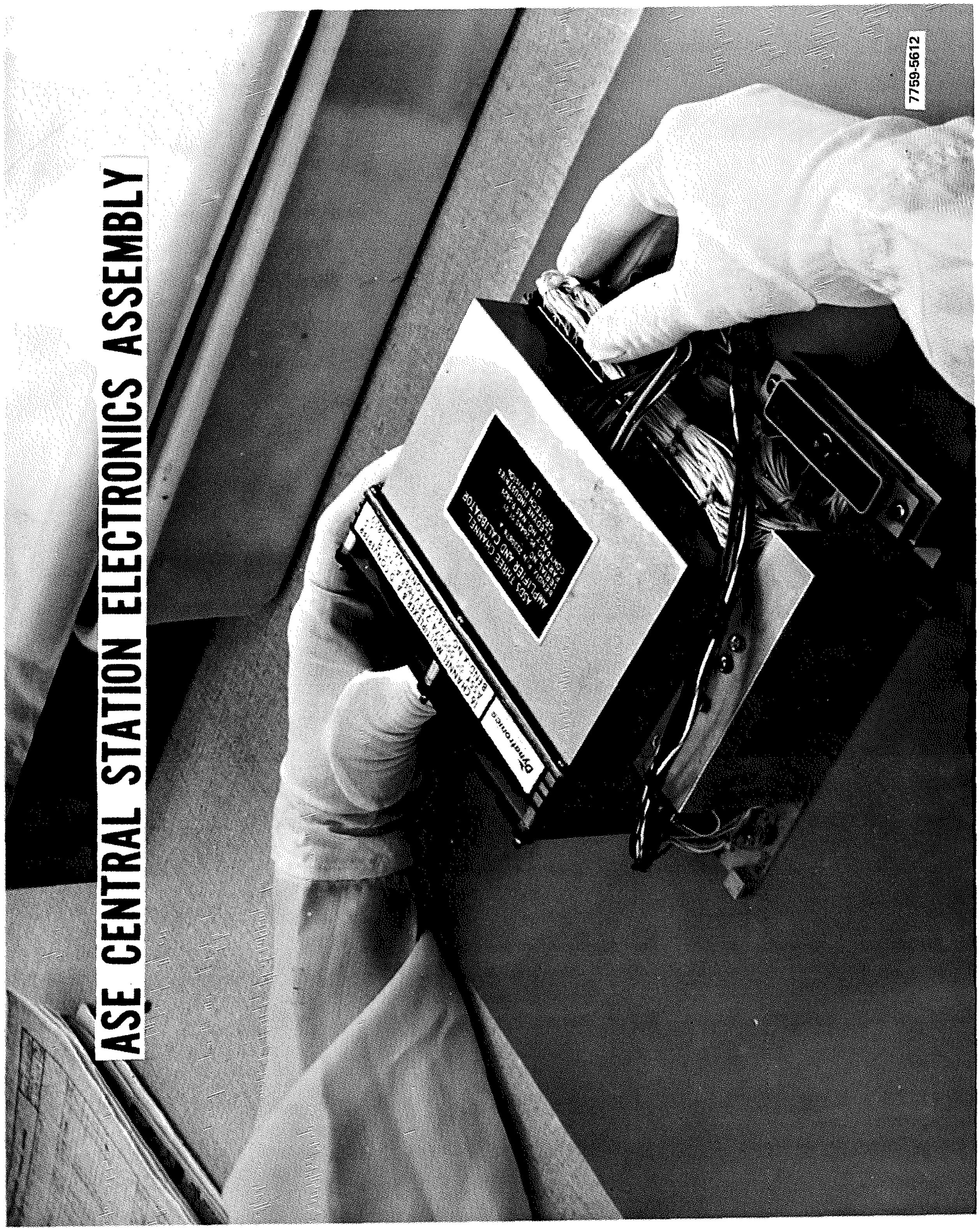
ASE CENTRAL ELECTRONICS FEATURES

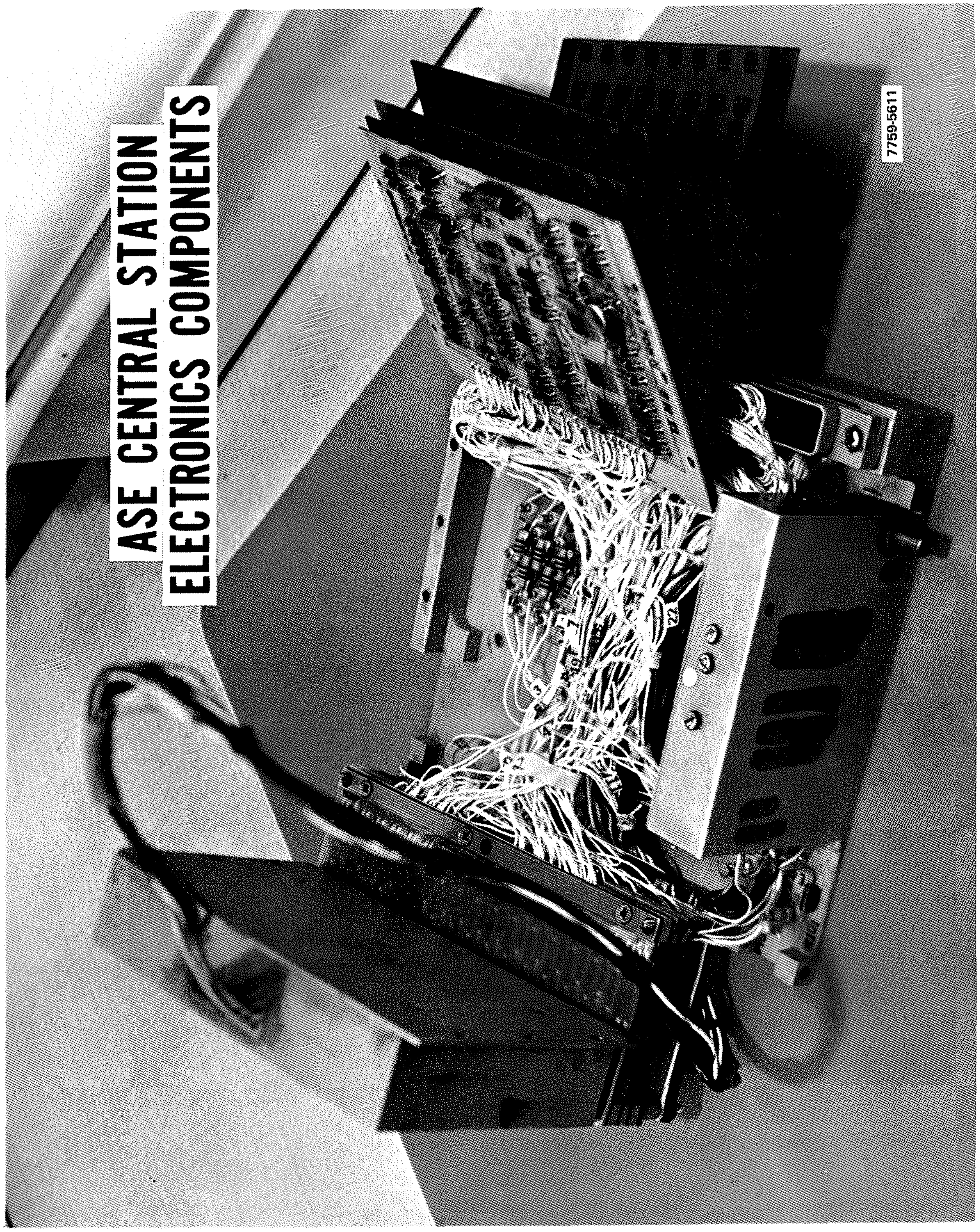
TIMING AND DATA (CONT)

- ANALOG MULTIPLEXER & ADC
  - ASE COMPRESSED SEISMIC DATA CONVERTED TO 5-BIT DIGITAL
  - ASE ENG & ALSEP HK (5 KEY PARAMETERS) CONVERTED TO 8-BIT DIGITAL, & BOTH READ OUT AS 4 BITS IN EACH OF TWO ASE WORDS
  - ADC CAL CIRCUIT GIVES 2-POINT CHECK

- TIMING & CONTROL
  - 4, 5, & 32 SEQUENCE COUNTER OPERATES ON 10.6 KHz SQUARE WAVE FROM DSS
  - PROVIDES FOR 5-BIT SUBWORDS, 4 PER ASE WORD (20 BITS) & 32 WORDS PER FRAME (640 BITS)
- DATA RATE, 10.6 KBPS (ALMOST ENTIRELY ASE DATA) GIVE:
  - RELATIVELY HIGH-FREQUENCY SEISMIC DATA
  - ACCURATE ENCODING & TRANSMISSION OF REAL-TIME EVENTS

7759-5653

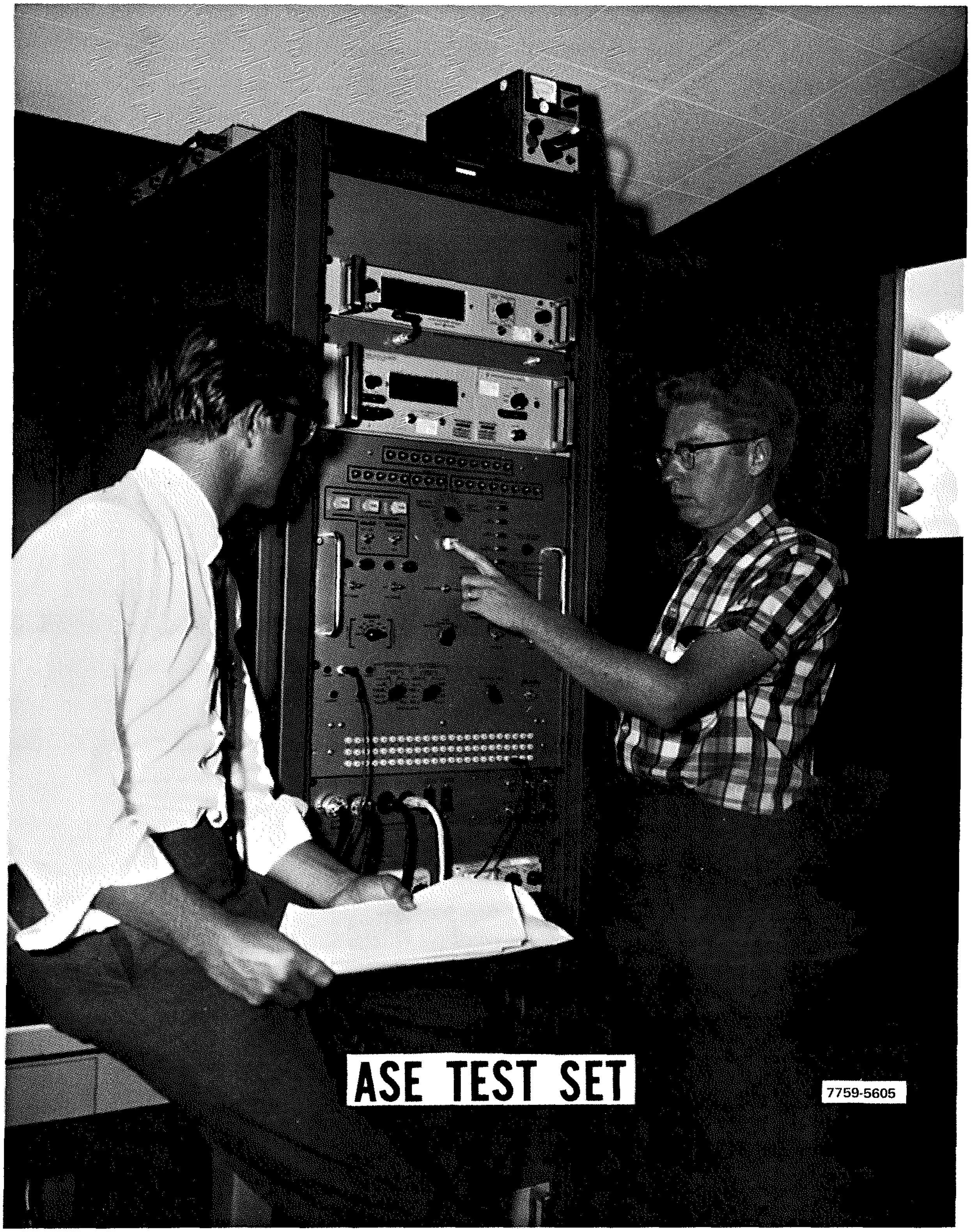

ASE CENTRAL STATION ELECTRONICS ASSEMBLY
7759-5612

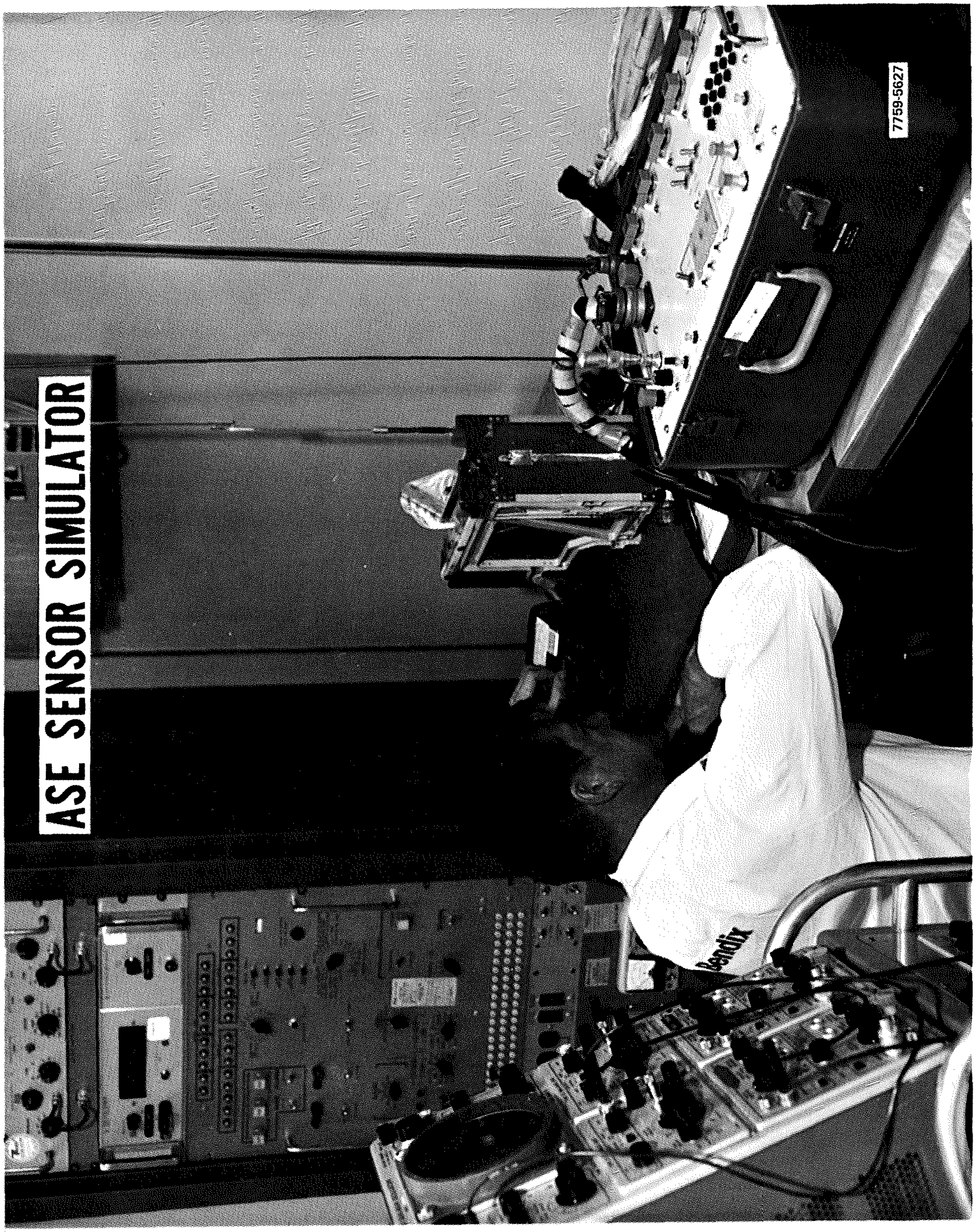

ASE CENTRAL STATION
ELECTRONICS COMPONENTS
7759-5611

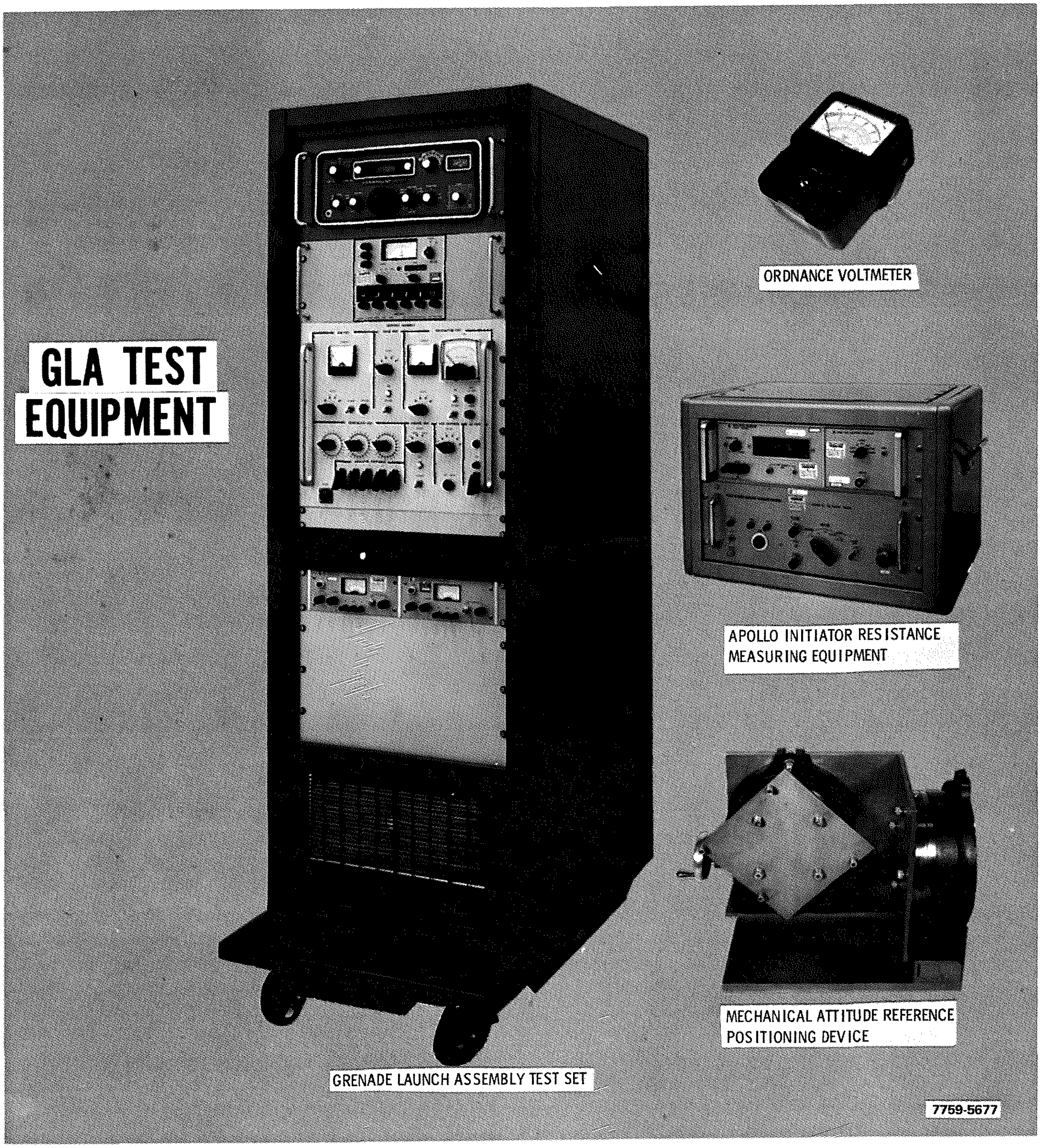
ASE SUBSYSTEM TEST EQUIPMENT

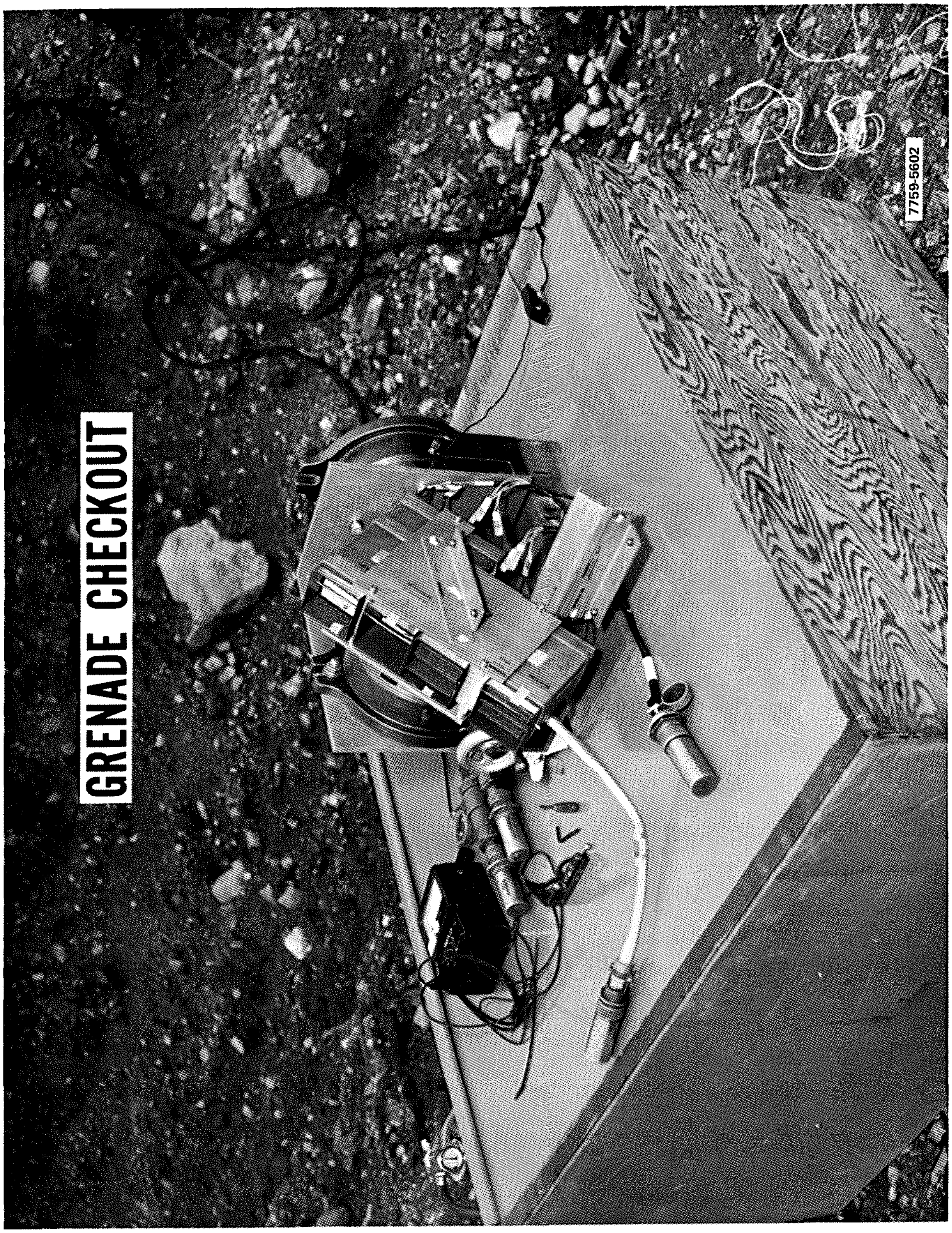
- ETS
  - SIMULATES CENTRAL STATION ELECTRONICS
- ASSS
  - SIMULATES GLA AND THUMPER
- DOME
  - DECOMMUTATES AND DISPLAYS ASE DATA
- GLATS
  - COMPLETE GLA CHECKOUT CAPABILITY
- MARPD
  - GLA MOUNTING AND ANGLE CONTROL
- AIRME
  - ORDNANCE ITEM CHECKOUT

7759-5678

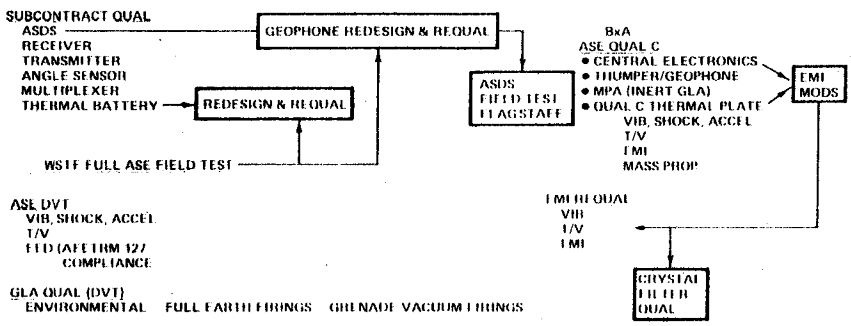

ASE TEST SET
7759-5605


ASE SENSOR SIMULATOR
7759-5627
Bendix


GLA TEST
EQUIPMENT
ORDNANCE VOLTMETER
APOLLO INITIATOR RESISTANCE
MEASURING EQUIPMENT
MECHANICAL ATTITUDE REFERENCE
POSITIONING DEVICE
GRENADE LAUNCH ASSEMBLY TEST SET
7759-5677


GRENADE CHECKOUT
7759-5602

ASE - EQUIPMENT LEVEL TESTING



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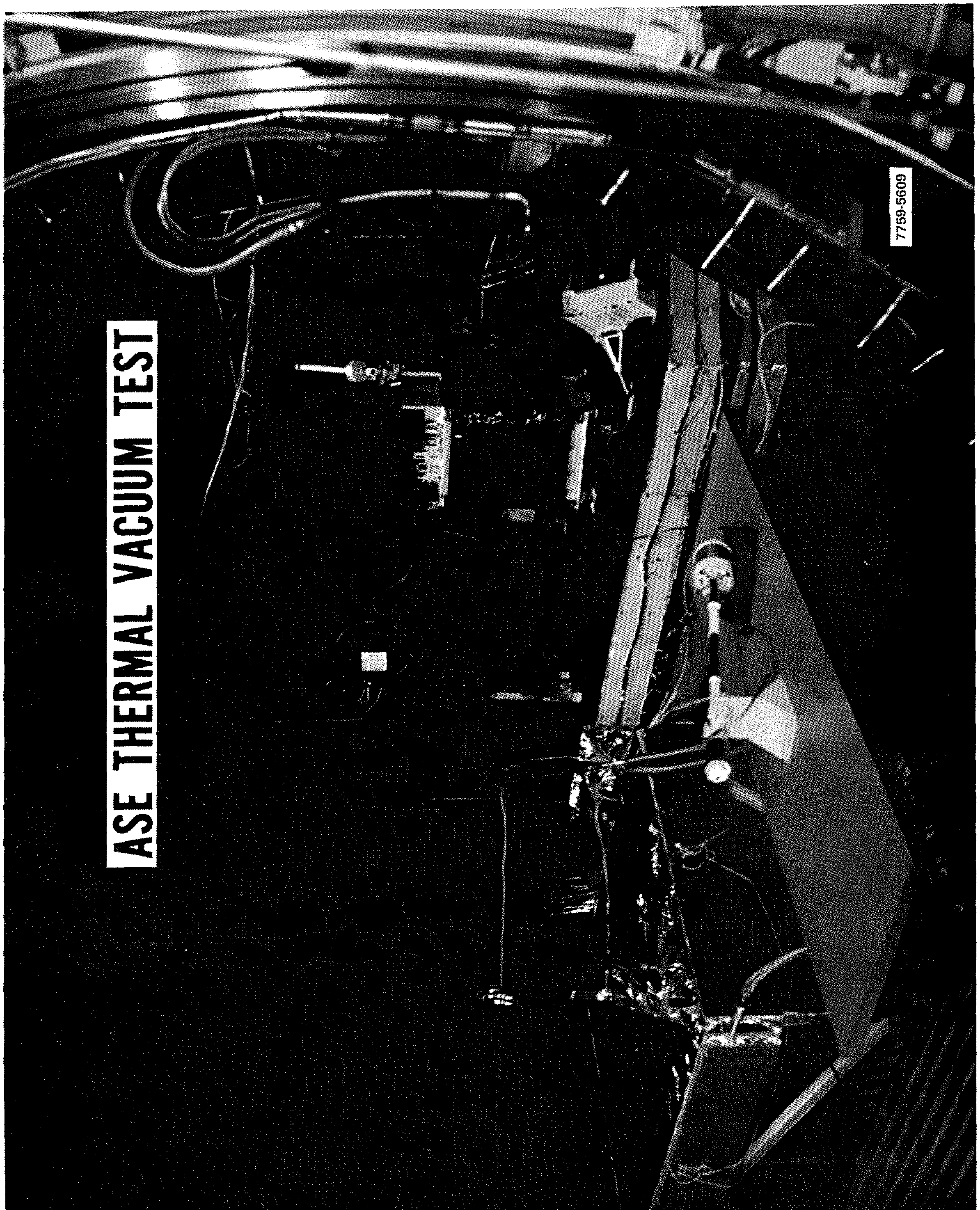
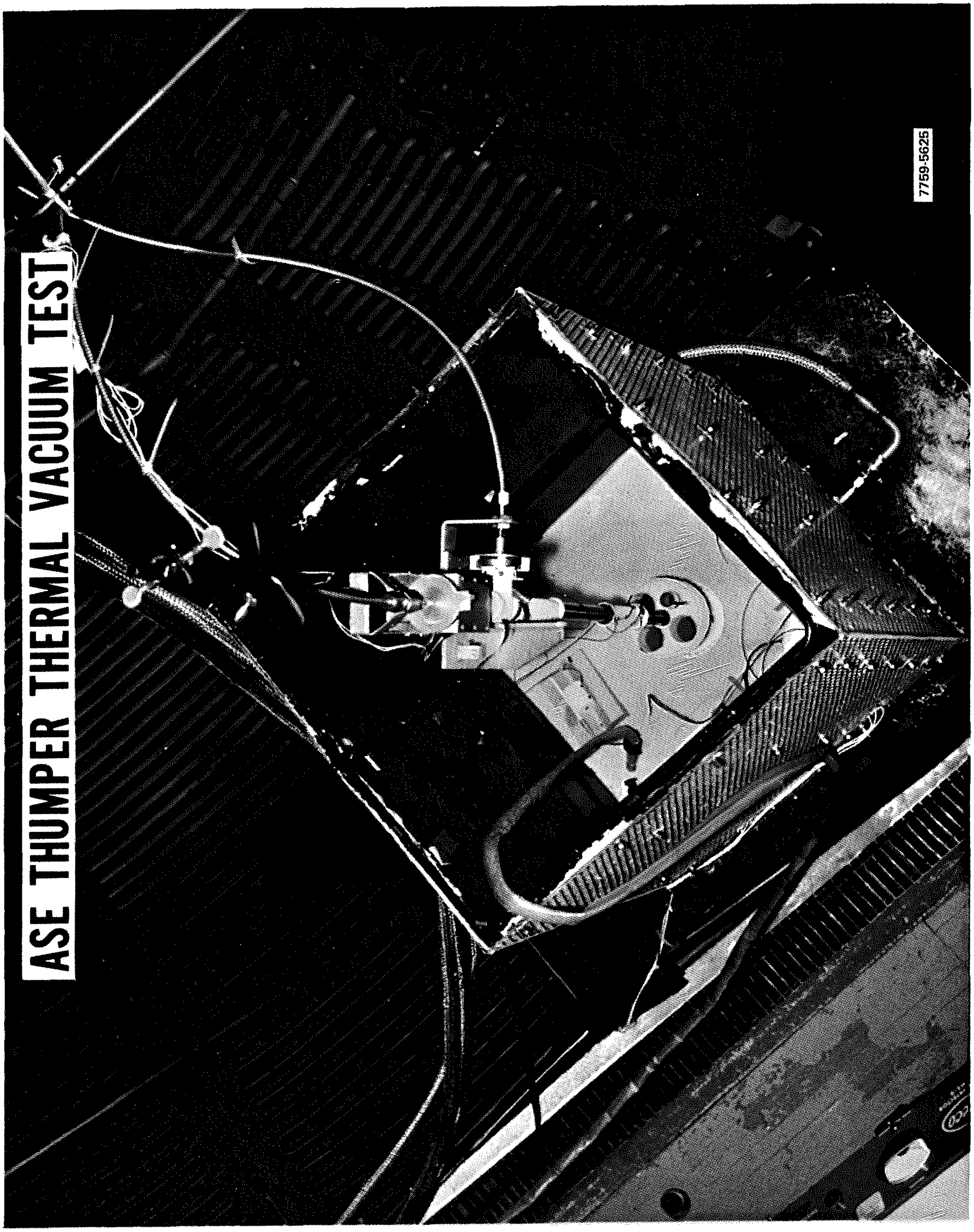

ASE THERMAL VACUUM TEST
7759-5609


ASE THUMPER THERMAL VACUUM TEST
7759-5625

GLA QUALIFICATION

GLA COMPONENTS

- ROCKET MOTORS
  - VIB, TEMP CYCLING
  - HOT, COLD FIRINGS (50)
- GRENADES
  - VIB, TEMP CYCLING
- SAFE/ARM MECHANISMS
  - HOT, COLD FIRINGS
- H.E. DETONATOR TESTS
- INITIATORS (SBASI)
- TRANSMITTER, THERMAL BATTERY — T/V, VIB, SHOCK (3300 G'S)
- ANGLE SENSOR — T/V, VIB, SHOCK (100 G'S)

GLA

- ENVIRONMENTAL
  - VIBRATION → AMBIENT (4 GLA'S)
  - SHOCK, ACCEL → LOW TEMP (1 GLA)
  - TEMP CYCLING → HIGH TEMP (1 GLA)

MPA GLA/MORTAR BOX

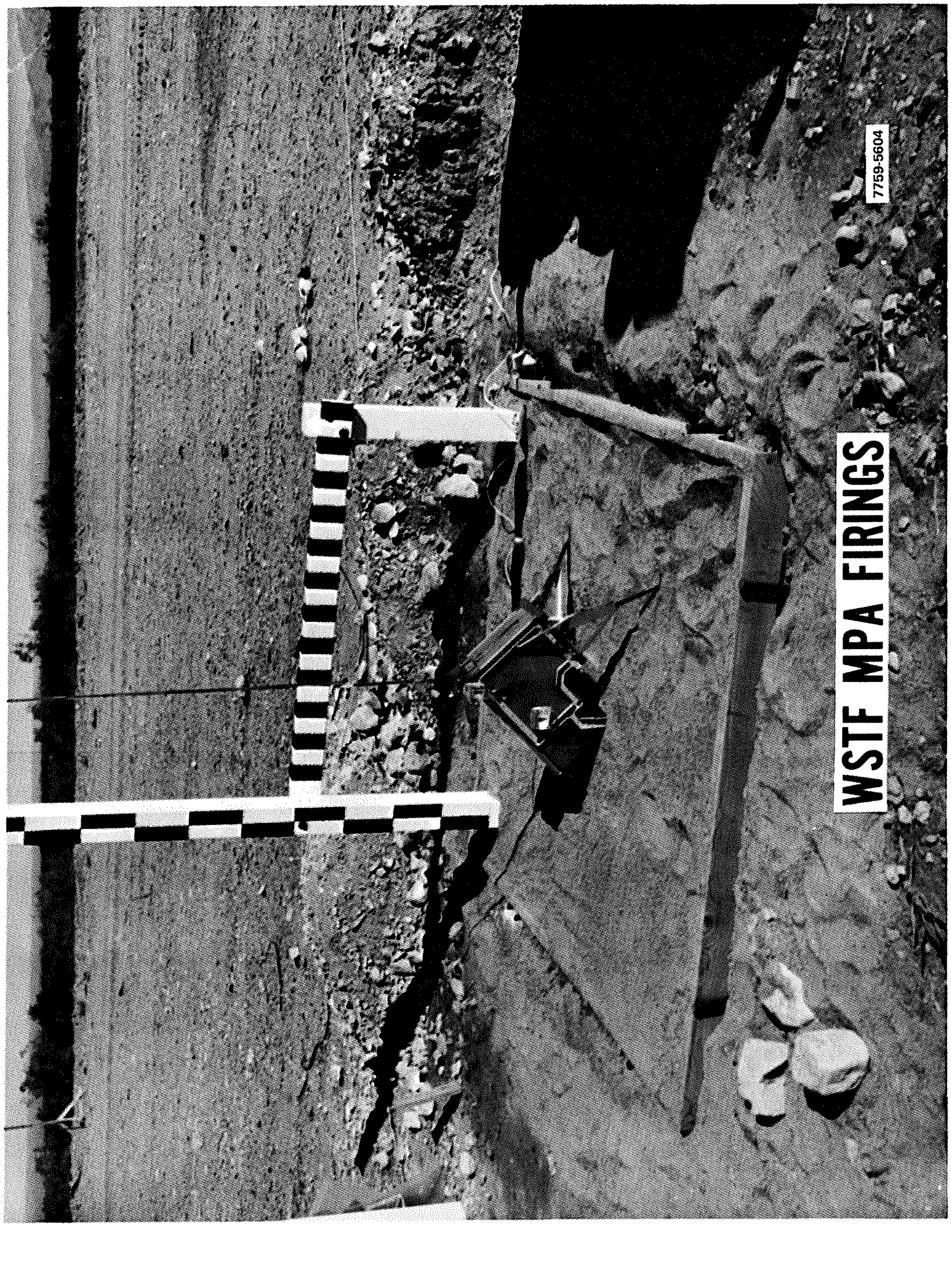
- FULL EARTH FIRINGS
  - AMBIENT (4 GLA'S)
  - LOW TEMP (1 GLA)
  - HIGH TEMP (1 GLA)
- BATTERY EVAL TESTS (3 GLA'S)
- CAMP PENDLETON
  - 2 FLIGHT GLA'S/M BOX
    - 2 GRENADES, COLD
    - 2 GRENADES, AMBIENT
    - 4 GRENADES, HOT

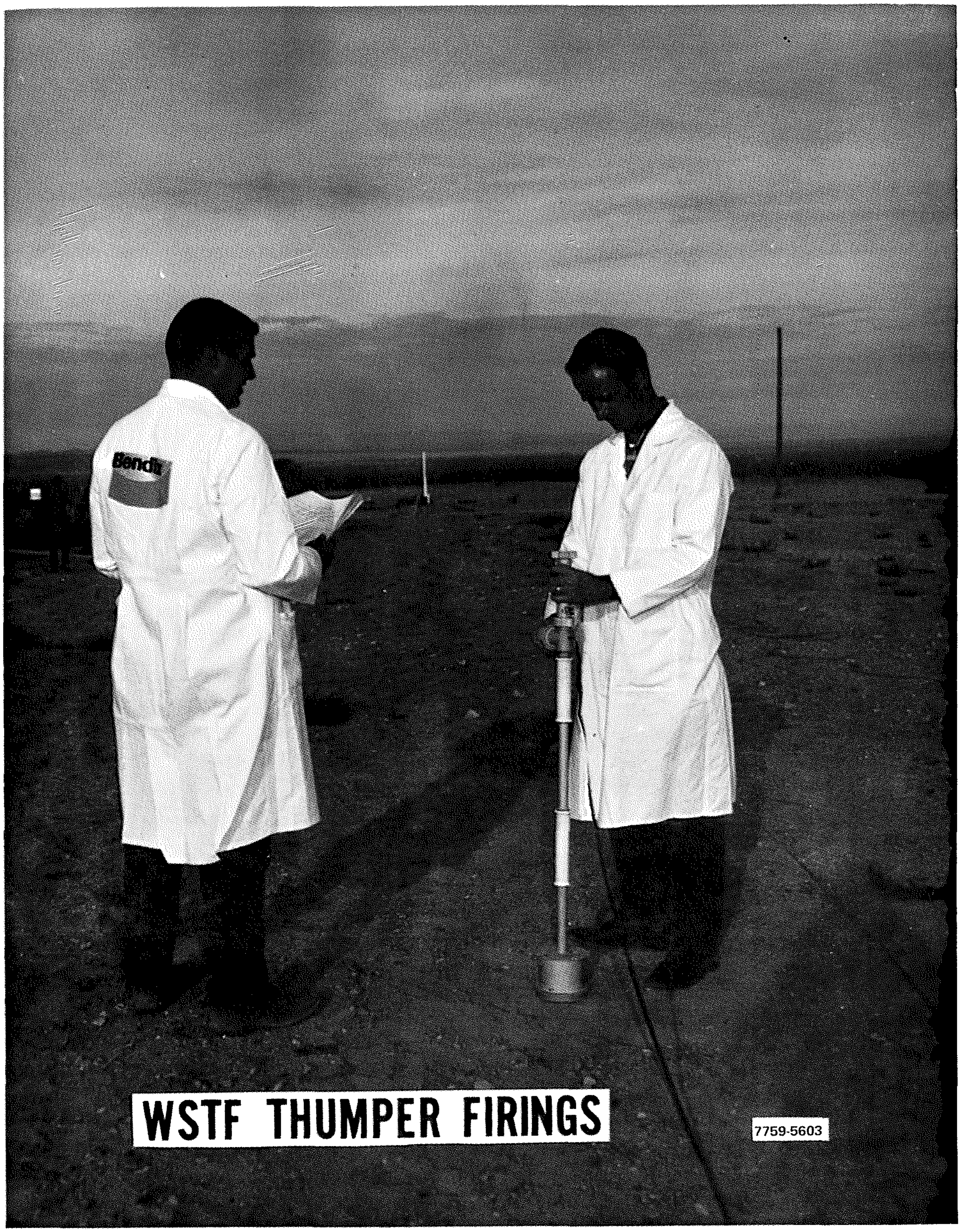
7759-5674

ASE SYSTEM TEST-WSTF

- FULL UP EXPERIMENT (DEPLOYED) TEST
  - EXPERIMENT TEST EQUIPMENT
- 4 TEST CATEGORIES
  - EXTRA CHARGE FIRINGS (1000, 3000 FT)
  - THUMPER FIRINGS, 21 ASI'S
  - MORTAR FIRINGS, 2 GLA'S (8 GRENADES)
  - SPECIAL GEOPHONE TESTS
- THUMPER STRUCTURAL INTEGRITY AND PERFORMANCE VERIFIED
- MPA STRUCTURAL INTEGRITY AND STABILITY VERIFIED
- OVERALL GLA PERFORMANCE VERIFIED
- RF LINK (UP TO 5000 FT) VERIFIED
- CENTRAL ELECTRONICS VERIFIED
- INTRODUCTION, DETECTION AND CONDITIONING OF SEISMIC ENERGY VERIFIED.

7759-5675

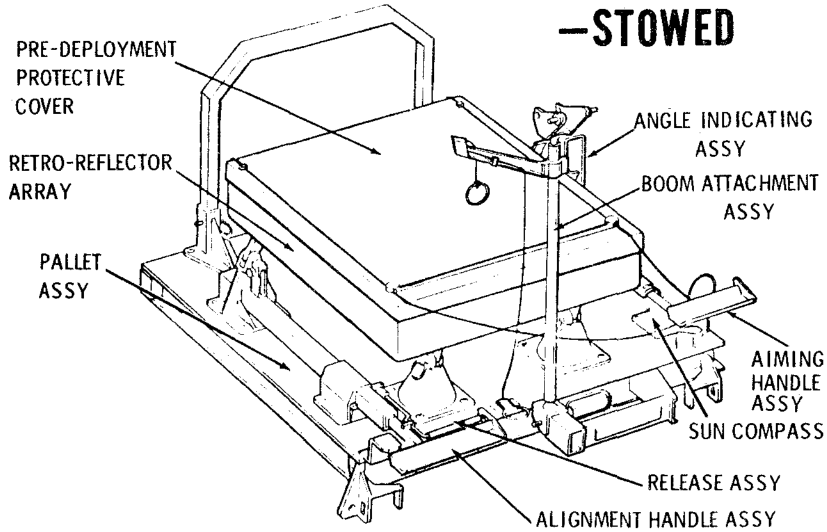

WSTF MPA FIRINGS
7759-5604


Bendix
WSTF THUMPER FIRINGS
7759-5603

Section 5

Laser Ranging Retro-Reflector Experiment

LASER RANGING RETRO-REFLECTOR EXPERIMENT —STOWED



7759-5340

EASEP/LRRR EXPERIMENT DESIGN CHARACTERISTICS

COMPONENTS

ARRAY:	100 FUSED SILICA RETROREFLECTORS PASSIVE THERMAL CONTROL
PALLET:	LM SEQ BAY INTERFACE EXPERIMENT BASE
SUPPORT STRUCTURE:	SUPPORT ARRAY/AIMING HANDLE
AIMING HANDLE	UNLOCK, TILT, LOCK ARRAY
ALIGNMENT HANDLE:	HOLD EXPERIMENT DURING ARRAY TILTING ROTATE EXPERIMENT ALIGN AND LEVEL EXPERIMENT
BOOM ATTACHMENT:	REMOVAL FROM LM CARRY EXPERIMENT TO SITE

7759-5336

EASEP/LRRR EXPERIMENT
DESIGN CHARACTERISTICS (CONT')

COMPONENTS (CONT.)

ANGLE INDICATING BRACKET: TILT INDICATION AND LOCK

SUN COMPASS PLATE } : ALIGNMENT INDICATION
GNOMON

LIQUID BUBBLE LEVEL: LEVEL INDICATION

REAR SUPPORT: SUPPORT IN UPRIGHT POSITION

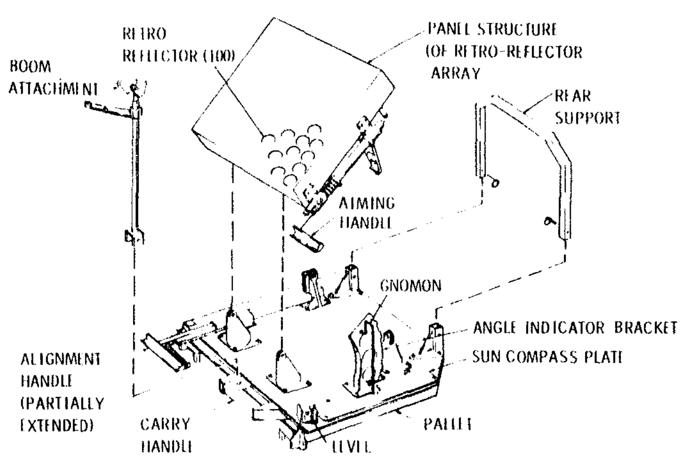
WEIGHT 51.91 LB

SIZE 26 x 27.25 x 17 IN. HIGH

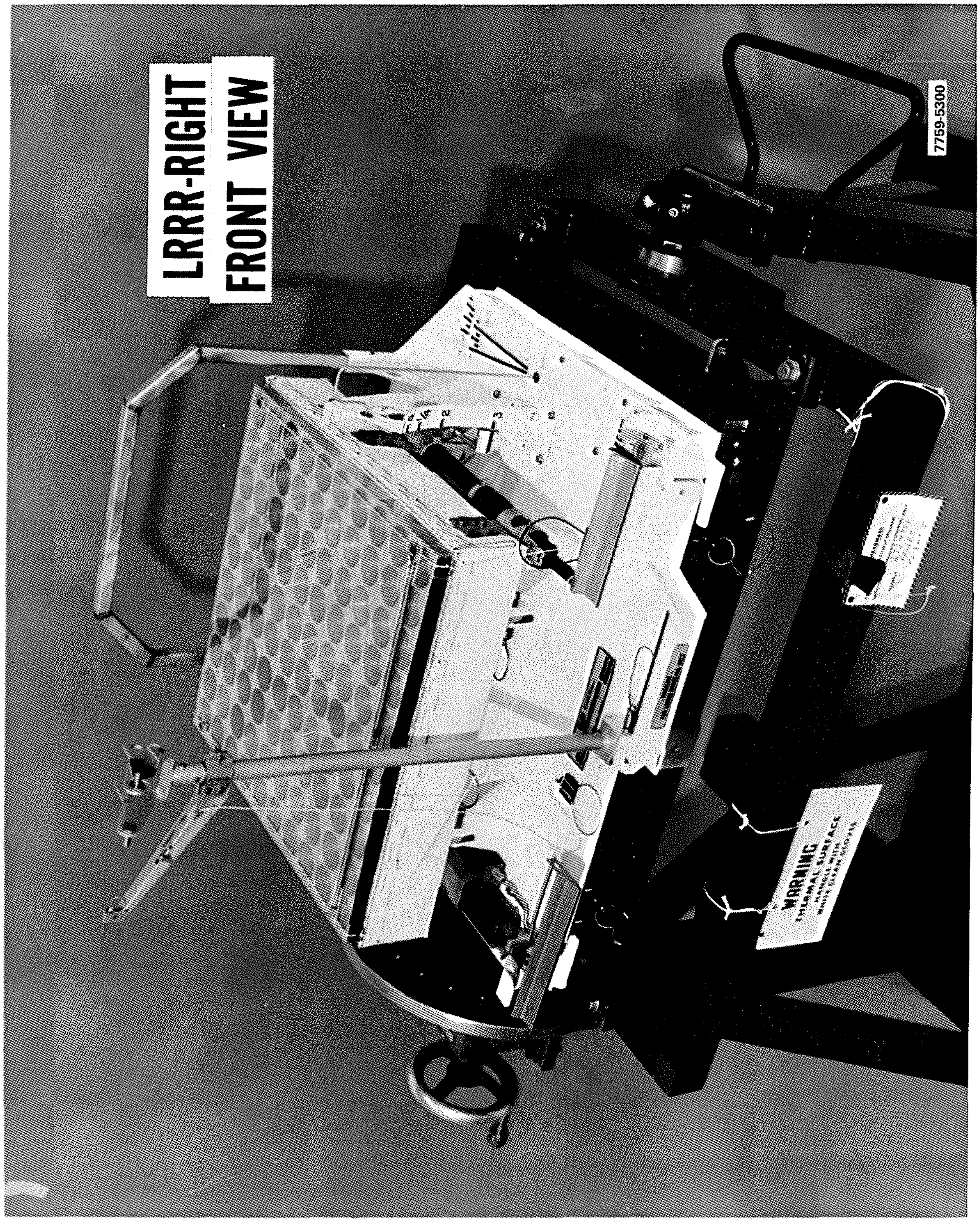
PROTECTIVE COVER: PROTECT RETROREFLECTORS FROM DUST, DIRT REMOVED IN DEPLOYMENT

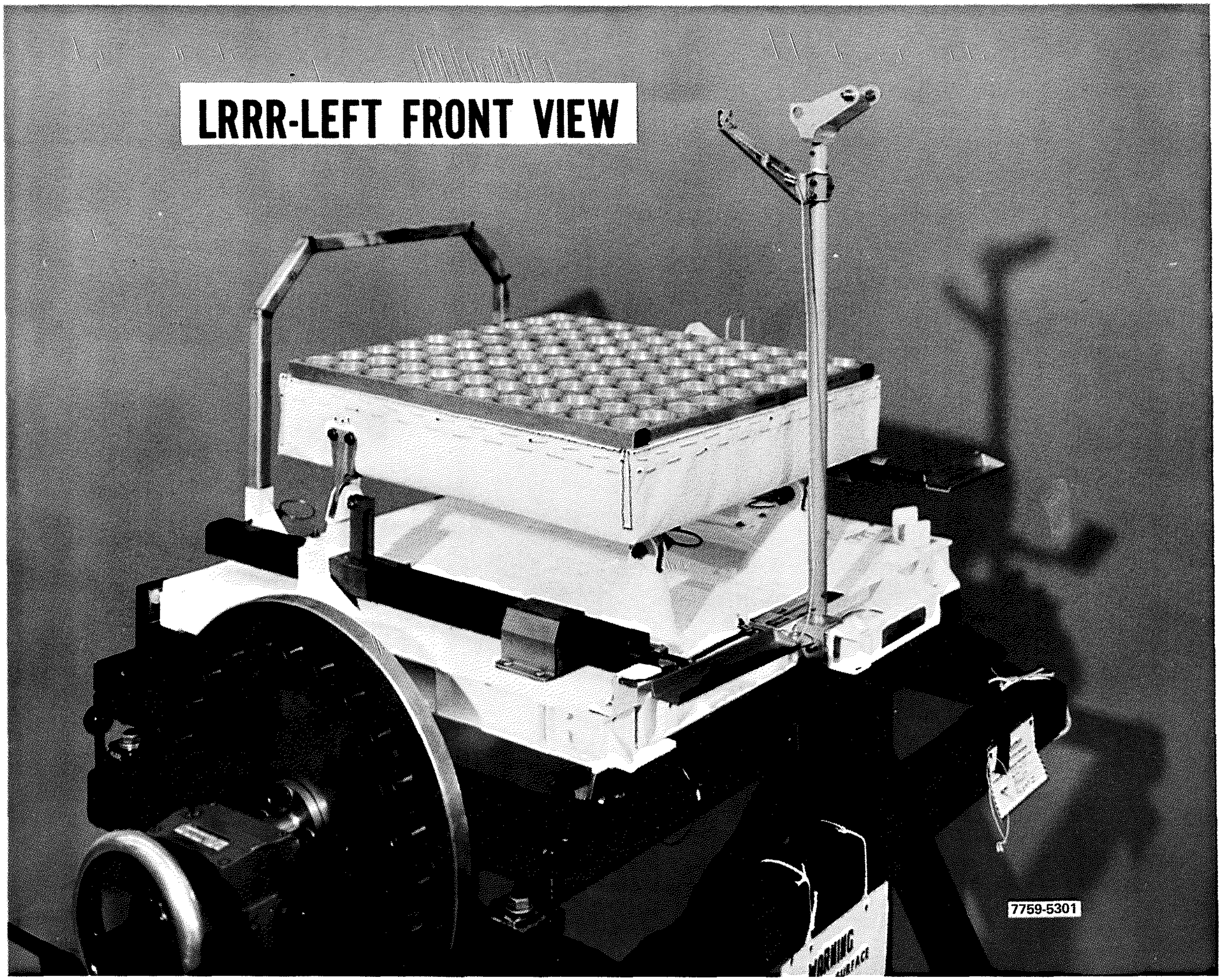
7759-5337

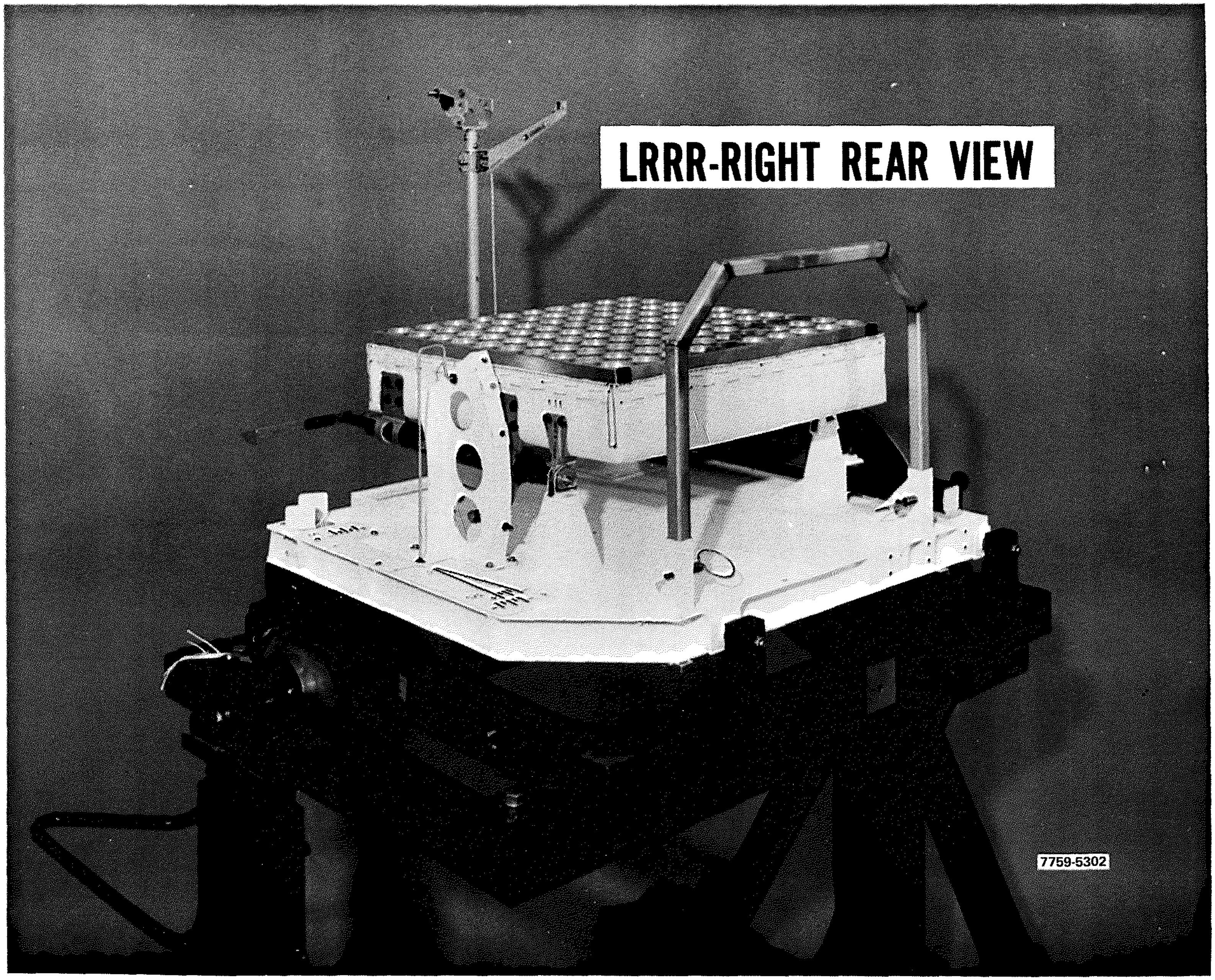
LRRR MECHANICAL ASSEMBLY

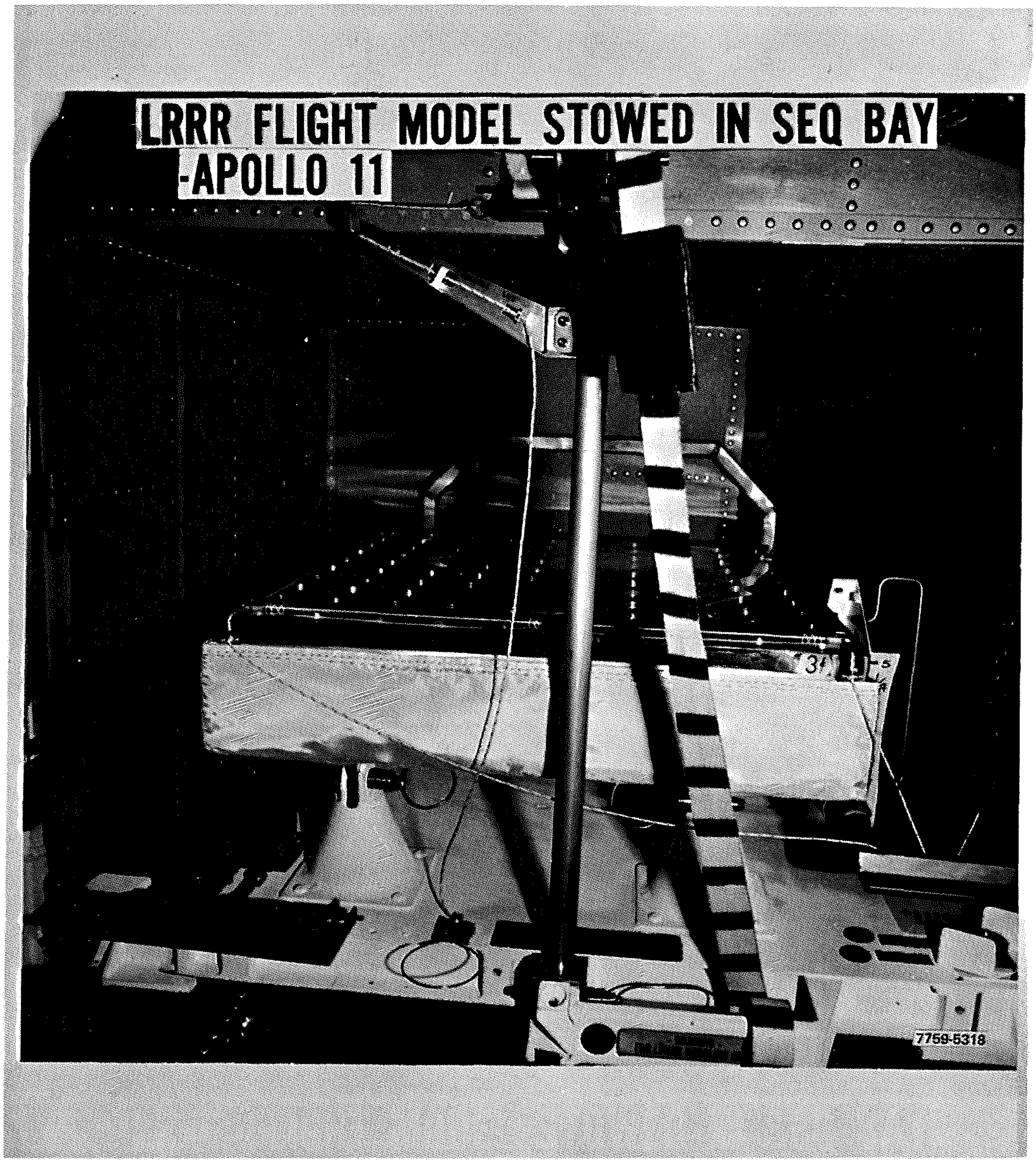


7759-5324

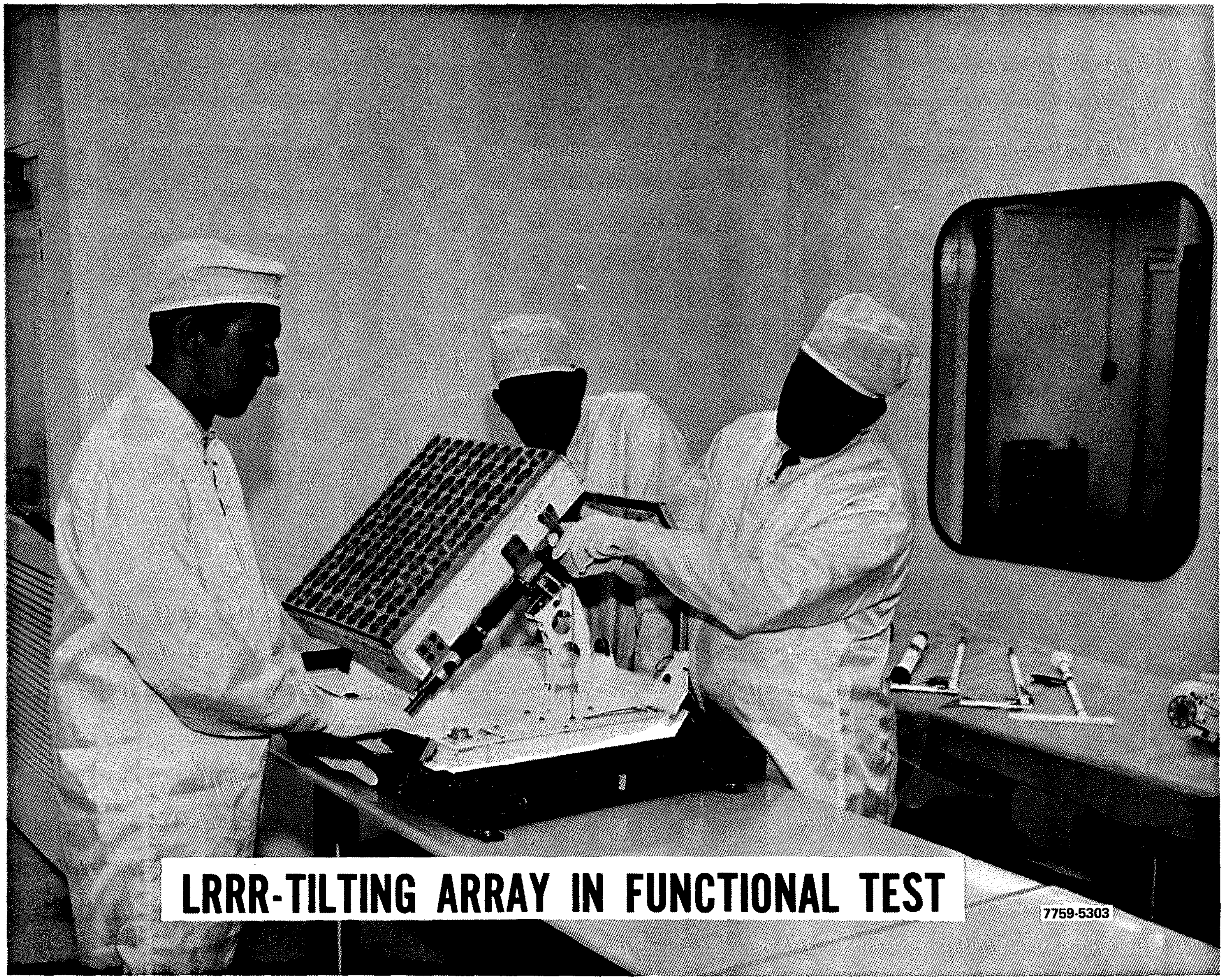

LRRR-RIGHT
FRONT VIEW
7759-5300
WARNING
THERMAL SURFACE


LRRR-LEFT FRONT VIEW
7759-5301

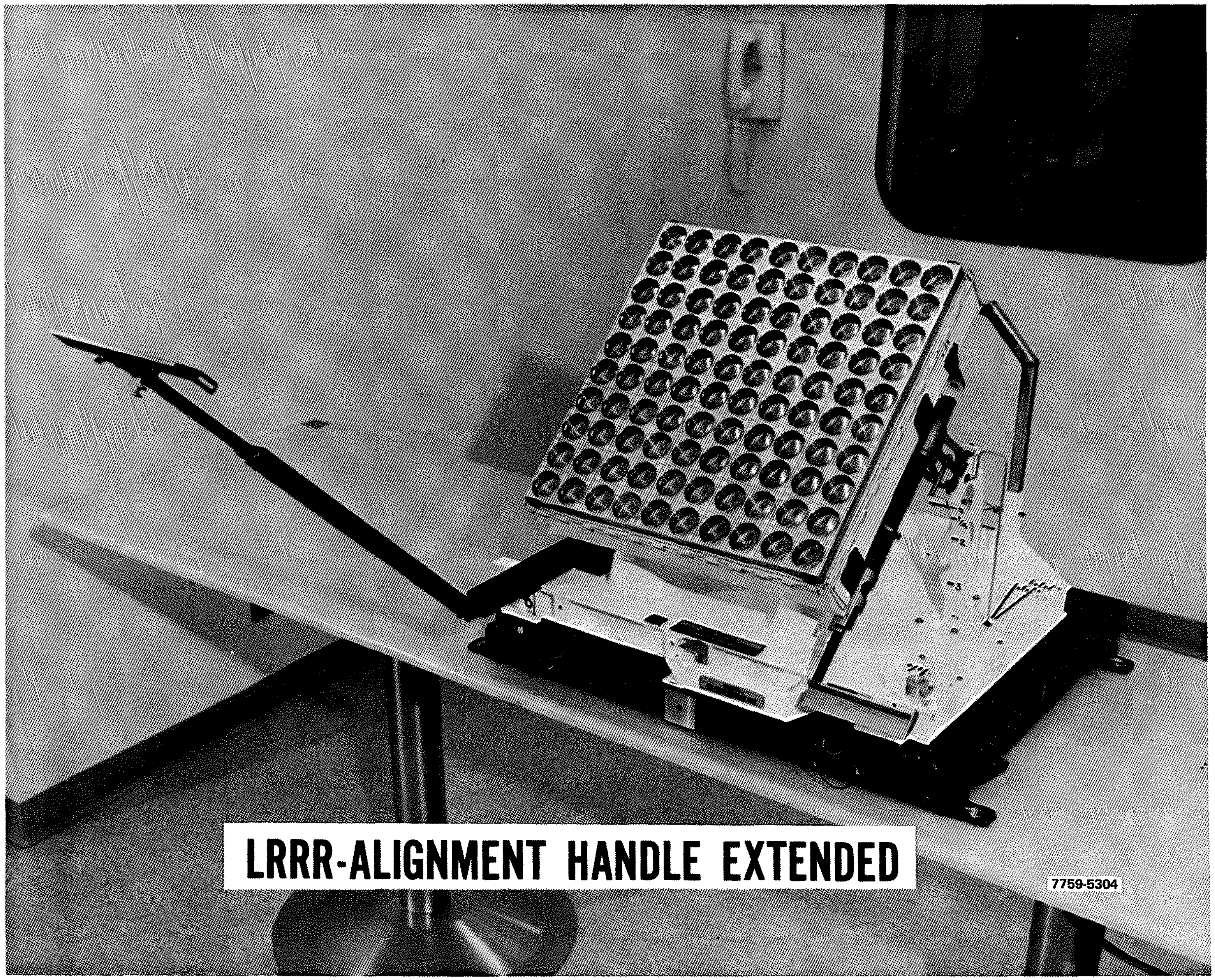

LRRR-RIGHT REAR VIEW
7759-5302



LRRR FLIGHT MODEL STOWED IN SEQ BAY -APOLLO 11

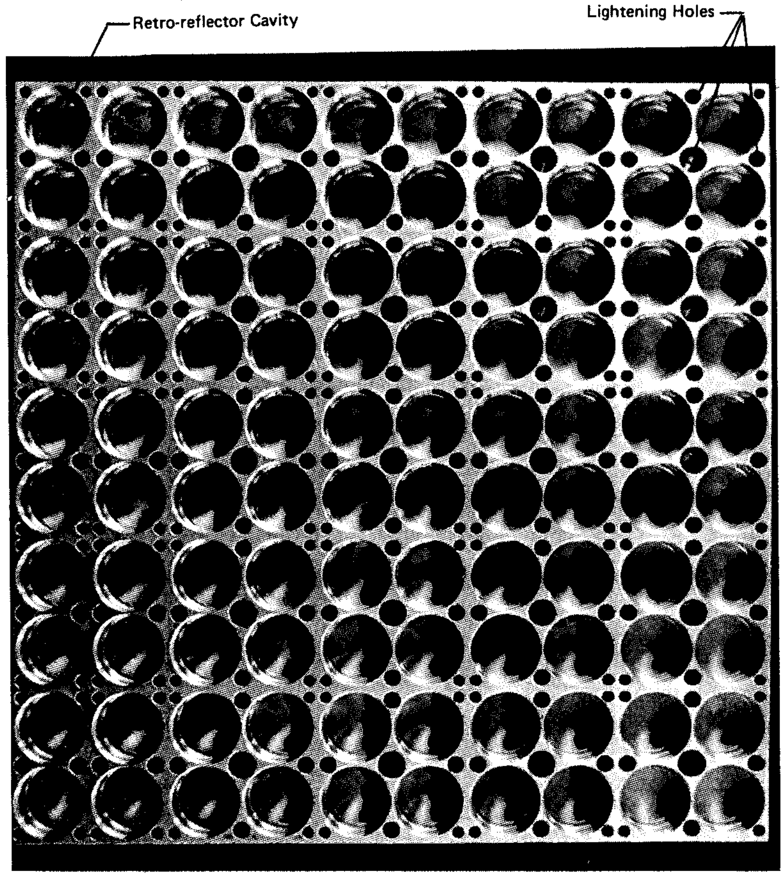


LRRR-TILTING ARRAY IN FUNCTIONAL TEST



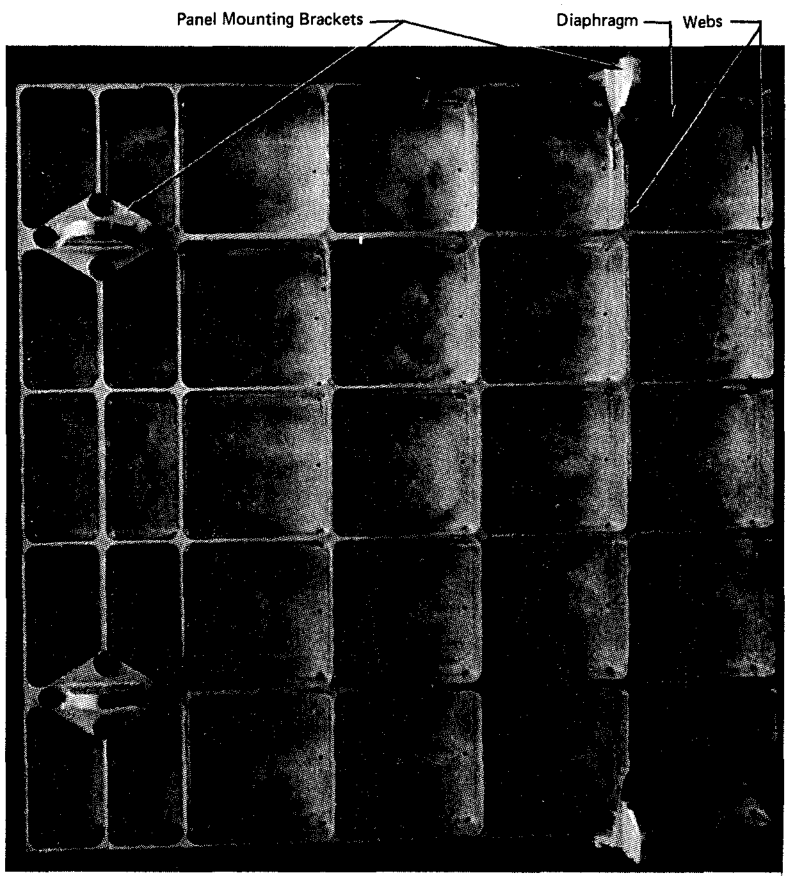
LRRR-ALIGNMENT HANDLE EXTENDED

ARRAY PANEL STRUCTURE



7759-5314A

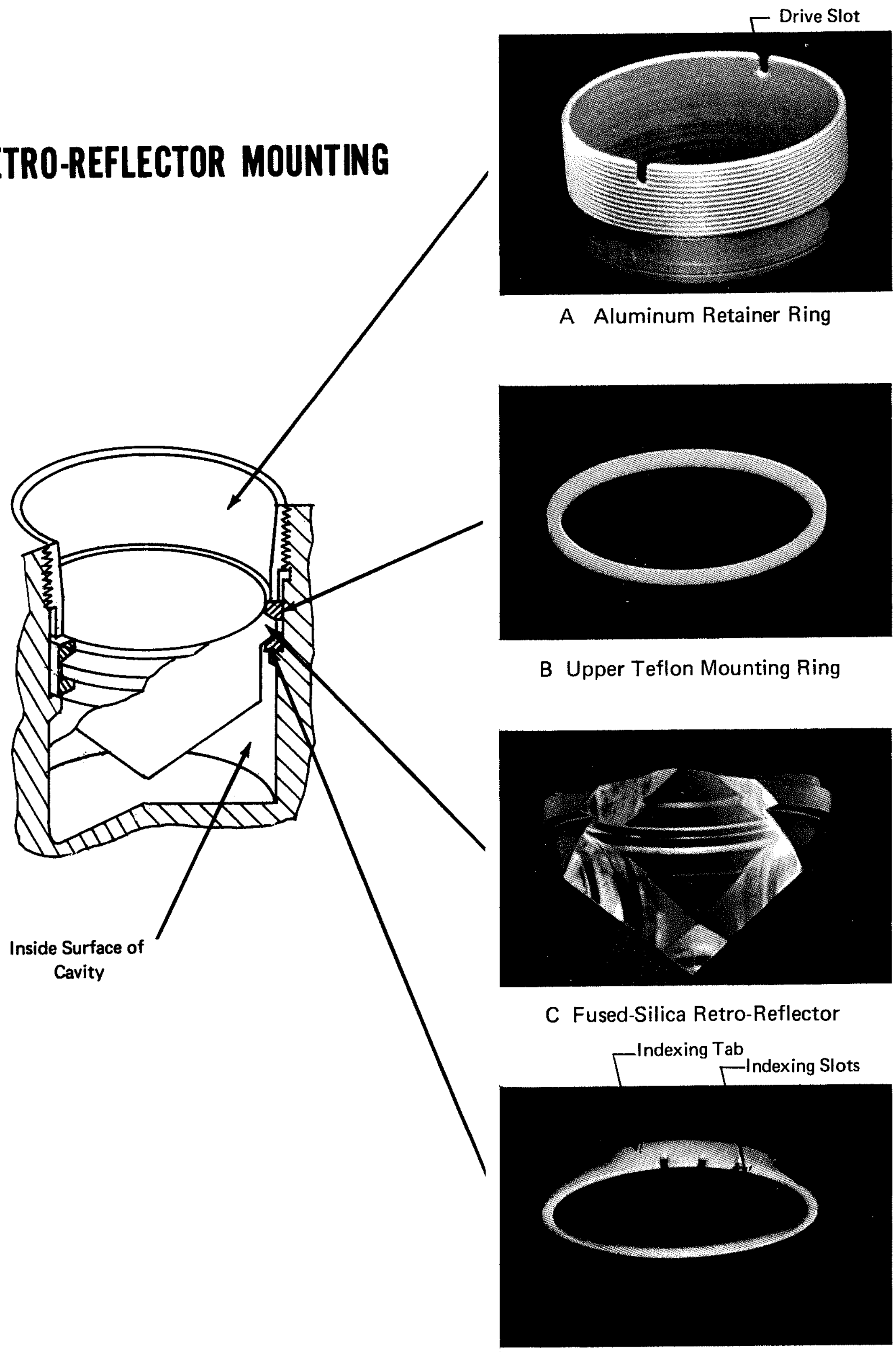
ARRAY PANEL STRUCTURE



B. REAR

7759-5314B

RETRO-REFLECTOR MOUNTING



A Aluminum Retainer Ring

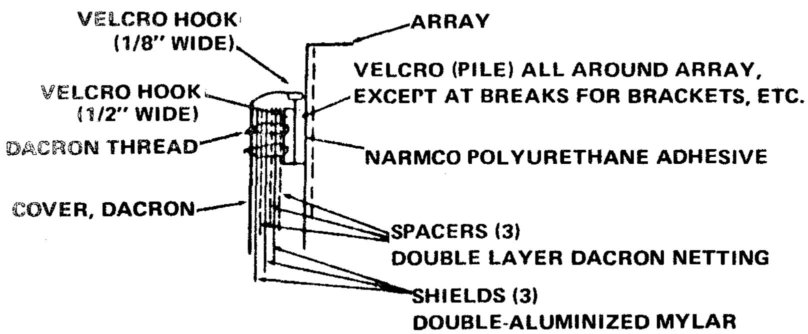
B Upper Teflon Mounting Ring

C Fused-Silica Retro-Reflector

D Lower Teflon Mounting Ring

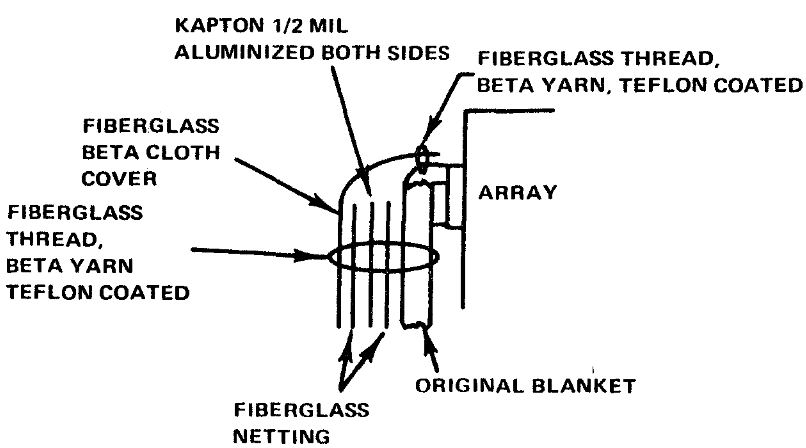
7759-5313

ORIGINAL MULTILAYER INSULATION BLANKET CROSS-SECTION



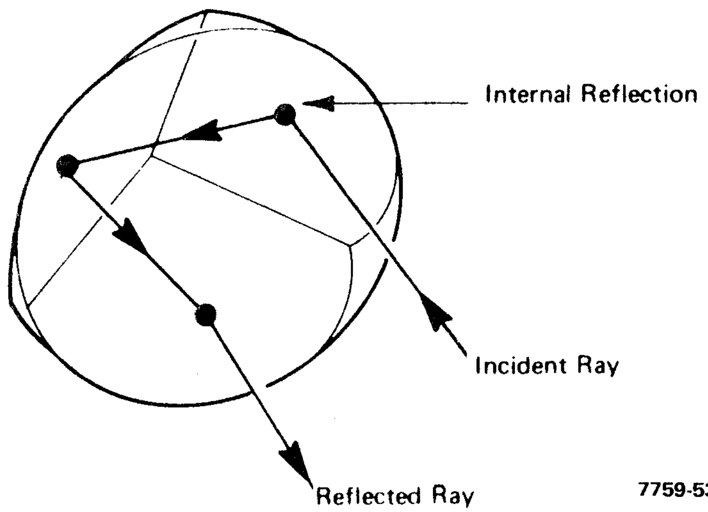
7759-5327

ASCENT HEATING THERMAL PROTECTION MOD KIT (INSTALLED AT KSC)



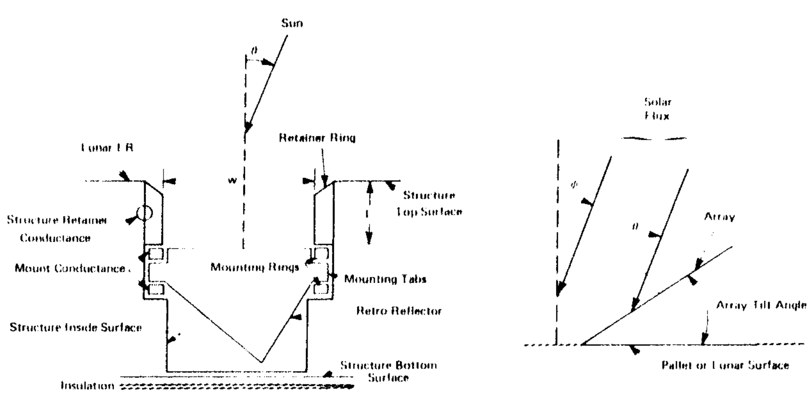
7759-5328

TYPICAL LASER RAY PATH IN RETRO-REFLECTOR



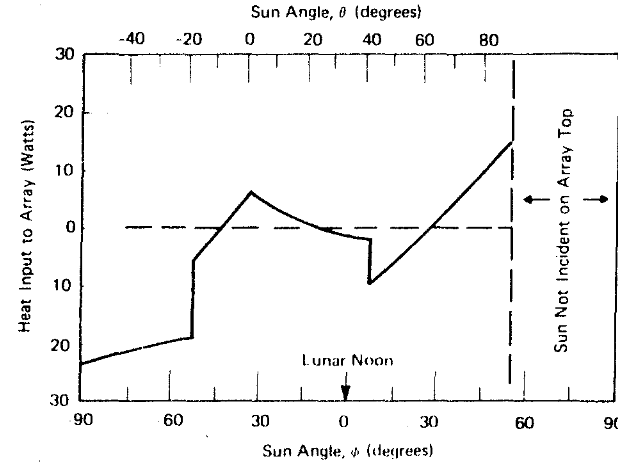
7759-5334

THERMAL MODEL AND DEFINITION OF SUN ANGLES



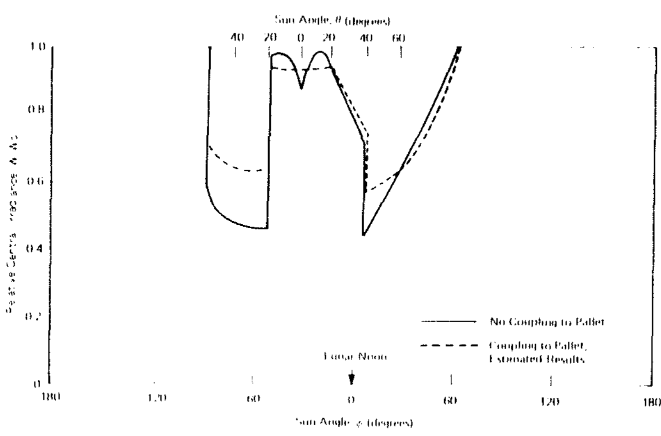
7759-5315

HEAT INPUT TO ARRAY FROM PALLET FOR 34° ARRAY TILT ANGLE



7759-5316

PREDICTED CENTRAL IRRADIANCE – FINAL DESIGN CALCULATIONS



7759-5317

EASEP/ASTRONAUT INTERFACE

	CONSTRAINT	RESOLUTION
SAFETY	BIOMEDICAL	SIMPLE TASKS REQUIRING MINIMAL EFFORT AND TIME DOSAGE RATE OF ISOTOPE HEATER NON-HAZARDOUS
	THERMAL	NO SIGNIFICANT THERMAL EXPOSURES
	SUIT PUNCTURE	NO SHARP EDGES; PSE UNCAGE USES APPROVED PYROTECHNIC
CAPABILITY	MOBILITY	NO EXCESSIVE REACH - NO KNEELING
	DEXTERITY	ALL MECHANISMS ACTUATED BY PULL PINS, HANDLES OR LANYARDS
	VISUAL	LEVEL/ALIGN INDICATORS COMPATIBLE WITH VISOR LIMITATIONS

REMOVE LRRR AND PSEP FROM LM, TRAVERSE TO DEPLOYMENT SITE, DEPLOY LRRR AND PSEP; TOTAL TIME APPROX 10 MIN

7769-5322

LRRR MECHANICAL FEATURES INFLUENCED BY CREW CONSIDERATIONS

ALIGNMENT HANDLE	:	REACH HEIGHT
		SUPPORT DURING ARRAY TILT
		HANDLE, TRIGGER, RELEASE MECHANISM CONFIGURATIONS
AIMING HANDLE	:	REACH HEIGHT
		HANDLE CONFIGURATION
		SPRING RETURN
ANGLE INDICATING BRACKET	:	VISIBILITY AND SIMPLICITY
SUN COMPASS	:	VISIBILITY AND SIMPLICITY
BUBBLE ELVEL	:	VISIBILITY AND SIMPLICITY
PROTECTIVE COVER	:	RING/LANYARD REMOVAL REACH HEIGHT
BOOM ATTACHMENT	:	RING/PULL PIN REMOVAL
		RING/LANYARD RELEASE FROM LM REACH HEIGHT

7759-5335

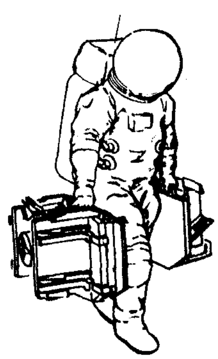
LRRR EMPLACEMENT CRITERIA

PARAMETER	REQUIREMENT	INDICATOR	COMMENTS
DISTANCE FROM LM	32 FT (MINIMUM	PACED OFF	CREW/PAYLOAD TRADEOFF
DIRECTION FROM LM	IN FOV OF OTHER ASTRONAUT	EYEBALL	MONITOR DEPLOYMENT (AVOID LM SHADOW AREA)
DISTANCE FROM PSEP	10 FT	PACED OFF	LRRR PROBABLY DEPLOYED FIRST
DIRECTION FROM PSEP	NOT DIRECTLY EAST OR WEST	EYEBALL	TO AVOID SHADOWING SOLAR PANELS
SITE SELECTION	LEVEL & FREE FROM RUBBLE	EYEBALL	CONSTRAINS LEVELING CAPABILITY
TILT OF THE ARRAY	SET TO PROPER POSITION	INDEX MARKS ON SECTOR	DIFFERENT FOR EACH LANDING SITE
LEVEL WRT INDICATOR	$\pm 5^{\circ}$ OF INDICATOR	BUBBLE	INTERACTS WITH ALIGNMENT
ALIGN, WRT SHADOW	$\pm 5^{\circ}$ OF INDICATOR LINE	COMPASS PLATE (PARTIAL ROSE)	ALIGN FOR LANDING SITE
BEFORE ROTATING UPRIGHT FOR FINAL ALIGNMENT LRRR MUST BE FACING AWAY FROM SUBEARTH POINT (FUNCTION OF LANDING SITE)			

7759-5320

TRAVERSE

- PICK UP BOTH PACKAGES
- WALK TO DEPLOYMENT SITE



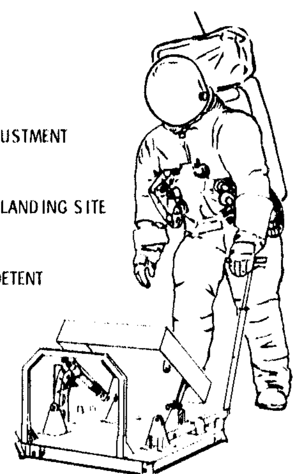
SITE SELECTION: APPROXIMATELY 30 FT FROM LM, IN FOV OF OTHER ASTRONAUT, IN AN AREA FREE OF RUBBLE

- LOWER PACKAGES TO LUNAR SURFACE

7759-5326

DEPLOY LRRR

- POSITION LRRR FOR DEPLOYMENT
  - ROUGH ALIGN LRRR WRT SUB-EARTH POINT
  - RELEASE DEPLOYMENT HANDLE AND EXTEND TO DETENT
  - PULL OUT ARRAY TILTING HANDLE TO ALLOW TILT ADJUSTMENT
- ADJUST LRRR TILT
  - ROTATE TILTING HANDLE TO SET TILT INDICATOR FOR LANDING SITE
- ROTATE LRRR UPRIGHT
  - ACTUATE DEPLOYMENT HANDLE TRIGGER TO RELEASE DETENT
  - FULLY EXTEND HANDLE
  - USE HANDLE TO ROTATE PACKAGE
- SET FINAL ALIGNMENT
  - ALIGN WRT SHADOW ON PARTIAL ROSE

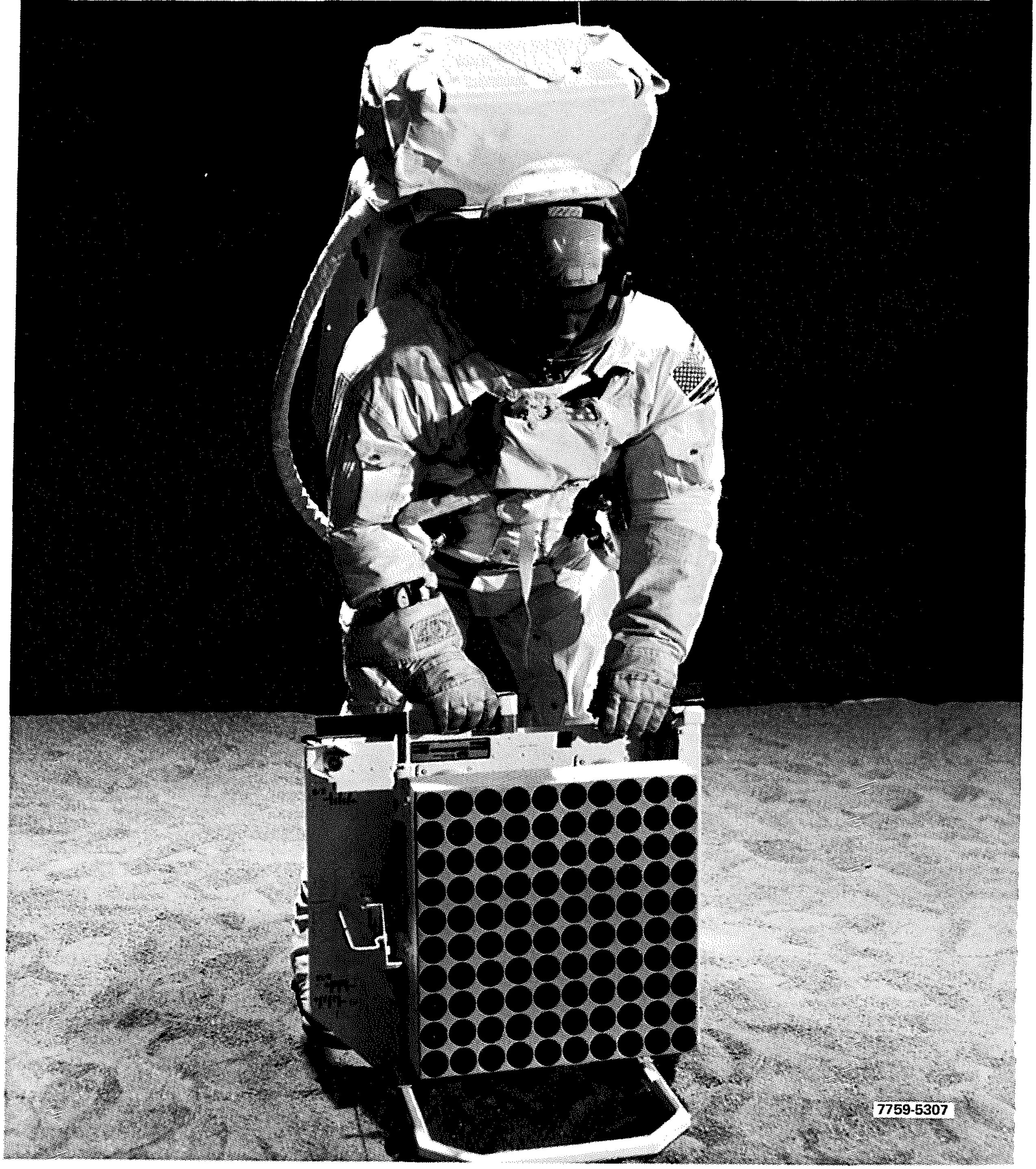


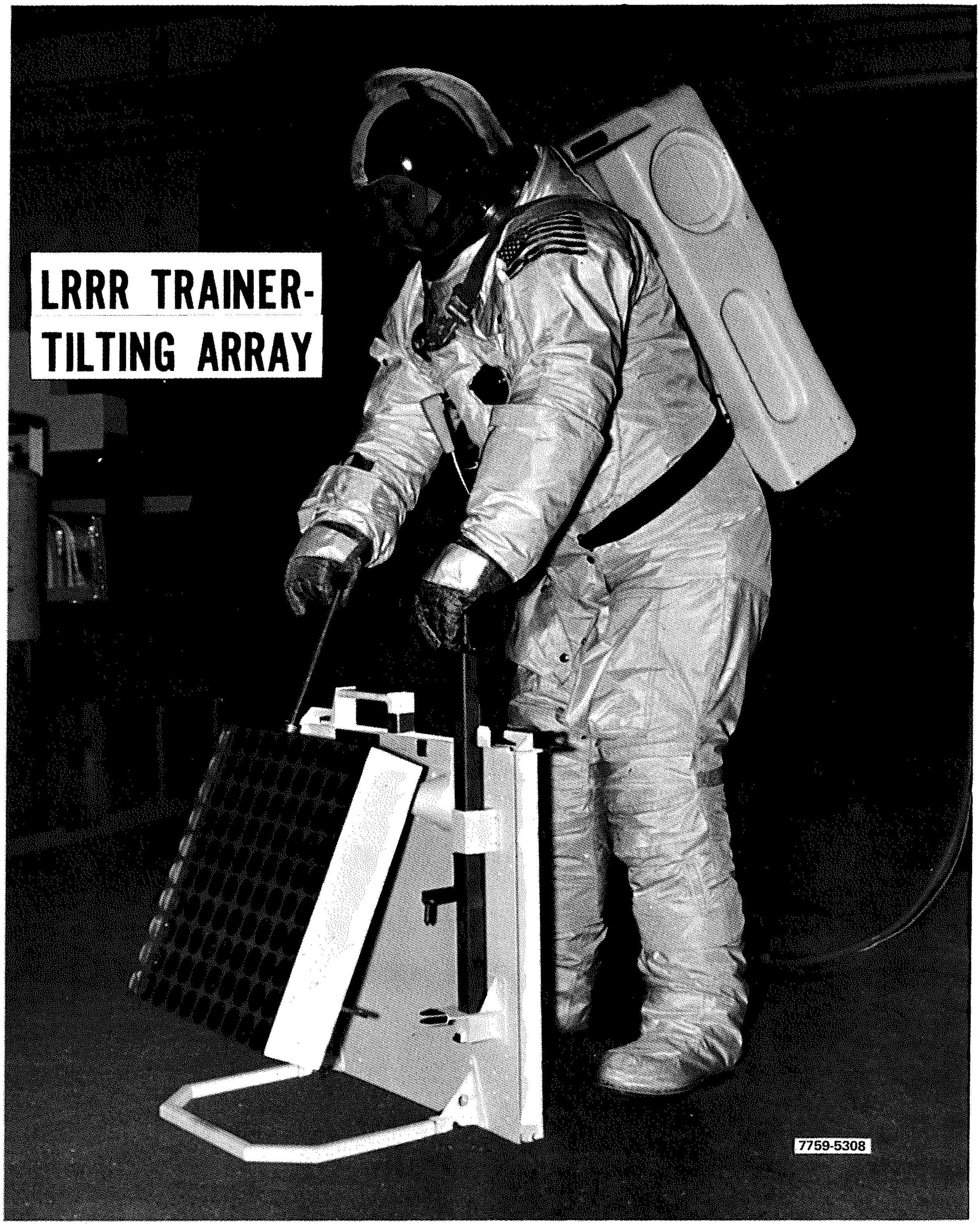
7759-532 5


LRRR BEING CARRIED TO DEPLOYMENT SITE
-APOLLO 11
7759-5319

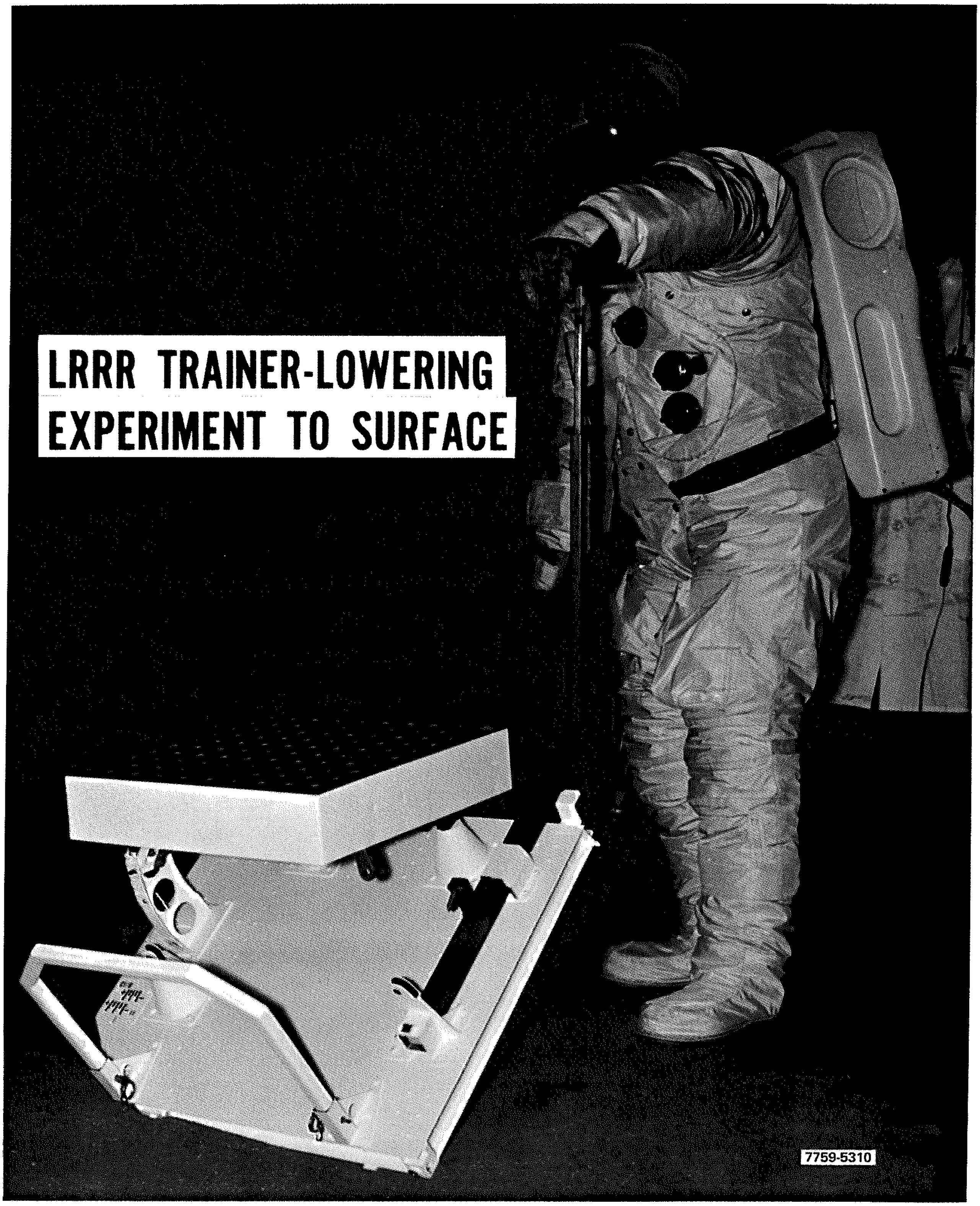

LRRR TRAINER RESTING ON REAR SUPPORT
7759-5306

LRRR TRAINER-RELEASING ALIGNMENT HANDLE




LRRR TRAINER-
TILTING ARRAY
7759-5308


LRRR TRAINER-EXTENDING
ALIGNMENT HANDLE
25
7759-5309


LRRR TRAINER-LOWERING
EXPERIMENT TO SURFACE
7759-5310

LRRR TRAINER-ALIGNING EXPERIMENT

LRRR DEPLOYED AT APOLLO 11 SITE

LRRR ARRAY TEST SUMMARY

DEVELOPMENT TESTS

MECHANICAL (VIBRATION AND SHOCK)

- SINGLE CORNER CELL
- ENGINEERING TEST MODEL (ETM)

OPTICAL ALIGNMENT

- BEFORE AND AFTER MECHANICAL TEST – ETM
- BEFORE, DURING, AFTER THERMAL CYCLING – ETM

THERMAL DISTORTION – ETM EXPOSED TO -320°F TO + 250°F

THERMAL CONDUCTANCE – SINGLE CORNER CELL

MOUNT TEMPERATURE COMPENSATION – SINGLE CORNER CELL

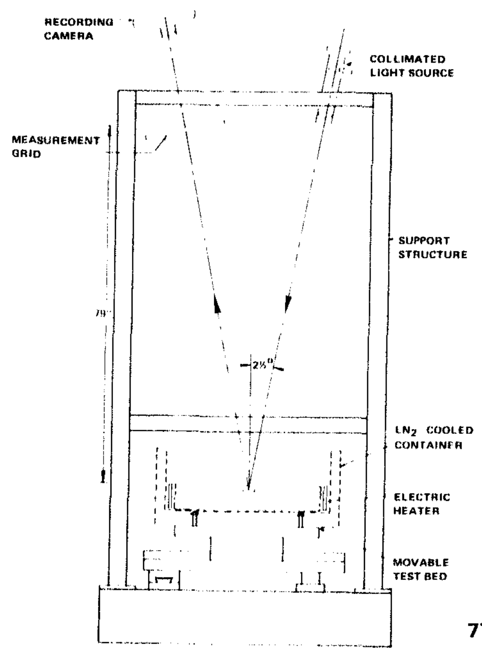
ACCEPTANCE TESTS (QUAL AND FLIGHT MODEL ARRAYS)

MECHANICAL (VIBRATION) – ACCEPTANCE LEVEL

OPTICAL ALIGNMENT – BEFORE AND AFTER MECHANICAL TESTS

7759-5331

OPTICAL ALIGNMENT TEST RANGE APPARATUS



7759-5339

ARRAY OPTICAL ALIGNMENT TESTS SUMMARY

MODEL	CONDITIONS	MAX DEVIATION OF INDIVIDUAL R-R FROM ARRAY POINTING DIRECTION (DEGREES)	DEVIATION OF ARRAY POINTING DIRECTION FROM ARRAY NORMAL (DEGREES)
ETM	BEFORE VIBRATION	0.18	0.07
	AFTER VIBRATION	0.29	0.08
ETM	ROOM TEMP	0.27	0.03
	-320°F	0.19	0.02
	ROOM TEMP	0.23	0.02
	+ 250°F	0.022	0.02
	ROOM TEMP	0.22	0.02
QUAL	BEFORE VIBRATION	0.18	0.01
	AFTER VIBRATION	0.18	0.02
FLIGHT	BEFORE VIBRATION	0.17	0.04
	AFTER VIBRATION	0.15	0.02
SPECIFICATION		$\pm$ 2.0°	$\pm$ 0.25°

7759-5332

LRRR EXPERIMENT TEST SUMMARY

- CREW ENGINEERING MOCK-UP
  - CREW INTERFACES
  - EARLY KSC WALK-THROUGH
- CREW TRAINER MODEL
  - CREW TRAINING
  - KC 135 TESTS
- KSC HANDLING MODEL
  - HANDLING PROCEDURE CHECKOUT
  - LM INSTALLATION TRAINING

7759-5329

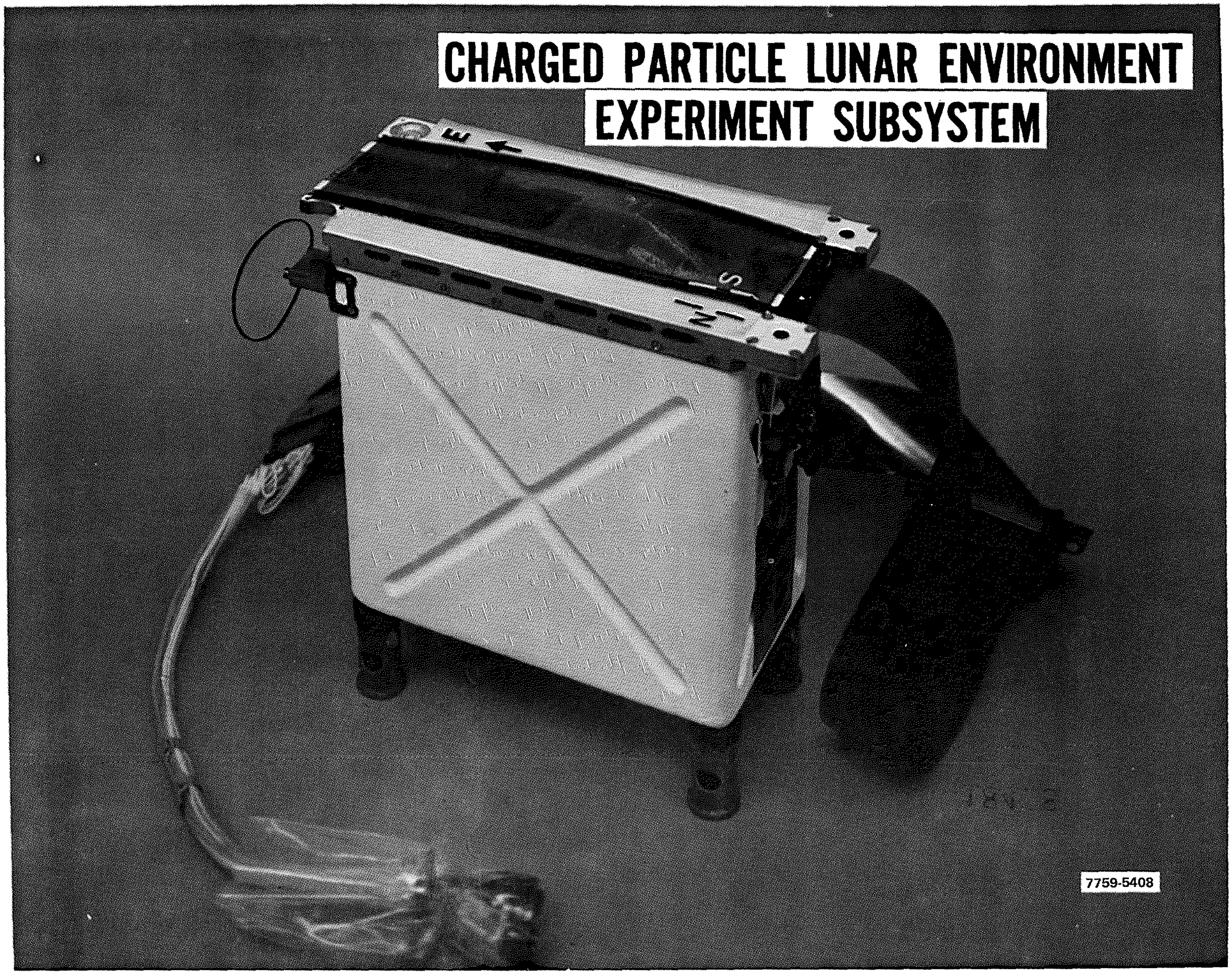
LRRR EXPERIMENT TEST SUMMARY (CONT')

- QUALIFICATION MODEL
  - MASS PROPERTIES
  - VIBRATION (ACCEPTANCE AND DESIGN LIMIT LEVELS)
  - SHOCK
  - ACCELERATION
  - MECHANICAL FUNCTIONAL DEPLOYMENT
  - THERMAL/VACUUM
- FLIGHT MODEL
  - MASS PROPERTIES
  - VIBRATION (ACCEPTANCE LEVELS)
  - ALSEP TUMBLE
  - MECHANICAL FUNCTIONAL DEPLOYMENT

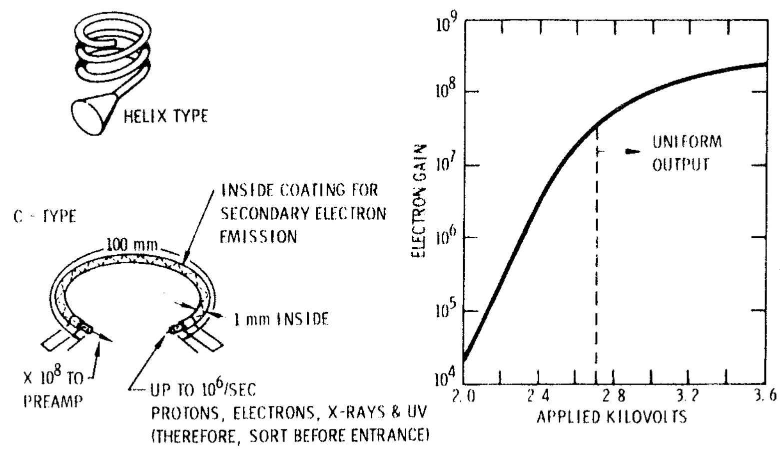
7759-5330

Section 6

Charged Particle Lunar Environment Experiment

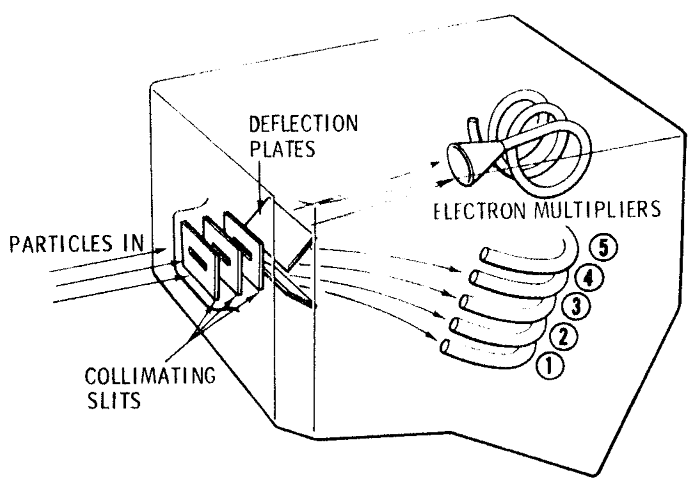

CHARGED PARTICLE LUNAR ENVIRONMENT
EXPERIMENT SUBSYSTEM
E
S
N
7759-5408

CHANNELTRON® ELECTRON MULTIPLIERS



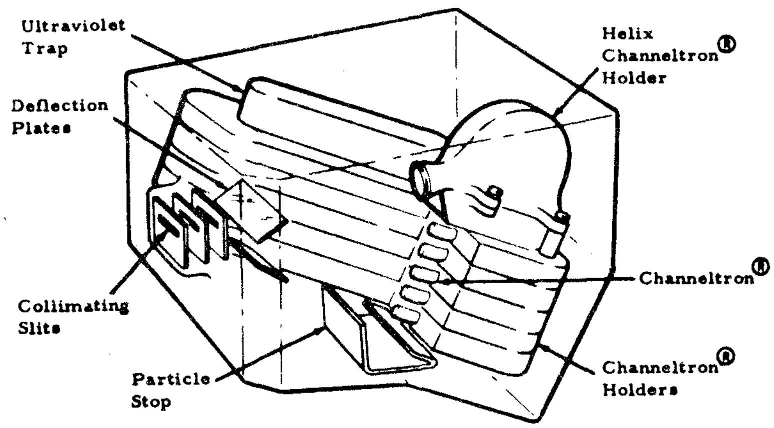
7759-5425

CPLEE PHYSICAL ANALYZER



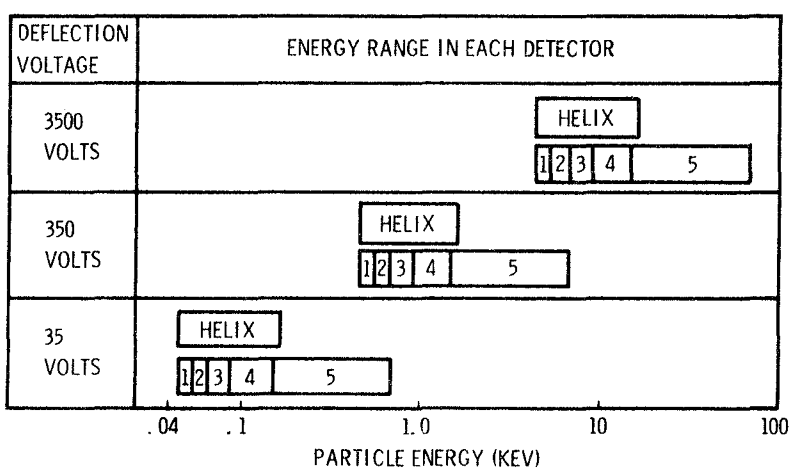
7759-5423

PHYSICAL ANALYZER



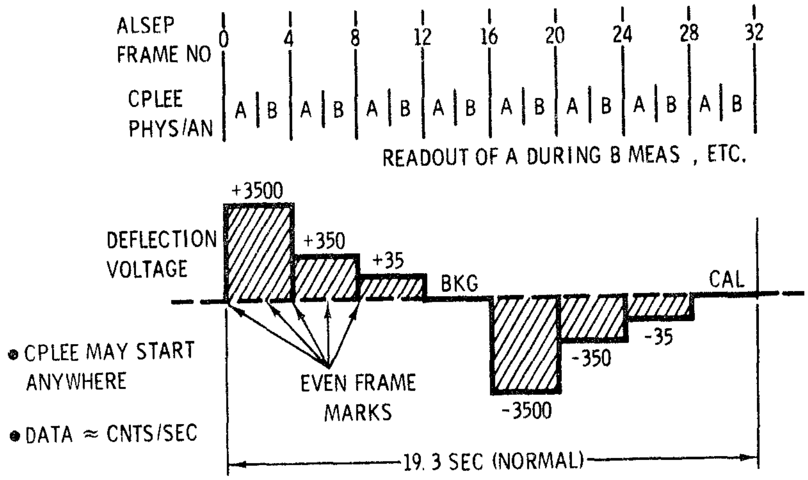
7759-5443

CPLEE ENERGY RANGES



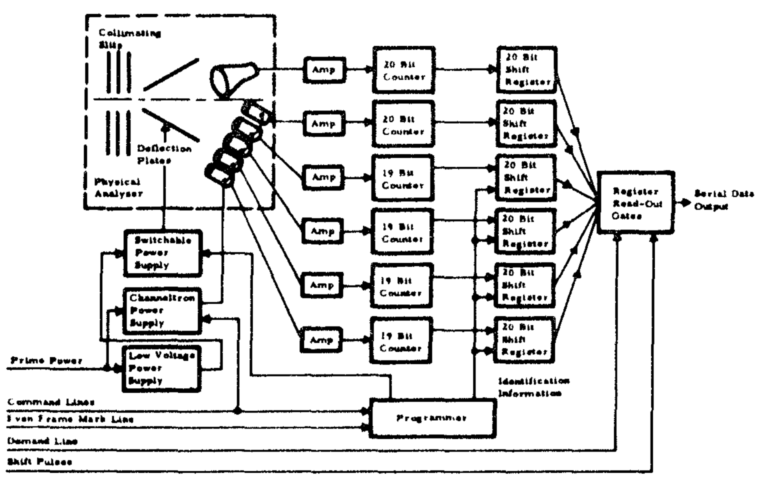
7759-5429

CPLEE TIMING SEQUENCE



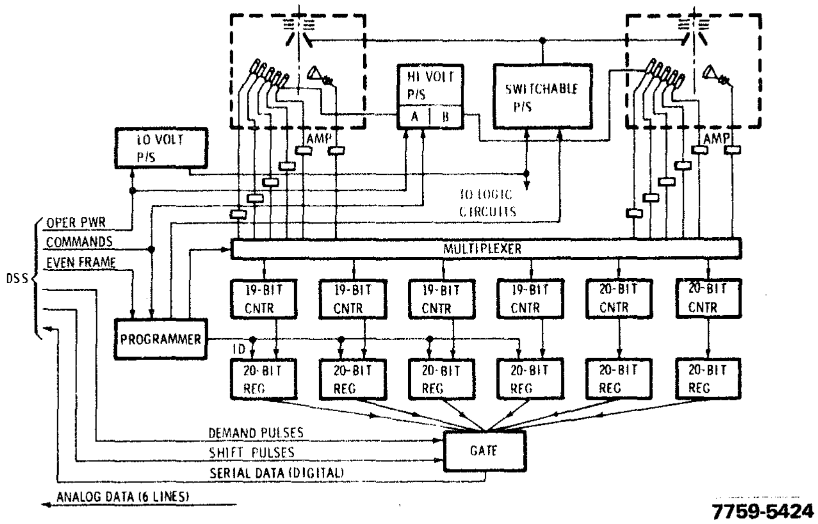
7759-5427

SIMPLIFIED BLOCK DIAGRAM OF CHARGED PARTICLE EXPERIMENT



7759-5445

CPLEE FUNCTIONAL DIAGRAM



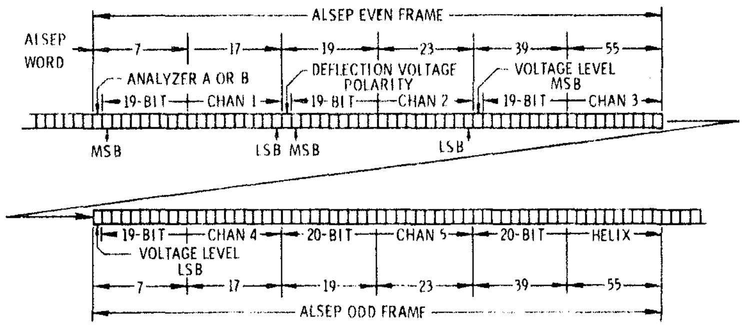
7759-5424

DIGITAL DATA OUTPUT FORMAT
CHARGED PARTICLE EXPERIMENT

ALSEP T/M Frame	1st Frame						2nd Frame					
CLPEE Word Number	1	2	3	4	5	6	1	2	3	4	5	6
No. of Count Data Bits	19		19		19		19		20		20	
No. of I. D. Bits	1		1		1		1		-		-	
Channeltron® Detector	No. 1		No. 2		No. 3		No. 4		No. 5		No. 6	
I. D. Bit Assignment	Analyzer A or B		Deflection Voltage Polarity		Deflection Voltage Level				——			

7759-5449

CPLEE DIGITAL DATA FORMAT

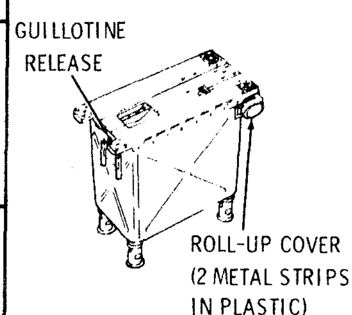


DC-01	THROUGH	DC-34	CPE DET SCI DATA
DC-85	THROUGH	DC-96	CPE CAL SIG
	DC - 97		CPE PHYS/AN ID
	DC - 98		CPE POLARITY ID
	DC - 99		CPE DEF LVL ID

7759-5432

CPLEE PERFORMANCE CHECKS

TECHNIQUE	CNT/SEC
BETA SOURCE IN DUST COVER FOR COMPLETE TEST DURING INITIAL OPERATION	0 TO 2000 (DEPENDING ON CHANNEL)
TEST OSCILLATOR INPUT TO ALL PREAMPS ONCE DURING EACH OPERATING CYCLE	≈350,000 Hz (FILLS 19TH BIT OF REGISTER)



7759-5430

CHARGED PARTICLE EXPERIMENT CHARACTERISTICS

COMMUNICATIONS

COMMANDS:	DATA:
• POWER OPER/STBY/OFF • 8 SPECIAL CMDs FOR: DUST COVER REMOVAL (1) AUTO/CMD THERMAL CONTROL (2) AUTO/CMD VOLTAGE PROGRAM TO SENSOR (3) CHANGE SENSOR GAIN (2) • BACKUP FROM TIMER TO REMOVE DUST COVER	• 6 DIGITAL WORDS PER ALSEP FRAME 99 BPS (APPROX) 97% SCIENCE, 3% HK 19.3 SEC NORMAL REP RATE • 6 ANALOG ENG PARAMETERS SAMPLED ONCE PER 54-SEC ALSEP SEQUENCE
DISPLAY: PRINTER/TV	

7759-5420

COMMAND SIGNALS
CHARGED PARTICLE EXPERIMENT

1. Thermal Control Bypass - On
2. Thermal Control Bypass - Off
3. Dust Cover Removal
4. Automatic Deflection Voltage Level Sequence - On
5. Step Deflection Voltage Level
6. Automatic Deflection Voltage Level Sequence - Off
7. Channeltron P. S. Voltage Increase - On
8. Channeltron P. S. Voltage Increase - Off

7759-5450

CPLEE COMMANDS

OCTAL COMMAND NUMBERS

- 111 CPE OPR HTR ON

  THIS COMMAND BYPASSES THE THERMOSTAT IN THE CPLEE AND TURNS THE OPERATIONAL HEATER ON. TO RESTORE AUTOMATIC THERMAL CONTROL THE EXPERIMENT POWER MUST BE COMMANDED TO STBY AND BACK TO OPER. THIS COMMAND HAS NO CONTROL OVER SURVIVAL (STBY) HEATERS.

- 112 CPE OPR HTR OFF

  THIS COMMAND BYPASSES THE THERMOSTAT IN THE CPLEE AND TURNS THE OPERATIONAL HEATER OFF, AND IS ALSO 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. THIS COMMAND HAS NO CONTROL OVER SURVIVAL HEATERS. (OPERATIONAL HEATER ON/OFF VIA 111 & 112 CAN BE RECYCLED INDEFINITELY.)

7759-5434

CPLEE COMMANDS (CONT')

- 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

  THIS COMMAND ADVANCES THE VOLTAGE ON THE CPLEE DEFLECTION PLATES ONE STEP EACH TIME IT IS USED, IN THE STANDARD SEQUENCE, WHEN THE SEQUENCE HAS BEEN STOPPED. IF AUTOMATIC SEQUENCE IS ON, THIS COMMAND HAS NO EFFECT.

7759-5435

CPLEE COMMANDS (CONT')

- 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. IT IS RESTORED TO AUTOMATIC SEQUENCE BY COMMAND 114 OR BY CYCLING CPLEE TO STBY AND BACK TO OPER.

- 120 CPE CHAN/HI SEL

  THIS COMMAND INCREASES THE VOLTAGE ACROSS THE CHANNELTRON ® ELECTRON MULTIPLIERS IN BOTH PHYSICAL ANALYZERS (A & B) TO THE HIGHER VALUE, ≈ 3200 VOLTS, IF IT IS AT THE LOWER SETTING, ≈ 2800 VOLTS (Δ= 400 VOLTS). IF THIS COMMAND IS SENT TWICE, WITHOUT COMMAND 121 BETWEEN, THE SECOND COMMAND HAS NO EFFECT.

7759-5436

CPLEE COMMANDS (CONT')

- 121 CPE CHAN/LO SEL

  THIS COMMAND DECREASES THE VOLTAGE ACROSS THE CHANNELTRON ® ELECTRON MULTIPLIERS IN BOTH PHYSICAL ANALYZERS (A & B) TO THE LOWER VALUE, ≈ 2800 VOLTS, IF IT IS AT THE HIGHER SETTING, ≈ 3200 VOLTS (Δ= 400 VOLTS). IF THIS COMMAND IS SENT TWICE, WITHOUT COMMAND 120 BETWEEN, THE SECOND COMMAND HAS NO EFFECT.

7759-5437

ANALOG VOLTAGE HOUSEKEEPING SIGNALS CHARGED PARTICLE EXPERIMENT

1. Switchable Power Supply Voltage
2. Channeltron P. S. Voltage—Analyzer A
3. Channeltron P. S. Voltage—Analyzer B
4. Voltage P. S.
5. Temperature of Physical Analyzer A
6. Temperature of Switchable P. S.

7759-5446

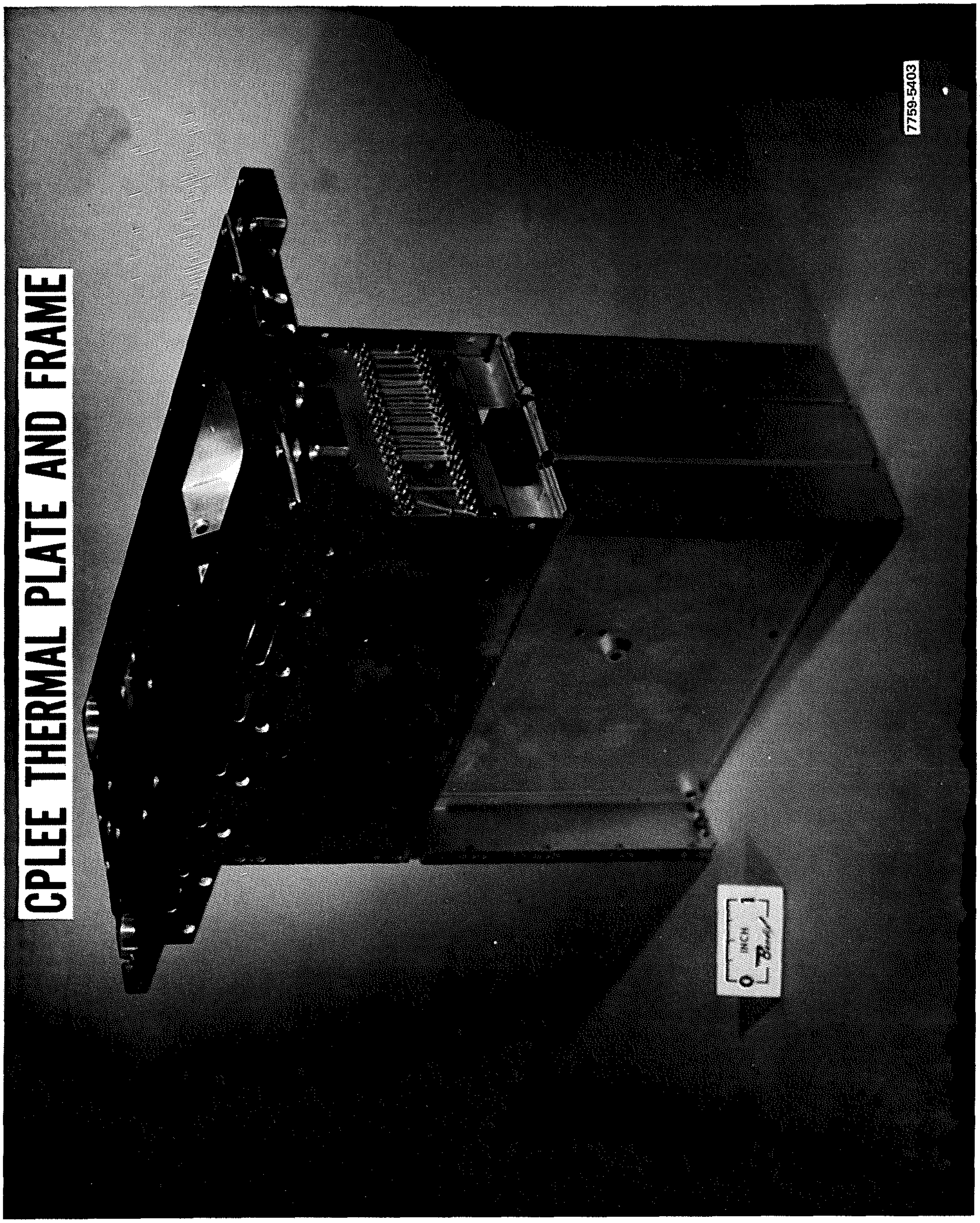
CPLEE ANALOG DATA

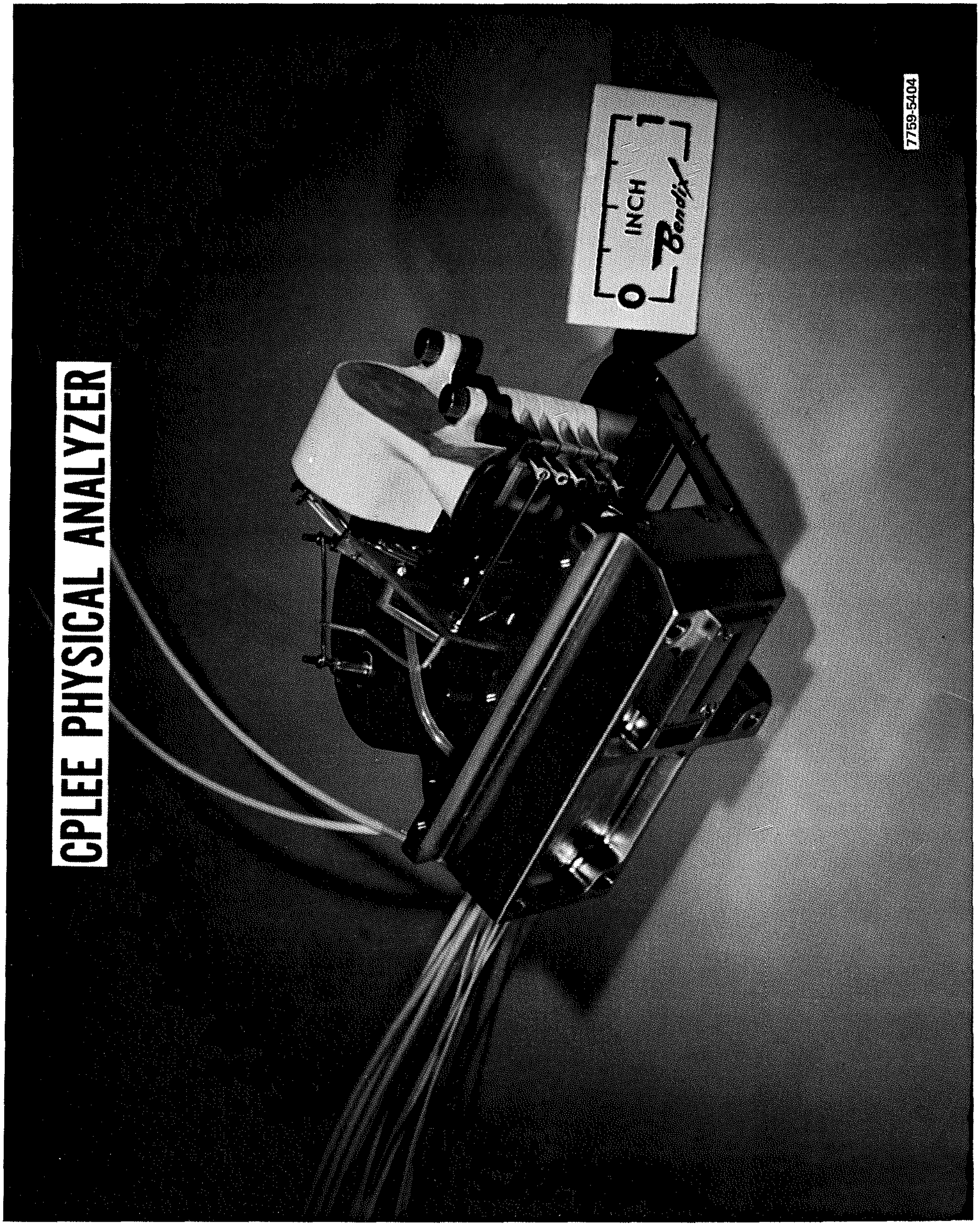
SAMPLED ONCE PER 54-SEC
ALSEP SEQUENCE (ALSEP WORD 33)

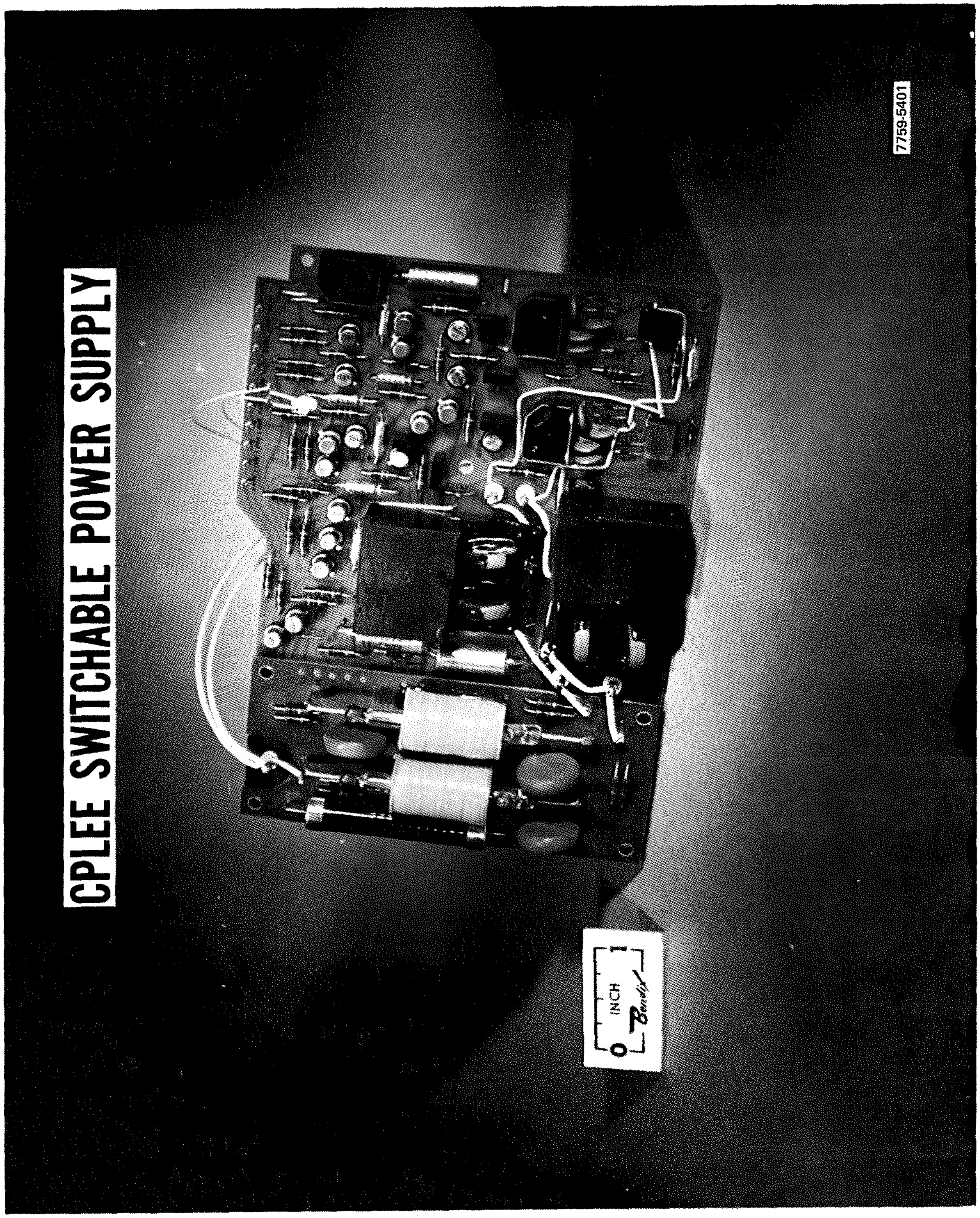
AC - 01	CPE	DEF P/S VOLTS
AC - 02	CPE	CHAN/1 VOLTS
AC - 03	CPE	CHAN/2 VOLTS
AC - 04	CPE	CONV VOLTS
AC - 05	CPE	PHYS/AN DEG C
AC - 06	CPE	DEF P/S DEG C

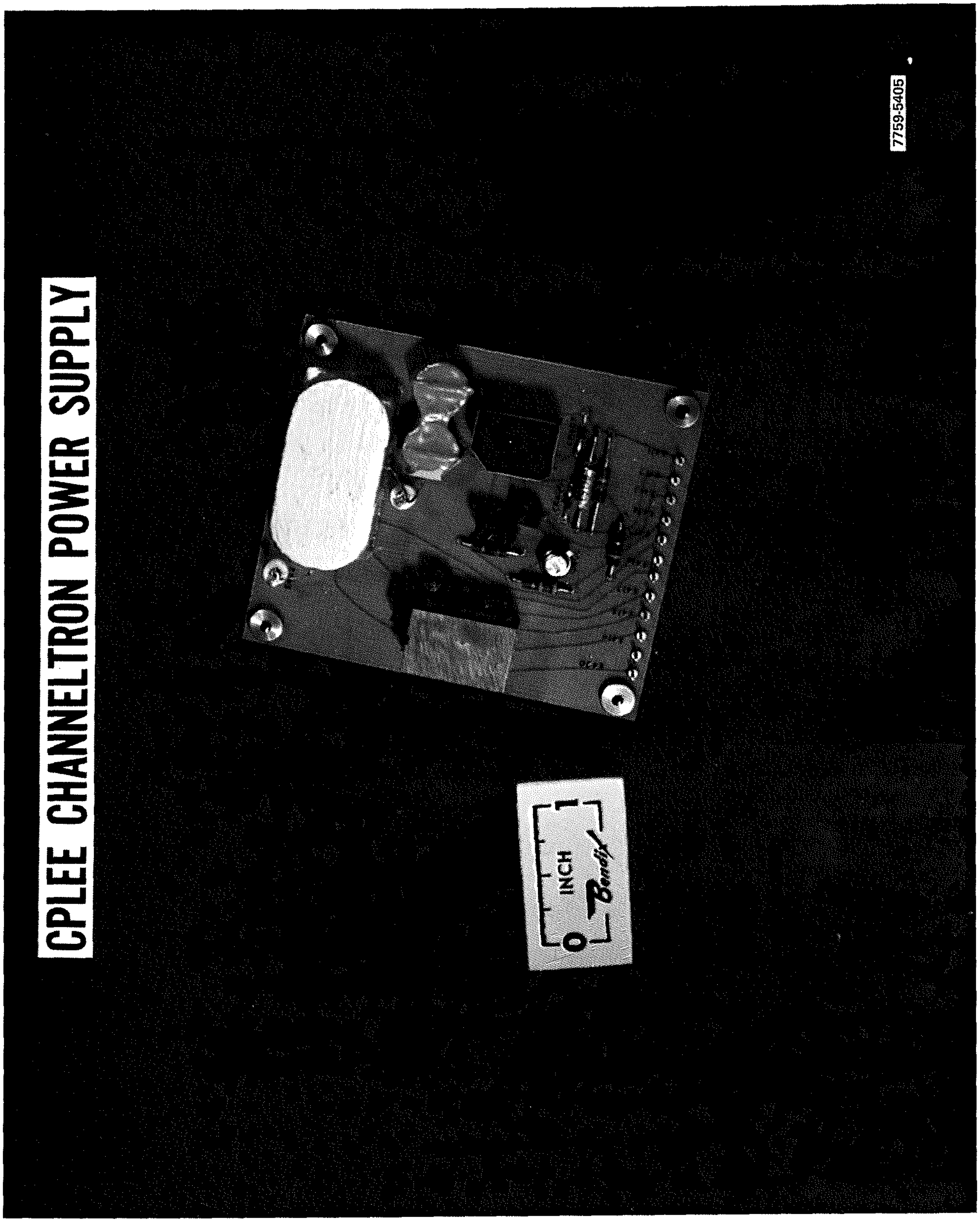
NOTE: AC - 05 IS TEMPERATURE OF PHYSICAL ANALYZER A

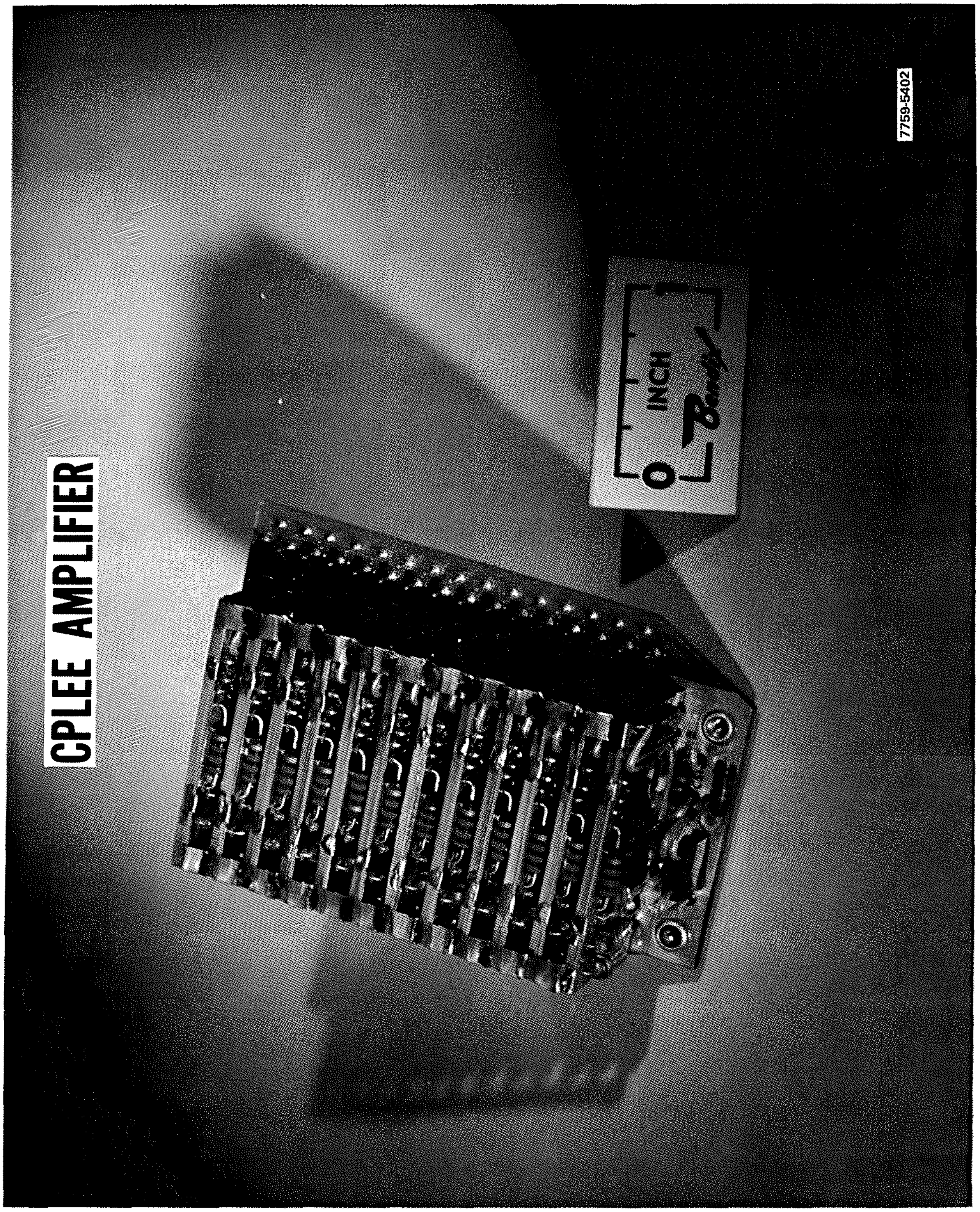
7759-5433

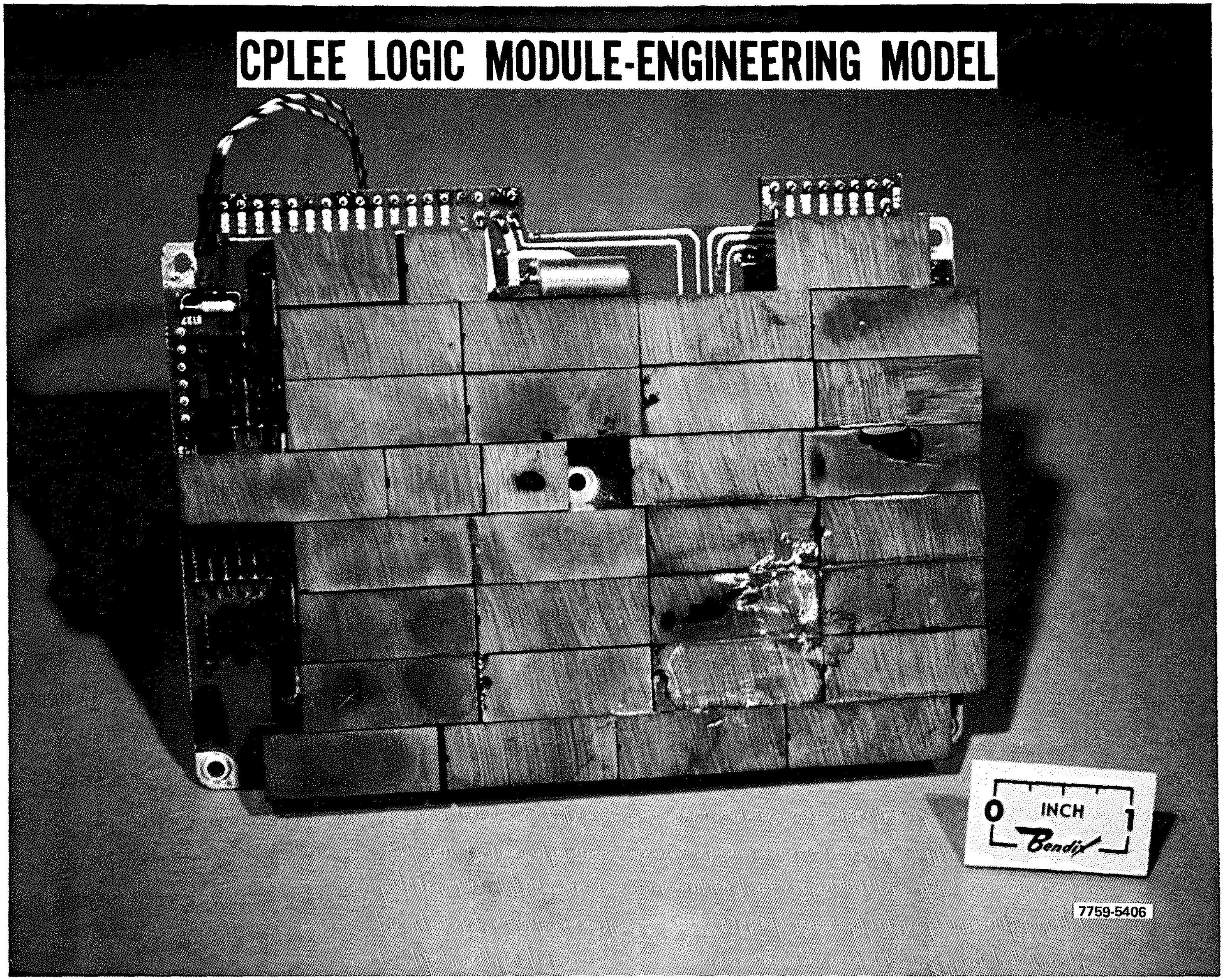

CPLEE THERMAL PLATE AND FRAME
7759-5403
INCH

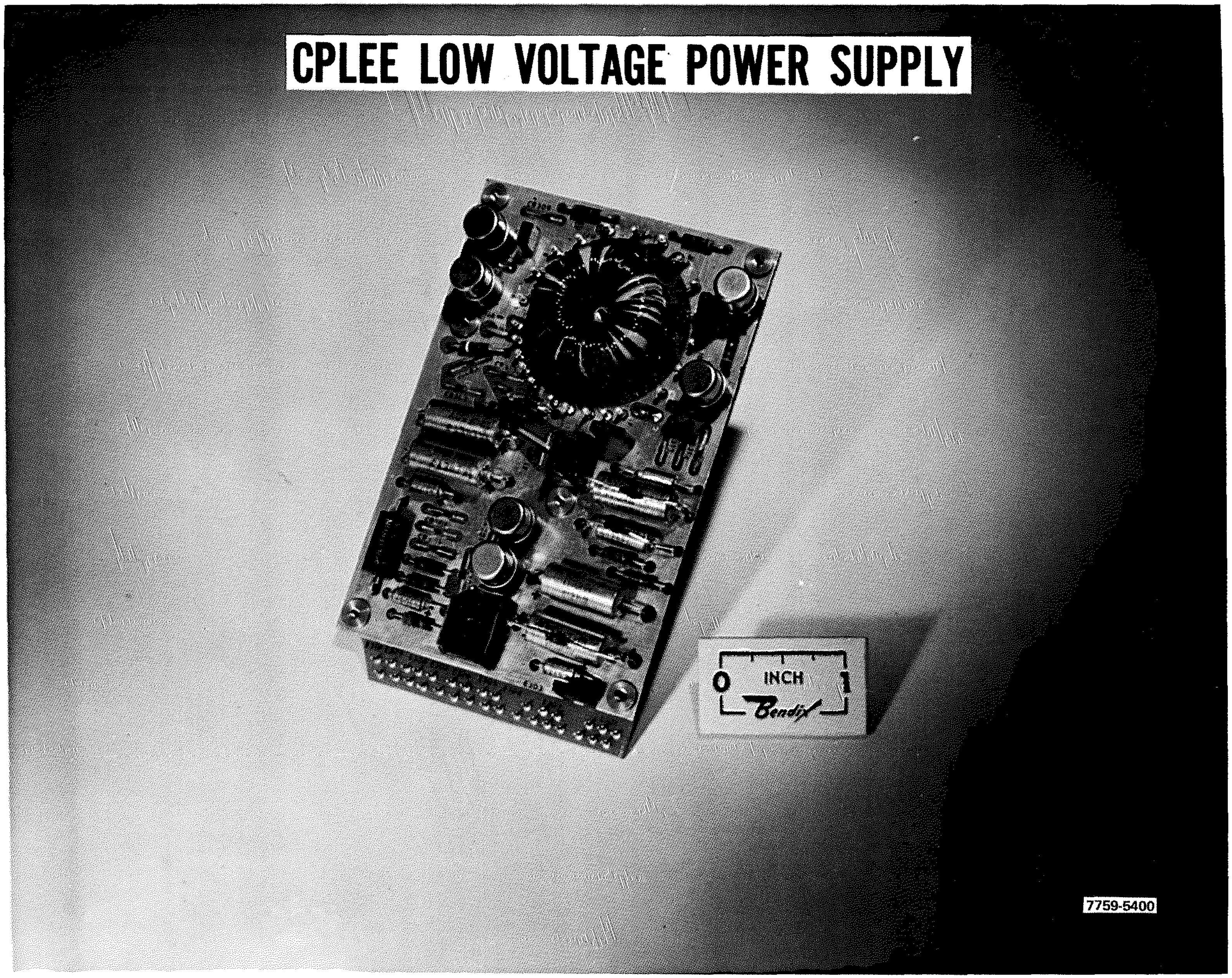

CPLEE PHYSICAL ANALYZER
0
INCH
1
Bendix
7759-5404


CPLEE SWITCHABLE POWER SUPPLY
7759-5401
0
INCH
1
Bendix

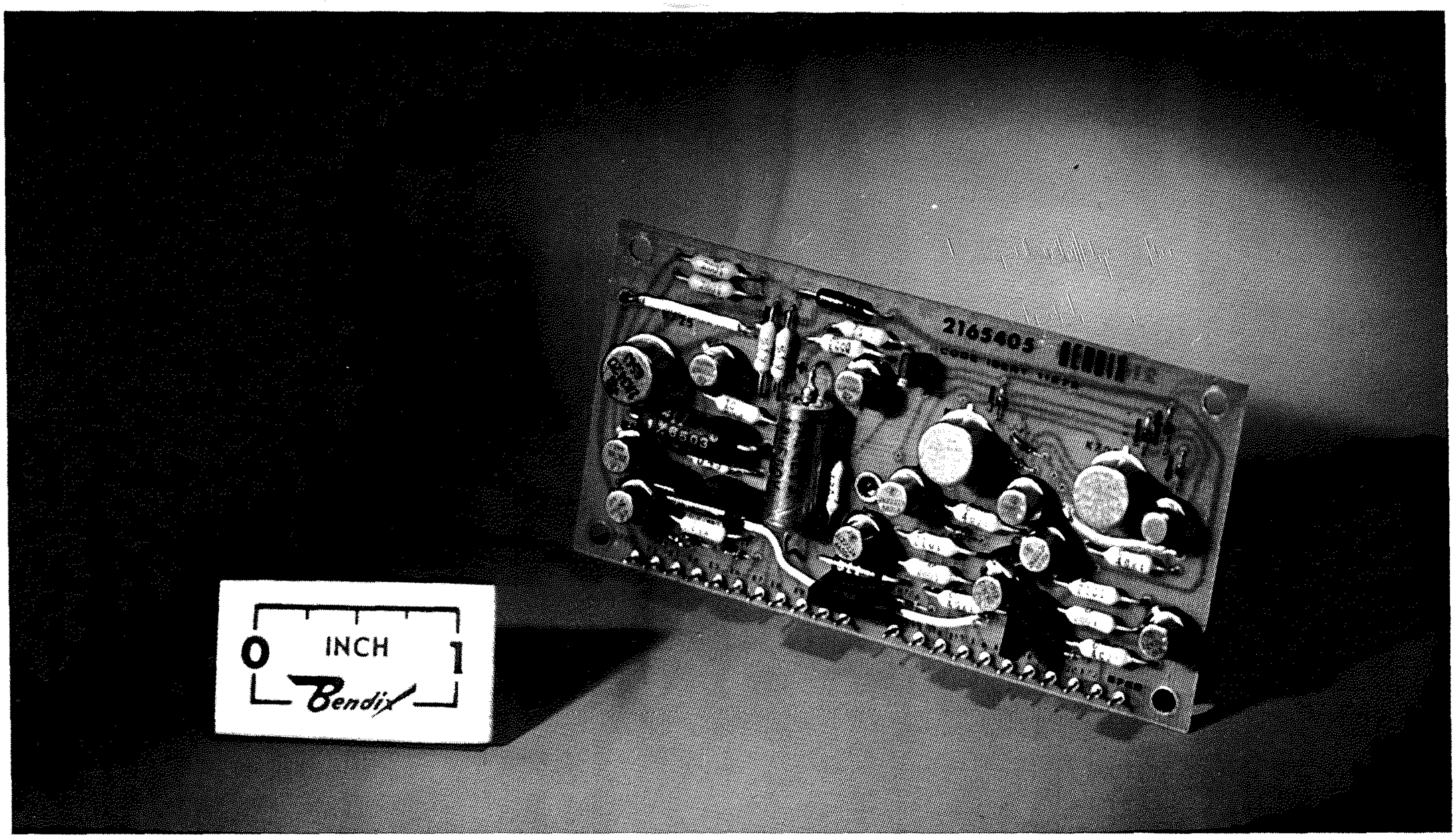

CPLEE CHANNELTRON POWER SUPPLY
7759-5405
0
INCH
1
Bendix


CPLEE AMPLIFIER
7759-5402
0
INCH
1

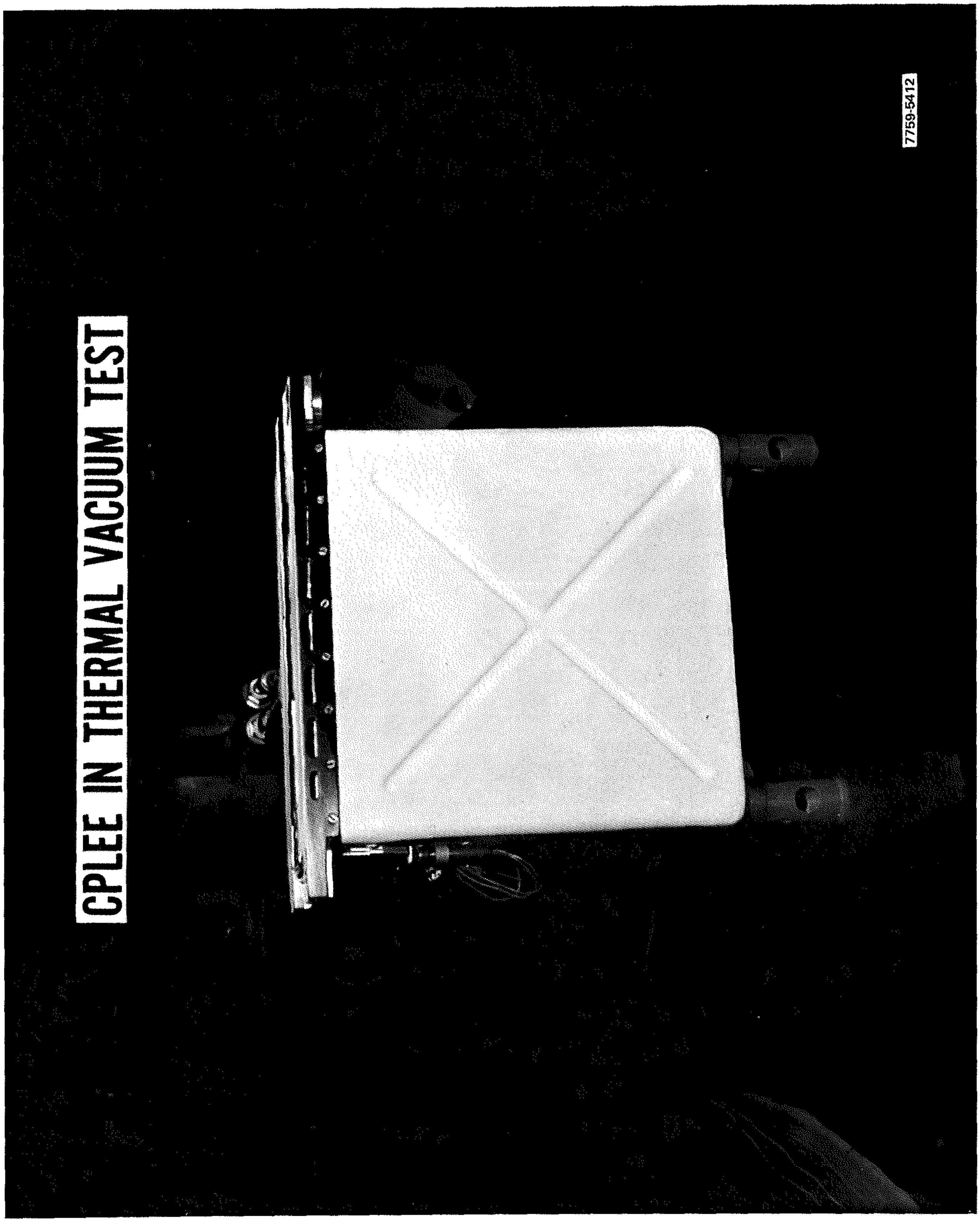

CPLEE LOGIC MODULE-ENGINEERING MODEL
0 INCH 1
Bendix
7759-5406

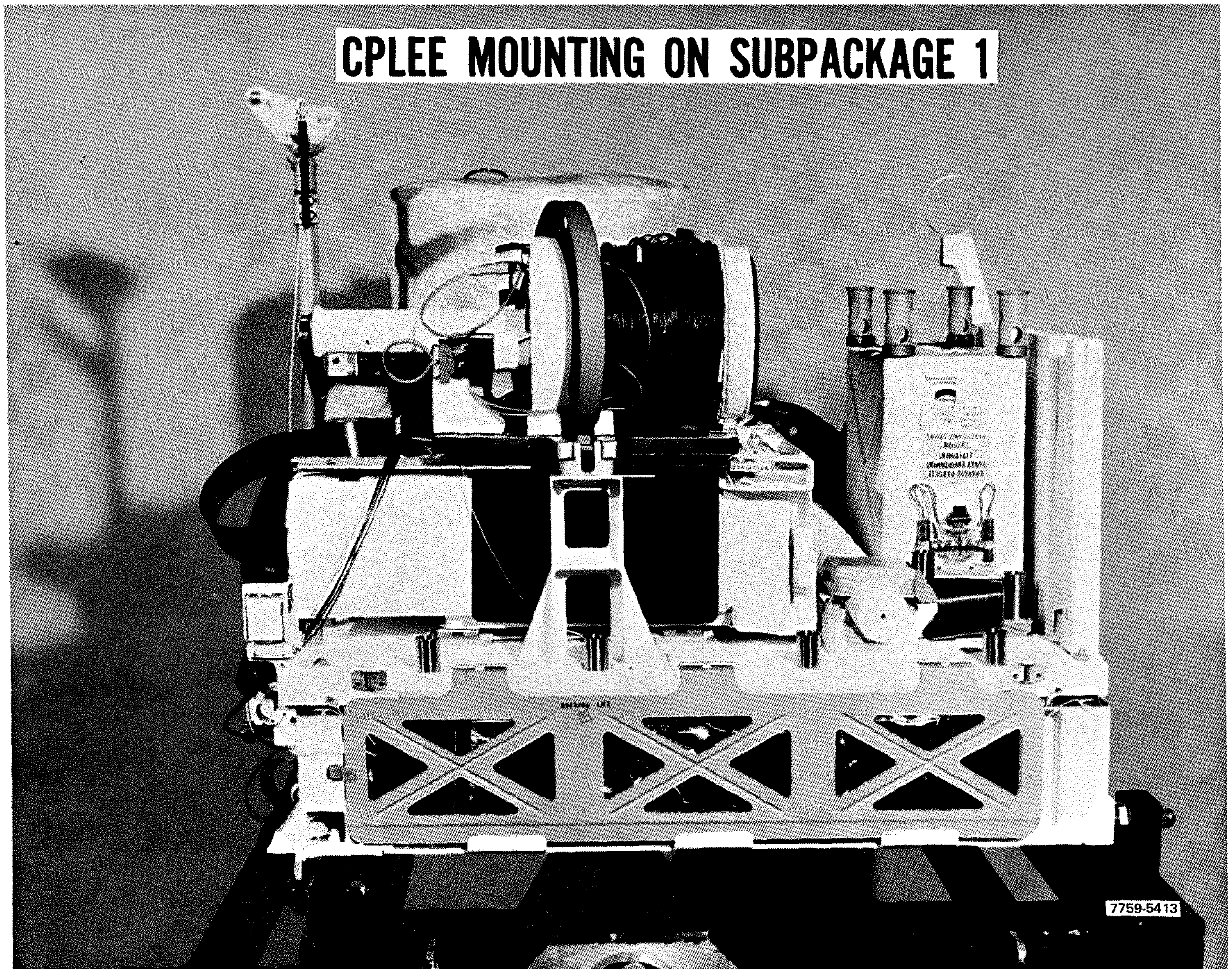

CPLEE LOW VOLTAGE POWER SUPPLY
0 INCH 1
Bendix
7759-5400

CPLEE ANCILLARY MODULE

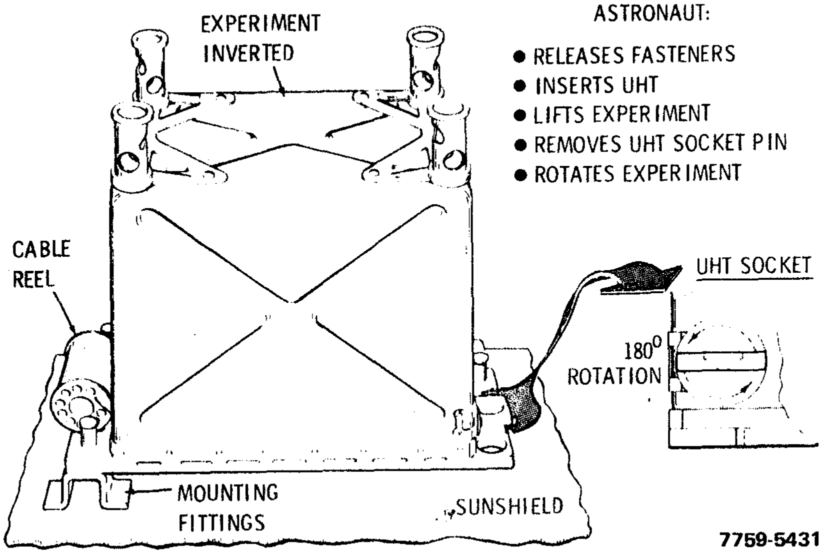


7759-5407


CPLEE IN THERMAL VACUUM TEST
7759-5412


CPLEE MOUNTING ON SUBPACKAGE 1
7759-5413

CPLEE TIE-DOWN



ASTRONAUT:

- RELEASES FASTENERS
- INSERTS UHT
- LIFTS EXPERIMENT
- REMOVES UHT SOCKET PIN
- ROTATES EXPERIMENT

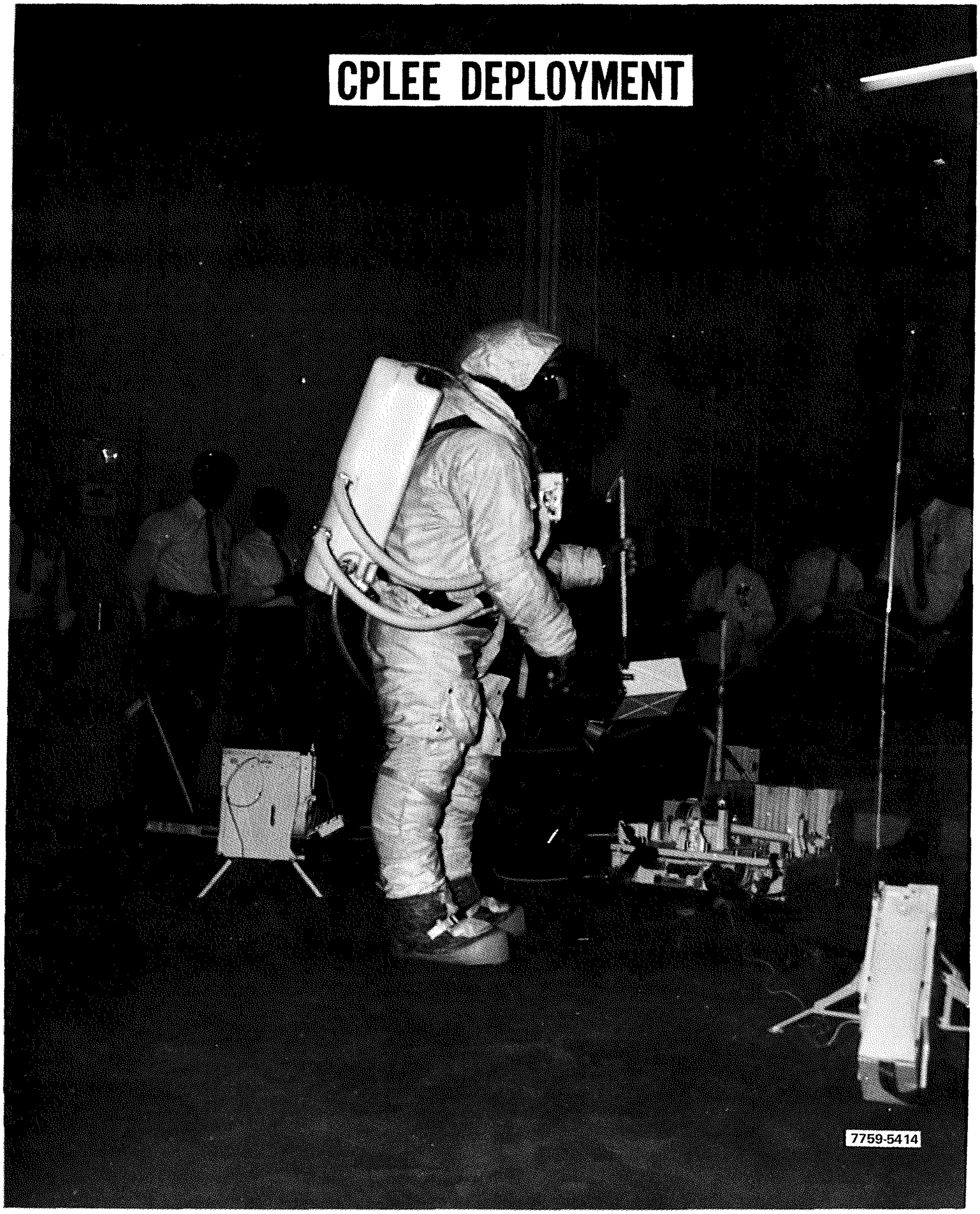
7759-5431

CHARGED PARTICLE EXPERIMENT CHARACTERISTICS

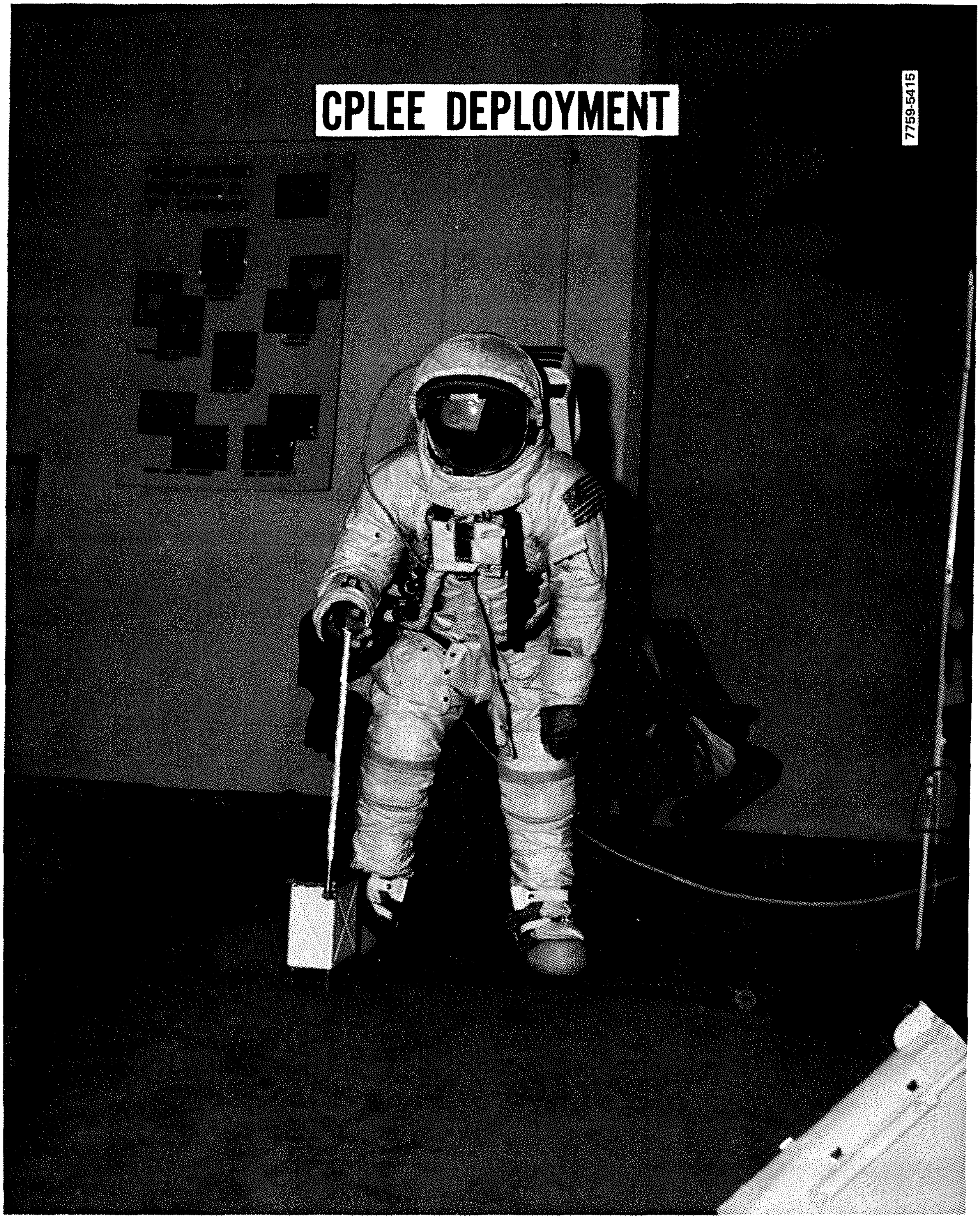
OPERATIONS

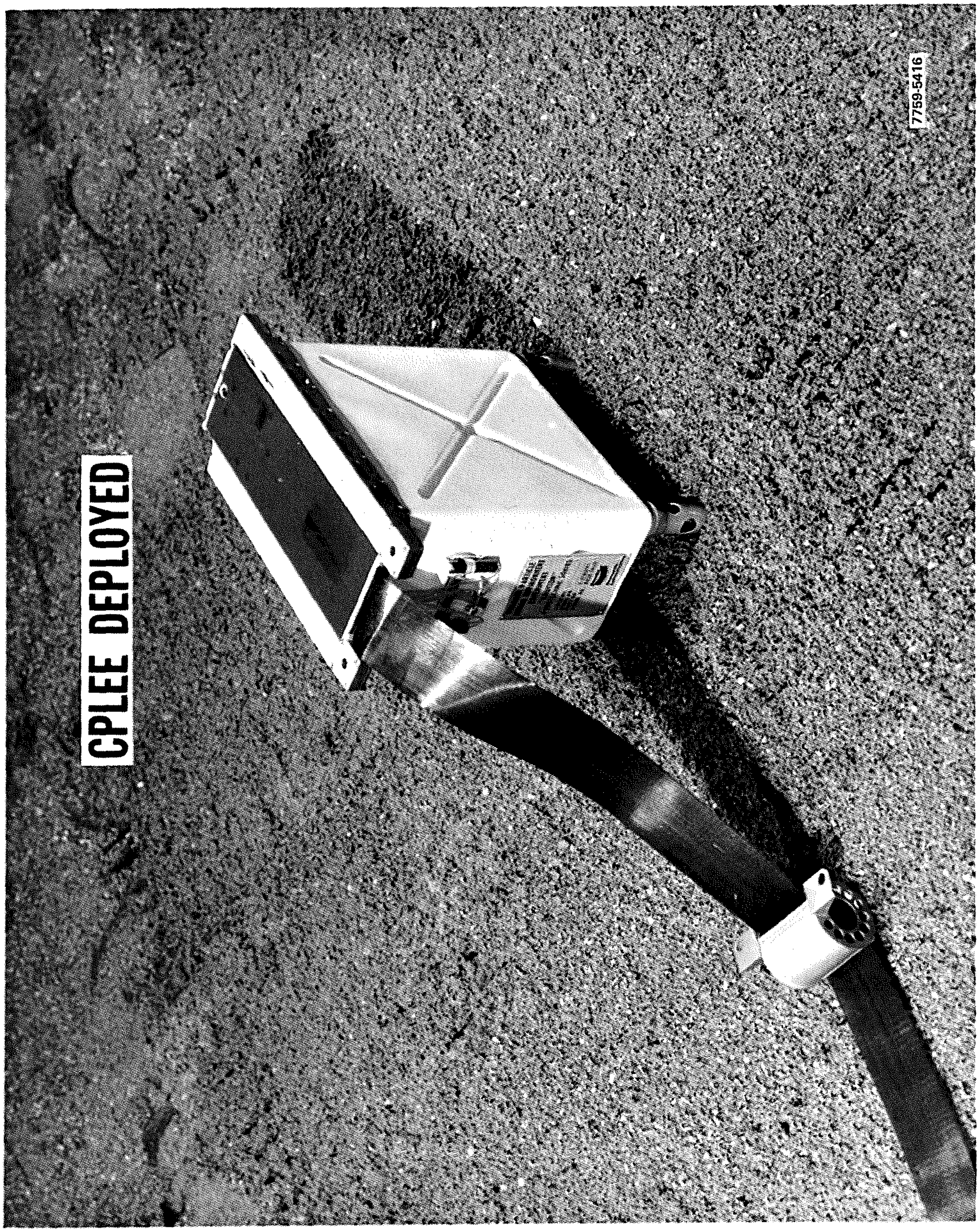
DEPLOYMENT	POST DEPLOYMENT
• LOCATE 10 FT FROM CENTRAL STATION • LEVEL ± 2.5 • ALIGN ± 2° WRT SHADOW (SCIENTIFIC & THERMAL) APPROX TIME, 2 MIN	• TURN ON (OPER) PRE-ASCENT • READ BASELINE DATA (COVER ON) • AFTER ASCENT REMOVE DUST COVER • CONTINGENCY CORRECTIVE ACTIONS

7759-5421

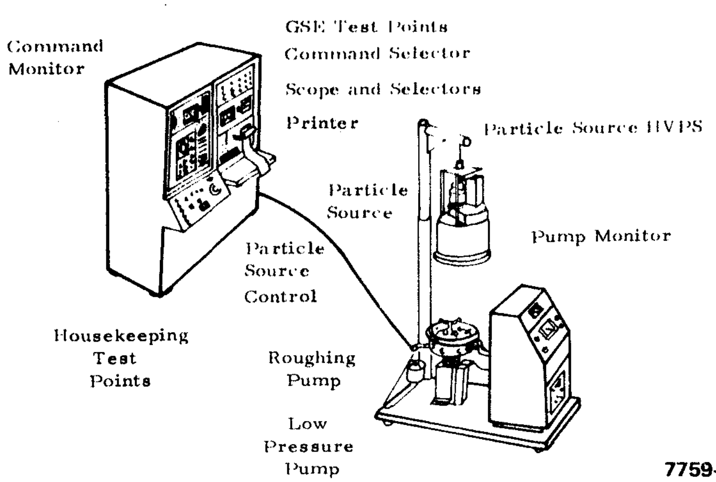


6-22


CPLEE DEPLOYMENT
7759-5415


CPLEE DEPLOYED
7759-5416

CPLEE TEST SET



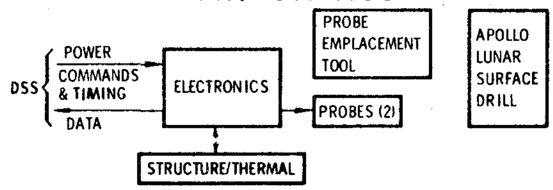
7759-5438

Section 7

Heat Flow Experiment

HEAT FLOW CHARACTERISTICS

COMPONENTS



PHYSICAL PARAMETERS

(NOT INC DRILL)

SIZE, IN: ELECTRONICS 13 x 9 x 8; PROBES 25.5 x 4.5 x 3.5 (IN PACKAGE)

EARTH WT, LB: 9.7 LB (TOTAL)

POWER, W: 3.9 TO 10.6

7759-5516

HEAT FLOW CHARACTERISTICS (CONT')

KEY FEATURES

- SENSOR CALIBRATION ON EARTH REQUIRES SPECIAL FACILITY
- AVOID DISTURBING LUNAR SURFACE REFLECTIVE PROPERTIES AROUND PROBES
- REQUIRES RADIATIVE THERMAL COUPLING BETWEEN PROBE & HOLE PLUS NO THERMAL SHORT-CIRCUIT TO SURFACE
- "THERMOSTATICALLY" CONTROLLED HEATER IN ELECTRONICS PACKAGE

7759-5517

HEAT FLOW CHARACTERISTICS

OPERATIONS

DEPLOYMENT	POST DEPLOYMENT
• LOCATE ELECTRONICS 30 FT FROM CENTRAL STATION • LEVEL $\pm 12°$ • ALIGN $\pm 5°$ WRT SHADOW (THERMAL) • DRILL HOLES (2) 3 METERS DEEP & PLACE PROBES IN BOTTOM OF HOLES USING TOOL • HOLES 30 FT APART & 16 FT FROM ELECTRONICS APPROX TIME, 9 MIN, PLUS 30 MIN FOR DRILLING	• TURN ON (OPER) PRE-ASCENT • READ GRADIENT DATA CONTINUOUSLY EXCEPT DURING CONDUCTIVITY TESTS • MAKE CONDUCTIVITY TESTS - TIMES FOR UP TO 48 HRS EACH TIME

7759-5518

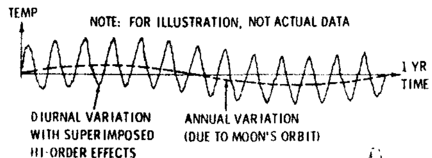
HEAT FLOW CHARACTERISTICS (CONT')

COMMUNICATIONS

COMMANDS:	DATA:
• POWER OPER/STBY/OFF • 10 SPECIAL CMDS FOR: SELECT GRADIENT, HI CONDUCTIVITY, OR LO CONDUCTIVITY MODES (3) SELECT MEASUREMENT SEQUENCE (6) SELECT & ACTIVATE CONDUCTIVITY HTRS (1)	• 1 DIGITAL WORD PER ALSEP FRAME (FOR 16 OUT OF EVERY 90 FRAMES) 3.0 BPS (APPROX) 65% SCIENCE, 35% HK 435 SEC REP RATE (FULL SEQUENCE) • 6 ANALOG ENG PARAMETERS SAMPLED ONCE PER 54 SEC ALSEP SEQUENCE
DISPLAY: X-Y PLOTTER OR PRINT (REQUIRES DATA ANALYSIS)	

7759-5519

HEAT FLOW SENSORS

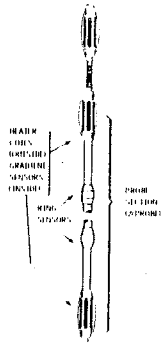


• PROBLEM: TO FIND THE SMALL DC COMPONENT IN A POSSIBLY LARGE AC WAVE

MODES OF OPERATION: MODE/G, MODE/LK, & MODE/HK PLUS MANY MEASUREMENT SEQUENCES

BASIC DATA WORD: 13-BIT OUTPUT OF ADC IN 2 ALSEP WORDS (PLUS ID)

TYPICAL BRIDGE READING (8 ALSEP WORDS):
(1) + EXCITATION
(2) + OUTPUT
(3) − EXCITATION
(4) − OUTPUT



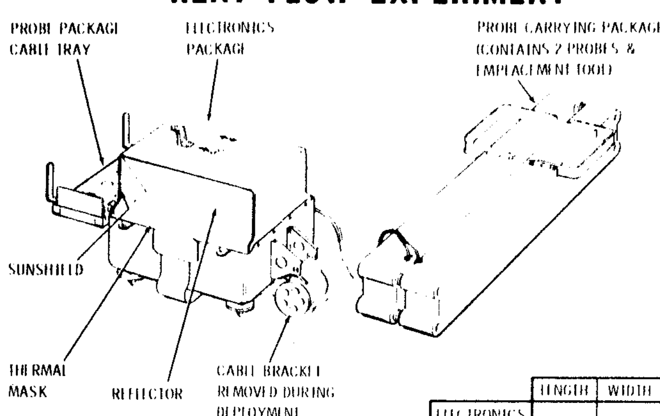
SENSOR TYPE: PLATINUM RESISTOR

SENSOR CIRCUITS:
- SETS OF FOUR SENSORS
- TWO COMBINATIONS (DIFFERENCE & AMBIENT) SELECTED BY INTERNAL LOGIC

DYNAMIC RANGE:
- TEMP DIFFERENCE (BRIDGE)
  HI SENSITIVITY ± 2° K (200° K TO 250° K)
  LO SENSITIVITY ±20° K (200° K TO 250° K)
- AMBIENT TEMP (RESISTANCE)
  200°K TO 250°K
- CABLE THERMOCOUPLES (ALONG PROBE CABLES)
  90°K TO 350°K (ACCURACY 0.3 C)
- THERMOCOUPLE REF JUNCTION (IN ELECTRONICS)
  20° C TO +60° C (ACCURACY 0.1°C)
- CONDUCTIVITY RANGE 5×10^{-6} TO 1×10^{-3} CAL/CM SEC °C

7759-5520

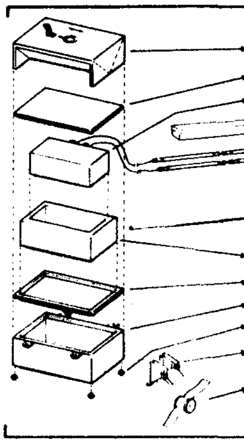
HEAT FLOW EXPERIMENT



	LENGTH	WIDTH	HEIGHT
ELECTRONICS PACKAGE	10	8	7.5
PROBE PACKAGE	25.5	3.5	5

7759-5521

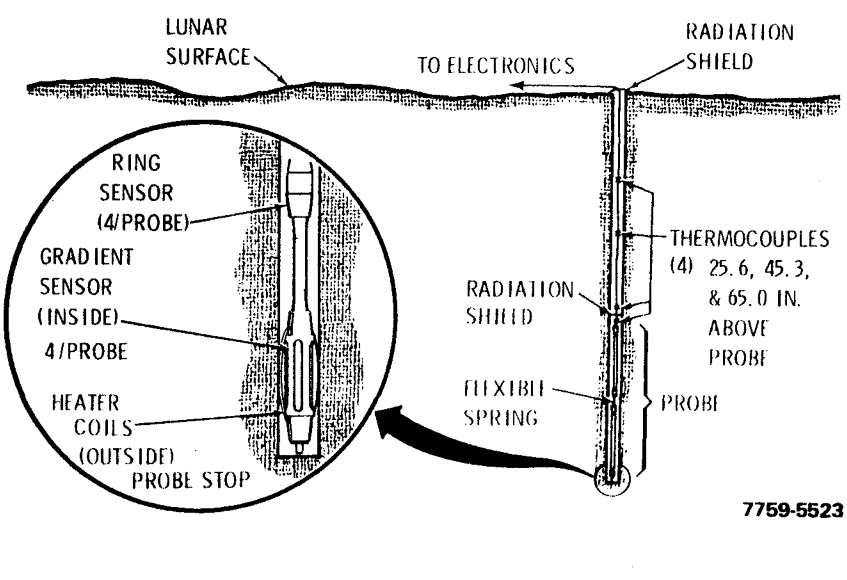
HFE SIZE AND WEIGHT



COMPONENT	SIZE, IN.	EARTH WT, LB
SUNSHIELD	10 x 6 x 4	.37
THERMAL PLATE	10 x 8 x 0.08	.40
ELECTRONICS	9 x 7 x 2.07	3.30
PROBE PACKAGE	25.5 X 4.5 X 3.5	
PROBES (2), EACH	1 DIA x 43 LONG	3.67
EMPLACEMENT TOOL (FULLY EXTENDED)	88 LONG	
THERMAL BAG	9.5 x 7.5 x 2.57	.30
INSULATING RING	10 x 8 x 0.4	.57
OUTER CASE	10 x 8 x 3.5	.46
LEGS (4)	0.75 x 0.75	.16
CABLE REEL SUPPORT, ETC.		.23
CABLE REEL	2.57 DIA x 2.6 LONG	.16
SCREWS, WASHERS, ETC.		.08
TOTAL		9.70

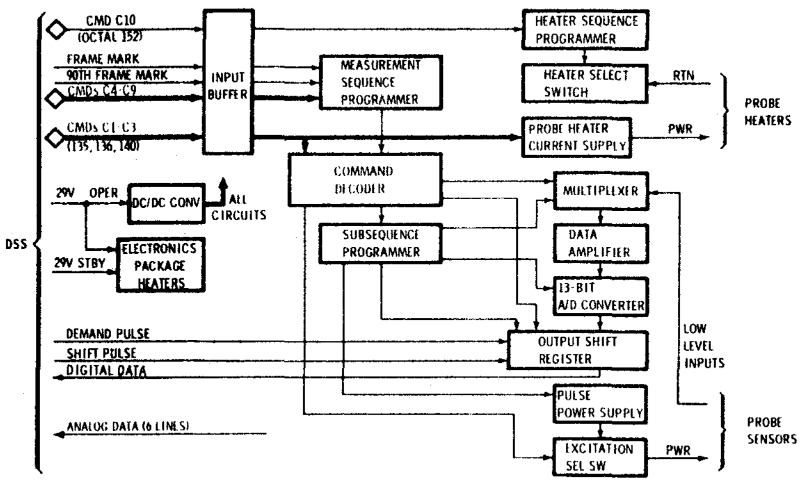
7759-5522

HFE PROBE DETAILS



7759-5523

HFE FUNCTIONAL DIAGRAM



7759-5524

HFE MODES OF OPERATION

	MODE: G, NORMAL GRADIENT (MODE 1)	LK, LOW CONDUCTIVITY (MODE 2)	HK, HIGH CONDUCTIVITY (MODE 3)
MEASUREMENT SEQUENCES	A. FULL (ALL MEAS) B. PROBE 1 PROBE 2 C.* DIFFERENTIAL TEMP (HI EXCITATION) DIFFERENTIAL TEMP (LO EXCITATION) AMBIENT TEMP REF JUNCTION TEMP & CABLE THERMOCOUPLES D. COMBINATIONS OF B & C	SAME AS GRADIENT	DIFFERENTIAL & AMBIENT TEMP FOR ONE BRIDGE (DEPENDING ON SELECTED HEATER)
BRIDGE SENSORS	GRADIENT	GRADIENT	RING (OR "REMOTE")
HEATERS	NONE	RING SOURCE	HEAT PULSE

*THESE MODES USED PRIMARILY FOR TESTS

7759-5525

HFE COMMAND SUMMARY

CMD HFE	NUMBERS OCTAL		
C1	135	HFE MODE/G SEL*	INITIALIZED TO THESE CONDITIONS AT POWER TURN-ON
C2	136	HFE MODE/LK SEL	
C3	140	HFE MODE/HK SEL	
C4	141	HFE SEQ/FUL SEL*	
C5	142	HFE SEQ/P1 SEL	
C6	143	HFE SEQ/P2 SEL	
C7	144	HFE LOAD 1	MEASUREMENT SELECT (ENCODED)
C8	145	HFE LOAD 2	
C9	146	HFE LOAD 3	
C10	152	HFE HTR STEPS	

INPUT BUFFER HOLDS COMMANDS FOR EXECUTION AT 90-FRAME MARK

7759-5526

HFE DIGITAL DATA FORMAT

ALSEP FRAME 90, 8 | 1, 9

R_2	R_1	0	P_4	P_3	P_2	P_1	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

(00) MEASUREMENT (SEQUENCE) REGISTER

2, 10 | 3, 11

R_2	R_1	M_1	M_2	M_3	0	0	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

(01) MODE REGISTER — HFE SCIENCE DATA (TYPICAL)

4, 12 | 5, 13

R_2	R_1	H_4	H_3	H_2	H_1	0	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

(10) CONDUCTIVITY HEATER REGISTER

6, 14 | 7, 15

R_2	R_1	0	0	0	0	0	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

(11) SUBSEQUENCE REGISTER (WORD ID)

7759-5527

HFE MODE REGISTER

THE MODE REGISTER IS PART OF THE HFE CMD DECODER AND RESPONDS TO CMDs 135, 136 AND 140. THE STATE OF THIS REGISTER IS READ OUT VIA TM

OCTAL	ABBR	HFE	MODE	TM $(M_1M_2M_3)$
135	MODE/G	MODE 1	NORMAL GRADIENT	100
136	MODE/LK	MODE 2	LOW CONDUCTIVITY	010
140	MODE/HK	MODE 3	HIGH CONDUCTIVITY	001

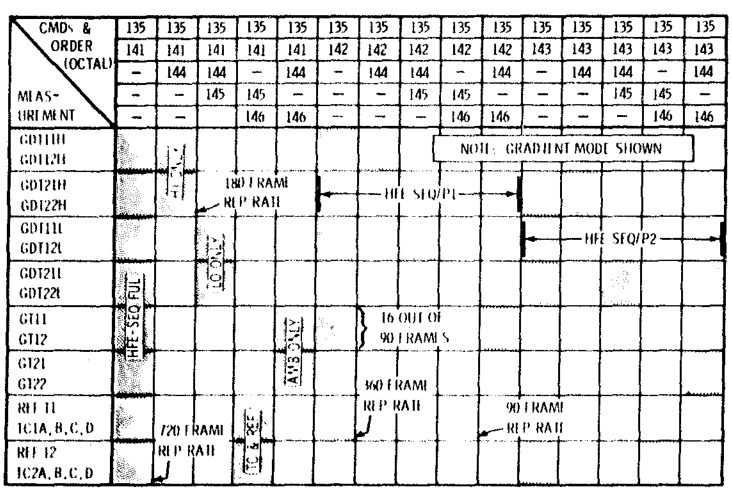
THE MODE SELECTED BY CMD AFFECTS THE DATA AS FOLLOWS:

MODE/G AND MODE/LK HAVE IDENTICAL TM (FORMATTED BY THE MEASUREMENT SEQUENCE PROGRAMMER AND SUBSEQUENCE PROGRAMMER) BUT IN MODE/LK THE PROBE HEATER CURRENT SUPPLY IS TURNED ON AND HEATERS RESPOND TO CMD 152.

MODE/HK BYPASSES THE MEASUREMENT SEQUENCE PROGRAMMER AND PRODUCES A SPECIAL TM OUTPUT FORMATTED BY THE SUBSEQUENCE PROGRAMMER AND HEATER SEQUENCE PROGRAMMER.

7759-5528

HFE GRADIENT MEASUREMENT OPTIONS



7759-5529

7-7

HFE MEASUREMENT SEQUENCE PROGRAMMER

THE MEASUREMENT SEQUENCE PROGRAMMER (MSP) IS A 16-STATE BINARY COUNTER USING 4 FLIP-FLOPS. ITS OPERATION CAN BE MODIFIED BY CMD TO PERFORM 8-STATE, 4-STATE, AND 2-STATE PROGRAMS. THE FLIP-FLOPS HAVE DUAL FUNCTIONS:

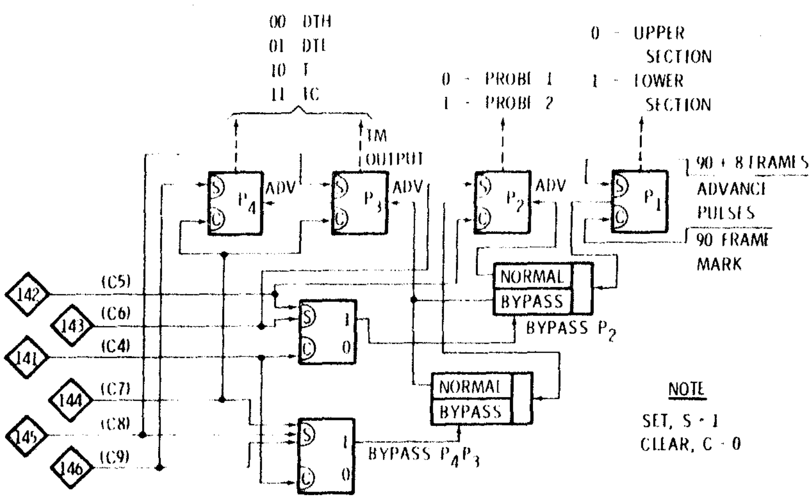
- FORMAT HFE DATA BY CONTROLLING GATES TO THE OUTPUT REGISTER
- SUPPLY MSP STATUS DATA FOR TM (P-BITS)

NOTE THAT EXECUTION OF A MEASUREMENT CMD (141 THROUGH 146) DOES NOT RESET MSP. OPERATION CONTINUES FROM PREVIOUS STATE.

IN DIAGRAM, THE SET (5) AND CLEAR (C) POSITIONS OF THE FLIP-FLOPS CORRESPOND TO ONE AND ZERO IN THE TM.

7759-5530

HFE MSP DIAGRAM



7759-5531

HFE SUBSEQUENCE PROGRAMMER

THE SUBSEQUENCE PROGRAMMER IS A 4-STATE COUNTER HAVING DUAL FUNCTIONS:

- CONTROL GATING OF DATA, WITHIN A SUBSET, TO THE OUTPUT REGISTER: (WHERE THE TYPE OF SUBSET IS CONTROLLED BY THE MSP)
- SUPPLY SUBSEQUENCE REGISTER STATUS DATA FOR TM (R-BITS)

THE STATE OF R_2R_1 CHANGES EVERY OTHER ALSEP FRAME (ONE 10-BIT WORD OF HFE DATA IN EACH ALSEP FRAME) STARTING WITH A RESET AT THE 90-FRAME MARK

THE TRANSITION FROM 11 TO 00 BETWEEN 7 AND 8 MARKS THE 90 + 8 FRAME. THIS ADVANCES P_1 FROM ZERO TO ONE

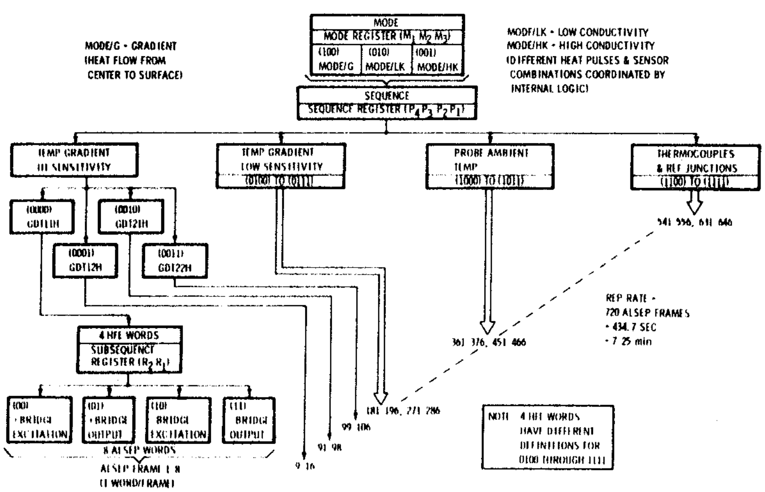
R_2 R_1	ALSEP	FRAME NO
00	90, 1	8, 9
01	2, 3	10, 11
10	4, 5	12, 13
11	6, 7	14, 15

R_2R_1 READ OUT AS FIRST TWO BITS IN EVEN NUMBERED ALSEP FRAME

FROM ALSEP FRAME 16 TO 89 THERE IS NO HFE DATA AND REGISTER CHANGES ARE INHIBITED

7759-5532

HFE TIMING FUNCTIONS



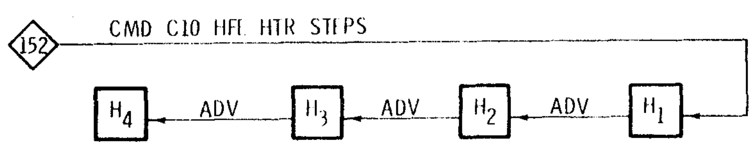
7759-5533

HFE GRADIENT MEASUREMENT INDEX

SYMBOL	ABBR	P-BITS	DATA SOURCE	PROBE/ BRIDGE	EXCITATION (SENSITIVITY)	(R_2R_1) SUBSET DATA
DH-01	GDT 11H	0000	DIFFERENTIAL BRIDGE (GRADIENT SENSORS)	1/UPPER	HIGH VOLTAGE	(00) + BRIDGE EXCITATION
DH-02	GDT 12H	0001		1/LOWER		(01) + BRIDGE OUTPUT
DH-03	GDT 21H	0010		2/UPPER		(10) - BRIDGE EXCITATION
DH-04	GDT 22H	0011		2/LOWER		(11) - BRIDGE OUTPUT
DH-05	GDT 11L	0100		1/UPPER	LOW VOLTAGE	(00) + BRIDGE CURRENT
DH-06	GDT 12L	0101		1/LOWER		(01) + BRIDGE OUTPUT
DH-07	GDT 21L	0110		2/UPPER		(10) - BRIDGE CURRENT
DH-08	GDT 22L	0111		2/LOWER		(11) - BRIDGE OUTPUT
DH-09	GT 11	1000	(RESISTANCE)	1/UPPER	HIGH VOLTAGE	(00) + BRIDGE EXCITATION
DH-10	GT 12	1001		1/LOWER		(01) + BRIDGE CURRENT
DH-11	GT 21	1010		2/UPPER		(10) - BRIDGE EXCITATION
DH-12	GT 22	1011		2/LOWER		(11) - BRIDGE CURRENT
DH-13	REF T1	1100	REF JUNCTION BR		HV	SAME AS DH-01 TO DH-04
DH-14 DH-24 DH-34 DH-44	TC1 GROUP	1101	THERMOCOUPLES IN CABLE OF PROBE 1 WRT REF T1			(00) REF T1-TC1 (4) (01) TC1 (4) TC1 (1) (10) TC1 (4)-TC1 (2) (11) TC1 (4)-TC1 (3) (1) IS AT TOP AND (4) IS AT BOTTOM
DH-15	REF T2	1110	SAME AS DH-13		HV	SAME AS DH-01 TO DH-04
DH-16 DH-26 DH-46 DH-66	TC2 GROUP	1111	THERMOCOUPLES IN CABLE OF PROBE 2 WRT REF T2			(00) REF T2-TC2 (4) (01) TC2 (4)-TC2 (1) (10) TC2 (4)-TC2 (2) (11) TC2 (4)-TC2 (3) (1) IS AT TOP AND (4) IS AT BOTTOM

7759-5534

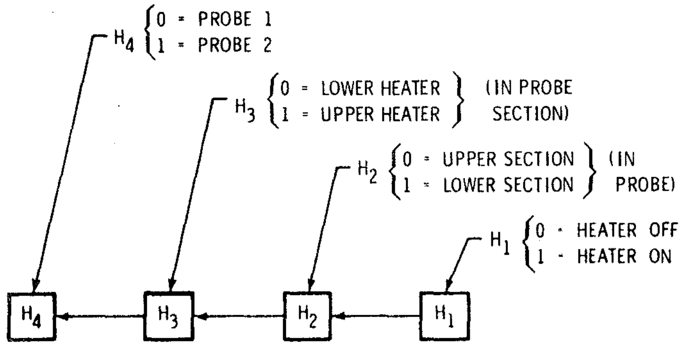
HFE HEATER SEQUENCE PROGRAMMER



- 16-STATE BINARY COUNTER USING 4 FLIP FLOPS
- STATUS TRANSMITTED IN TM AS H-BITS (ALL 3 MODES)
- EFFECT ON OPERATION AND DATA:
  - MODE/G – NO EFFECT (CAN BE ADVANCED VIA CMD 152 BUT PROBE HEATER CURRENT SUPPLY IS OFF)
  - MODE/LK – CONTROLS ON/OFF STATUS OF 8 HEATERS (4/PROBE) IN LOW MODE OF PROBE HEATER CURRENT SUPPLY
  - MODE/HK – CONTROLS DATA OUTPUT AND ON/OFF STATUS OF 8 HEATERS IN HIGH MODE OF PROBE HEATER CURRENT SUPPLY
- PROBE HEATER ON/OFF STATUS IN ANALOG TM (ALSEP WORD 33)

7759-5535

HFE HEATER SELECT CODE



$H_3 H_2$	HTR NUMBER
00	2
01	4 (BOTTOM)
10	1 (TOP)
11	3

EXAMPLE: WHEN H-BITS - 1011, HEATER H24 IS ON (WHERE H24 INDICATES FOURTH HEATER IN PROBE 2)

NOTE: THIS CODE APPLIES TO HEATER CONTROL IN BOTH MODE/LK AND MODE/HK

7759-5536

HFE MEASUREMENTS IN MODE/HK

SYMBOL	ABBR	PROBE	BRIDGE	$H_4H_3H_2H_1$	SYMBOL	ABBR	PROBE	BRIDGE	$H_4H_3H_2H_1$
DH 50	RDT 11	1	1	0000	DH 70	RDT 21	2	1	1000
DH 51	RT 11	1	1	0000	DH 71	RT 21	2	1	1000
DH 52	RDT 11	1	1	0001	DH 72	RDT 21	2	1	1001
DH 53	RT 11	1	1	0001	DH 73	RT 21	2	1	1001
DH 60	RDT 12	1	2	0010	DH 80	RDT 22	2	2	1010
DH 61	RT 12	1	2	0010	DH 81	RT 22	2	2	1010
DH 62	RDT 12	1	2	0011	DH 82	RDT 22	2	2	1011
DH 63	RT 12	1	2	0011	DH 83	RT 22	2	2	1011
DH 56	RDT 11	1	1	0100	DH 76	RDT 21	2	1	1100
DH 57	RT 11	1	1	0100	DH 77	RT 21	2	1	1100
DH 58	RDT 11	1	1	0101	DH 78	RDT 21	2	1	1101
DH 59	RT 11	1	1	0101	DH 79	RT 21	2	1	1101
DH 66	RDT 12	1	2	0110	DH 86	RDT 22	2	2	1110
DH 67	RT 12	1	2	0110	DH 87	RT 22	2	2	1110
DH 68	RDT 12	1	2	0111	DH 88	RDT 22	2	2	1111
DH 69	RT 12	1	2	0111	DH 89	RT 22	2	2	1111

- DATA ALTERNATES BETWEEN DIFFERENCE (BRIDGE) AND AMBIENT (RESISTANCE) MEASUREMENTS FOR THE SET OF RING SENSORS NEAREST THE SELECTED HEATER

ALSEP FRAMES	P_1 (a)	MEAS. TYPE (b)	ABBR (c)
0 TO 7	0	DIFFERENCE	RDTNN
8 TO 15	1	AMBIENT	RTNN

- NOTES

(a) P BITS, OTHER THAN P_1, ARE MEANINGLESS IN MODE/HK

(b) MEASUREMENT CONTENT

R_2R_1	DIFFERENCE	AMBIENT
00	+ BRIDGE EXCITATION VOLTS	
01	+ BRIDGE OUTPUT	+ BRIDGE CURRENT
10	BRIDGE EXCITATION VOLTS	
11	BRIDGE OUTPUT	BRIDGE CURRENT

(c) NN IDENTIFIES SENSOR (BRIDGE) LOCATION

7759-5537

HFE COMMAND DETAILS

OCTAL CMD NUMBER

135 HFE MODE/G SEL

THIS CMD (C1) IS A 1-STATE CMD. IT PLACES THE HFE IN THE GRADIENT, OR NORMAL, MODE OF OPERATION IN WHICH MEASUREMENTS ARE OBTAINED FROM THE GRADIENT SENSORS AND CABLE THERMOCOUPLES UNDER THE CONTROL OF THE MSP. CMD 135 ALSO TURNS OFF THE PROBE HEATER CURRENT SUPPLY. DIFFERENT MEASUREMENT SEQUENCES IN MODE/G MAY BE SELECTED BY TRANSMITTING SUBSEQUENT CMDs. AT POWER TURN-ON, THE HFE INITIALIZES IN MODE/G. IF THE HFE IS IN MODE/G, TRANSMISSION OF CMD 135 HAS NO EFFECT.

NOTE THAT THE HFE INPUT BUFFER HOLDS CMDs FOR EXECUTION AT THE 90-FRAME MARK; THUS, SEQUENTIAL CMDs MUST BE TRANSMITTED AT LEAST 54 SEC APART.

7759-5538

HFE COMMAND DETAILS (CONT')

136 HFE MODE/LK SEL

THIS CMD (C2) IS A 1-STATE CMD. IT PLACES THE HFE IN THE LOW CONDUCTIVITY, OR RING SOURCE, MODE OF OPERATION IN WHICH MEASUREMENTS, AND SEQUENCES, ARE IDENTICAL TO MODE/G. IT ALSO TURNS ON THE PROBE HEATER CURRENT SUPPLY IN THE LOW (RING SOURCE) MODE ALLOWING HEATERS TO BE ACTIVATED BY CMD 152. IF THE HFE IS IN MODE/LK, TRANSMISSION OF CMD 136 HAS NO EFFECT.

140 HFE MODE/HK SEL

THIS CMD (C3) IS A 1-STATE CMD. IT PLACES THE HFE IN THE HIGH CONDUCTIVITY, OR HEAT PULSE, MODE OF OPERATION IN WHICH MEASUREMENTS ARE OBTAINED FROM THE RING (OR REMOTE) SENSORS UNDER THE CONTROL OF THE HEATER SEQUENCE PROGRAMMER. NOTE THAT CMD 144 (C7) MUST ALSO BE TRANSMITTED BEFORE VALID DATA WILL BE OBTAINED IN MODE/HK. EITHER CMD MAY BE TRANSMITTED FIRST. CMD 140 ALSO TURNS ON THE PROBE HEATER CURRENT SUPPLY IN THE HIGH, OR HEAT PULSE, MODE ALLOWING HEATERS TO BE ACTIVATED BY CMD 152. IF THE HFE IS IN MODE/HK, TRANSMISSION OF CMD 140 HAS NO EFFECT.

7759-5539

HFE COMMAND DETAILS (CONT')

141 HFE SEQ/FUL SEL

THIS CMD (C4) IS A 1-STATE CMD. IT CANCELS THE EFFECT OF CMDs 142 THROUGH 146 CAUSING THE MSP TO PERFORM ITS FULL 16-STATE CYCLE OF OPERATION IN MODE/G OR MODE/LK. IF TRANSMITTED DURING MODE/HK OPERATION, THIS CMD WILL CAUSE INVALID OPERATION UNTIL CMD 144 IS EXECUTED. AT POWER TURN-ON, THE HFE INITIALIZES IN SEQ/FUL. IF THE HFE IS IN MODE/G OR MODE/LK AND IN SEQ/FUL, TRANSMISSION OF CMD 141 HAS NO EFFECT.

142 HFE SEQ/P1 SEL

THIS CMD (C5) IS A 1-STATE CMD AND ALTERNATES WITH CMD 143 TO SELECT ONLY ONE PROBE FOR MEASUREMENT. IN MODE/HK THIS CMD IS MEANINGLESS. IN MODE/G AND MODE/LK IT CAUSES THE MSP TO LOCK FLIP-FLOP P_2 IN THE CLEAR STATE AND BYPASS P_2. THUS THE MSP ACTS AS AN 8-STATE COUNTER IF CMD 141 WAS PREVIOUSLY EXECUTED, OR AS A 2-STATE COUNTER IF CMD 144, 145 OR 146 WAS PREVIOUSLY EXECUTED. SEQ/P1 IS CLEARED BY SUBSEQUENT EXECUTION OF CMD 141.

7759-5540

HFE COMMAND DETAILS (CONT')

143 HFE SEQ/P2 SEL

THIS CMD (C6) IS A 1-STATE CMD AND ALTERNATES WITH CMD 142 TO SELECT ONLY ONE PROBE FOR MEASUREMENT. IT HAS THE SAME CHARACTERISTICS AS CMD 142 EXCEPT THAT FLIP-FLOP P_2 IS LOCKED IN THE SET STATE.

144 HFE LOAD 1

THIS CMD (C7) IS A 1-STATE CMD AND IS USED ALONE OR IN COMBINATION WITH CMD 145 OR 146 TO POSITION AND LOCK TWO FLIP-FLOPS (P_4 P_3) OF THE MSP. CMD 144 PLACES P_4P_3 IN THE CLEAR POSITION (00) AND BYPASSES THOSE STEPS. THE MSP THEN ACTS AS A 4-STATE COUNTER IF CMD 141 WAS PREVIOUSLY EXECUTED AND AS A 2-STATE COUNTER IF CMD 142 OR 143 WAS PREVIOUSLY EXECUTED. THIS APPLIES TO MODE/G AND MODE/LK. IN MODE/HK CMD 144 MUST BE EXECUTED TO OBTAIN VALID DATA. CMDs 145 OR 146 MAY BE USED IN MODE/G OR MODE/LK, FOLLOWING CMD 144, TO LOCK P_4 P_3 IN THE 10 OR 01 STATE RESPECTIVELY. THE EFFECT OF CMD 144 IS CLEARED BY SUBSEQUENT EXECUTION OF CMD 141. NOTE: WHEN IN MODE/G OR MODE/LK 00 STATE PROVIDES HIGH EXCITATION DIFFERENTIAL TEMPERATURE DATA ONLY.

7759-5541

HFE COMMAND DETAILS (CONT')

145 HFE LOAD 2

THIS CMD (C8) IS A 1-STATE CMD AND IS USED IN COMBINATION WITH EITHER CMD 144 (PRECEDING 145) OR CMD 146 (PRECEDING OR FOLLOWING 145) TO POSITION AND LOCK P_4 P_3 (SEE CMD 144). CMD 145 POSITIONS FLIP-FLOP P_3 IN THE SET STATE. THEREFORE, 144-145 YIELDS 01 (LOW EXCITATION DIFFERENTIAL TEMPERATURE DATA ONLY) WHILE 145-146 YIELDS 11 (CABLE THERMOCOUPLE DATA ONLY). EXECUTION OF THIS CMD IN MODE/HK CAUSES INVALID DATA UNTIL CMD 144 IS EXECUTED. THE EFFECT OF CMD 145 IS CLEARED BY SUBSEQUENT EXECUTION OF CMD 141.

146 HFE LOAD 3

THIS CMD (C9) IS A 1-STATE CMD OPERATING ESSENTIALLY THE SAME AS CMD 145 EXCEPT THAT IT POSITIONS FLIP-FLOP P_4 IN THE SET STATE. WHEN PRECEDED BY CMD 144 IT YIELDS 10 FOR P_4 P_3 (AMBIENT TEMPERATURE DATA ONLY). EXECUTION OF THIS CMD IN MODE/HK CAUSES INVALID DATA UNTIL CMD 144 IS EXECUTED.

7759-5542

HFE COMMAND DETAILS (CONT')

152 HFE HTR STEPS

THIS CMD (C10) IS A 16-STATE CMD WHICH ADVANCES THE HEATER EXCITATION PROGRAMMER (H_4 H_3 H_2 H_1) EACH TIME THE CMD IS EXECUTED. IN MODE/G THE PROGRAMMER ADVANCES BUTH THERE IS NO OTHER EFFECT SINCE THE PROBE HEATER CURRENT SUPPLY IS OFF. IN MODE/LK THE EXECUTION OF CMD 152 ALTERNATES THE HEATER STATUS BETWEEN ON AND OFF, SIMULTANEOUSLY STEPPING THROUGH THE 8 HEATERS (CURRENT SUPPLY IS ON FULL TIME AND HEATER ELEMENTS ARE SWITCHED IN AND OUT OF CIRCUIT). IN MODE/HK THE HEATER EXCITATION PROGRAMMER (ADVANCED BY CMD 152) ALSO SELECTS THE DATA TO BE SAMPLED.

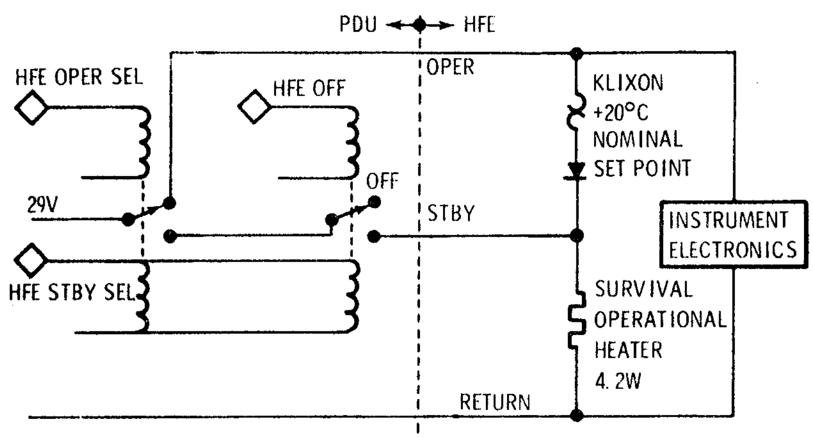
7759-5543

HFE ANALOG DATA

AH-01	HFE +5V SUPPLY	EACH SAMPLED ONCE EVERY 54 SEC ALSEP SEQUENCE
AH-02	HFE -5V SUPPLY	
AH-03	HFE +15V SUPPLY	
AH-04	HFE -15V SUPPLY	
AH-05	(DELETED)	
AH-06	HFE HTR/LK ON/OFF	
AH-07	HFE HTR/HK ON/OFF	

7759-5544

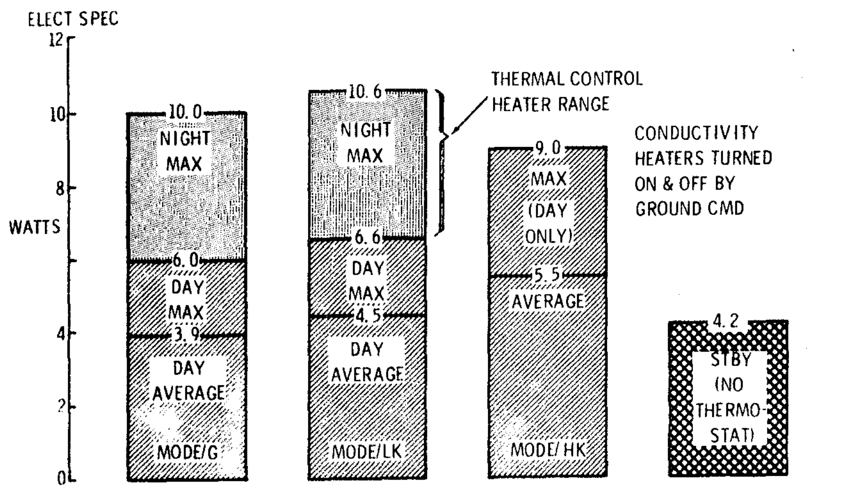
HFE THERMAL CONTROL



NOTE: ADDITIONAL THERMOSTAT TURNS A PORTION OF INSTRUMENT ELECTRONICS ON/OFF BETWEEN MEASUREMENTS IF TEMP IS LOW/HIGH

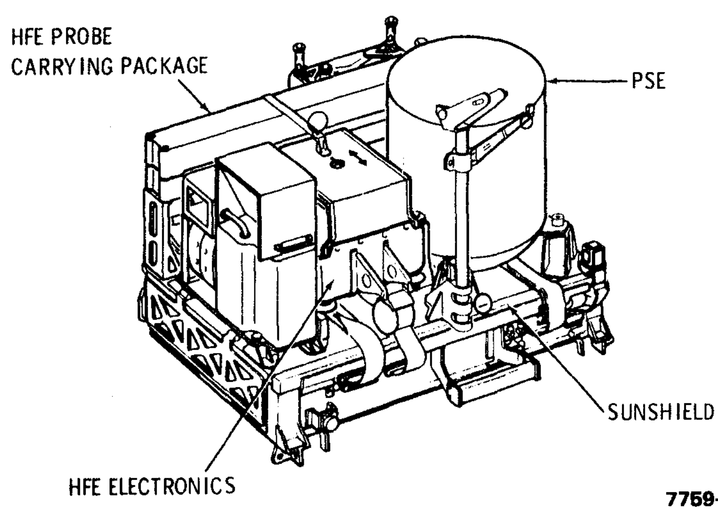
7759-5545

HFE POWER PROFILE



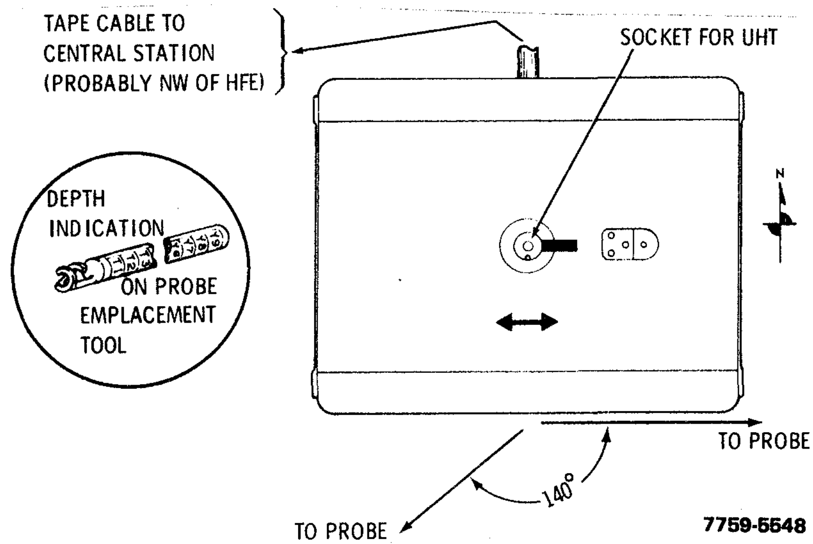
7759-5546

HFE TIE-DOWN



7759-5547

HFE ALIGNMENT MARKINGS



7759-5548

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	AWAY FROM RTG	2	EYEBALL	GREATER THAN 80° FROM RTG
	LEVEL	±12° OF VERTICAL	2	EYEBALL	INTERACTS WITH ALIGNMENT
	ALIGN WRT SHADOW	±5° OF E-W	2	ARROW** AND SHADOWS	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	AT LEAST 140° APART	1	PAINT LINES***	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. AVOID MAJOR DISTURBANCES (TRAMPLING, ETC.) AND SHADOWS IN 17 ft CIRCLE AROUND PROBE.			
SPECIAL REQUIREMENTS		**ARROW NOMINALLY POINTS EAST-WEST ***PAINT LINES GIVE 120° DIRECTIONS CENTERED ON N-S AXIS BUT ALLOW ESTIMATION OF OTHER DIRECTIONS.			

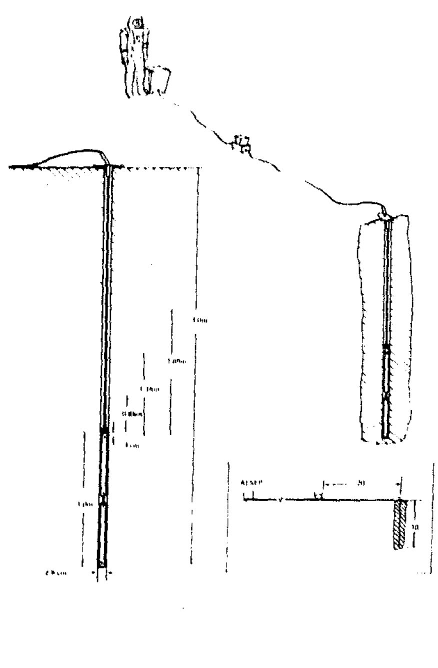
7759-5549

DESIGN GOALS AND HEAT FLOW EXPERIMENT MEASUREMENTS

	Probe Temperature (Lower Meter)	Lunar Subsurface Temperature (Upper 2 Meters)	Temperature Difference in Lower Meter for 50-cm Length	Thermal Conductivity
Range	200-250°K	90-350°K	± 20°C	5 x 10^{-6} to 1 x 10^{-3} cal/cm-sec°C
Resolution	0.1°C	0.5°C	0.001°C	± 20%
Accuracy	± 0.1°C	± 0.5°C	± 0.003°C	± 20%
Stability	0.1°C/year	0.5°C/year	0.003°C/year	–

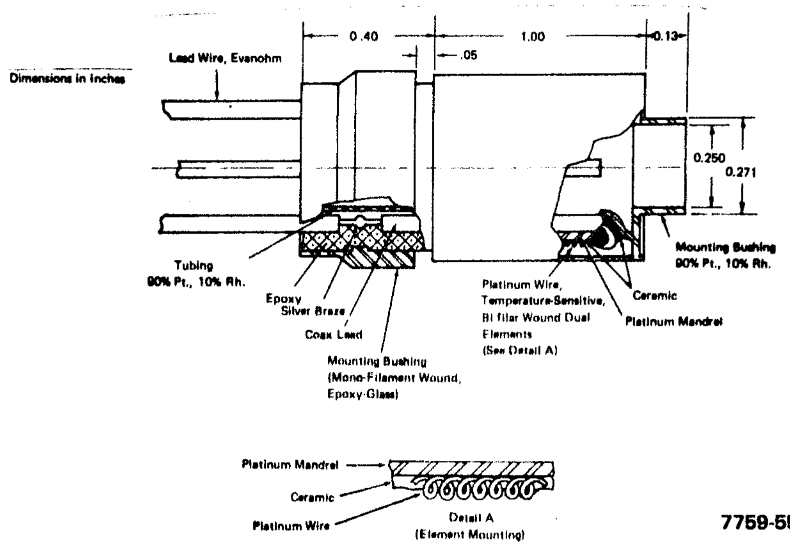
7759-5550

TYPICAL PROBE EMPLACEMENT



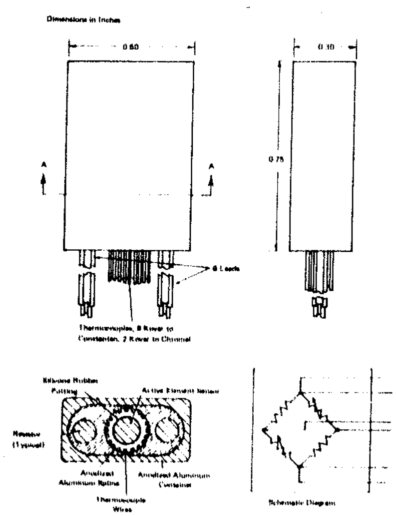
7759-5551

GRADIENT SENSOR



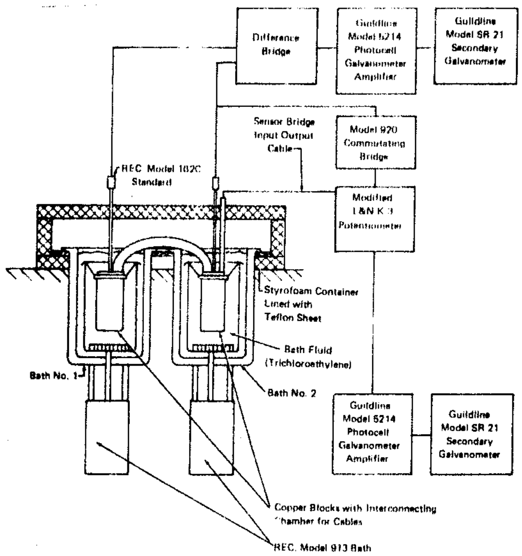
7759-5552

ELECTRONICS BOX THERMOCOUPLE REFERENCE SENSOR



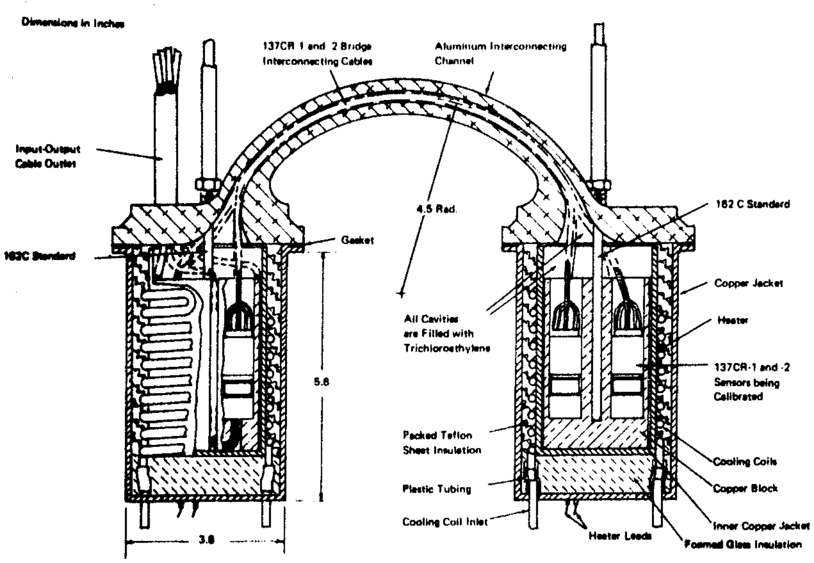
7759-5554

CALIBRATION APPARATUS-SCHEMATIC BLOCK DIAGRAM



7759-5555

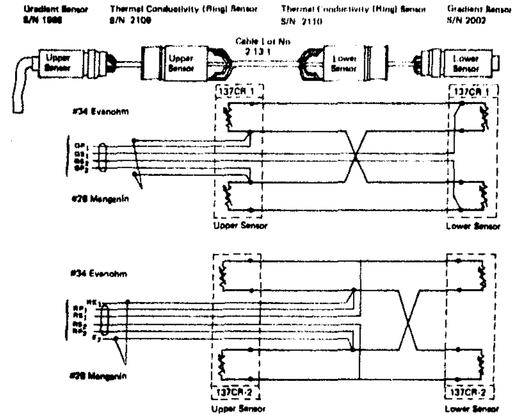
CALIBRATION APPARATUS DETAILS



7759-5556

7-20

TYPICAL CALIBRATION DATA FOR RING AND GRADIENT SENSORS

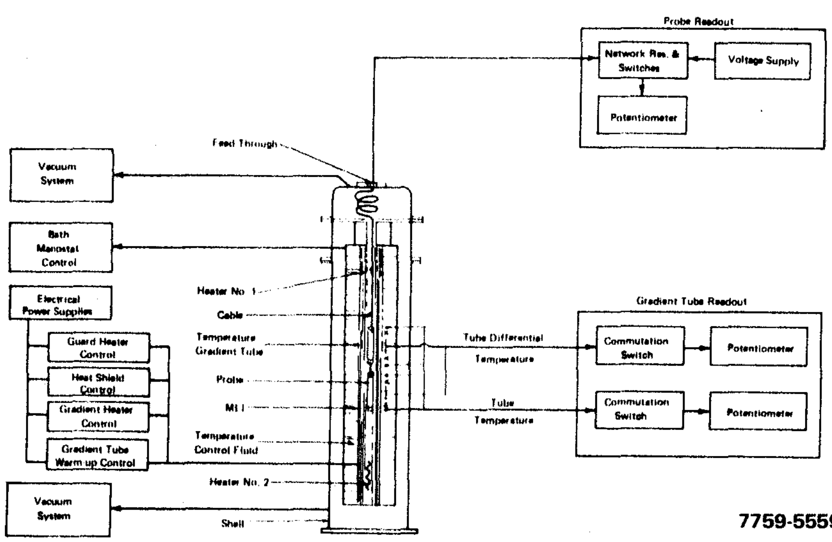


Lead Resistance – Ohms

R_{P_1}	664.986	G_{P_1}	660.323
R_{P_2}	679.109	G_{P_2}	667.701
R_{E_1}	60.616	G_{E_1}	58.257
R_{E_2}	58.646	G_{E_2}	58.869

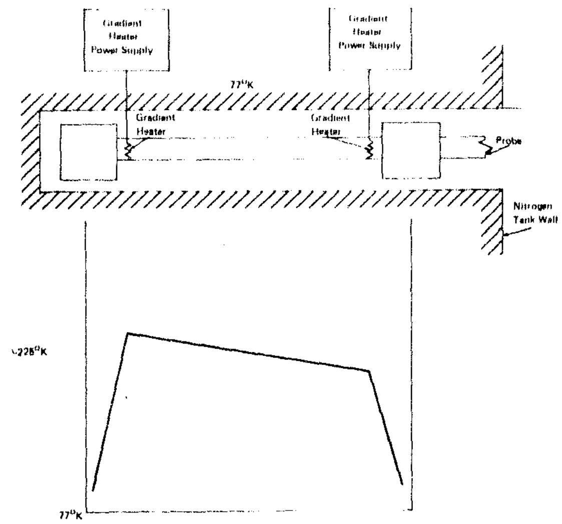
7759-5557

TEMPERATURE GRADIENT TEST APPARATUS AND INSTRUMENTATION SCHEMATIC BLOCK DIAGRAM



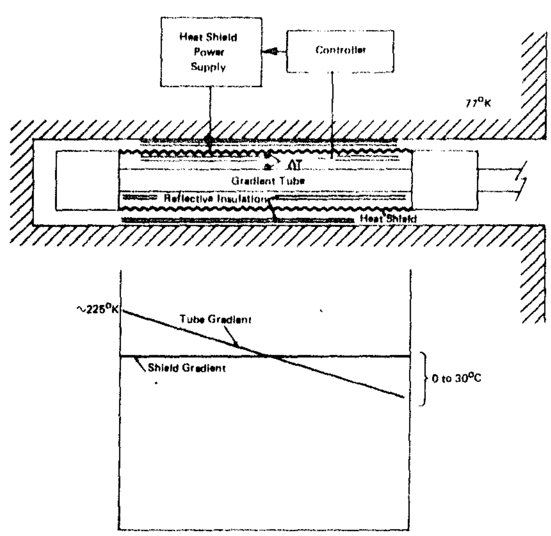
7759-5559

GRADIENT TUBE HEATERS



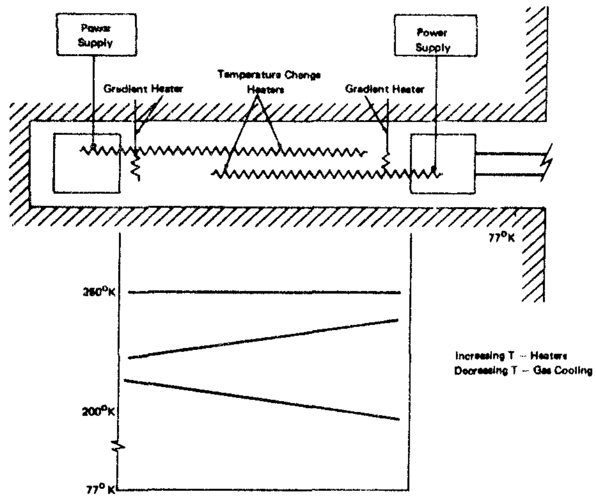
7759-5560

GRADIENT TUBE HEAT SHIELD



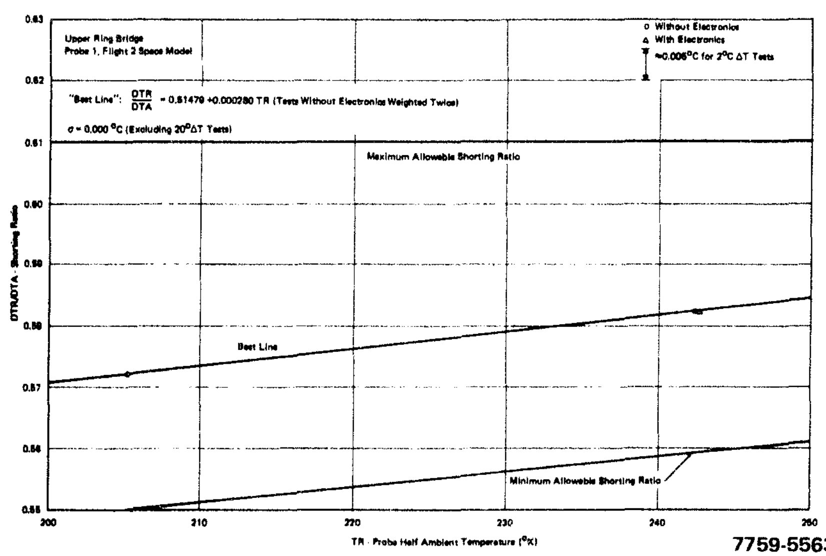
7759-5561

GRADIENT TUBE ASSEMBLY ALTERATION OF T & ΔT



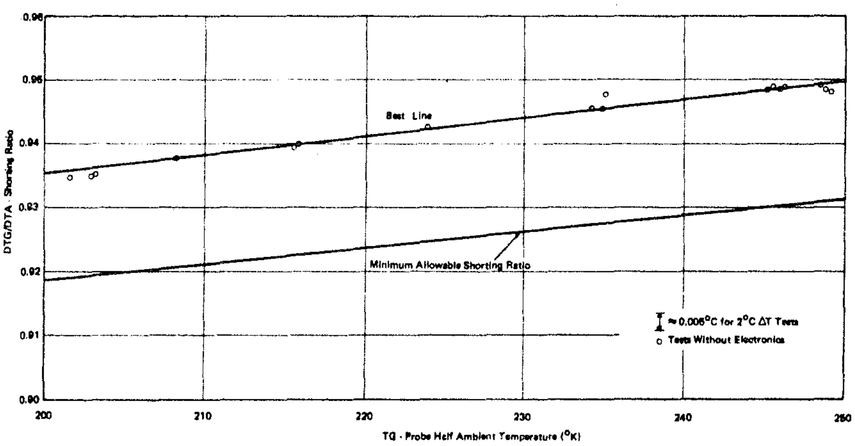
7759-5562

TYPICAL RING BRIDGE SHORTING RATIOS



7759-5563

BRASSBOARD HEAT FLOW PROBE SHORTING RATIOS-LOWER GRADIENT BRIDGE



7759-5564

TEMPERATURE GRADIENT APPARATUS TESTS

Legend

P Prototype
S01 System Qualification
S02 System Qualification Spare
F2 Flight 2
F2S Flight 2
F2S Flight 2 Spare
F1 Flight 1

S/N	Probe Model	Probe Half	Bridge S/N	Ambient Temperature Mean Error (°C) 2" Tests	10" Tests	Zero Offset (°C)	Best Line Equation* Constant a	Slope b	Std Dev from Best Line ΔT (°C) 2" Tests
1	P-1	Upper	2211	0.06	0.10	0.001	0.87518	0.000322	0.003
		Lower	2208	0.04	0.06	0.000	0.87085	0.000306	0.012
	P-2	Upper	2215	0.06	0.06	0.001	0.89277	0.000271	0.002
		Lower	2210	0.06	0.14	0.000	0.88670	0.000289	0.002
2	S01-1	Upper	2214	0.01	0.06	0.002	0.86726	0.000134	0.0005
		Lower	2212	0.01	0.00	0.001	0.87808	0.000281	0.001
	S01-2	Upper	2218	0.04	0.07	0.001	0.90087	0.000263	0.0014
		Lower	2217	0.05	0.17	0.001	0.88000	0.000241	0.002
3	S02-1	Upper	2219	0.05	0.09	0.002	0.91234	0.000230	0.0010
		Lower	2220	0.05	0.10	0.001	0.87742	0.000272	0.0018
	S02-2	Upper	2221	0.08	0.14	0.001	0.90716	0.000204	0.0009
		Lower	2222	0.03	0.03	0.001	0.80340	0.000211	0.0007
4	F2-1	Upper	2227	0.03	0.06	0.000	0.88776	0.000283	0.0015
		Lower	2223	0.01	0.02	0.000	0.90281	0.000222	0.0008
	F2-2	Upper	2230	0.03	0.01	0.001	0.88049	0.000297	0.0006
		Lower	2226	0.01	0.01	0.000	0.89228	0.000212	0.0008
5	F2S-1	Upper	2228	0.011	0.01	0.000	0.90646	0.000262	0.0001
		Lower	2230	0.017	0.03	0.000	0.87107	0.000122	0.0014
	F2S-2	Upper	2231	0.010	0.00	0.001	0.88081	0.000260	0.0010
		Lower	2225	0.05	0.06	0.001	0.87779	0.000276	0.0016
6	F1-1	Upper	2214	0.04	0.02	0.000	0.87789	0.000297	0.0001
		Lower	2232	0.045	0.01	0.001	0.88198	0.000788	0.0002
	F1-2	Upper	2236	0.03	0.05	0.002	0.87386	0.000131	0.0004
		Lower	2241	0.02	0.12	0.001	0.87186	0.000208	0.0018
	Acceptance Levels			0.10°C [illegible]		0.004	Not Specified		0.005

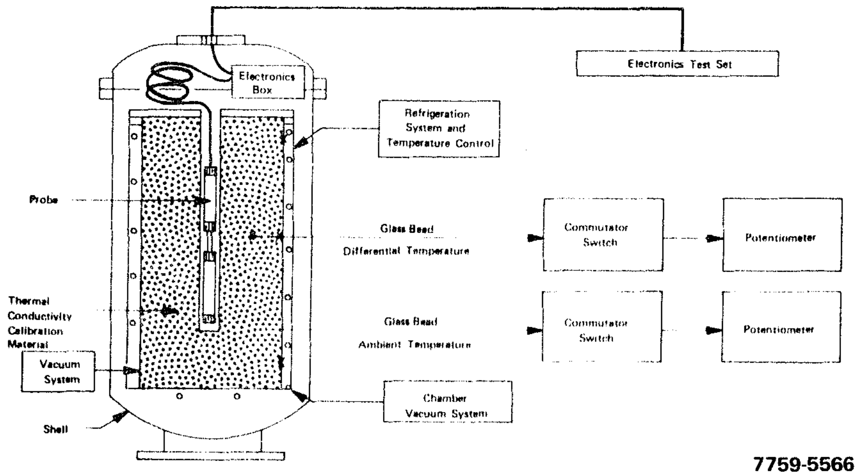
Notes

*DTG/DTA = a + bTG

[illegible] attributable to electronics

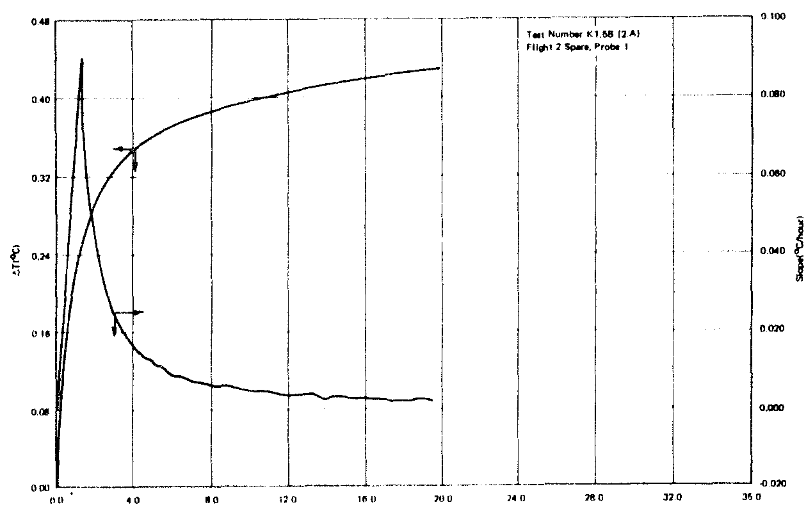
7759-5565

THERMAL CONDUCTIVITY APPARATUS AND TEST INSTRUMENTATION PRINCIPAL ELEMENTS



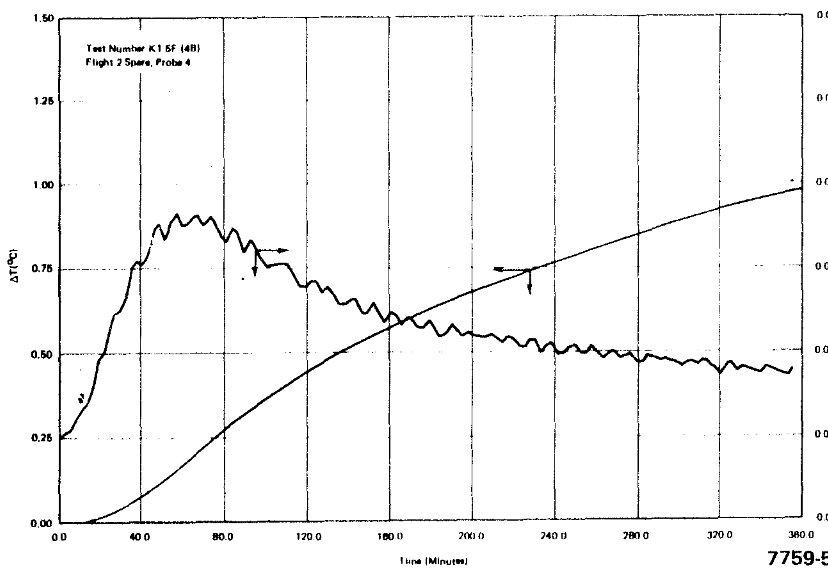
7759-5566

TYPICAL THERMAL CONDUCTIVITY MEASUREMENTS-MODE 2

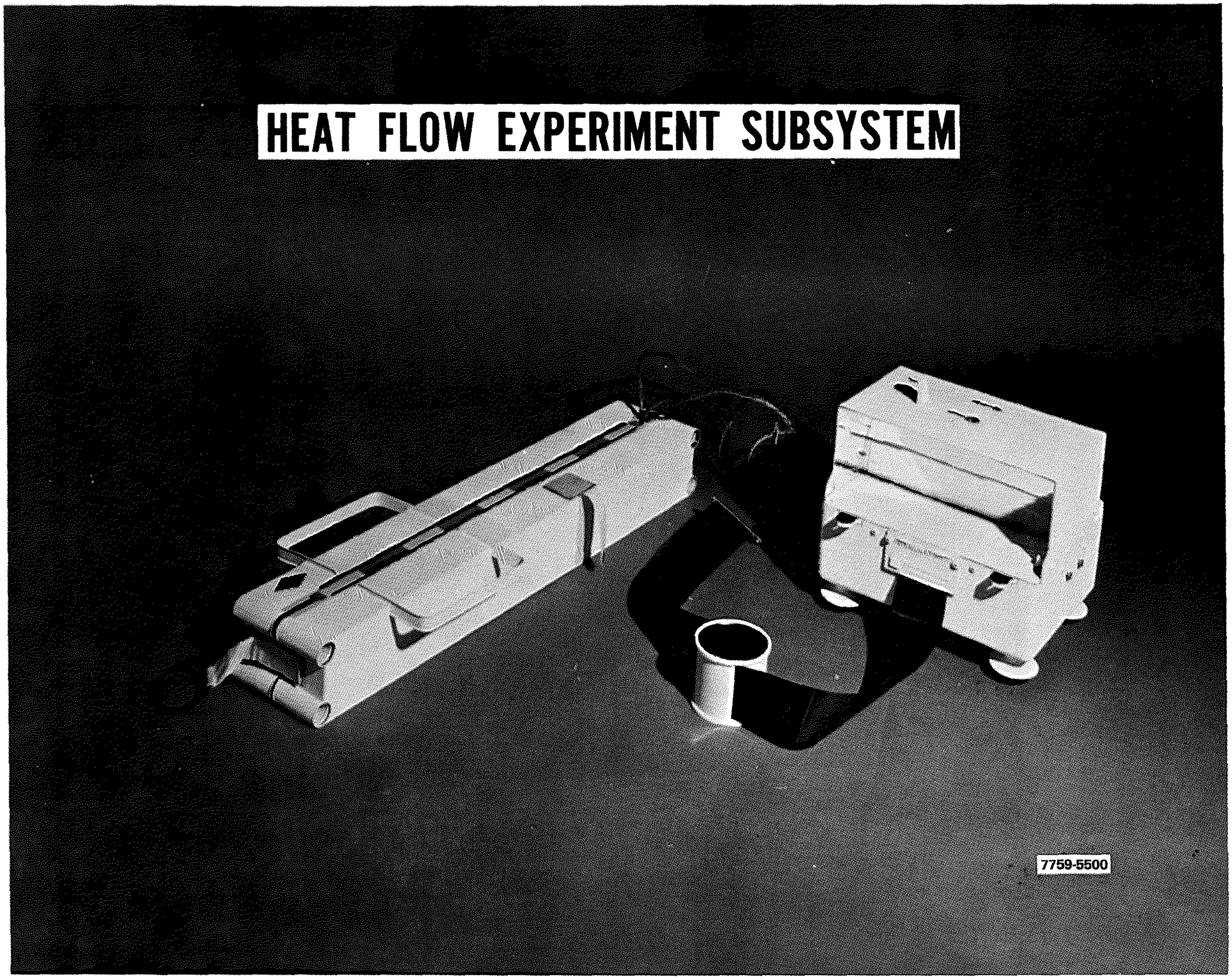


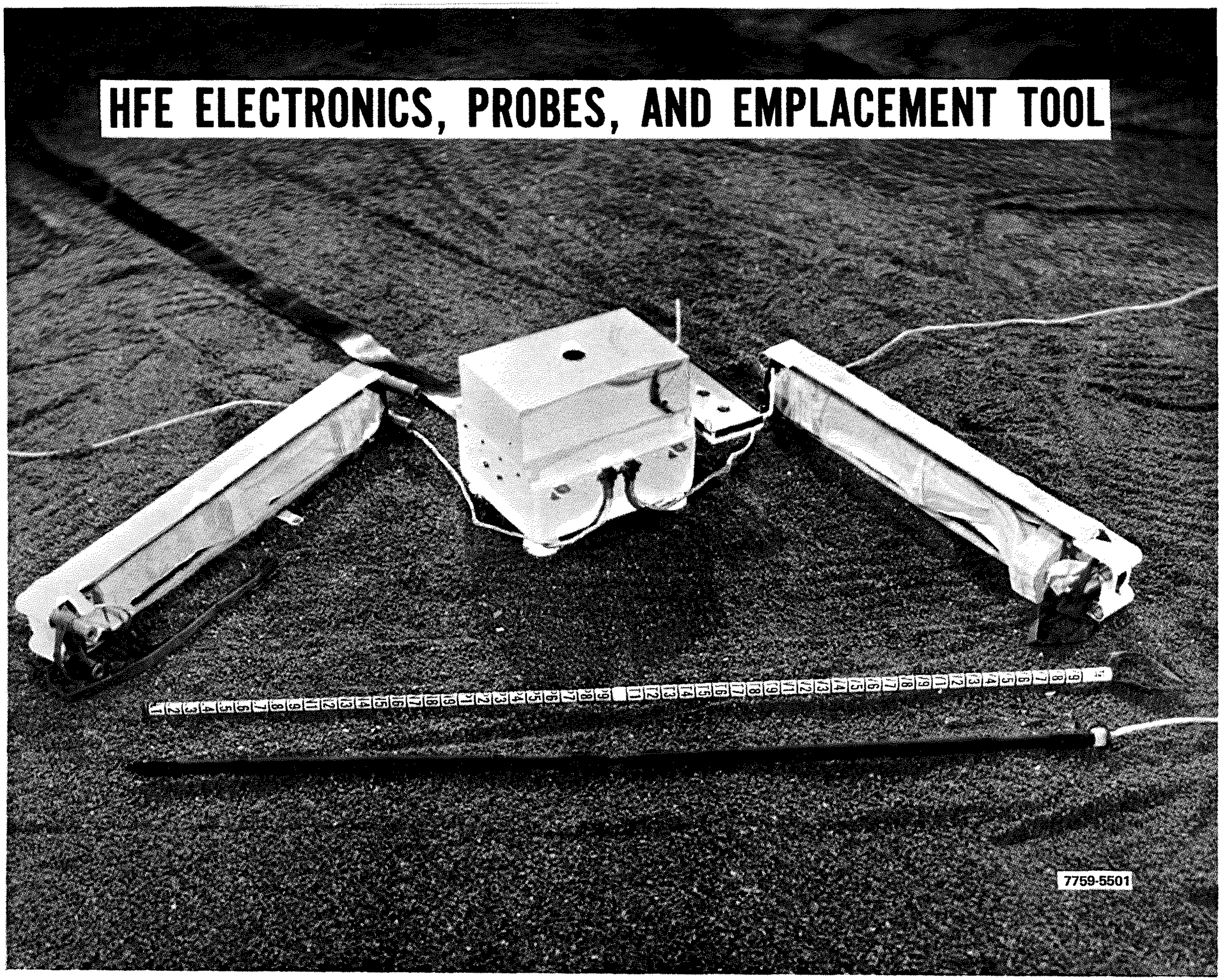
7759-5567

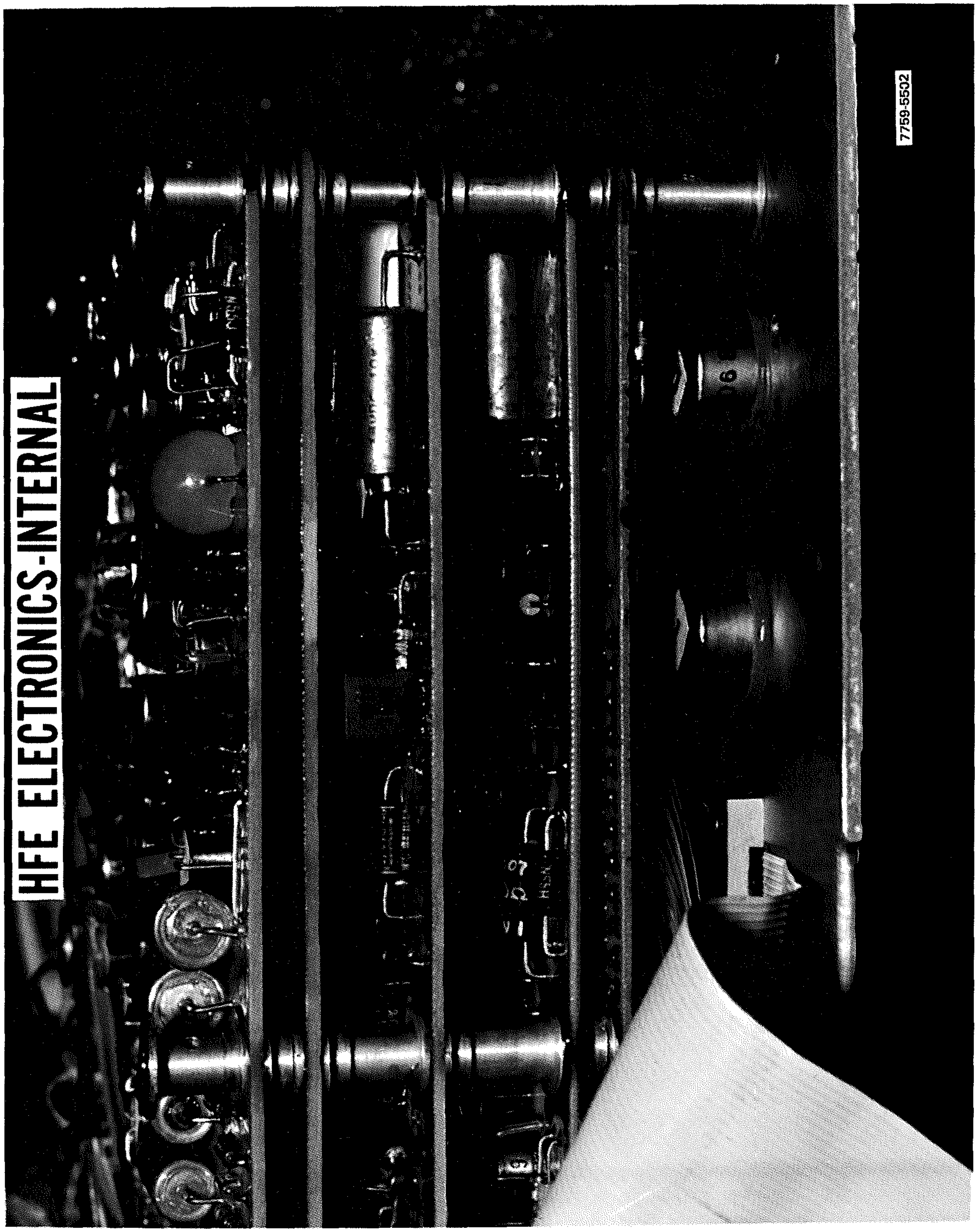
TYPICAL THERMAL CONDUCTIVITY MEASUREMENTS-MODE 3

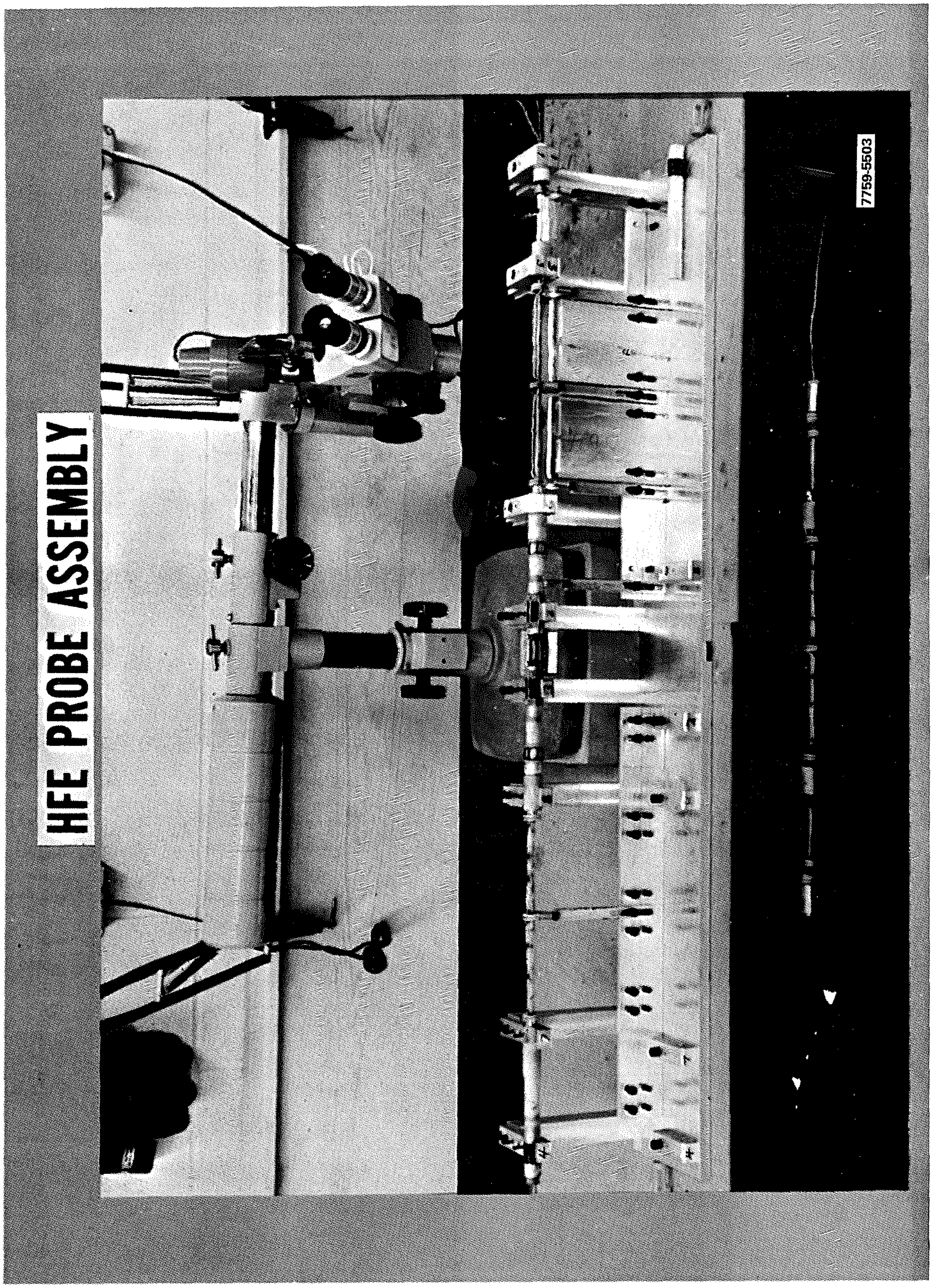


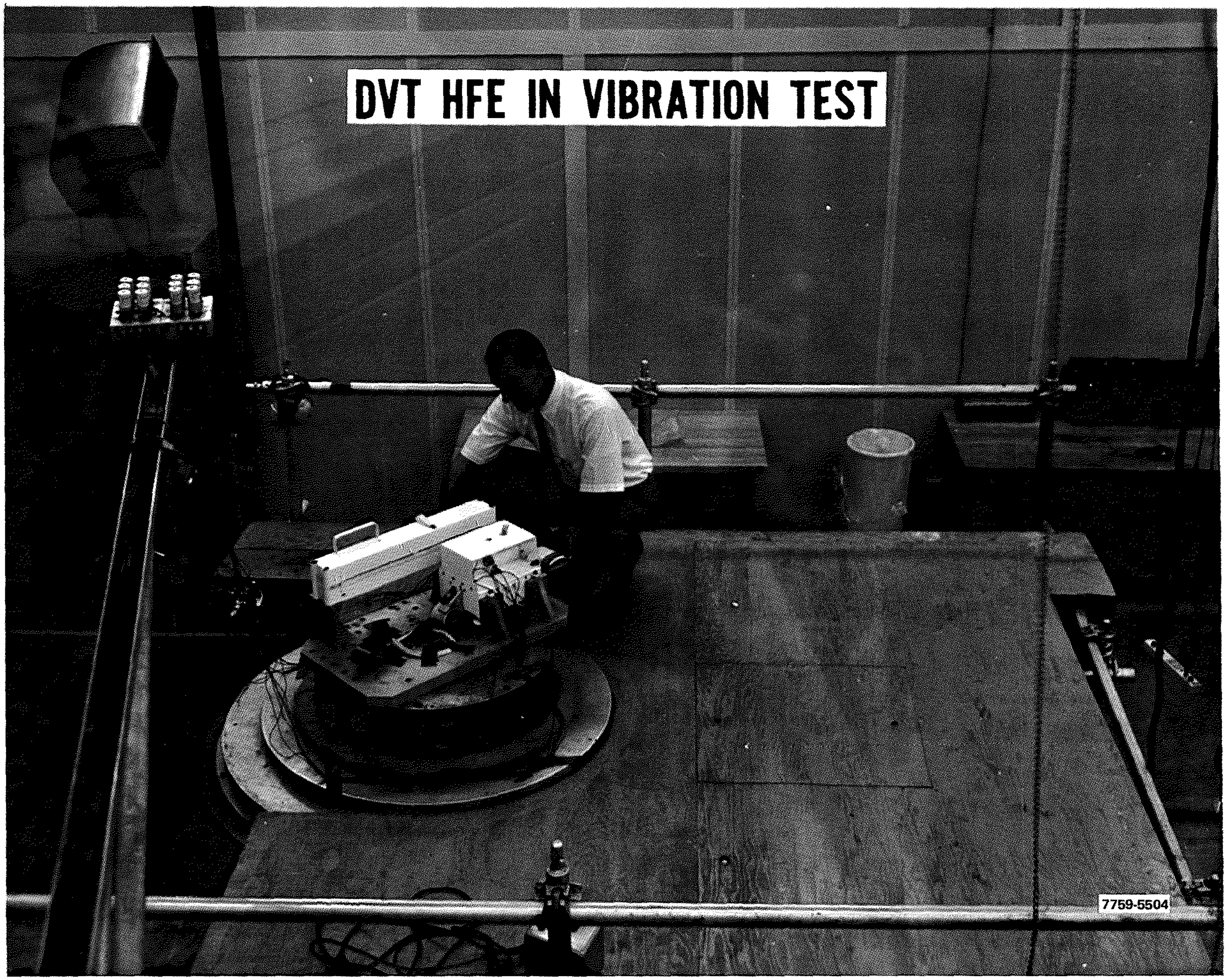
7759-5568

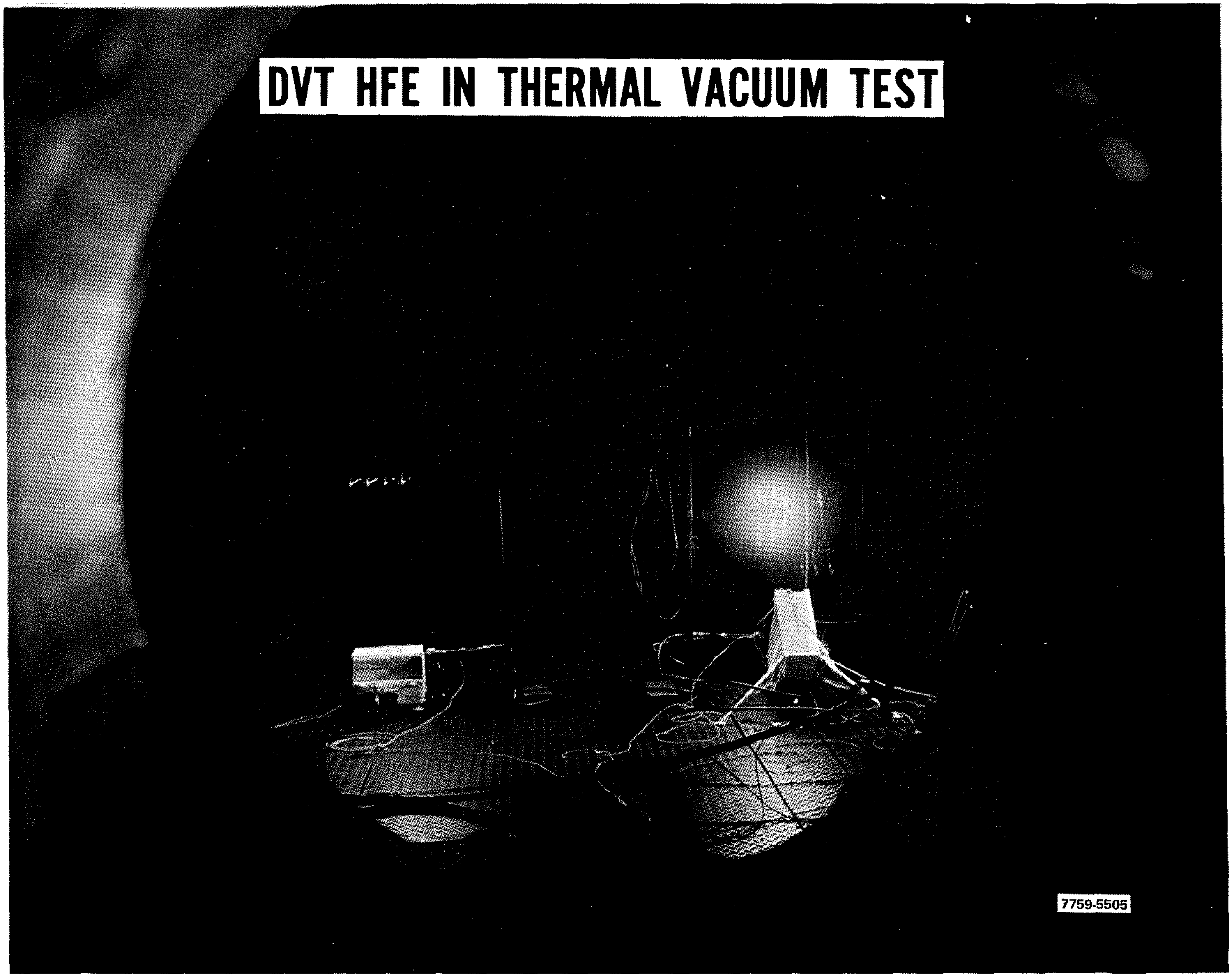

HEAT FLOW EXPERIMENT SUBSYSTEM
7759-5500

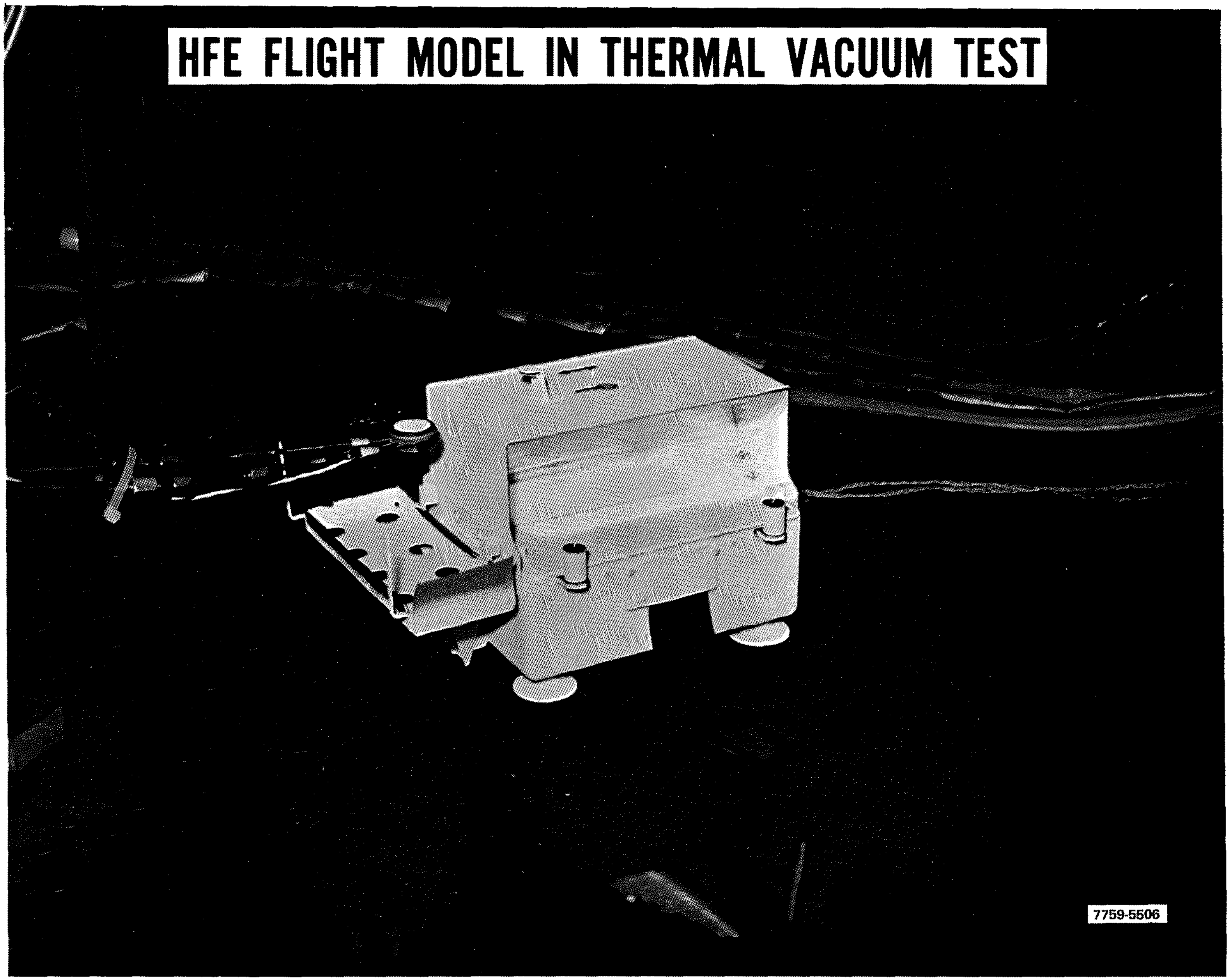

HFE ELECTRONICS, PROBES, AND EMPLACEMENT TOOL
7759-5501

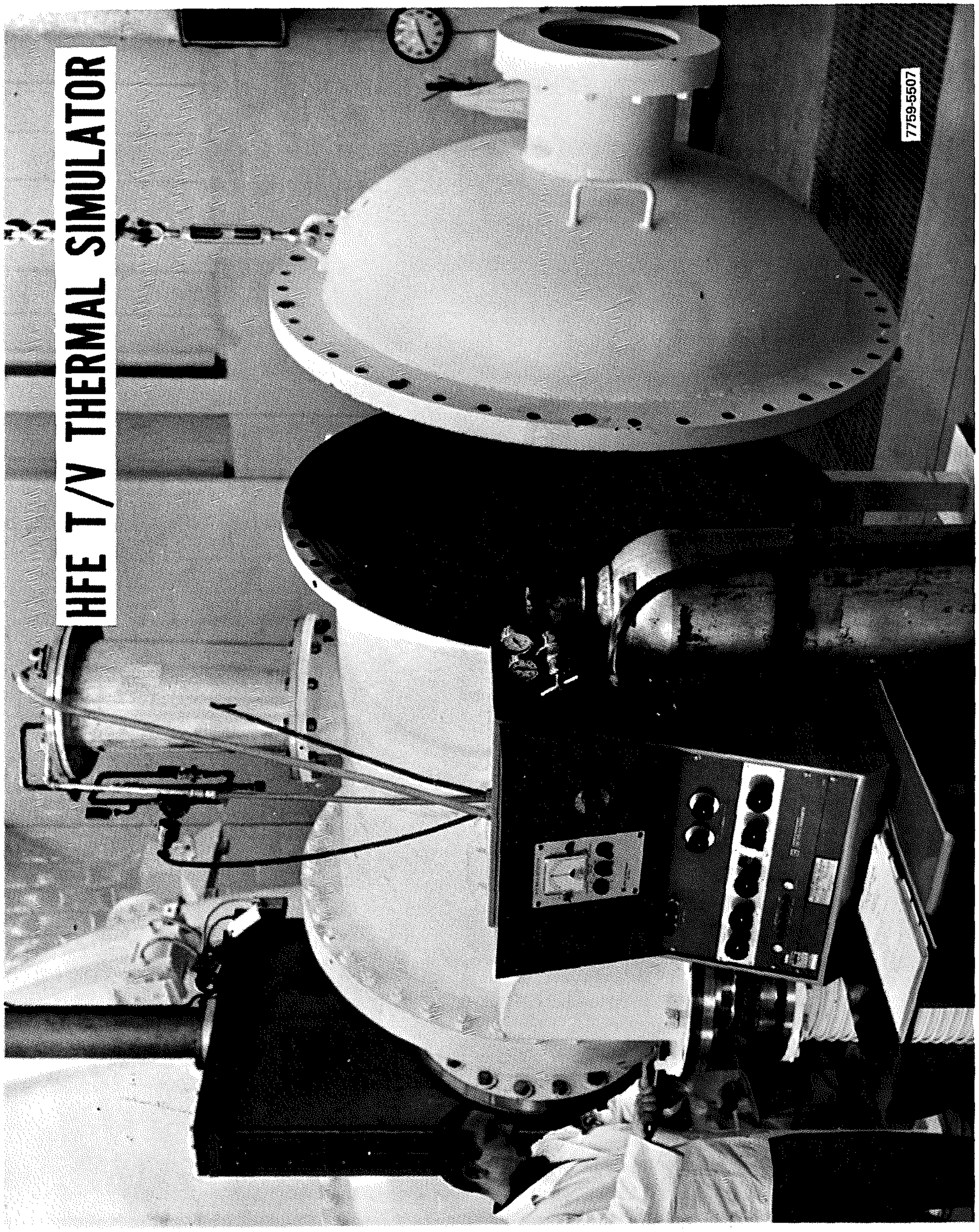

HFE ELECTRONICS-INTERNAL
7759-5502

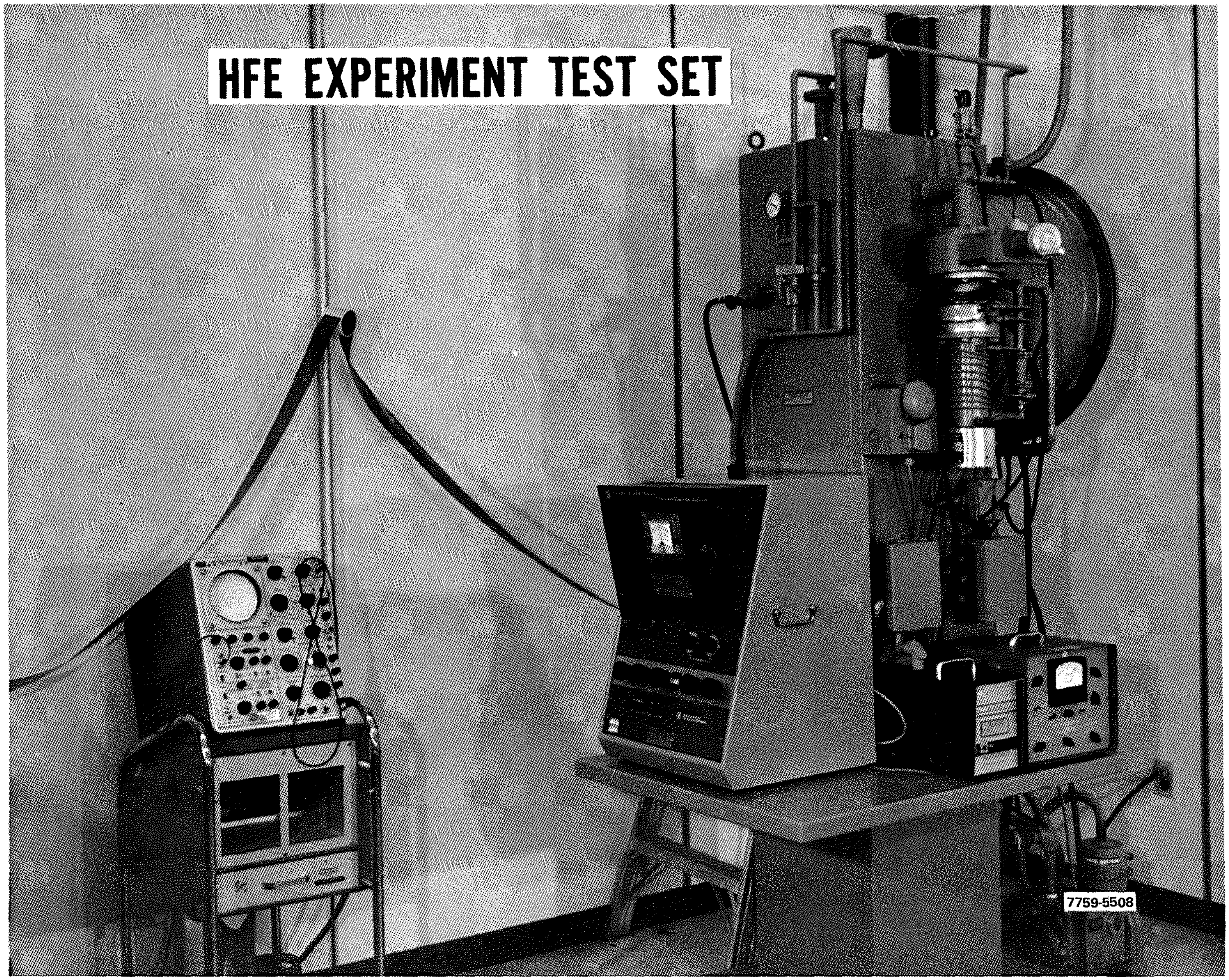

HFE PROBE ASSEMBLY
7759-5503

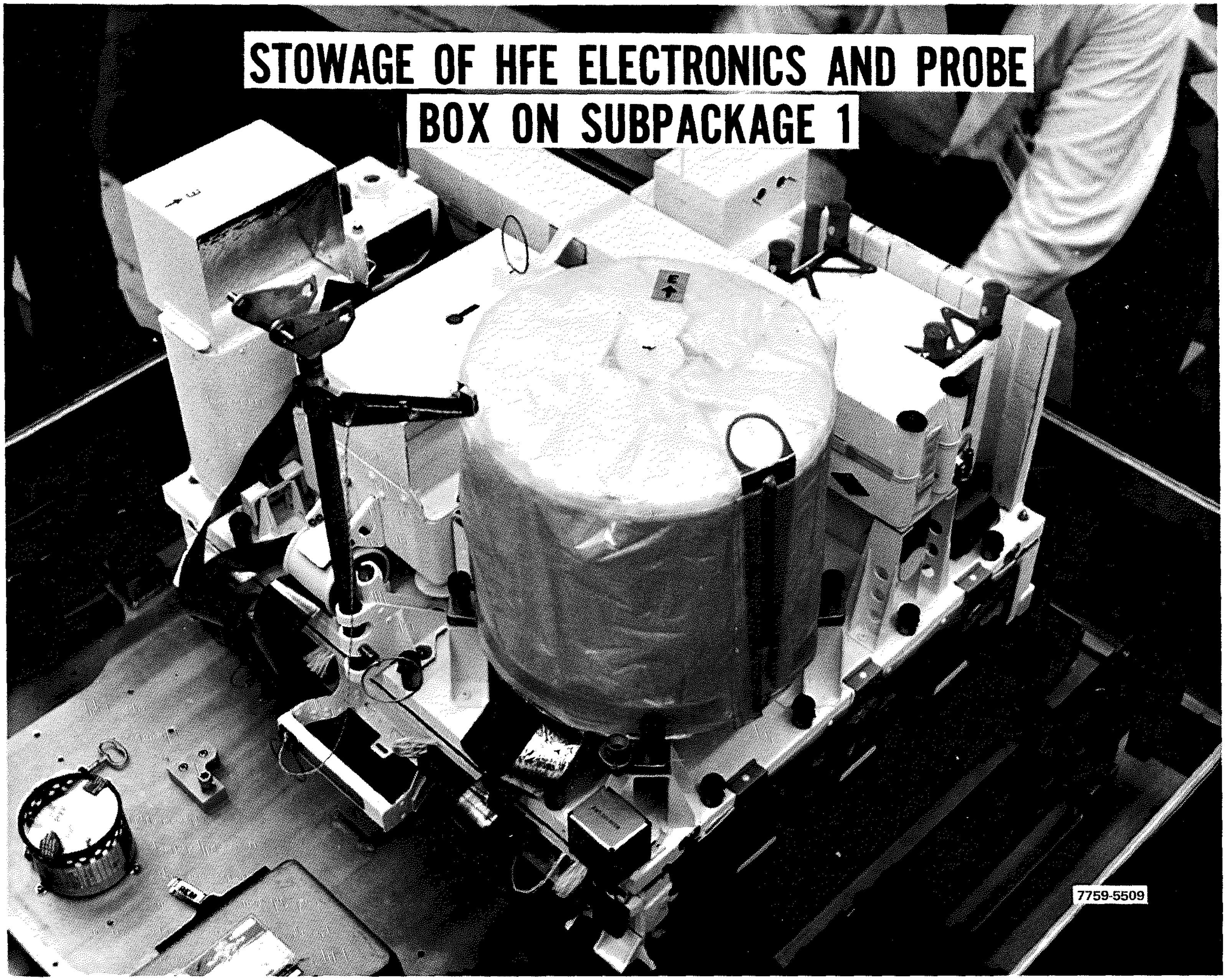

DVT HFE IN VIBRATION TEST
7759-5504


DVT HFE IN THERMAL VACUUM TEST
7759-5505

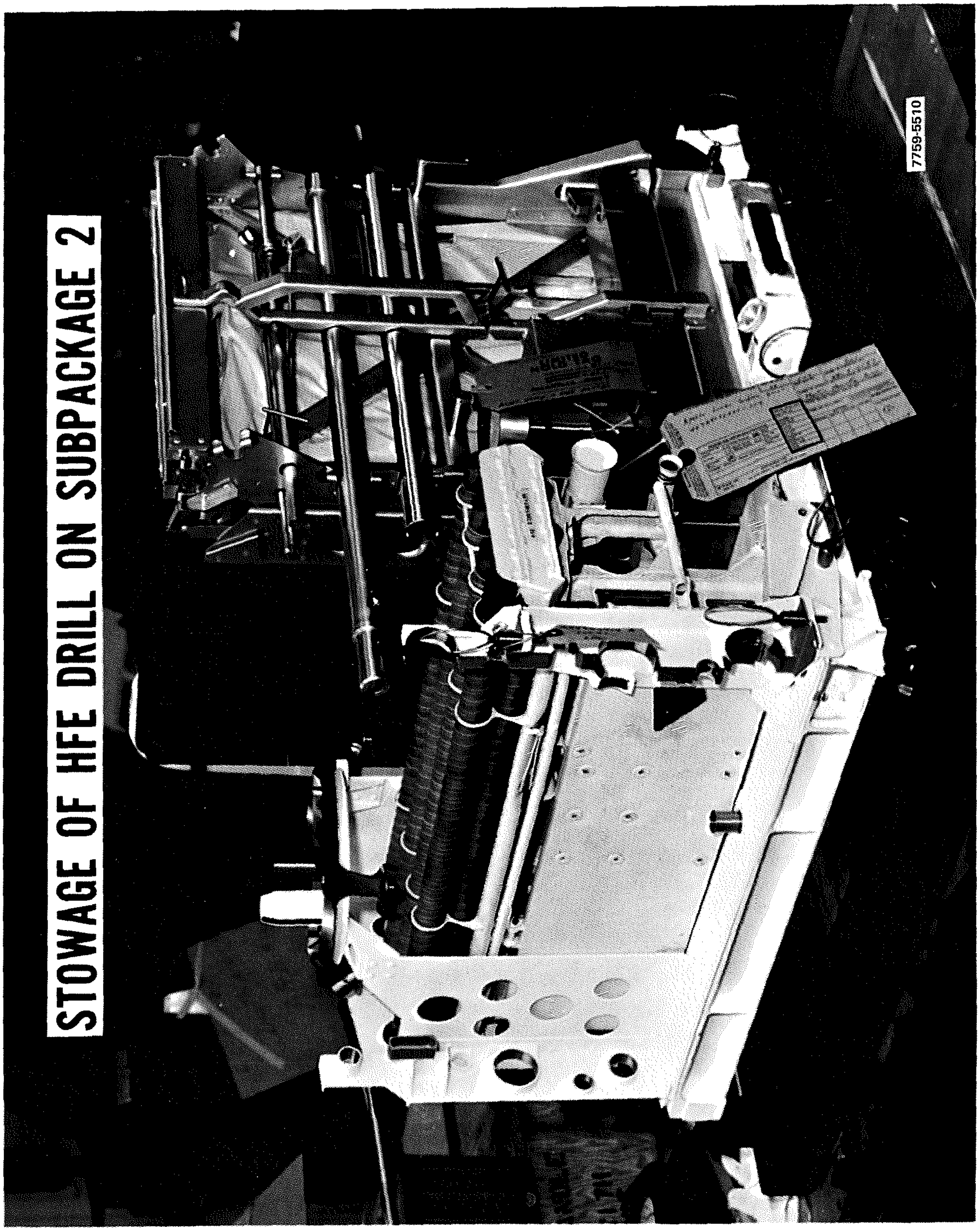

HFE FLIGHT MODEL IN THERMAL VACUUM TEST
7759-5506

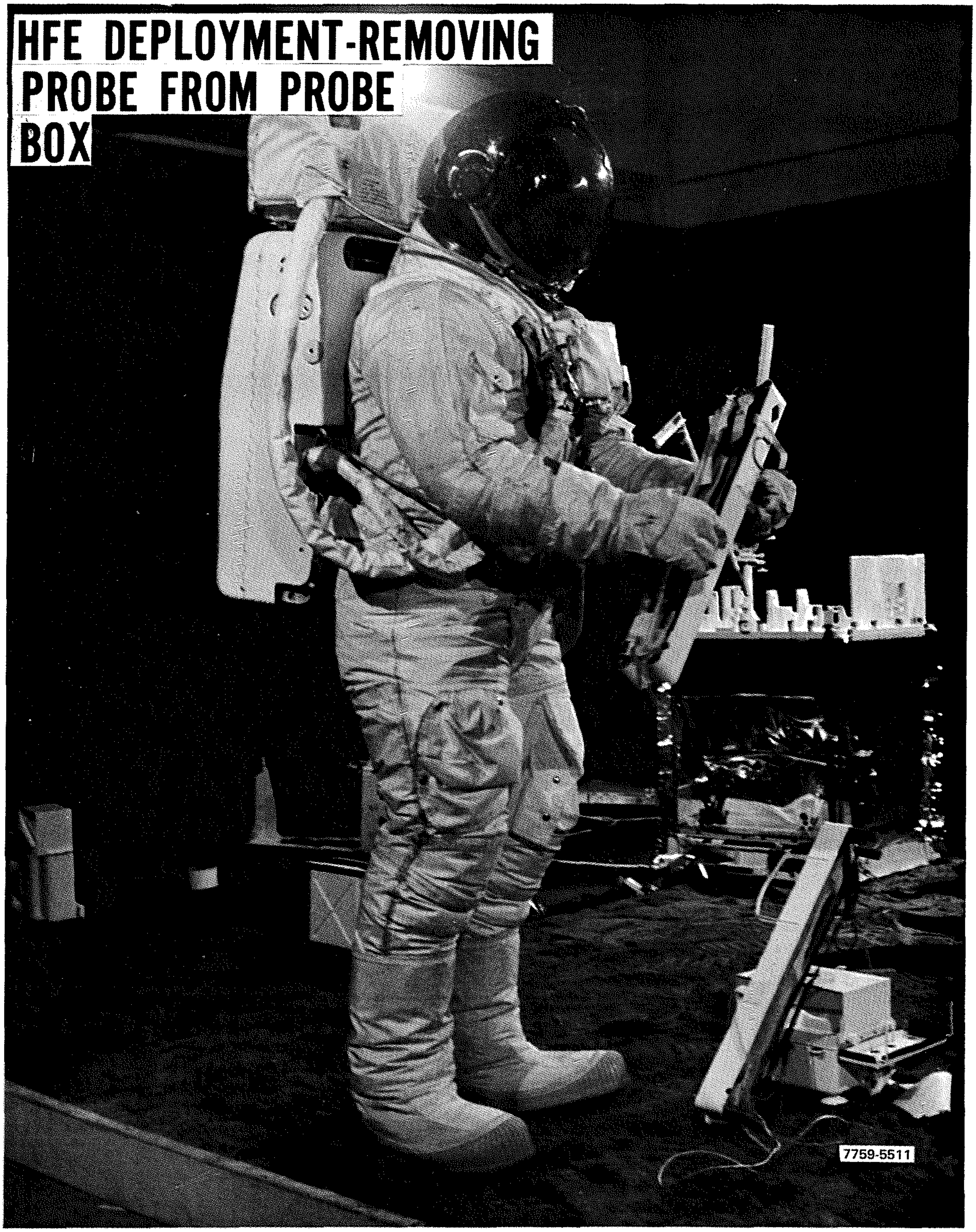

HFE T/V THERMAL SIMULATOR
7759-5507

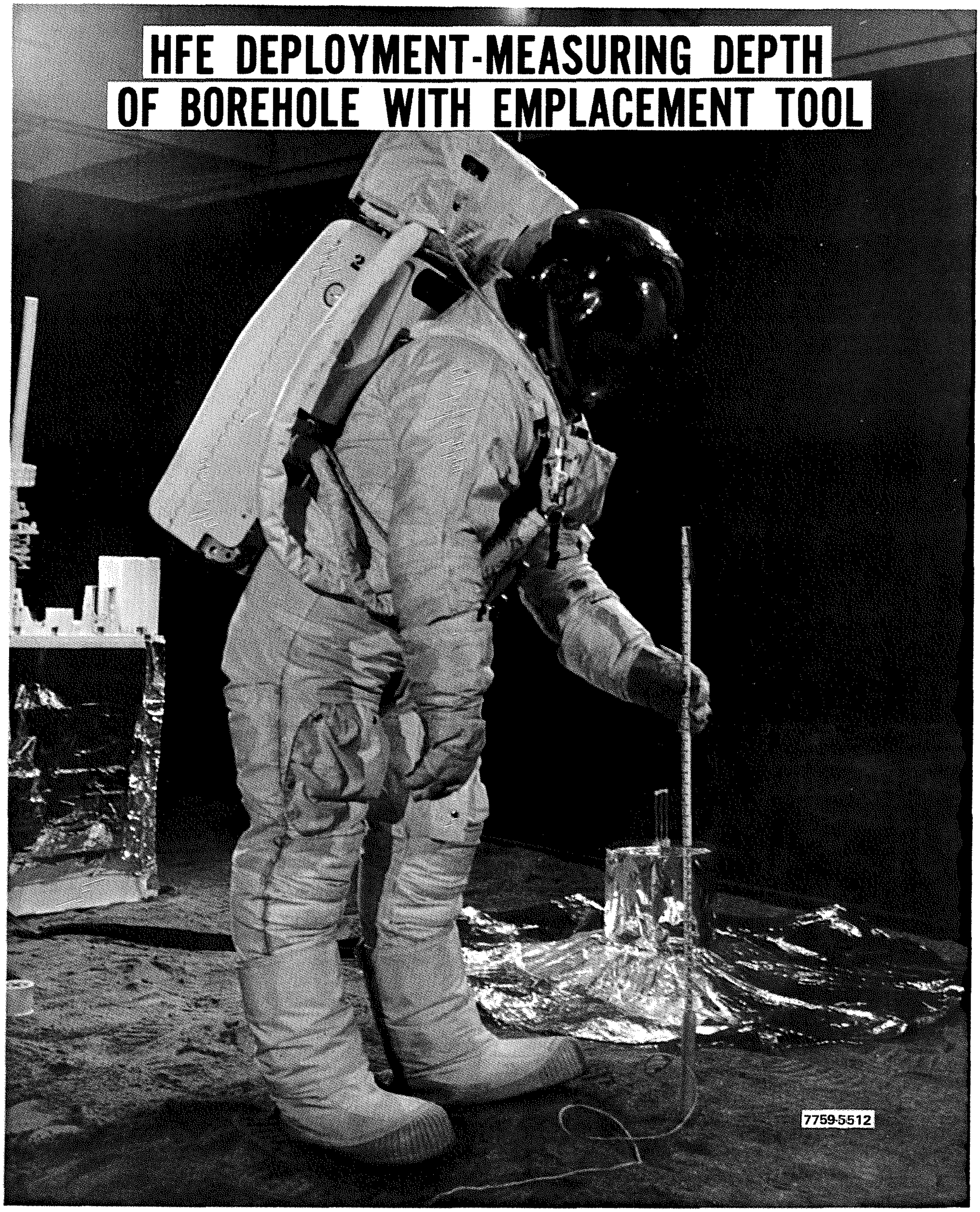

HFE EXPERIMENT TEST SET
7759-5508

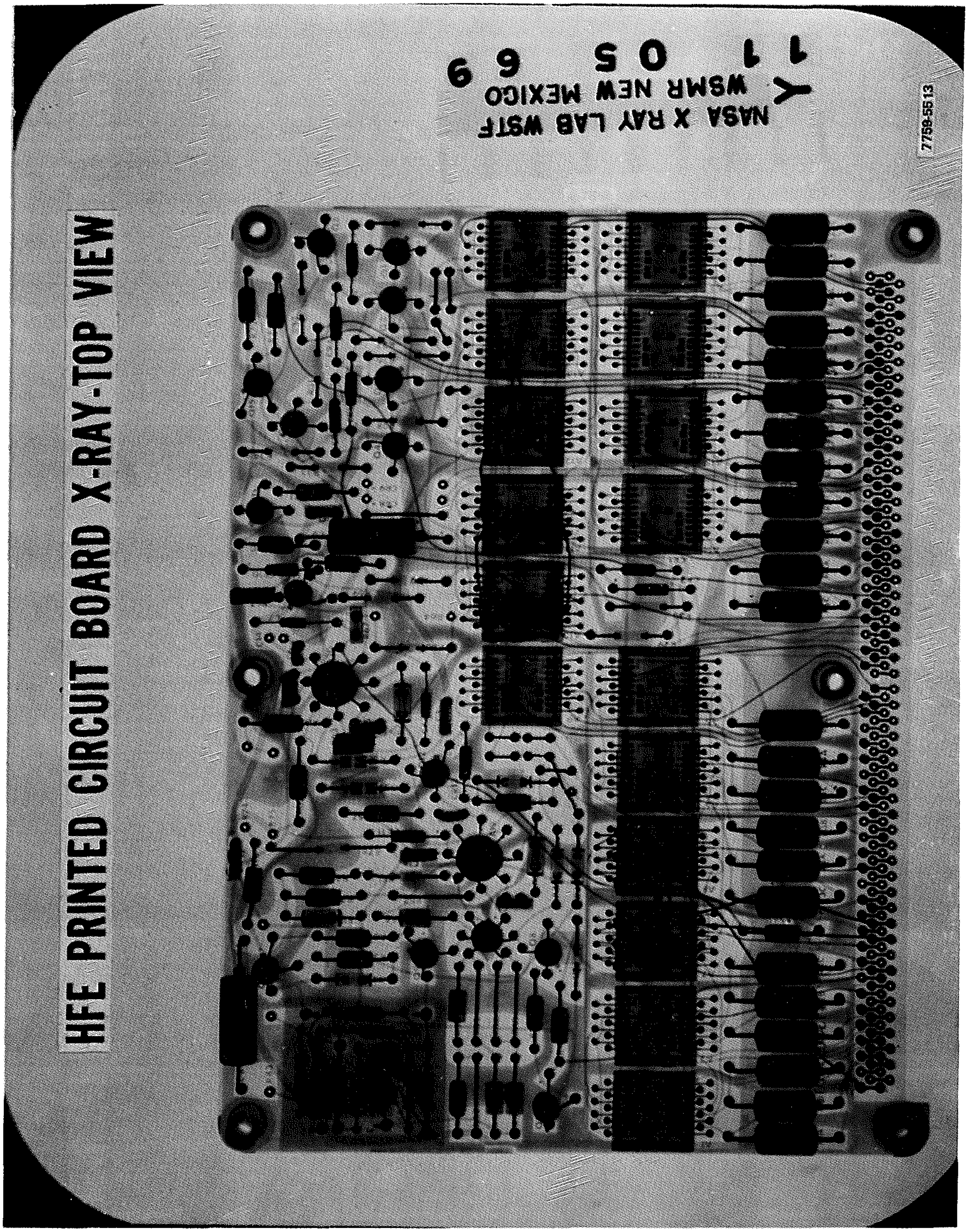


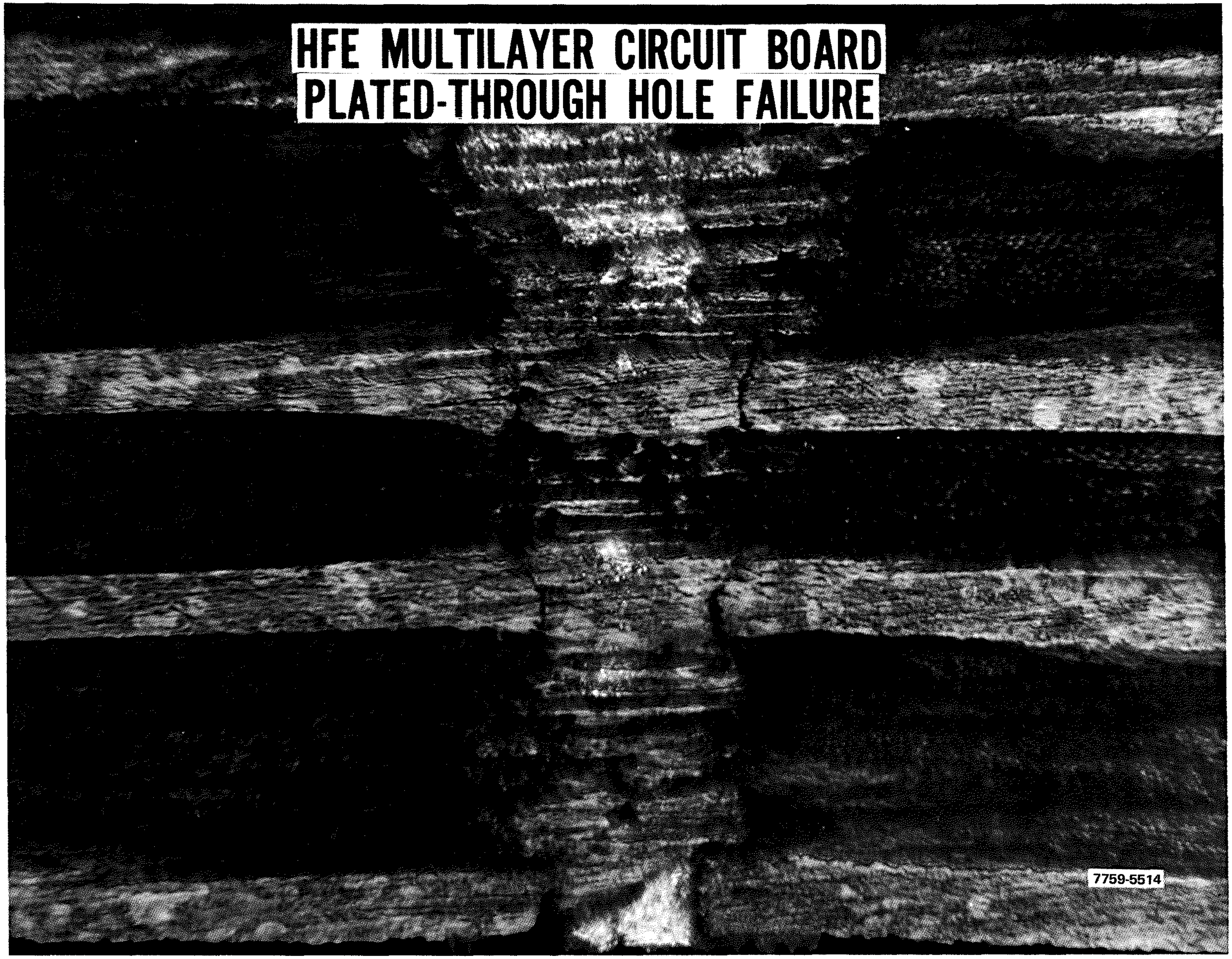
STOWAGE OF HFE ELECTRONICS AND PROBE BOX ON SUBPACKAGE 1

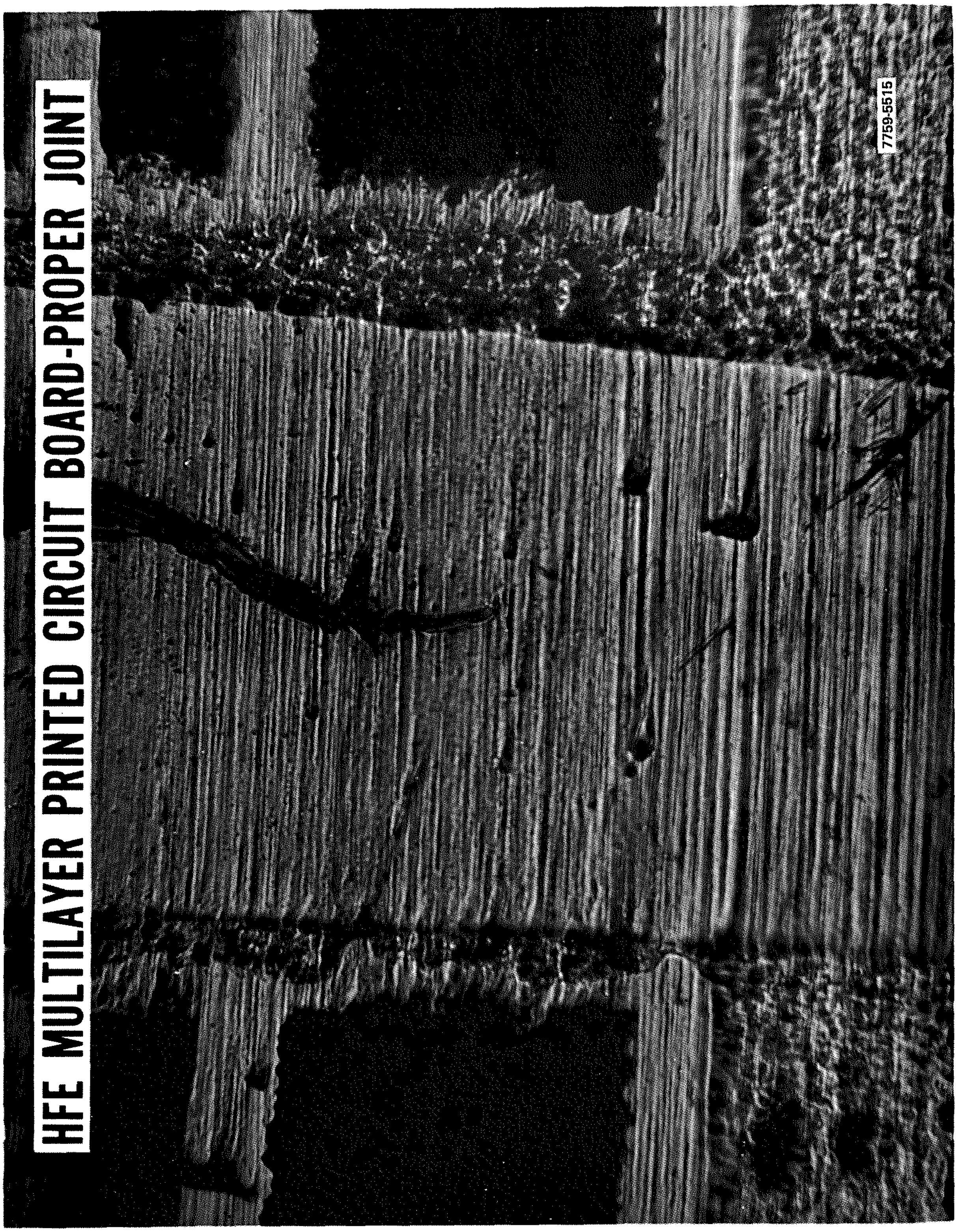

STOWAGE OF HFE DRILL ON SUBPACKAGE 2
7759-5510


HFE DEPLOYMENT-REMOVING PROBE FROM PROBE BOX
7759-5511

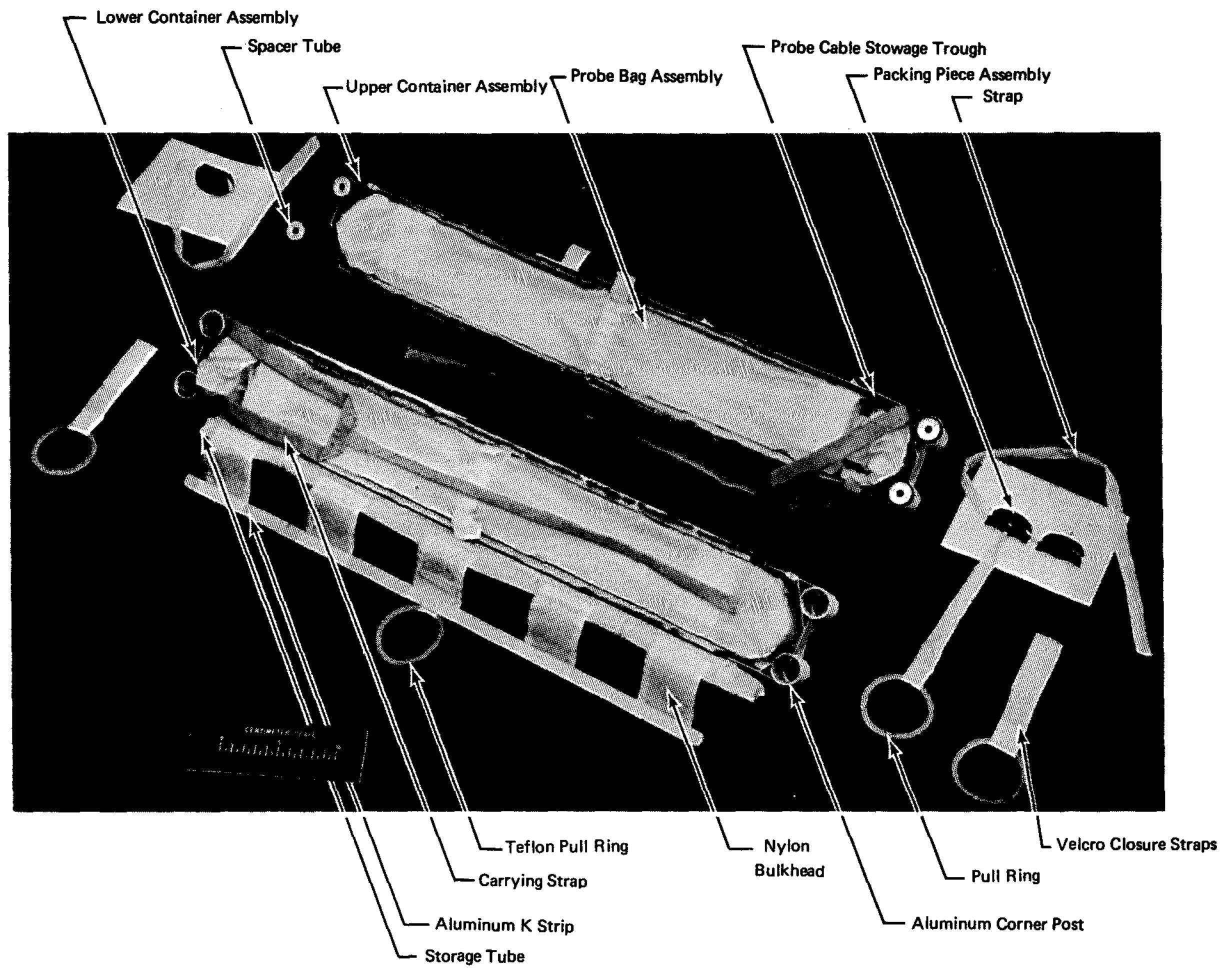

HFE DEPLOYMENT-MEASURING DEPTH
OF BOREHOLE WITH EMPLACEMENT TOOL
2
7759-5512


HFE PRINTED CIRCUIT BOARD X-RAY-TOP VIEW
NASA X RAY LAB WSTF
WSMR NEW MEXICO
11 05 69
7759-5513


HFE MULTILAYER CIRCUIT BOARD
PLATED-THROUGH HOLE FAILURE
7759-5514

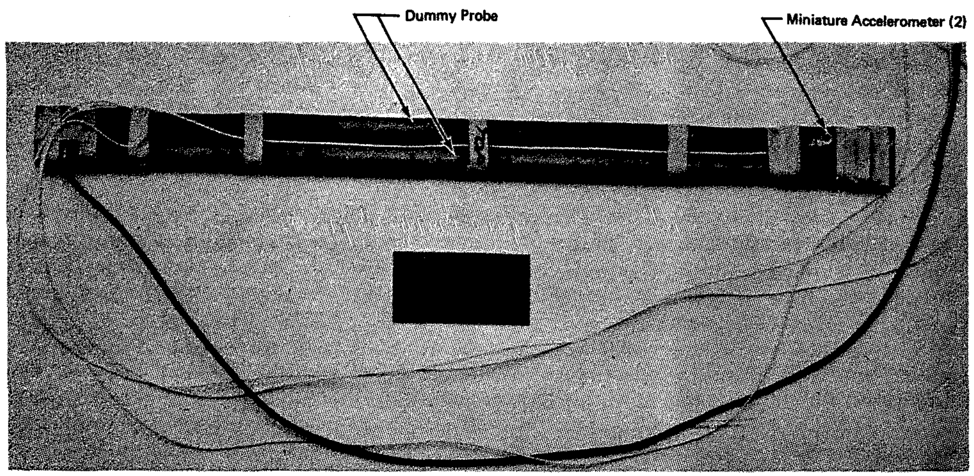

HFE MULTILAYER PRINTED CIRCUIT BOARD-PROPER JOINT
7759-5515

PROBE PACKAGE ASSEMBLY-OPEN

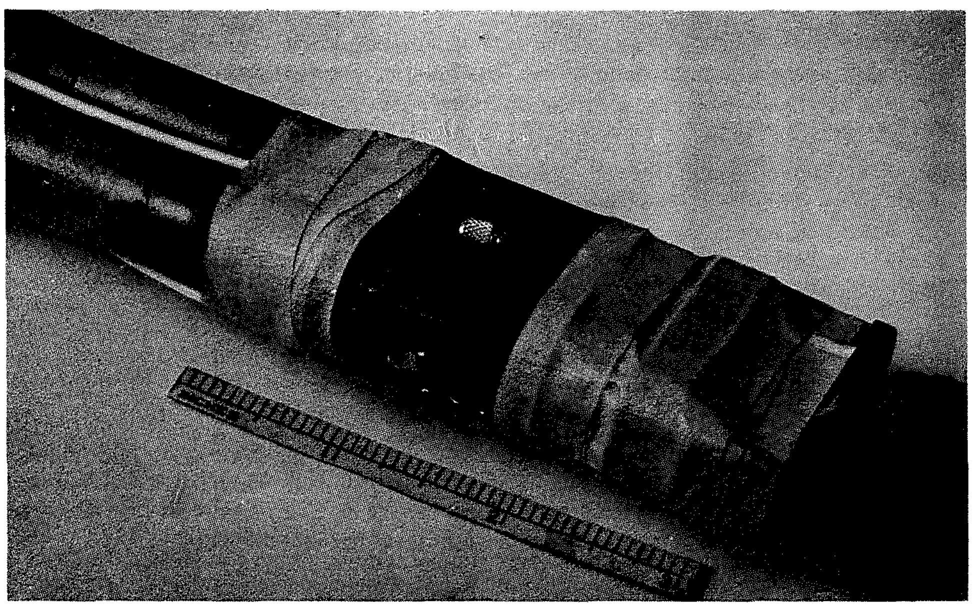


7759-5553

INSTRUMENTED DUMMY PROBE



A. Overall View



B. Detail of Accelerometers

7759-5558

Section 8

Alsep System Design Constraints and Design Selection

DESIGN CONSTRAINTS AND SELECTION

DESIGN CONSTRAINTS
ALSEP POWER HISTORY
POWER MANAGEMENT
- POWER REDUCTION
- OVERLOAD PROTECTION
- EXPERIMENT POWER SWITCHING

UPLINK
ANTENNA POINTING
MISSION TERMINATION
CENTRAL STATION THERMAL CONTROL
ADDITIONAL DESIGN APPROACHES

7759-5720

DESIGN CONSTRAINTS (ORIGINAL EXHIBIT B)

LIFETIME:	CONTINUOUS OPERATION FOR ONE YEAR
RELIABILITY:	GOAL OF 0.9 FOR SYSTEM OPERATION
TOTAL SYSTEM WEIGHT:	185 LBS
VEHICLE CONSTRAINTS:	SEQ BAYS
	VOLUME: 15 FT^3 WEIGHT: 210 LBS TOTAL TEMPERATURE: 0 to 160°F
	EXTERNAL - FUEL CASK
	VOLUME: CONSTRAINED BY SLA WITHDRAWAL LINE WEIGHT: 25 LBS THERMAL: 100 BUT'S PER HOUR INPUT TO LM
	LAUNCH, BOOST, LUNAR DESCENT VIBRATION
LUNAR SURFACE:	TEMPERATURE: -300°F TO +250°F
	VACUUM: LESS THAN 10^{-12} TORR
	SURFACES: ASSUME ALL SURFACES EXPOSED TO RADIATION ARE DUST COVERED AND UV DEGRADED

7759-5706

DESIGN CONSTRAINTS (ORIGINAL EXHIBIT B) CONT'

POWER:

SNAP-27 RTG - 56 WATTS AT ONE YEAR

OPERATION:

OPERATE 3 TO 4 ALSEP'S SIMULTANEOUSLY

BIT ERROR RATES:

UPLINK: 10^{-9}

DOWNLINK: 10^{-4}

MSFN/MCC

ANTENNAS: 30 FOOT DISH WITH INFREQUENT USE OF 85 FOOT DISHES PERMISSIBLE

OPERATION: REAL TIME SUPPORT
- CONTINUOUSLY FIRST 45 DAYS
- 2 HOURS PER DAY THEREAFTER

REAL TIME SUPPORT OF TWO SYSTEMS SIMULTANEOUSLY

ALL RECEIVED DATA IS RECORDED

7759-5707

DESIGN CONSTRAINTS (ORIGINAL EXHIBIT B) CONT'

DEPLOYMENT SITE:

LATITUDE: $\pm 5^{\circ}$

LONGITUDE: $\pm 45^{\circ}$ $\pm 45^{\circ}$

SOLAR ELEVATION ANGLE 7° TO 30° (45° GOAL)

ASTRONAUT ACTIVITIES AND INTERFACES

SIMPLE AND SAFE

DEPLOYMENT TIME: 90 MINUTE MAXIMUM (F-1)

DEPLOYMENT DISTANCE: 300 TO 1000 FEET

CAPABILITIES:

REACH: WORKING 28" to 66"

MAXIMUM 22" TO 72"

VISUAL: HIGH-CONTRAST INDICATORS

7759-5708

ASTRONAUT INTERFACES

SAFETY

BIOMED: WITHIN EXERTION AND LIFE SUPPORT LIMITATIONS

TEMPERATURES: NO CONTACT WITH EXTREMELY HOT SURFACES

PUNCTURES: NO SHARP EDGES, ETC.; NO HAZARDOUS PYROTECHNICS
NO EXPOSED HIGH VOLTAGE POINTS

CAPABILITY

MOBILITY: LIMITATIONS ON REACH (UP AND DOWN) KNEELING, TWISTING, ETC.

DEXTERITY: HANDLE SIZE COMPATIBLE WITH GLOVES, NO ADJUSTMENTS REQUIRING EXTREME PRECISION

VISUAL: HIGH-CONTRAST INDICATORS FOR LEVELING AND ALIGNMENT

7759-5722

CHANGES IN CONSTRAINTS

WEIGHT:

$\left.\begin{array}{l}\text{SEQ BAYS: 220 LBS}\\ \text{EXTERNAL: 65 LBS}\end{array}\right\}$ 285 LBS

POWER RTG OUTPUT:

63 WATTS MINIMUM, 70 WATTS TYPICAL, 80 WATTS MAXIMUM

SITE:

$\left.\begin{array}{l}\text{LONGITUDE: } \pm 45^{o}\\ \text{LATITUDE: } \pm 45^{o}\end{array}\right\}$ PLUS MARIUS HILLS FLIGHT 4 AND SUBSEQUENT

TURN OFF:

TWO YEARS OR LONGER

7759-5709

SCIENITIC MERIT AS FUNCTION OF TIME

SIDE/CCIG SWS LSM	MOST OF THE SCIENCE OBJECTIVES ARE OBTAINED AT COMPLETION OF SUCCESSFUL OPERATION FOR ONE LUNAR DAY. FURTHER OPERATION PROVIDES CONFIRMING DATA.
PSE	A SIGNIFICANT NUMBER OF IMPACTS OR TECTONIC EVENTS MUST BE OBSERVED. DATA IS GREATLY ENHANCED BY SIMULTANEOUS OPERATION OF TWO OR MORE SEISMOMETERS.

ESTIMATED FULFILLMENT OF SCIENCE OBJECTIVES

30 DAYS	50%
90 DAYS	75%
180 DAYS	85%
1 YEAR	100%

PERFORMANCE INCENTIVES

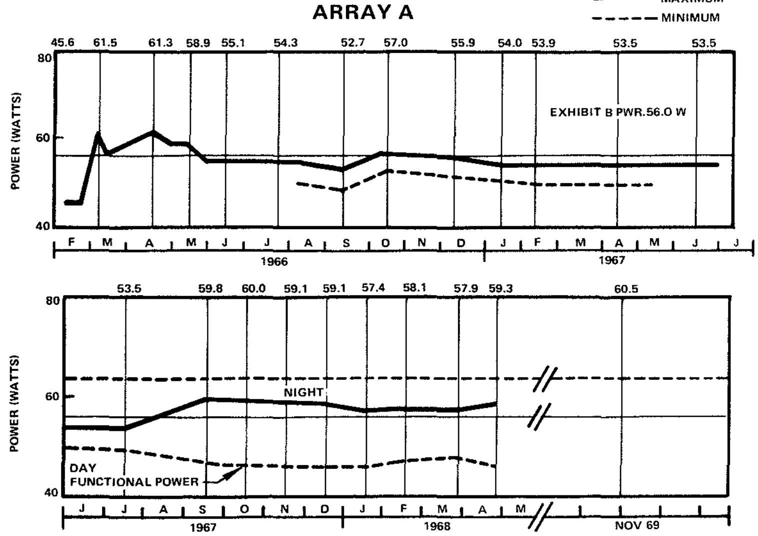
1 MINUTE	12.5%
10 DAYS	27.5%
30 DAYS	42.5%
90 DAYS	67.5%
180 DAYS	80.5%
360 DAYS	87.5%
TURN OFF	100

7759-5710

ALSEP SYSTEM

POWER VS TIME
ARRAY A

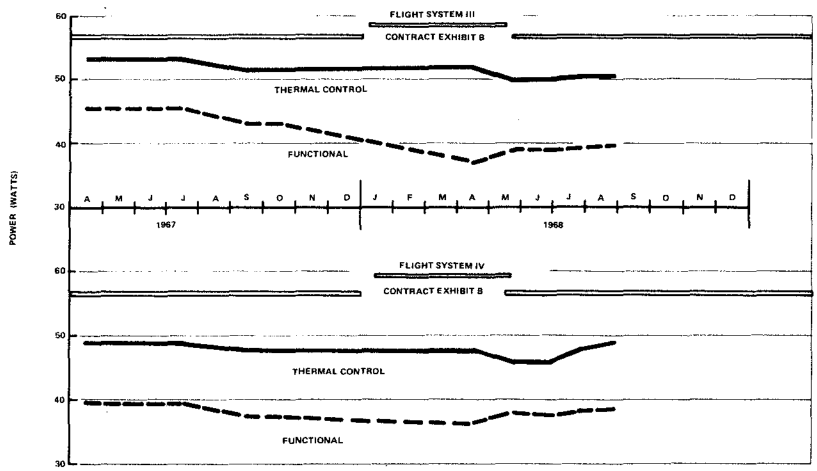
OPERATIONAL POWER
———— MAXIMUM
- - - - - MINIMUM



7759-5705

8-4

ESTIMATED SYSTEM OPERATIONAL POWER



7759-5713

POWER MANAGEMENT

POWER REDUCTION PROGRAM

POWER OVERLOAD PROTECTION

EXPERIMENT POWER SWITCHING

POWER/THERMAL CONTROL CONSIDERATIONS

7759-5724

DESIGN APPROACHES TO REDUCE POWER

POWER CONDITIONING UNIT

- AUTOTRANSFORMER FOR HIGHER EFFICIENCY

DATA PROCESSOR

- CHANGE LOGIC FOR REDUCED POWER 25 to 14.5 WATTS

COMMAND DECODER

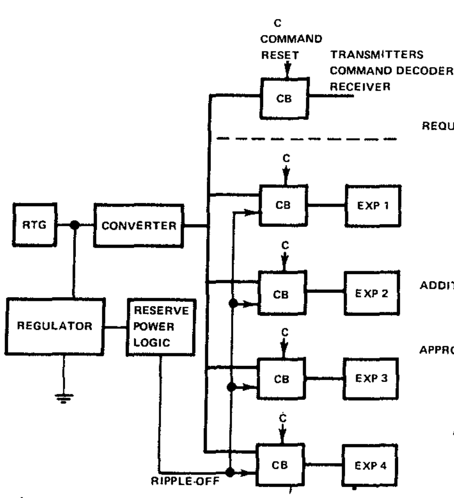
- LOGIC CHANGE
- PARTIAL REDUNDANCY VERSUS FULL REDUNDANCY

RTG CABLE

- LARGE CONDUCTOR SIZE TO REDUCE LOSSES

7759-5718

POWER OVERLOAD PROTECTION



REQUIREMENT:

- PROTECT CENTRAL STATION FROM CATASTROPHIC FAULTS
- AUTOMATIC OPERATION WITHOUT GROUND CONTROL
- ALLOW FOR REASONABLE TURN-ON AND SWITCHING TRANSIENTS
- MAINTAIN LOGIC STATUS DURING FAULT

ADDITIONAL CONSTRAINT:

- TIMING CONSISTENT WITH POWER SOURCE DYNAMIC RESPONSE

APPROACH:

- RESETTABLE CIRCUIT BREAKERS - FAULT PROTECTION AT 500 MA
- TIME CONSTANTS - ALLOWS REASONABLE TRANSIENTS, PROTECTS AGAINST SERIOUS OUT-OF-REFULATION CONDITION
- RIPPLE OFF – SLOW DEGRADATION PROTECTION

7759-5714

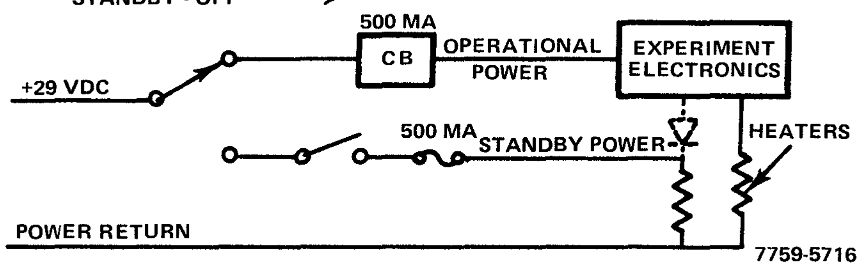
EXPERIMENT POWER SWITCHING/EXPERIMENT SURVIVAL

REQUIREMENT:
PROVIDE SCHEME TO PERMIT EXPERIMENTS TO SURVIVE FOR PERIODS WITHOUT OPERATING POWER-ON

ADDITIONAL CONSTRAINT:
TWO HOURS PER DAY REAL TIME COVERAGE AFTER 45 DAYS

APPROACH:

$\left.\begin{array}{l}\text{OPERATE}\\ \text{STANDBY (SURVIVAL)}\\ \text{STANDBY - OFF}\end{array}\right\}$ POWER MODES



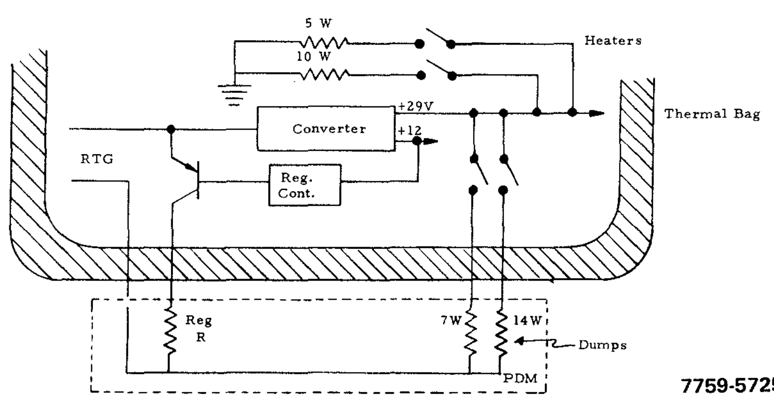
7759-5716

POWER SUBSYSTEM/CENTRAL STATION THERMAL CONTROL

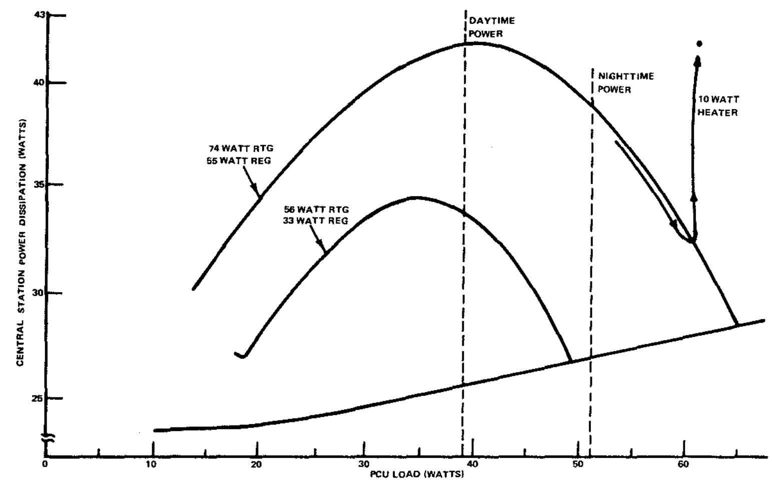
REQUIREMENT: OBTAIN THE BEST USE OF AVAILABLE POWER AND POWER SWITCHING MODES FOR IMPROVED THERMAL CONTROL

APPROACH: DAYTIME IMPROVEMENTS - COMMANDABLE 7 AND 14 WATT DUMP LOADS

NIGHTTIME IMPROVEMENTS - COMMANDABLE 5 AND 10 WATT HEATERS



7759-5725



7759-5715

POWER CONVERTER CONSIDERATIONS

REQUIREMENTS:

- HIGH EFFICIENCY
- DESIRABLE TO PRESENT CONSTANT LOAD TO RTG
- REDUCE OUTPUT RIPPLE
- PROVIDE SURGE AND TRANSIENT CAPABILITY

ALTERNATE APPROACHES TO PCU DESIGN:

REGULATOR	CONVERTER	FILTERING
SHORTING	AUTOTRANSFORMER	MODEST OUTPUT CAPACITANCE AND TRANSIENT CONTROL
SHUNT	ISOLATED TRANSFORMER	LARGE FILTERS

DESIGN SELECTION: SHUNT REGULATOR/AUTOTRANSFORMER/MODEST FILTERING

- HIGH EFFICIENCY
- BETTER EMI CHARACTERISTICS
- SIZE AND WEIGHT

7759-5717

ANTENNA POINTING REQUIREMENTS

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

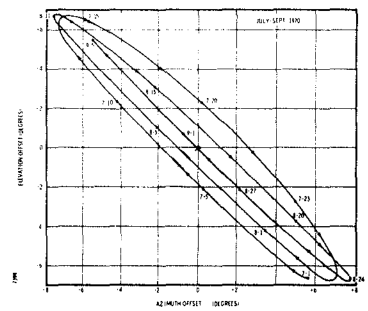
PRINCIPAL EFFECTS:

- ± 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 LATTITUDE DUE TO:
  - INCLINATION OF MOON'S ROTATION AXIS TO ITS ORBITAL PLANE

SECONDARY EFFECTS:

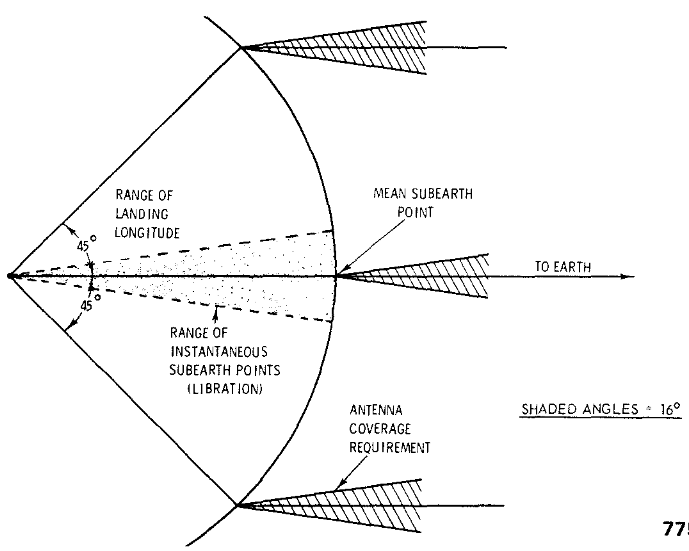
- NON-SPHERICAL EARTH & MOON
- SOLAR PETURBATIONS
- GYROSCOPE & PENDULUM COUPLING

COMBINED EFFECTS: PATTERN CHANGES MONTHLY & YEARLY



7759-5700

ANTENNA POINTING REQUIREMENT



7759-5701

ANTENNA AND ANTENNA POINTING

REQUIREMENT:

POINT AT THE NOMINAL CENTER OF EARTH'S MOVEMENT PATTERN

TOTAL ALLOWABLE LEVELING, ALIGNMENT, AND MECHANISM ERROR $\cdot 5^{\circ}$

ACCEPTABLE GAIN UP TO 17° OFF AXIS

ALTERNATIVE:

TECHNIQUE { BORESIGHT AT EARTH AND OFFSET / LOCAL VERTICAL, E-W REFERENCE

MECHANISM { BALL AND SOCKET / GEARS AND GIMBAL

SELECTION:

ANTENNA - AXIAL HELIX - ACCEPTABLE GAIN TO 22°

LOCAL VERTICAL, E-W REFERENCE

AIMING MECHANISM, TWO GIMBAL - GEARED SYSTEM

ASTRONAUT CAPABILITY

HIGHER CONFIDENCE

7759-5712

UPLINK APPROACH

REQUIREMENTS:

TURN-ON, INITIALIZE EXPERIMENTS

INITIATE EXPERIMENT MODE CHANGES

OPERATE THREE SYSTEMS SIMULTANEOUSLY

PROVIDE MODULATION SCHEME WITH ADEQUATE SECURITY

MCC COMPATIBILITY

APPROACHES:

REDUNDANCY

FULLY REDUNDANT WITHOUT TIMER
PARTIALLY REDUNDANT WITH TIMER

MODULATION

SIMPLE MODULATION/ADDRESS SCHEMES
SPREAD SPECTRUM MODULATOR

APPROACH SELECTED:

1. PARTIALLY REDUNDANT WITH ON BOARD TIMER

POWER SAVINGS

2. 21 BIT COMMAND WITH ONE AND TWO KHZ MODULATION

SIMPLICITY AND RELIABILITY
AMPLE ADDRESS CAPABILITY
SUFFICIENT ADDRESS AND MESSAGE SECURITY

7759-5711

DATA LINK ANALYSIS

REQUIREMENT: BIT ERROR RATES — UPLINK: 10^{-9}

DOWNLINK: 10^{-4}

BORESIGHT ANTENNA GAIN: 15.2 DB

UPLINK: 2119 MHz	DOWNLINK: 2276.5 TO 2279.5 MHz
10 KW TRANSMITTER POWER	1 WATT OUTPUT POWER
IF S/N MARGIN	LINK MARGIN
30 FT + 9.3 DB	NORMAL BIT RATE - 1.06K BPS
85 FT + 18.1 DB	30 FT DISH - + 7.2 DB
	ASE BIT RATE -10.6 K BPS
	85 FT DISH -+6.5 DB

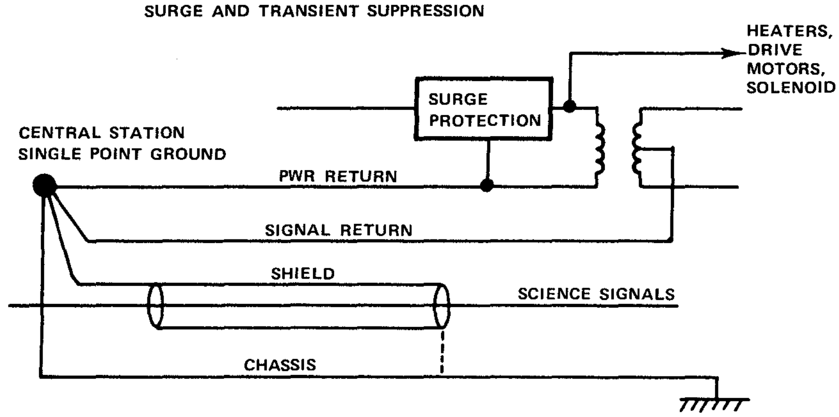
7759-5703

ISOLATION AND GROUNDING

EXPERIMENT INTERFACES

DC ISOLATION OF SIGNAL GROUND, CHASSIS RETURN, AND POWER RETURN

SURGE AND TRANSIENT SUPPRESSION



7759-5721

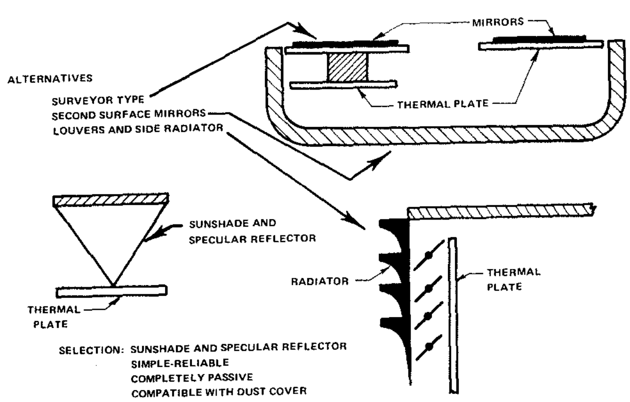
MISSION TERMINATION

REQUIREMENT;	TURN OFF DOWNLINK AT END OF ONE YEAR
APPROACHES:	HIGHLY REDUNDANT UPLINK/NO TIMER
	MECHANICAL TIMER - BATTERY AND PRIME POWER SOURCE DRIVER
	SOLID STATE ELECTRONIC TIMER
	CHEMICAL TIMERS
ADDITION CONSTRAINT:	(DIRECTED INTERPRETATION OF EXECUTIVE ORDER)
	ON BOARD MISSION TERMINATION DEVICE INDEPENDENT OF UPLINK
SELECTION:	BATTERY OPERATED MECHANICAL TIMER
	LOW POWER, WEIGHT, VOLUME
	USER DATA

7759-5704

CENTRAL STATION THERMAL CONTROL

REQUIREMENT: 0 TO 125°F ON THERMAL PLATE
ALL HORIZONTAL SURFACES ARE DUST COVERED



SELECTION: SUNSHADE AND SPECULAR REFLECTOR
SIMPLE-RELIABLE
COMPLETELY PASSIVE
COMPATIBLE WITH DUST COVER

7759-5719

ADDITIONAL DESIGN APPROACHES OR CONSIDERATIONS NOT DISCUSSED

POWER:

- REGULATOR RANGE
- RTG TEMPERATURE WINDOW VERSUS ACCURACY
- PCU HOLD OFF CIRCUIT/RTG WARM UP
- TURN ON USING ASTROSWITCHES

DATA SUBSYSTEM:

- PULSE RISE AND FALL TIMES AND REPETITION RATE VERSUS CROSSTALK
- LOGIC NOISE IMMUNITY

THERMAL:

- REDUCTION OF HEAT LEAK USING MANGANIN WIRE

EXPERIMENT INTERFACES:

- SELECTION OF FLAT CONDUCTOR CABLE OVER CONVENTIONAL CABLING
- POWER DISTRIBUTION OVER LONG LINES (SIDE AND LSM)
- PULSE RISE AND FALL TIME CONTROL IN FLAT CONDUCTOR CABLING
- VARIABLE EXPERIMENT INTERFACES
- ISOLATION AND GROUNDING PHILOSOPHY

7759-5723

ALSEP FLIGHT 1 RELIABILITY

Subsystem	Reliability Goal	Current Reliability Prediction
Power	0.9900	0.9819
Data	0.9642	0.8766
Structural/Thermal	0.9997	0.9926
Passive Seismic	0.9900	0.9322
Magnetometer	0.9900	0.7644*
Solar Wind	0.9900	0.8543*
SIDE/CCGE	0.9900	0.6803*

*GFE Predictions Furnished by NASA.

7759-5702

Section 9

Alsep Structural Design

SYSTEM REQUIREMENTS AND CONSTRAINTS

- LM INSTALLATION
- MASS PROPERTIES
- PRELAUNCH OPERATIONS
- LAUNCH, FLIGHT AND LANDING
- REMOVAL FROM LM
- ASTRONAUT INTERFACE
- LUNAR ENVIRONMENT
- DATA TRANSMISSION AND RECEPTION
- GENERAL DESIGN CRITERIA

7759-5847

MECHANICAL CRITERIA

STRUCTURAL ELEMENTS

- WITHSTAND LOADS OF LAUNCH, FLIGHT, & LUNAR LANDING
- WITHSTAND LOADS ASSOCIATED WITH DEPLOYMENT
- SUPPORT THE EQUIPMENT ON THE LUNAR SURFACE

JOINTS, FITTINGS & FASTENERS

- HOLD SECURELY IN LOCKED POSITIONS
- RELEASE & FUNCTION DURING DEPLOYMENT

SPECIAL JIGS & SHIPPING CONTAINERS PROVIDE PROTECTION FOR PRELAUNCH HANDLING, TRANSPORTATION, & STORAGE

7759-5811

ASTRONAUT INTERFACE

SAFETY

BIOMED: WITHIN EXERTION AND LIFE SUPPORT LIMITATIONS

TEMPERATURES: NO CONTACT WITH EXTREMELY HOT SURFACES

PUNCTURES: NO SHARP EDGES, ETC.; NO HAZARDOUS PYROTECHNICS

CAPABILITY

MOBILITY: LIMITATIONS ON REACH (UP & DOWN), KNEELING, TWISTING, ETC.

DEXTERITY: KNOBS & HANDLES SIZED TO FIT GLOVES, MINIMUM USE OF FINE ADJUSTMENTS, FEW ELECTRICAL CONNECTORS MATED ON MOON

VISUAL: INDICATORS (LEVELING & ALIGNMENT) PROVIDE HIGH CONTRAST; STRIPES ON PACKAGE EDGES WHERE THERMAL DESIGN PERMITS

7759-5846

ASTRONAUT CONSTRAINTS

REACH PARAMETERS

MAXIMUM	–	60 INCHES
ABOVE LUNAR SURFACE	–	28 INCHES FOR WORKING AND MANIPULATING 22 INCHES FOR GRASPING OBJECTS

FORCE PARAMETERS

KNOBS

0.75" DIA	–	3.8 LB MAX
1.00" DIA	–	5.0 LB MAX
1.25" DIA	–	7.6 LB MAX
1.50" DIA	–	9.6 LB MAX

PUSH/PULL, RIGHT/LEFT, UP/DOWN	–	20 LB MAX
DYNAMETRIC FORCE	–	10 LB MAX
STATIC LOAD	–	60 LB MAX

7759-5880

ASTRONAUT CONSTRAINTS (CONT')

VIEWING ANGLES

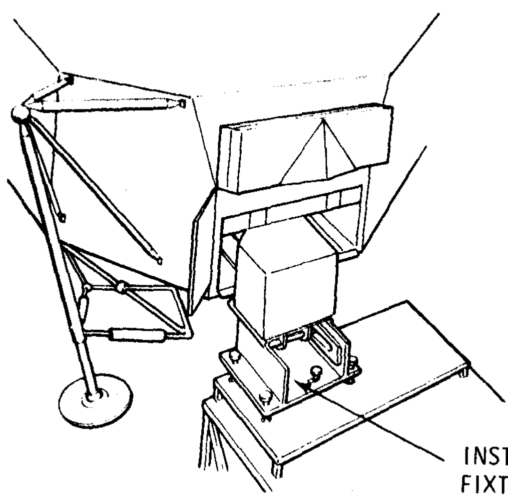
OPTIMUM	–	30° CONE CIRCUMSCRIBED BY 15° RIGHT AND LEFT, 0° UP AND 30° DOWN FROM THE HORIZONTAL LINE-OF-SIGHT.
MAXIMUM	–	90° RIGHT AND LEFT, 70° UP AND 85° DOWN FROM HORIZONTAL LINE-OF-SIGHT.
CONTRAST	–	BLACK CHARACTERS ON WHITE BACKGROUND – PREFERRED.
	–	BLACK CHARACTERS ON YELLOW OR GOLD BACKGROUND – ACCEPTABLE.
	–	ORANGE CHARACTERS ON WHITE BACKGROUND – ACCEPTABLE.

SAFETY

THERMAL	–	250° MAXIMUM – SUIT CAPABILITY
MECHANICAL	–	0.030" RADII ON ALL EXPOSED EDGES AND CORNERS – TEFLON TAPE OR SUBSTITUTE ACCEPTABLE WHERE MATERIAL THICKNESS PRECLUDES REQUIRED RADII.
ELECTRICAL	–	NO ASTRONAUT INTERCONNECTION OF ELECTRICALLY HOT CABLES.
ORDINANCE	–	REDUNDANCE REQUIRED TO ACTUATE ORDINANCE.

7759-5881

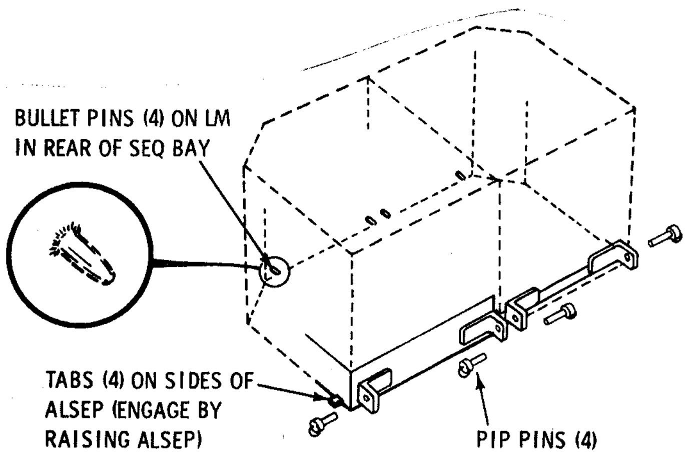
INSTALLATION IN LUNAR MODULE



- SLIDE IN
- LIFT AND INSERT PIP PINS
- CLOSE THERMAL DOOR

7759-5849

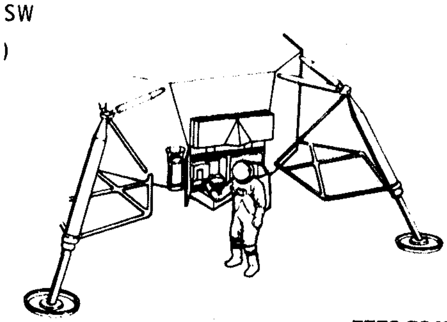
LM HARD POINTS



7759-5832

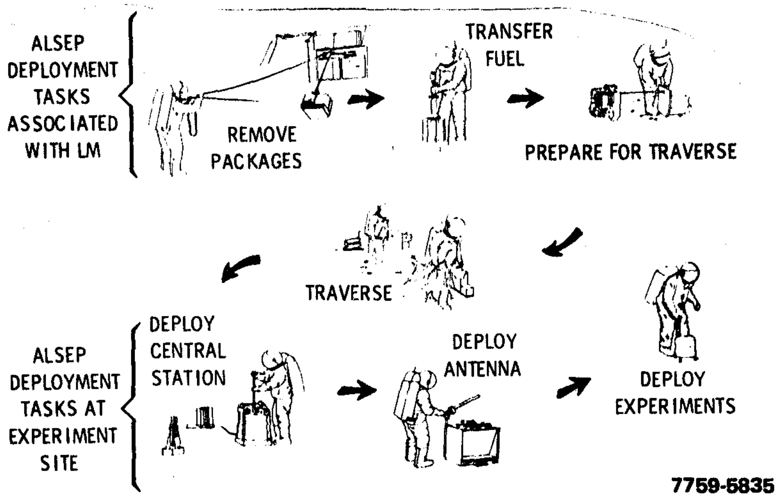
REMOVAL FROM LUNAR MODULE

- BOTTOM OF SEQ BAY 18 IN. TO 60 IN. FROM SURFACE & ± 15° TILT (ANY DIRECTION)
- CLOSE LM DOOR FOR THERMAL INTEGRITY
- LANDING LOCATION WITHIN ± 5° FROM EQUATOR & ± 45° E - W
- LM PROBABLY LANDS FACING NW OR SW
- SUN ANGLE 7° TO 20° (POSSIBLE 45°) ABOVE HORIZON AND RISING
- ALHT REMOVAL SEPARATELY OR ATTACHED TO ALSEP

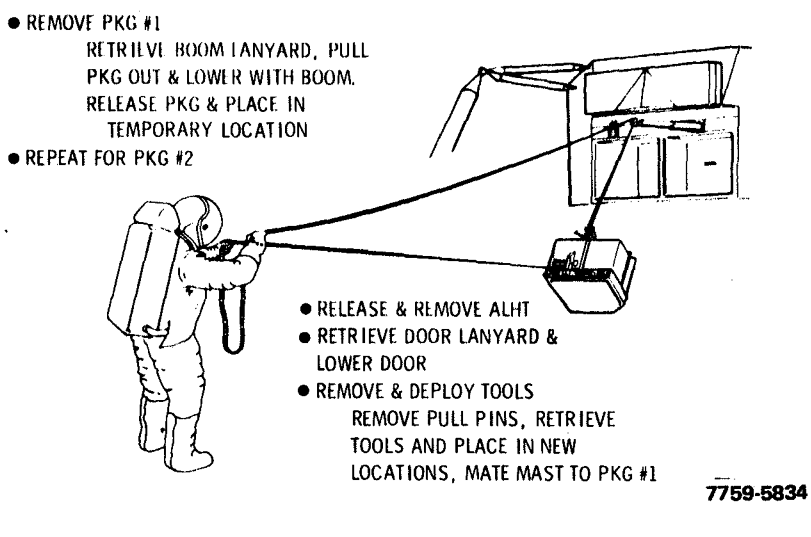


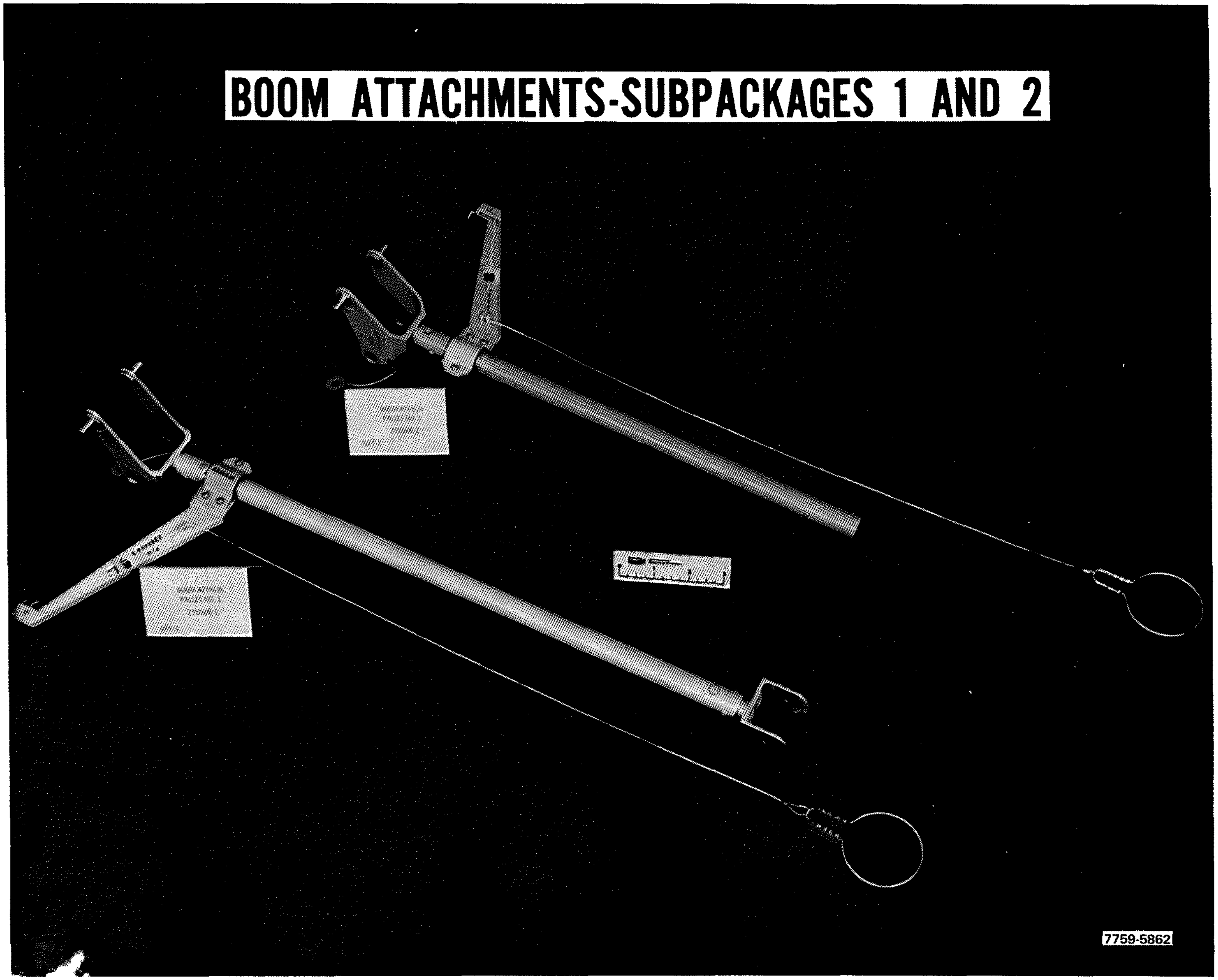
7759-5845

LUNAR SURFACE PHASE



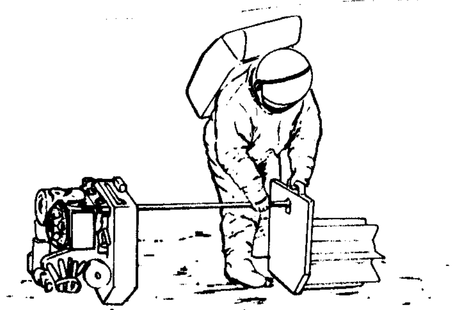
REMOVE PACKAGES




BOOM ATTACHMENTS-SUBPACKAGES 1 AND 2
7759-5862

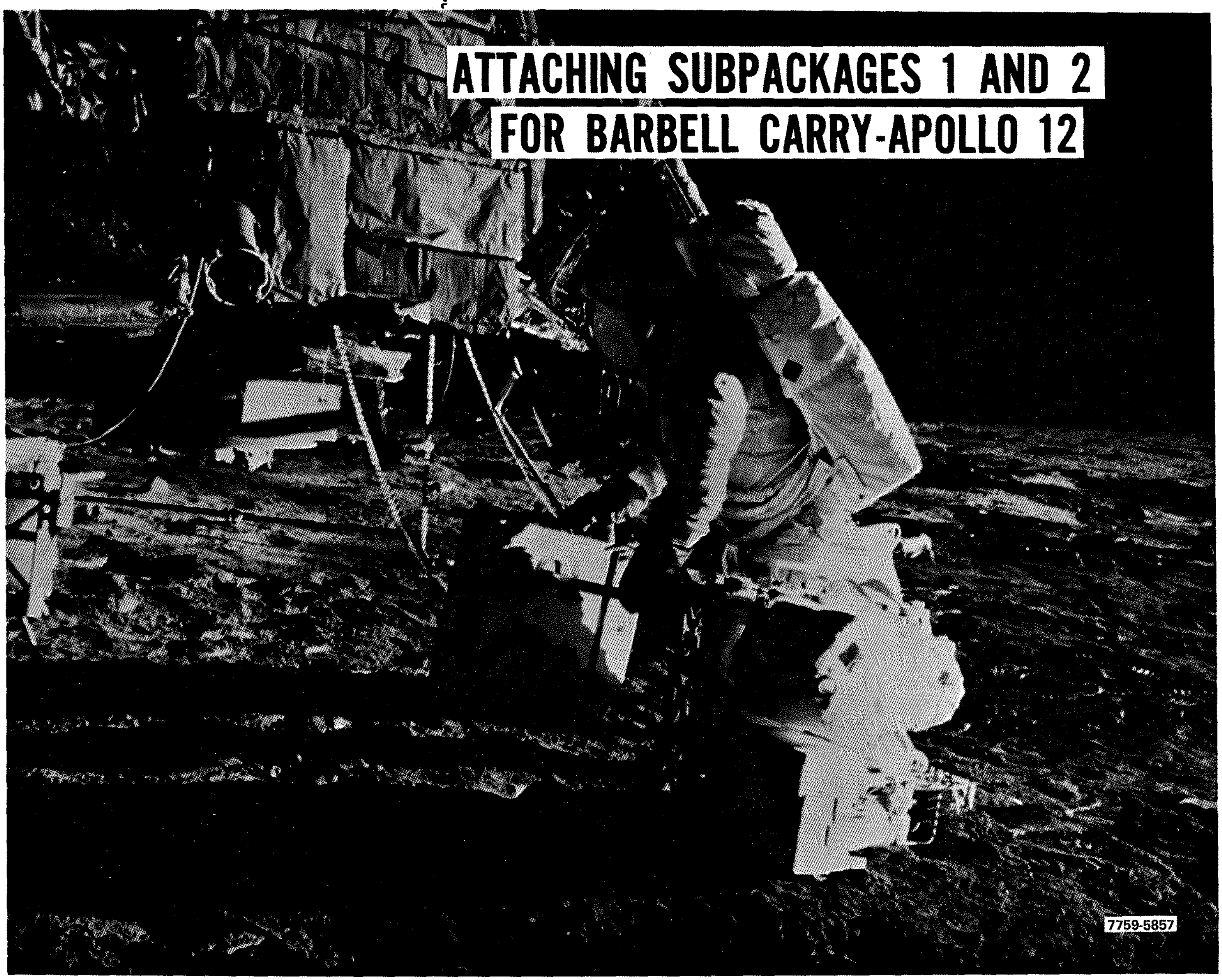
REMOVING SUBPACKAGE 2 FROM SEQ BAY-APOLLO 12

PREPARE FOR TRAVERSE



- ROTATE & RE-ORIENT PKG #2
- JOIN MAST TO PKG #2
  (ALREADY MATED TO PKG #1)

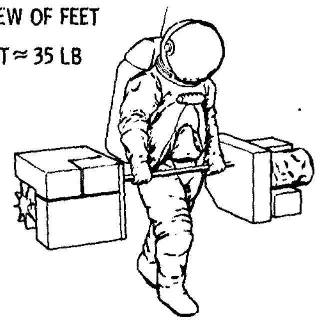
7759-5836



ATTACHING SUBPACKAGES 1 AND 2
FOR BARBELL CARRY-APOLLO 12

BARBELL CARRY

- ALLOWS ALL EQUIPMENT TO BE CARRIED BY ONE MAN IN ONE TRAVERSE
- SUITCASE HANDLES FOR TWO-MAN OR BACKUP CARRY MODE
- GIVES GOOD BALANCE & VIEW OF FEET
- EQUIVALENT EARTH WEIGHT ≈ 35 LB

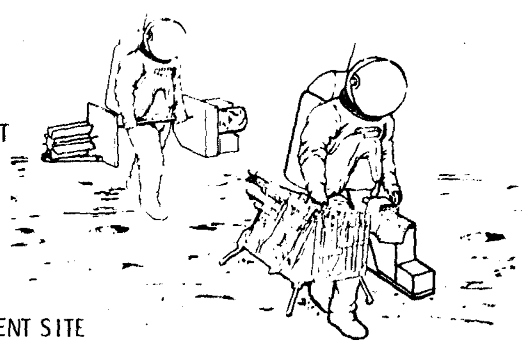


- MAY BE SET DOWN TO REST
- CARRY BAR LATER USED AS ANTENNA MAST

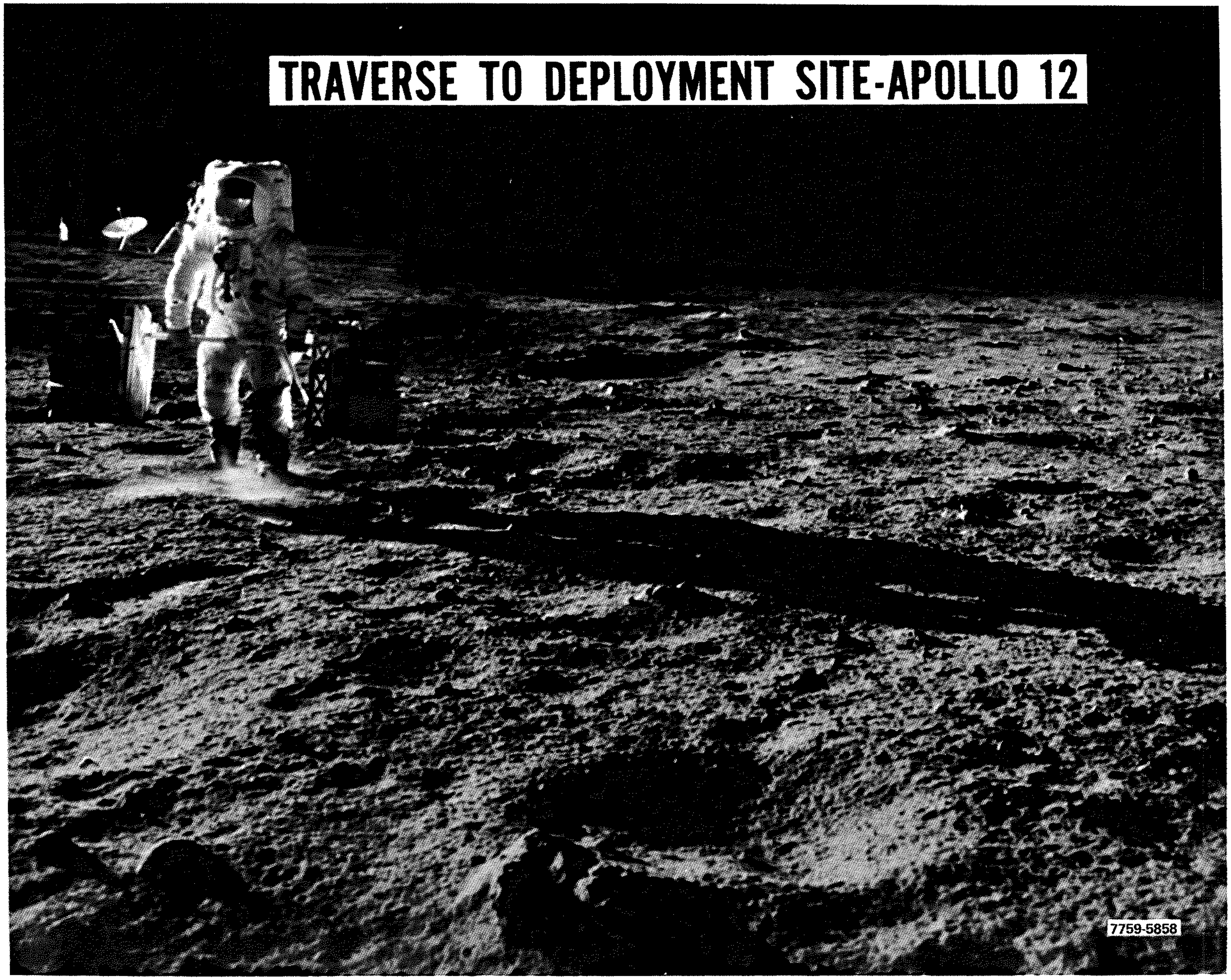
7759-5839

TRAVERSE

- COMMANDER
  CARRIES SUBPALLET & ALHT
  LEADS & PICKS ROUTE
- LM PILOT
  CARRIES ALSEP BARBELL
- REST, AS NECESSARY
- COMMANDER PICKS DEPLOYMENT SITE



7759-5838

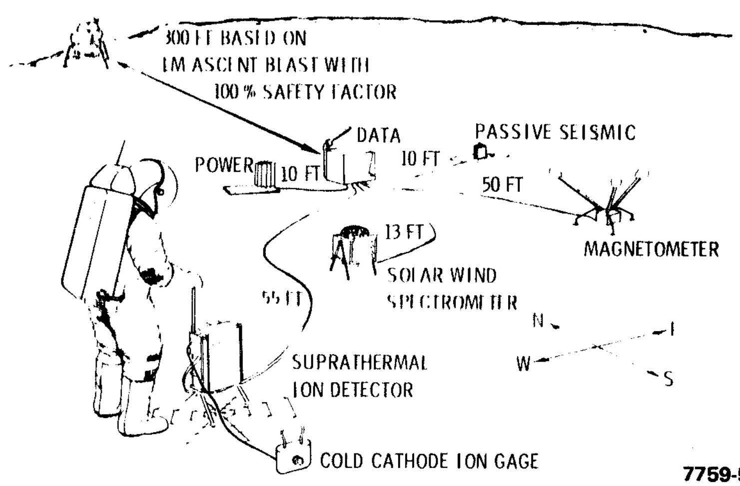

TRAVERSE TO DEPLOYMENT SITE-APOLLO 12
7759-5858

DEPLOY EXPERIMENTS

SWS	PSE	LSM	SIDE
CARRY 13 FT EXTEND LEVELING LEGS PLACE ON SURFACE (PARTIALLY SELF-LEVELING) ALIGN BY SHADOWS	CARRY 10 FT REMOVE GIRDLE PLACE ON STOOL UNFOLD SHROUD LEVEL BY BALL INDICATOR READ ALIGNMENT BY GNOMON SHADOW	CARRY 50 FT DEPLOY SUPPORT LEGS PLACE ON SURFACE UNFOLD SENSOR ARMS REMOVE PRA COVERS LEVEL BY BUBBLE ALIGN BY SHADOWGRAPH READ SHADOWGRAPH ALIGNMENT	CARRY 55 FT PLACE ON SURFACE DEPLOY GROUND SCREEN RELEASE CCIG EMPLACE SIDE ON GROUND SCREEN EMPLACE CCIG LEVEL BY BUBBLE ALIGN BY SHADOWS

7759-5842

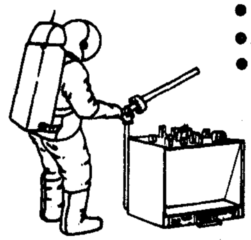
DEPLOYMENT FOR ALSEP 1



7759-5840

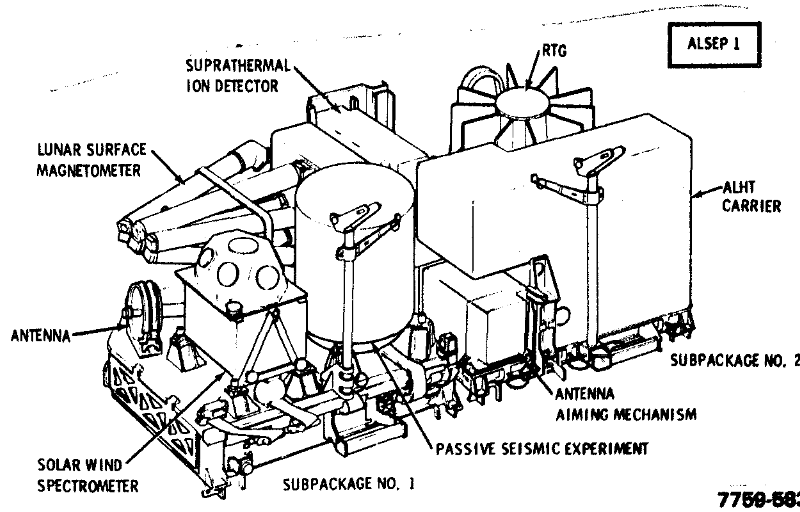
DEPLOY ANTENNA

- ASSEMBLE ANTENNA
  - INSTALL MAST ON CENTRAL STATION
  - INSTALL AIMING MECHANISM ON MAST
  - INSTALL ANTENNA ON AIMING MECHANISM
- ORIENT ANTENNA
  - ENTER COARSE & FINE ADJUSTMENTS IN AZIMUTH
  - ENTER COARSE & FINE ADJUSTMENTS IN ELEVATION
  - LEVEL AIMING MECHANISM BASE
  - ALIGN E-W WRT SHADOW
  - RECHECK LEVEL

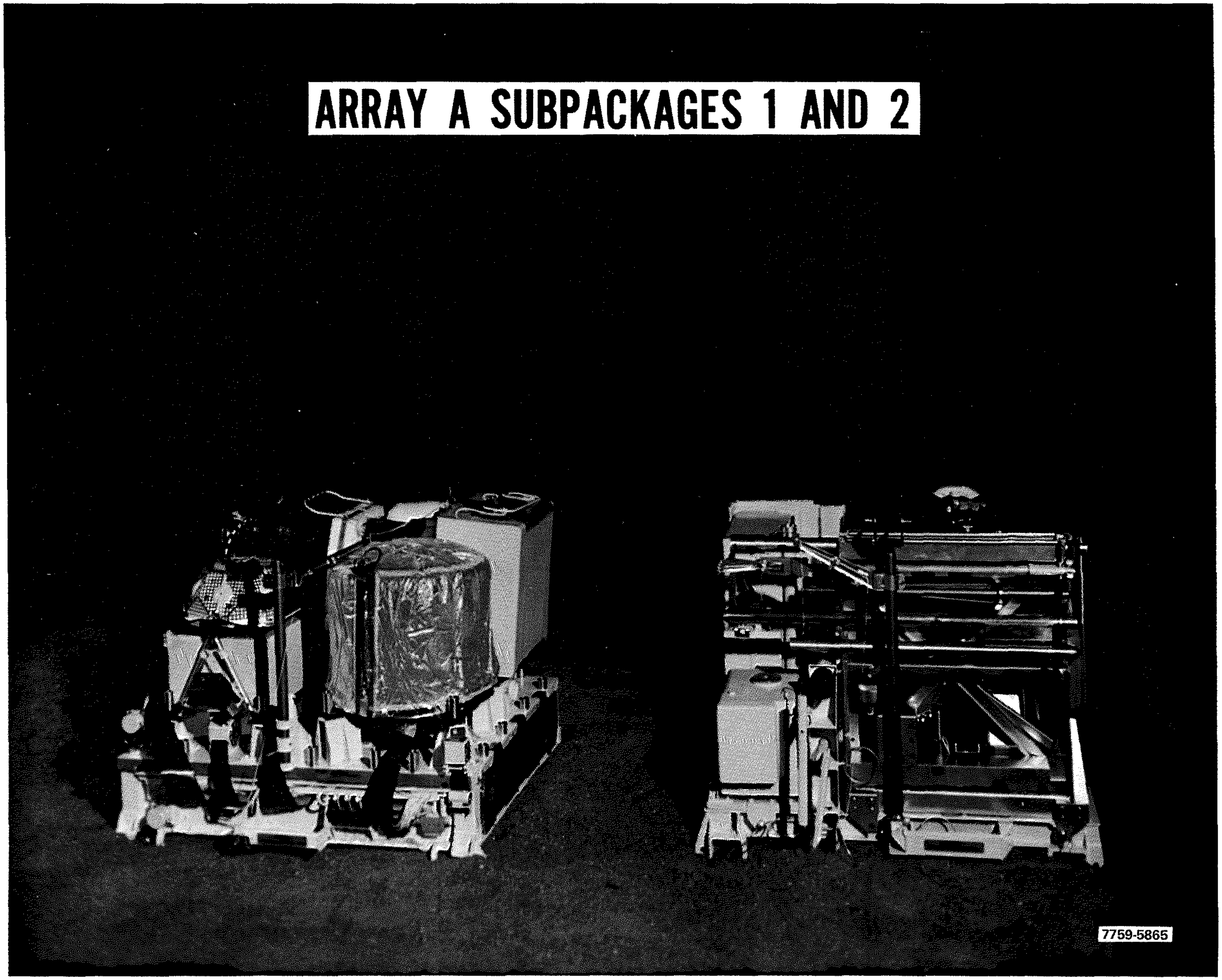


7759-5841

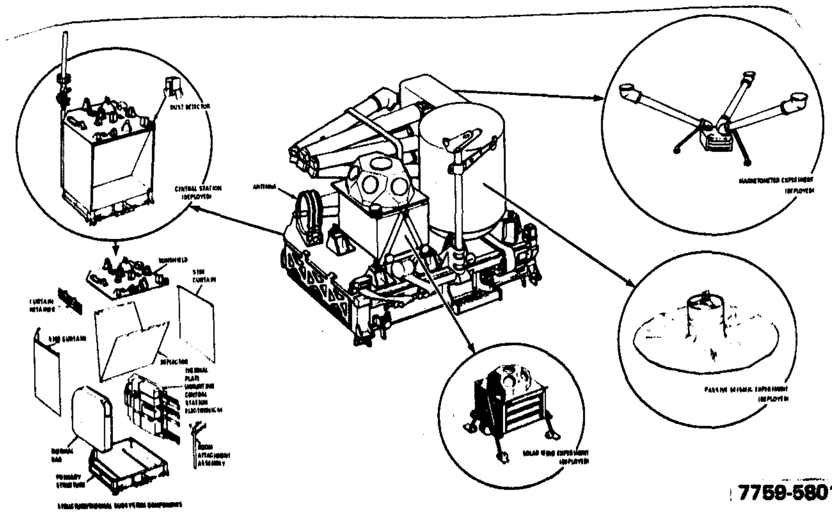
STOWED CONFIGURATION



7759-5833

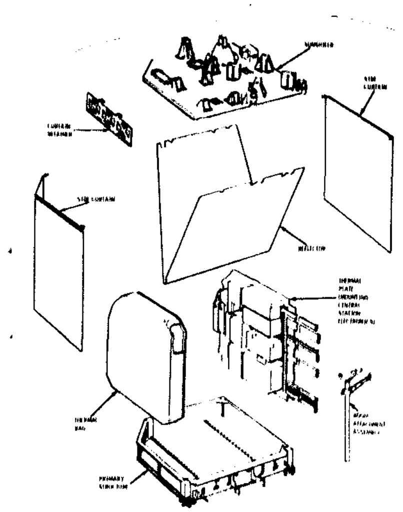

ARRAY A SUBPACKAGES 1 AND 2
7759-5865

ALSEP FLIGHT 1 SUBPACKAGE 1

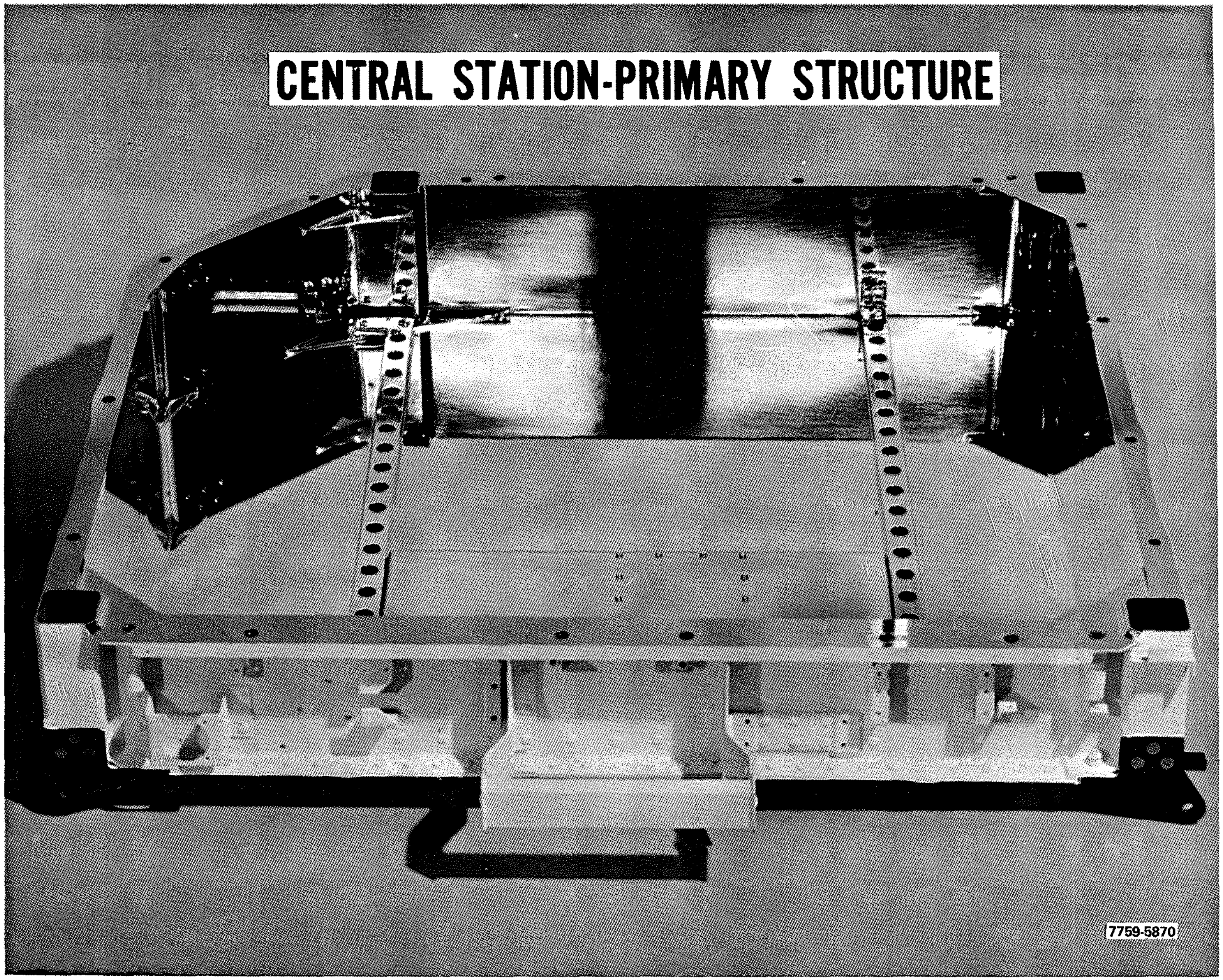


7759-5801

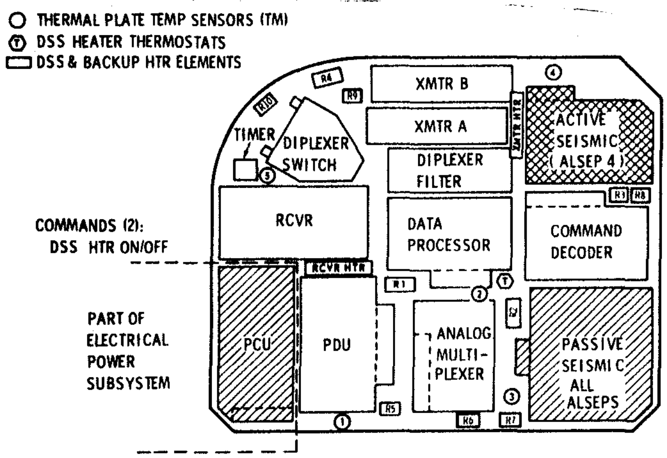
STRUCTURE, SUBPACKAGE NO. 1



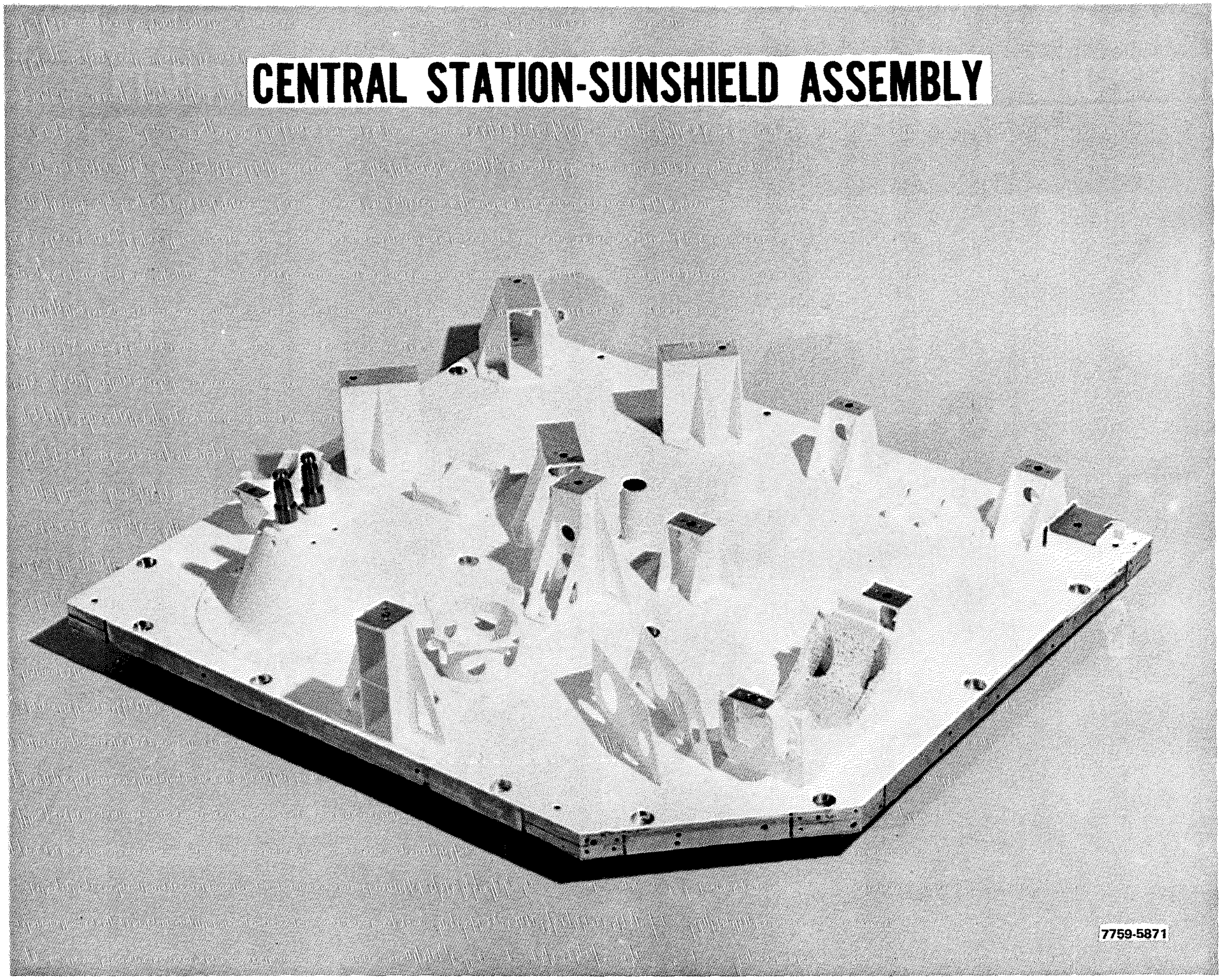
7759-5806


CENTRAL STATION-PRIMARY STRUCTURE
7759-5870

ELECTRONICS COMPARTMENT

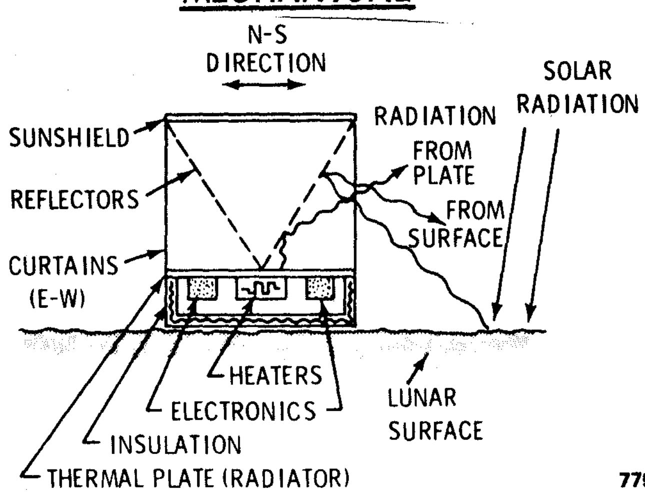


7759-5815


CENTRAL STATION-SUNSHIELD ASSEMBLY
7759-5871

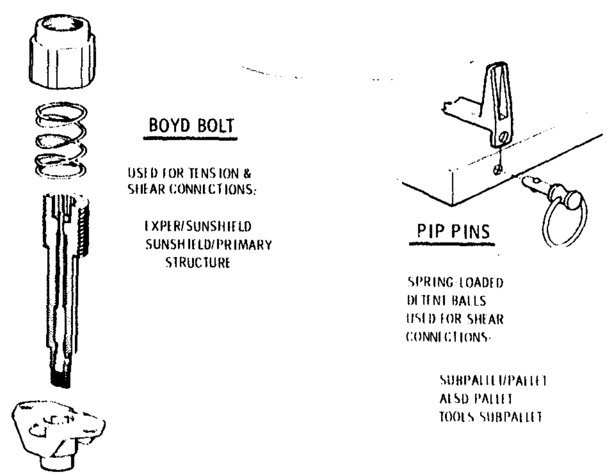
CENTRAL STATION THERMAL CONTROL

MECHANICAL



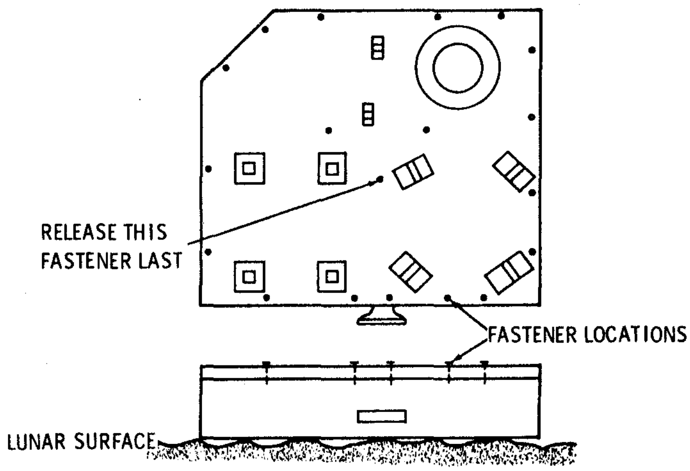
7759-5814

FASTENERS



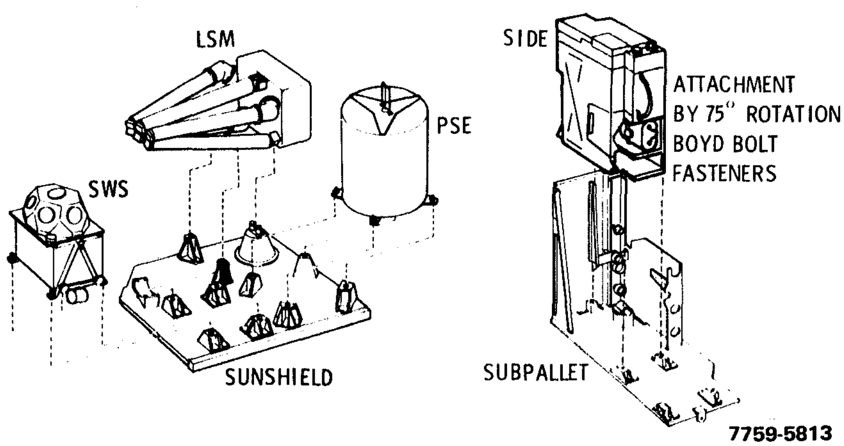
7759-5828

SUNSHIELD TIE-DOWN



7759-5831

EXPERIMENT MOUNTING PROVISIONS



7759-5813

CABLES, REELS AND CONNECTORS

CONDUCTORS (COPPER)
- WIDTH 0.025 IN. } EQUIV #32 AWG
- THICKNESS 0.002 IN. }
- SPACING 0.050 IN. CENTER TO CENTER
- RESISTANCE:

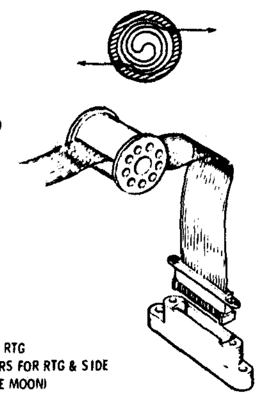
TEMP, °C	OHMS/1000 FT
-175	4.4
20	18.8
125	26.5

- MUTUAL CAPACITANCE: 5 PF/FT

INSULATION ("KAPTON" H-FILM, FEP TEFLON SANDWICH)
- KAPTON: 0.002 IN. THICKNESS (OUTER)
- FEP TEFLON: 0.002 IN. THICKNESS (INNER)
- RESISTANCE: 3×10^6 MEG OHMS/FT

CABLE
- WEIGHT ≈ 0.5 LB/1000 FT/ CONDUCTOR
- ALSEP USES OVER 4000 CONDUCTOR-FT (SAVES 10 LB COMPARED TO ROUND CABLE)
- USES MULTIPLE CONDUCTORS IN PARALLEL FOR HEAVY CURRENTS
- CONNECT EVERY OTHER LEAD FOR SHIELDING

UNREELS IN BOTH DIRECTIONS SIMULTANEOUSLY



SPECIAL CABLE FOR RTG
SPECIAL CONNECTORS FOR RTG & SIDE
(TO BE MATED ON THE MOON)

7759-5825

LEVEL AND ALIGN INDICATORS

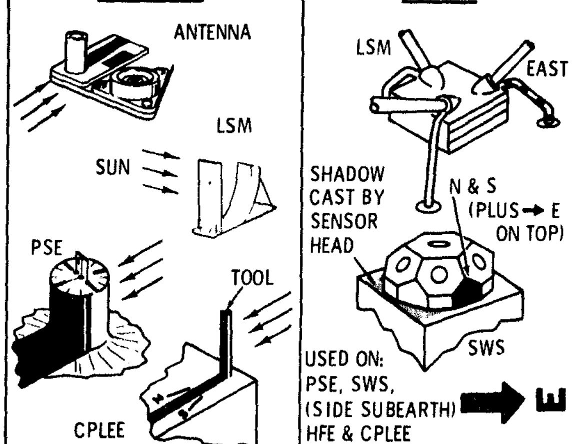
BUBBLE

RING ON FACE INDICATES REQUIRED SETTING

USED ON:
- ANTENNA
- LSM
- SIDE
- CPLEE

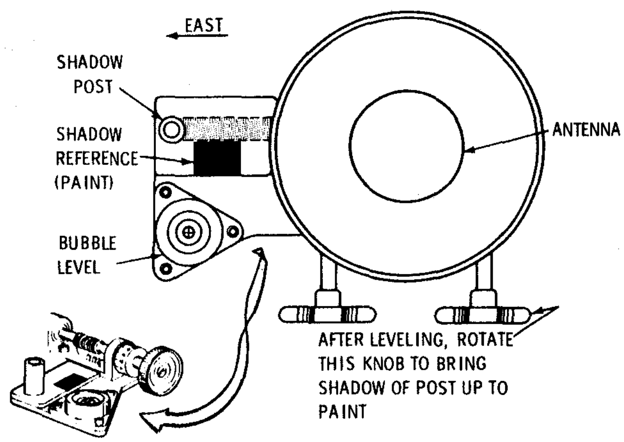
PSE HAS BALL

COMPASS | **PAINT**



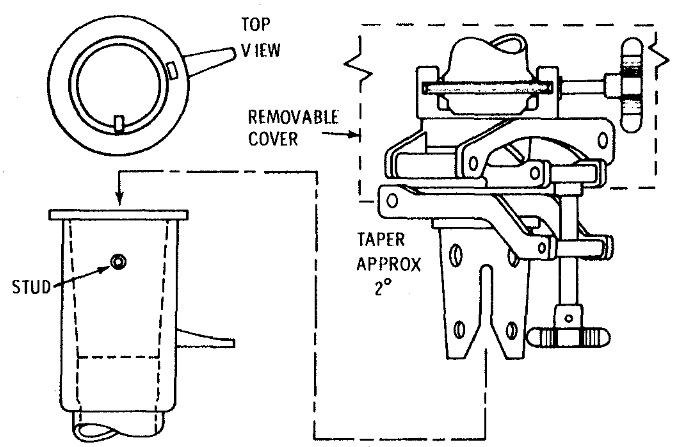
7759-5824

STRUCTURE/THERMAL ALIGNMENT MARKINGS

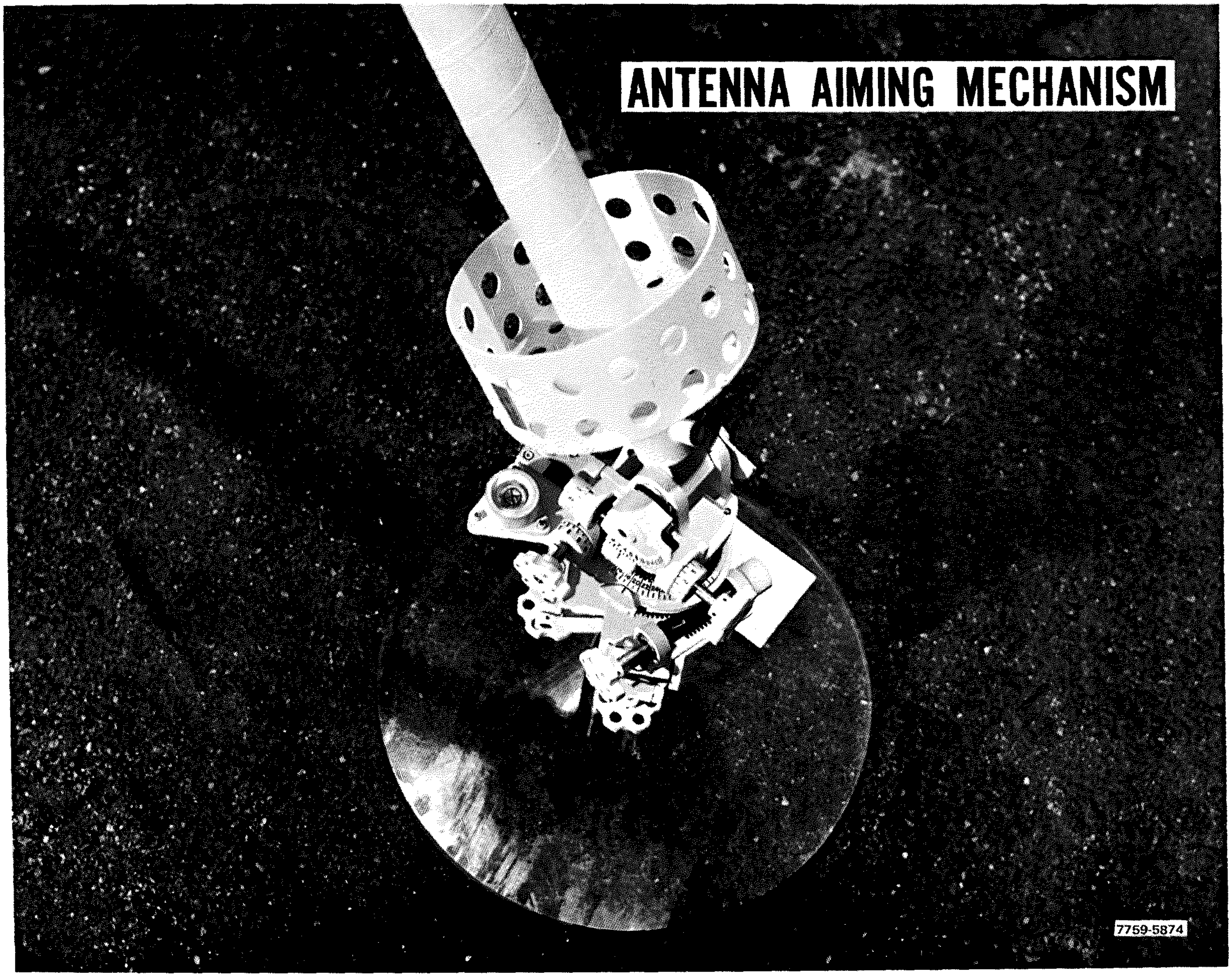


7759-5823

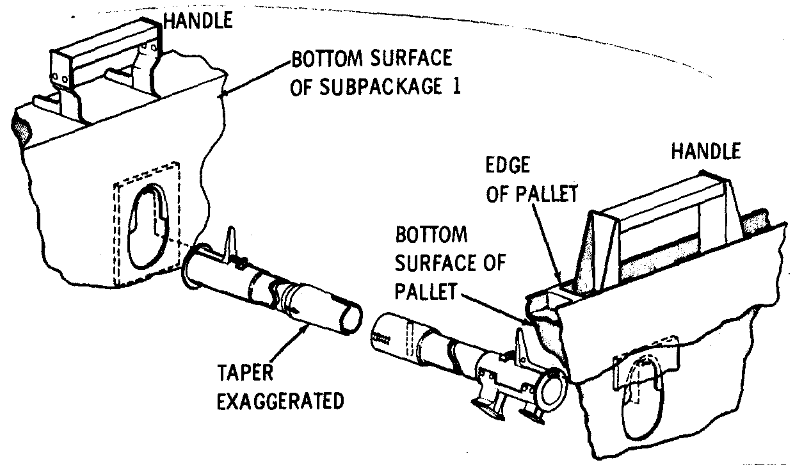
MAST/AIMING MECHANISM



7759-5843

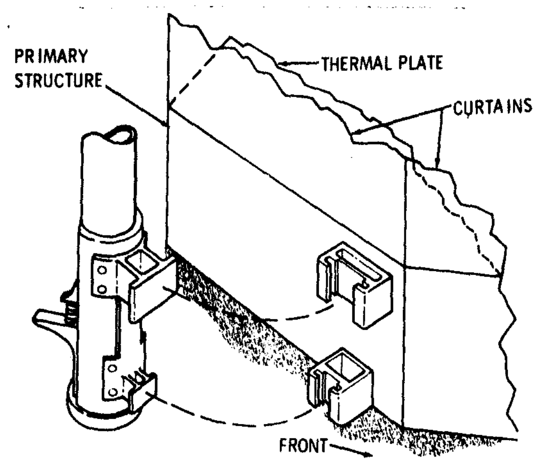

ANTENNA AIMING MECHANISM
7759-5874

MAST/CARRY BAR

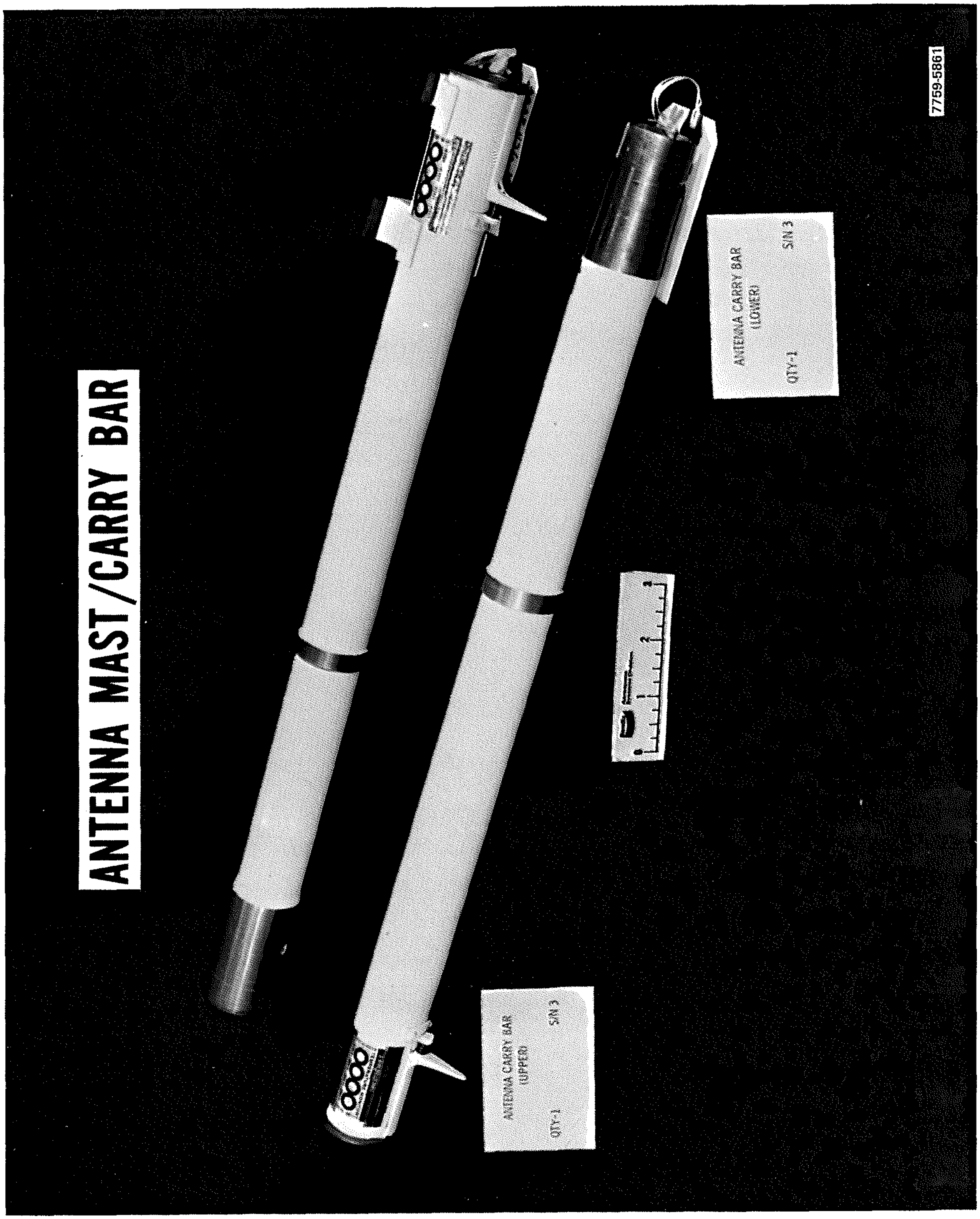


7759-5829

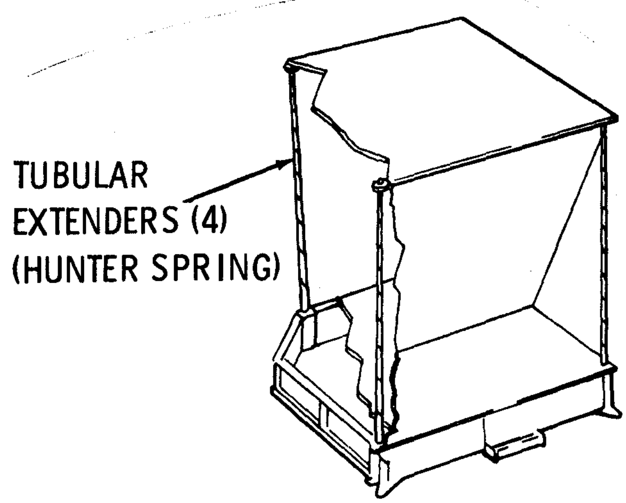
MAST/PRIMARY STRUCTURE



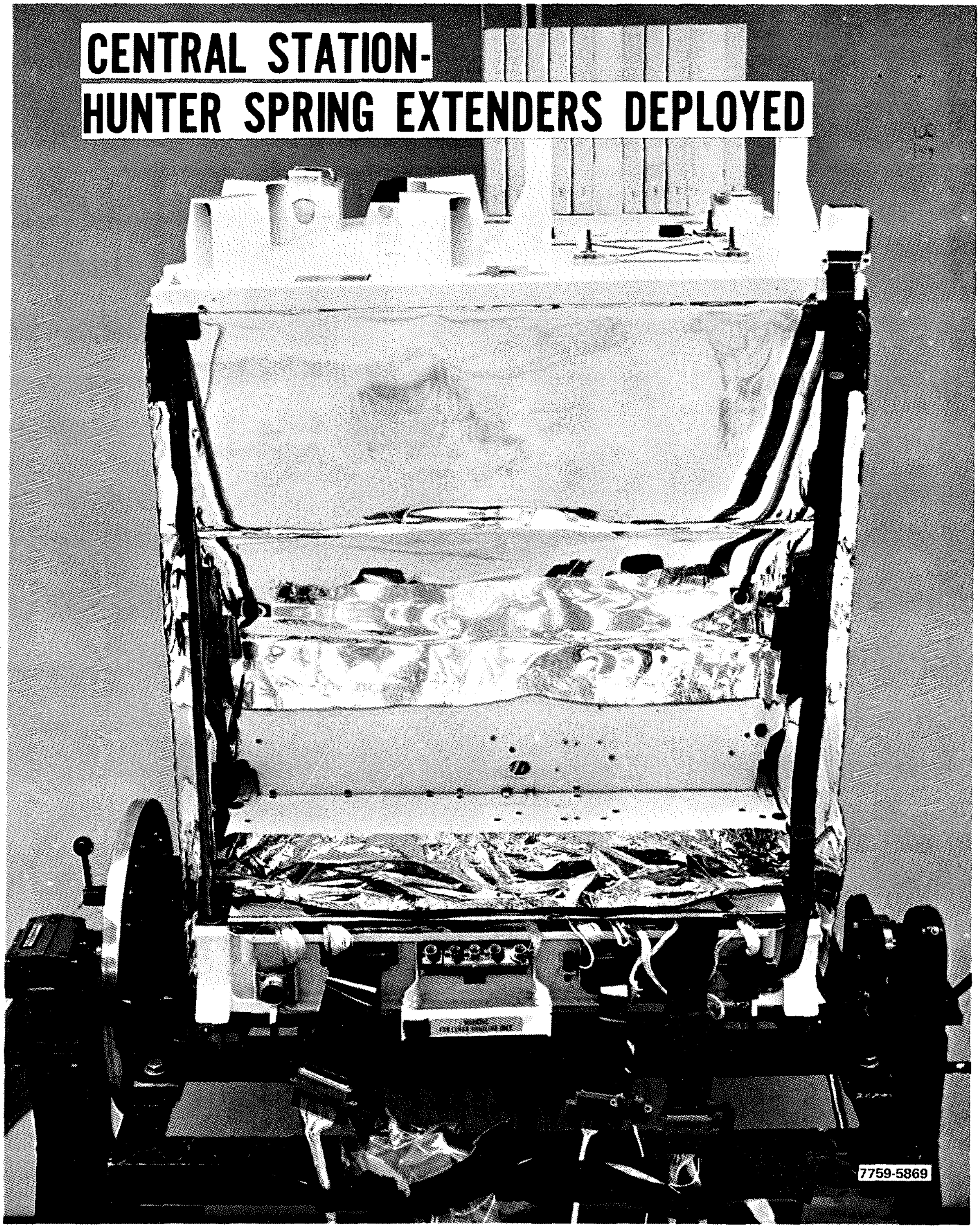
7759-5844


ANTENNA MAST/CARRY BAR
7759-5861
ANTENNA CARRY BAR
(LOWER)
QTY-1
S/N 3
ANTENNA CARRY BAR
(UPPER)
QTY-1
S/N 3

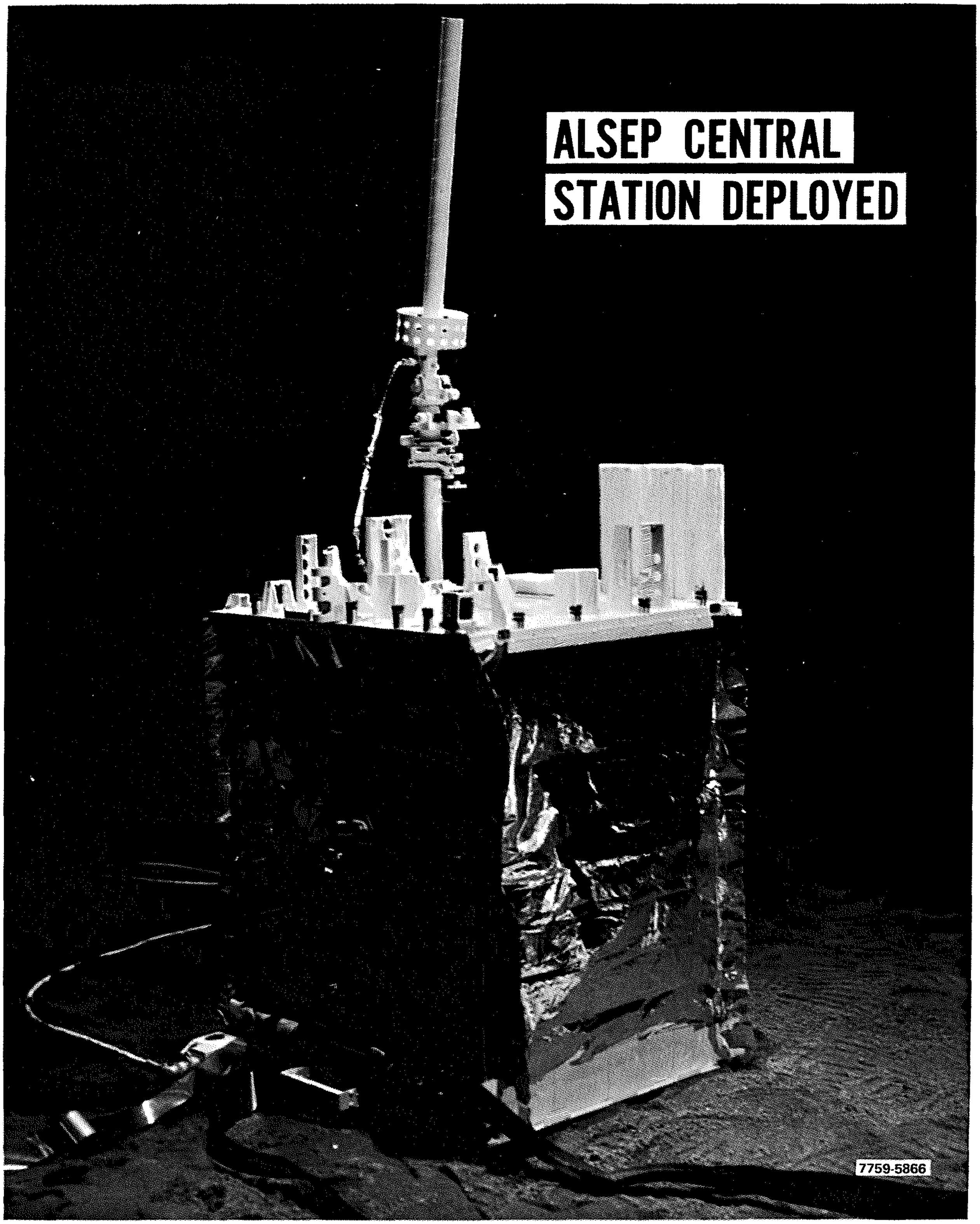
EXTENDERS

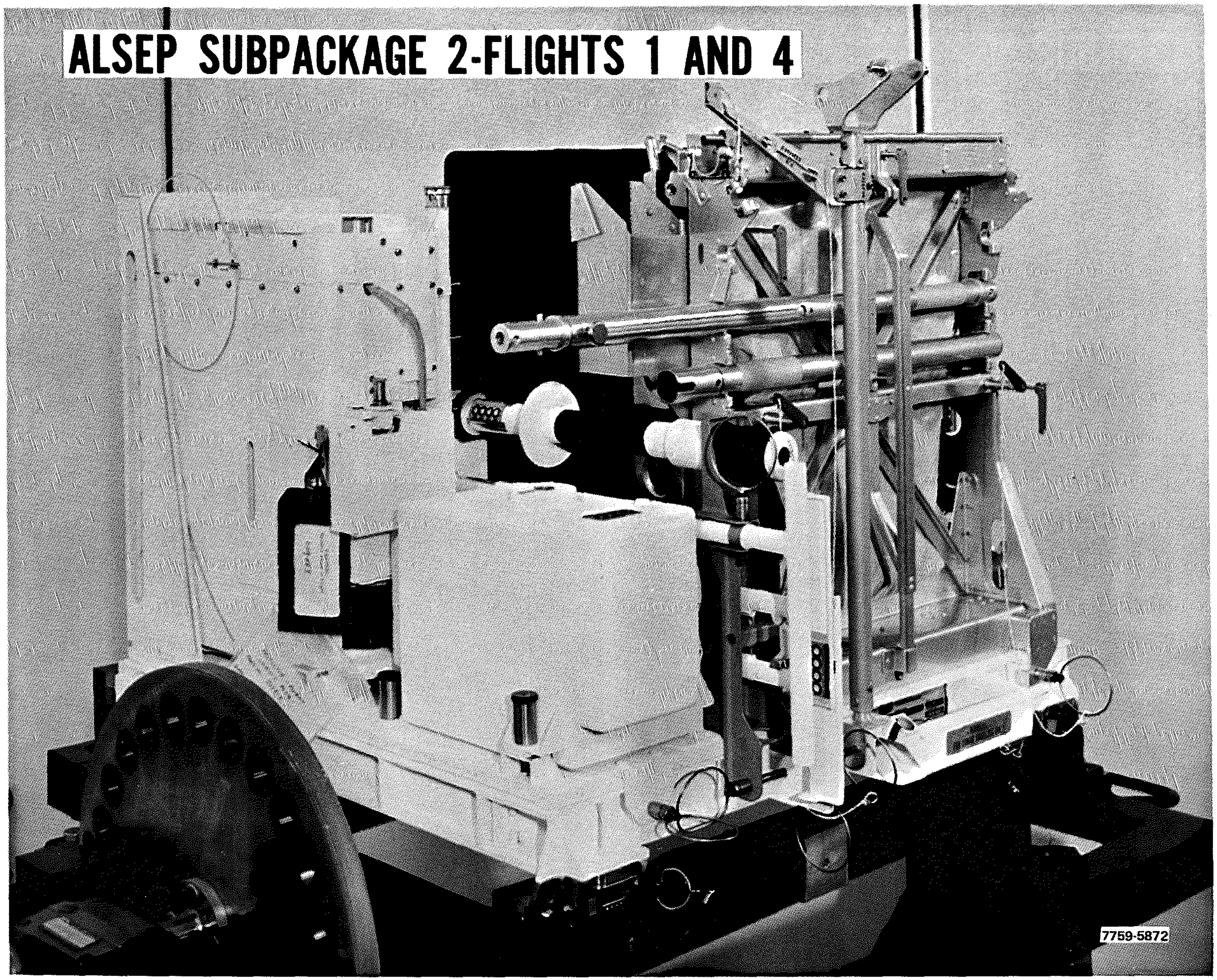


7759-5826

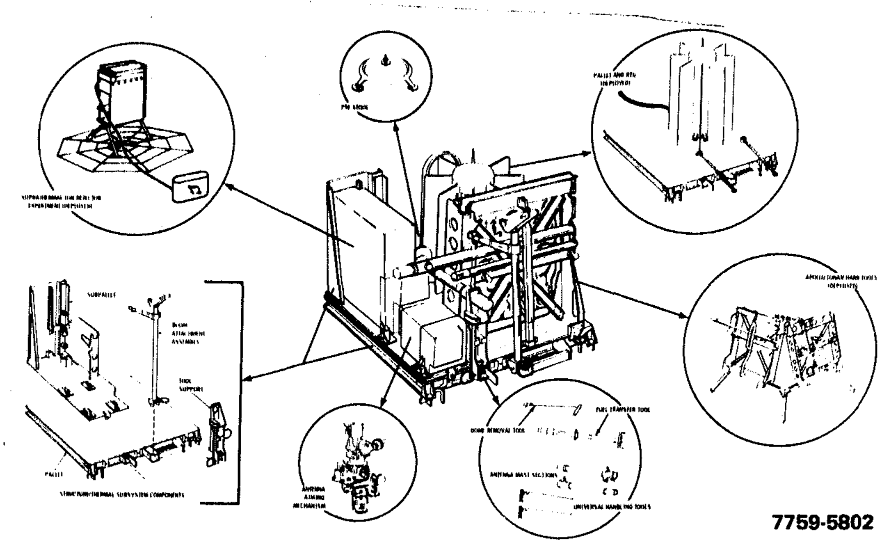


CENTRAL STATION-
HUNTER SPRING EXTENDERS DEPLOYED

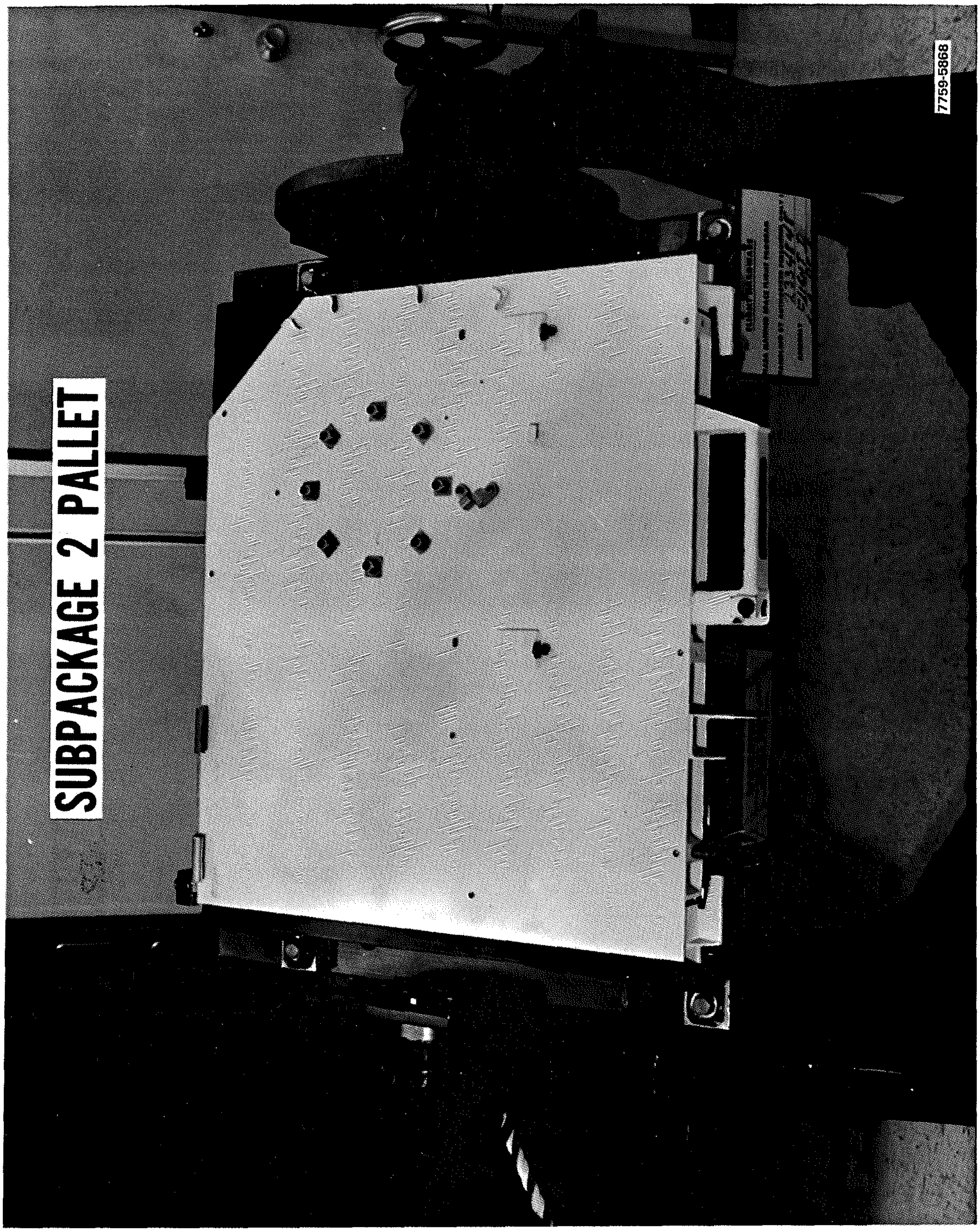

ALSEP CENTRAL
STATION DEPLOYED
7759-5866

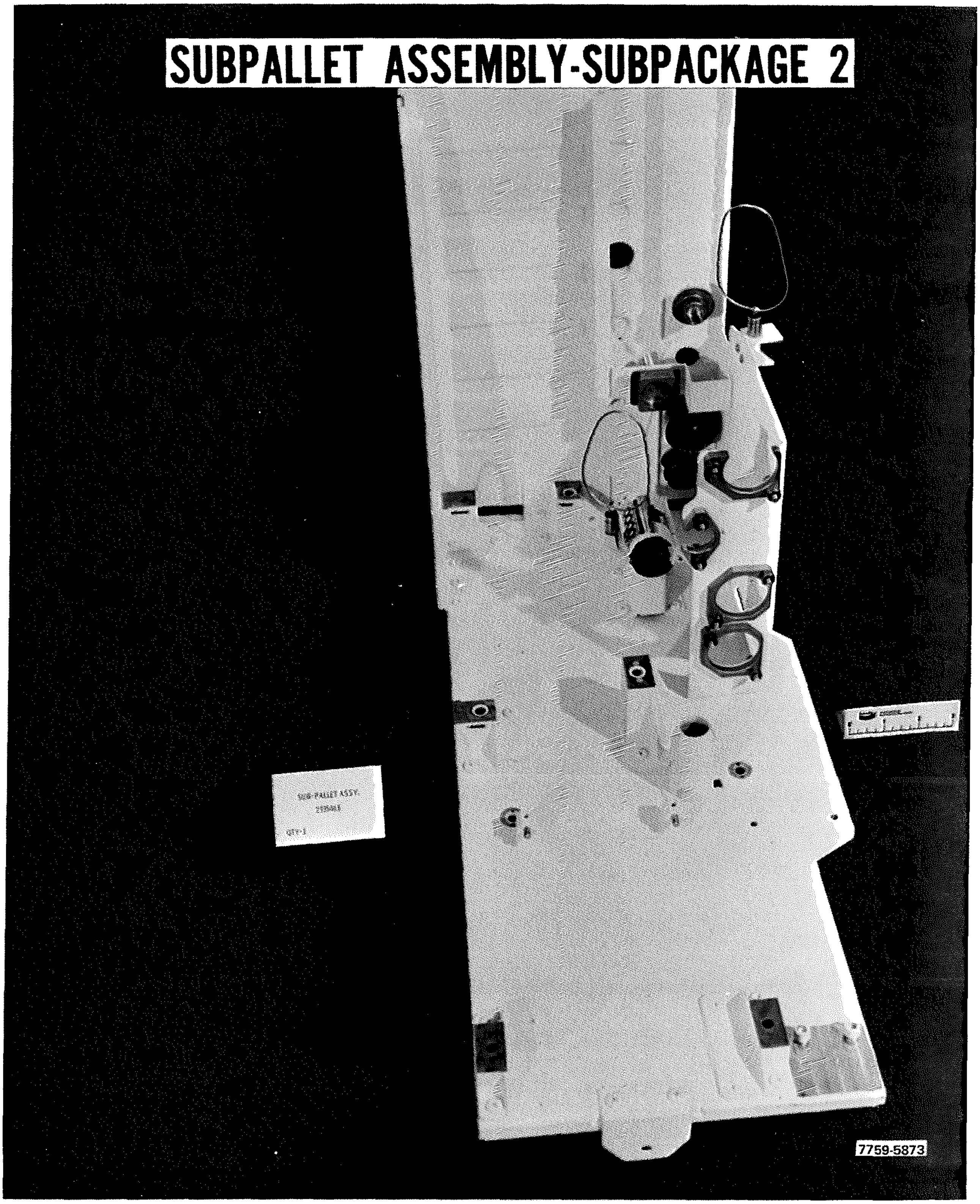

ALSEP SUBPACKAGE 2-FLIGHTS 1 AND 4
7759-5872

ALSEP SUBPACKAGE 2 (FLIGHTS 1 & 4)

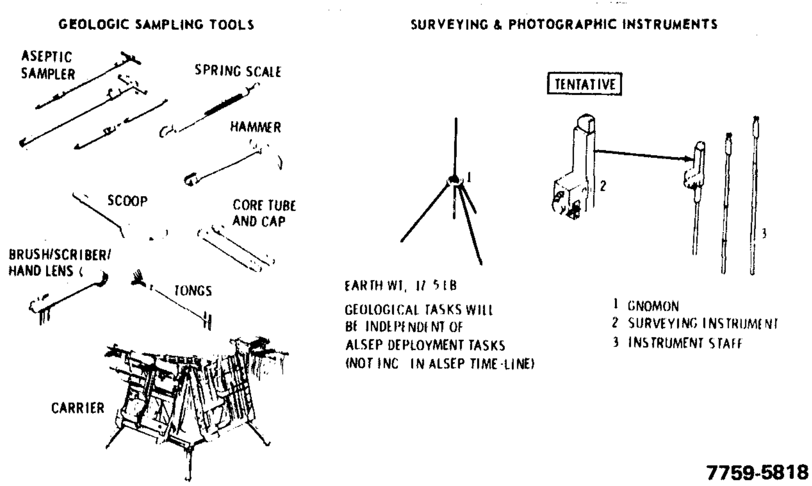


7759-5802

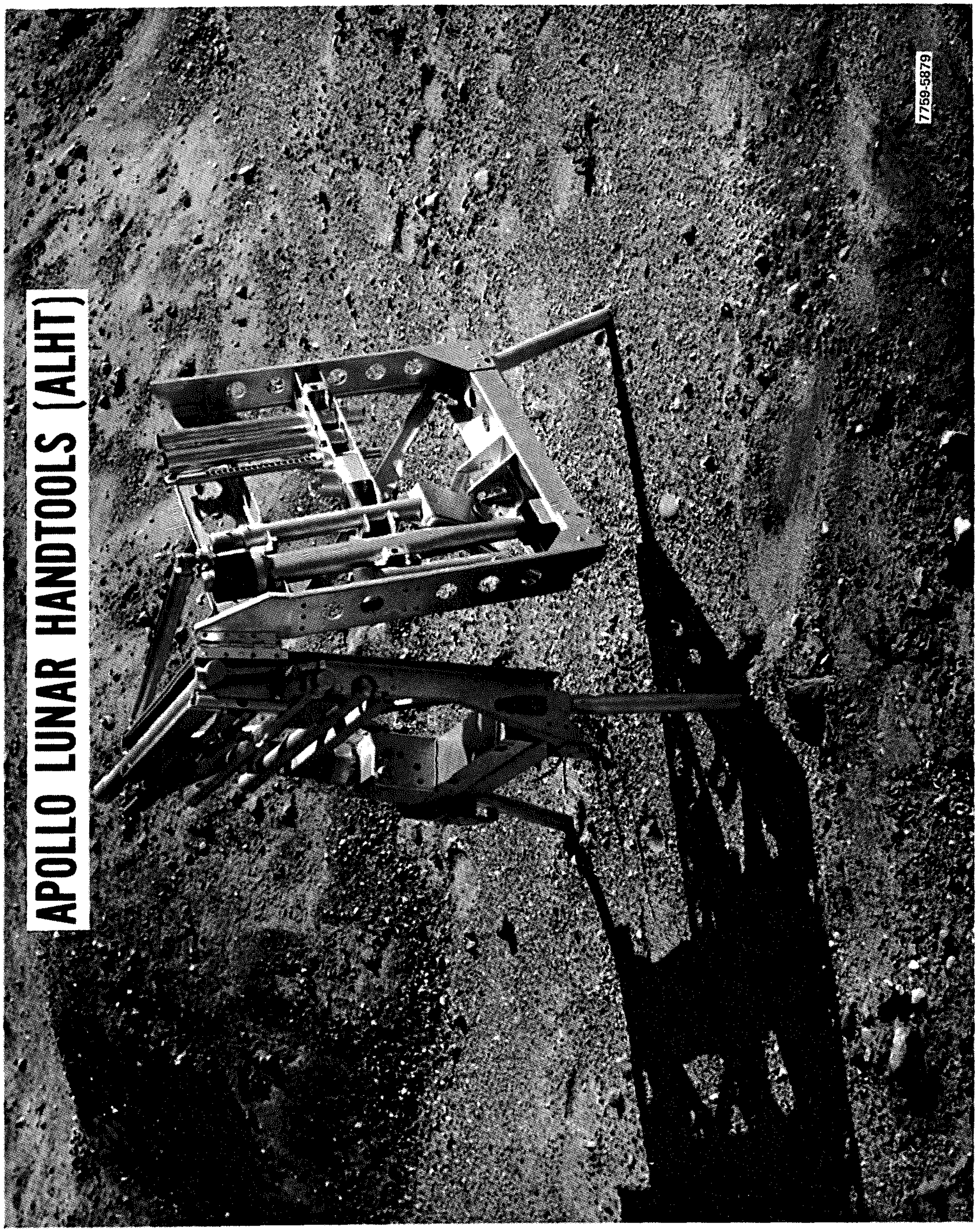

SUBPACKAGE 2 PALLET
7759-5868


SUBPALLET ASSEMBLY-SUBPACKAGE 2
7759-5873

APOLLO LUNAR HAND TOOLS

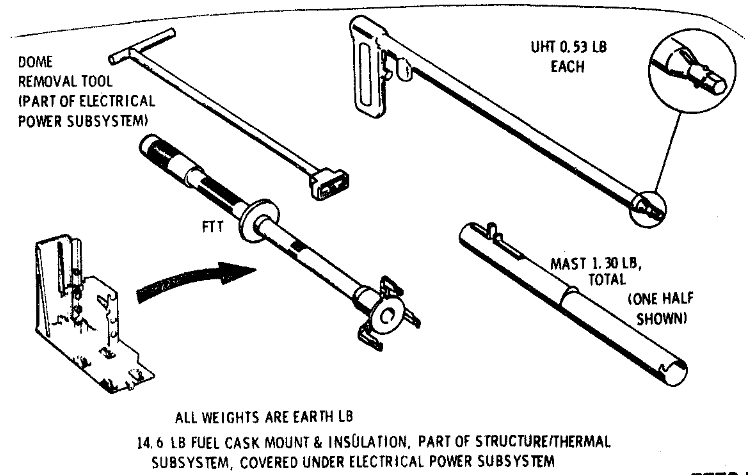


7759-5818


APOLLO LUNAR HANDTOOLS (ALHT)
7759-5879

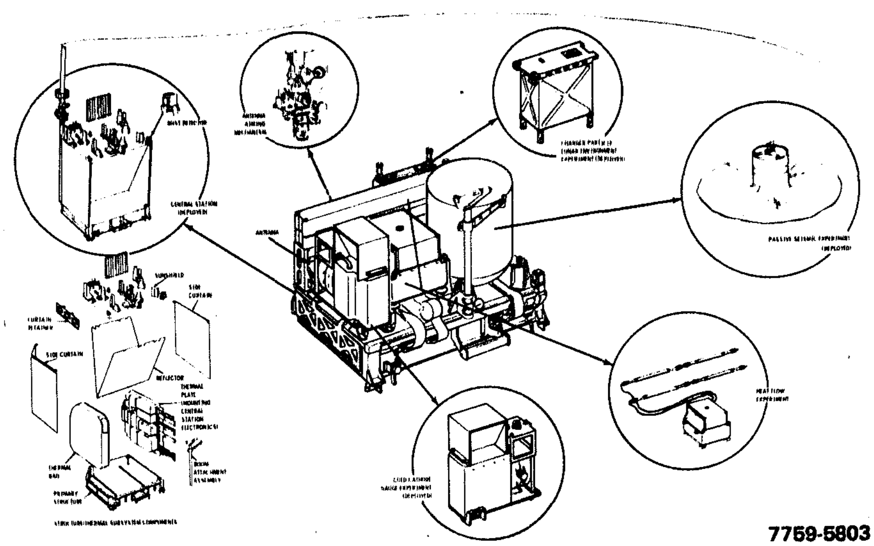

UNIVERSAL HANDTOOLS (UHT'S)
7759-5859

SPECIAL TOOLS



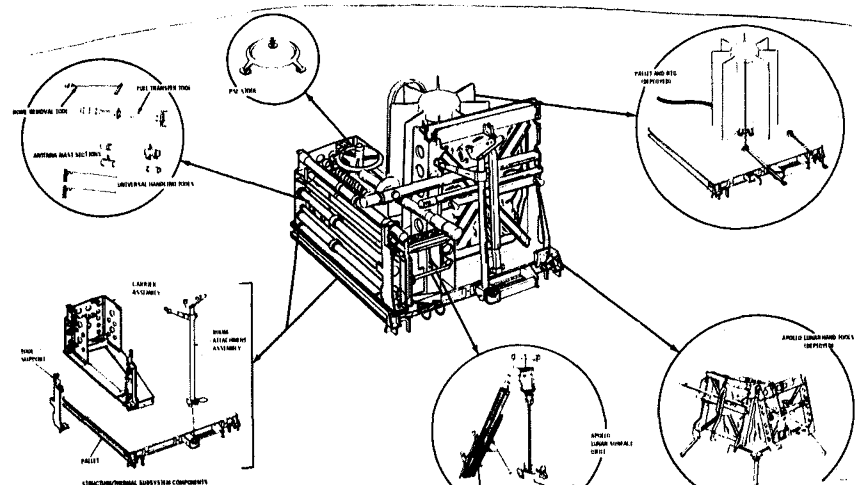
7759-5816

ALSEP FLIGHT 3 SUBPACKAGE 1



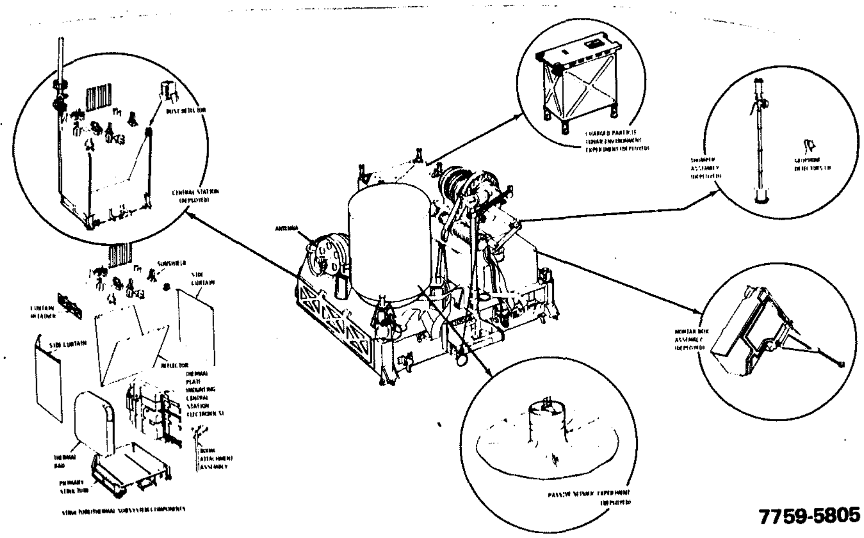
7759-5803

ALSEP FLIGHT 3 SUBPACKAGE 2

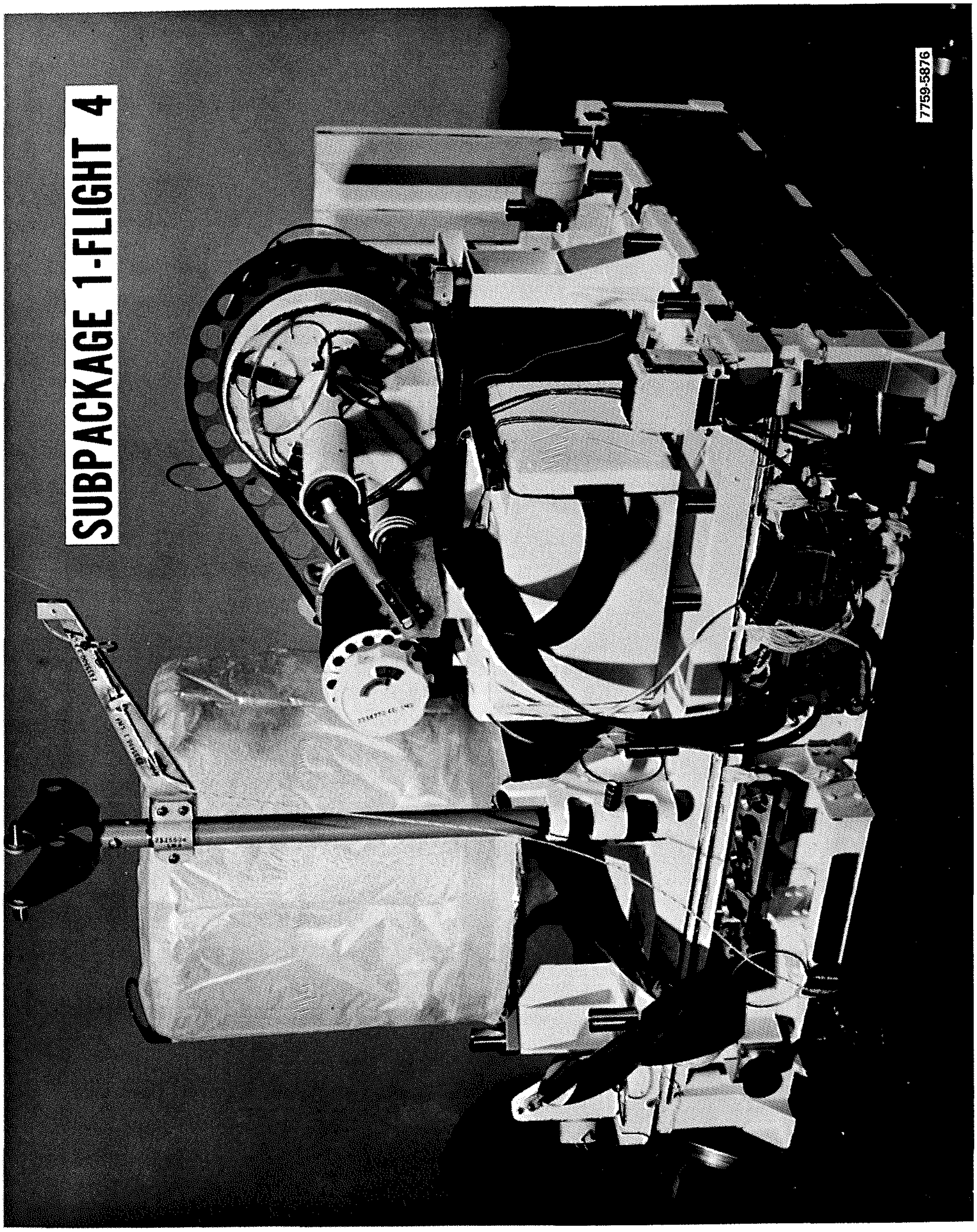


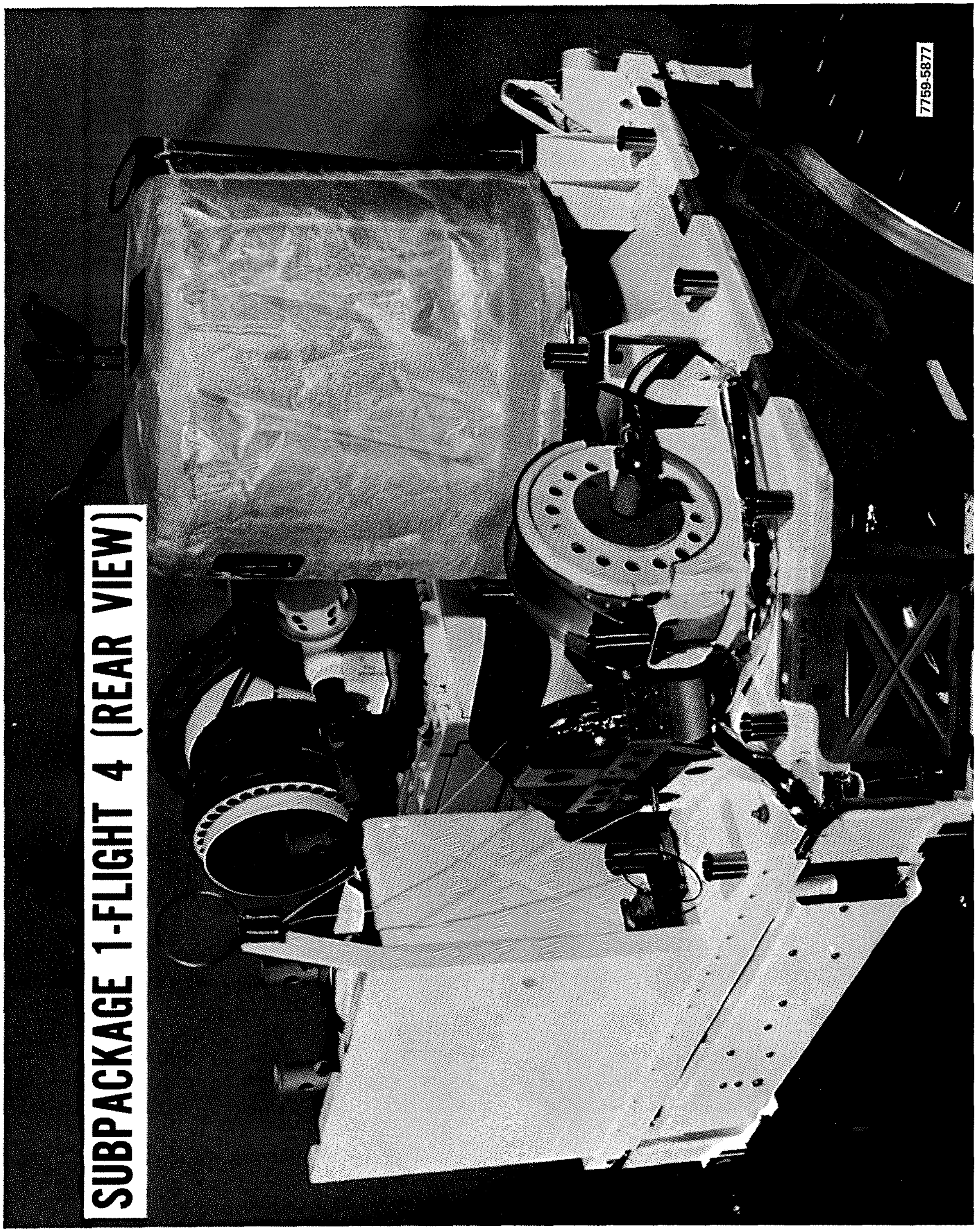
7759-5804

ALSEP FLIGHT 4 SUBPACKAGE 1



7759-5805


SUBPACKAGE 1-FLIGHT 4
7759-5876


SUBPACKAGE 1-FLIGHT 4 (REAR VIEW)
7759-5877

ALSEP STEADY-STATE ACCELERATION LEVEL (DESIGN-LIMIT)

LEVEL: 14 g

DURATION: 60 SEC. (MINIMUM)

AXIS: + X (ONLY)

TOLERANCES: PER MIL. STD. 810 B

7759-5882

ORIGINAL ALSEP DYNAMIC ENVIRONMENTAL SPECIFICATIONS (GAEC ICD NO. LIS-360-22302)

ACCELERATION: 4.9 g (MAX., +X AXIS)

SHOCK:	0 to 20 MSEC.	INCREASING RAMP
	20 TO 220 MSEC.	10.8 g DWELL
	220 TO 260 MSEC.	DECREASING RAMP

VIBRATION:

LAUNCH & BOOST

SINUSOIDAL:	1 SWEEP/AXIS @ OCT/MIN	
	5-18.5 hz 0.154 IN. DIA.	
	18.5 - 100 2.69 g - PEAK	
RANDOM:	5 MIN/AXIS	
	10 - 23 Hz	+12 DB/OCT
	23 - 80	0.0148 g^2/Hz
	80 - 105	+12 DB/OCT
	105 - 950	0.0444 g^2/Hz
	950 - 1250	-12 DB/OCT
	1250 - 2000	0.0148 g^2/Hz

7759-5883

ORIGINAL DYNAMIC ENVIRONMENTAL SPECIFICATIONS (CONT')

LUNAR DESCENT

SINUSOIDAL:	1 SWEEP/AXIS @ OCT/MIN	
	5-19.4 Hz	0.01 IN. DIA.
	19.4-100	1.92 g-PEAK
RANDOM:	12.5 MIN./AXIS	
	15-100 Hz	0.013 g^2/Hz
	100-176	-6 DB/OCT
	176-2000	0.010 g^2/Hz

NOTE: ABOVE LEVELS ARE INDUCED (ACCEPTANCE) - DESIGN LIMIT LEVELS ARE DEFINED TO BE INDUCED ACCELERATION LEVELS TIMES 1.3.

7759-5884

ALSEP ENGINEERING TESTS

TEST ITEM	DATE	TEST*	LEVEL	AXES	OBJECTIVE
Proto-1 (SP-1)	June 1967	Vibration (Sine & Random)	Design Limit	x, y, z	Dynamic Response of ALSEP Structure
Proto-1 (SP-1) (Solid Sunshield)	Sept. 1967	Vibration (Sine & Random)	Design Limit	x, y, z	Dependence of Dynamic Response upon Number of Fasteners & Pre-Load
LSM Proto-1 (SP-1)	Oct. 1967	Vibration (Sine & Random)	Design Limit	x, y, z	Dynamic Response of LSM and SWS
Proto-A (SP-1 & 2)	Oct. 1967	Vibration (Sine & Random)	Design Limit	x, y, z	Demonstration of ALSEP Structural Integrity
Proto-2 (SP-1)	Apr. 1968	Vibration (Sine & Random)	Design Limit	x, y, z	Variation of Dynamic Response with Reduction of Fastener -- with Off-Loaded Experiments
Proto-2 (SP-2)	July 1968	Vibration (Sine & Random)	Design Limit	x, y, z	Variation of Dynamic Response with Off-Loaded Experiments

* Prior to the LSM Proto-1 Tests the original ALSEP Test Levels were revised per LTA-3 tests results.

7759-5885

ALSEP QUALIFICATION TESTS

TEST ITEM	SUBPACKAGE	DATE	TEST	LEVEL	AXES
QUAL SA	1 & 2	APR. 1968	VIBRATION (SINE & RANDOM)	ACCEPTANCE	X, Y, Z
		JUNE 1968	VIBRATION (SINE & RANDOM)	DESIGN LIMIT	X, Y, Z
		JUNE 1968	SHOCK	DESIGN LIMIT	X, Y, Z
		JULY 1968	STEADY STATE ACCELERATION	DESIGN LIMIT	X
D-2 FLT. SPARE	1	AUG. 1968	VIBRATION (SINE & RANDOM)	ACCEPT & DES LIM	X, Y, Z
	2	SEPT. 1968	VIBRATION (SINE & RANDOM)	ACCEPT & DES LIM	X , Y, Z
QUAL SB	1 & 2	DEC. 1968	VIBRATION (SINE & RANDOM)	DESIGN LIMIT	X, Y, Z
		JAN. 1969	SHOCK	DESIGN LIMIT	X, Y, Z
		JAN. 1969	STEADY STATE ACCELERATION	DESIGN LIMIT	X
QUAL C	1	MARCH 1969	SHOCK	DESIGN LIMIT	X, Y, Z
		MAY 1969	VIBRATION (SINE & RANDOM)	DESIGN LIMIT	X, Y, Z
		MAY 1969	STEADY STATE ACCELERATION	DESIGN LIMIT	X

7759-5886

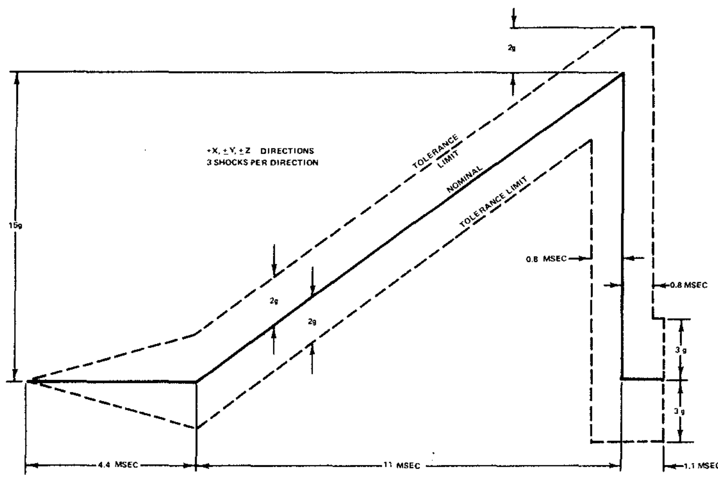
ALSEP FLIGHT ACCEPTANCE TESTS

ITEM	DATE	TEST	LEVEL	AXES
D-2 FLIGHT (SP-1 & 2)	AUG. 1968	VIBRATION (SINE & RANDOM)	ACCEPTANCE	X, Y, Z
FLIGHT 1 (SP-1 & 2) ARRAY A	SEPT. 1968	VIBRATION (SINE & RANDOM)	ACCEPTANCE	X, Y, Z
FLIGHT 2 (SP-1 & 2)	SEPT. 1968	VIBRATION (SINE & RANDOM)	ACCEPTANCE	X, Y, Z
FLIGHT 3 (SP-1 & 2) ARRAY B	DEC. 1968	VIBRATION(SINE & RANDOM)	ACCEPTANCE	X, Y, Z
FLIGHT 4 (SP-1) ARRAY C	NOV. 1968	VIBRATION (SINE & RANDOM)	ACCEPTANCE	X, Y, Z

7759-5887

ALSEP LIMIT LEVEL SHOCK SPECIFICATION

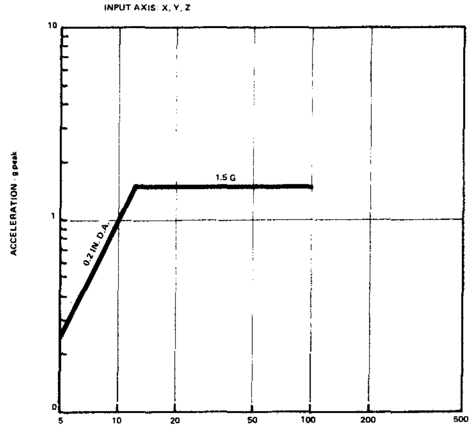
(REF. MIL. STD. 810B)



7759-5888

NOMINAL DESIGN LIMIT* VIBRATION LEVELS

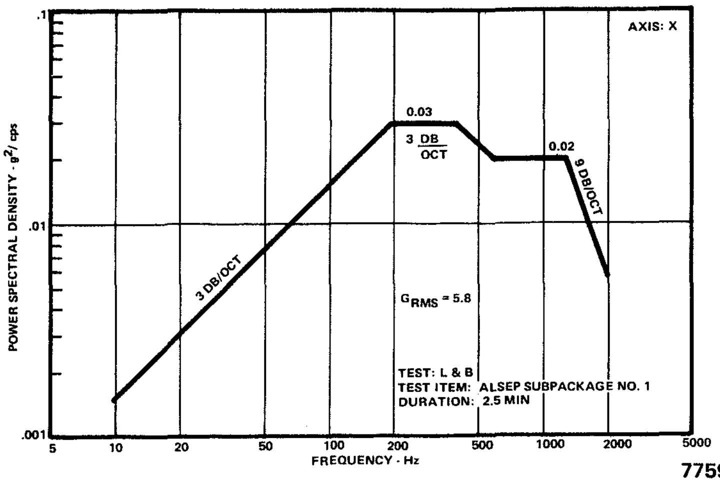
TEST ITEM: ALSEP SUBPACKAGES 1 & 2
SWEEP RATE: ¼ OCT/MIN
INPUT AXIS: X, Y, Z



*COMBINED L & B AND LUN. DES.

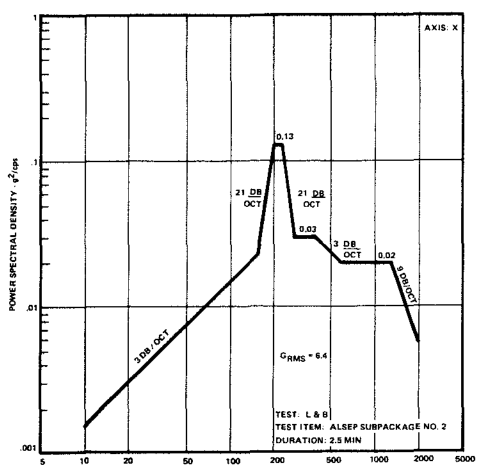
7759-5889

NOMINAL DESIGN LIMIT RANDOM VIBRATION SPECTRUM



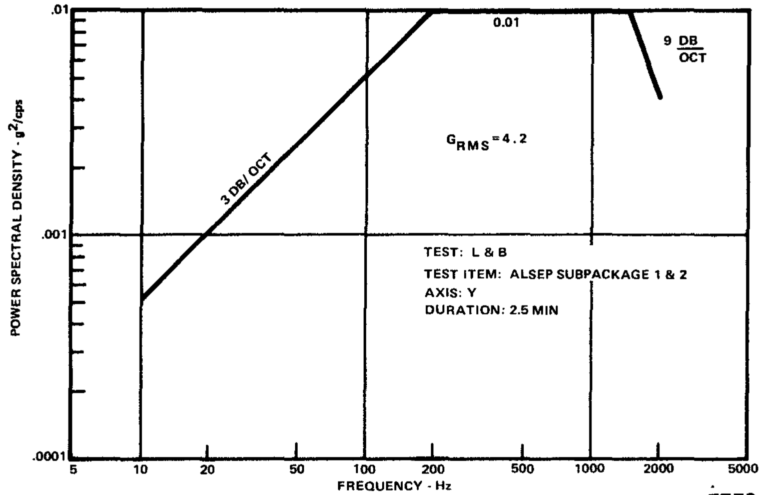
7759-5890

NOMINAL DESIGN LIMIT RANDOM VIBRATION SPECTRUM



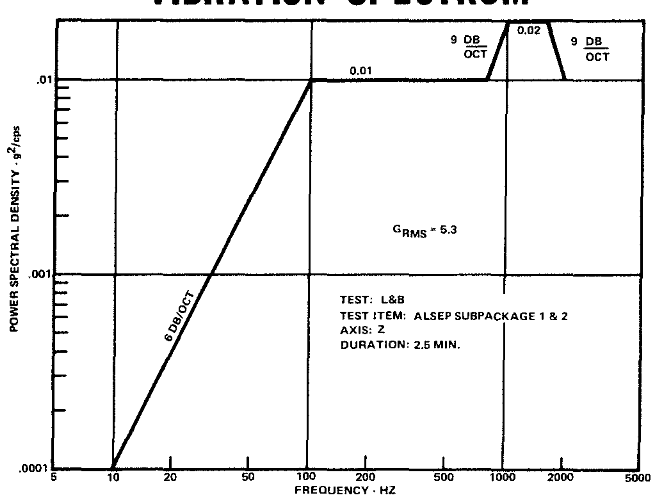
7759-5891

NOMINAL DESIGN LIMIT RANDOM VIBRATION SPECTRUM



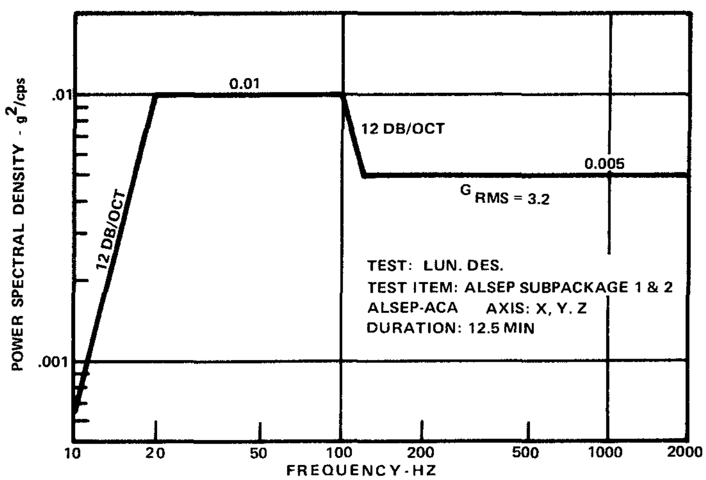
7759-5892

NOMINAL DESIGN LIMIT RANDOM VIBRATION SPECTRUM



7759-5893

NOMINAL DESIGN LIMIT RANDOM VIBRATION SPECTRUM

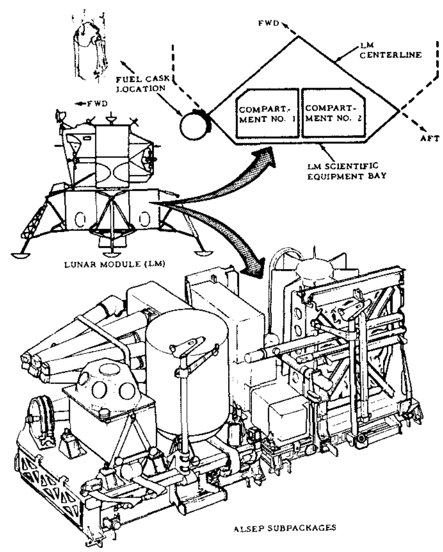


7759-5894

Section 10

Alsep Thermal Design

LOCATION OF ALSEP WITHIN THE LM



7759-5908

SUMMARY OF SYSTEMS REQUIRING THERMAL CONTROL ON ALSEP AND EASEP

1.	CENTRAL STATION (C/S)
2.	EXPERIMENTS A. PASSIVE SEISMIC (PSE) B. ACTIVE SEISMIC (ASE) C. MAGNETOMETER (ME) D. SOLAR WIND (SWE) E. SUPRATHERMAL ION DETECTOR (SIDE) F. HEAT FLOW (HFE) G. CHARGED PARTICLE (CPLEE) H. COLD CATHODE GAUGE (CCGE)
3.	RADIOISOTOPE THERMOELECTRIC GENERATOR (RTG)
4.	GRAPHITE LM FUEL CASK (GLFC)
5.	CREW A. CASK DOME TOOL (DRT) B. FUEL TRANSFER TOOL (FTAT) C. UNIVERSAL HANDLING TOOL (UHT)
6.	LUNAR HAND TOOLS (ALHT)
7.	ANTENNA
8.	SUBPACKAGE 2
9.	PASSIVE SEISMIC EXPERIMENT PACKAGE (PSEP)
10.	LASER RANGING RETRO-REFLECTOR (LRRR)

7759-5917

CENTRAL STATION THERMAL CONTROL REQUIREMENTS AND CONSTRAINTS

THERMAL

. PASSIVE THERMAL CONTROL

. TEMPERATURE LIMITS

	SYSTEM	COMPONENT
OPERATING	0° TO 125°F	-22° TO 158°F
NON-OPERATING	0° TO 160°F	-65° TO 160°F

. DUST (α = 1) ON ALL HORIZONTAL SURFACES EXPOSED TO SOLAR RADIATION

. LM ASCENT STAGE PLUME HEATING (2 BTU/FT^2)

DEPLOYMENT

. MINIMUM CREW DEPLOYMENT TASKS

. DEPLOYMENT DISTANCE > 300 FEET

. EAST - WEST ALIGNMENT - ±5 DEGREES

. VERTICAL ALIGNMENT - ±5 DEGREES

. LOCAL SLOPES - ±5 DEGREES

. LATITUDE - ±45 DEGREES

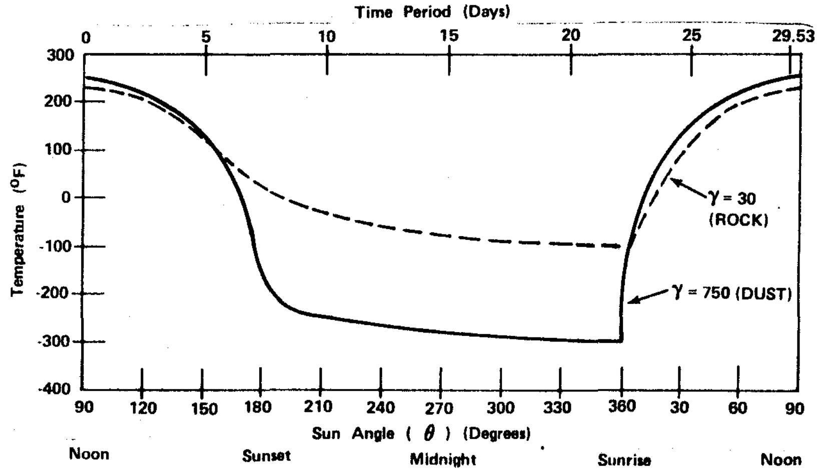
7759-5902

LUNAR ENVIRONMENTS

. LUNAR SURFACE TEMPERATURE	-300° to + 250°F	
. SPACE TEMPERATURE	-460°F	
. INCIDENT SOLAR ENERGY	130 WATTS/FT^2	
. LUNAR ALBEDO (AVERAGE)	.07	
. LUNAR SURFACE EMITTANCE (AVERAGE)	.93	
. LUNAR SURFACE THERMOPHYSICAL PROPERTIES:	DUST	ROCK
THERMAL CONDUCTIVITY (CAL/SEC-CM-C)	1×10^{-5}	2.2×10^{-3}
SPECIFIC HEAT (CAL/gm°C)	.2	.2
DENSITY (gm/cm3)	.9	2.5
THERMAL INERTIA $(kgc)^{-1/2}$	750	30

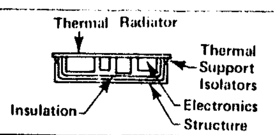
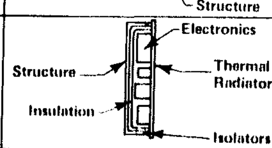
7759-5903

VARIATION OF LUNAR SURFACE TEMPERATURE AT LUNAR EQUATOR DURING A COMPLETE LUNATION



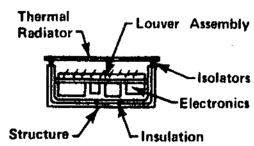
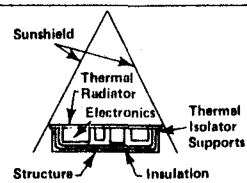
7759-5907

INITIAL ALSEP CENTRAL STATION THERMAL CONTROL CONCEPTS

Concept	Design Schematic	Thermal Plate Temp Range - °F Solar Absorptance, α_s Nominal	Degraded	Comments
Direct Horizontal Radiator		0 to 120	0 to 290	Excellent design if no dust, but strongly affected by dust. Straightforward design. No alignment requirements.
Direct Vertical Radiator (Radiator Faces Lunar Pole)		0 to 195	0 to 195	Possibly unaffected by dust. Can be seriously degraded by misalignment. Lunar day temperatures excessive.

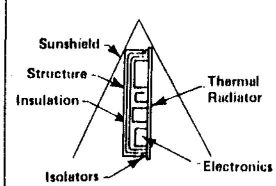
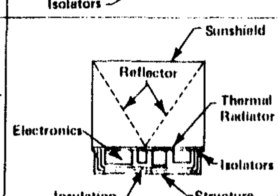
7759-5904

INITIAL ALSEP CENTRAL STATION THERMAL CONTROL CONCEPTS (CONT')

CONCEPT	DESIGN SCHEMATIC	THERMAL PLATE TEMP RANGE - °F SOLAR ABSORPTANCE α/S NOMINAL	 DEGRADED	COMMENTS
Direct Horizontal Radiator with Louvers		50 to 115	50 to 285	Gives best temperature range. No alignment requirements. Adversely affected by dust. Active thermal control.
Horizontal Radiator with A Frame Sunshield		0 to 160	0 to 160	Unaffected by dust. Requires alignment. Lunar day temperatures excessive.

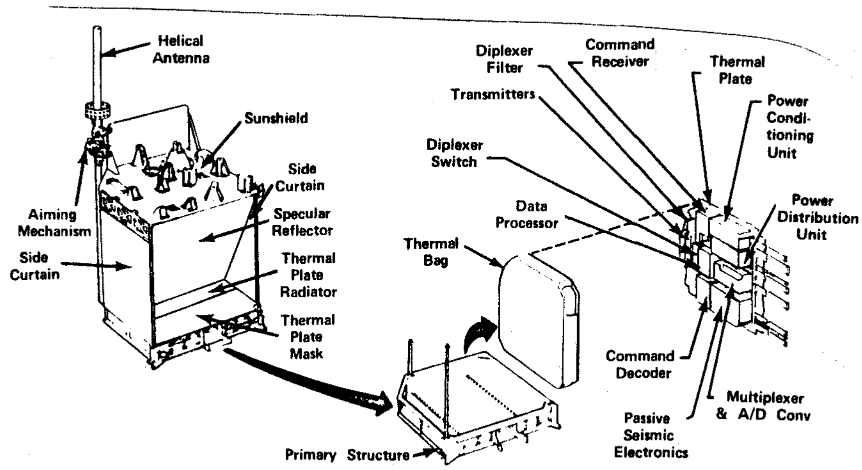
7759-5905

INITIAL ALSEP CENTRAL STATION THERMAL CONTROL CONCEPTS (CONT')

CONCEPT	DESIGN SCHEMATIC	THERMAL PLATE TEMP RANGE °F SOLAR ABSORPTANCE NOMINAL	 DEGRADED	COMMENTS
Vertical Radiator with A Frame Sunshield		0 to 190	0 to 190	Unaffected by dust. Requires alignment. Lunar day temperatures excessive.
Horizontal Radiator with Sunshield and Reflector		0 to 126	0 to 126	Selected concept. Unaffected by dust. Requires alignment. Uses specular reflector.

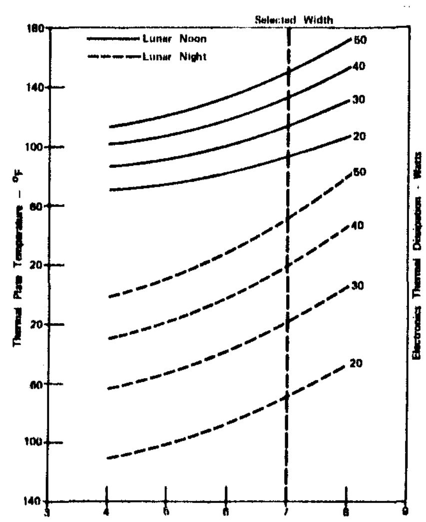
7759-5906

PRIMARY COMPONENTS OF DATA SUBSYSTEM THERMAL CONTROL SYSTEM



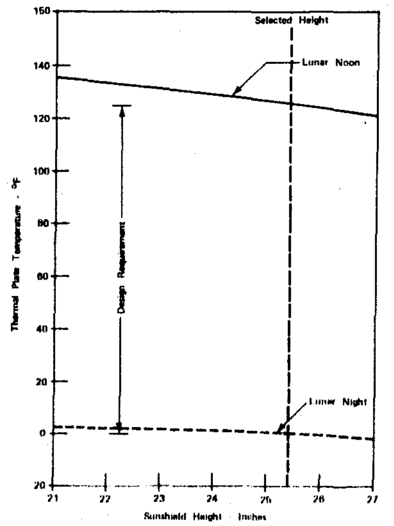
7759-5913

THERMAL PLATE TEMPERATURE AS A FUNCTION OF INSULATION MASK WIDTH AND INTERNAL ELECTRONICS POWER DISSIPATION



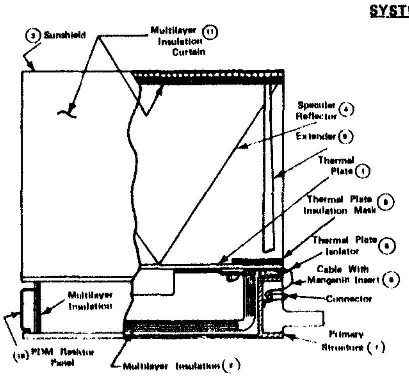
7759-5911

EFFECT OF SUNSHIELD HEIGHT ON THERMAL PLATE TEMPERATURE



7759-5912

KEY DESIGN FEATURES OF ALSEP CENTRAL STATION

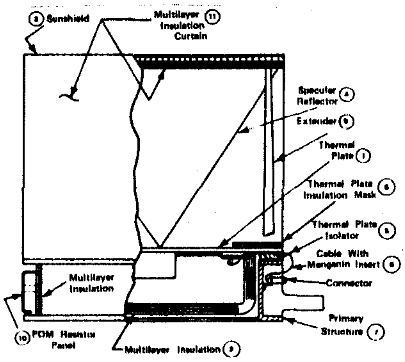


SYSTEM FEATURE

1. THERMAL PLATE – RADIATES ALL INTERNAL ELECTRONICS DISSIPATION TO SPACE
2. MULTILAYER INSULATION BAG – PROVIDES MAJOR RADIATIVE AND CONDUCTIVE ISOLATION FROM LUNAR THERMAL ENVIRONMENTS
3. SUNSHIELD – PREVENTS DIRECT SOLAR HEATING AND DUST DEGRADATION OF THERMAL PLATE
4. SPECULAR REFLECTOR – MINIMIZES THERMAL RADIATIVE ENERGY INTERCHANGE BETWEEN THERMAL PLATE AND MOON VIA THE SUNSHIELD
5. THERMAL PLATE ISOLATORS – PROVIDE THERMAL PLATE ISOLATION FROM LUNAR SURFACE THROUGH PRIMARY STRUCTURE AFTER DEPLOYMENT
6. MANGANIN CABLE INSERTS – REDUCE CONDUCTION HEAT LEAK VIA ELECTRICAL CABLES TO CENTRAL STATION

7759-5900

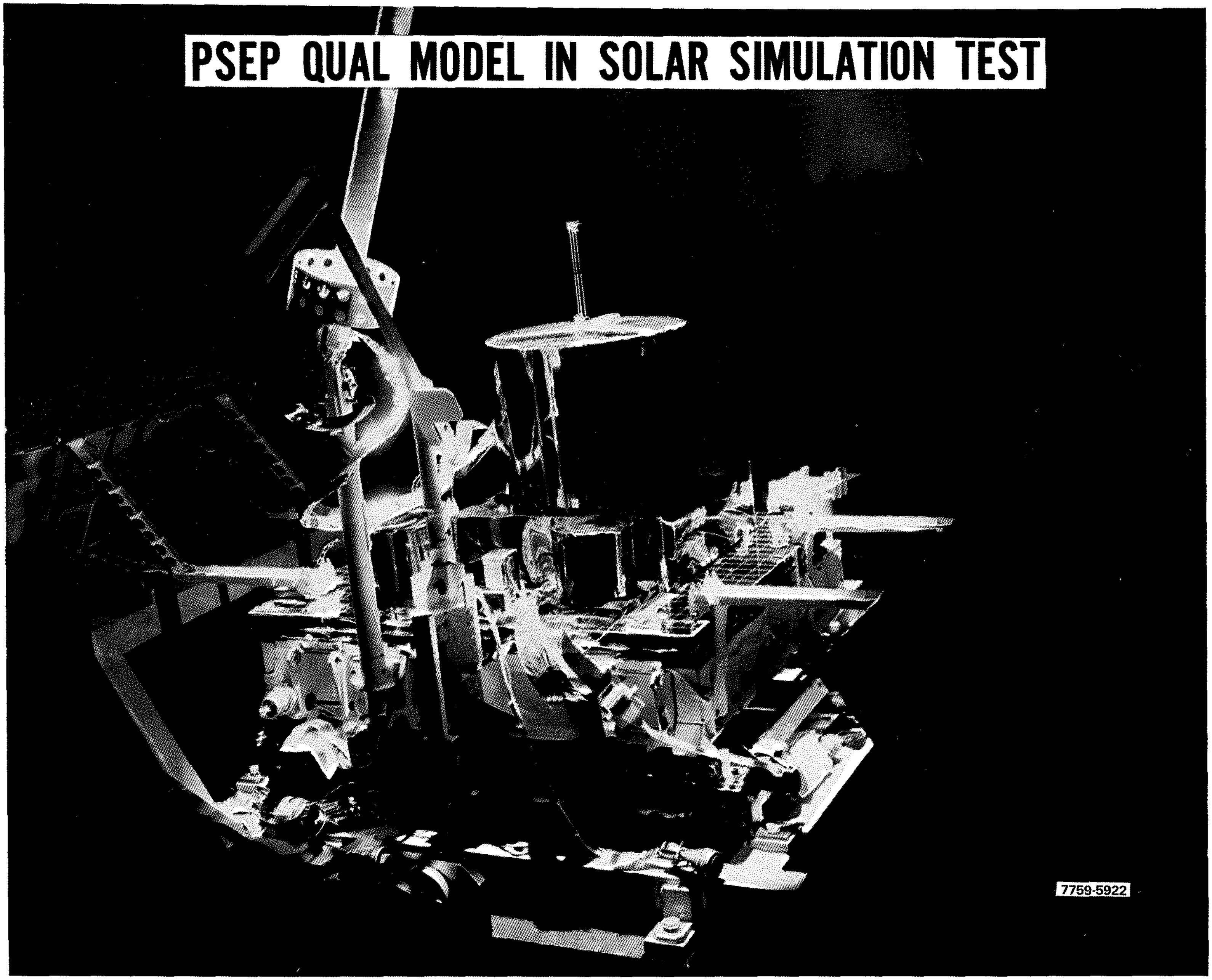
KEY DESIGN FEATURES OF ALSEP CENTRAL STATION (CONT')

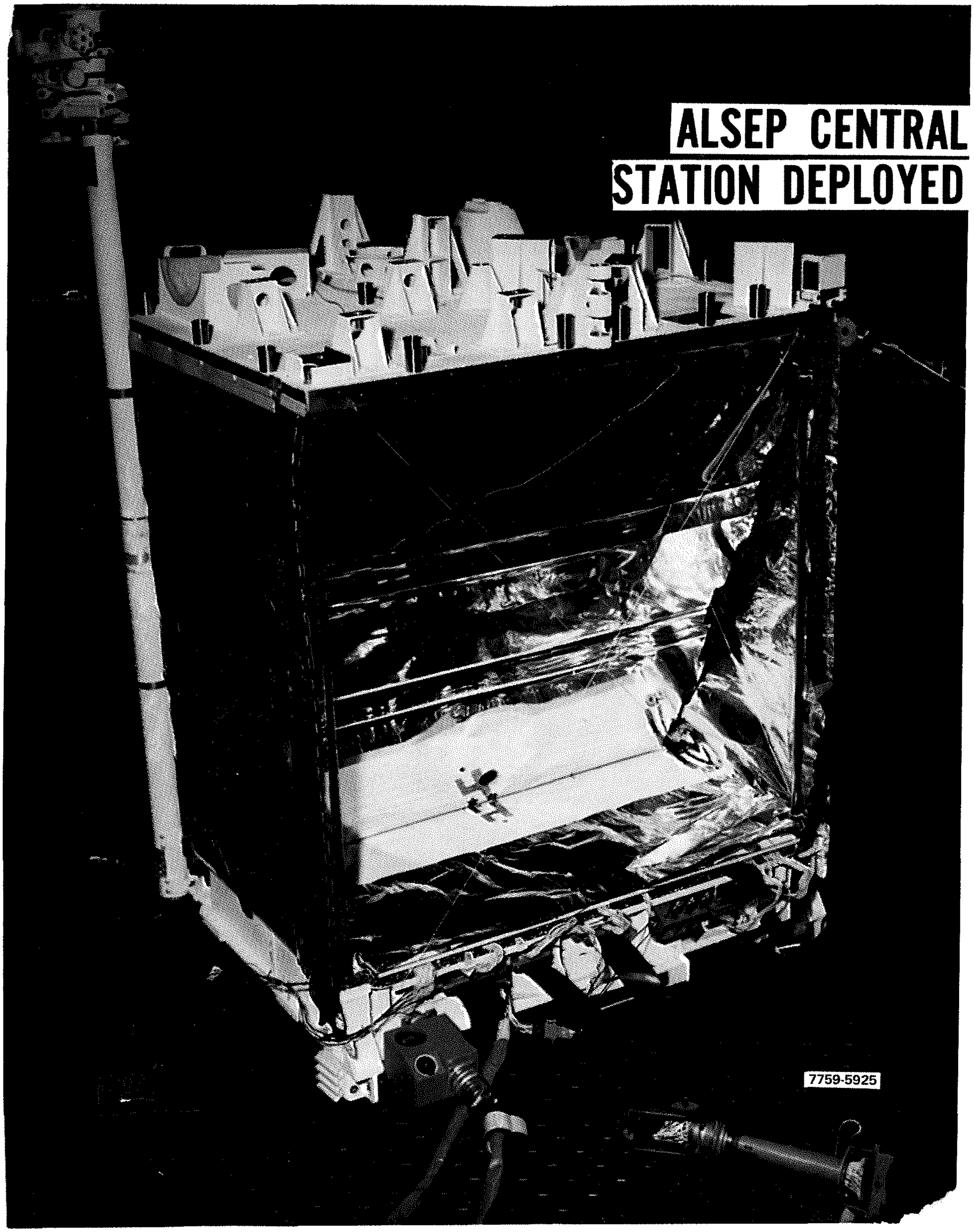


SYSTEM FEATURE

7. PRIMARY STRUCTURE – SUPPORT STRUCTURE FOR SUBPACKAGE 1. PROVIDES INITIAL ISOLATION FROM LUNAR SURFACE
8. THERMAL PLATE INSULATION MASK – CENTERS THERMAL PLATE TEMPERATURE SWING BETWEEN 0 AND 125°F AND MINIMIZES SOLAR HEATING ON THERMAL PLATE
9. SUNSHIELD EXTENDERS – PROVIDE 26" SEPARATION DISTANCE BETWEEN SUNSHIELD AND THERMAL PLATE
10. POWER DISSIPATION MODULE (PDM) – DISSIPATES EXCESS RTG ELECTRICAL POWER NOT UTILIZED BY ALSEP
11. MULTILAYER SIDE CURTAINS – PREVENT DIRECT SOLAR ENERGY ON THERMAL PLATE

7759-5901


PSEP QUAL MODEL IN SOLAR SIMULATION TEST
7759-5922


ALSEP CENTRAL
STATION DEPLOYED
7759-5925

COMPARISON OF EASEP AND ALSEP THERMAL CONTROL SYSTEMS

	EASEP	ALSEP
• TEMP SPECIFICATION	-65° TO 140°F	0° TO 125°F
TYPE DESIGN	DIRECT	INDIRECT
• PASSIVE	YES	YES
• SUNSHIELD	NO	YES
• SPECULAR REFLECTOR & SIDE CURTAINS	NO	YES
• ISOTOPE HEATERS	YES	NO
• THERMAL COATINGS	MIRRORS	S-13G WHITE PAINT
• THERMAL DISSIPATION		
DAY	63W	38W
NIGHT	30W	38W
• RADIATOR AREA	2.2 FT^2	2.1 FT^2
• STRUCTURE ISOLATION	CLEVIS BOLTS	ACTUATION SPRINGS
• PDM DUMP COMMANDS	5, 10 & 15W	7, 14 & 21W
• HEATERS		
THERMOSTAT	NONE	10W
COMMANDABLE	NONE	5 & 10W
• ALIGNMENT		
HORIZONTAL	± 5°	± 5°
EAST - WEST	± 5°	± 5°
• DEBRIS, DUST, ENGINE CONTAMINATION PROTECTION	NONE	PARTIAL
• PLUME PROTECTOR	YES	NO
• DEPLOYMENT DISTANCE	70 TO 100 FT	>300 FT

7759-5920

SUMMARY OF ALSEP AND EASEP THERMAL COATINGS

	COATING DESCRIPTION	PROPERTIES α/ϵ	COMMENT
1.	IITRI S-13G WHITE PAINT	.2/.9	STABLE, ORGANIC WHITE COATING FOR RADIATORS
2.	IITRI Z 93 WHITE PAINT	.18/.95	VERY STABLE, INORGANIC WHITE COATING FOR RADIATORS
3.	SECOND SURFACE MIRRORS	.05/.80	VERY STABLE, SILVER VACUUM DEPOSITED ON .008" FUSED SILICA FOR RADIATORS
4.	ALUMINIZED MYLAR AND KAPTON FILMS		LOW AND HIGH TEMPERATURE SUPERINSULATION MATERIAL
	ALUMINIZED SIDE	.10/.03	
	FILM SIDE	.40/.80	
5.	3M 401 ORGANIC WHITE PAINT	.30/.85	DURABLE SHORT TERM STABLE WHITE COATING FOR ASTRONAUT TOOLS
6.	GOLD PLATING	.25/.04	LOW EMITTANCE COATING FOR ELECTRONICS AND THERMAL SHIELD
7.	ALUMINIZED TEFLON	.14/.04	OUTER SUPERINSULATION SHROUD COVER
8.	POLISHED ALUMINUM	.21/.04	LOW EMITTANCE SURFACE FOR THERMAL RADIATION ISOLATION
9.	3M BLACK VELVET OR MICOBOND BLACK	.9/.9	BLACK FLAT ABSORBER
10.	SOLAR CELLS	.80/.83	BLUE/RED COVER GLASS
11.	SiO OVER ALUMINIZED MYLAR AND KAPTON FILM	.1/.25 to .15/.60	SUPERINSULATION SHROUD COVER

7759-5918

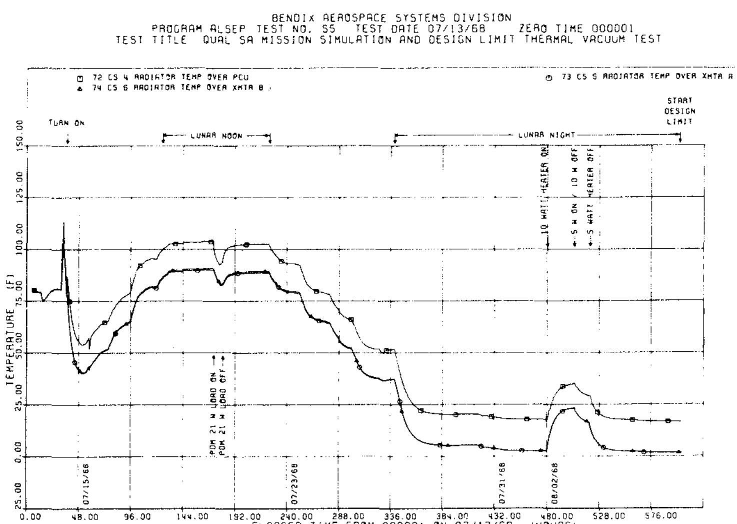
DESCRIPTION OF ALSEP QUAL AND FLIGHT T/V TESTS

QUALIFICATION (MISSION SIM)	LUNAR DAY	LUNAR NIGHT
LUNAR SURFACE TEMP.	+250°F	-300°F
SOLAR SIMULATION	130 WATTS/FT^2	---
CRYOWALL TEMP.	-300°F	-300°F
CHAMBER PRESSURE	$>10^{-6}$ TORR	$>10^{-6}$ TORR
CHAMBER TEST DURATION	15 DAYS	15 DAYS

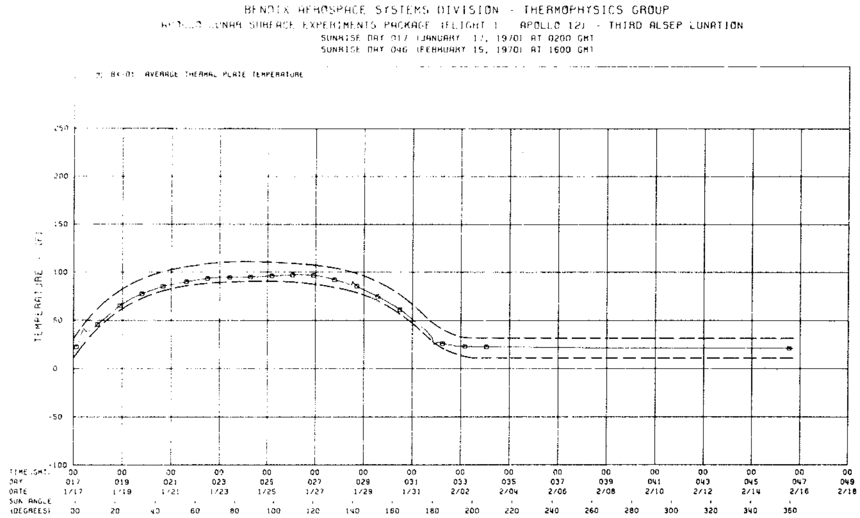
ACCEPTANCE	LUNAR DAY	LUNAR NIGHT
LUNAR SURFACE TEMP.	+250°F	-300°F
SOLAR SIMULATION	130 WATTS/FT^2	---
CRYOWALL TEMP.	-300°F	-300°F
CHAMBER PRESSURE	$>10^{-6}$ TORR	$>$ x 10^{-6} TORR
CHAMBER TEST DURATION	2.5 DAYS	2.5 DAYS

7759-5919

THERMAL PLATE TEMPERATURES FOR SIMULATED LUNAR OPERATION

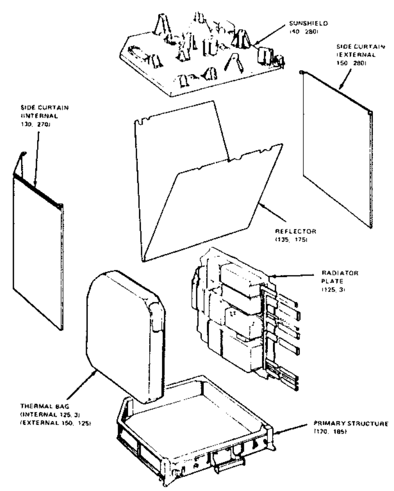


7759-5910



7759-5909

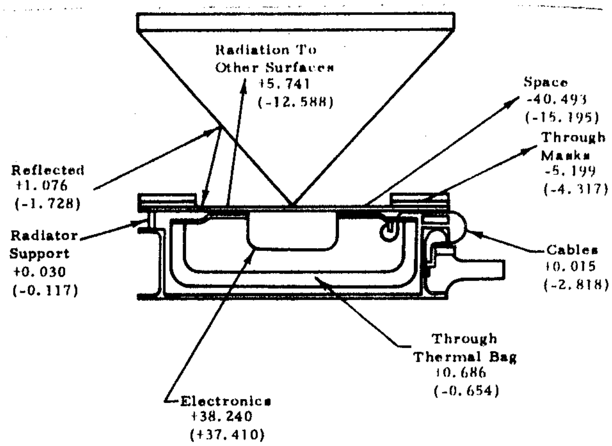
PRIMARY COMPONENTS OF CENTRAL STATION THERMAL CONTROL SYSTEM



7759-5921

10-12

THERMAL BALANCE ON RADIATOR PLATE OF QUAL SA MISSION SIMULATION MODEL IN REAL LUNAR ENVIRONMENT



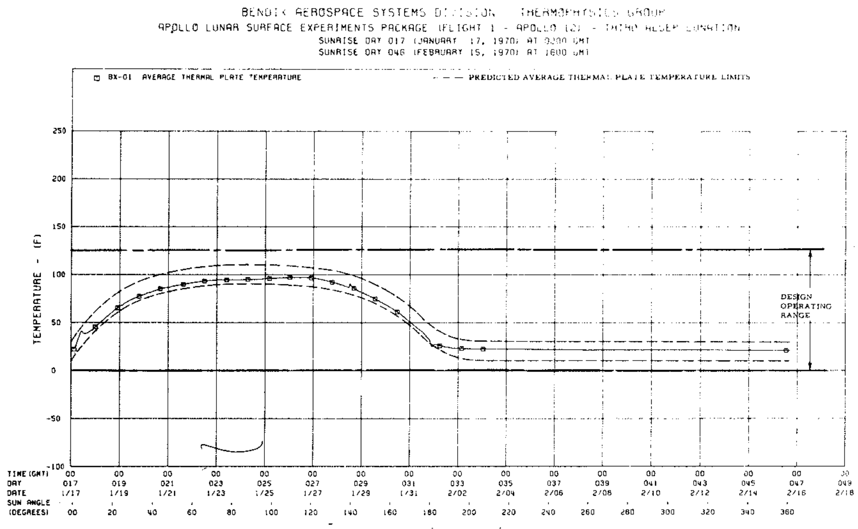
+ Into Radiator
- From Radiator

All values are in watts

xxx Noon
(xxx) Night

7759-5914


ALSEP CENTRAL STATION DEPLOYED
ON LUNAR SURFACE-APOLLO 12
7759-5926



7759-5915

ALSEP FLIGHT 1
THERMAL PERFORMANCE SUMMARY

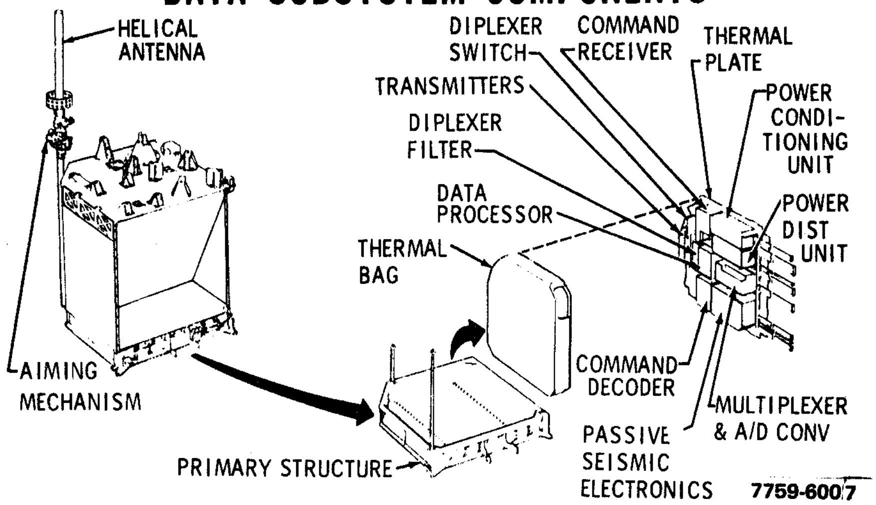
	SPECIFICATION TEMP, °F	LUNAR DAY TEMP, °F	LUNAR NIGHT TEMP, °F	DAY TO NIGHT SWING, °F	COMMENT
CENTRAL STATION	0 TO 125	97	22	75	FOR HEATER OFF NIGHT TEMP WAS 0°F.
PSE	107 TO 143	134	75	59	DESIGN CHANGE FOR APOLLO 13 (F 3) PSE
LSM	-22 TO 144	175	-22	197	DESIGN CHANGE FOR APOLLO 15 (A-2) LSM
SWE	-13 TO 140	145	1	144	
SIDE	-22 TO 158	170	12	158	DUST ON RADIATOR PLATE MIRRORS DURING CREW DEPLOYMENT

7759-5923

Section 11

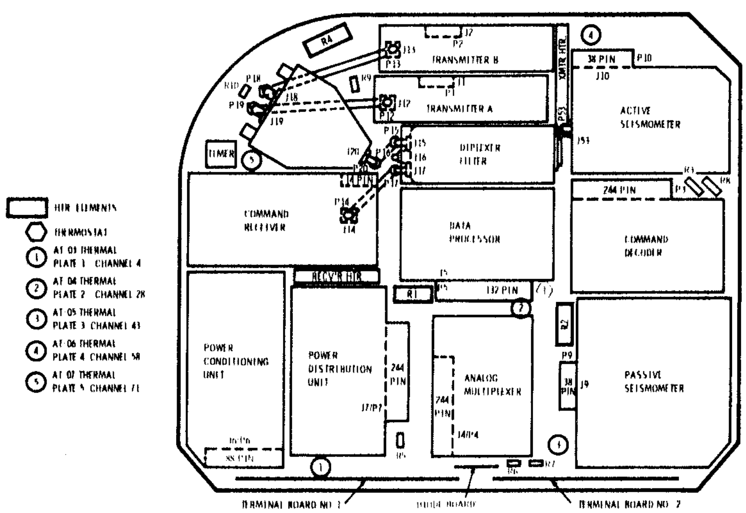
Alsep Central Station Electrical Design

CENTRAL STATION DATA SUBSYSTEM COMPONENTS



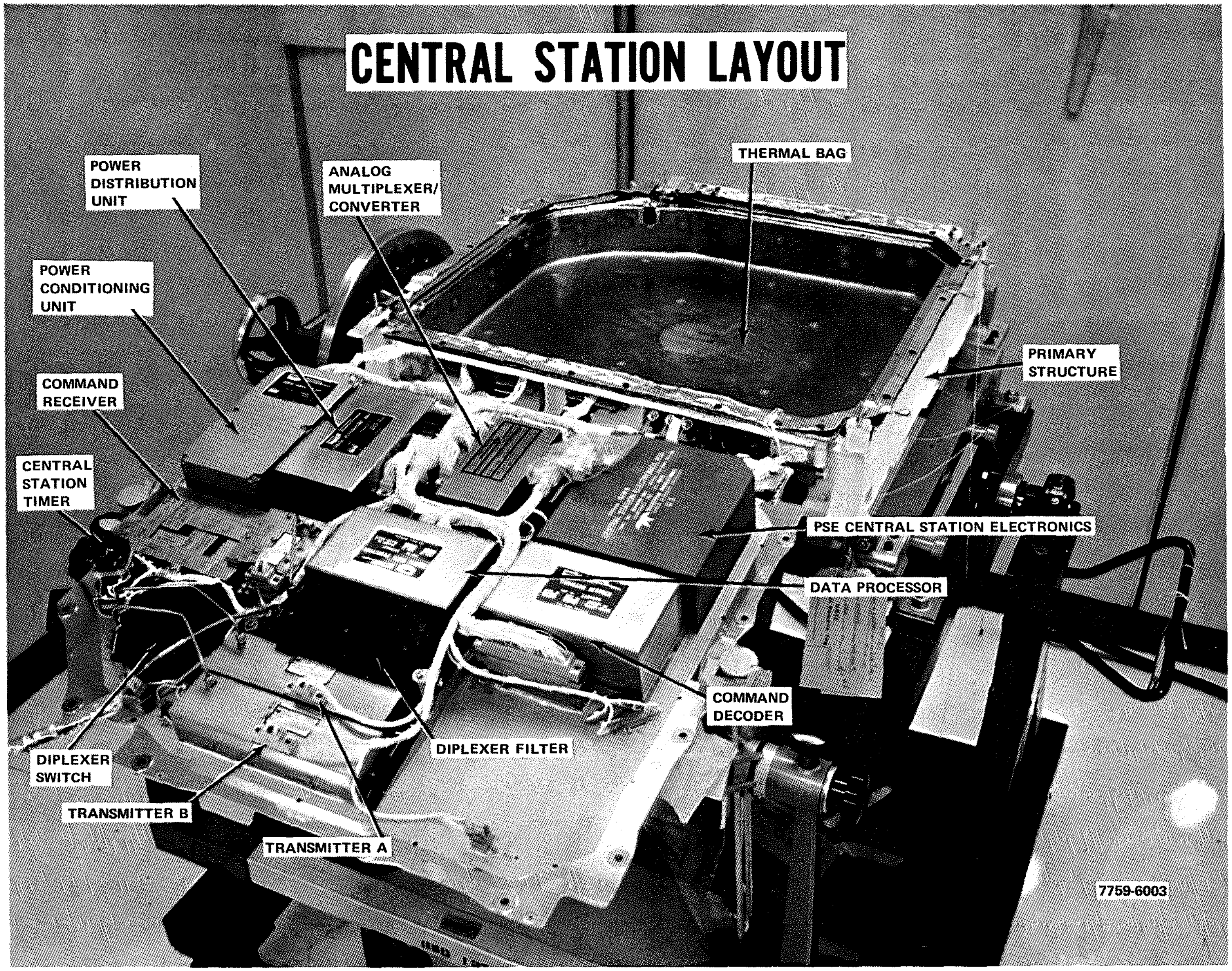
7759-6007

CENTRAL STATION SENSORS AND HEATERS



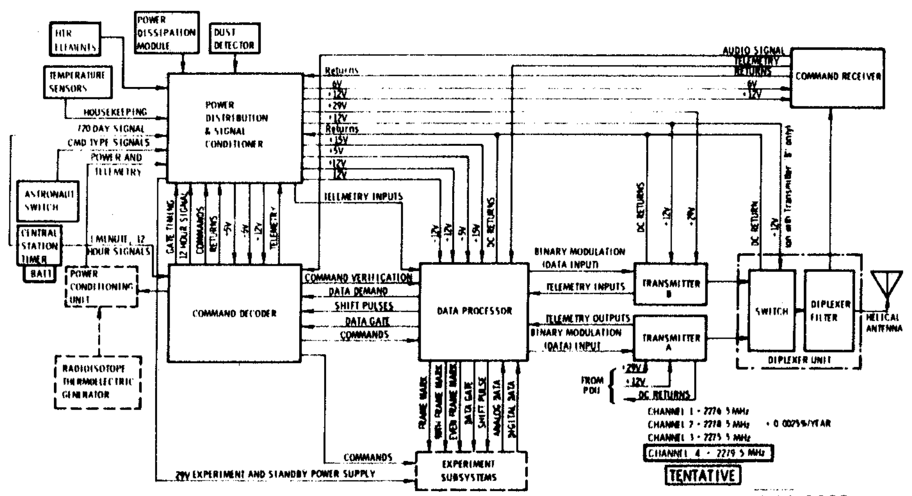
7759-6008

11-1



CENTRAL STATION LAYOUT
THERMAL BAG
POWER DISTRIBUTION UNIT
ANALOG MULTIPLEXER/ CONVERTER
POWER CONDITIONING UNIT
PRIMARY STRUCTURE
COMMAND RECEIVER
CENTRAL STATION TIMER
PSE CENTRAL STATION ELECTRONICS
DATA PROCESSOR
COMMAND DECODER
DIPLEXER FILTER
DIPLEXER SWITCH
TRANSMITTER B
TRANSMITTER A
7759-6003

DATA SUBSYSTEM BLOCK DIAGRAM



7759-6008

ALSEP COMMAND LINK

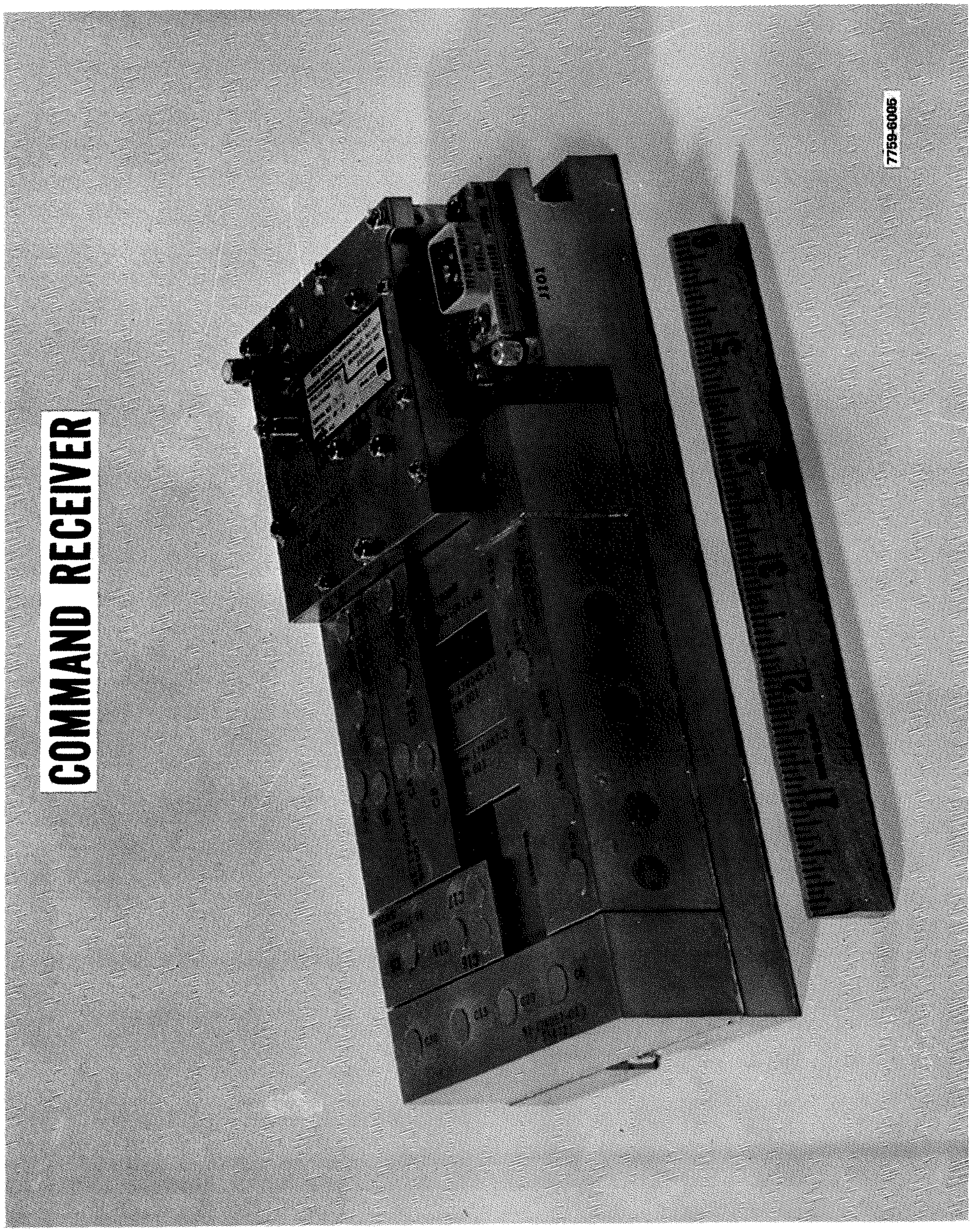
* ANTENNA
* DIPLEXER
* COMMAND RECEIVER
* COMMAND DECODER

7759-6010A

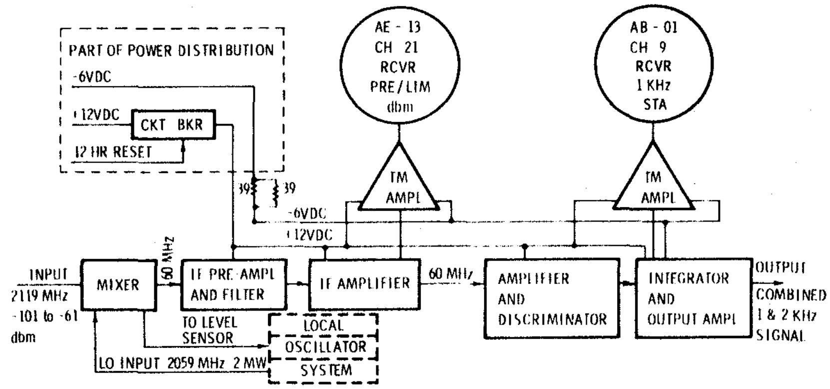
COMMAND LINK CHARACTERISTICS

FUNCTION/PARAMETER	ALSEP	MSFN
1. FREQUENCY	2119 ± 0.001 % MHz	2119 MHz
2. MODULATION	–	PM, ± 3 RADIANS
3. MODULATING SIGNAL	–	1 KHz SINE WAVE SYNC SIGNAL LINEARLY ADDED TO A 2 KHz SUBCARRIER
4. DATA RATE		1000 bps
5. IF BANDWIDTH (3 db)	275 ± 25 KHz	–
6. RECEIVER DYNAMIC RANGE	- 101 TO - 61 dbm	–
7. PERMISSIBLE Pe (PROBABILITY OF BIT ERROR)	10^{-9}	
8. REQUIRED PREDETECTION S/N FOR 10^{-9} BER	+ 12 db	
9. S/N MARGIN FOR Pe of 10^{-9} (30' ANTENNA)	NOMINAL +9.3 db WORST CASE +3.7 db	

7759-6010B

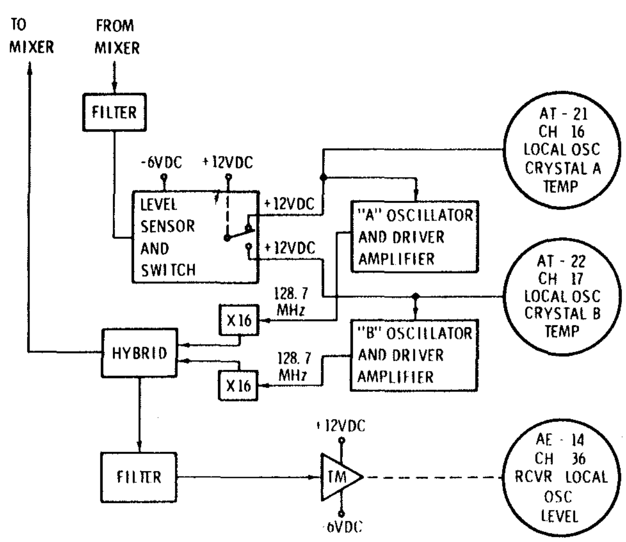

COMMAND RECEIVER
7759-6005

COMMAND RECEIVER
SIMPLIFIED BLOCK DIAGRAM



7759-6011

COMMAND RECEIVER
LOCAL OSCILLATOR BLOCK DIAGRAM



7759-6012

COMMAND RECEIVER TELEMETRY SUMMARY

CHANNEL 36	AE-14	RCVR LOCAL OSC LEVEL • DETECTOR CIRCUIT SAMPLES OSCILLATOR SIGNAL. DETECTED SIGNAL IS THEN AMPLIFIED TO PROPER TM LEVEL
CHANNEL 16	AT-21	LOCAL OSC CRYSTAL A TEMP • USES THERMISTOR/RESISTOR NETWORK POWERED BY 12 VDC. • THERMISTOR IS CEMENTED (EPOXY) TO CRYSTAL CAN.
CHANNEL 17	AT-22	LOCAL OSC CRYSTAL B TEMP • USES THERMISTOR/RESISTOR NETWORK POWERED BY 12 VDC. • THERMISTOR IS CEMENTED (EPOXY) TO CRYSTAL CAN.

7759-6013A

COMMAND RECEIVER TELEMETRY SUMMARY

CHANNEL 9	AB-01	CMD DEMOD 1KHz PRESENT • SIGNAL IS OBTAINED FROM RECEIVER'S AUDIO OUTPUT. • USES 1KHz BANDPASS AMPLIFIER AND DIODE DETECTOR.
CHANNEL 21	AE - 13	RCVR PRE-LIMITING LEVEL • DIODES IN FINAL STAGE OF IF PROVIDE HARD LIMITING. • TM SIGNAL PROVIDED BY THE LIMITING DIODE CURRENT.

7759-6013B

COMMAND RECEIVER SPECIFICATIONS

• INPUT FREQUENCY	2119 MHz ± 0.001%
• INPUT SIGNAL LEVEL	-101dbm to -61dbm
• NOISE FIGURE	10db MAXIMUM
• LOCAL OSC FREQUENCY	2059 MHz ± 0.0025%/YR
• INTERMEDIATE FREQUENCY	60 MHz
• IF 3db BANDWIDTH	250 to 350 KHz WITH AN INPUT SIGNAL LEVEL OF -100dbm
• IF REJECTION	60db MINIMUM AT 3.4 MHz

• AUDIO OUTPUT SIGNAL
  (a) LEVEL - 0.8 VOLT/RADIAN (UP TO ± 3.0 RADIANS)
  (b) FREQ - 100 Hz TO 5 KHz

7759-6014A

COMMAND RECEIVER SPECIFICATIONS (CONT)

• POWER

+ 12 VDC AT 55 MILLIAMPERES (NOMINAL) - SUPPLIED THROUGH A CIRCUIT BREAKER RATED AT 150 MILLIAMPERES (NOMINAL). CIRCUIT IS AUTOMATICALLY GIVEN A RESET COMMAND EVERY 12 HOURS.

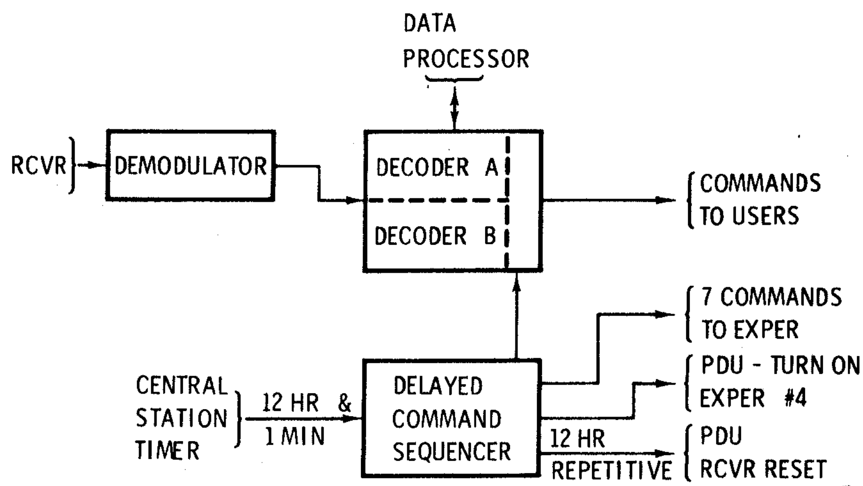
- 6VDC AT 55 MILLIAMPERES (NOMINAL) - SYSTEM PROTECTION PROVIDED BY SERIES RESISTOR.

• CONNECTORS - RF - COAXIAL OSM 210-2
  - OTHER - HUGHES WST0014M20BNH00

7759-6014B

COMMAND DECODER

COMMAND DECODER SIMPLIFIED BLOCK DIAGRAM



7759-6015

COMMAND DECODER

* CONTAINS A DEMODULATOR
  - TO GENERATE AN NRZ-C BIT STREAM FROM THE PHASE MODULATED COMPOSITE 1 & 2 KHz AUDIO INPUT.
  - WHICH DETECTS " THRESHOLD" TO START DECODER "SEARCH MODE".
  - TO GENERATE 1, 2 AND 4 KHz TIMING CLOCKS WHICH ARE SYNCHRONIZED WITH THE 1KHz SYNC SUBCARRIER RECEIVED FROM THE MSFN.
* ACCEPTS COMMAND SIGNALS FROM THE MSFN NETWORK AND PROVIDES UP TO 100 UNIQUE COMMANDS TO USERS.

7759-6016A

COMMAND DECODER (CONT)

* A COMMAND FROM THE MSFN CONSISTS OF A 2KHz SUBCARRIER PHASE MODULATED WITH A 1KHz SUBCARRIER TO PRODUCE 61 SERIAL BITS WITH THE FOLLOWING FORMAT.

20 BITS	7 BITS	7 BITS	7 BITS	20 BITS
1	2	3	4	5

1. - PREAMBLE - ALL ONES OR ALL ZEROS
2. - ADDRESS INDIVIDUAL ALSEP (A or B DECODER)
3. - COMMAND COMPLEMENT
4. - COMMAND
5. - TIMING (EXECUTION) - ALL ONES OR ALL ZEROS

7759-6016B

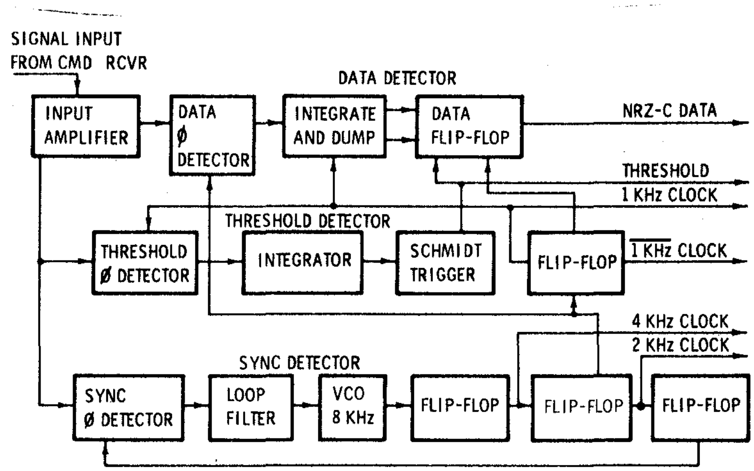
COMMAND DECODER ADDRESSING

- THE SEVEN ADDRESS BITS ARE USED TO UNIQUELY COMMAND FOUR SEPARATE ALSEPs DEPLOYED ON THE LUNAR SURFACE.
- EACH COMMAND DECODER HAS AN "A" SECTION AND A REDUNDANT "B" SECTION. EITHER MAY BE SELECTED TO PROCESS A COMMAND BY TRANSMITTING THE PROPER ADDRESS CODE.
- CODES

ALSEP	ADDRESS NO. (OCTAL)	CODE PATTERN	COMMAND DECODER NUMBER
1	130	1011000	1A
	30	0011000	1B
2	116	1001110	2A
	16	0001110	2B
3	151	1101001	3A
	51	0101001	3B
4	25	0010101	4A
	65	0110101	4B

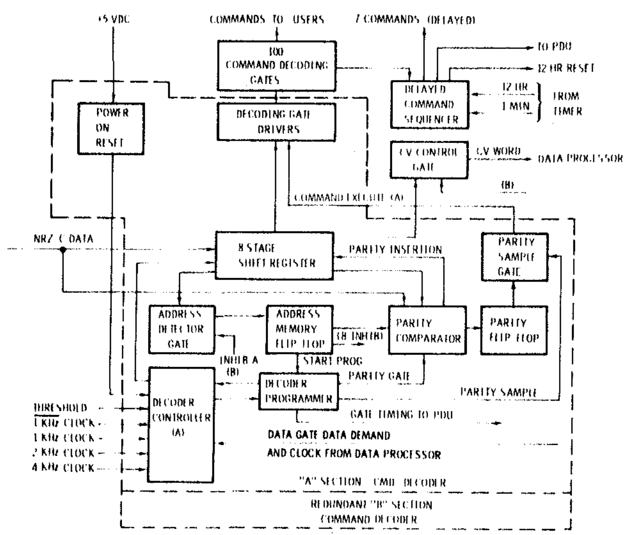
7759-6017

COMMAND DEMODULATOR



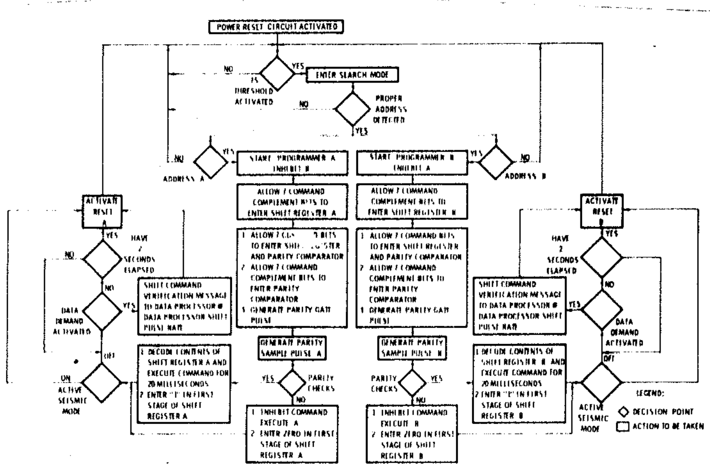
7759-6018

COMMAND DECODER SECTION BLOCK DIAGRAM-DIGITAL



7759-6019

FUNCTIONAL FLOW CHART COMMAND DECODER



7759-6020

COMMAND DECODER DELAYED COMMAND SEQUENCER

* PROVIDES A BACKUP FEATURE FOR LOCAL GENERATION OF COMMANDS IN CASE THE COMMAND LINK CANNOT BE ESTABLISHED
* GENERATES 7 ONE-TIME COMMANDS AFTER A DELAY OF 96 (PLUS) HOURS FROM START OF "PET" (WHERE "PET" STARTS AT THE TIME THE ASTRONAUT MATES THE RTG WITH THE CENTRAL STATION BY INSERTING P22 INTO J22)
* COMMANDS ARE IDENTICAL TO THOSE GENERATED IN RESPONSE TO SIGNALS FROM THE MSFN AND ARE OR'ED IN THE COMMAND LINE DRIVER.

7759-6021A

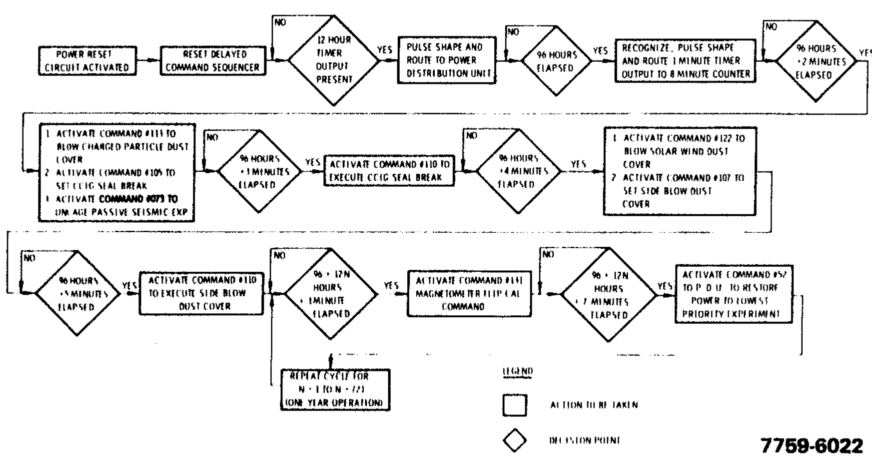
COMMAND DECODER DELAYED COMMAND SEQUENCER (CONT)

* DELAYED (ONE-TIME) COMMANDS ARE IDENTIFIED AS FOLLOWS:

FUNCTION	TIME OF EXECUTION	COMMAND NUMBER (OCTAL)
REMOVE CPLEE DUST COVER	96 HRS & 2 MIN	113
SET CCIG SEAL BREAK	96 HRS & 2 MIN	105
UNCAGE PSE	96 HRS & 2 MIN	073
EXECUTE CCIG SEAL BREAK	96 HRS & 3 MIN	110
SWS DUST COVER REMOVAL	96 HRS & 4 MIN	122
SET SIDE DUST COVER	96 HRS & 4 MIN	107
EXECUTE SIDE DUST COVER REMOVAL	96 HRS & 5 MIN	110

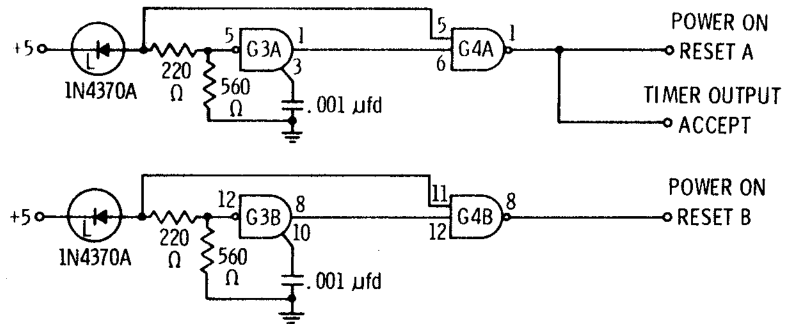
7759-6021B

DELAYED COMMAND SEQUENCER FUNCTIONAL FLOW CHART



7759-6022

COMMAND DECODER POWER RESET



FEATURES

DETECTS INITIAL POWER TURN-ON OR MOMENTARY POWER INTERRUPTION TO -

1. SET COMMAND DECODER IN SEARCH MODE
2. SET COMMAND DECODER IN "TIMER ACCEPT" MODE
3. START DELAYED COMMAND SEQUENCER

7759-6023

COMMAND DECODER-OTHER LOCAL COMMANDS

THE FOLLOWING REPETITIVE COMMANDS ARE GENERATED WITHIN THE COMMAND DECODER:

1 - PSE CALIBRATE - COMMAND #065
- OCCURS 12 HOURS AFTER T_0 AND EVERY 12 HOURS THEREAFTER

2 - RECEIVER CIRCUIT BREAKER RESET
- OCCURS 12 HOURS AFTER T_0 AND EVERY 12 HOURS THEREAFTER

3 - MAGNETOMETER FLIP-CALIBRATE - COMMAND #131
- FIRST OCCURRENCE IS 108 HOURS PLUS 1 MIN AFTER T_0 - REPEATS EVERY 12 HOURS THEREAFTER

4 - RESTORE POWER TO LOW PRIORITY EXPERIMENT - CMD #052
- FIRST OCCURRENCE IS 108 HOURS AND 7 MINUTES AFTER T_0 AND EVERY 12 HOURS THEREAFTER

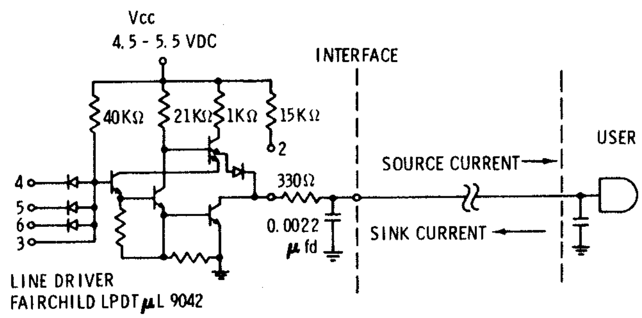
* ALL ABOVE COMMANDS MAY BE INHIBITED BY TRANSMITTING COMMAND #033

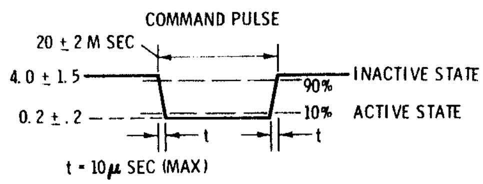
➤ COMMAND #033 IS CONSIDERED CRITICAL! SHOULD THE COMMAND LINK BE LOST FOLLOWING TRANSMISSION OF CMD #033, THEN ALL LOCALLY GENERATED COMMANDS WOULD BE LOST

7759-6024

COMMAND DECODER INTERFACE CIRCUIT

(ONE EACH FOR 100 COMMANDS)





DRIVER SPECIFICATION

SOURCE I ≤ 45μ AMP
(INACTIVE STATE)

SINK I ≤ 750μ AMP
(ACTIVE STATE)

7759-6025

COMMAND DECODER TELEMETRY SUMMARY

* COMMAND VERIFICATION (CV) WORD
  - LOCATED IN WORD 46 OF TELEMETRY FORMAT FOR FLIGHT SYSTEMS 1 & 2 AND IN WORD 5 FOR FLIGHT SYSTEMS 3 & 4
  - CONSISTS OF 2 ZEROS, THE RECEIVED COMMAND AND A PARITY BIT
  - EXAMPLE OF CV WORD RECEIVED AT THE MSFN

0	0	0	0	1	1	1	1	0	1

FILLER BITS | COMMAND (OCTAL 36) | PARITY

ONCE FOR EACH CMD TRANSMITTED

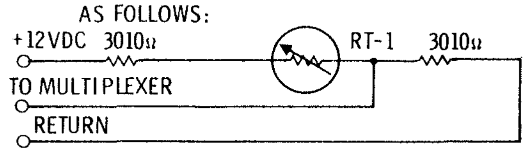
  - PARITY " ONE" VERIFIES BIT BY BIT CHECK OF COMMAND WITH COMPLEMENT.
  - THE SEVEN COMMAND BITS IDENTIFY THE BINARY CODE DETECTED BY THE COMMAND DECODER.

7759-6026

COMMAND DECODER TELEMETRY SUMMARY

CHANNEL	48	AT-31	COMMAND DECODER BASE TEMP *SIGNAL OBTAINED FROM THERMISTOR LOCATED NEAR CENTER OF BASE PLATE
CHANNEL	49	AT-32	COMMAND DECODER INTERNAL TEMP *THERMISTOR LOCATED ON "PULSE SHAPER" PRINTED CIRCUIT BOARD
CHANNEL	61	AT-33	COMMAND DEMODULATOR, VCO TEMP *THERMISTOR LOCATED ON DEMODULATOR PRINTED CIRCUIT BOARD

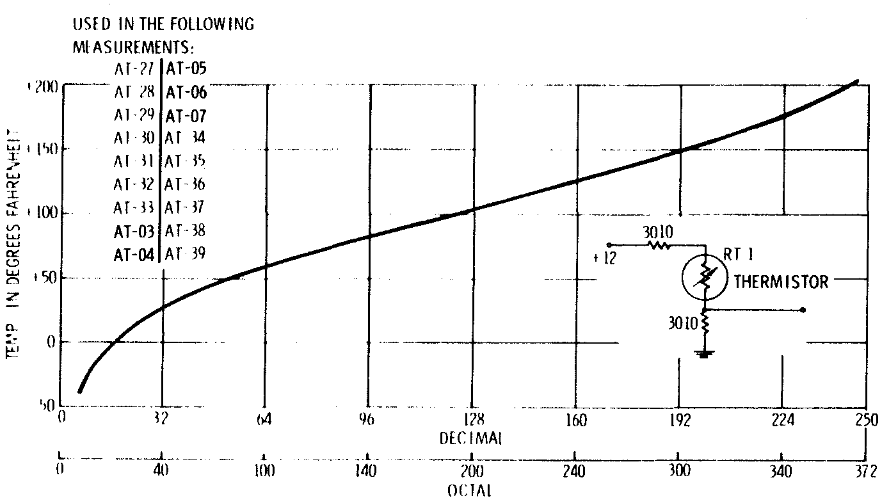
CIRCUITS - TEMPERATURE SENSING CIRCUITS ARE ARRANGED AS FOLLOWS:



RT-1 "FENWAL" ISO-CURVE 15K ohm THERMISTOR.

7759-6027

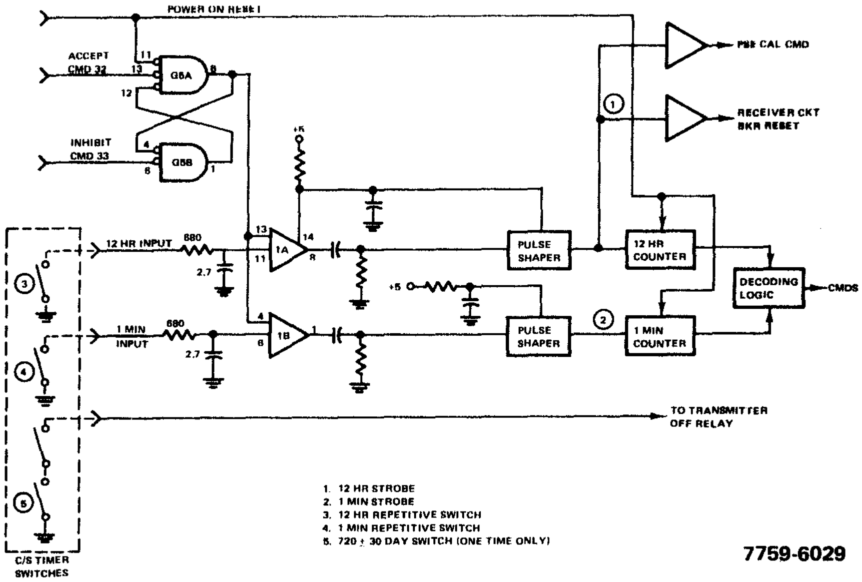
TELEMETRY READOUT VS. TEMPERATURE



7759-6028

11-17

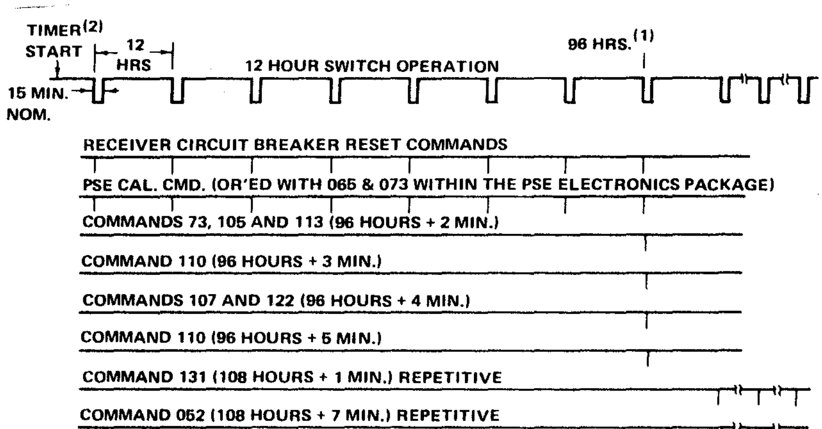
CMD DECODER/TIMER INTERFACE



1. 12 HR STROBE
2. 1 MIN STROBE
3. 12 HR REPETITIVE SWITCH
4. 1 MIN REPETITIVE SWITCH
5. 720 ± 30 DAY SWITCH (ONE TIME ONLY)

7759-6029

DELAYED CMD TIME SEQUENCE



NOTES:

(1) " 96 HOUR POINT" IS 84 TO 96 HOURS AFTER SYSTEM ACTIVATION
(2) "SYSTEM ACTIVATION" ON FLIGHT SYSTEM 3 AND FLIGHT SYSTEM 4
(3) ALL DELAYED COMMANDS WILL BE REPEATED IN 96 HOURS FOLLOWING EACH ACTIVATION OF THE POWER RESET CIRCUIT

7759-6030

COMMAND DECODER

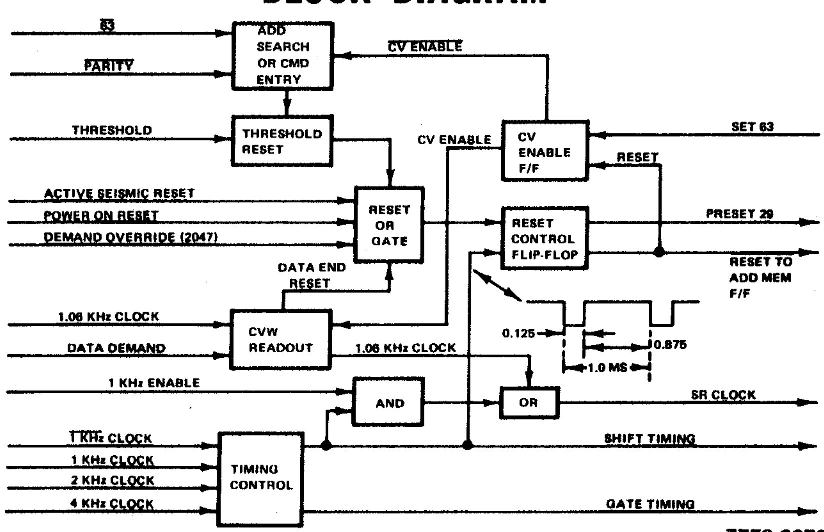
OPERATING MODE SEQUENCE

MODE	STARTED BY:	TERMINATED BY:
1. ADDRESS SEARCH	DECODER RESET (THRESHOLD TRUE)	ADDRESS RECOGNITION; STARTS THE COUNTER FROM COUNT OF 29
2. COMMAND WORD ENTRY	ADDRESS RECOGNITION	COUNT OF 43; CLEARS PARITY SAMPLE, TERMINATING THE UPLINK SHIFTING
3. COMMAND EXECUTION	COUNT OF 43	COUNT OF 63; SETS COMMAND VERIFICATION ENABLE FLIP-FLOP
4. CV WORD READOUT	COUNT OF 63	1. DATA END RESET, OR 2. COUNT OF 2047, DEMAND OVERRIDE

MAIN CONTROL FUNCTIONS
- SHIFT REGISTER CLOCK WAVEFORM CONTROL
- DECODER RESET
- NOTE THAT THE PROGRAMMER COUNTER IS STARTED BY ADDRESS RECOGNITION

7759-6077

DECODER CONTROLLER SIMPLIFIED BLOCK DIAGRAM

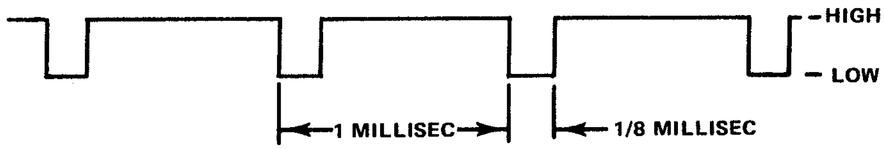


7759-6078

"CV 177 ANOMALY" MECHANISM

– IS DUE TO DATA END RESET BEING PREVENTED FROM RESETTING THE RESET CONTROL FLIP-FLOP

1. DATA END RESET IS A SHORT PULSE
2. RESET CONTROL FLIP-FLOP IS AN R-S FLIP FLOP TRIGGERED BY "LOWS"
3. RESET CONTROL FLIP-FLOP SET INPUT IS THE SHIFT TIMING SIGNAL WITH THE FOLLOWING WAVEFORM:



7759-6079

"CV 177 ANOMALY" MECHANISM (CONT')

4. WHEN THE SET INPUT IS LOW, THE RESET OUTPUT OF THE FLIP-FLOP CANNOT BE DRIVEN LOW, I.E., TO ITS "ACTIVE" LEVEL.
5. DUE TO THE ASYNCHRONISM BETWEEN THE UPLINK AND DOWNLINK, THE SHORT DATA END RESET PULSE WILL COINCIDE WITH A SET PULSE 1 IN 8 TIMES (AVERAGE).
6. COINCIDENCE RESULTS IN A SECOND CV WORD CONTAINING THE UPLINK TRAILER AS DATA, I.E., ALL "1'S".
7. FINALLY, THE DECODER IS RESET BY THE NEXT DATA END RESET OR BY DEMAND OVERRIDE.

7759-6080

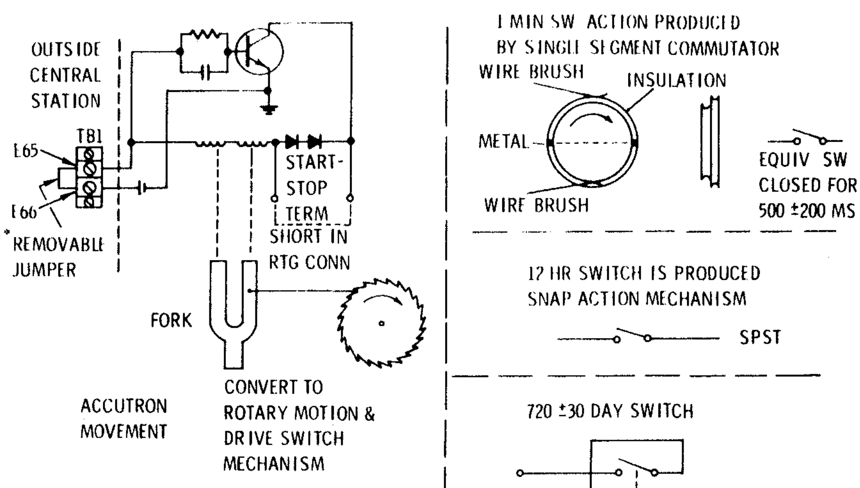

TIMER AND BATTERY
MALLORY
E63
E62
7759-6031

CENTRAL STATION TIMER

- THE CST IS AN ACCUTRON MECHANISM OBTAINED FROM THE BULOVA WATCH CO.
- A TUNING FORK IS USED TO ACCURATELY CONTROL SWITCH CLOSURE TIME
- SIZE: 1.32 x 1.32 x 2.63 INCHES
- WEIGHT: 0.265 POUNDS
- POWER IS PROVIDED BY A SEPARATE BATTERY
- TWO MODES OF OPERATION ARE PROVIDED-
  - "STOP MODE" - POWER IS APPLIED AND FORK IS OSCILLATING AT LOW LEVEL - ROTARY MOTION IS NOT PRODUCED. MAXIMUM CURRENT IS 7 MICROAMPERES. THIS MODE IS USED FROM FINAL TEST UNTIL DEPLOYMENT ON THE LUNAR SURFACE
  - "START MODE" - ADDITIONAL POWER IS APPLIED FOR INCREASED AMPLITUDE OF FORK OSCILLATION. ROTARY MOTION IS PRODUCED TO DRIVE THE SWITCH MECHANISM. MAXIMUM CURRENT IS 12 MICROAMPERES

7759-6032

CENTRAL STA TIMER MECHANISM



*JUMPER IS REMOVED AND 360 Hz SIGNAL APPLIED TO START FORK.

7759-6033

CENT STA TIMER BATTERY

- CONSISTS OF A P.R. MALLORY ZINC-MERCURIC-OXIDE, TYPE RMCC1W CELL, IN A SPECIAL PACKAGE FOR ALSEP. BASIC CELL IS CALLED "PACER"
- INITIAL TERMINAL VOLTAGE IS 1.5 VOLTS MAXIMUM
- MINIMUM CELL CAPACITY IS 750 MILLIAMPERE HOURS
- CELL CAPACITY IS DERATED TO 375 MILLIAMPERE HOURS FOR ALSEP
- CELL CAPACITY IS GUARANTEED AFTER STORAGE (OPEN CIRCUIT) FOR UP TO 2 YEARS
- OPERATING TEMPERATURE IS -27 to +162^{0}F

7759-6034

TIMER PROBLEM/TEST SUMMARY

BASED ON A DETAILED ANALYSIS OF TEST DATA AND CONFERENCES BETWEEN BENDIX/BULOVA – ENGINEERING/RELIABILITY/MATERIALS GROUPS, NASA/MSC PERSONNEL, CHEMISTS AT GSFC, CHEMISTS AND METALLURGISTS AT MAL/KSC, BALL BROS. HARD VACUUM LUBRICATION SPECIALISTS, APPLICATIONS ENGINEERS AT DOW CORNING, DR. F. J. CLAUSS AT LMSC, MR. ROBERT TROMBLEY AT THE NEY CO., AND DR. P. WALDRON AT LINCOLN LABS, IT WAS DECIDED TO MODIFY THE ALSEP TIMERS AS FOLLOWS:

7759-6071

TIMER PROBLEM/TEST SUMMARY MODIFICATIONS (CONT)

- REPLACE BERYLLIUM/COPPER WHEELS WITH PALINEY 7 WHEELS TO IMPROVE WEAR CHARACTERISTICS
- LUBRICATE ALL JEWELS WITH KRYTOX; ELIMINATE LUBRICATION ON WHEEL SPOKES TO PREVENT WHEEL TACKINESS
- REPLACE NEOPRENE SEALS WITH VITON SEALS TO ELIMINATE SULPHUR
- USE ELECTRON MICROSCOPE TO PERFORM PRE-ASSEMBLY INSPECTION OF EACH WHEEL TO ASSURE THAT ALL TEETH ARE ACCURATELY FORMED DURING MFG/CUTTING OPERATION
- PERFORM POST-ASSEMBLY INSPECTION OF JEWEL ALIGNMENT ON WHEEL TEETH TO PREVENT MISALIGNMENT AND POSSIBLE WEAR ACCELERATION DUE TO CHISELING. USE 216X MICROSCOPE

7759-6072

TIMER PROBLEM/TEST SUMMARY RESULTS (CONT)

TWO TIMERS, MODIFIED AS ABOVE, WERE SUBJECTED TO T/V TESTS. THE TEST CONSISTED OF 36 TEMPERATURE CYCLES FROM -10 TO +150^{o}F AT 10^{-5} TORR OR BETTER. FOLLOWING THE TEST EXAMINATION AT KSC WITH A SEM, THERE WAS NO DEGRADATION OF TEETH AND NO EVIDENCE OF DEBRIS. BASED ON THIS ANALYSIS, THE TIMERS WERE JUDGED TO BE SATISFACTORY FOR FLIGHT.

7759-6073

TIMER PROBLEM/TEST SUMMARY

DATE/SN	TEST	LUB	SYMPTOM/PROBLEM
6/67 J93705	VAC AMB T	MOEBIUS OIL IN JEWEL	SEIZURE OF MINUTE SWITCH COMMUTATOR AND BRUSH
PROBLEM/ CORRECTIVE ACTION			
COMMUTATOR COATED WITH EPON823 -- SMALL SEGMENT LEFT BARE TO PROVIDE SWITCH FUNCTION. ADDED SINTERED NYLON CHIP IMPREGNATED WITH DC704 SILICON OIL ADJACENT TO BRUSH CONTACT FOR VAPOR LUBRICATION.			
7/67 J93705	VAC AMB T	MOEBIUS OIL IN JEWEL	AFTER 3622 HOURS IN VACUUM, COULD NOT REPEATEDLY SWITCH OPERATING MODES
PROBLEM/ CORRECTIVE ACTION			
MOEBIUS, WHICH HAD VAPORIZED LEAVING GUMMY SUBSTANCE IN JEWELS, WAS REPLACED WITH DCFS1265 FLUROSILICONE OIL. FS1281 GREASE ADDED TO SPOKE OF INDEX WHEEL.			

7759-6074

TIMER PROBLEM/TEST SUMMARY

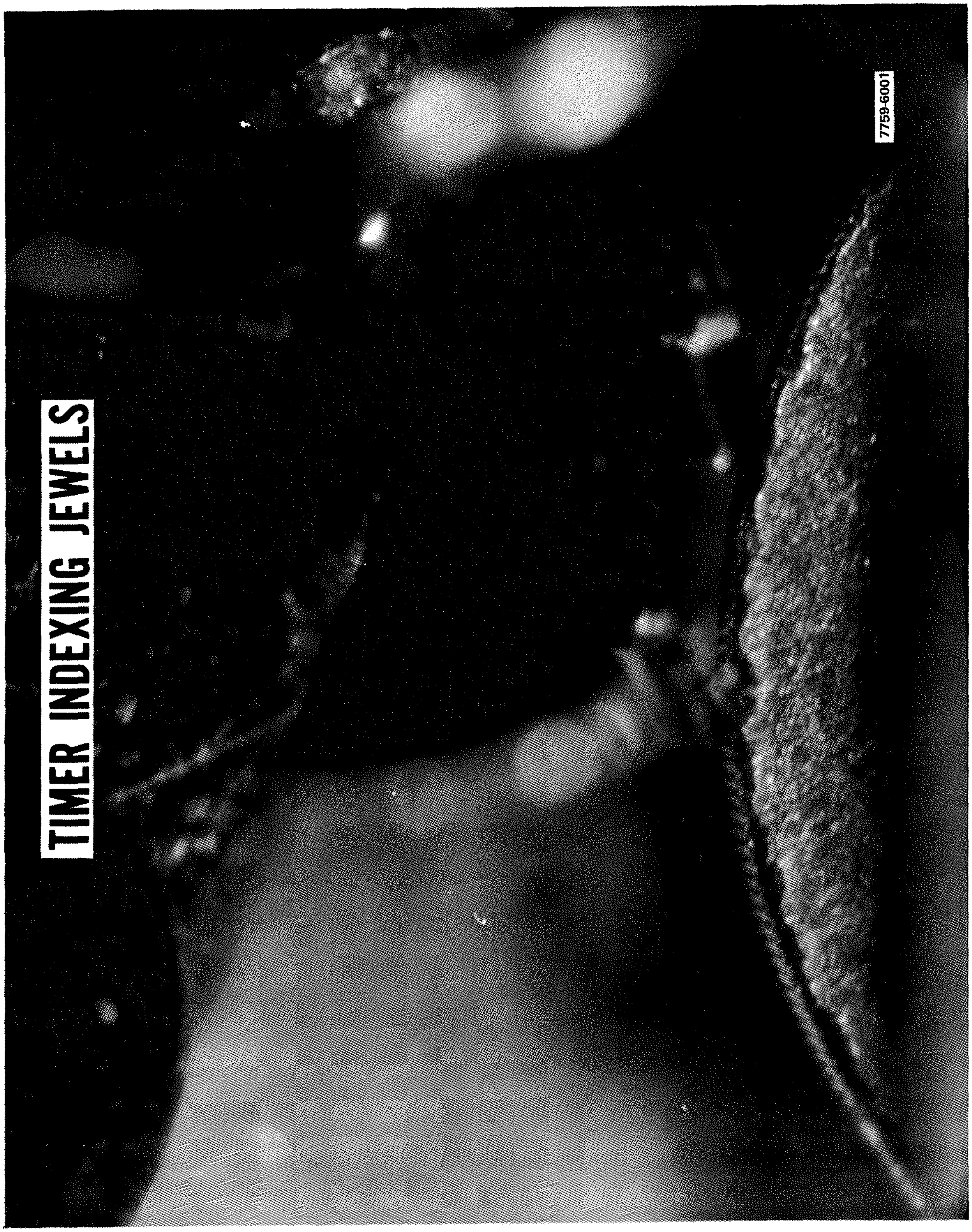
DATE/SN	TEST	LUB	SYMPTOM/PROBLEM
6/68 J93705	T/V -20 TO + 150°F	FS1265 AND FS1281	TACKY WHEEL AND JEWELS. DEBRIS ON PANEL JEWEL AND TEETH AFTER 36 T/V CYCLES. SLOW OPERATION AT -20°F.
PROBLEM CORRECTIVE ACTION			
FS1281, WHICH HAD MIGRATED ONTO TEETH, WAS REMOVED FROM WHEEL SPOKE.			
9/68 J93705	T/V 36 DAYS -10 to +150°F	FS1265 OIL IN JEWEL	SLOW ON 31st DAY (-10°F). STOPPED ON 32nd DAY (-10°F).
PROBLEM/ CORRECTIVE ACTION			
ACCUMULATION OF DARK SUBSTANCE ON TEETH IMPAIRED INDEXING. FS1265 OIL REPLACED WITH FS1281 GREASE WITH DC519 BARRIER COATING TO PREVENT MIGRATION OF LUBRICANT. WHEEL MATERIAL CHANGED FROM BeCu TO PALIMEY 7 WITHOUT LUB.			

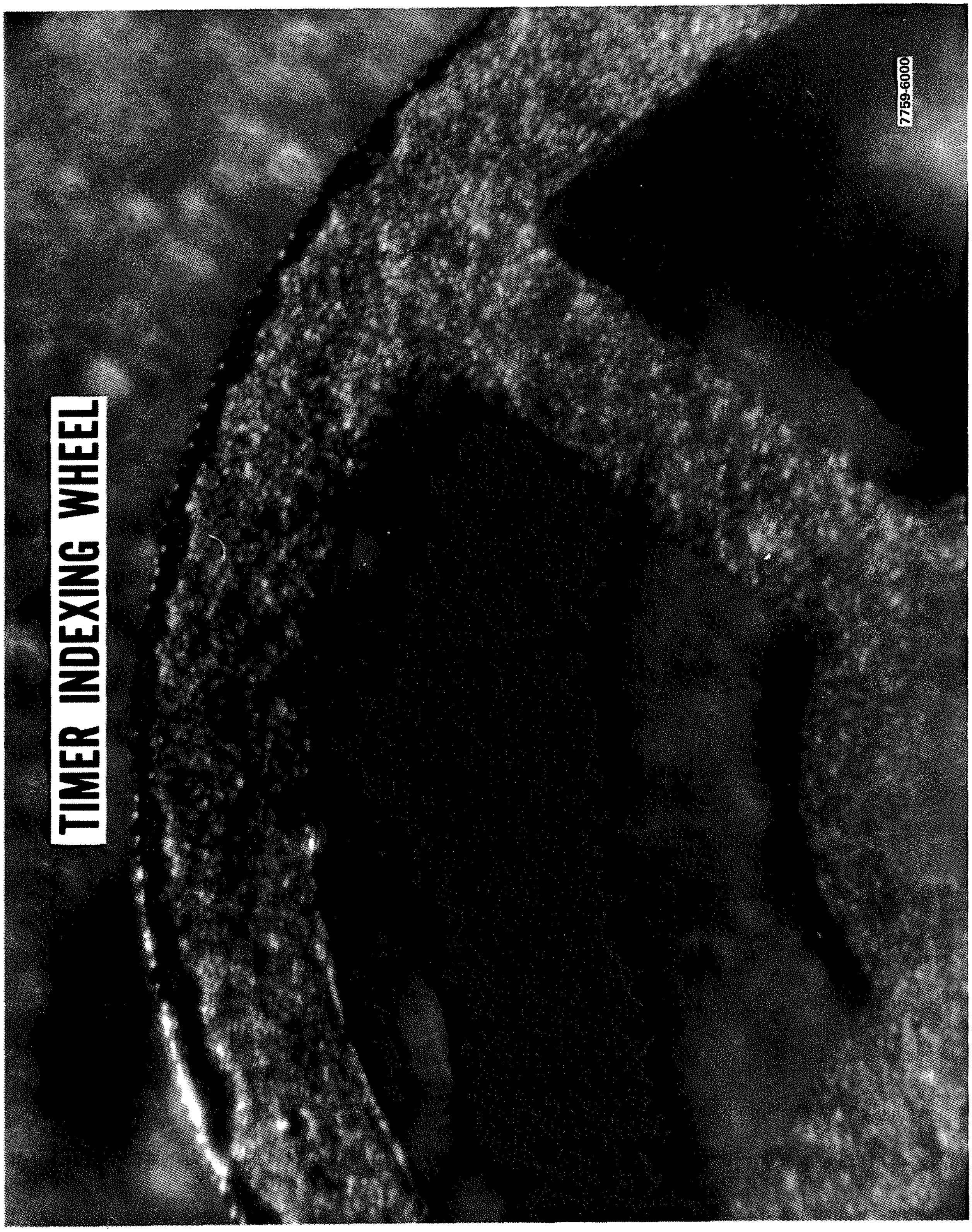
7759-6075

TIMER PROBLEM/TEST SUMMARY

DATE/SN	TEST	LUB	SYMPTOM/PROBLEM
9/68 E44046	T/V 36 DAYS -10 to +150°F	FS1265 IN JEWEL FS1281 on SPOKE	STOPPED THREE TIMES DURING TEST - ALL AT LOW TEMP. LIMIT.
PROBLEM/ CORRECTIVE ACTION ANALYSIS AT MAL/KSC REVEALED TEETH COATED WITH DEBRIS. ELECTRON MICROPROBE REVEALED THAT DEBRIS CONSISTED PRIMARILY OF SILICONE AND SULPHUR WITH BASE MATERIALS.			
12/68 56 MOVEMENTS VARIOUS MATERIALS	T/V SIMULATED HERMETIC SEAL	-CONVELEX-10 -FS1281 -KRYTOX -SPC. BULOVA GREASE	VARIOUS FAILURES - COMBINATION OF PALIMEY 7 WHEEL WITH KRYTOX LUB OPERATE WELL UNDER ALL CONDITIONS WITH ONLY SLIGHT WHEEL WEAR WHICH RESULTED FROM MISALIGNMENT OF JEWELS ON WHEEL TEETH.

7759-6076

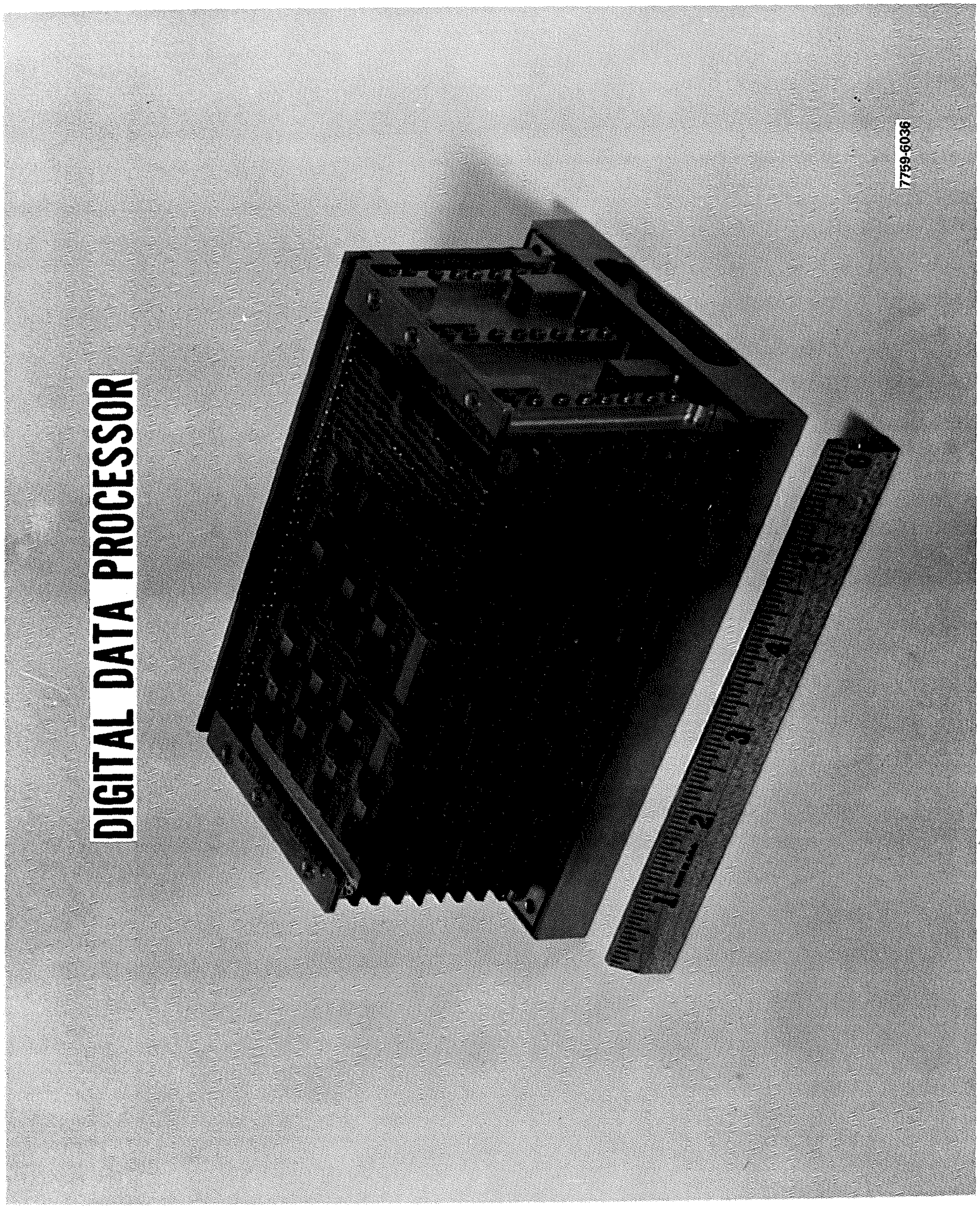

TIMER INDEXING JEWELS
7759-6001


TIMER INDEXING WHEEL
7759-6000

ALSEP TELEMETRY LINK

* DIGITAL DATA PROCESSOR (DDP)
  * MULTIPLEXER/CONVERTER
    * TRANSMITTERS (TWO)
      * DIPLEXER/SWITCH
        * ANTENNA

7759-6035


DIGITAL DATA PROCESSOR
7759-6036

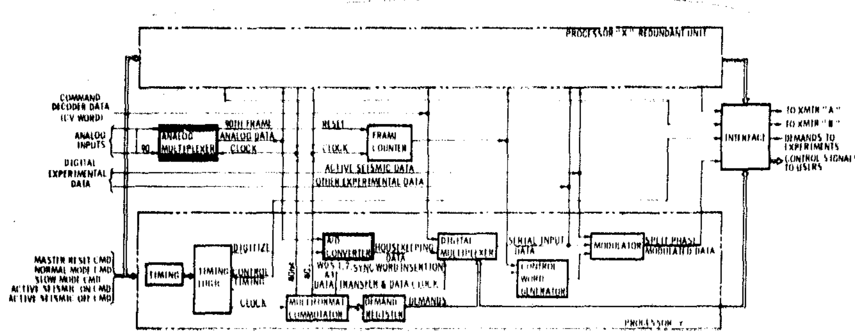
DIGITAL DATA PROCESSOR

THE DIGITAL DATA PROCESSOR -

* IS THE FOCAL POINT FOR THE COLLECTION, FORMATTING AND CONTROL OF ALL TELEMETERED DATA
* CONTAINS COMMAND SELECTABLE "X" AND "Y" SECTIONS. EXCEPT FOR THE FRAME COUNTER AND INTERFACE CIRCUITS, THE DDP IS FULLY REDUNDANT
* HAS 3 MODES OF OPERATION DEFINED AS "NORMAL" (1060b/s), "SLOW" (530b/s) AND ACTIVE SEISMIC (10,600b/s)
* USES A CRYSTAL OSCILLATOR TO DERIVE ALL TIMING AND CONTROL SIGNALS
* COLLECTS DATA INTO A 64 WORD FRAME REPEATING EACH 604 MILLISECONDS. EACH WORD CONSISTS OF 10 BITS OR ABOUT 9.43 MILLISECONDS (NORMAL MODE)
* PROCESSES COLLECTED DATA INTO THE REQUIRED TELEMETRY FORMAT IS SERIAL FORM. EACH DATA SOURCE IS SAMPLED AT LEAST ONCE PER FRAME

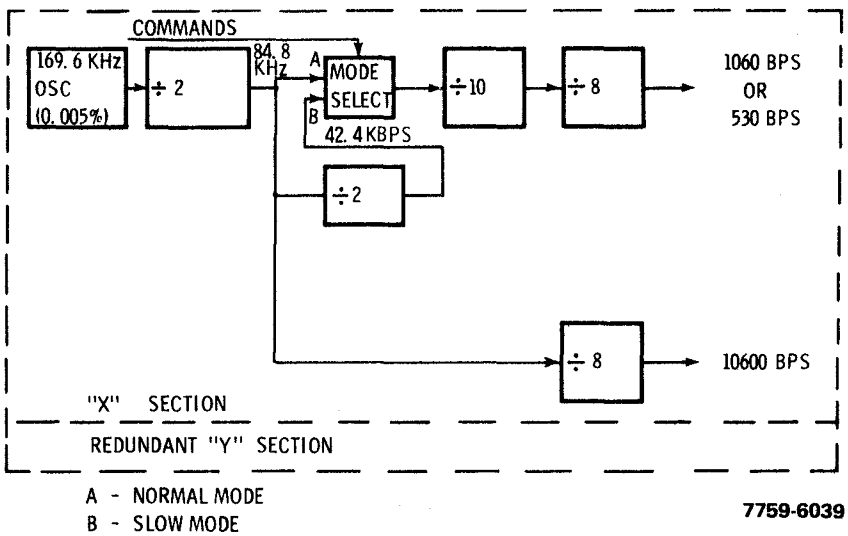
7759-6037

DATA PROCESSOR
SIMPLIFIED BLOCK DIAGRAM



7759-6038

GENERATION OF BASIC CLOCKS



7759-6039

DIGITAL DATA PROCESSOR

- CONTROL WORD GENERATOR
  - GENERATES THE 22-BIT SYNCHRONIZATION CODE
  - PROVIDES MODE, FRAME AND ALSEP ID IN THE LAST 8 BITS OF THE 30-BIT SYNCH WORD
- SPLIT PHASE MODULATOR
  - ENCODES DATA INTO INTO A "SPLIT PHASE" SIGNAL
  - PCM "0" IS REPRESENTED BY "01" AND CAUSES A POSITIVE PHASE TRANSITION
  - PCM "1" IS REPRESENTED BY A "10" AND CAUSES NEGATIVE PHASE TRANSITION
- FRAME COUNTER
  - IS NOT REDUNDANT
  - CONTAINS A COUNTER WHICH IS ADVANCED ONE STEP PER 64 WORD FRAME
  - IS RESET BY A 90TH FRAME "END OF FRAME" SIGNAL FROM THE MULTIPLEXER/CONVERTER

7759-6040

DIGITAL DATA PROCESSOR

- MULTIFORMAT COMMUTATOR
  - USES 2 DIVIDE BY 8 COUNTERS WITH GATING FOR ANY ONE OF 64 CONSECUTIVE PERIODS (WORDS).
  - PRODUCES SIGNALS OF ONE WORD LENGTH AND MULTIPLES OF ONE WORD LENGTH TO SELECT AND GATE DATA INTO A MODULATOR
  - CONTAINS A "PATCH PLANE" FOR FLEXIBLE WORD ASSIGNMENTS
- DEMAND REGISTER
  - ACTS AS A BUFFER BETWEEN THE DEMAND DECODER ASSEMBLY AND THE DEMAND LINES TO ELIMINATE GATING TRANSIENTS
  - ACTS AS A MASTER SWITCH TO INHIBIT ALL DEMANDS DURING ASE MODE

7759-6041-A

DIGITAL DATA PROCESSOR (CONT')

- DIGITAL MULTIPLEXER
  - CONTAINS A 10-BIT SHIFT REGISTER TO ACCEPT 8 PARALLEL BITS FROM THE A/D CONVERTER OR 8 SERIAL BITS FROM THE COMMAND DECODER.
  - SHIFTS OUT 10-BIT WORDS WITH "ZEROS" IN THE TWO MOST SIGNIFICANT FIGURES. BITS ARE SHIFTED HIGH ORDER FIRST.

7759-6041-B

FORMAT FLIGHT SYSTEM

1 x	2 x	3 x	4 X	5 0	6 X	7 S	8 X
9 -	10 X	11 -	12 X	13 -	14 X	15 I	16 X
17 0	18 X	19 0	20 X	21 0	22 X	23 S	24 X
25 -	26 X	27 -	28 X	29 -	30 X	31 I	32 X
33 H	34 X	35 •	36 X	37 •	38 X	39 S	40 X
41 -	42 X	43 -	44 X	45 -	46 CV	47 I	48 X
49 0	50 X	51 0	52 X	53 0	54 X	55 S	56 I
57 -	58 X	59 -	60 X	61 -	62 X	63 I	64 X

# OF WORDS PER FRAME	LEGEND	ASSIGNMENTS
3	x	CONTROL
29	- X	PASSIVE SEISMIC (SHORT PERIOD)
12	-	PASSIVE SEISMIC (LONG PERIOD SEISMIC)
2	•	PASSIVE SEISMIC (LONG PERIOD TIDAL + TEMP)
7	-0	MAGNETOMETER
4	S	SOLAR WIND
5	I	SUPRATHERMAL ION DETECTOR/CCGE
0	-HF	HEAT FLOW
0	CP	CHARGED-PARTICLE
1	CV	COMMAND VERIFICATION (ALL ZEROS IF NO COMMAND)
1	H	HOUSEKEEPING
	NA	NOT ASSIGNED (ALL ZEROS TRANSMITTED)
0	CG	COLD CATHODE GUAGE EXPERIMENT (MSC)

EACH BOX CONTAINS ONE 10 BIT WORD. TOTAL REPRESENTS ONE FRAME OR 640 BITS.

7759-6042

TELEMETRY FORMAT
FLEXIBLE WORD ASSIGNMENTS

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

WORDS MARKED WITH X ARE ASSIGNED BY DRAWING DURING FABRICATION OF THE DIGITAL DATA PROCESSOR'S MULTI-FORMAT COMMUTATOR.

7759-6043

FORMAT FLIGHT SYSTEM #3

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

# OF WORDS PER FRAME	LEGEND	ASSIGNMENTS
3	x	CONTROL
30	X	PASSIVE SEISMIC (SHORT PERIOD)
12	-	PASSIVE SEISMIC (LONG PERIOD SEISMIC)
2	•	PASSIVE SEISMIC (LONG PERIOD TIDAL + TEMP)
0	0	MAGNETOMETER
0	S	SOLAR WIND
0	I	SUPRATHERMAL ION DETECTOR/CCGE
1	HF	HEAT FLOW
6	CP	CHARGED PARTICLE
1	CV	COMMAND VERIFICATION (ALL ZEROS IF NO COMMAND)
1	H	HOUSEKEEPING
3	NA	NOT ASSIGNED (ALL ZEROS TRANSMITTED)
5	CG	COLD CATHODE GUAGE EXPERIMENT (MSC)

EACH BOX CONTAINS ONE 10 BIT WORD. TOTAL REPRESENTS ONE FRAME OR 640 BITS.

7759-6044

FORMAT FLIGHT SYSTEM #4

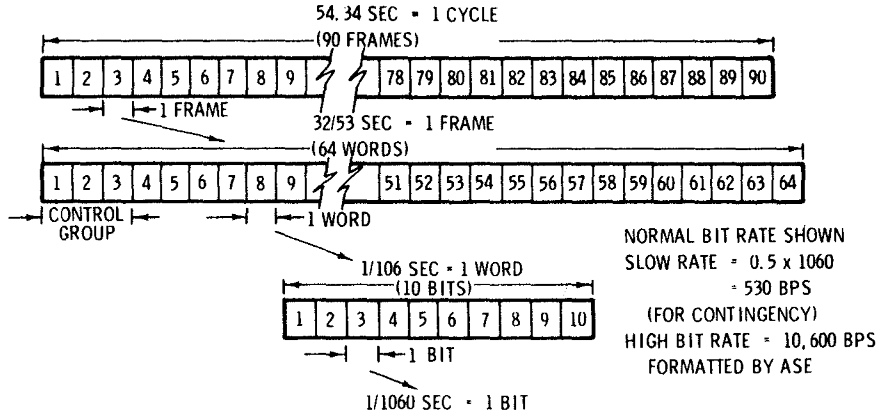
1 x	2 x	3 x	4 X	5 CV	6 X	7 CP	8 X
9 -	10 X	11 -	12 X	13 -	14 X	15 I	16 X
17 CP	18 X	19 CP	20 X	21 NA	22 X	23 CP	24 X
25 -	26 X	27 -	28 X	29 -	30 X	31 I	32 X
33 H	34 X	35 •	36 X	37 •	38 X	39 CP	40 X
41 -	42 X	43 -	44 X	45 -	46 X	47 I	48 X
49 NA	50 X	51 NA	52 X	53 NA	54 X	55 CP	56 I
57 -	58 X	59 -	60 X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

# OF WORDS PER FRAME	LEGEND	ASSIGNMENTS
3	x	CONTROL
30	X	PASSIVE SEISMIC (SHORT PERIOD)
12	-	PASSIVE SEISMIC (LONG PERIOD SEISMIC)
2	•	PASSIVE SEISMIC (LONG PERIOD TIDAL + TEMP)
0	0	MAGNETOMETER
0	S	SOLAR WIND
5	I	SUPRATHERMAL ION DETECTOR/CCGE
0	HF	HEAT FLOW
6	CP	CHARGED PARTICLE
1	CV	COMMAND VERIFICATION (ALL ZEROS IF NO COMMAND)
1	H	HOUSEKEEPING
4	NA	NOT ASSIGNED (ALL ZEROS TRANSMITTED)
0	CG	COLD CATHODE GUAGE EXPERIMENT (MSC)

EACH BOX CONTAINS ONE 10 BIT WORD. TOTAL REPRESENTS ONE FRAME OR 640 BITS.

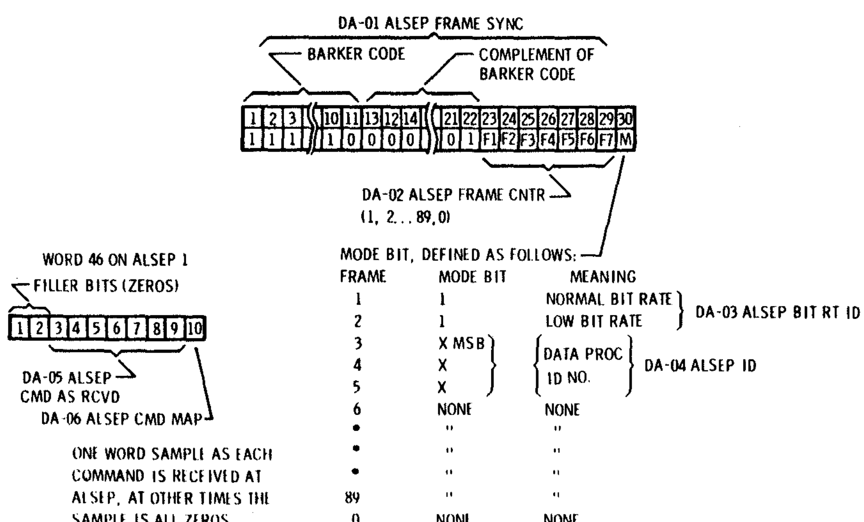
7759-6045

ALSEP DATA FORMAT



7759-6046

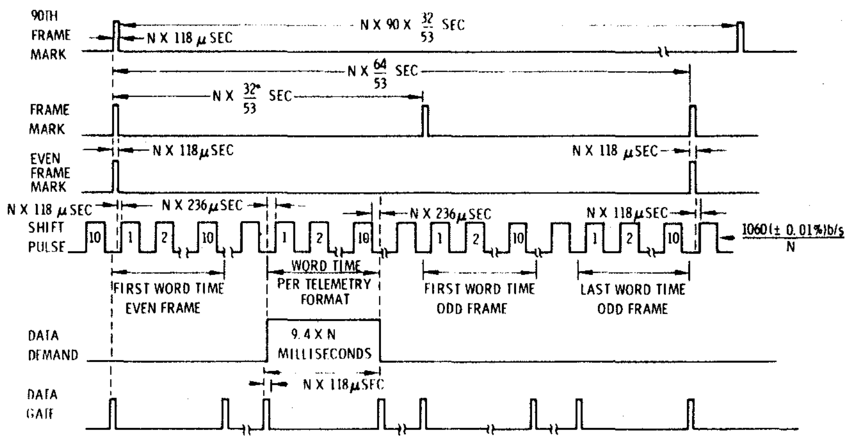
CONTROL WORDS AND CMD VERIFICATION



FRAME	MODE BIT	MEANING
1	1	NORMAL BIT RATE
2	1	LOW BIT RATE
3	X MSB	DATA PROC ID NO.
4	X	
5	X	
6	NONE	NONE
•	"	"
•	"	"
•	"	"
89	"	"
0	NONE	NONE

7759-6047

DATA PROCESSOR TIMING/CONTROL SIGNALS

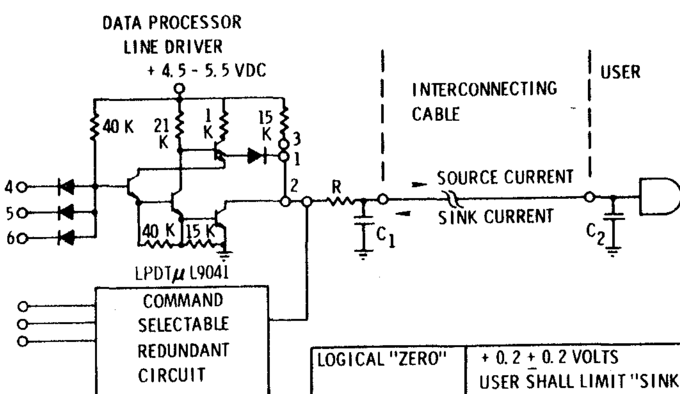


N = 1 FOR NORMAL MODE OF 1060 bps
N = 2 FOR SLOW MODE OF 530 bps
LOGIC LEVELS: "ONE", + 4.0 ± 1.5 VOLTS; "ZERO", + 0.2 ± 0.2 VOLTS

7759-6048

$^*\frac{32}{53}$ SEC = $\frac{640 \text{ BITS PER FRAME}}{1060 \text{ bps}}$ ALL OTHER TIMES ARE ACCURATE ONLY TO THE SIGNIFICANT FIGURE SHOWN.

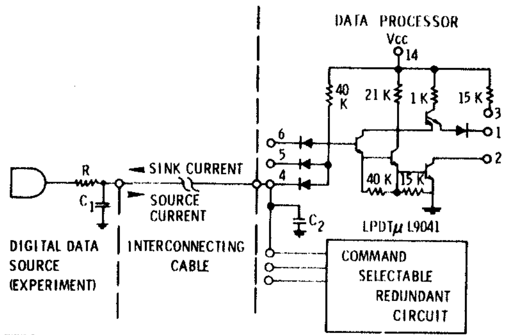
TIMING/CONTROL SIGNAL INTERFACE



LOGICAL "ZERO"	+ 0.2 ± 0.2 VOLTS USER SHALL LIMIT "SINK" CURRENT TO 0.75 ma OR LESS
LOGICAL "ONE"	+ 4.0 ± 1.5 VOLTS USER SHALL LIMIT "SOURCE" CURRENT TO 0.045 ma OR LESS
R, C_1 & C_2	CONTROL RISE AND FALL TIME

7759-6049

EXPERIMENT/DATA PROCESSOR INTERFACE
DIGITAL DATA



LOGICAL "ZERO"	+ 0.2 + 0.2 VOLTS THE SOURCE LINE DRIVER MUST BE CAPABLE OF "SINKING" UP TO 0.215 ma
LOGICAL "ONE"	+ 4.0 + 1.5 VOLTS THE SOURCE LINE DRIVER MUST BE CAPABLE OF "SOURCING" UP TO 0.012 ma
R, C1, & C2	CONTROL RISE AND FALL TIME

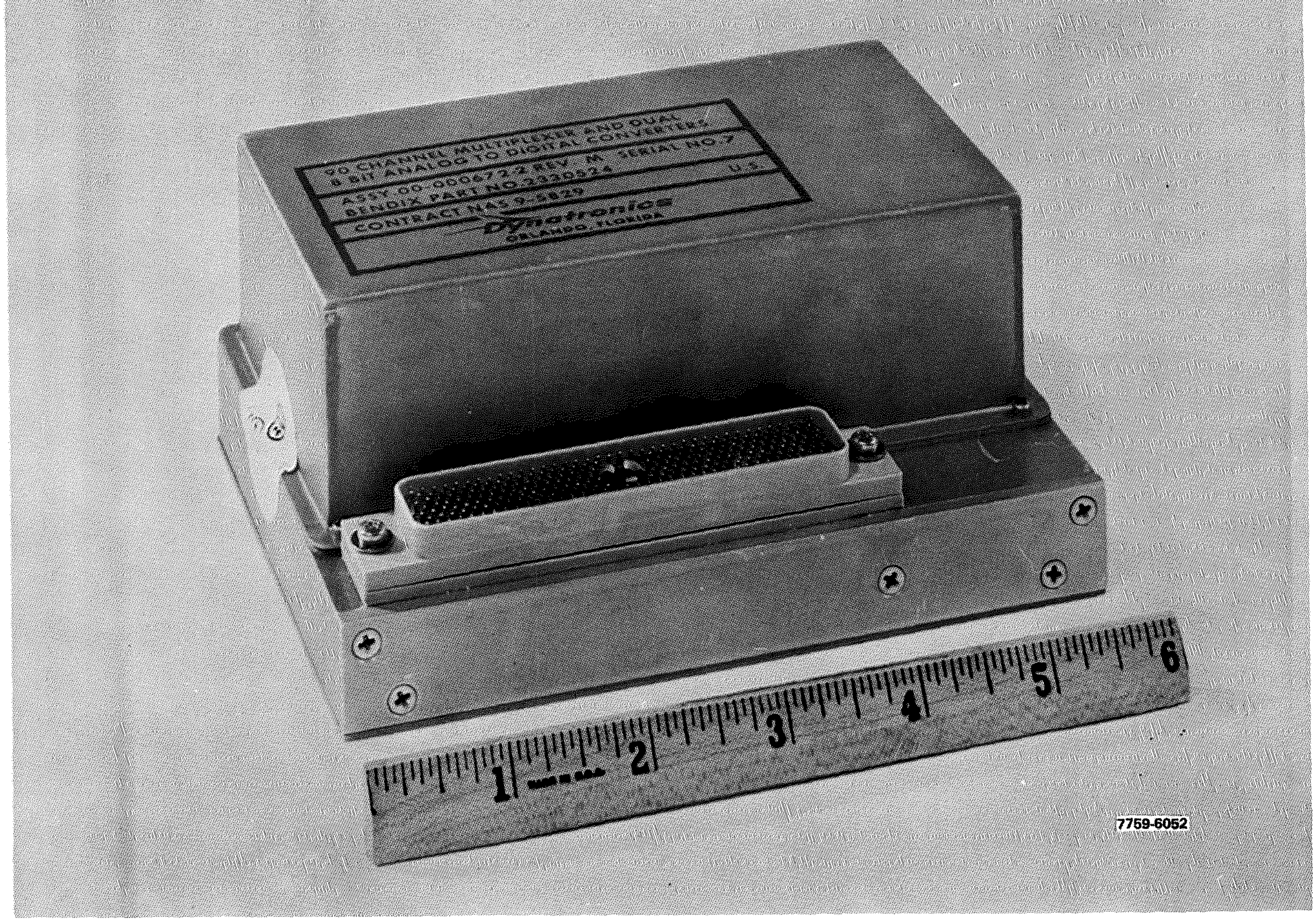
7759-6050

DIGITAL DATA PROCESSOR
TELEMETRY SUMMARY

CHANNEL 2	AE-01	0.25 VDC CALIBRATION OF ADC A ZENER DIODE AND RESISTIVE DIVIDER IS USED TO PROVIDE AN ACCURATE REFERENCE VOLTAGE FOR TM CHANNEL CALIBRATION
CHANNEL 3	AE-02	4.75 VDC CALIBRATION OF ADC THIS VOLTAGE IS OBTAINED FROM THE SAME NETWORK AS THE 0.25 VDC AND PROVIDES A SECOND CALIBRATION POINT
CHANNEL 46	AT-29	DIGITAL DP, BASE TEMPERATURE USES A THERMISTOR LOCATED ON THE BASE PLATE
CHANNEL 47	AT-30	DIGITAL DP, INTERNAL TEMPERATURE USES A THERMISTOR LOCATED ON ONE OF THE PRINTED CIRCUIT BOARDS

7759-6051

ANALOG MULTIPLEXER CONVERTER



ANALOG MULTIPLEXER/CONVERTER
PHYSICAL DESCRIPTION

SIZE	2.62 x 4.23 x 5.92 inches	
WEIGHT	2.2 pounds	
POWER	REQUIRES A TOTAL OF 1435 MILLIWATTS (NOMINAL AT ROOM AMBIENT) AT THE FOLLOWING VOLTAGE LEVELS-	
	65 milliwatts at + 15 vdc	
	150 milliwatts at + 12 vdc	
	1100 milliwatts at + 5 vdc	
	120 milliwatts at - 12 vdc	
PARTS COUNT	INTEGRATED CIRCUITS	76
	FIELD EFFECT TRANSISTORS	156
	TRANSISTORS	185
	DIODES	307
	ZENER DIODES	9
	CAPACITORS	158
	RESISTORS	102
	CRYSTALS	2
PACKAGING	ALL PARTS ARE MOUNTED ON 15 TWO LAYER PCBs	
CONNECTOR	HUGHES - 244 PIN	

7759-6053

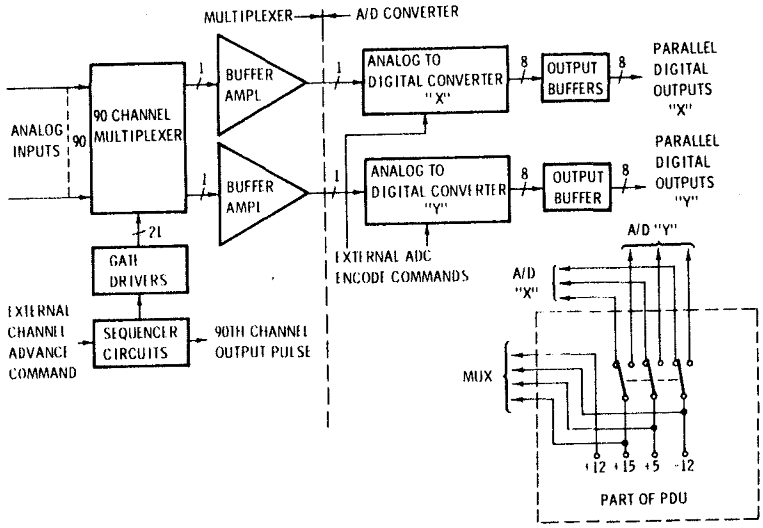
ANALOG MULTIPLEXER/CONVERTER

THE COMPONENT -

- CONSISTS OF A 90 CHANNEL ANALOG MULTIPLEXER, A SEQUENCER, BUFFER AMPLIFIERS AND TWO EIGHT-BIT A/D CONVERTERS WITH BUFFERED OUTPUTS
- USES REDUNDANT GATES, DRIVERS AND A/D CONVERTERS FOR RELIABLE OPERATION
- MONITORS UP TO 90 DATA SOURCES ON A SEQUENTIAL SAMPLE BASIS. REQUIRES ABOUT 54 SECONDS FOR ONE COMPLETE SEQUENCE OF SAMPLES
- CONVERTS EACH INPUT INTO AN 8-BIT BINARY WORD
- PROVIDES THE 8-BIT BINARY WORD IN PARALLEL TO THE DIGITAL MULTIPLEXER OF THE DDP

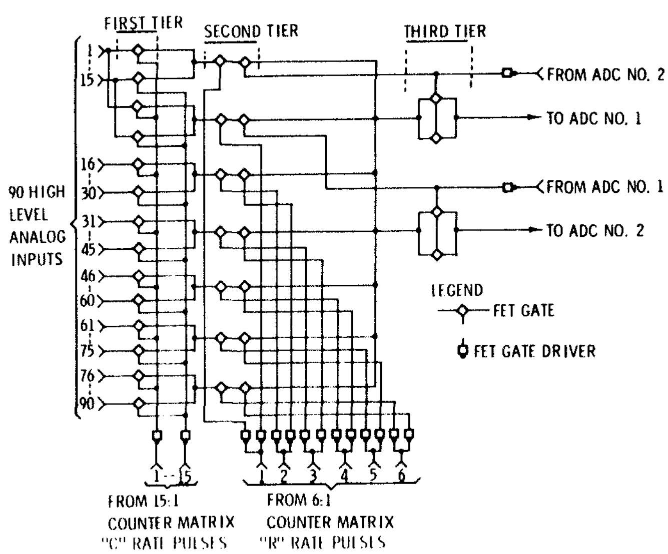
7759-6054

SIMPLIFIED BLOCK DIAGRAM



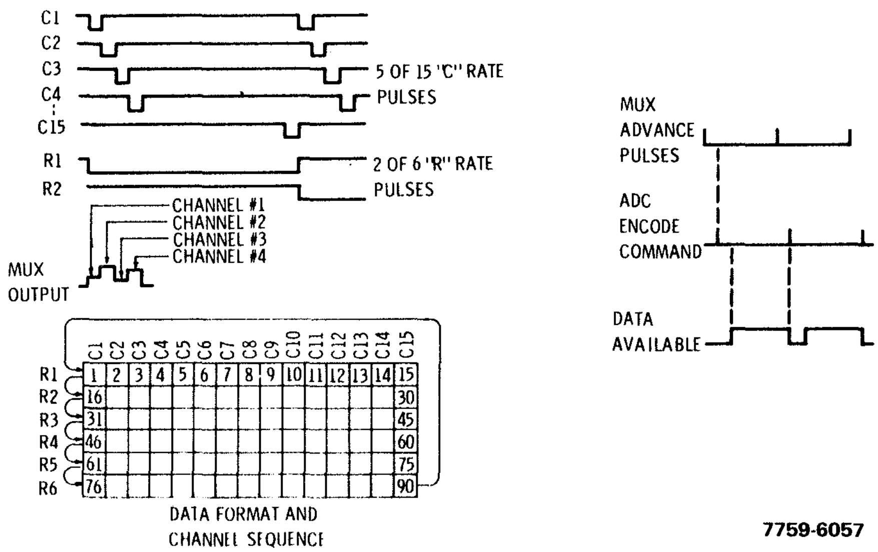
7759-6055

MULTIPLEXER GATE ARRANGEMENT DIAGRAM



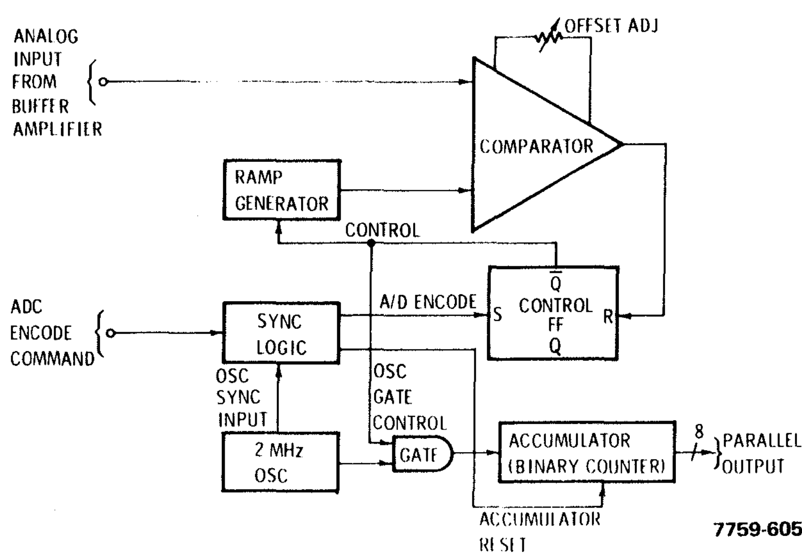
7759-6056

MULTIPLEXER TIMING DIAGRAM



7759-6057

A/D CONVERTER FUNCTIONAL BLOCK DIAGRAM



7759-6058

INPUT REQUIREMENTS

ANALOG INPUTS

RANGE 0 TO +5 volts

INPUT Z $\geq$ 1 megohm (ON state)

$\geq$50 megohms (OFF state)

SOURCE Z $\leq$ 10 k ohms

*PROPER OPERATION WITH AN OVERVOLTAGE OF

+8 to -6.5 volts for channels 21, 36, 45, & 80

+8 to -9 volts for channels 6, 7, 26, 52, 67, & 70

+8 to -5 volts for all other channels

IS NOT DAMAGED BY AN OVERVOLTAGE OF ± 12 VOLTS ON ANY CHANNEL.

ADVANCE PULSE

REQUIRED FOR ADVANCING MULTIPLEXER THROUGH ITS 90 CHANNELS. SUPPLIED BY DDP

ADC START (ENCODE) PULSE

DRIVES SYNC LOGIC TO START A/D CONVERSION. SUPPLIED BY DDP

*PROPER OPERATION IS NOT GUARANTEED BEYOND PLUS AND MINUS OPERATIONAL LIMITS

7759-6059

ANALOG MULTIPLEXER/CONVERTER OUTPUTS

BINARY OUTPUT

00000000	FOR A NEGATIVE INPUT
00000001	FOR ZERO INPUT
11111110	FOR +5 VOLTS INPUT
11111111	FOR GREATER THAN +5 VOLTS INPUT

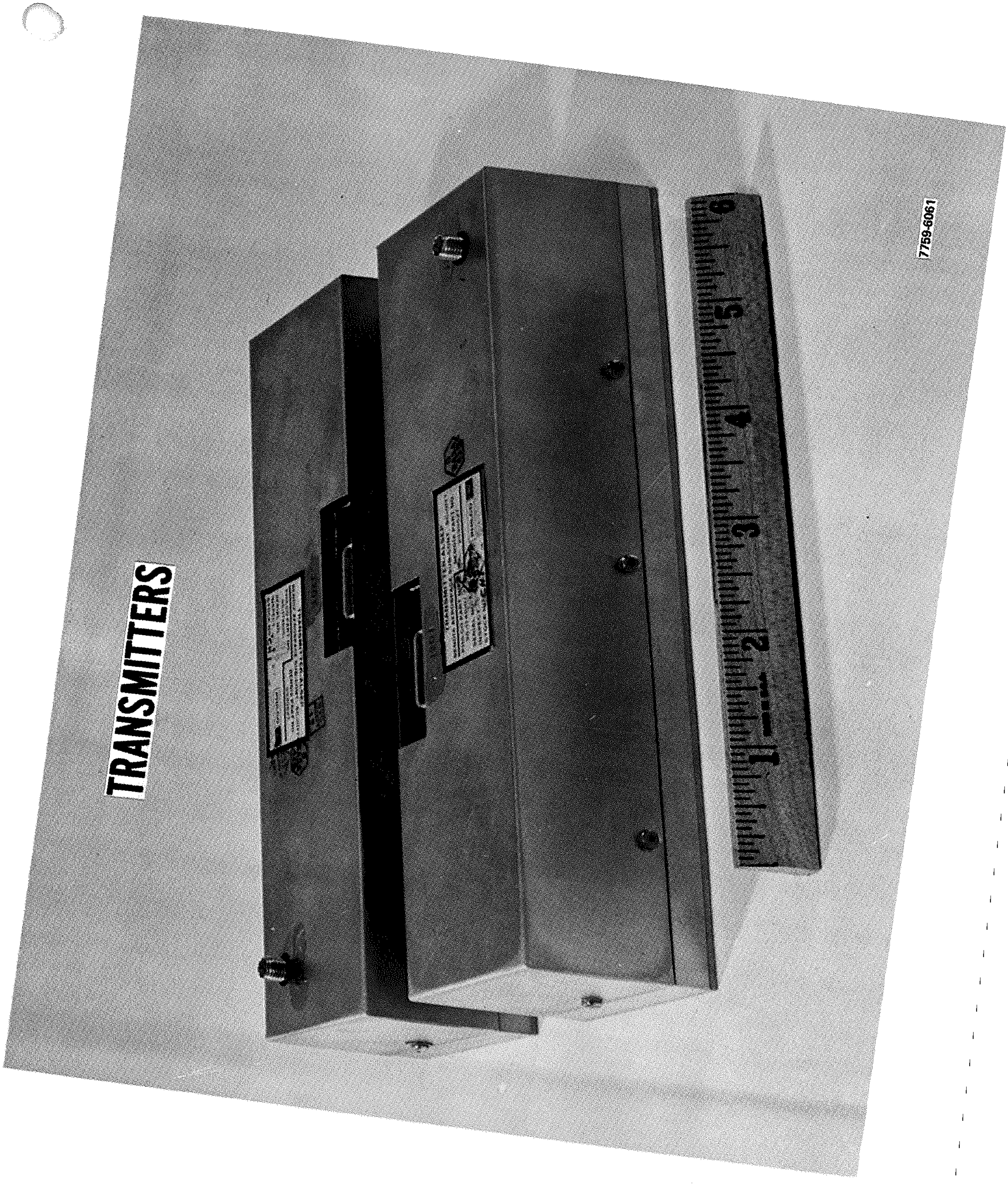
LOGICAL "0" IS +4.0 ± 1.5 VOLTS

LOGICAL "1" IS +0.2 ± 0.2 VOLTS

TEMPERATURE TELEMETRY

CHANNEL 33	AT-27	BASE TEMP (SIGNAL OBTAINED BY A THERMISTOR/ RESISTOR NETWORK POWERED BY +12 VDC THERMISTOR LOCATED ON BASE PLATE)
CHANNEL 34	AT-28	INTERNAL TEMP (SAME AS ABOVE EXCEPT THERMISTOR MOUNTED ON PCB)

7759-6060


TRANSMITTERS
7759-6061

TRANSMITTER

PHYSICAL DESCRIPTION

- SIZE 1.5 x 2 x 7.5 inches
- WEIGHT 1.17 pounds (each)
- POWER 8 watts at 29 VDC
  0.5 watts at 12 VDC
- EMPLOYS MODULAR CONSTRUCTION WITH 11 SEPARATE CIRCUIT MODULES
- MODULES ARE MOUNTED ON A MILLED MAGNESIUM BASE PLATE WITH INTER-MODULE WIRING THROUGH MILLED PASSAGEWAYS

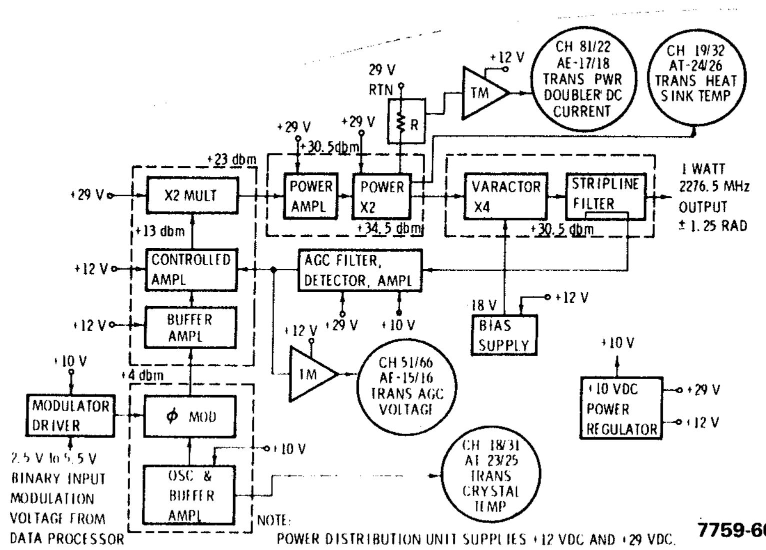
7759-6062

TRANSMITTER

* PROVIDES A MINIMUM OF 1 WATT INTO A 50 OHM LOAD WITH A MAXIMUM VSWR OF 1.3:1
* PROPER CRYSTAL IS INSTALLED DURING MANUFACTURE FOR OPERATION ON EITHER 2276.5 MHz (CHANNEL #1), 2278.5 MHz (CHANNEL #2) OR 2275.5 MHz (CHANNEL #3). 2279.5 MHz (CHANNEL #4) IS ASSIGNED BUT NOT IMPLEMENTED
* FREQUENCY STABILITY IS 0.0025%/YEAR
* TWO IDENTICAL COMPONENTS, TRANS A AND TRANS B, ARE PROVIDED WITH ONE IN STANDBY
* EITHER A OR B MAY BE SELECTED BY COMMAND FROM THE MSFN
* IF ONE IS SWITCHED "OFF" DUE TO AN OVERCURRENT CONDITION, THE OTHER IS AUTOMATICALLY SWITCHED "ON"
* IF COMMANDED "OFF" A RESISTOR (HEATER) IS AUTOMATICALLY SWITCHED ON FOR CENT STA THERMAL STABILITY

7759-6063

TRANSMITTER, BLOCK DIAGRAM

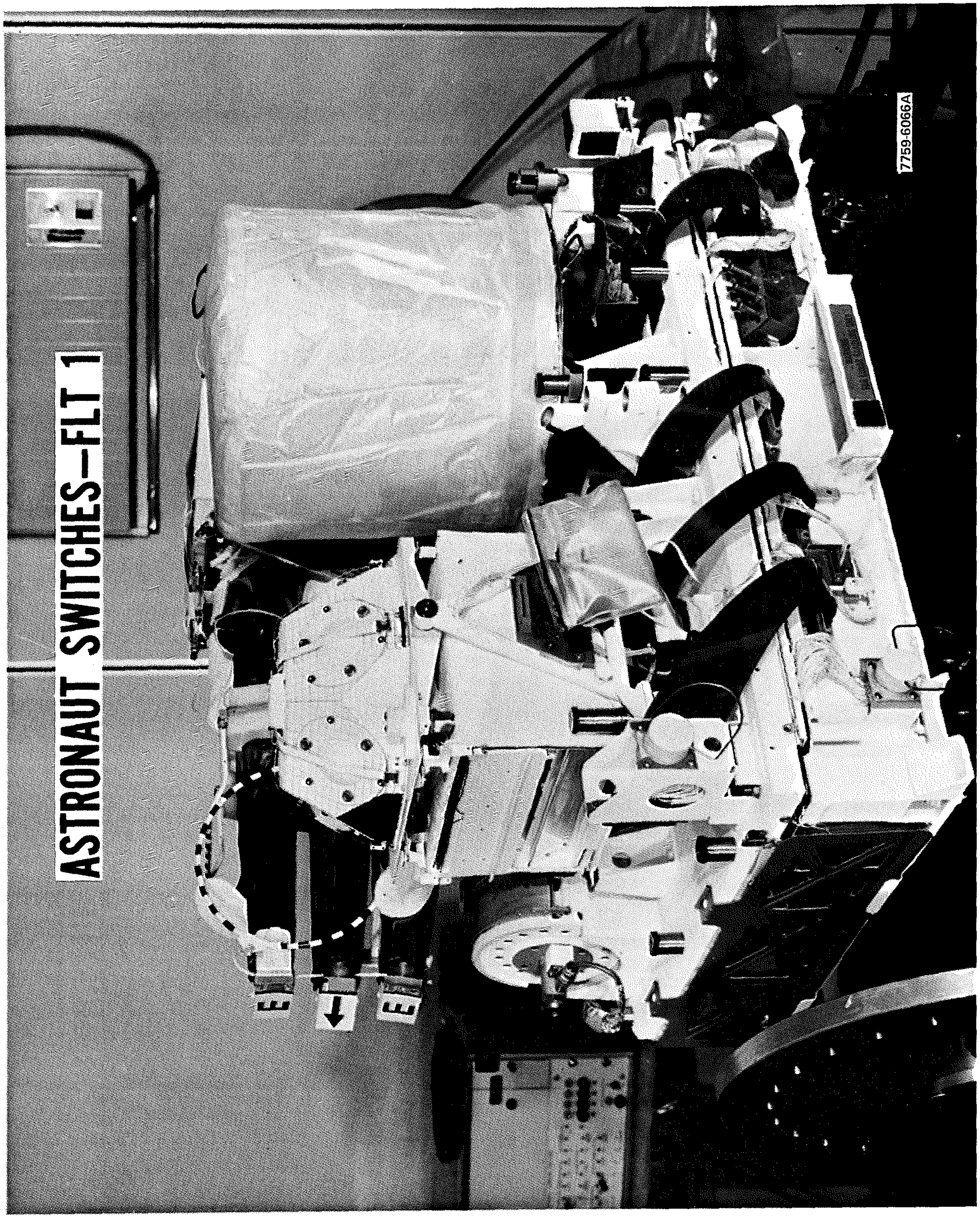


7759-6064

TRANSMITTER TELEMETRY SUMMARY

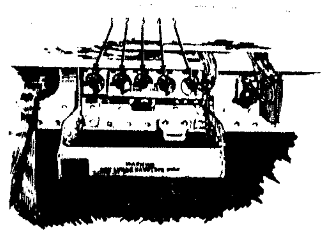
TRANSMITTER A		TELEMETRY DATA	TRANSMITTER B	
CHANNEL	SYMBOL		CHANNEL	SYMBOL
18	AT-23	TRANSMITTER CRYSTAL TEMP USES A 15 K OHM THERMISTOR AND 2 RESISTORS TO DEVELOP SIGNAL. PARTS ARE LOCATED IN OSC -BUFFER-MODULATOR MODULE	31	AT-25
19	AT-24	TRANSMITTER HEAT SINK TEMP USES A 15 K OHM THERMISTOR AND 2 RESISTORS TO DEVELOP SIGNAL. LOCATED IN POWER DOUBLER	32	AT-26
51	AE-51	TRANS AGC VOLTAGE AGC VOLTAGE IS AMPLIFIED TO GIVE TM SIGNAL OF PROPER LEVEL	66	AE-16
81	AE-17	TRANS PWR DOUBLER DC CURRENT SIGNAL OBTAINED FROM SMALL RESISTOR IN POWER RETURN	22	AE-18

7759-6065


ASTRONAUT SWITCHES—FLT 1
7759-6066A


ASTRONAUT SWITCHES—FLT 4
- WARNING -
FOR LUNAR HANDLING ONLY
7759-6066B

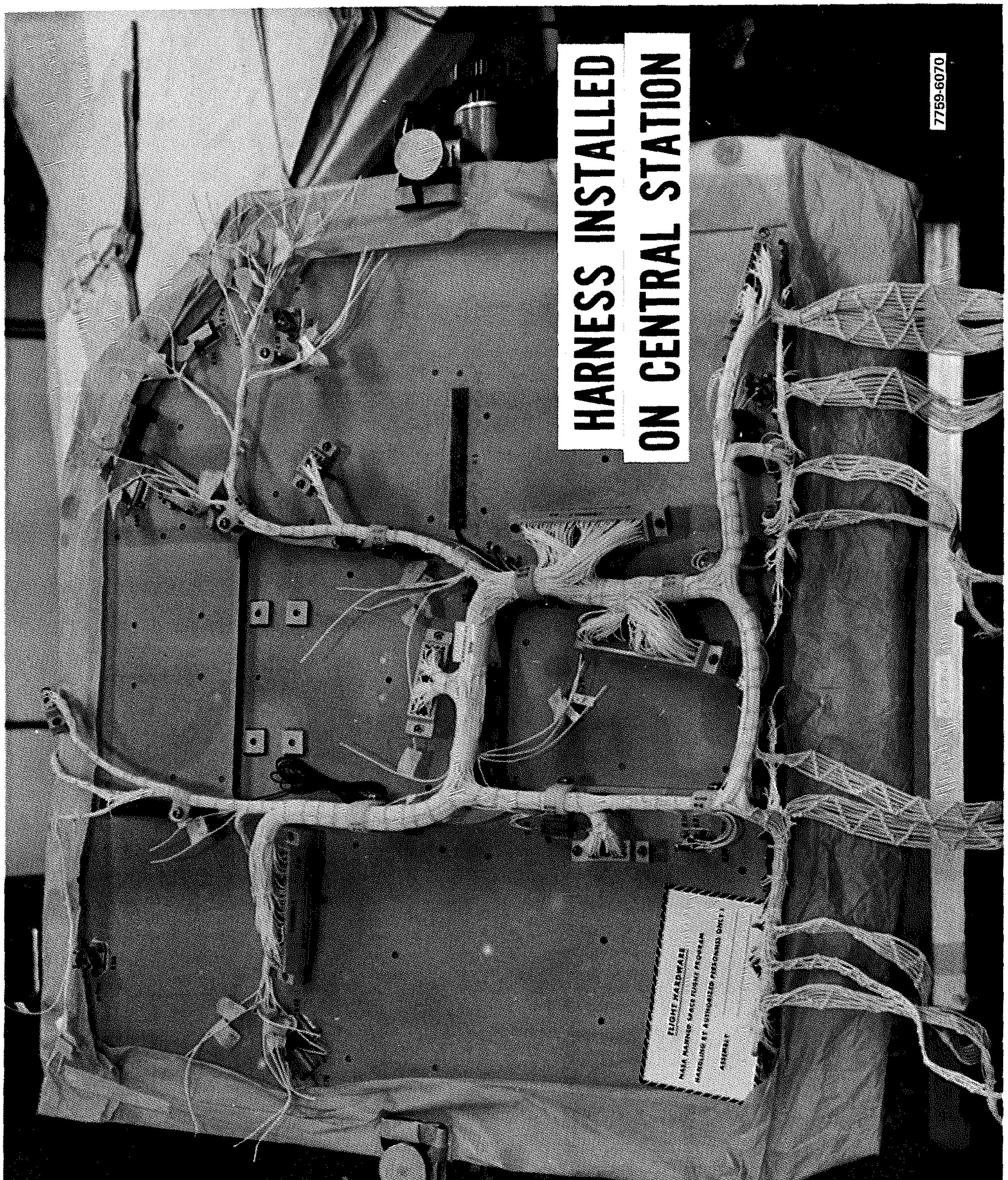
ASTRONAUT SWITCHES



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" • RESET RCVR CKT BKR
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)	ACTIVATED DURING DEPLOYMENT • 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 CCW 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.

7759-6067

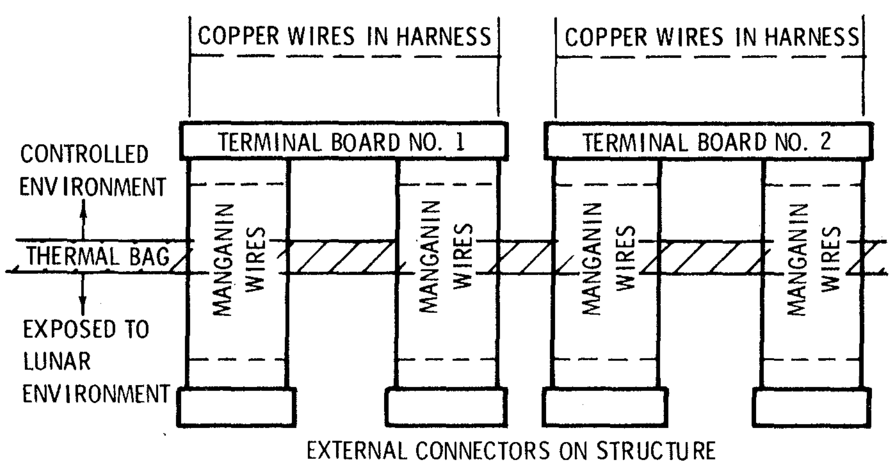

HARNESS INSTALLED
ON CENTRAL STATION
7759-6070

WIRE HARNESS

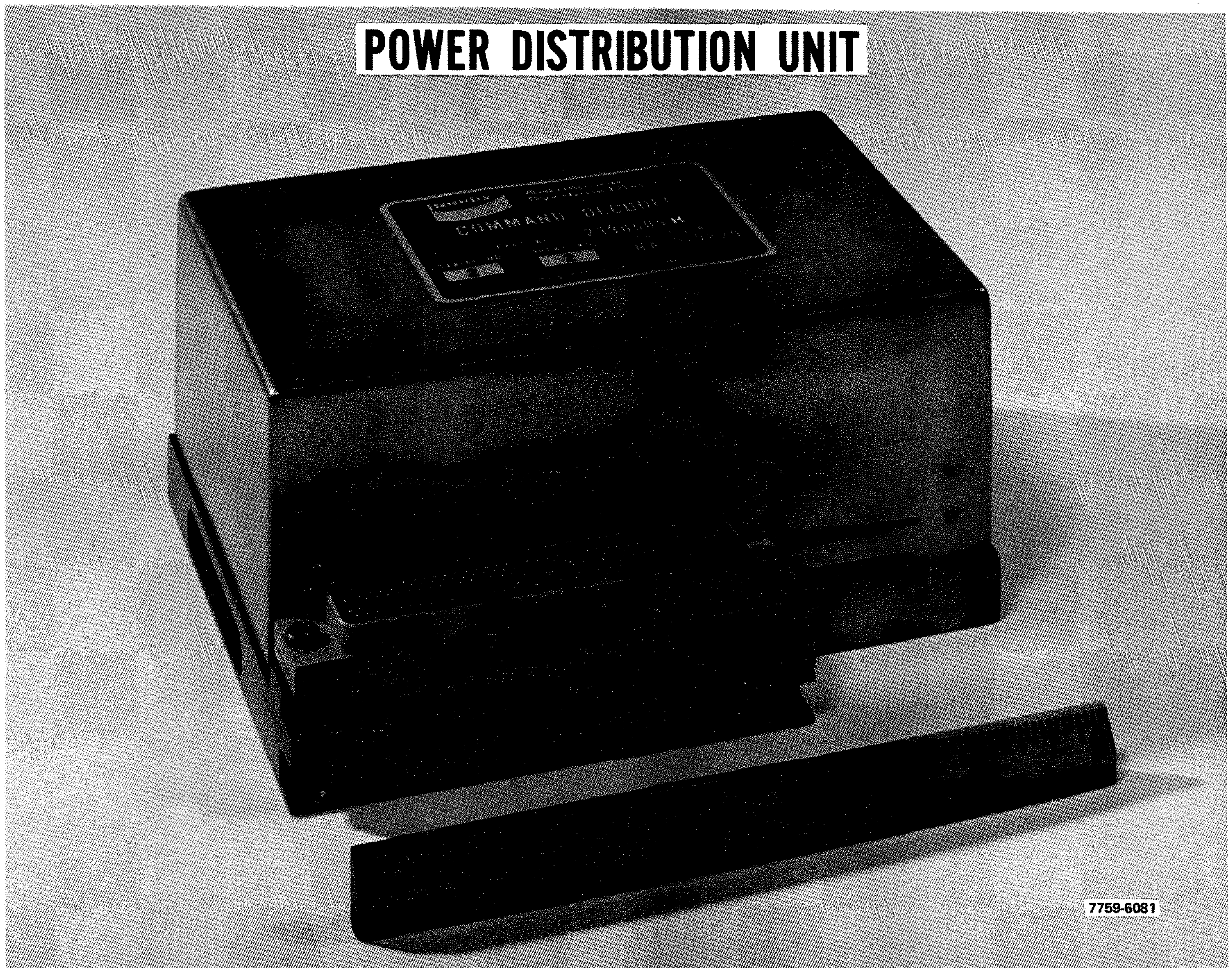
- ALL COMPONENTS ARE INTERCONNECTED WITH A PRE-FORMED WIRE HARNESS WHICH PROVIDES THE PROPER MATING PLUGS
- WITHIN THE THERMALLY CONTROLLED AREA, AWG# 24 SINGLE CONDUCTOR, STRANDED, COPPER WIRE IS USED
- TWO PRINTED CIRCUIT TERMINAL BOARDS ARE USED TO PERMIT TRANSITION FROM COPPER TO MANGANIN FOR WIRES WHICH MUST GO OUTSIDE THE THERMALLY CONTROLLED AREA
- TO REDUCE THERMAL CONDUCTION, MANGANIN WIRE, WHICH HAS A THERMAL CONDUCTIVITY ABOUT 1/17 THAT OF COPPER, IS USED BETWEEN THE PC TERMINAL BOARDS AND EXTERNAL INTERFACES (CONNECTORS). BECAUSE OF THE HIGH CURRENT, + AND - WIRES TO THE RTG CONNECTOR ARE COPPER
- CONNECTORS USED ARE MADE BY HUGHES, SCHJELDAHL, DEUSTCH AND MICRODOT

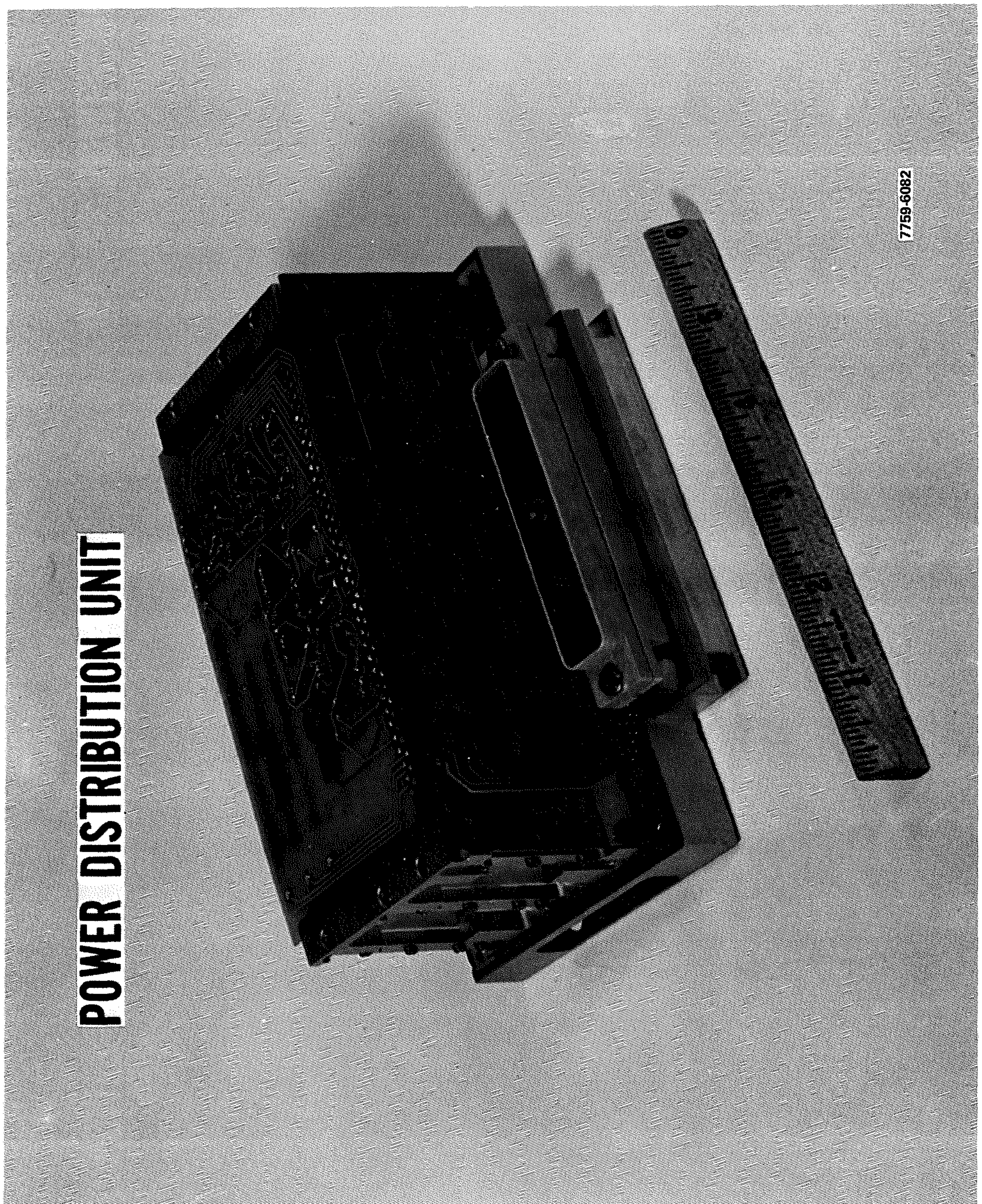
7759-6068

HARNESS TO EXTERNAL CONNECTORS



7759-6069


POWER DISTRIBUTION UNIT
COMMAND
7759-6081


POWER DISTRIBUTION UNIT
7759-6082

POWER DISTRIBUTION UNIT

THE PDU -

- PROVIDES FOR THE DISTRIBUTION AND CONTROL OF POWER TO EXPERIMENTS AND CENT STA COMPONENTS
- CONTAINS CIRCUITRY TO PROTECT THE SYSTEM AGAINST OVER-LOADS OCCURING FROM COMPONENT FAILURES
- PROVIDES SIGNAL CONDITIONING FOR CENT STA AND POWER SUBSYSTEM TELEMETRY SIGNALS
- WILL, BY SEQUENTIAL TURN-OFF OF 3 EXPERIMENTS, ADJUST THE TOTAL POWER DEMAND TO A VALUE WITHIN THE AVAILABLE POWER LIMIT
- UPON SENSING A POWER OVERLOAD CONDITION, WAITS ABOUT 135 MILLISECONDS BEFORE SWITCHING AN EXPERIMENT TO STANDBY
- PROVIDES MOUNTING SPACE FOR THE "DUST DETECTOR" ELECTRONICS

7759-6083

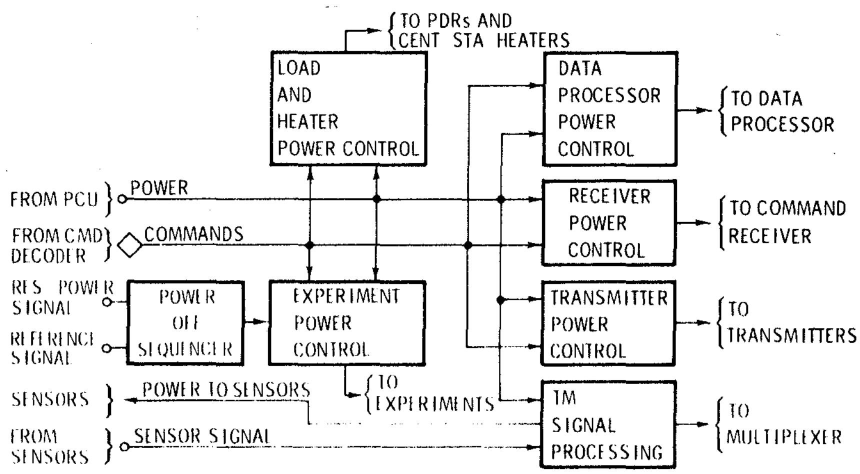
POWER DISTRIBUTION UNIT

PHYSICAL DESCRIPTION OF THE PDU

* SIZE 2.8 x 4 x 7.25 inches
* WEIGHT 2.29 pounds
* POWER 375 milliwatts at +29 VDC
  75 milliwatts at +15 VDC
  735 milliwatts at +12 VDC
  85 milliwatts at + 5 VDC
  8 milliwatts at - 6 VDC
  475 milliwatts at -12 VDC
* PARTS COUNT - 17 FLATPACKS, 238 RESISTORS
  37 TRANSISTORS, 44 CAPACITORS
  11 AMPLIFIERS, 7 FUSES
  98 DIODES, 2 THERMISTORS
  27 RELAYS
* PACKAGING - ALL PARTS ARE MOUNTED ON 5 PCBs
* CONNECTOR - HUGHES - 244 PIN

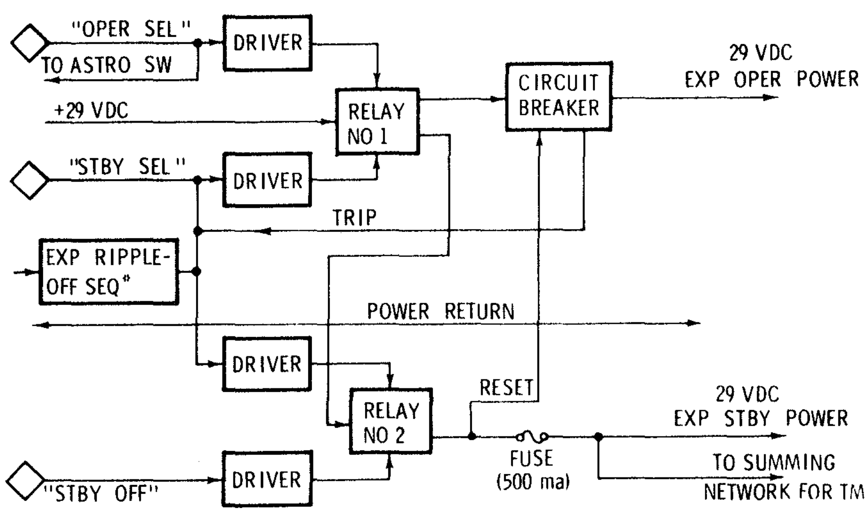
7759-6084

SIMPLIFIED BLOCK DIAGRAM PDU



7759-6085

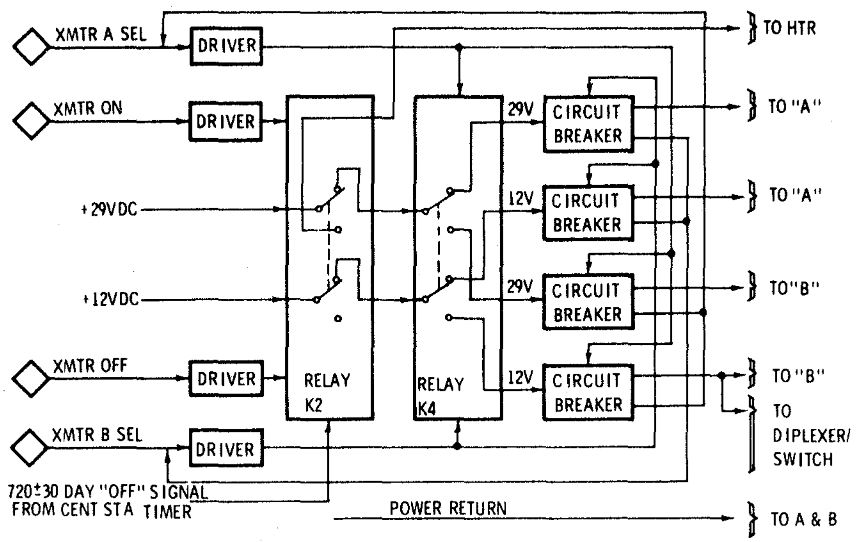
EXPERIMENT POWER CONTROL (1 OF 4)



*NOTE: RIPPLE-OFF SEQ USED ON 1, 3 & 4 ONLY

7759-6086

TRANSMITTER POWER CONTROL

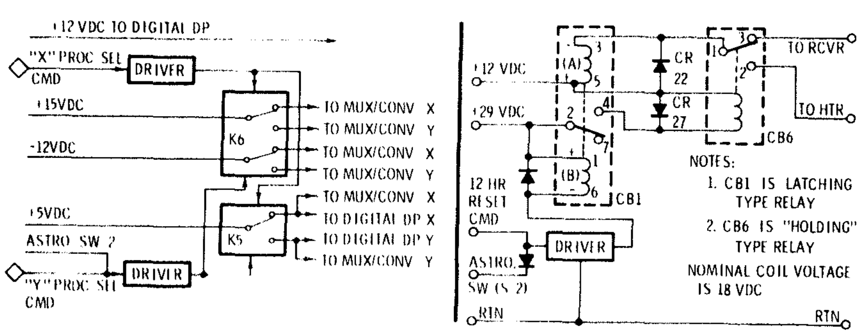


7759-6087

DATA PROCESSOR & CMD RCVR PWR CONTROL CKTS

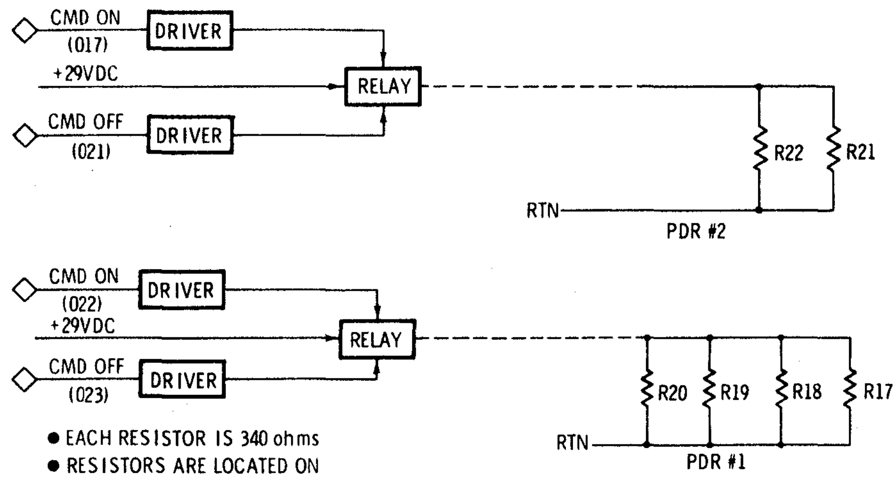
DATA PROCESSOR

COMMAND RECEIVER



7759-6088

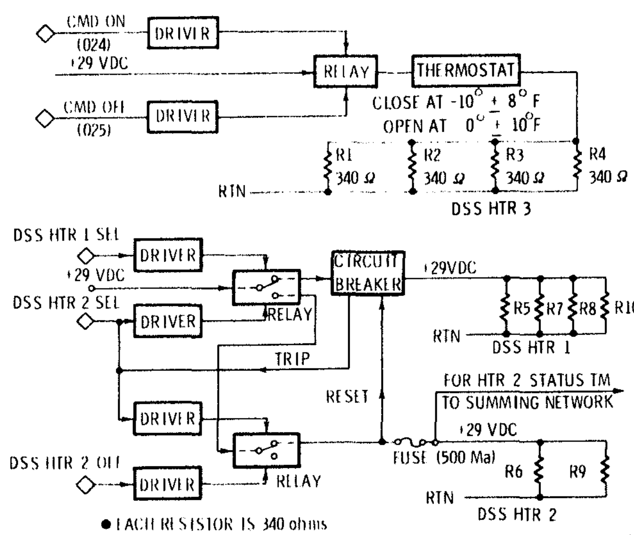
SWITCHING FOR POWER DUMP RESISTORS



- EACH RESISTOR IS 340 ohms
- RESISTORS ARE LOCATED ON EXTERIOR OF CENTRAL STATION

7759-6089

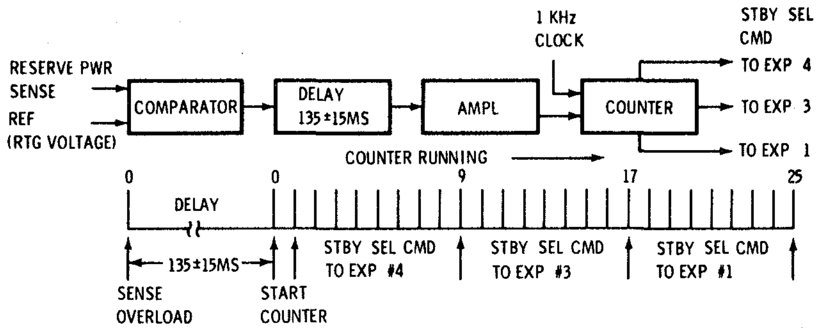
SWITCHING FOR CENTRAL STA HEATERS



- EACH RESISTOR IS 340 ohms
- RESISTORS ARE MOUNTED ON THERMAL PLATE

7759-6090

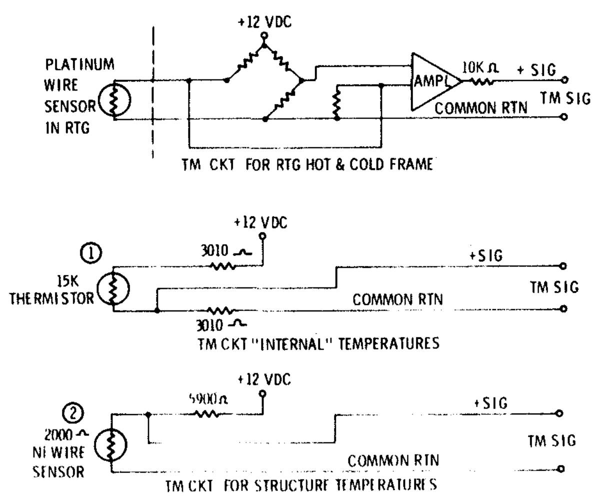
EXPERIMENT RIPPLE-OFF SEQUENCE



- _IF OVERLOAD CONDITION EXISTS FOR 135 ±15MS, THEN FROM COUNT 1 to COUNT 9 A "STBY SEL" CMD IS ISSUED TO EXP #4.
- AFTER 9MS, IF OVERLOAD STILL EXISTS, A "STBY SEL" CMD IS ISSUED TO EXP #3 FROM COUNT 9 TO COUNT 17.
- IF OVERLOAD STILL EXISTS, A "STBY SEL" CMD IS ISSUED TO EXP #1 FROM COUNT 17 TO COUNT 25.
- WHEN OVERLOAD IS CLEARED THE COUNTER IS RESET AND FURTHER EXPERIMENT SWITCHING IS INHIBITED.

7759-6091

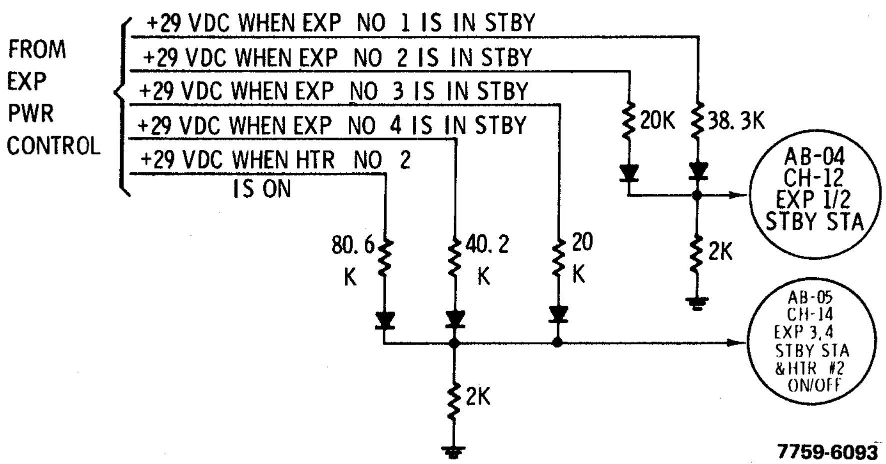
PDU TELEMETRY CIRCUITS



① FENWAL ISO CURVE THERMISTOR 15K OHMS
② TYLAN FG-108 NICKEL WIRE SENSOR 2000 OHMS

7759-6092

EXP PWR MODE TM



7759-6093

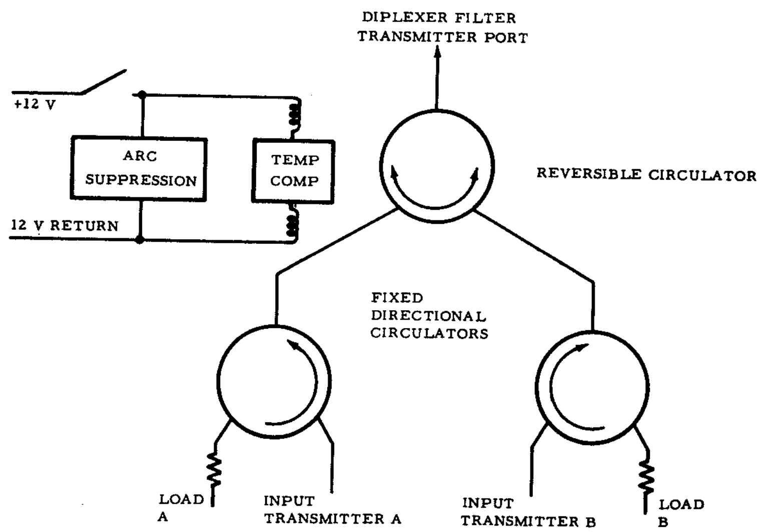
CENTRAL STATION TEMPERATURE MEASUREMENTS

TEMPERATURE MEASUREMENT	NUMBER OF POINTS	RANGE	ACCURACY
RTG HOT FRAME	3	950° TO 1150°F	±5°F
RTG COLD FRAME	3	400° TO 600°F	±5°F
EXTERNAL STRUCTURE TEMP.	7	-300° TO +200°F	±15°F
INTERNAL STRUCTURE TEMP.	6	-50° TO +200°F	±10°
C/S COMPONENT TEMP.	19	-50° TO +200°F	±10°F

7759-6094


DIPLEXER SWITCH
7759-6097
DIPLEXER SWITCH

DATA SUBSYSTEM DIPLEXER SWITCH DIAGRAM

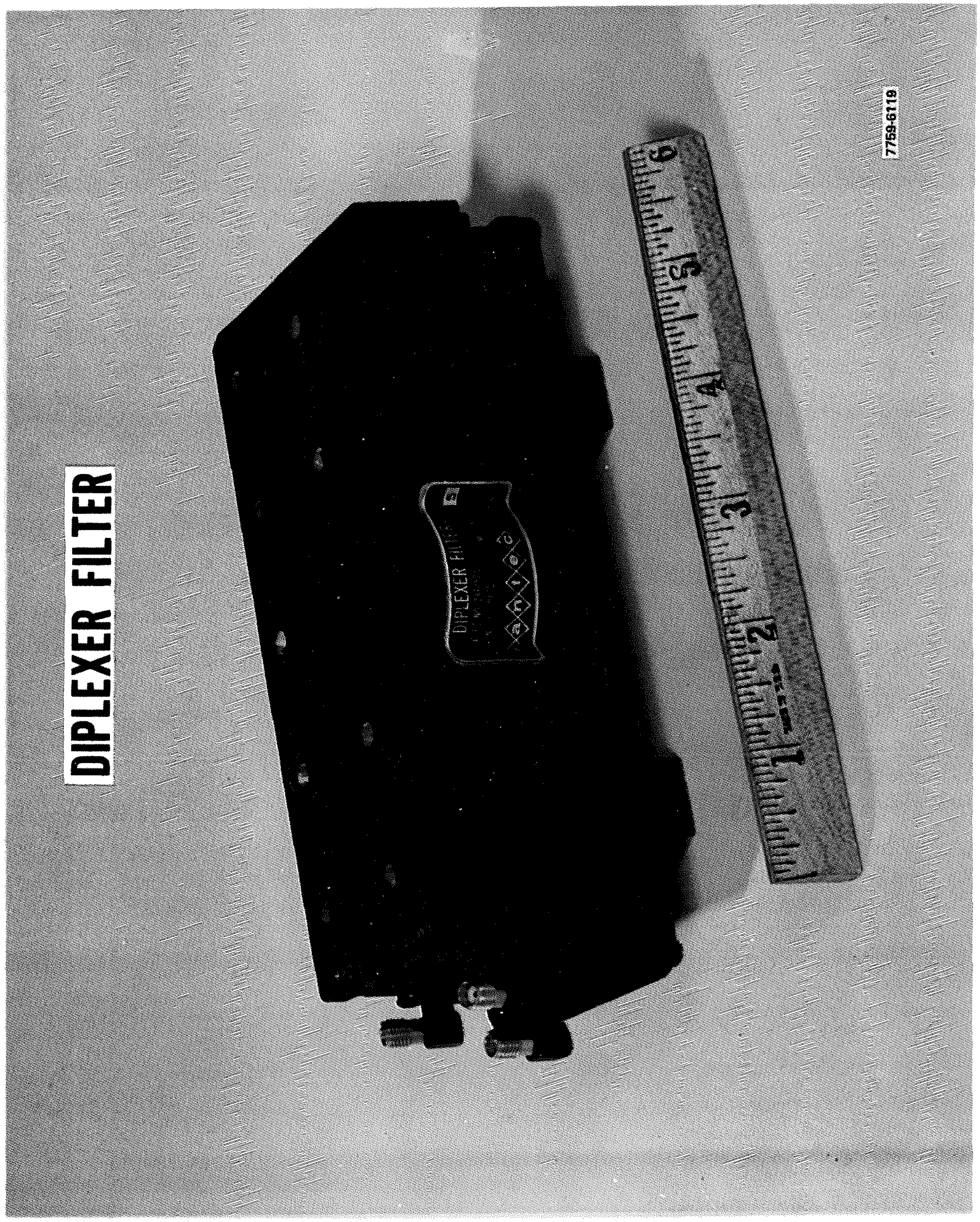


7759-6098

DATA SUBSYSTEM DIPLEXER SWITCH LEADING PARTICULARS

Characteristic	Value
Insertion loss	0.5 db
VSWR	1.14:1
Center frequency	
Isolation for 3 db bandwidth (4 MHz)	30-40 db
Switching voltage	12 vdc
DC power (position B)	150 MW
DC power (position A)	0
Switching time	120 milliseconds
RF power capability	1.5 watts
Weight	1.28 pounds
Stray magnetic field (steady-state)	10 gamma at 3 feet
Form factor	4 x 4.5 x 1.3 inches

7759-6099


DIPLEXER FILTER
7759-6119

DIPLEXER

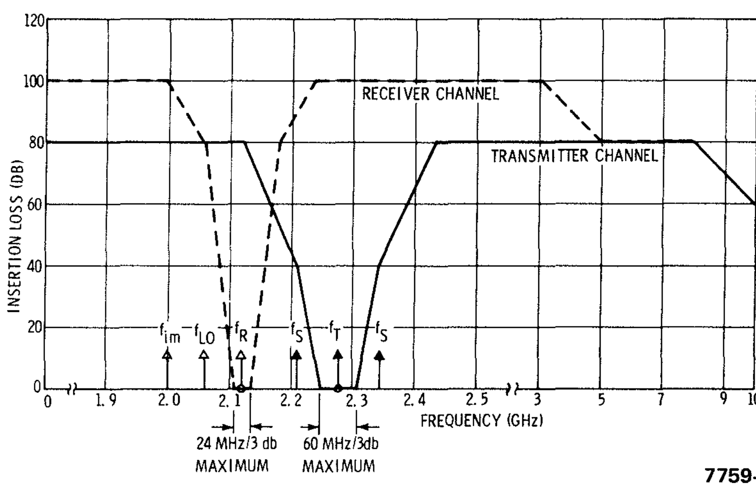
- PROVIDES TRANSMITTER/RECEIVER ISOLATION WITH A COMMON ANTENNA
- USES TUNEABLE CAVITY BANDPASS FILTERS - 5 IN TRANSMIT AND 5 IN RECEIVE PATH
- CHARACTERISTICS

RECEIVER PATH	MEAS	SPEC
INSERTION LOSS	1.30 db	2.5 db
VSWR	1.10:1	1.36:1
CENTER FREQUENCY:	2119	2118-2120 MHz
MAX 3 db BANDWIDTH	11.0 MHz	24 MHz
MIN 3 db BANDWIDTH	11.0 MHz	2.18 MHz
TRANSMITTER PATH		
INSERTION LOSS:	0.70 db	0.8 db
VSWR	1.10:1	1.36:1
CENTER FREQUENCY	2275-2280 MHz	2275-2280 MHz
MAX 3 db BANDWIDTH	45 MHz	60 MHz
MIN 3 db BANDWIDTH	45 MHz	5.35 MHz
POWER HANDLING CAPABILITY	20.0 WATTS	1.5 WATTS

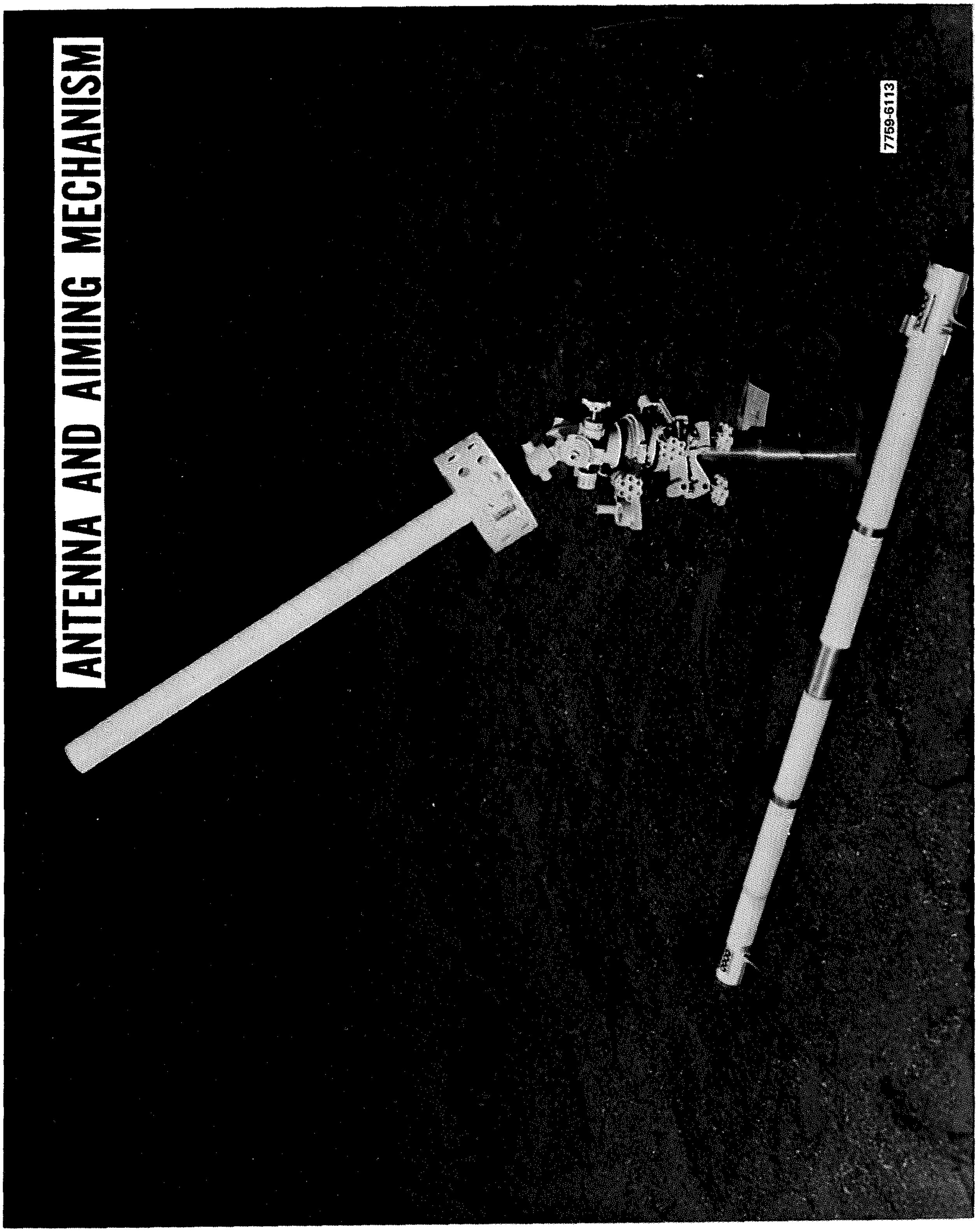
- MISCELLANEOUS
  - DIMENSIONS - 2.5 x 2.5 x 6.88 INCHES
  - WEIGHT - 0.9 POUNDS

7759-6120

DIPLEXER FILTER MINIMUM REJECTION REQUIREMENTS



7759-6121


ANTENNA AND AIMING MECHANISM
7759-6113

ANTENNA DESCRIPTION

* FLAT "RIBBON-LIKE" COPPER CONDUCTOR WRAPPED AROUND FIBERGLASS-EPOXY TUBE
* 1 1/2 INCHES IN DIAMETER AND 23 INCHES LONG
* USES 5" GROUND PLANE WITH A 2" CYLINDRICAL SKIRT
* IMPEDANCE MATCHING TRANSFORMER AT ANTENNA FEED POINT MATCHES THE ANTENNA IMPEDANCE TO A 50 OHM COAXIAL LINE
* DESIGNED FOR EASY ATTACHMENT TO THE POINTING MECHANISM WITH "QUICK-CONNECT" SPRING LOADED DETENTS
* COATED WITH WHITE REFLECTING THERMAL PAINT
* WEIGHT - 1.28 POUNDS INCLUDING CONNECTOR AND CABLE

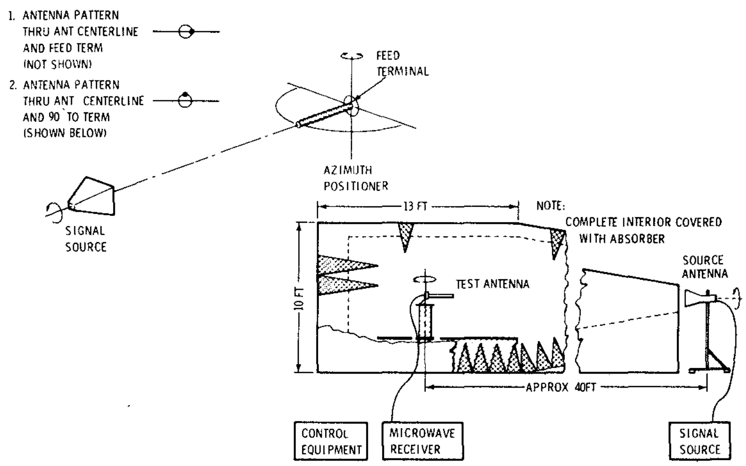
7759-6114

ANTENNA CHARACTERISTICS

	TRANSMIT		RECEIVE	
	SPEC	MEAS	SPEC	MEAS
GAIN				
ON BORESIGHT	15.2 db	16.0 db	14.7 db	15.2 db
BEAMWIDTH AT 11.0 db GAIN			27°	36°
BEAMWIDTH AT 11.5 db GAIN	27°	33°		
AXIAL RATIO	3 db	1.3 db	3 db	1.0 db
INPUT VSWR	1.25 : 1	1.20 : 1	1.5 : 1	1.20 : 1
SIDELOBE LEVEL	-10 db	-11 db	-10 db	11.3 db
WEIGHT (ACTUAL)	1.28 LBs (including cable)			

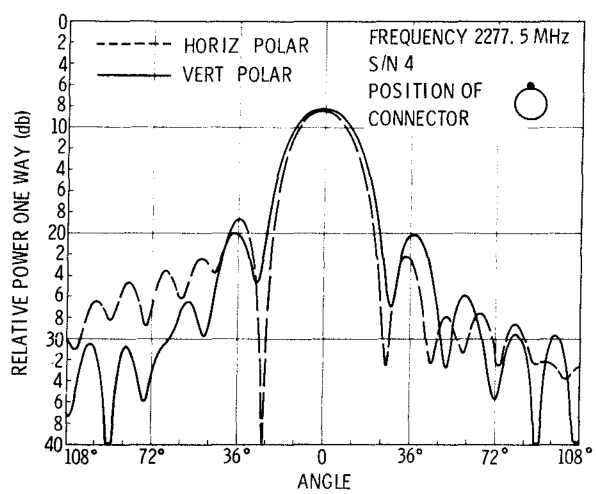
7759-6115

ANTENNA TEST



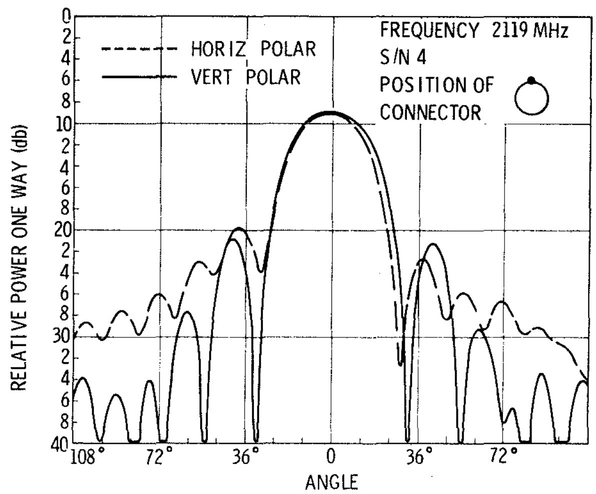
7759-6116

ANTENNA PATTERN (DOWNLINK)

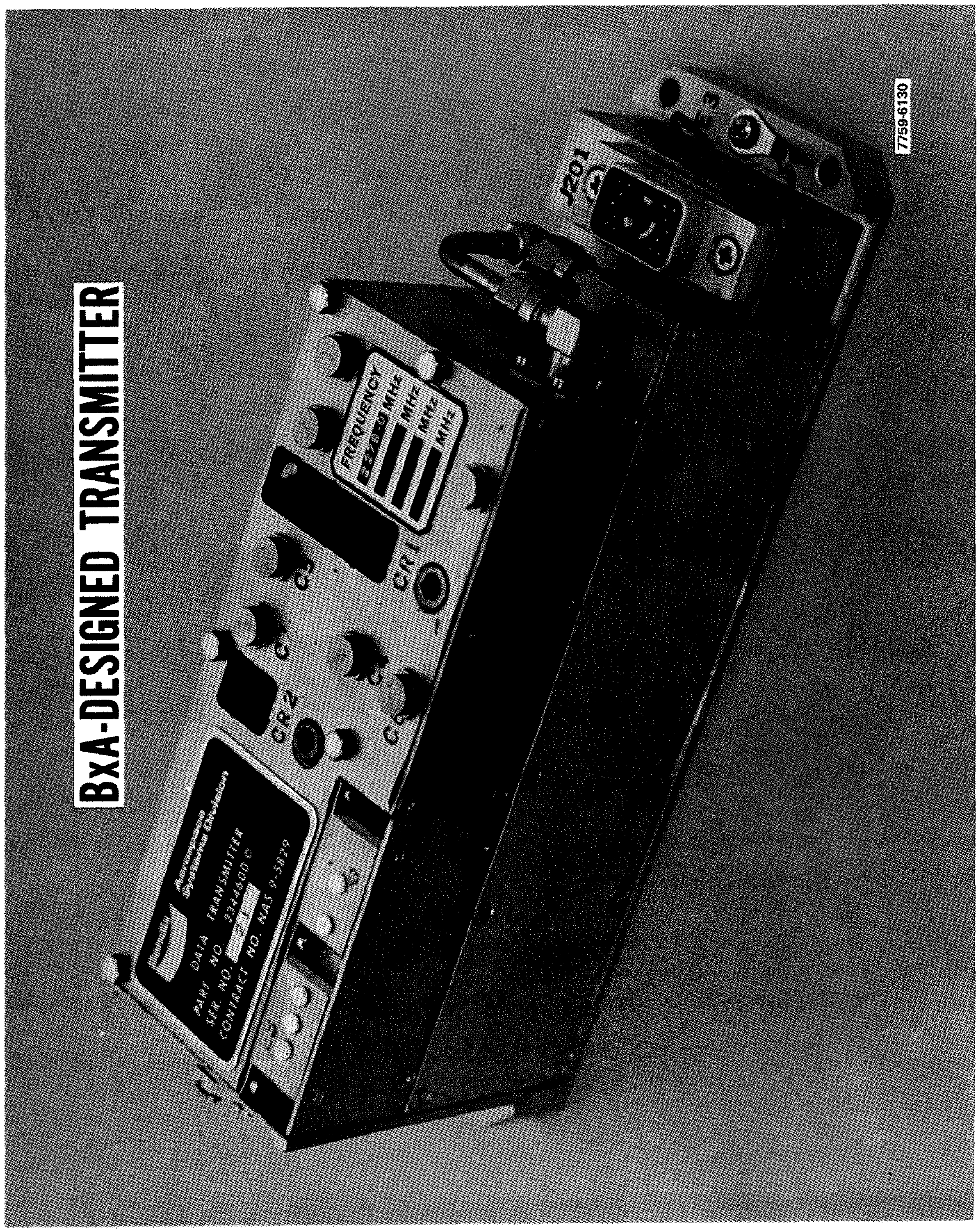


7759-6117

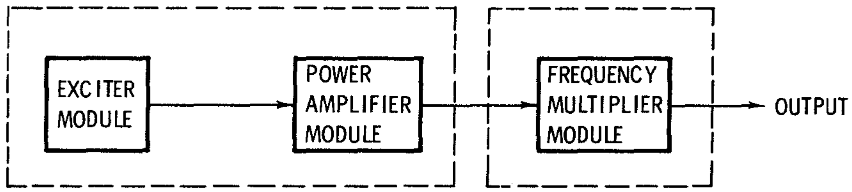
ANTENNA PATTERN
(UPLINK)



7759-6118

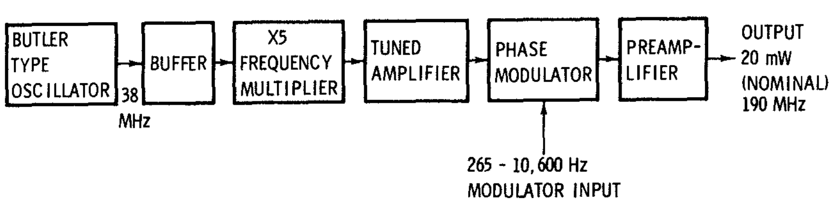

BxA-DESIGNED TRANSMITTER
7759-6130
J201
FREQUENCY
MHz
CR1
CR2
DATA TRANSMITTER
CONTRACT NO. NAS 9-5829

BENDIX DATA SYSTEMS TRANSMITTER BLOCK DIAGRAM



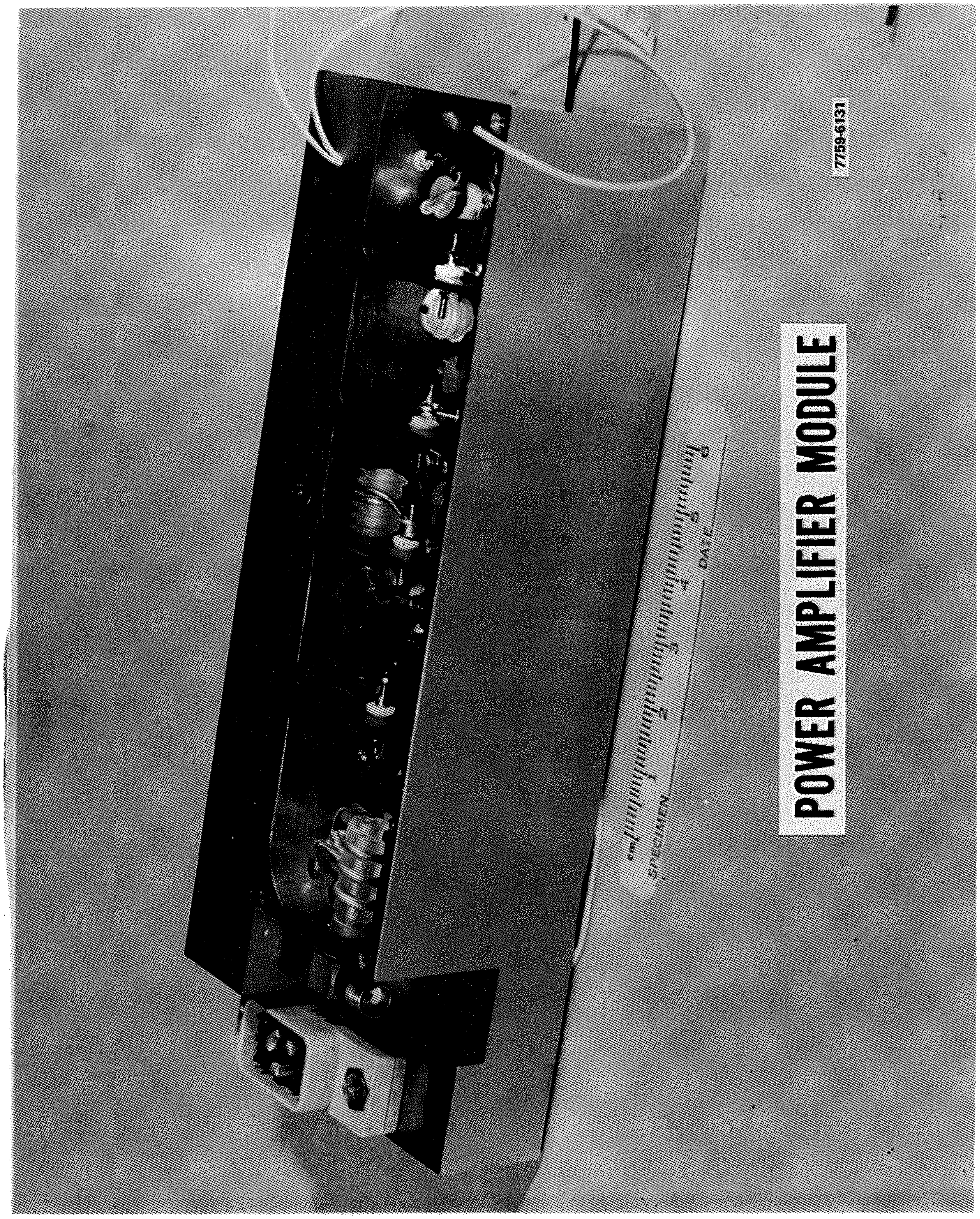
7759-6123

EXCITER MODULE BLOCK DIAGRAM



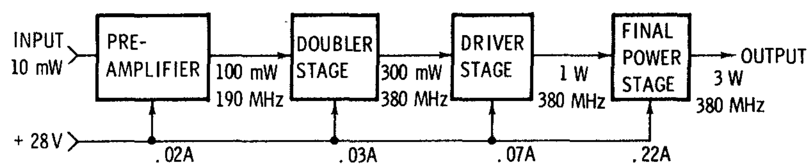
7759-6124

11-67

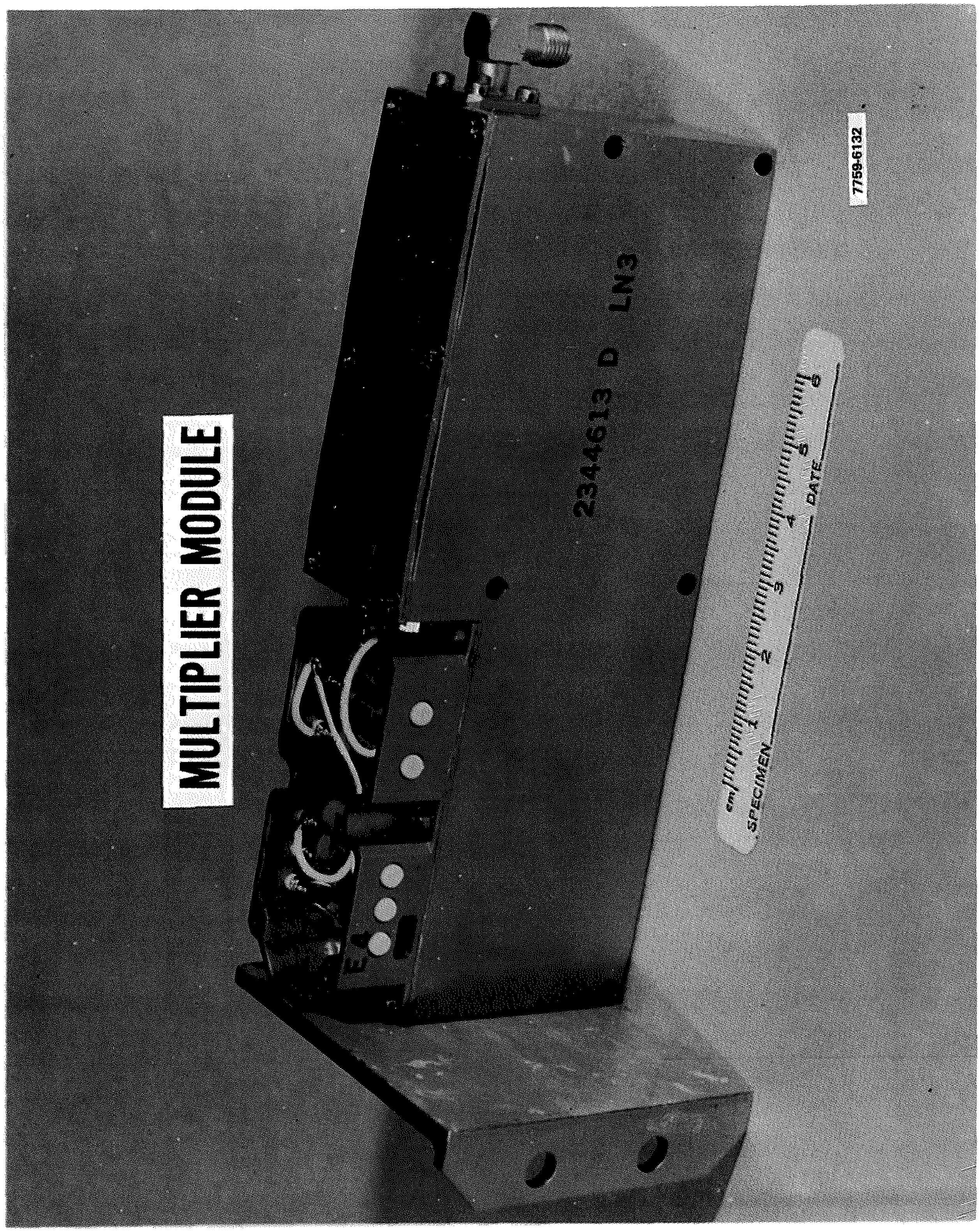


11-68

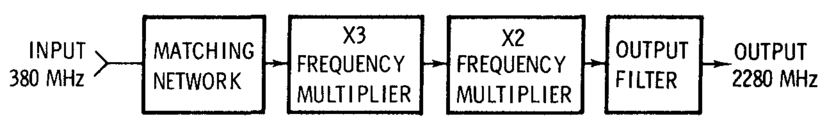
POWER AMPLIFIER MODULE
BLOCK DIAGRAM



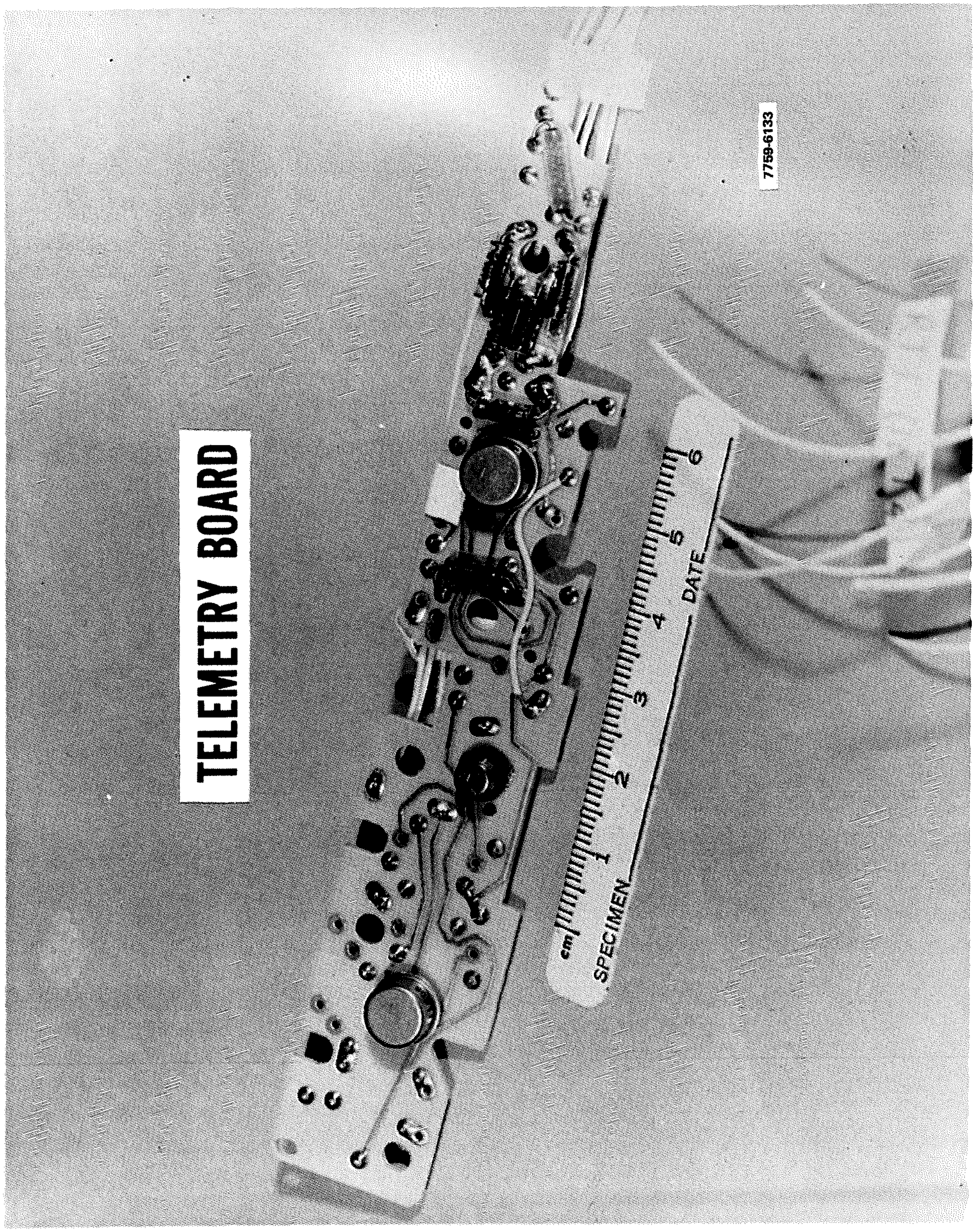
7759-6125

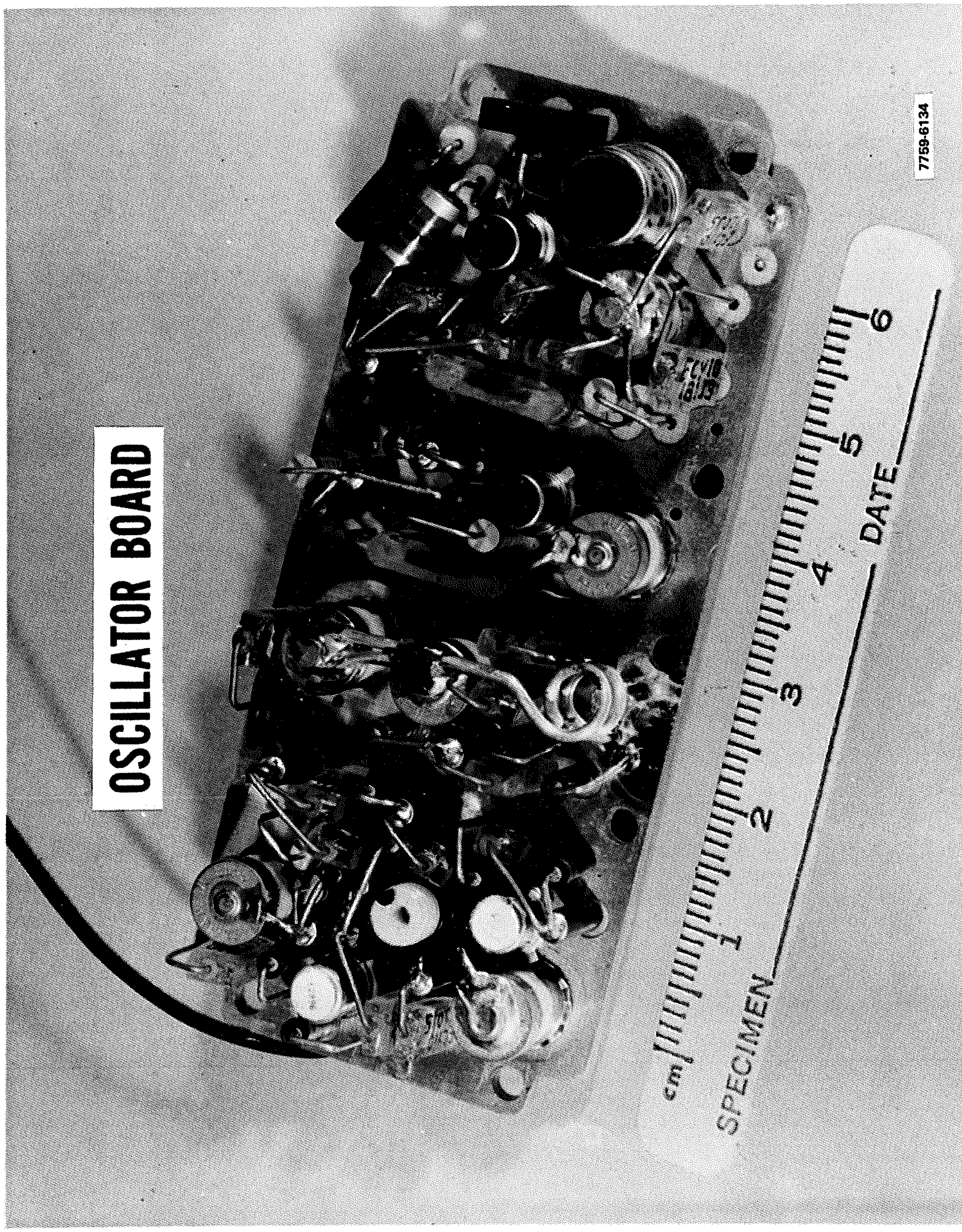

MULTIPLIER MODULE
2344613 D LN3
7759-6132
SPECIMEN
DATE

FREQUENCY MULTIPLIER MODULE
BLOCK DIAGRAM



7759-6126

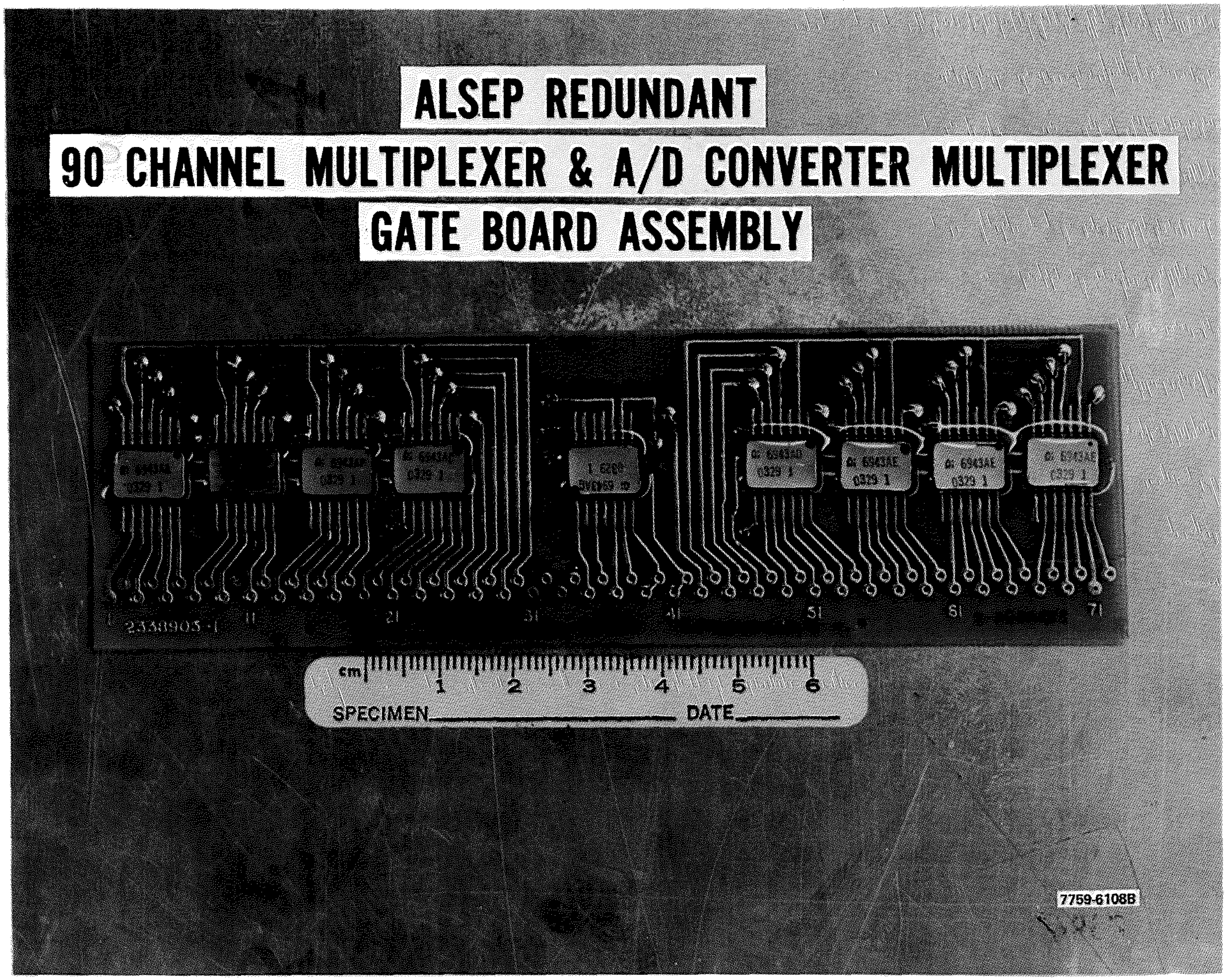

TELEMETRY BOARD
7759-6133
SPECIMEN
DATE

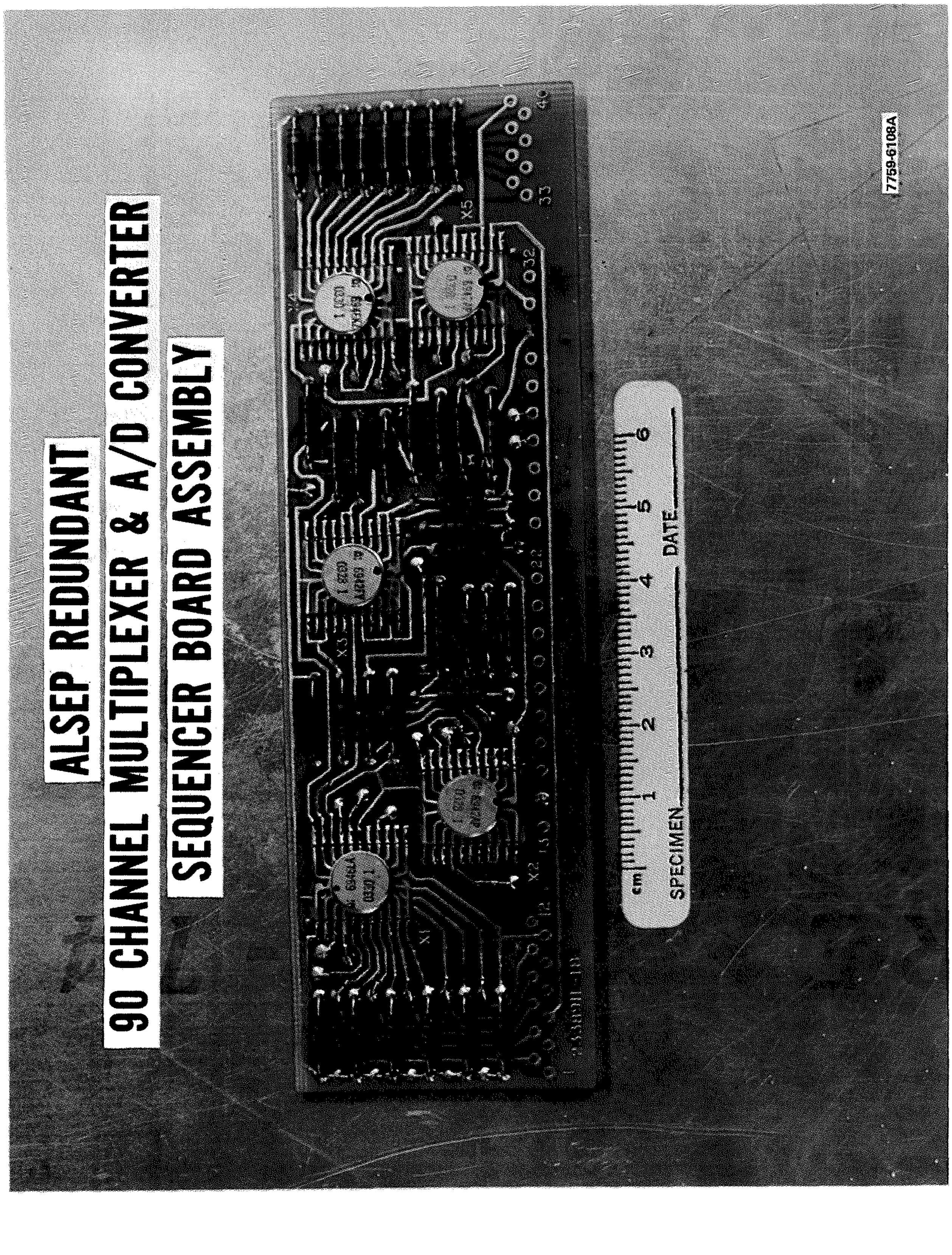

OSCILLATOR BOARD
7759-6134
cm 1 2 3 4 5 6
SPECIMEN
DATE

ANALOG MULTIPLEXER/ CONVERTER-FLIGHT MODEL A2

7759-6107

11-74


ALSEP REDUNDANT
90 CHANNEL MULTIPLEXER & A/D CONVERTER MULTIPLEXER
GATE BOARD ASSEMBLY
2338905-1
cm 1 2 3 4 5 6
SPECIMEN
DATE
7759-6108B


ALSEP REDUNDANT
90 CHANNEL MULTIPLEXER & A/D CONVERTER
SEQUENCER BOARD ASSEMBLY
7759-6108A

ANALOG MULTIPLEXER/CONVERTER

THE COMPONENT –

- CONSISTS OF DUAL 90 CHANNEL ANALOG MULTIPLEXERS, SEQUENCERS, BUFFER AMPLIFIERS AND 8-BIT A/D CONVERTERS WITH BUFFERED OUTPUTS
- USES REDUNDANT GATES, SEQUENCERS AND A/D CONVERTERS FOR RELIABLE OPERATION
- MONITORS UP TO 90 DATA SOURCES ON A SEQUENTIAL SAMPLE BASIS. REQUIRES ABOUT 54 SECONDS FOR ONE COMPLETE SEQUENCE OF SAMPLES
- CONVERTS EACH INPUT INTO AN 8-BIT BINARY WORD
- PROVIDES THE 8-BIT BINARY WORD IN PARALLEL TO THE DIGITAL MULTIPLEXER OF THE DDP

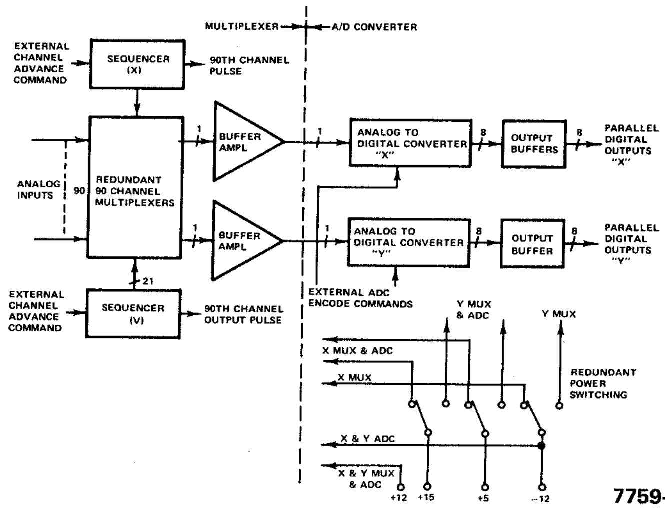
7759-6105

ANALOG MULTIPLEXER/CONVERTER PHYSICAL DESCRIPTION

SIZE	2.62 X 4.23 X 5.92 INCHES
WEIGHT	1.83 POUNDS
POWER	REQUIRES A TOTAL OF 1435 MILLIWATTS (NOMINAL AT ROOM AMBIENT) AT THE FOLLOWING VOLTAGE LEVELS–
	100 MILLIWATTS AT + 15 VDC
	650 MILLIWATTS AT + 12 VDC
	750 MILLIWATTS AT + 5 VDC
	650 MILLIWATTS AT – 12 VDC
PACKAGING	ALL PARTS ARE MOUNTED ON 11 TWO LAYER PCBs
CONNECTOR	HUGHES - 244 PIN

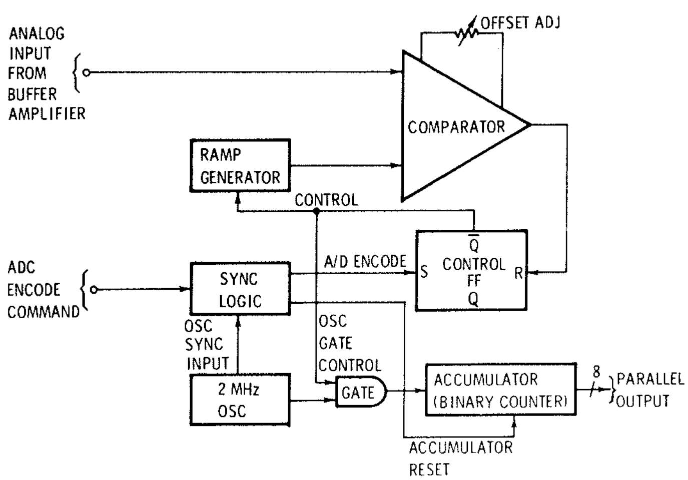
7759-6106

SIMPLIFIED BLOCK DIAGRAM



7759-6109

A/D CONVERTER FUNCTIONAL BLOCK DIAGRAM



7759-6110

11-78

INPUT REQUIREMENTS

ANALOG INPUTS

RANGE	0 TO +5 VOLTS
INPUT Z	$\geq$ 1 MEGOHM (ON STATE)
	$\geq$ 50 MEGOHMS (OFF STATE)
SOURCE Z	$\leq$ 50 K OHMS

PROPER OPERATION WITH AN OVERVOLTAGE OF $\pm$ 12 VOLTS ON ANY CHANNEL

ADVANCE PULSE

REQUIRED FOR ADVANCING MULTIPLEXER THROUGH ITS 90 CHANNELS
SUPPLIED BY DDP

ADC START (ENCODE) PULSE

DRIVES SYNC LOGIC TO START A/D CONVERSION. SUPPLIED BY DDP

7759-6111

ANALOG MULTIPLEXER/CONVERTER OUTPUTS

BINARY OUTPUT -

00000000	FOR A NEGATIVE INPUT
00000001	FOR ZERO INPUT
11111110	FOR +5 VOLTS INPUT
11111111	FOR GREATER THAN +5 VOLTS INPUT

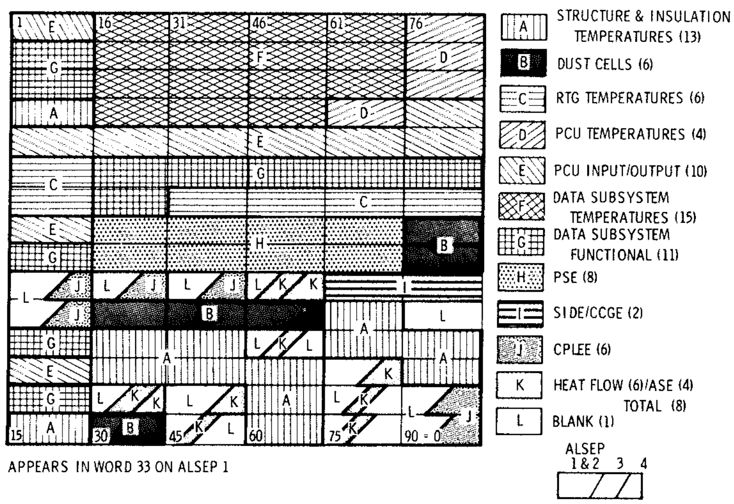
LOGICAL "0" IS +4.0 $\pm$1.5 VOLTS
LOGICAL "1" IS +0.2 $\pm$ 0.2 VOLTS

TEMPERATURE TELEMETRY

CHANNEL 33	AT-27	BASE TEMP (SIGNAL OBTAINED BY A THERMISTOR/ RESISTOR NETWORK POWERED BY +12 VDC THERMISTOR LOCATED ON BASE PLATE)
CHANNEL 34	AT-28	INTERNAL TEMP (SAME AS ABOVE EXCEPT THERMISTOR MOUNTED ON PCB)

7759-6112

ANALOG MULTIPLEXER CHANNEL ASSIGNMENTS

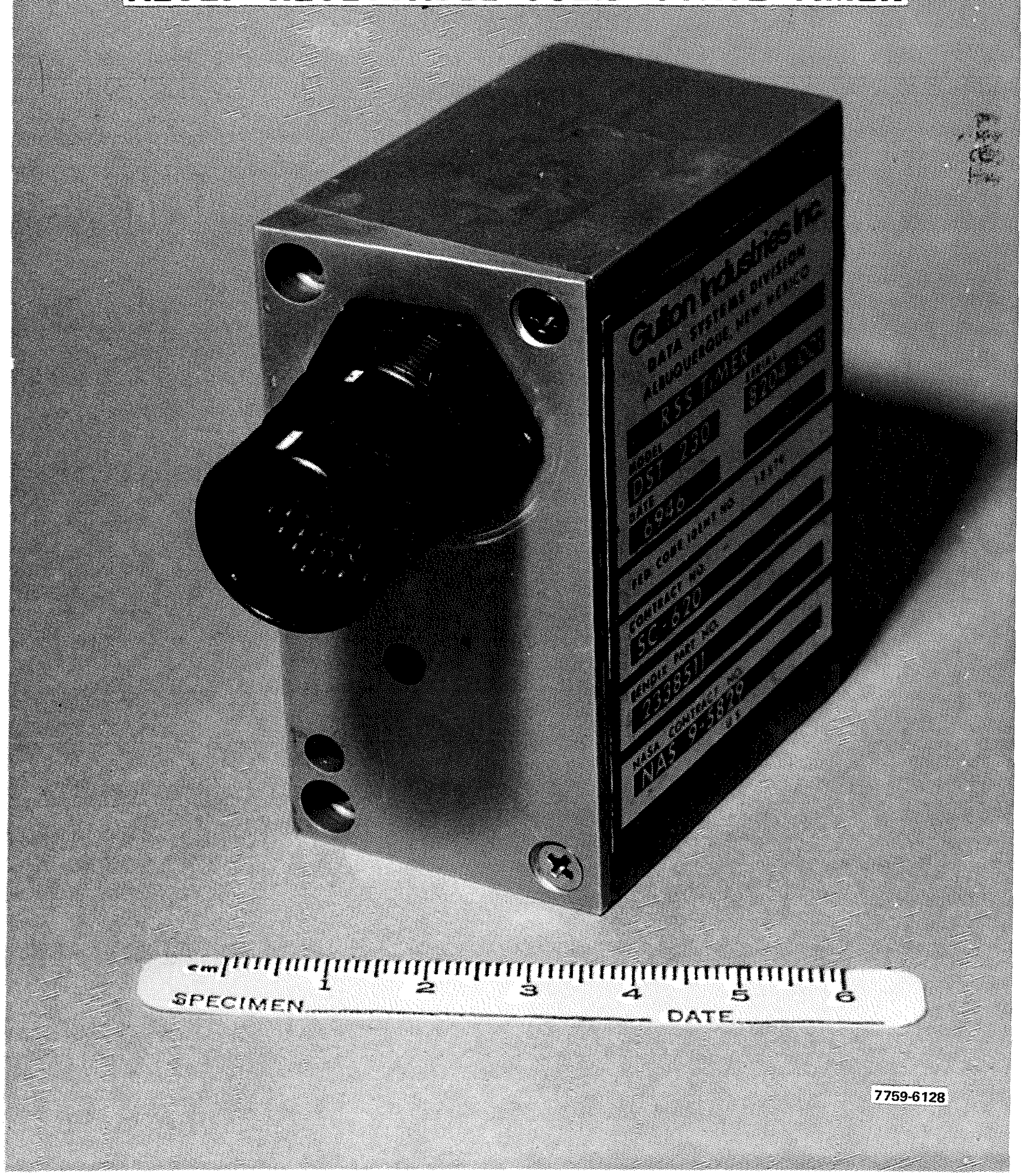


APPEARS IN WORD 33 ON ALSEP 1

7759-6122

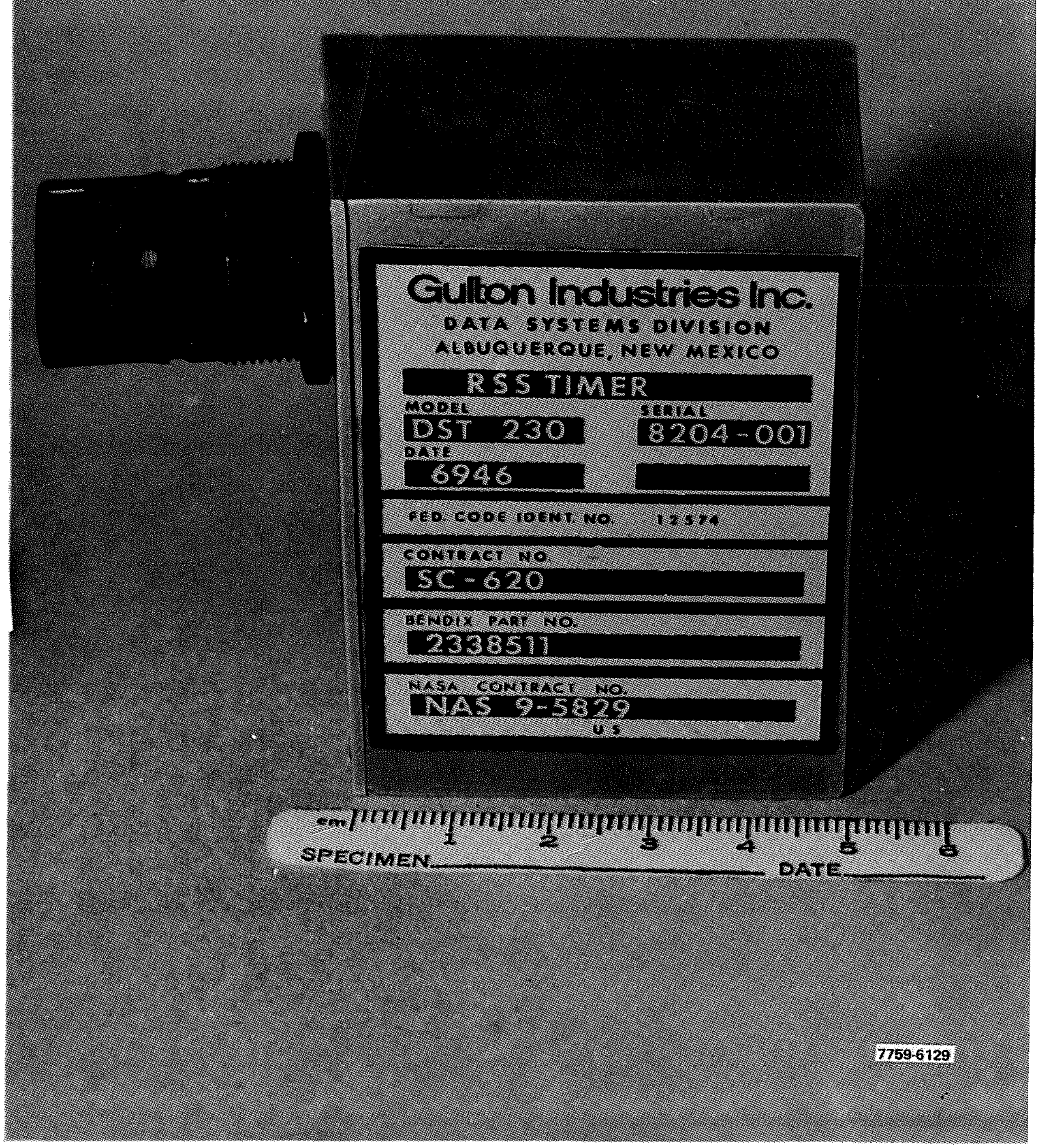

ALSEP RESETTABLE SOLID STATE TIMER
(RSST)
Gulton Industries Inc.
DATA SYSTEMS DIVISION
ALBUQUERQUE, NEW MEXICO
SPECIMEN
DATE
7759-6127

ALSEP RESETTABLE SOLID STATE TIMER



11-82

ALSEP RESETTABLE SOLID STATE TIMER



11-83

MAJOR DESIGN PARAMETERS– ALSEP RESETTABLE SOLID STATE TIMER (RSST)

TIME-OUT PERIOD:	3 MONTHS + 6 DAYS (NOMINAL) & IS COMMAND RESETTABLE TO EXTEND TIME-OUT BY ADDITIONAL 3 MONTH PERIODS
TIMING ACCURACY:	$\pm$ 5 PERCENT ($\pm$ 5 DAYS)
OPERATING VOLTAGE:	+ 10 TO + 14 VOLTS DC
CURRENT DRAIN:	LESS THAN 20 MILLIAMPS STEADY STATE (100 MILLIAMPS PEAK)
SIZE AND WEIGHT:	2.00" X 1.38" X 2.80" HEIGHT. LESS THAN 7 OUNCES
CONSTRUCTION:	ALL SOLID STATE (EXCEPT RELAY) COUNTERS (REGISTERS) ARE RCA COS-MOS ALL OTHER ELECTRONIC PARTS ARE DISCRETE THREE 2" X 2.8" PRINTED CIRCUIT BOARDS USED UNIT IS REPAIRABLE

7759-6100

MAJOR RSST DESIGN PARAMETERS (CONT')

ENVIRONMENTAL:	OPERATES FROM -22°F TO +158°F @ SEA LEVEL TO 10^{-12}mmHg. 20 G-PEAK SHOCK, 14 G ACCELERATION. 5.7 G-RMS RANDOM VIBRATION. COMPATIBLE WITH MIL-I-26600 AND MSC-ASPO-EMI-10A EMI REQUIREMENTS AND ALSEP POWER LINE RIPPLE AND TRANSIENT REQUIREMENTS.
RELIABILITY:	PREDICTED PROBABILITY OF SUCCESS IS GREATER THAN .996 PER TWO YEAR OPERATION (ASSUMING RESET AT 3 MONTH INTERVALS). THE PROBABILITY OF AVOIDING AN EARLY TIME-OUT IS PREDICTED AT BETTER THAN .999 FOR TWO YEARS OF OPERATION.

7759-6101

KEY FUNCTIONS-ALSEP
RESETTABLE SOLID STATE TIMER (RSST)

- PROVIDES SPDT LATCHING RELAY CLOSURE AT 3 MONTH TIME-OUT TO DISABLE THE DATA TRANSMITTER (VIA PDU TRANSMITTER CONTROL). (COMMAND LINK BACKUP FUNCTION)
- PROVIDES 18 HOUR AND 1 MINUTE CALIBRATION AND UNCAGING PULSES FOR COMMAND LINK BACKUP.
- PROVIDES SHORT CIRCUIT FAILURE PROTECTION. (250 MILLIAMP AT WORST CASE FAILURE MODE)

7759-6102

KEY RSST FUNCTIONS (CONT')

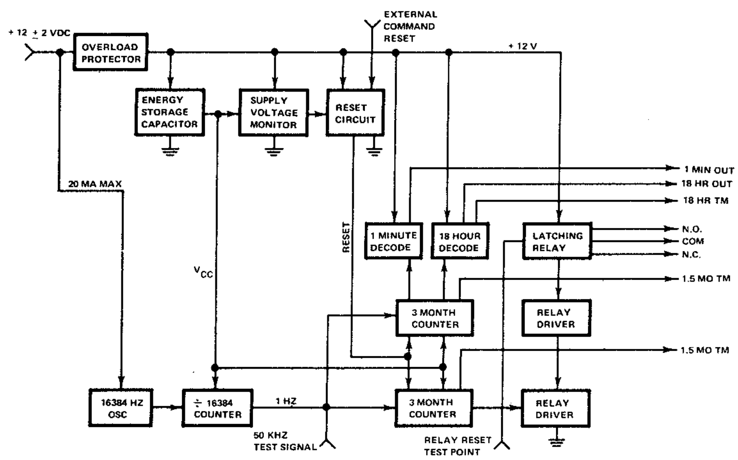
- PROVIDES 30 SECOND POWER DROPOUT COUNTER PERIOD RETENTION
- PROVIDES LOW VOLTAGE AND SLOW POWER TURN-ON PROFILE FAIL-SAFE OPERATION (TIMER RESET WILL OCCUR PRIOR TO SPURIOUS TIME-OUT)
- HOUSEKEEPING TELEMETRY:

  A) 1.5 MONTH +3 DAYS ELAPSED TIME TELEMETRY (EACH COUNTER)
  B) 18 HOUR ELAPSED TIME TELEMETRY (TOGGLE)

- TEST: CAN BE OPERATED IN "SPEED-UP" MODE WITH AN EXTERNAL TEST SIGNAL TO BE TIMED-OUT IN 3 MINUTES IN ORDER TO FULLY TEST ALL FUNCTIONS. THE RELAY IS RESETTABLE FOR TEST PURPOSES

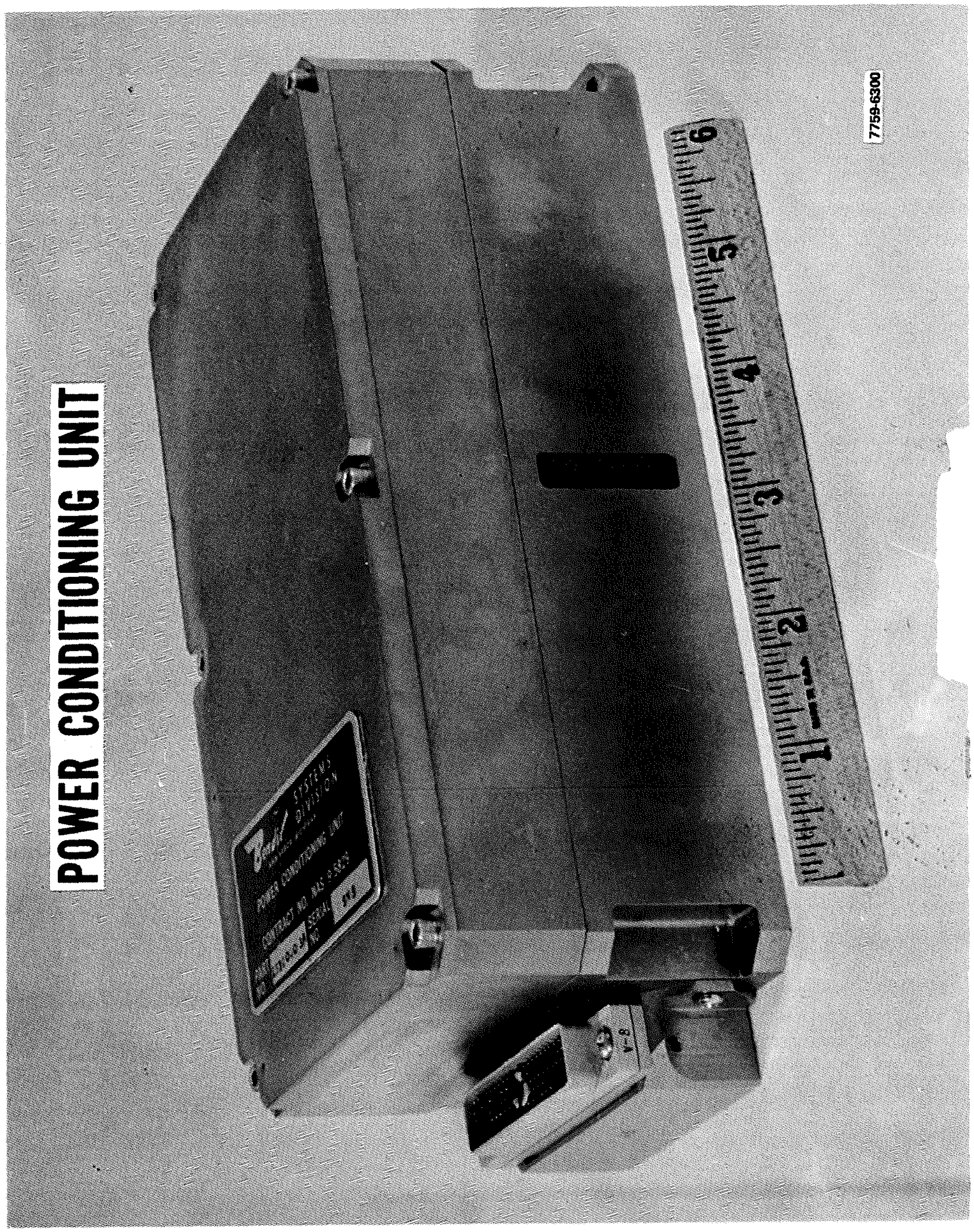
7759-6103

FUNCTIONAL BLOCK DIAGRAM-RSST

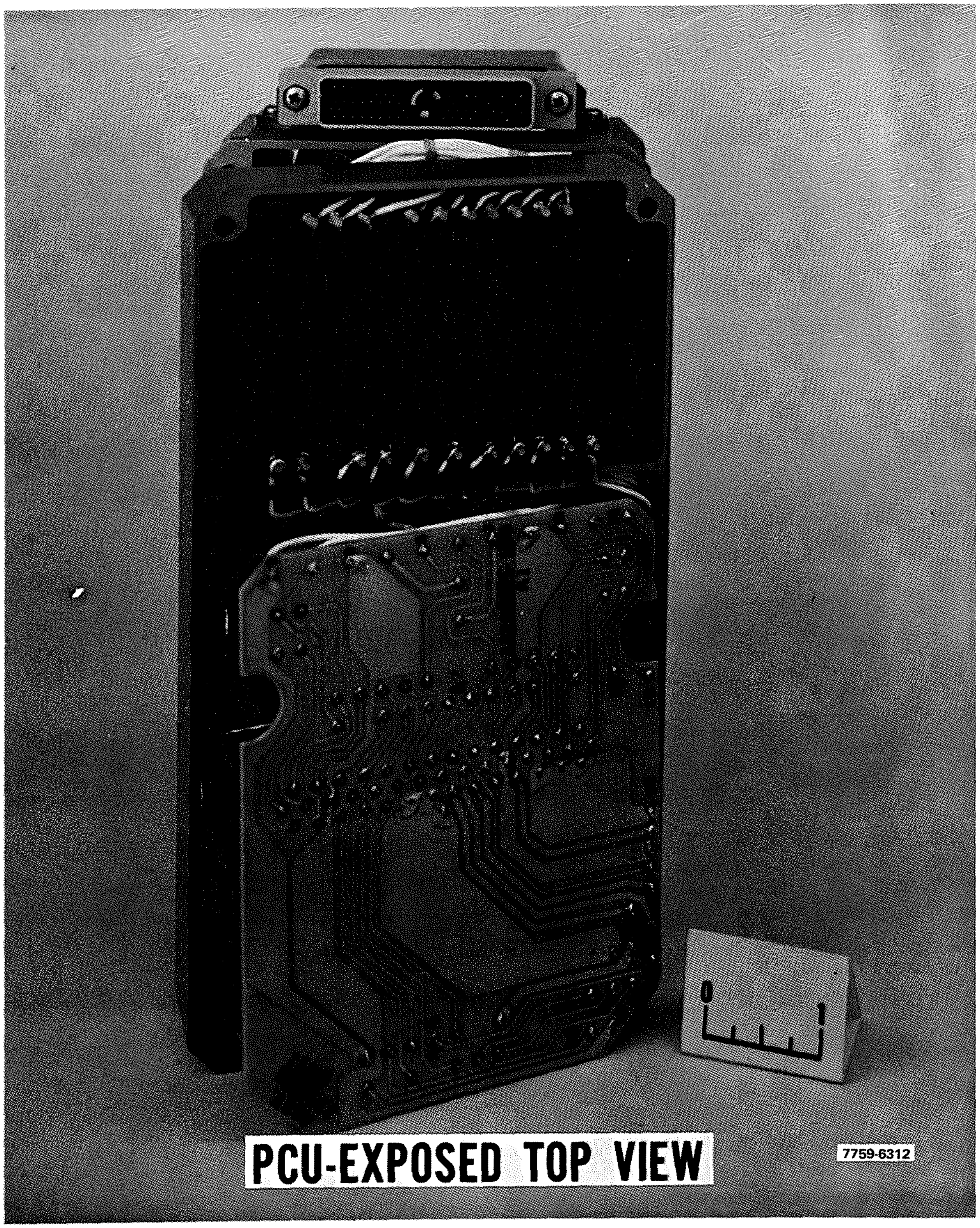


7759-6104

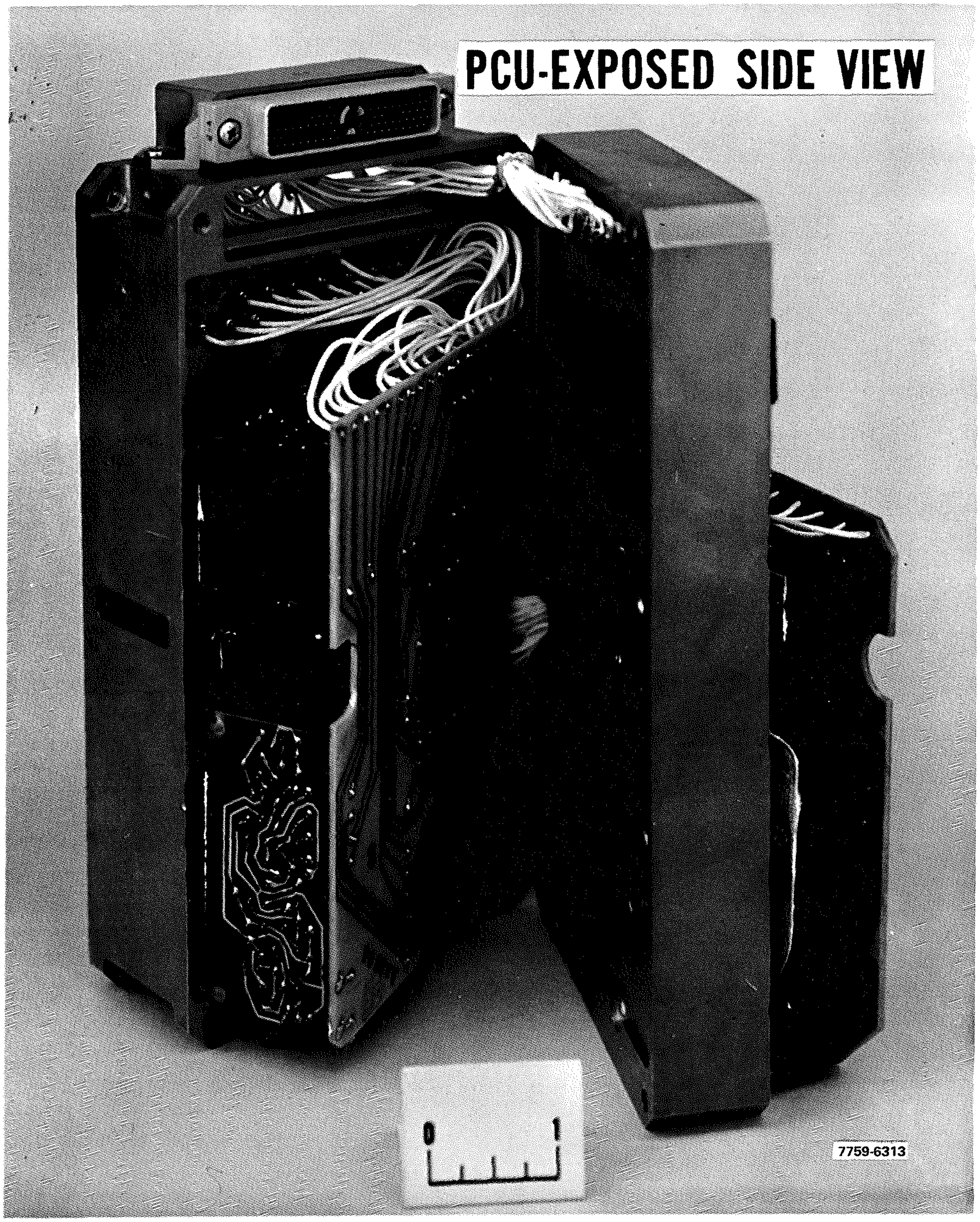
11-86

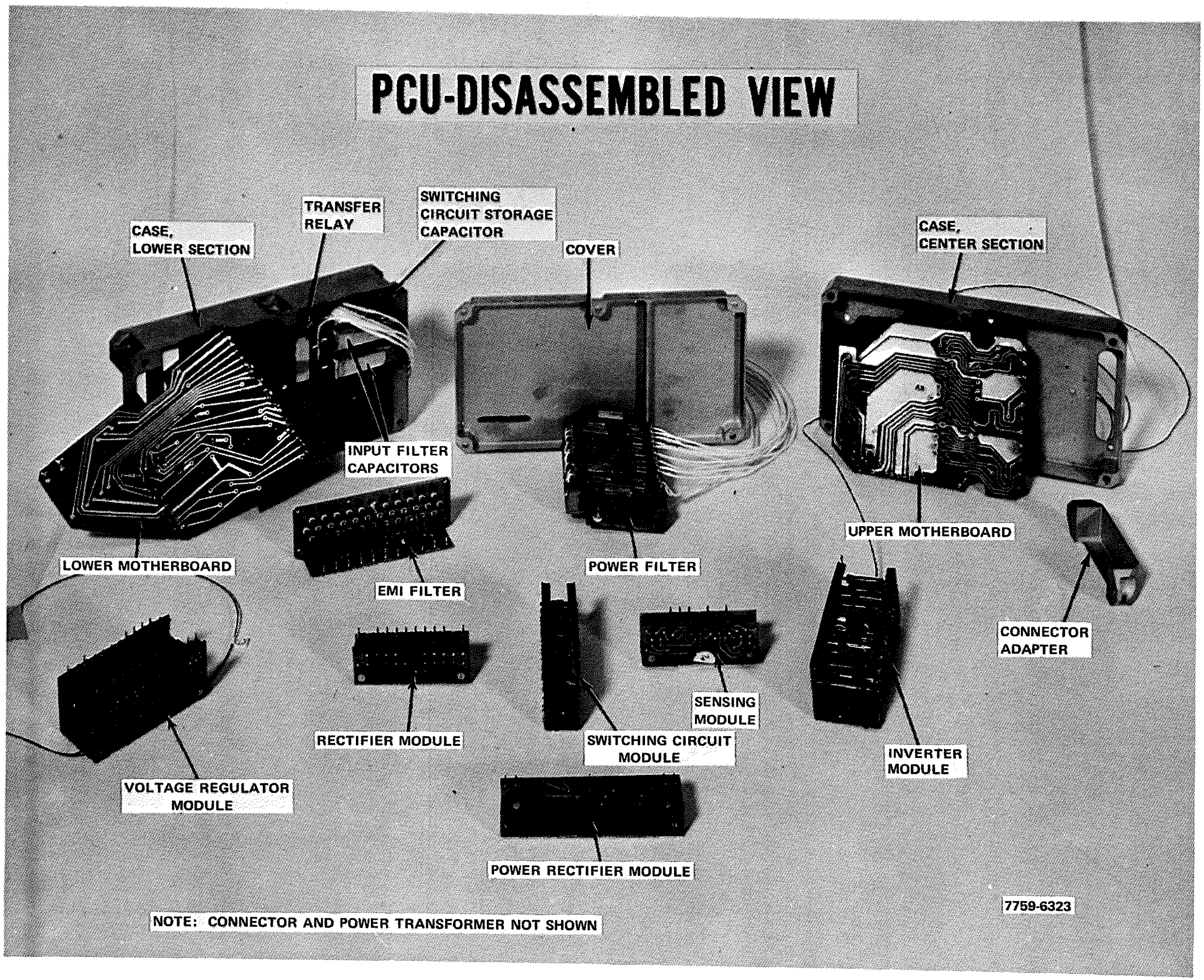


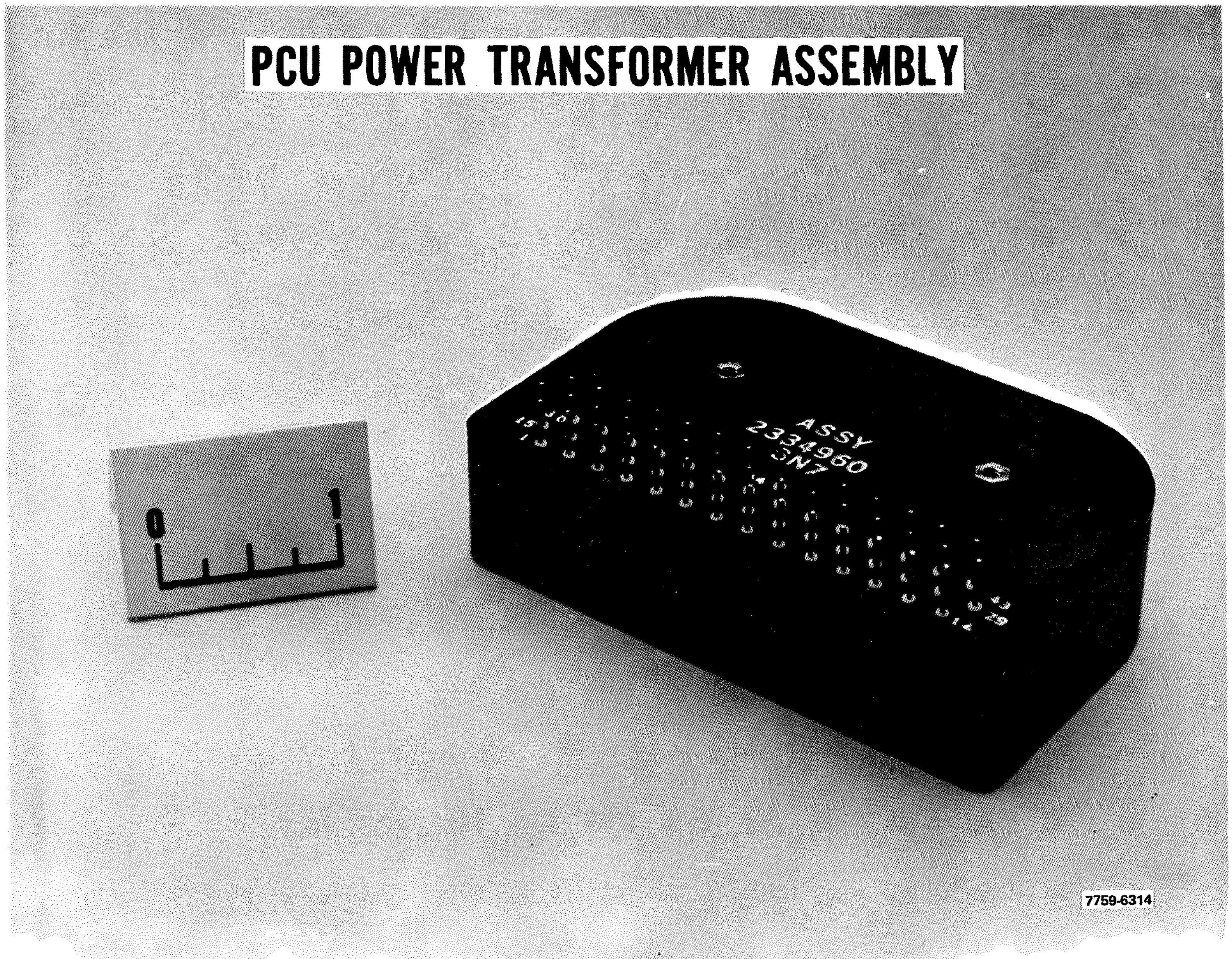
POWER CONDITIONING UNIT



PCU-EXPOSED TOP VIEW


PCU-EXPOSED SIDE VIEW
0
1
7759-6313


PCU-DISASSEMBLED VIEW
CASE, LOWER SECTION
TRANSFER RELAY
SWITCHING CIRCUIT STORAGE CAPACITOR
COVER
CASE, CENTER SECTION
INPUT FILTER CAPACITORS
LOWER MOTHERBOARD
EMI FILTER
POWER FILTER
UPPER MOTHERBOARD
CONNECTOR ADAPTER
RECTIFIER MODULE
SWITCHING CIRCUIT MODULE
SENSING MODULE
INVERTER MODULE
VOLTAGE REGULATOR MODULE
POWER RECTIFIER MODULE
7759-6323
NOTE: CONNECTOR AND POWER TRANSFORMER NOT SHOWN


PCU POWER TRANSFORMER ASSEMBLY
ASSY
2334960
SN7
0
1
7759-6314

POWER CONDITIONING UNIT

PHYSICAL DESCRIPTION

SIZE - 8.36 X 4.14 X 2.94 IN.

WEIGHT - 4.5 POUNDS

POWER - THE INTERNAL DISSIPATION OF THE POWER CONDITIONING UNIT (PCU) DEPENDS ON THE INPUT POWER, THE OUTPUT POWER AND THE REGULATOR RANGE. TYPICAL INTERNAL DISSIPATION CURVES ARE SHOWN IN FOLLOWING INFORMATION.

PARTS COUNT -	TRANSISTORS	27	RELAY	1
	DIODES	44	THERMISTORS	4
	ZENER DIODES	4	INDUCTORS	11
	CAPACITORS	71	TRANSFORMERS	8
	RESISTORS	87		

PACKAGING - SEVEN CORDWOOD MODULES ARE MOUNTED ON A "MOTHER BOARD". THERMAL REQUIREMENTS ARE MET BY USING MACHINED, GOLD-PLATED, MAGNESIUM CASES FOR THE MODULES.

CONNECTOR - HUGHES - 88 PIN

7759-6301

PCU FEATURES

* CONSISTS OF REDUNDANT POWER CONDITIONERS WITH BOTH AUTOMATIC AND COMMANDABLE SELECTION OF THE STANDBY SECTION. OVER/UNDER VOLTAGES ARE SENSED FOR AUTOMATIC SWITCHING FROM PCU#1 TO PCU#2.
* PROVIDES 6 REGULATED DC OUTPUT VOLTAGES WITH NOMINAL VALUES OF +29, +15, +12, +5, -6, AND -12 VOLTS.
* CONTAINS FILTERS TO LIMIT OUTPUT RIPPLE VOLTAGE TO BE APPROXIMATELY 150 MILLIVOLTS PEAK-TO-PEAK.
* OPERATES AT AN EFFICIENCY OF ABOUT 85% WITH A 48 WATT LOAD.

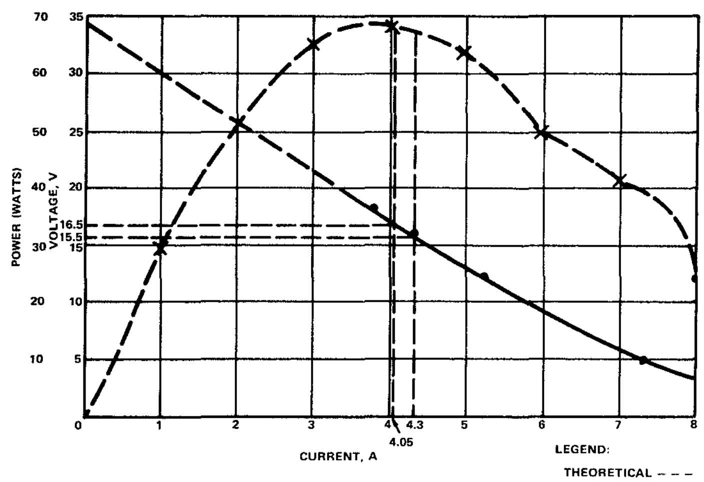
7759-6302A

PCU FEATURES (CONT)

* HAS 'HOLD-OFF' CIRCUIT ON PC#1 TO PREVENT STARTING UNTIL RTG POWER IS SUFFICIENT TO PERMIT PCU OPERATION WITH REGULATION.
* TO MAINTAIN THE RTG TEMPERATURE WITHIN SAFE LIMITS, THE PCU HOLDS THE RTG LOAD AT A (RELATIVELY) CONSTANT VALUE.
* PROVIDES TM SIGNALS FOR MONITORING RTG CURRENT, RTG VOLTAGE, SHUNT REGULATOR CURRENT AND TEMPERATURES.
* PROVIDES RESERVE POWER REFERENCE AND RESERVE POWER LEVEL SIGNALS TO RIPPLE-OFF CIRCUITS IN THE PDU.

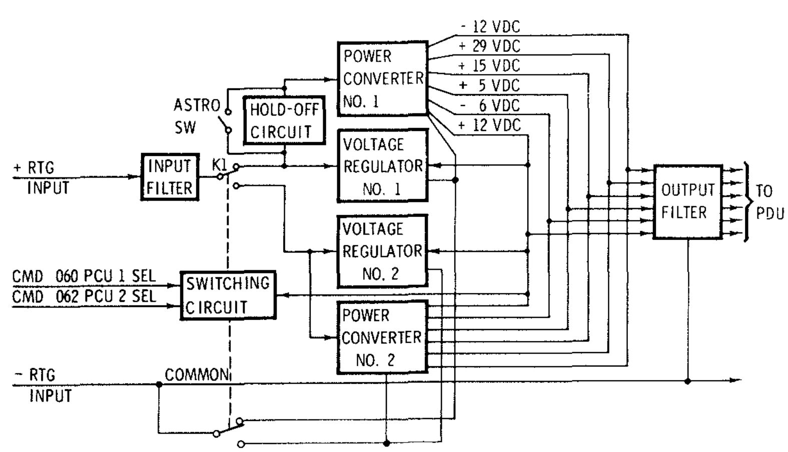
7759-6302B

TYPICAL RTG/PCU INTERFACE CHARACTERISTICS



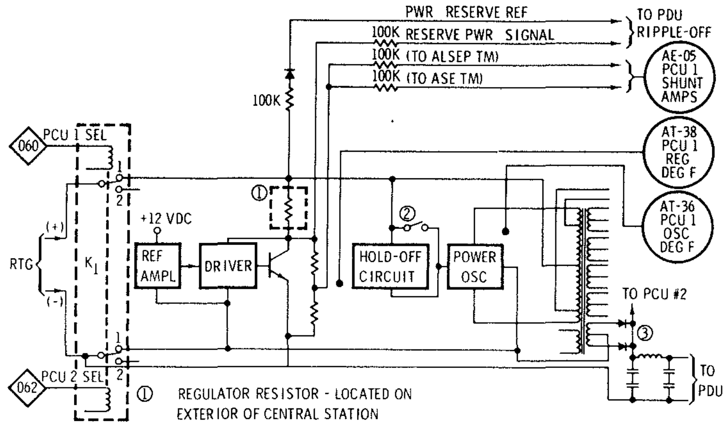
7759-6328

SIMPLIFIED BLOCK DIAGRAM - PCU



7759-6327

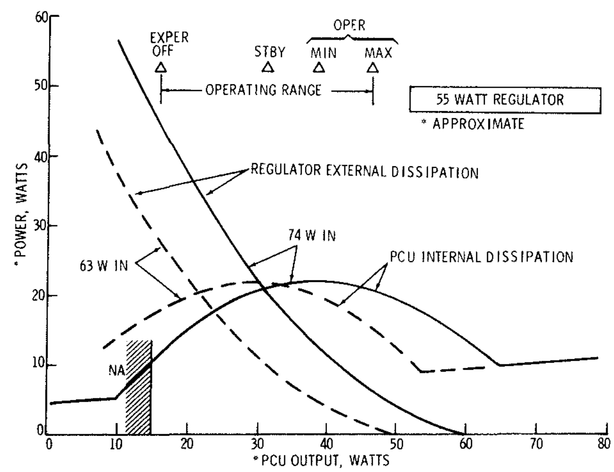
PCU 1 DIAGRAM



① REGULATOR RESISTOR - LOCATED ON EXTERIOR OF CENTRAL STATION
② HOLD-OFF CIRCUIT ON PCU #1 ONLY. SWITCH IS ASTRONAUT SWITCH S-1
③ TYPICAL (1 OF 6) RECTIFIER/FILTER CIRCUIT. FILTER IS COMMON TO BOTH PCU #1 & PCU #2.

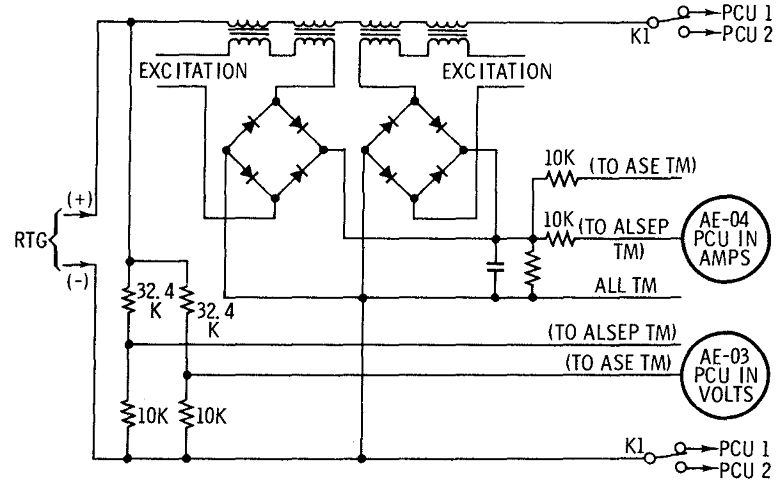
7759-6311

PCU POWER/THERMAL RELATIONSHIP



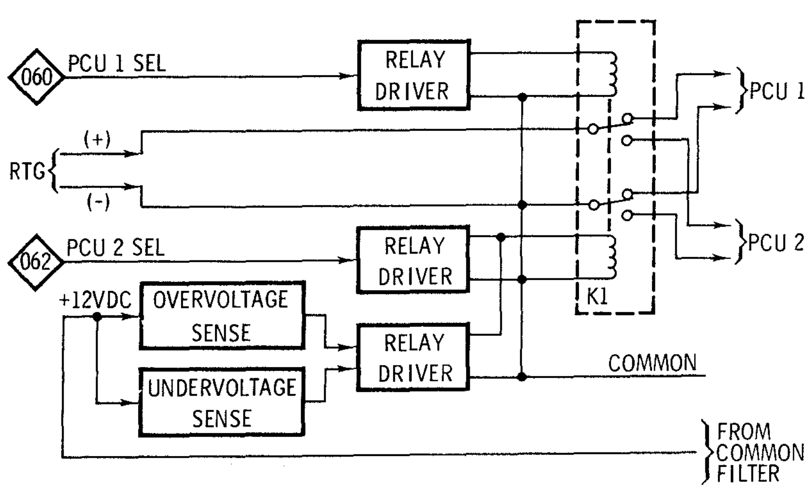
7759-6303

RTG CURRENT AND VOLTAGE TM



7759-6304

PCU SELECTION FUNCTION



7759-6305

EPS DATA

FROM RTG	FROM PCU	FROM PDU
AR-01 HOT FRAME 1 DEG F	AT-36 PCU 1 OSC DEG F	AE-07 PCU + 29V OUT
AR-02 HOT FRAME 2 DEG F	AT-37 PCU 2 OSC DEG F	AE-08 PCU + 15V OUT
AR-03 HOT FRAME 3 DEG F	AT-38 PCU 1 REG DEG F	AE-09 PCU + 12V OUT
AR-04 CLD FRAME 1 DEG F	AT-39 PCU 2 REG DEG F	AE-10 PCU + 5V OUT
AR-05 CLD FRAME 2 DEG F	AE-03 PCU IN VOLTS	AE-11 PCU - 12V OUT
AR-06 CLD FRAME 3 DEG F	AE-04 PCU IN AMPS	AE-12 PCU - 6V OUT
	AE-05 PCU 1 SHUNT AMPS	
	AE-06 PCU 2 SHUNT AMPS	

7759-6306

EPS COMMANDS

OCTAL CMD NUMBERS

017 DISSIP R1 ON

THIS CMD ACTUATES RELAY K-16, IN THE PDU, TO THE POSITION THAT APPLIES +29 VDC TO A 7-WATT POWER DISSIPATION RESISTOR, AND IS USED TO OPTIMIZE THE LOAD ON THE PCU.

021 DISSIP R1 OFF

THIS CMD ACTUATES RELAY K-16, IN THE PDU, TO THE POSITION THAT REMOVES +29 VDC FROM THE 7-WATT POWER DISSIPATION RESISTOR.

022 DISSIP R2 ON

THIS CMD ACTUATES RELAY K-17, IN THE PDU, TO THE POSITION THAT APPLIES +29 VDC TO A 14-WATT POWER DISSIPATION RESISTOR, AND IS USED TO OPTIMIZE THE LOAD ON THE PCU.

7759-6307A

EPS COMMANDS (CONT)

023 DISSIP R2 OFF

THIS CMD ACTUATES RELAY K-17, IN THE PDU, TO THE POSITION THAT REMOVES +29 VDC FROM THE 14-WATT POWER DISSIPATION RESISTOR.

060 PCU 1 SEL

THIS CMD ACTUATES RELAY K-01, IN THE PCU, WHICH APPLIES +16 VDC FROM THE RTG TO PCU 1 AND SIMULTANEOUSLY DEENERGIZES PCU 2. PCU 1 IS PRESET TO BE ENERGIZED AT INITIAL LUNAR ACTIVATION. NOTE THAT THERE IS AN AUTOMATIC SWITCH-OVER 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. IN THE EVENT AUTOMATIC SWITCH-OVER TO PCU 2 HAS OCCURRED, THIS COMMAND MUST BE FLAGGED AS HIGHLY CRITICAL. THE CAUSE OF THE SWITCH-OVER MUST BE DETERMINED BEFORE THIS COMMAND IS EXECUTED.

7759-6307B

EPS COMMANDS (CONT)

062 PCU 2 SEL

THIS CMD ACTUATES RELAY K-01, IN THE PCU, WHICH APPLIES +16 VDC FROM THE RTG TO PCU 2 AND SIMULTANEOUSLY DEENERGIZES PCU 1. NOTE THAT AT THE TIME OF LUNAR ACTIVATION, PCU 2 IS DEENERGIZED, WITH NO MEANS TO DETERMINE ITS CONDITION. FURTHER NOTE THAT THERE IS NO AUTOMATIC SWITCH-OVER 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.

7759-6307C

PCU DESIGN FEATURES

1. SHUNT REGULATOR
   - PROVIDES LOAD FOR RTG
   - ALL POWER IN THE REGULATOR IS AVAILABLE ON DEMAND
2. STORAGE TIME COMPENSATION
   - REDUCES LOSSES
   - REDUCES RIPPLE
   - REDUCES FILTER SIZE
3. HIGH FREQUENCY OSCILLATION
   - REDUCES SIZE AND WEIGHT

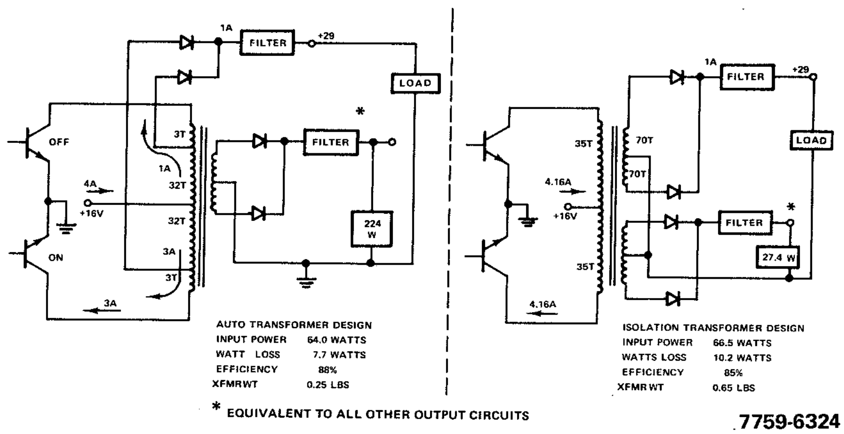
7759-6325

PCU DESIGN FEATURES (CONT')

4. AUTOTRANSFORMER FOR +29 VOLT LINE
   - IMPROVES EFFICIENCY AND REDUCES SIZE AND WEIGHT COMPARED TO CONVENTIONAL ISOLATION TRANSFORMER DESIGN (NET IMPROVEMENT; 1.0 LBS AND 2.5 WATTS FOR ALSEP PCU)
   - IMPOSES CONSTRAINTS TO THE DESIGN
     a. ISOLATION IMPOSSIBLE
     b. POSITIVE VOLTAGE MUST BE GREATER THAN THE INPUT VOLTAGE, ASSUMING A BALANCED OUTPUT
     c. NEGATIVE VOLTAGE RESULTS IN A DISADVANTAGE
     d. MAX ADVANTAGE AT INPUT VOLTAGE - DIMINISHES AS OUTPUT VOLTAGE INCREASES

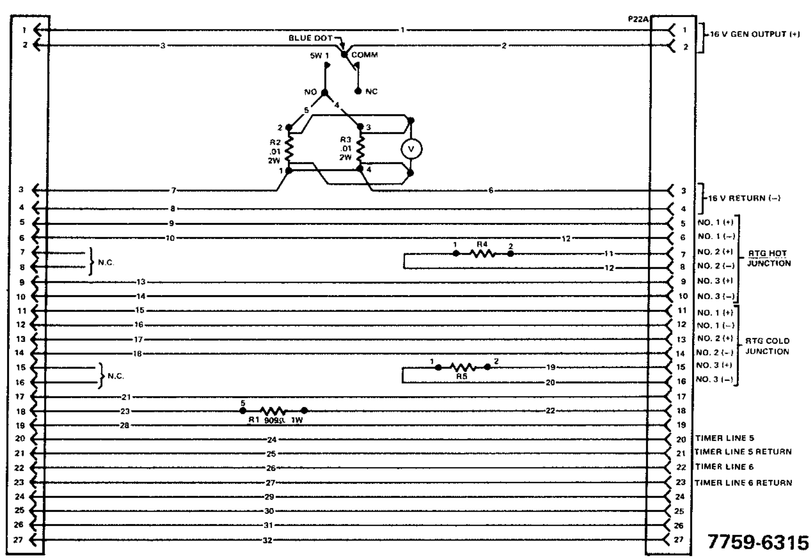
7759-6326

PCU–COMPARISON OF AUTOTRANSFORMER AND ISOLATION TRANSFORMER DESIGN {OUTPUT POWER IDENTICAL}



7759-6324

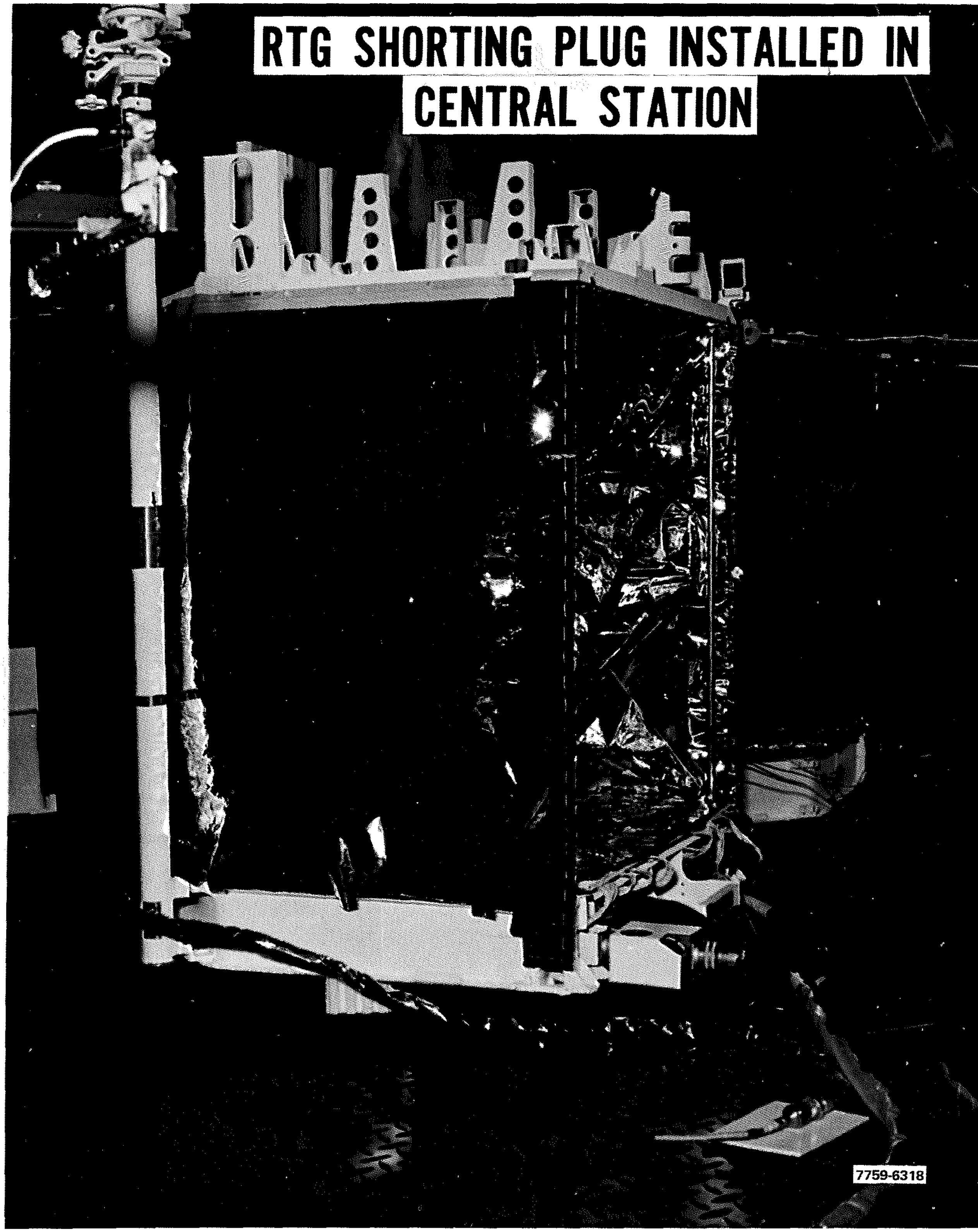
SHORTING PLUG SCHEMATIC – FLIGHT 1



7759-6315

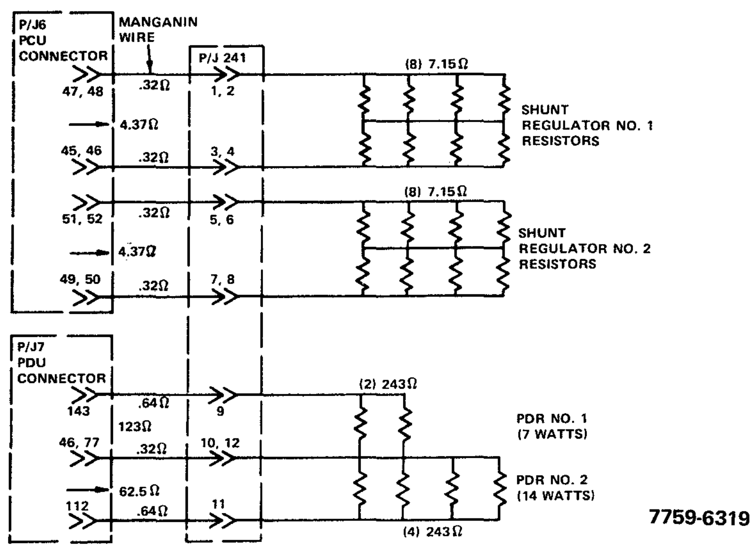
RTG SHORTING PLUG-TOP VIEW


RTG SHORTING PLUG-SIDE VIEW
7759-6317

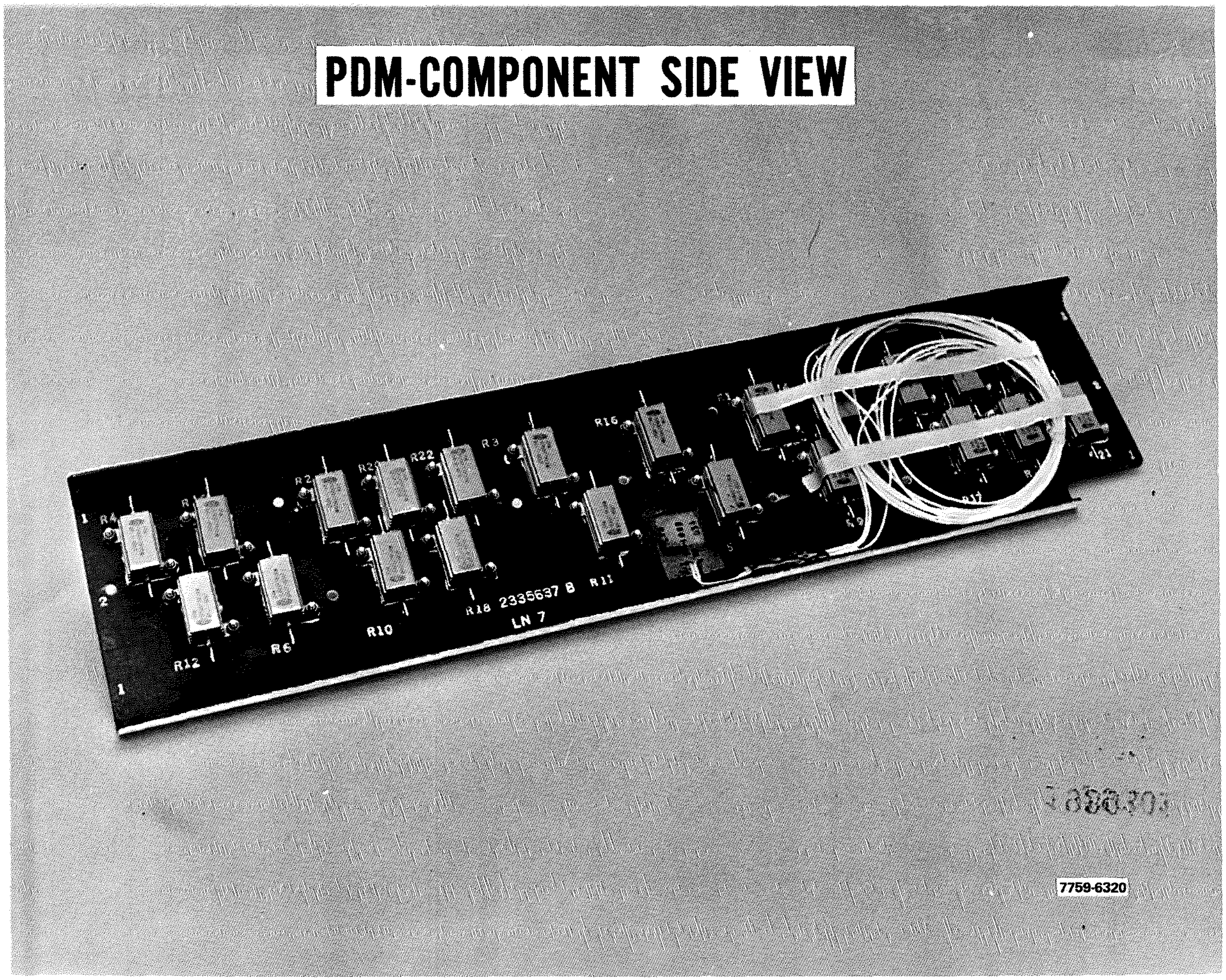


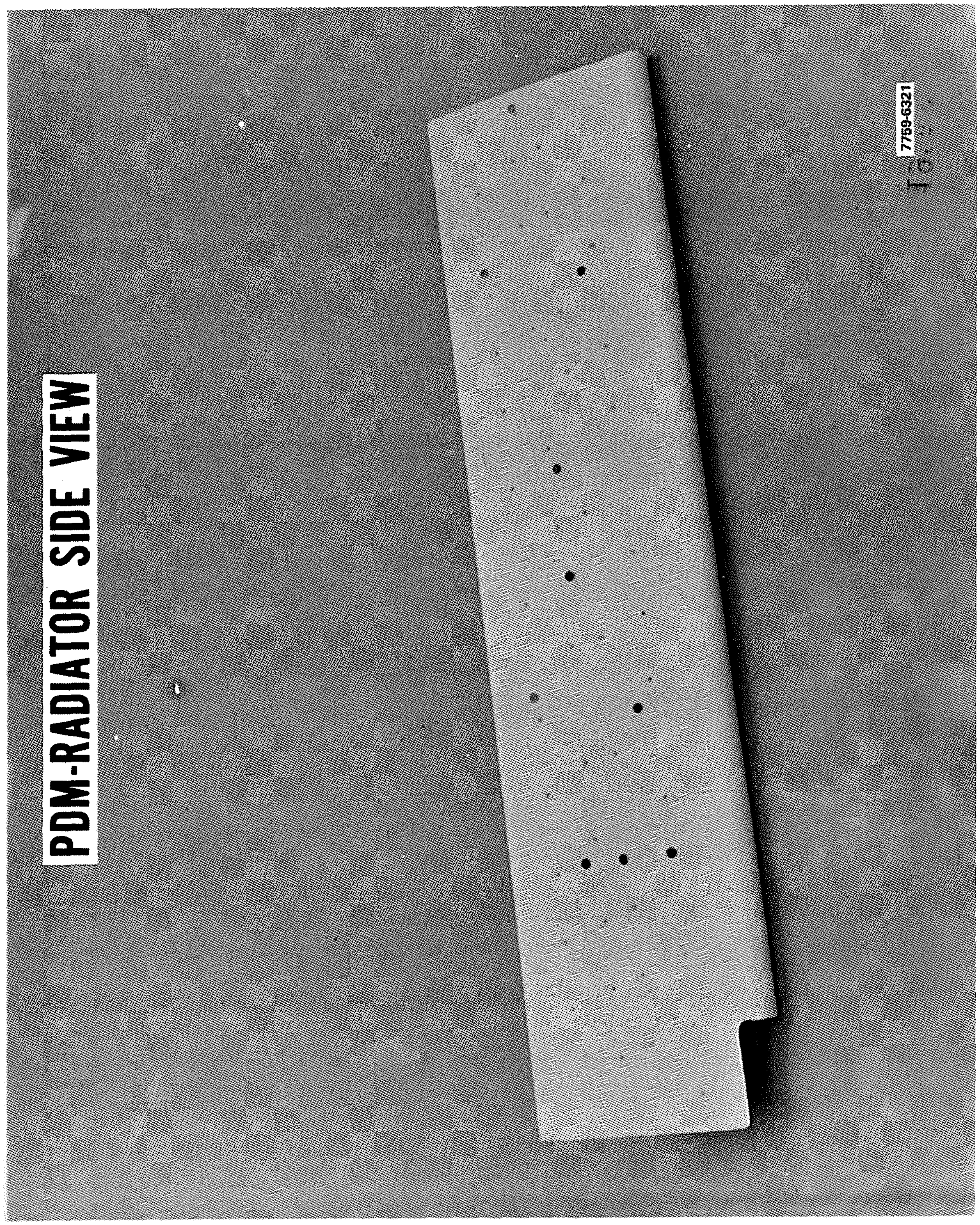
RTG SHORTING PLUG INSTALLED IN CENTRAL STATION

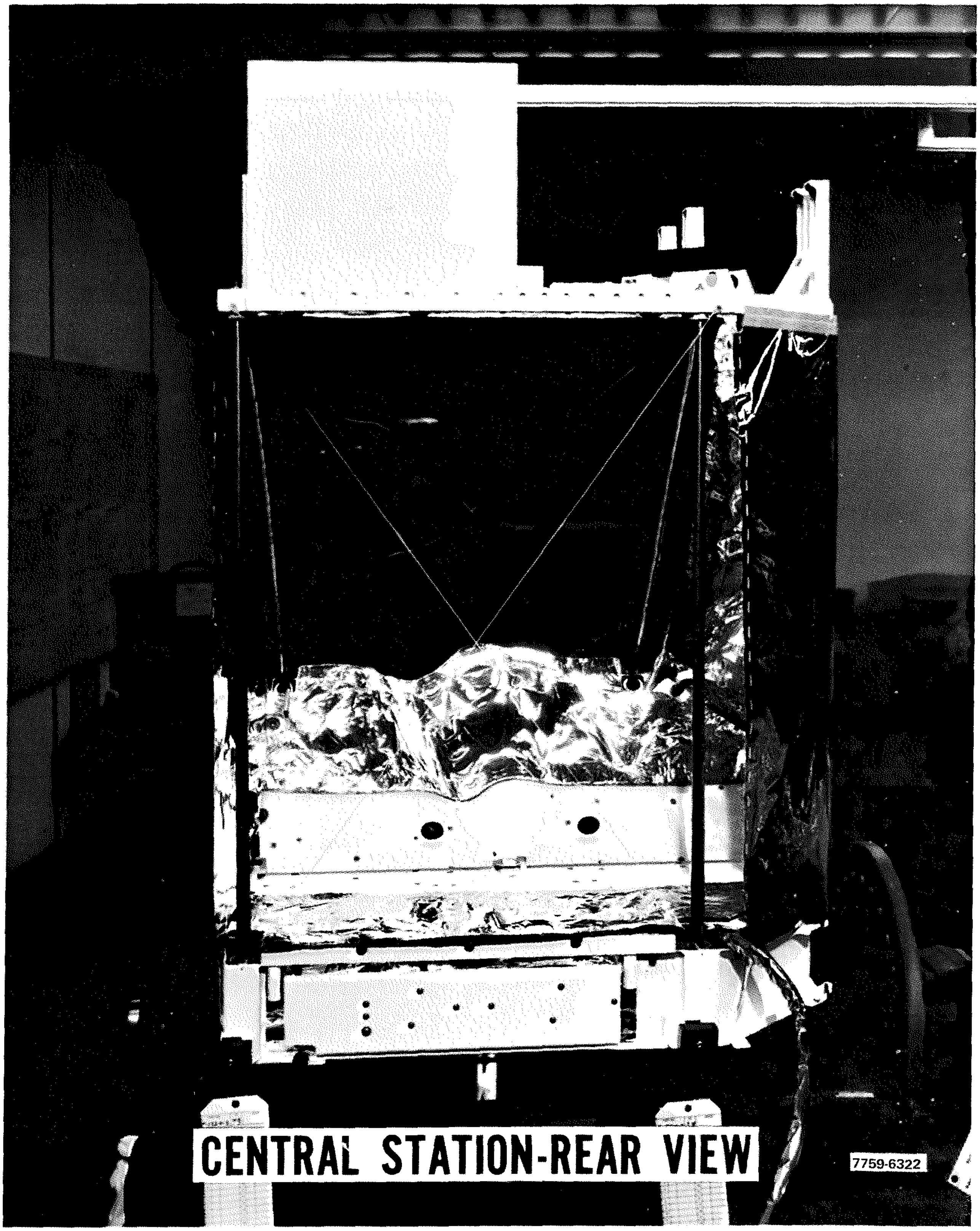
PDM-SCHEMATIC



7759-6319


PDM-COMPONENT SIDE VIEW
R18 2335637 B
LN 7
R16
R11
R3
R22
R10
R6
R12
R4
7759-6320


PDM-RADIATOR SIDE VIEW
7759-6321



CENTRAL STATION-REAR VIEW

Section 12

Alsep Test Program

ALSEP TEST PROGRAM

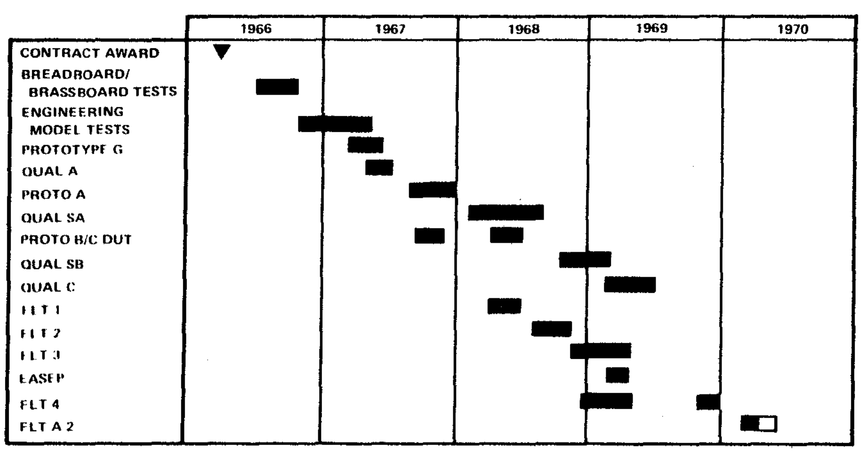
ALSEP TEST PROGRAM - THREE PHASES

1. ENGINEERING EVALUATION - ENGINEERING, PROTOTYPE TESTS
2. FORMAL SYSTEM PERFORMANCE VERIFICATION TESTS - QUALIFICATION TESTS
3. FORMAL SYSTEM ACCEPTANCE TESTING - FLIGHT ACCEPTANCE TESTS

7759-6400

ALSEP TEST PROGRAM

TEST SCHEDULE



7759-6401

12-1

ALSEP TEST PROGRAM

ENGINEERING EVALUATION TESTS

1) PART - DEVICE TESTS
2) CENTRAL STATION COMPONENT - PCU, PDU, DP, CD, ETC.
   - BREADBOARD
   - BRASSBOARD
   - ENGINEERING MODEL
   - PROTOTYPE
3) EXPERIMENT
   - DEVELOPMENT - BREADBOARD, STRUCTURAL/THERMAL
   - ENGINEERING MODEL - DVT
   - PROTOTYPE
4) SYSTEM LEVEL TESTS
   - ENGINEERING STRUCTURAL/THERMAL MODELS
   - ENGINEERING MODEL
   - PROTOTYPE MODEL
     - PROTO G
     - PROTO A
     - PROTO B
     - PROTO C

7759-6402

ALSEP TEST PROGRAM

SYSTEM PERFORMANCE VERIFICATION TESTS - QUALIFICATION

1) CENTRAL STATION COMPONENT
   - PRE-INTEGRATION ACCEPTANCE (PIA) TESTS
2) EXPERIMENTS
   - PRE-INTEGRATION ACCEPTANCE (PIA) TESTS
3) CENTRAL STATION
   - CENTRAL STATION INTEGRATION
   - CENTRAL STATION VERIFICATION
4) SYSTEM
   - EXPERIMENT INTEGRATION TESTS (EIT)
   - ACCEPTANCE TESTS
   - DESIGN LIMIT TESTS
   - MISSION SIMULATION TESTS
5) QUALIFICATION MODELS
   - QUAL SA
   - QUAL B
   - QUAL C
   - EASEP - LRRR AND PSEP

7756-6403

ALSEP TEST PROGRAM

SYSTEM ACCEPTANCE TESTS - FLIGHT ACCEPTANCE TESTS

1) CENTRAL STATION COMPONENTS
   - COMPONENT PIA
2) EXPERIMENTS
   - EXPERIMENT PIA
3) CENTRAL STATION
   - CENTRAL STATION INTEGRATION
   - CENTRAL STATION VERIFICATION
4) SYSTEM
   - EXPERIMENT INTEGRATION TESTS (EIT)
   - FLIGHT ACCEPTANCE TESTS
5) FLIGHT MODELS
   - FLIGHTS 1, 2, 3, AND 4
   - FLIGHT A-2
   - EASEP - LRRR AND PSEP

7759-6404

ALSEP TEST PROGRAM

COMPONENT QUALIFICATION TESTS - NEW A-2, D COMPONENTS

- TIMER, RSST
- MULTIPLEXER
- TRANSMITTERS
- RECEIVER

COMPONENT LEVEL TESTING

- BREADBOARD - BRASSBOARD
- ENGINEERING MODEL - DVT
- PROTOTYPE
- QUALIFICATION
- FLIGHT

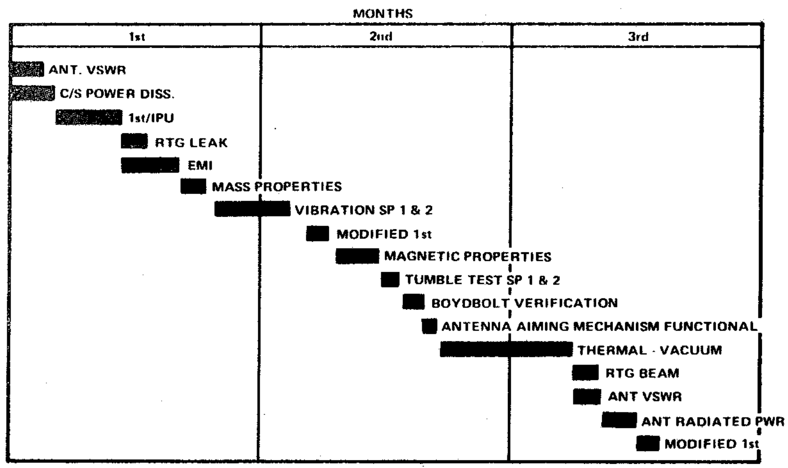
COMPONENT FLIGHT SPARE TESTING

- ACCEPTANCE
  - FUNCTIONAL
  - VIBRATION
  - -22^{o}F TO 158^{o}F FUNCTIONAL

7759-6405

ALSEP TEST PROGRAM

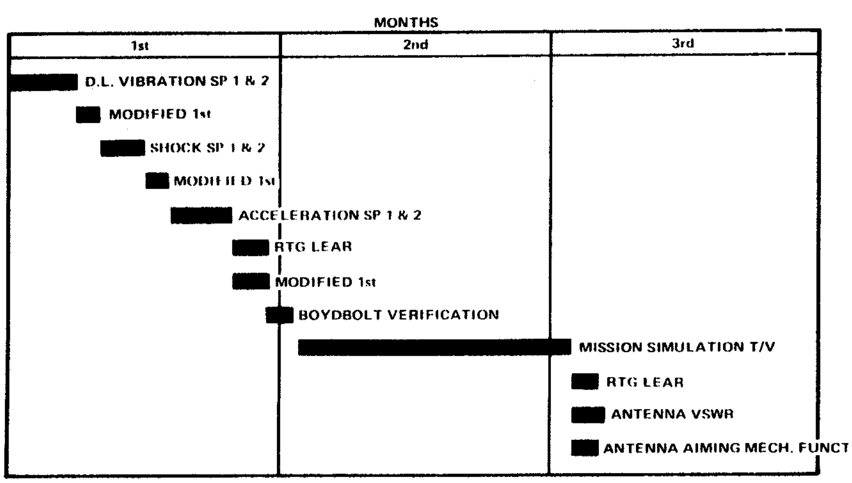
TYPICAL ACCEPTANCE TEST SCHEDULE



7759-6406

ALSEP TEST PROGRAM

TYPICAL QUALIFICATION (DESIGN LIMIT) TEST SCHEDULE



7759-6407

ASLEP TEST PROGRAM

TEST PROGRAM DOCUMENTATION

1) TEST PROCEDURES — ALL QUAL AND FLIGHT PROCEDURES ARE TYPE I DOCUMENTS

   ALL ENGINEERING AND PROTOTYPE PROCEDURES ARE TYPE II DOCUMENTS

   CHANGES BY APPROVED VARIATIONS AND CRD/ECN

2) PRE AND POST TEST MEETINGS - EACH TEST

3) QTRR AND QAR FOR QUALIFICATION

4) FTRR AND CARR FOR EACH FLIGHT MODEL

5) DISCREPANCY REPORTS, FAILURE REPORTS, FAILURE ANALYSIS REPORTS

6) TEST REPORTS

   FLIGHT - PRE AND POST TEST MEETING MINUTES, AS RUN TEST PROCEDURES, DISCREPANCY REPORTS

   QUAL - SAME AS FLIGHT PLUS ENGINEERING ANALYSIS

7759-6408

ALSEP CASK ASSEMBLY TEST PROGRAM MATRIX

ACCEPTANCE	FLIGHT QUALIFICATION MODEL	FLIGHT 1	FLIGHT SPARE	FLIGHT 2	FLIGHT 3	FLIGHT 4	D2/M5 QUAL	D2/M5 FLIGHT
ASSEMBLY OF ACA & INSTRUMENTATION INSTALLATION	X	X	X	X	X	X	X	X
WEIGHT & CG	X	X	X	X	X	X	X	X
LAUNCH VIBRATION	X	X	X	X	X	X	X	X
FUNCTIONAL TILT TEST	X	X	X	X	X	X		
INSPECTION	X	X	X	X	X	X	X	X
QUALIFICATION								
INSTRUMENTATION INSTALLATION	X						X	
ON-PAD COOLING SIM	X							
THERMAL VAC SLA ON	X							
THERMAL VAC SLA OFF	X							
SLA OFF SOLAR SIM ON	X							
INSPECTION	X							
Z LAUNCH VIBRATION	X						X	
Y LAUNCH VIBRATION	X						X	
X LAUNCH VIBRATION	X						X	
X LUNAR DESCENT	X							
X SHOCK	X							
Y LUNAR DESCENT	X							
Y SHOCK	X							
Z LUNAR DESCENT	X							
Z SHOCK	X							
FUNCTIONAL TILT	X							
INSPECTION	X						X	

77596432

ALSEP TEST PROGRAM

CENTRAL STATION POWER DISSIPATION

- OBJECTIVE
  - OBTAIN CENTRAL STATION POWER CHARACTERIZATION
- TEST ITEM
  - CENTRAL STATION
- TEST METHOD
  - CENTRAL STATION POWER CONSUMPTION UNDER VARIABLE LOADS
  - CALIBRATE HK-1 AGAINST ACTUAL INPUT VOLTAGE
  - CALIBRATE HK-5 AGAINST ACTUAL INPUT CURRENT
  - DETERMINE RANGE OF SHUNT REGULATORS IN PCU'S
  - CALIBRATE HK-8 AND HK-13 AGAINST ACTUAL SHUNT REGULATOR CURRENTS
  - MEASURE COMMANDABLE HEATER POWER AND PDM POWER
  - VERIFY RIPPLE OFF CIRCUITRY

7759-6409

ALSEP TEST PROGRAM

AMBIENT 1ST

- OBJECTIVES

  ASSURE CORRECT FUNCTIONAL PERFORMANCE OF ALSEP AS A SYSTEM: CENTRAL STATION, ALL EXPERIMENTS AND RTG

  OBTAIN A BASELINE SYSTEM TEST PRIOR TO SUBSEQUENT ENVIRONMENTAL TESTS
- TEST ITEM

  ALSEP CENTRAL STATION, ALL EXPERIMENTS, RTG
- TEST METHOD

  DRIVE RTG WITH EFC; VERIFY POWER OUTPUT CHARACTERISTICS

  TURN ON CENTRAL STATION, VERIFY PROPER OPERATION AND STATUS

  TURN ON EXPERIMENTS, VERIFY RESPONSE TO COMMANDS AND CORRECT FUNCTION OF EACH EXPERIMENT PRIOR TO TURN ON OF ADDITIONAL EXPERIMENTS

  WITH EXPERIMENTS ON, SEND ALL COMMANDS, VERIFY CORRECT CENTRAL STATION AND EXPERIMENT OPERATION

7759-6410

ALSEP TEST PROGRAM

SYSTEM EMI

- OBJECTIIVE
  - ASSURE ALSEP COMPLIANCE WITH RADIATED AND CONDUCTED SUSCEPTIBILITY AND INTERFERENCE
- TEST ITEM
  - DEPLOYED ALSEP SYSTEM WITH EXPERIMENTS
- TEST METHOD
  - CONDUCTED INTERFERENCE, 15 KHZ TO 25 MHZ
  - CONDUCTED SUSCEPTIBILITY, 50 HZ TO 250 MHZ
  - RADIATED INTERFERENCE, 150 KHZ TO 10 GC
  - RADIATED SUSCEPTIBILITY, 15 KHZ TO 10 GC
  - TRANSIENT CONDUCTED 7.5 V, 10μ SEC, PULSES
  - RECEIVER REJECTION, 150 KHZ TO 10 GHZ

7759-6411

ALSEP TEST PROGRAM

SYSTEM STRAY FIELD MAGNETIC PROPERTIES

- OBJECTIVE

  ESTABLISH THAT MAGNETIC FIELDS PRODUCED BY ALSEP WILL BE $\leq$ 0.25 GAMMA AT THE LOCATION OF LSM
- TEST ITEM

  DEPLOYED ALSEP SYSTEM
- REQUIREMENT

  $<$ 0.25 GAMMA AT LSM, NORMALLY DEPLOYED (50 FEET)

  $<$ 10 GAMMA AT 10 FEET, AS TESTED
- TEST METHOD

  CENTRAL STATION, SWS, SIDE, PSE SETUP IN CHAMBER PER EMI TEST LAYOUT, TEST MAGNETOMETER PROBE AT LSM POSITION (10 FEET FROM CENTRAL STATION)

  X, Y, Z STRAY FIELDS MEASURED WITH CENTRAL STATION ON, EXPERIMENTS IN STANDBY, EXPERIMENTS TURNED ON IN SEQUENCE

  CHAMBER FACILITY CALIBRATED (EMPTY) WITH TEST MAGNETOMETER PROBE TO ADJUST FOR DISTORTION PRODUCED BY CHAMBER

7759-6412

ALSEP TEST PROGRAM

STOWED MAGNETIC PROPERTIES

- OBJECTIVE
  - DETERMINE THE PERMANENT AND REMANENT MAGNETIC FIELDS OF ALSEP
- TEST ITEM
  - SUBPACKAGES 1 AND 2 STOWED
- TEST REQUIREMENTS
  - PERMANENT FIELD AT 10 FEET <10 GAMMA
  - REMANENT FIELD AT 10 FEET <50 GAMMA
- TEST METHOD
  - SUBPACKAGE IN HELMHOLTZ COIL
  - DEGAUSS
  - MEASURE PERMANENT FIELD AT 10 FEET, S/P ROTATED IN EACH AXIS
  - STANDARDIZE - APPLY 25 GAUSS D.C. FIELD, EACH AXIS IN TURN
  - MEASURE REMANENT FIELD AT 10 FEET, S/P ROTATED IN EACH AXIS
  - DEGAUSS
  - RE-MEASURE PERMANENT FIELD AT 10 FEET

7759-6413

ALSEP TEST PROGRAM

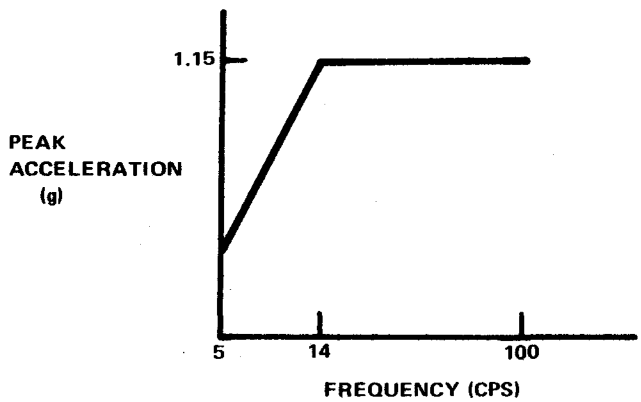
VIBRATION TEST

- OBJECTIVE
  - VERIFY ABILITY OF SUBPACKAGES TO WITHSTAND ACCEPTANCE LEVEL VIBRATIONS
- TEST ITEM
  - SUBPACKAGES 1 AND 2
- TEST METHOD
  - ONE SINE AND TWO RANDOM VIBRATIONS IN EACH OF THE THREE PRINCIPAL ALSEP AXES
  - VISUAL MONITORING DURING TEST AND INSPECTION AT TEST COMPLETION
  - EACH SUBPACKAGE VIBRATED SEPARATELY WHILE NON-OPERATING
  - ACCEPTANCE LEVELS ARE AT ANTICIPATED FLIGHT INDUCED. QUAL LEVELS ARE 1.3 TIMES HIGHER THAN ACCEPTANCE FOR SINE AND $(1.3)^2$ TIMES HIGHER FOR RANDOM

7759-6414

ALSEP TEST PROGRAM

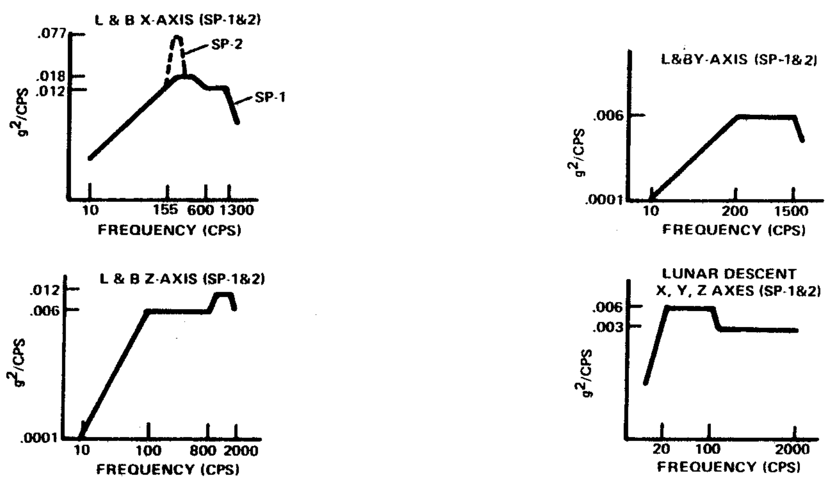
(ALSEP SUBPACKAGES)



7759-6415

ALSEP TEST PROGRAM

(ALSEP SUBPACKAGES)



7759-6416

ALSEP TEST PROGRAM

SHOCK TEST (QUAL ONLY)

- OBJECTIVE
  - VERIFY ABILITY OF SUBPACKAGES TO WITHSTAND QUAL LEVEL SHOCK
- TEST ITEM
  - SUBPACKAGES 1 AND 2
- TEST METHOD
  - 3 SAWTOOTH SHOCK PULSES IN EACH OF THE ±X, ±Y, ±Z ALSEP AXES
  - SHOCK PULSES ARE 15 G, 11 MILLISECONDS, SAWTOOTH PULSES PER MIL-STD-810B
  - EACH SUBPACKAGE TESTED SEPARATELY WHILE NON-OPERATING

7759-6417

ALSEP TEST PROGRAM

ACCELERATION TEST (QUAL ONLY)

- OBJECTIVE
  - VERIFY ABILITY OF SUBPACKAGES TO WITHSTAND QUAL LEVEL ACCELERATION
- TEST ITEM
  - SUBPACKAGES 1 AND 2
- TEST METHOD
  - 14 G ACCELERATION FOR ONE MINUTE IN +X ALSEP AXIS
  - EACH SUBPACKAGE TESTED SEPARATELY WHILE NON-OPERATING

7759-6418

ALSEP TEST PROGRAM

THERMAL VACUUM TEST

- OBJECTIVE
  - TO VERIFY SYSTEM START UP AND OPERATION UNDER SIMULATED LUNAR VACUUM AND TEMPERATURE CONDITIONS
- TEST ITEM
  - DEPLOYED ALSEP SYSTEM WITH RTG

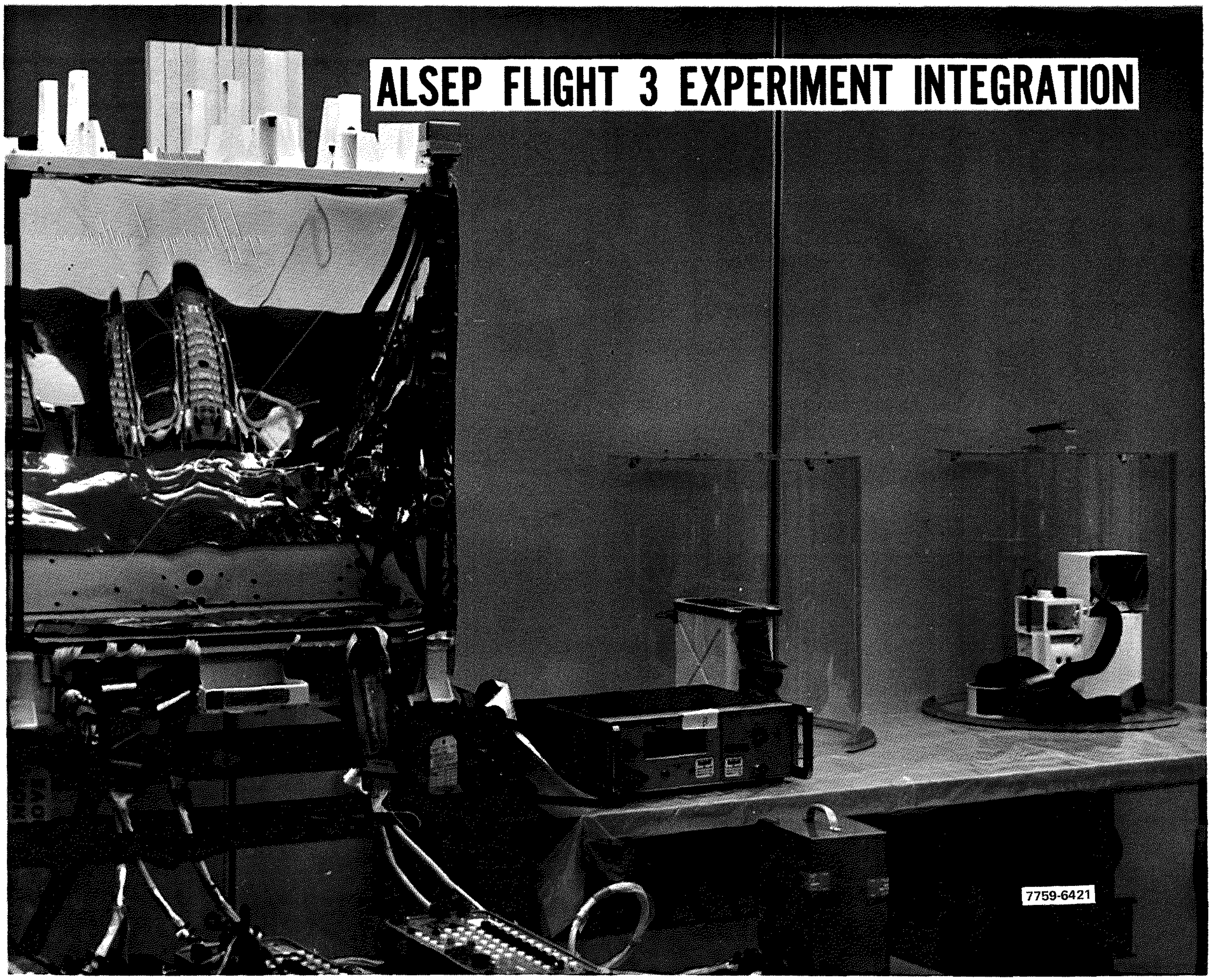
TEST SEQUENCE

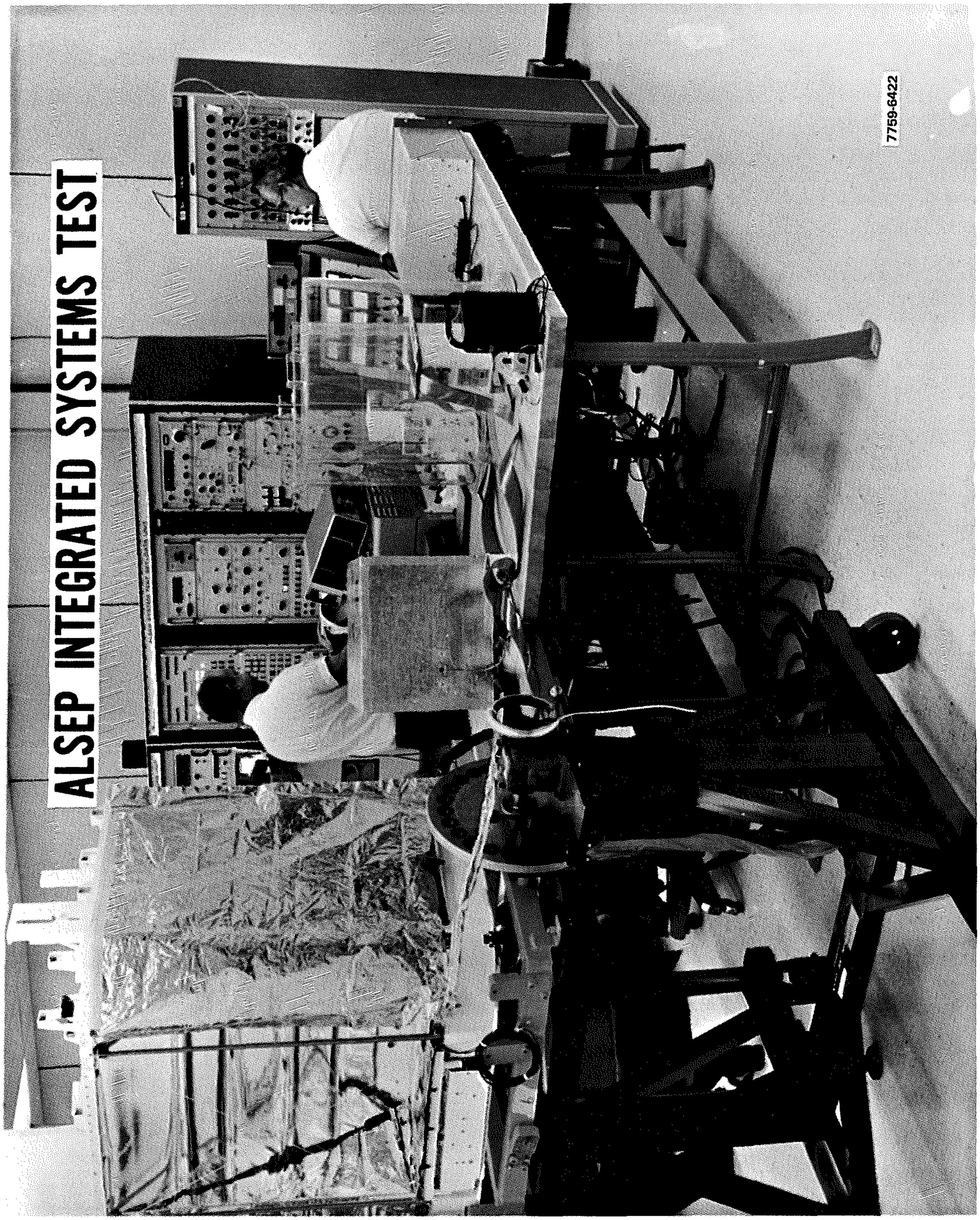
- OPEN DOOR 1ST
- LUNAR MORNING 1ST*
- LUNAR NOON 1ST*
- CROSSTALK TEST*
- LUNAR NIGHT 1ST*
- OPEN DOOR 1ST

*10^{-6} TORR

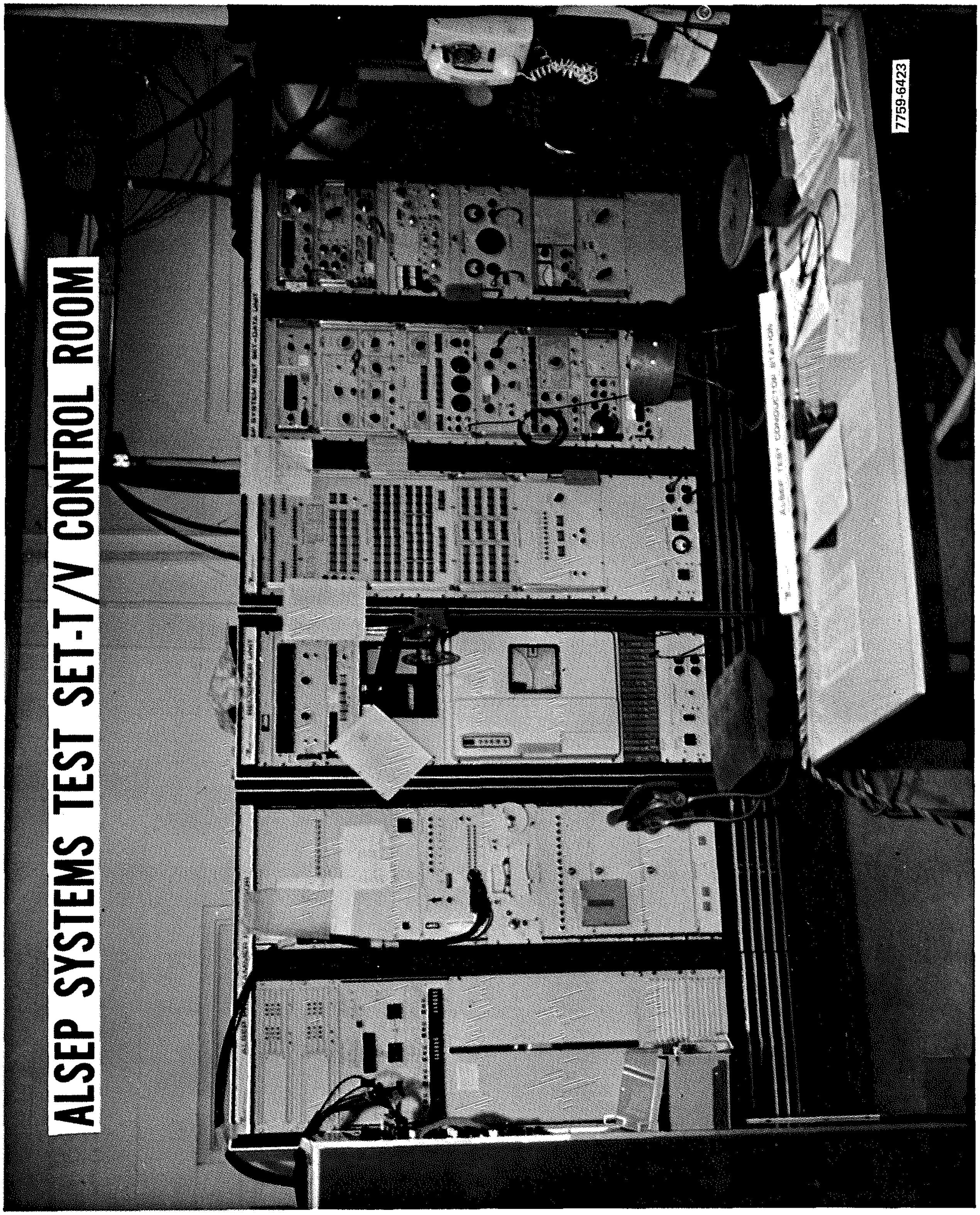
7759-6419

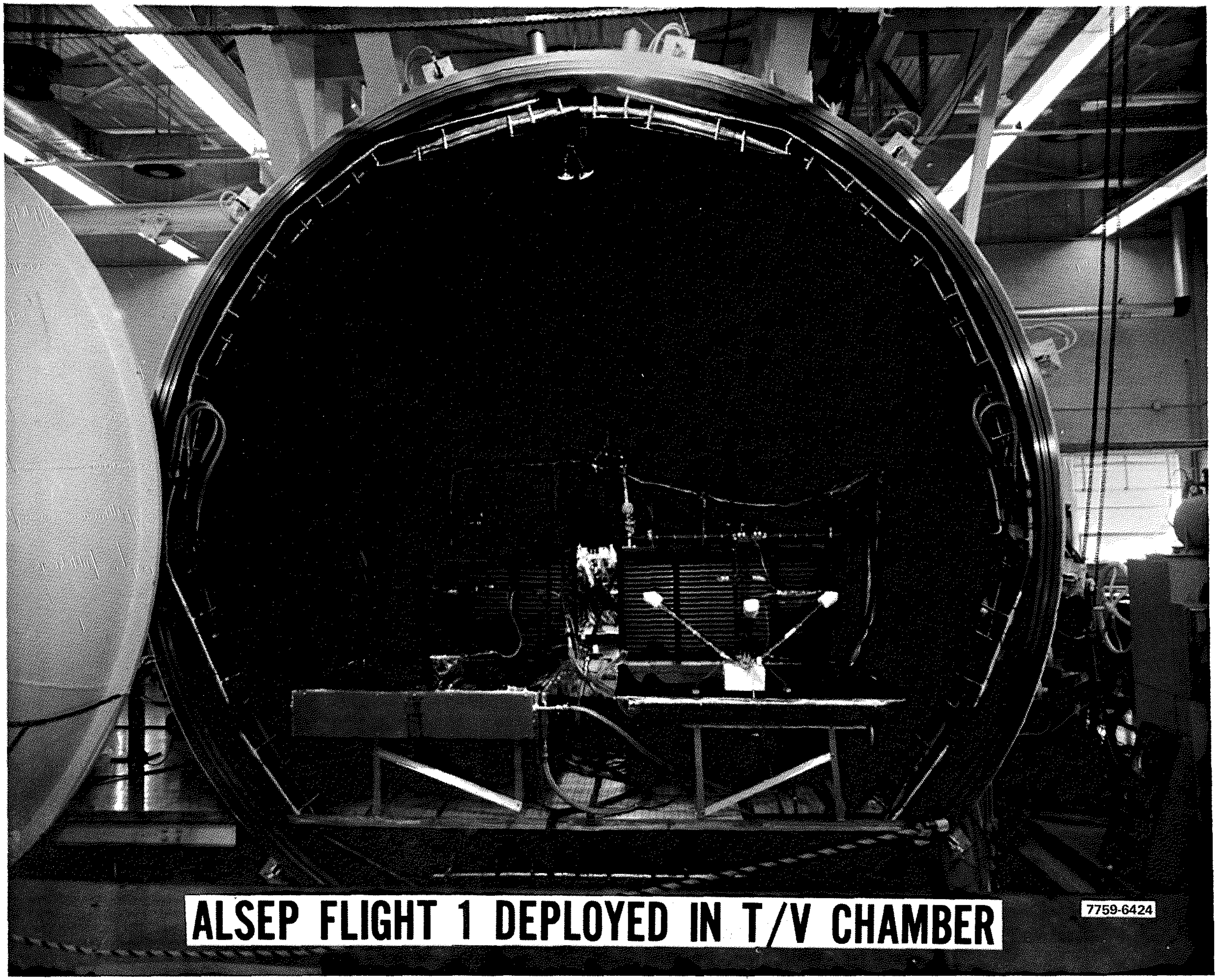

ALSEP FLIGHT I EXPERIMENT INTEGRATION
7759-6420

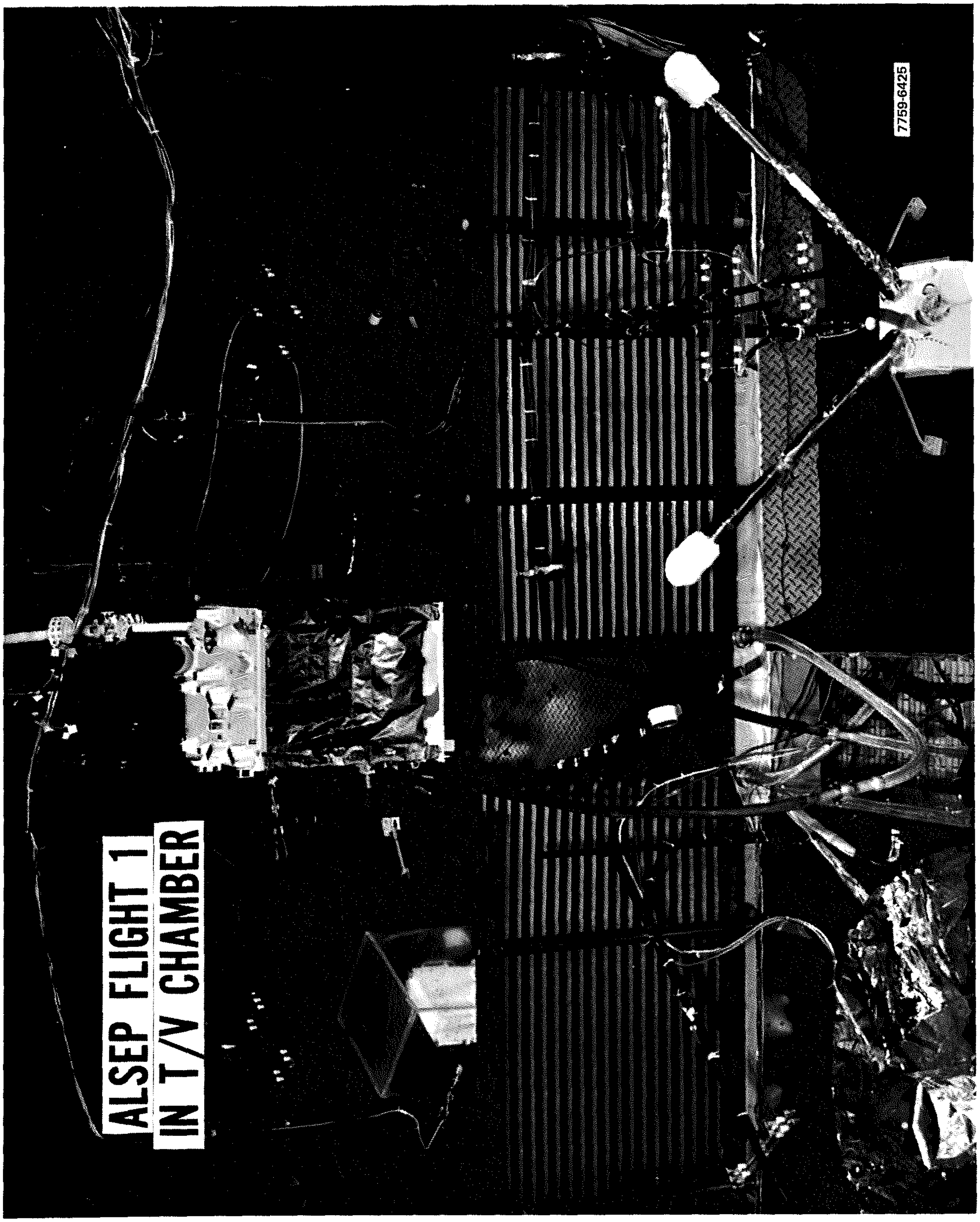

ALSEP FLIGHT 3 EXPERIMENT INTEGRATION
7759-6421

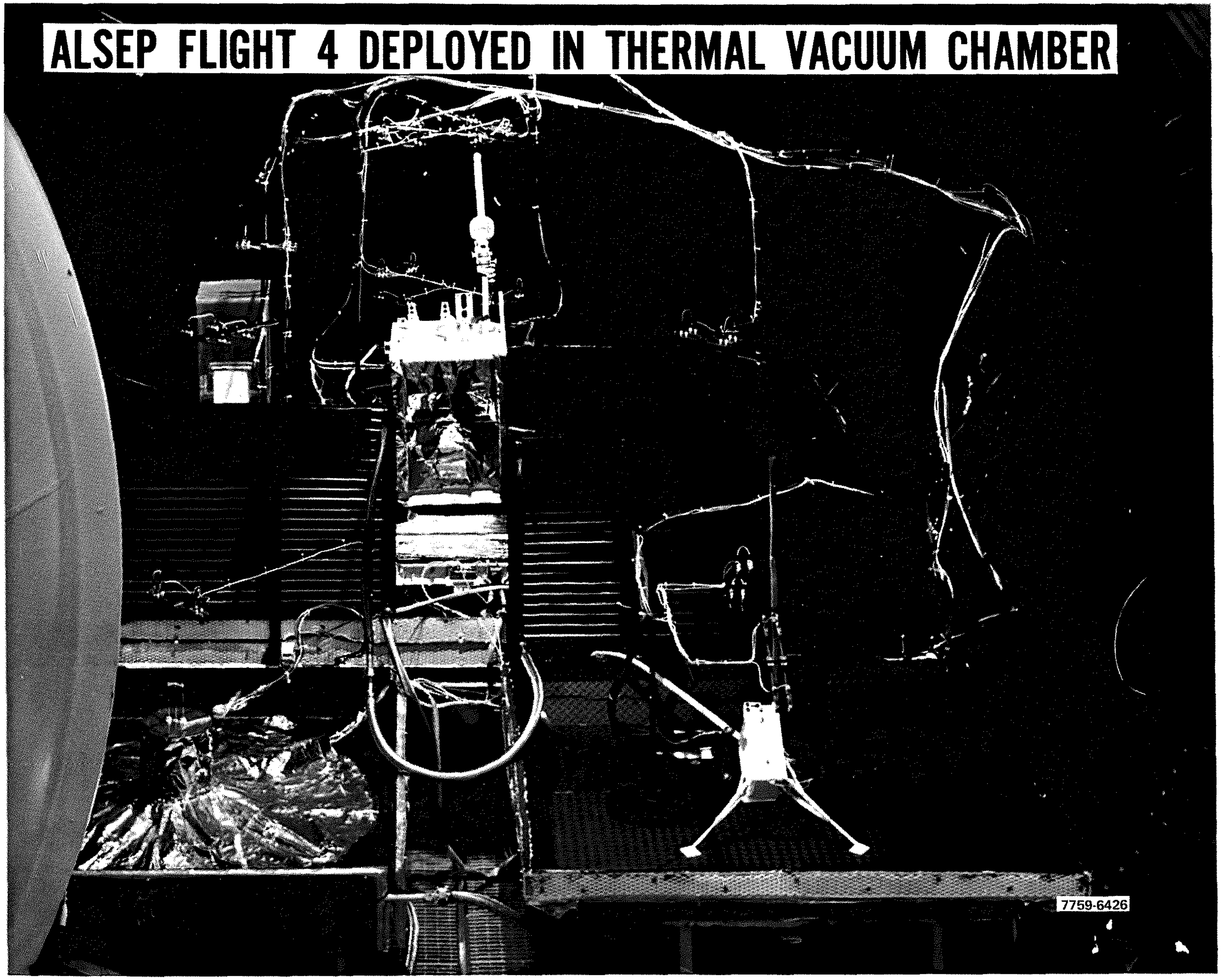


12-14

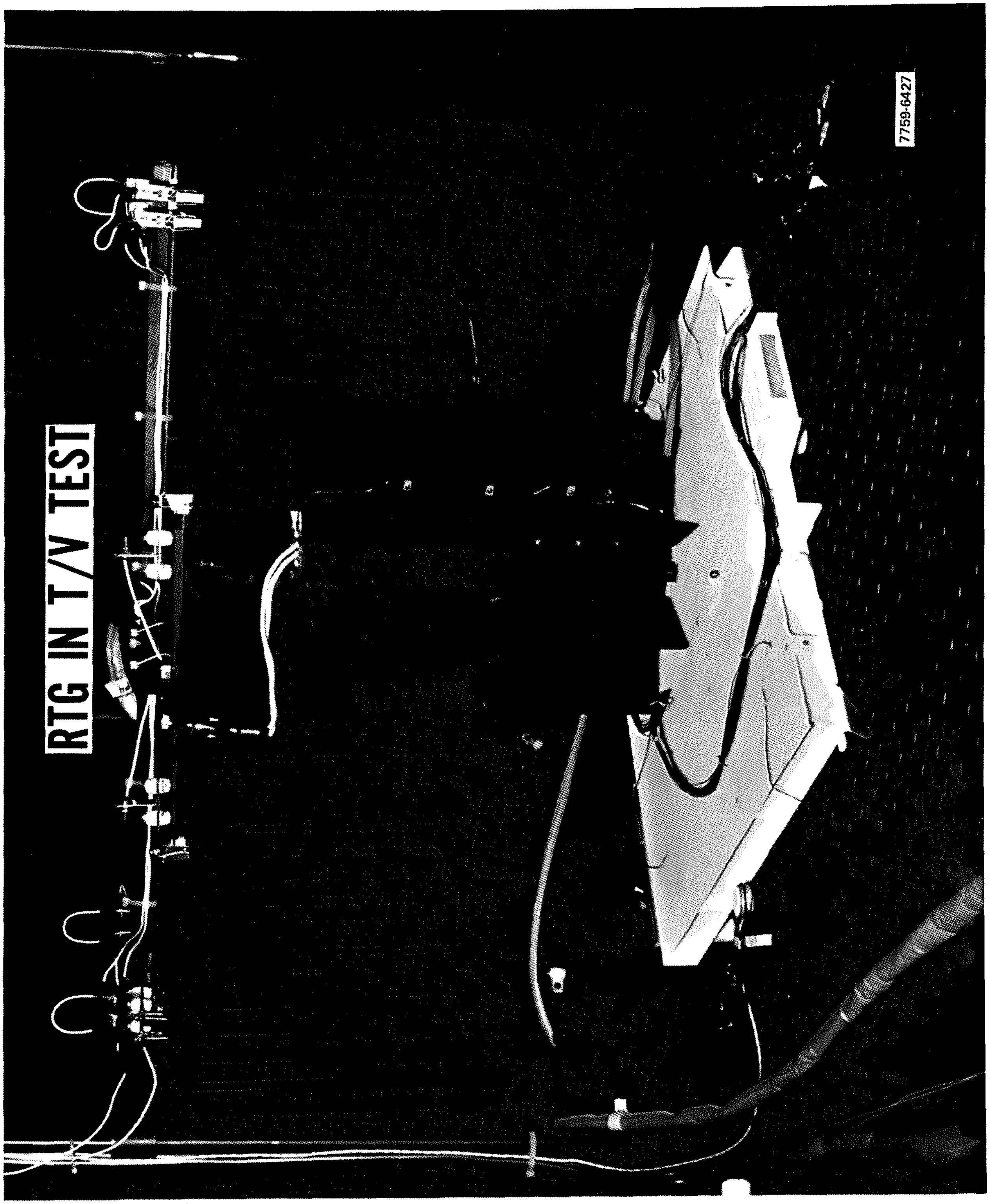

ALSEP SYSTEMS TEST SET-T/V CONTROL ROOM
7759-6423

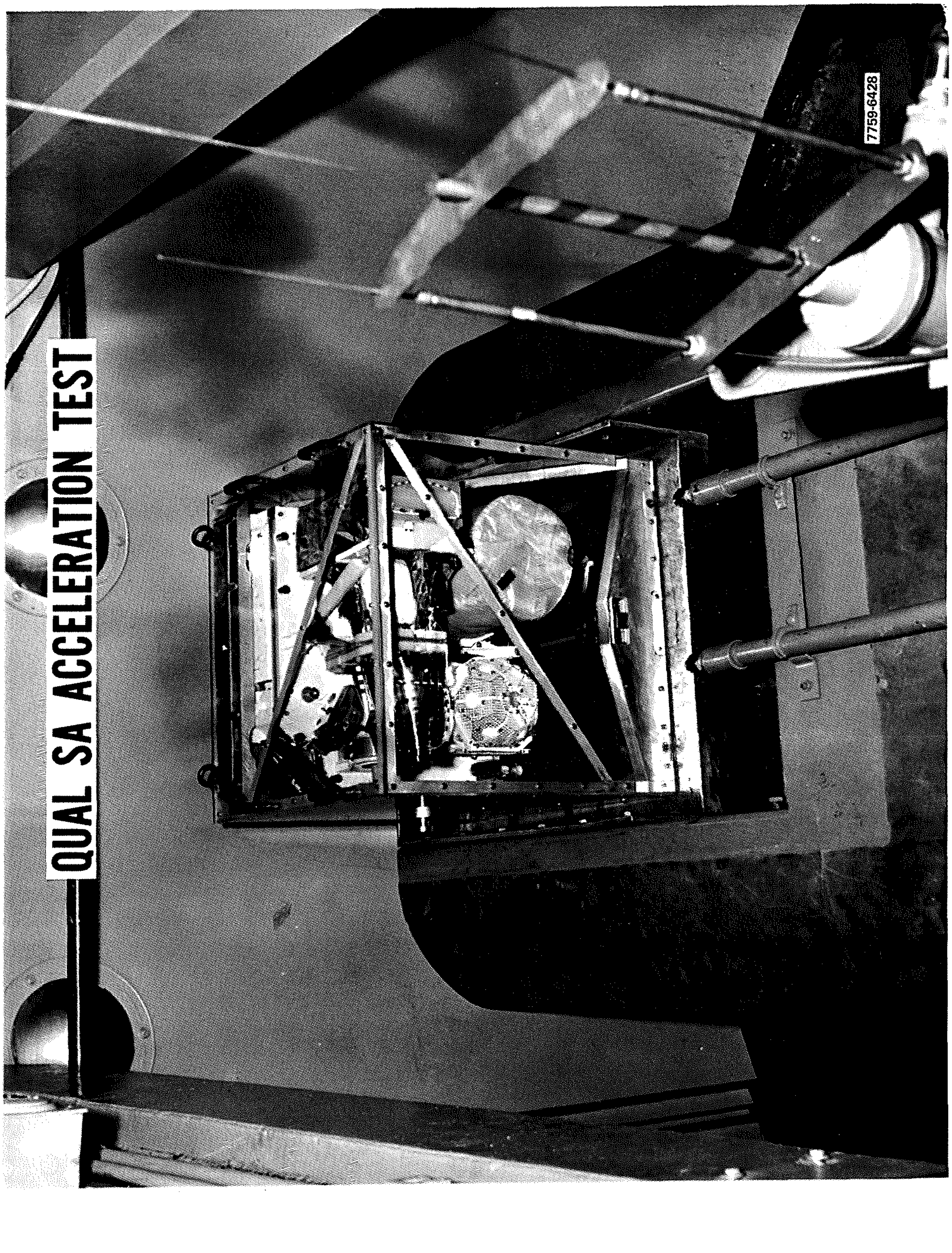

ALSEP FLIGHT 1 DEPLOYED IN T/V CHAMBER
7759-6424

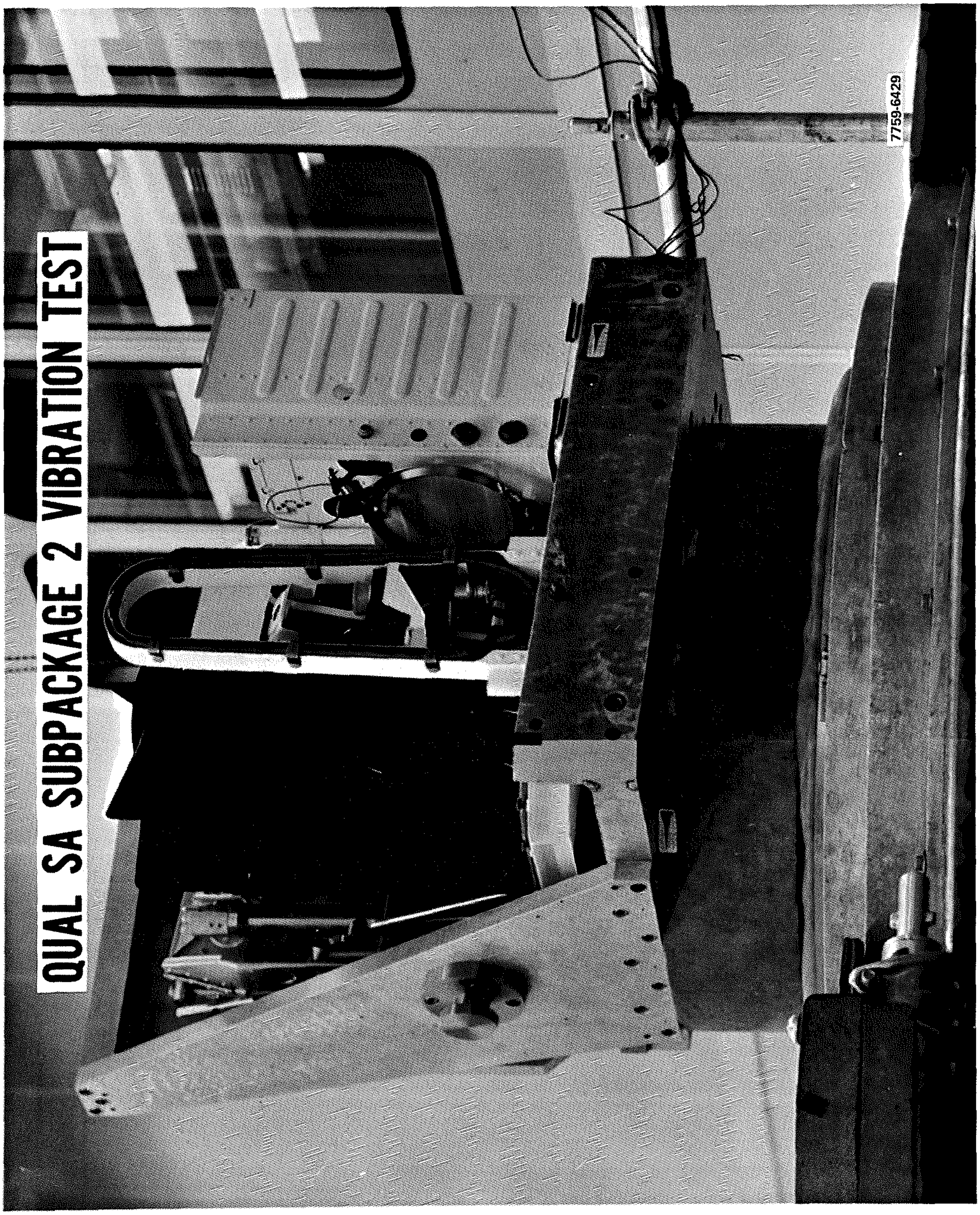

ALSEP FLIGHT 1
IN T/V CHAMBER
7759-6425

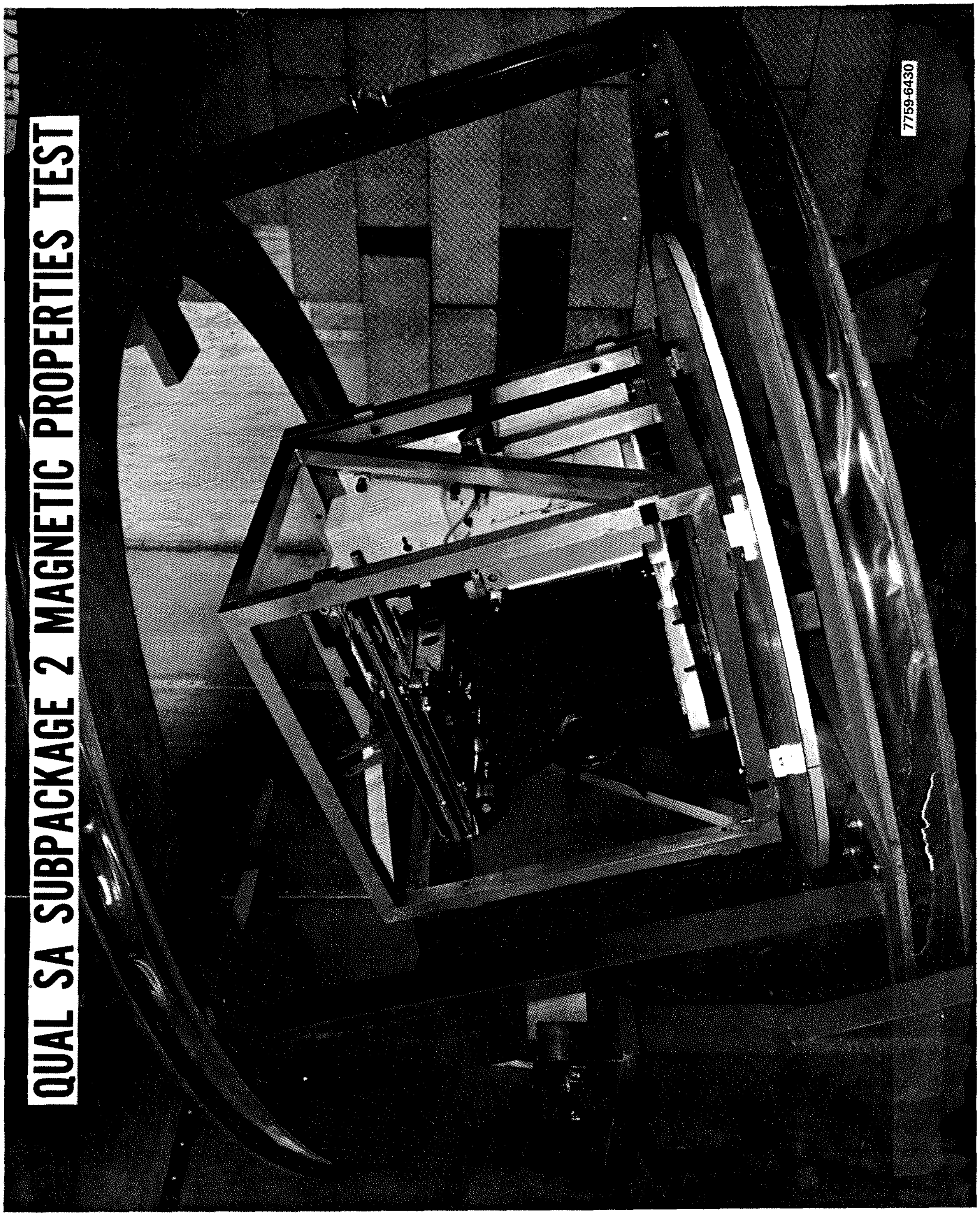


ALSEP FLIGHT 4 DEPLOYED IN THERMAL VACUUM CHAMBER

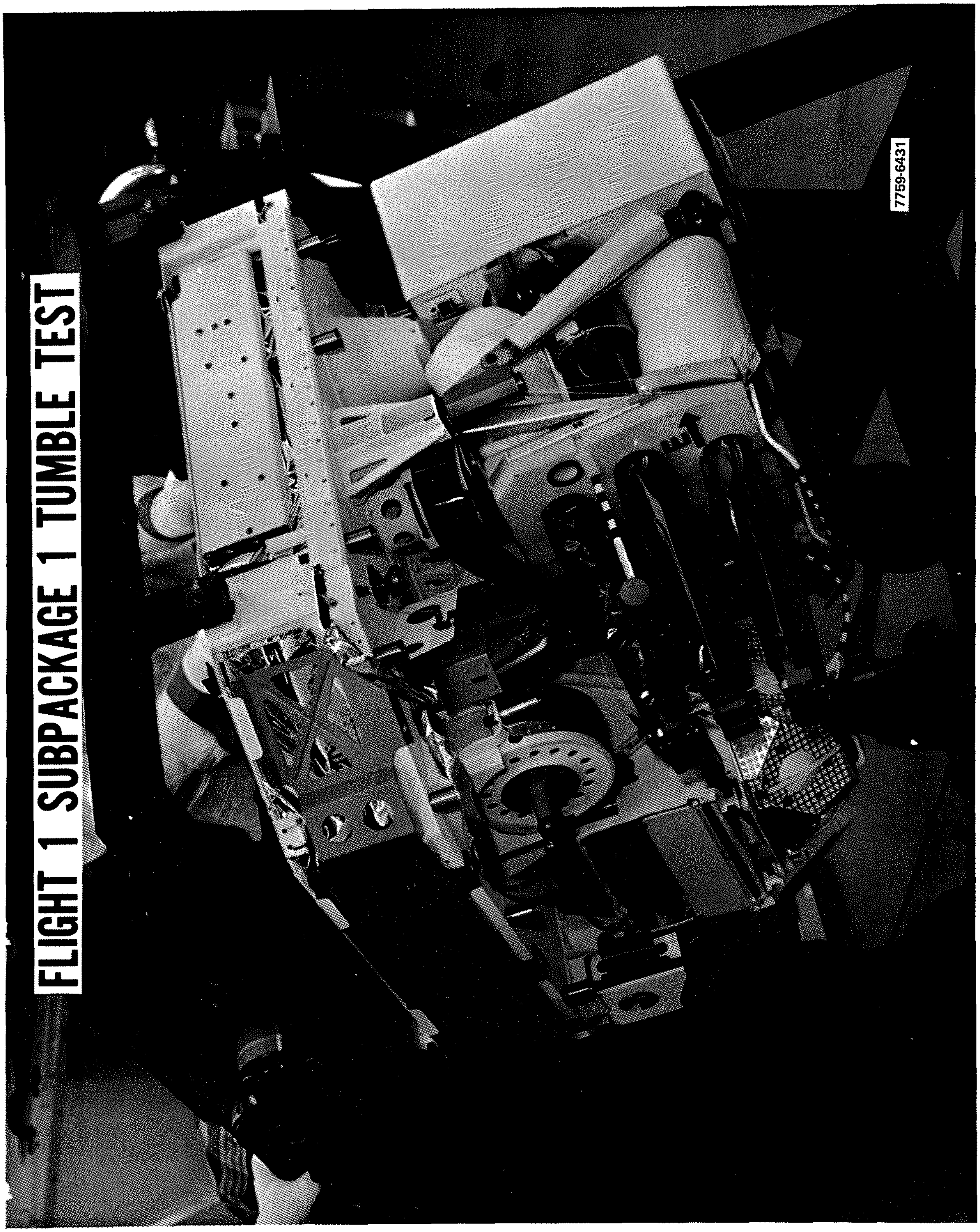

RTG IN T/V TEST
7759-6427


QUAL SA ACCELERATION TEST
7759-6428


QUAL SA SUBPACKAGE 2 VIBRATION TEST
7759-6429



QUAL SA SUBPACKAGE 2 MAGNETIC PROPERTIES TEST


FLIGHT 1 SUBPACKAGE 1 TUMBLE TEST
7759-6431

Section 13

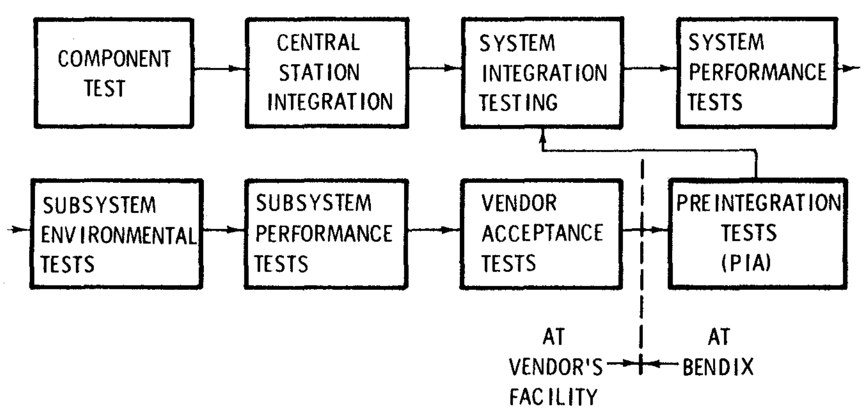
Alsep Test Equipment

ALSEP TEST EQUIPMENT REQUIREMENTS

1. CENTRAL STATION
   - MODULES
   - COMPONENTS
   - DATA SUBSYSTEM
2. EXPERIMENTS
3. SYSTEM

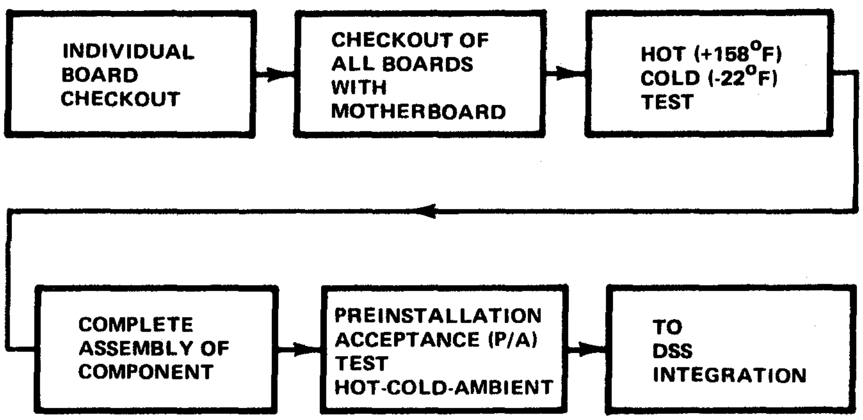
7759-6500

ACCEPTANCE TEST FLOW SUMMARY

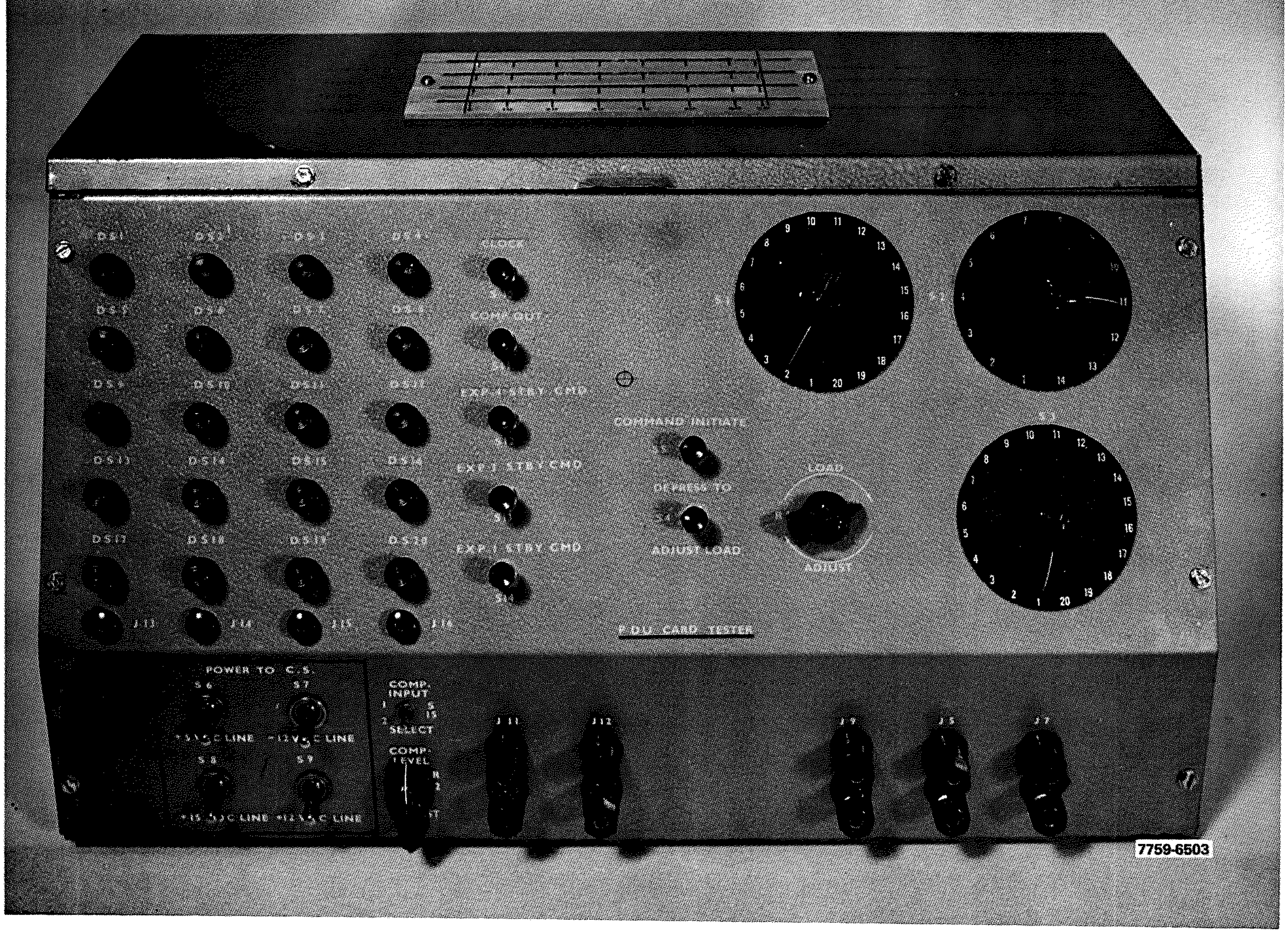


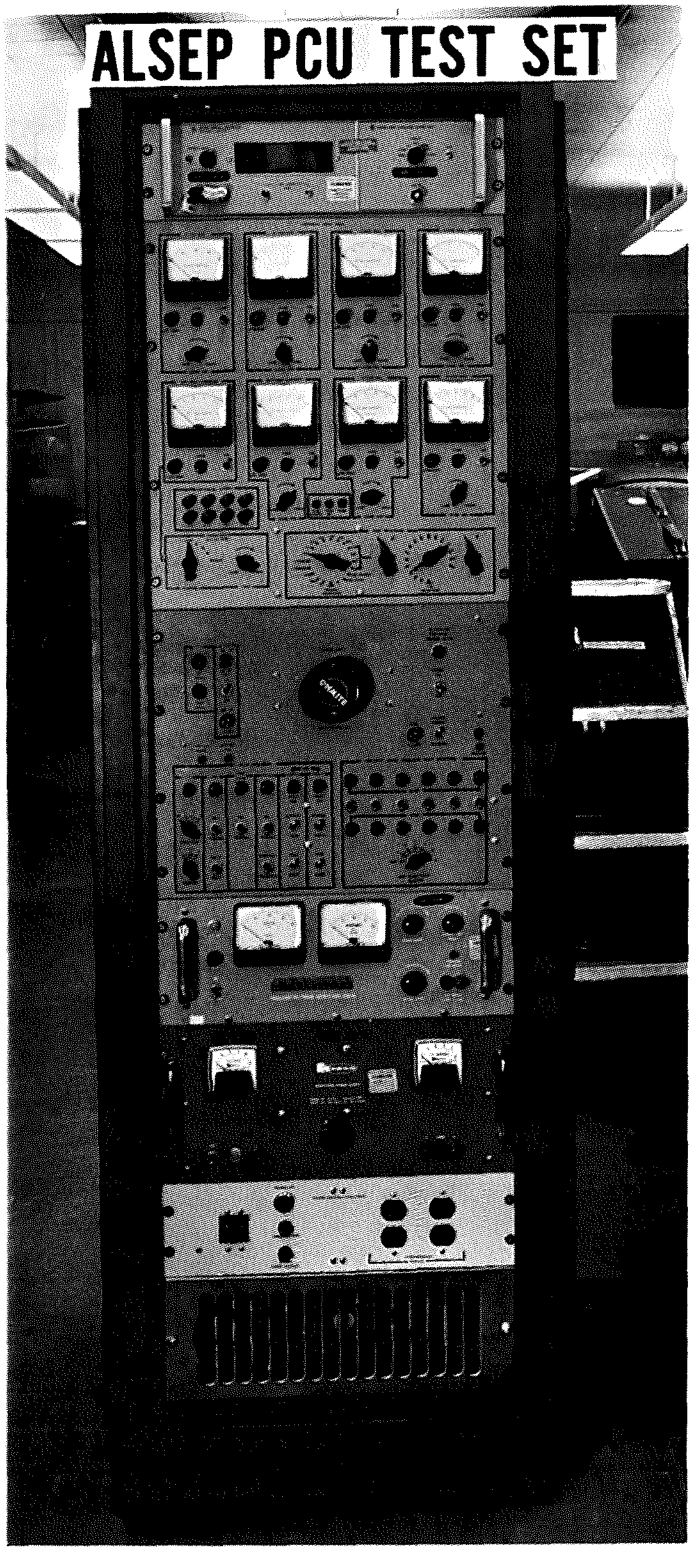
7759-6501

TYPICAL IN-HOUSE COMPONENT FLOW DIAGRAM



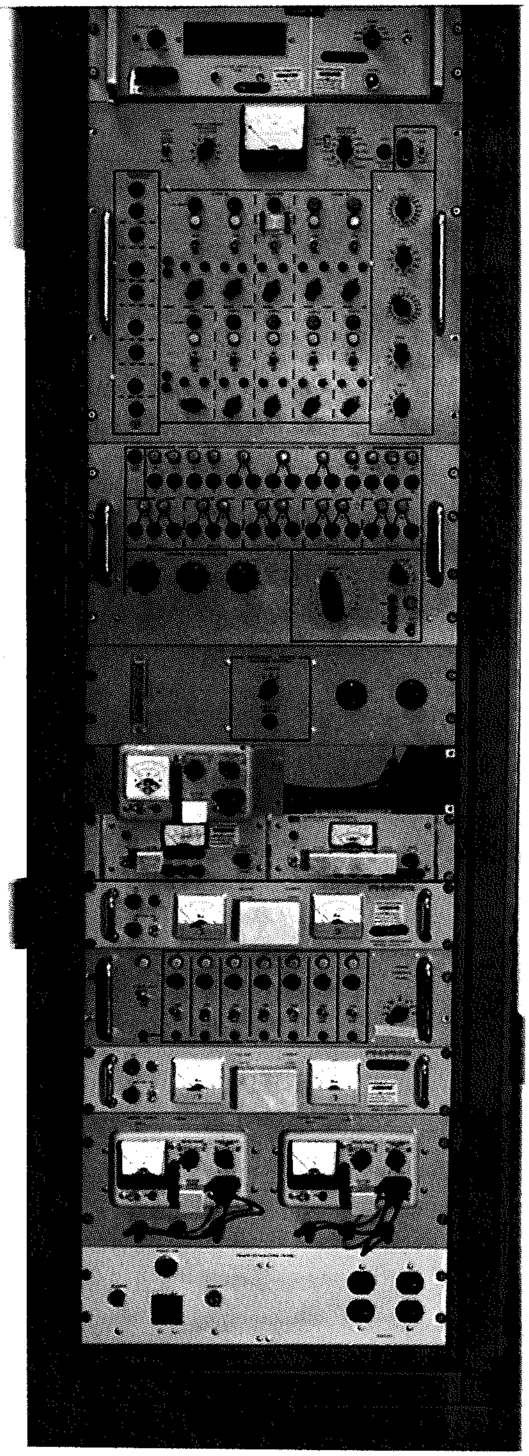
TYPICAL MODULE/BOARD TEST SET



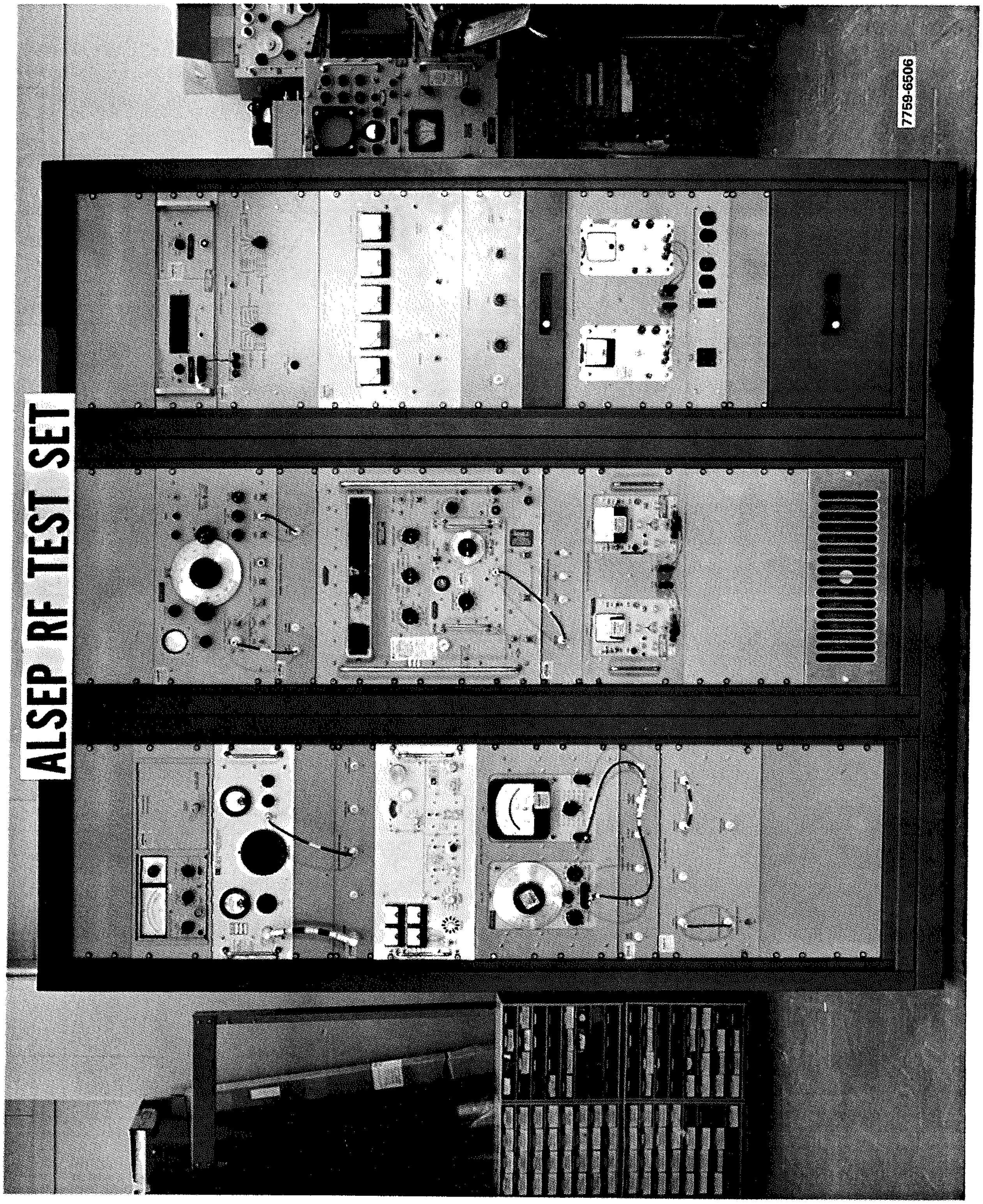


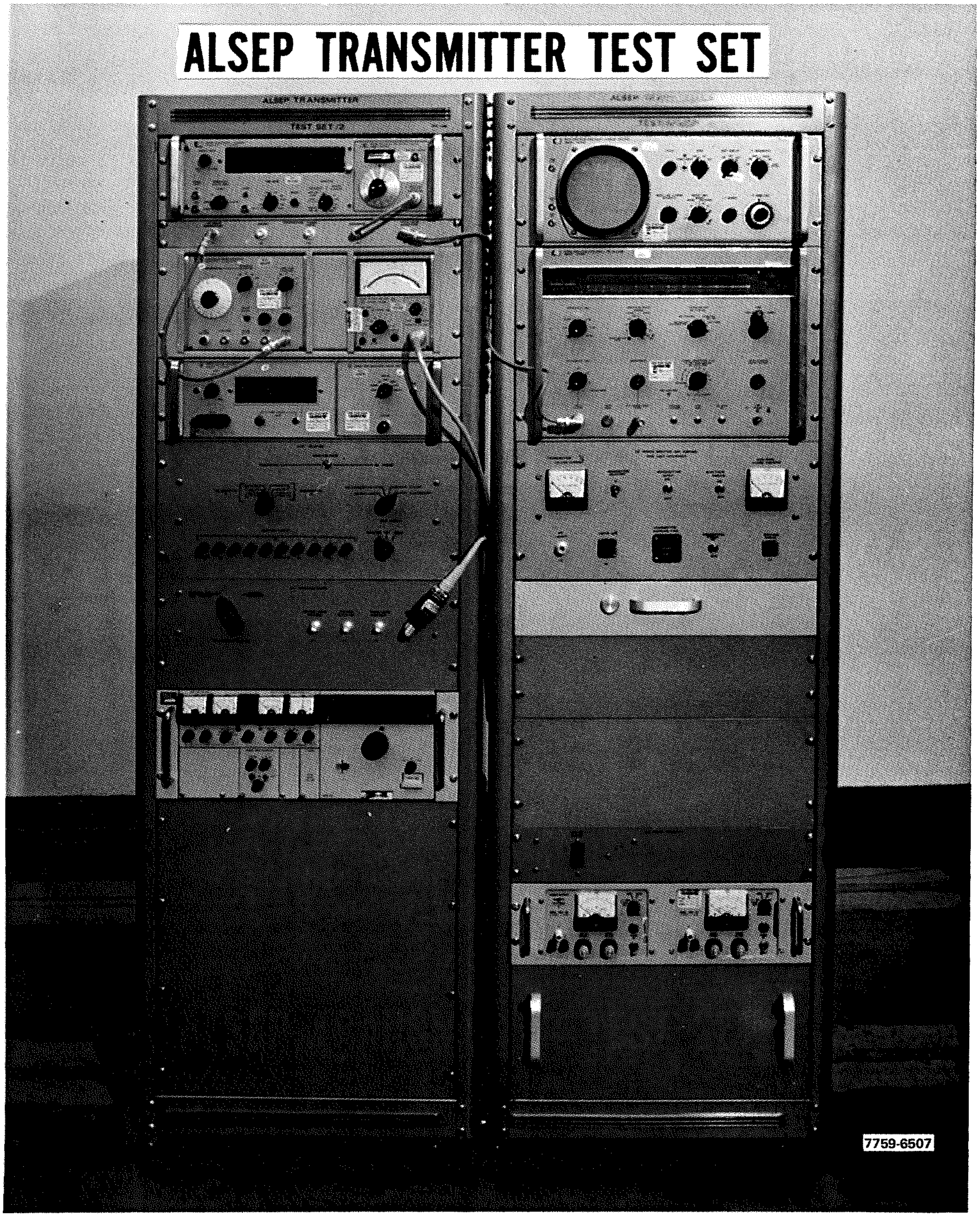
7759-6504

ALSEP PDU TEST SET

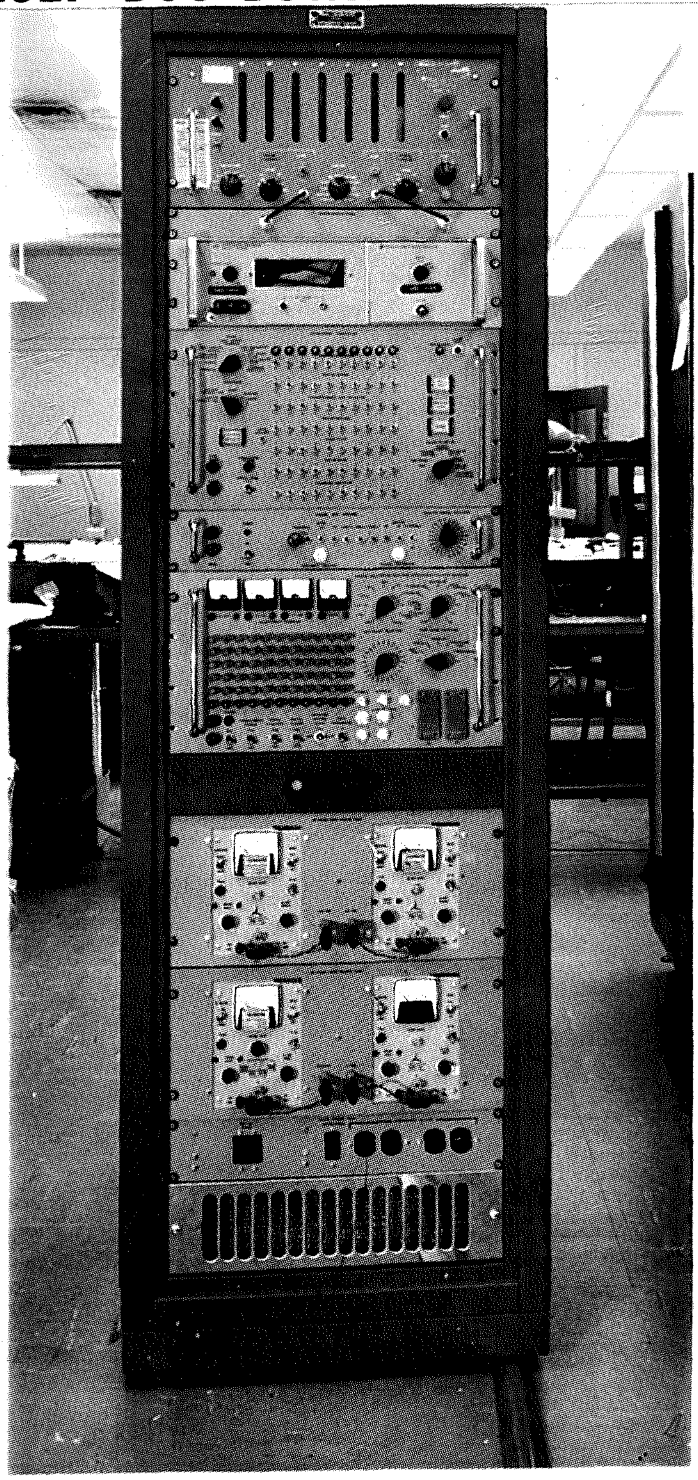


7769-6505

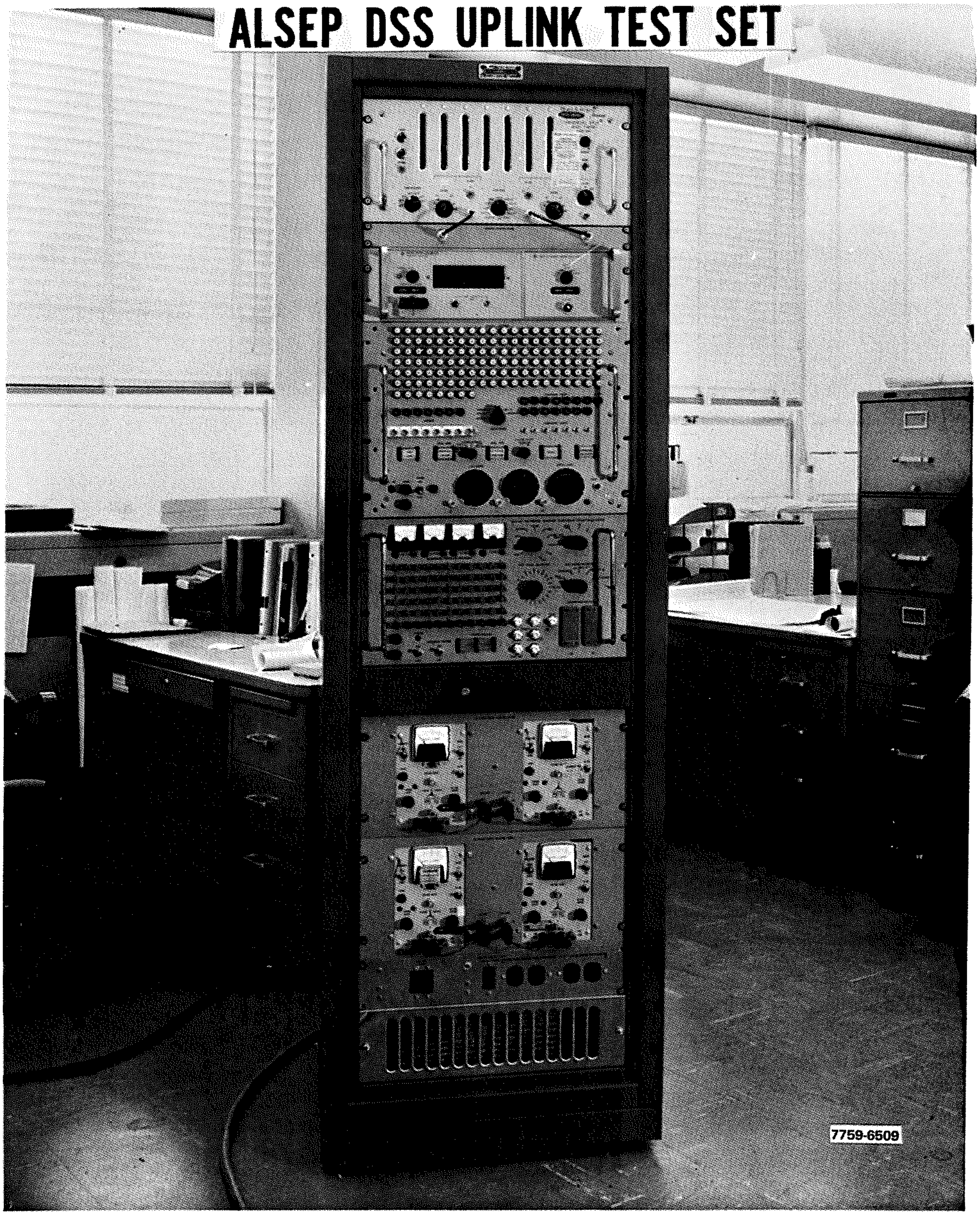

ALSEP RF TEST SET
7759-6506


ALSEP TRANSMITTER TEST SET
7759-6507

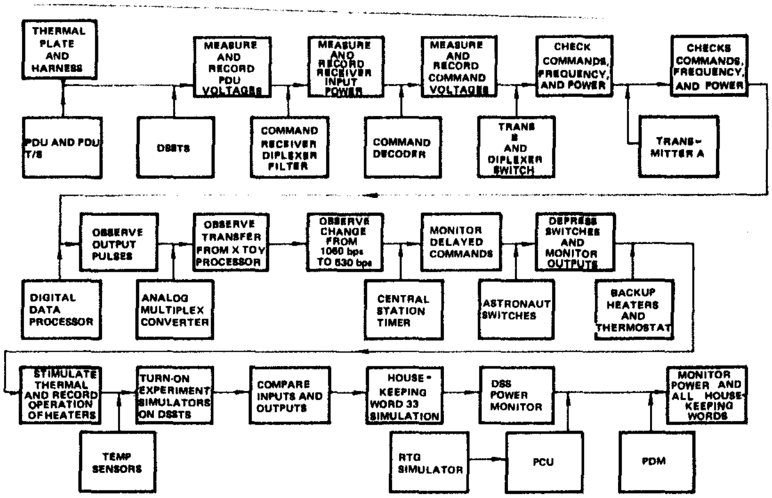
ALSEP DSS DOWNLINK TEST SET



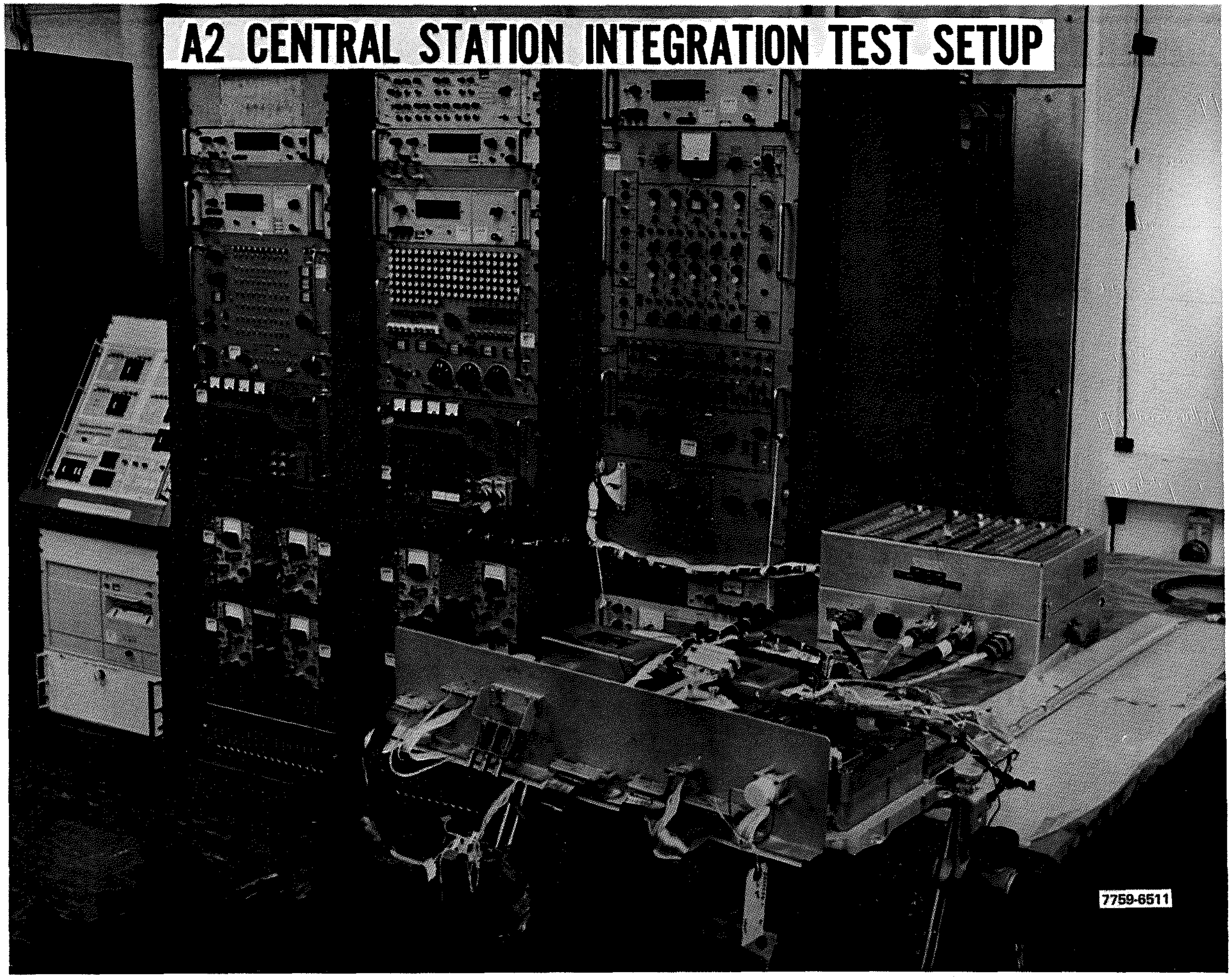
7759-6508


ALSEP DSS UPLINK TEST SET
7759-6509

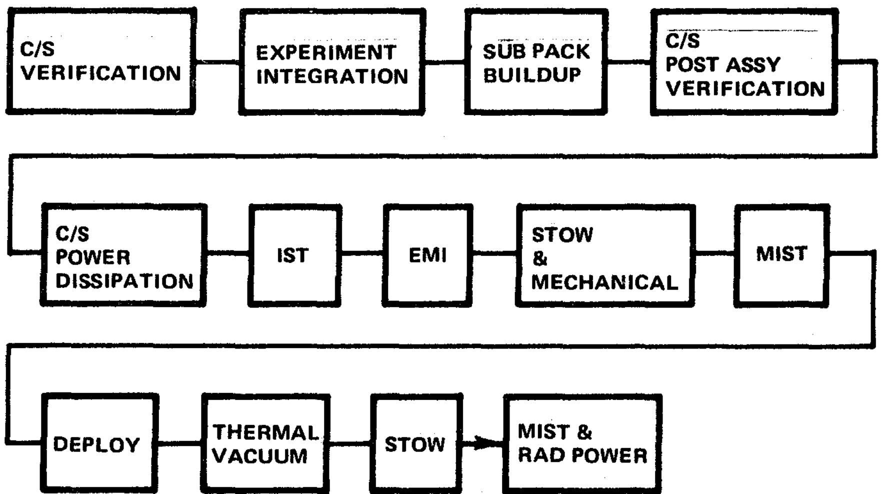
CENTRAL STATION INTEGRATION



7759-6510

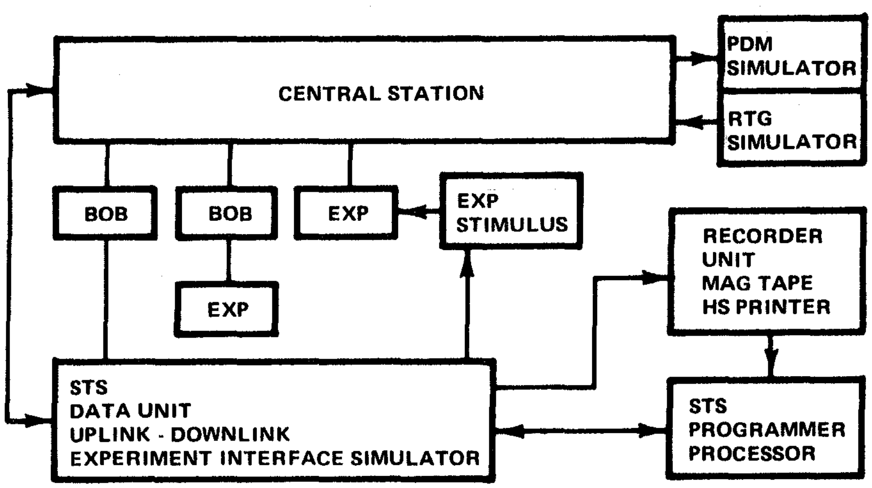

A2 CENTRAL STATION INTEGRATION TEST SETUP
7759-6511

SYSTEM TEST FLOW

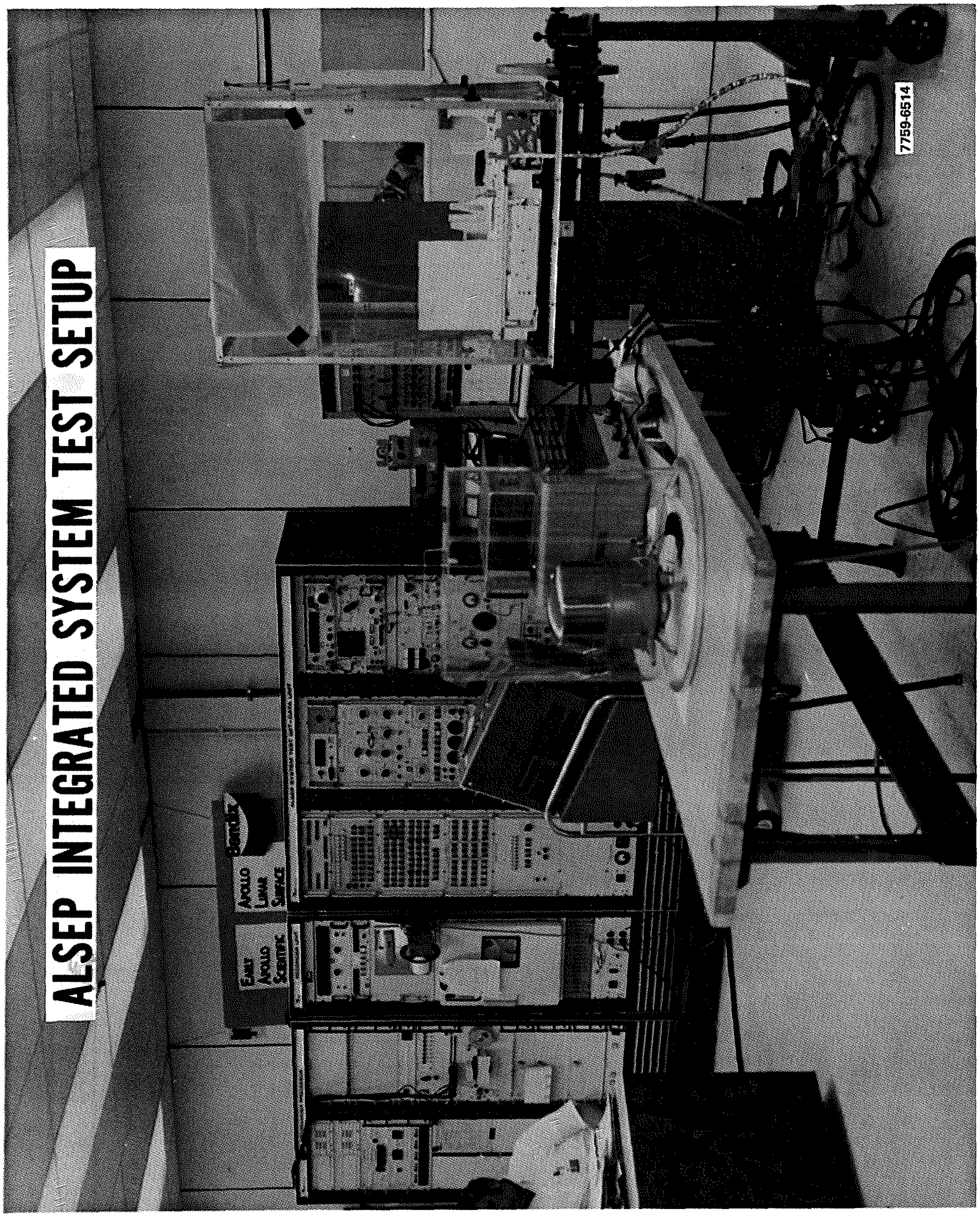


7759-6512

BASIC SYSTEM TEST SETUP



7759-6513

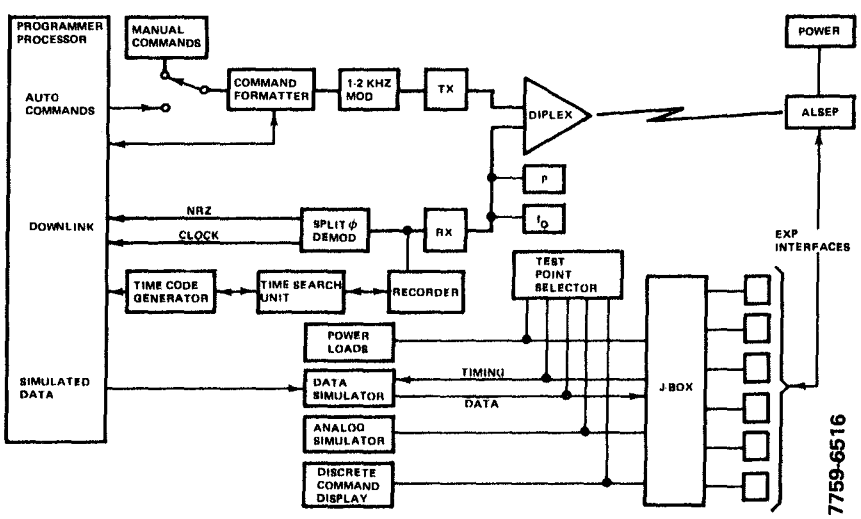

ALSEP INTEGRATED SYSTEM TEST SETUP
Bendix
Apollo Lunar Surface
Early Apollo Scientific
7759-6514

SYSTEM TEST SET CAPABILITIES

1. UPLINK SIGNAL GENERATION
2. DOWNLINK SIGNAL RECEPTION
3. DOWNLINK SIGNAL RECORDING
4. DOWNLINK SIGNAL PROCESSING
   - DECOMMUTATION
   - LIMIT CHECKING
   - D/A CONVERSION
5. DISPLAYS
   - POWER/FREQUENCY
   - PRINTER
   - ANALOG STRIP CHART
6. C/S INTERFACE DIGITAL & ANALOG SIMULATION
   - LOADS
   - VOLTAGE/CURRENT
   - PULSE CHARACTERISTICS
   - SIGNAL CONDITIONING
   - EXPERIMENT DATA SIMULATION

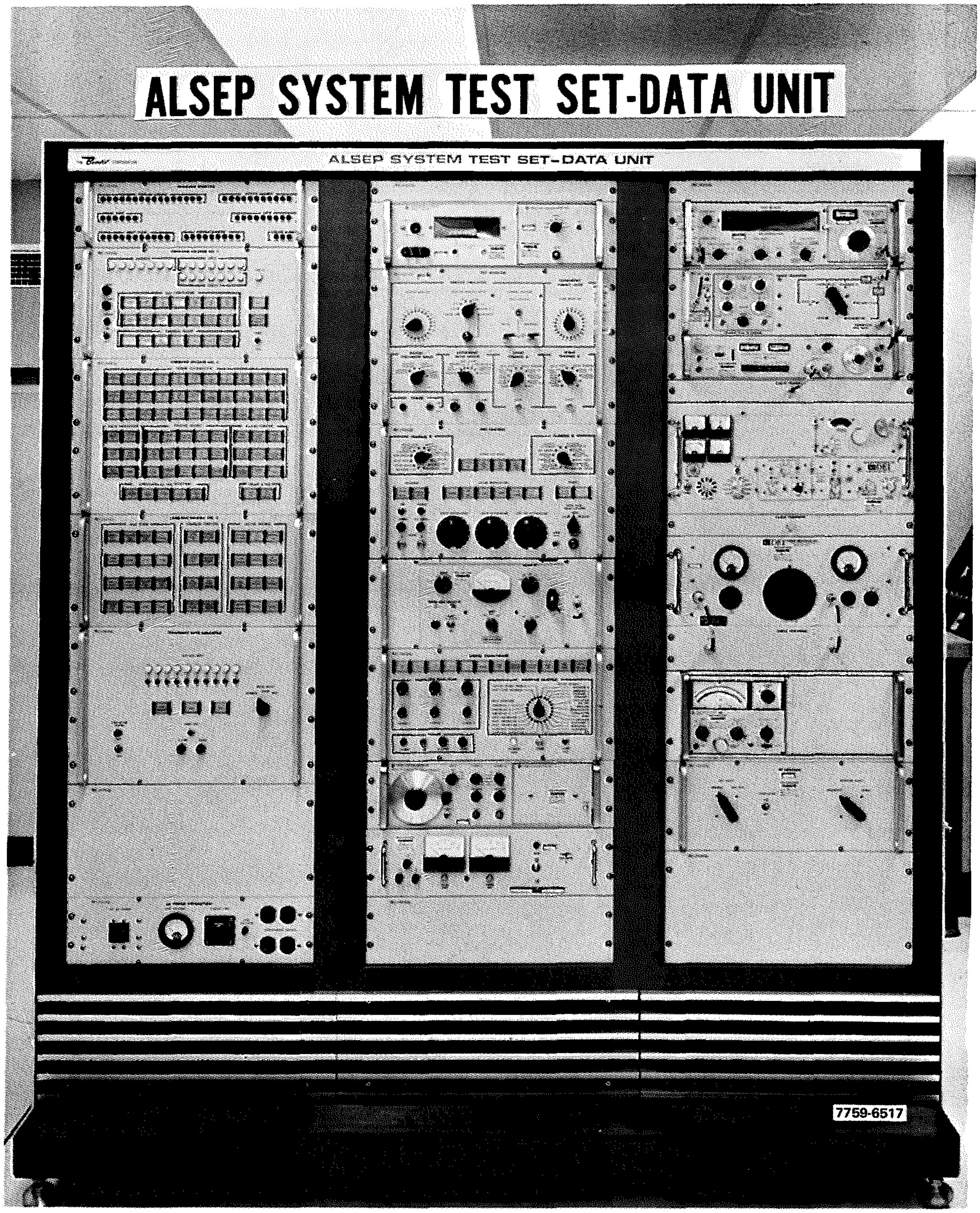
7759-6515

SYSTEM TEST SET BLOCK DIAGRAM

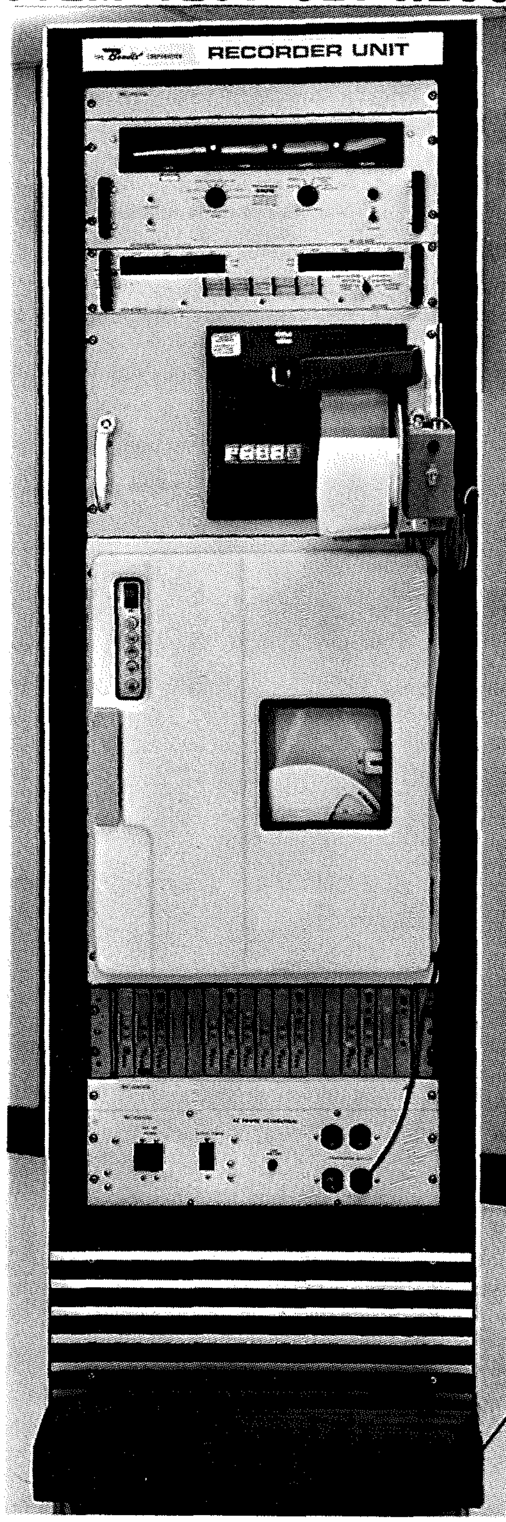


7759-6516

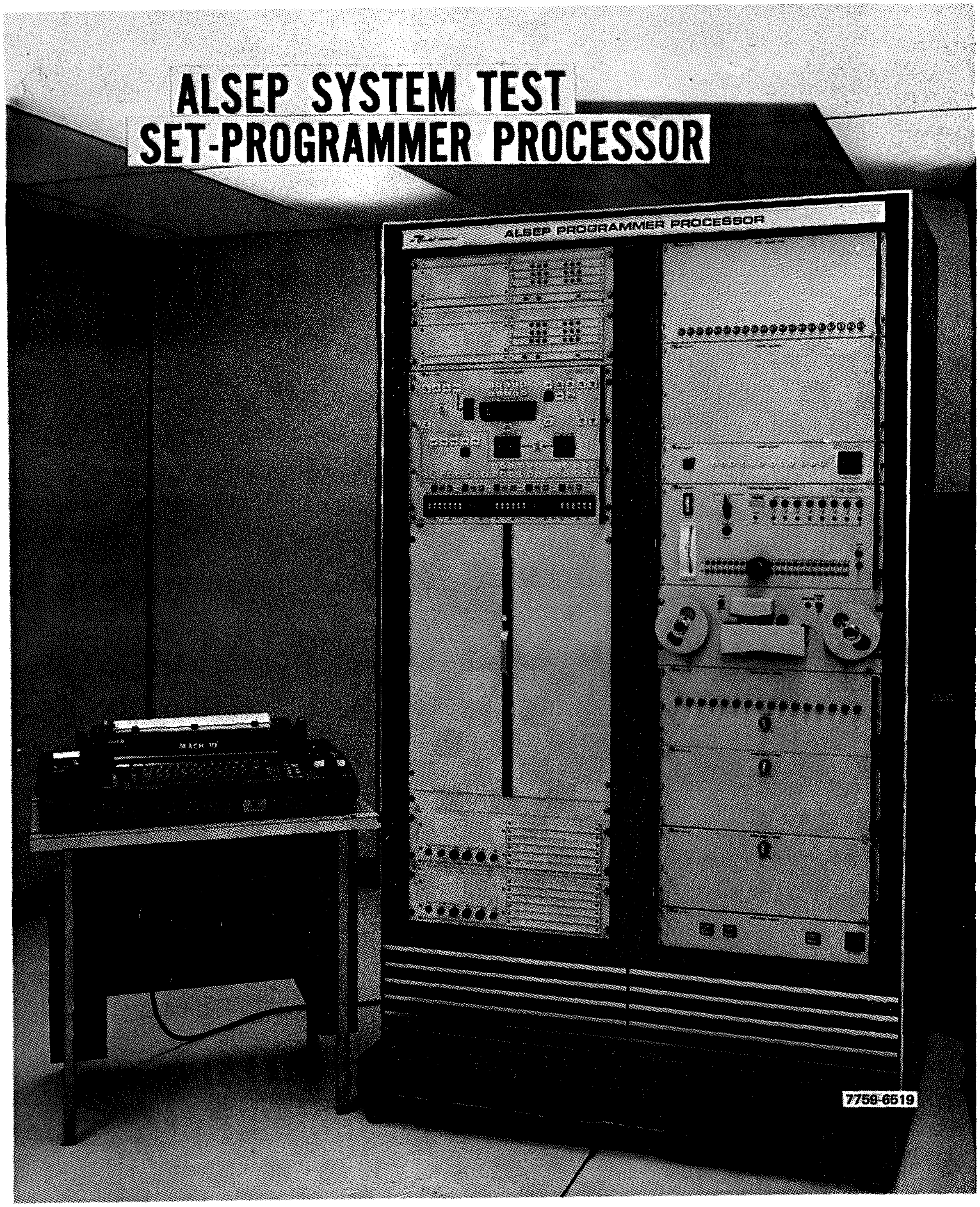
13-14


ALSEP SYSTEM TEST SET-DATA UNIT
ALSEP SYSTEM TEST SET-DATA UNIT
7759-6517

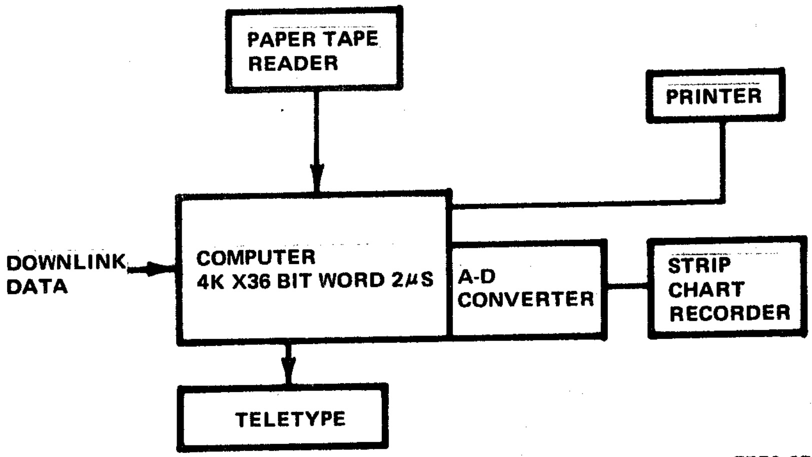
ALSEP SYSTEM TEST SET-RECORDER UNIT



7759-6518


ALSEP SYSTEM TEST
SET-PROGRAMMER PROCESSOR
ALSEP PROGRAMMER PROCESSOR
MACH 10
7759-6519

STS PROGRAMMER PROCESSOR
BLOCK DIAGRAM



7759-6520

STS PROGRAMMER PROCESSOR
MAIN SOFTWARE

PROGRAMS:

EXECUTIVE
DECOMMUTATION
LIMIT TABLE OVERLAY (CMALT)

FUNCTIONS:

MACHINE CONTROL
DECOMMUTATION OF MAIN FRAME & HOUSEKEEPING INCLUDING PSE DATA

LIMIT CHECKING

CONVERTS SEISMIC DATA FOR ANALOG RECORDING

PRINT HK DATA ON OT OR CHANGE FLAG CONDITIONS

CONTINUOUS PRINT AVAILABLE ON DEMAND

PRINT COMMAND TRANSMISSION AND VERIFICATION

PRINT STATION IDENT, MODE, TIME & PROCESSOR STATUS

7759-6521

STS PROGRAMMER PROCESSOR EXPERIMENT SOFTWARE

PROGRAMS:

FIXED BASIC ROUTINE
VARIABLE LIMIT TABLE OVERLAY
TEMPERATURE MONITORS
SPECIAL ROUTINES
ASE PROGRAM

FUNCTIONS:

SUBFRAME DECOMMUTATION

COMMAND TRACKING

AUTOMATIC COMMAND SEQUENCING - SWS

PRINT EXPERIMENT DATA FORMAT ON CHANGE OR OT FLAG
CONTINUOUS PRINT AVAILABLE ON DEMAND

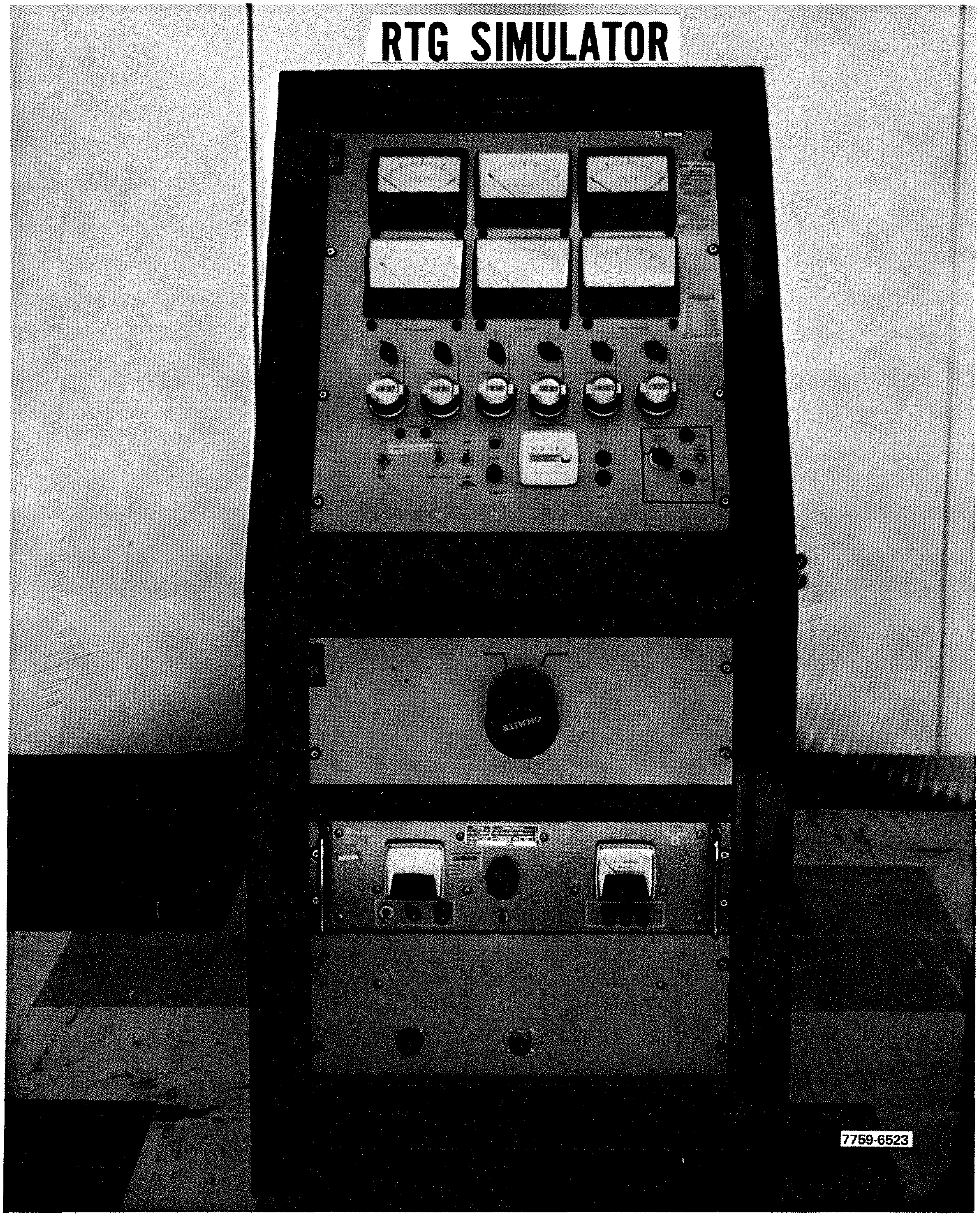
DATA ANALYSIS -
SWE DATA AVERAGING

HFE - GAIN, OFFSET & DIFFERENCE RATIO
CALCULATIONS

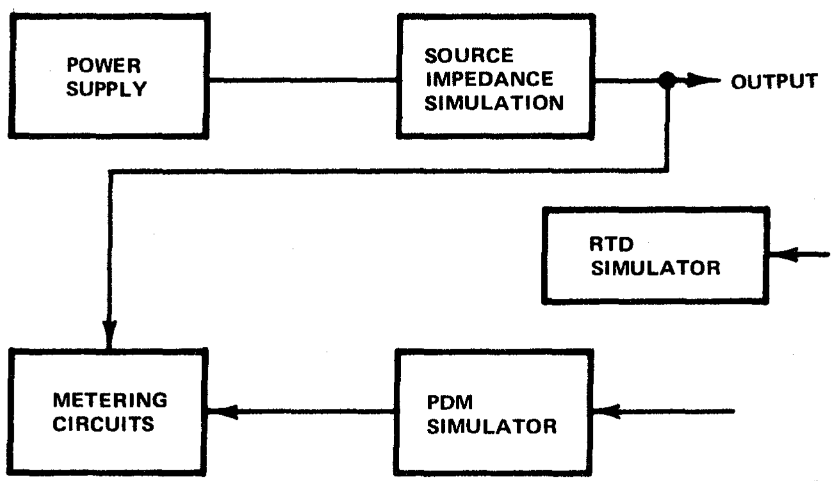
LOG DECOMPRESSION FOR ASE SEISMIC DATA

7759-6522

13-19


RTG SIMULATOR
OHMITE
7759-6523

RTG SIMULATOR BLOCK DIAGRAM



7759-6524

Section 14

Alsep Reliability

ALSEP RELIABILITY REQUIREMENTS

- CAPABLE OF OPERATING FOR AN EXTENDED PERIOD OF TIME IN A HOSTILE LUNAR ENVIRONMENT
- EACH EXPERIMENT & MAJOR SUBSYSTEM HAS A RELIABILITY GOAL OF (.99), FOR 1 YEAR OF OPERATION
- ALSEP SYSTEM MUST HAVE MAXIMUM RESISTANCE TO SINGLE POINT FAILURE SOURCES
- FAILURE SHALL NOT PROPAGATE THROUGHOUT THE SYSTEM

7759-6600

RELIABILITY PROGRAM

- DEVELOP A RELIABILITY PROGRAM PLAN BASED ON NPC 250-1
- DEVELOP RELIABILITY GUIDELINES FOR SUB-CONTRACTORS

7759-6601

KEY RELIABILITY FUNCTIONS

- RELIABILITY PROGRAM MANAGEMENT
- SUBCONTRACTOR & SUPPLIER CONTROL
- RELIABILITY PREDICTIONS
- FAILURE MODES EFFECTS & CRITICALITY ANALYSES
- DESIGN REVIEW & CHANGE REVIEW
- PARTS & MATERIALS
- FAILURE REPORTING, FAILURE ANALYSIS & CORRECTION ACTION
- TEST EVALUATION
- SPECIFICATION, DRAWING, AND PROCEDURE REVIEW & APPROVAL
- DOCUMENTATION

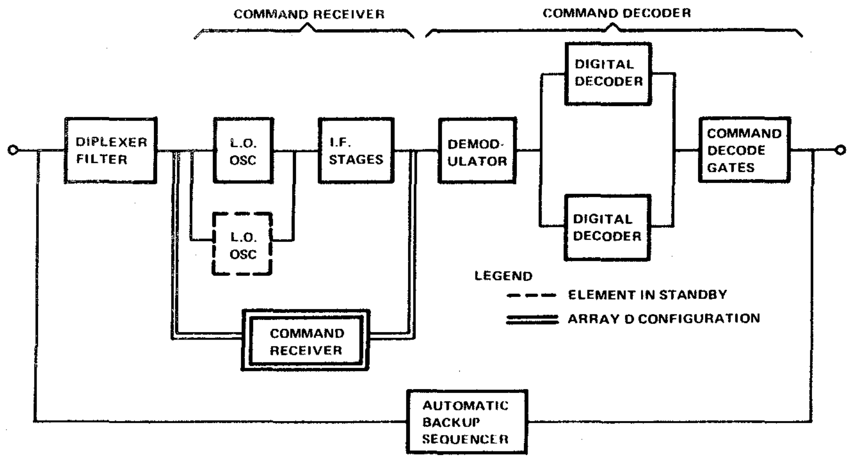
7759-6602

SYSTEM RELIABILITY APPROACH

- ANALYZE SYSTEM DESIGN CONSTRAINTS
- ANALYZE ARRAY CONFIGURATION
- IDENTIFY INCOMPATIBILITIES BETWEEN SYSTEM RELIABILITY & PROPOSED ARRAYS EMPLOYING MATH MODELING & PREDICTION TECHNIQUES
- PERFORM TRADEOFF ANALYSES FOR DESIGN RELIABILITY OPTIMIZATION WITHIN PROGRAM CONSTRAINTS

7759-6603

CENTRAL STATION UPLINK ELECTRONICS SIMPLIFIED RELIABILITY BLOCK DIAGRAM



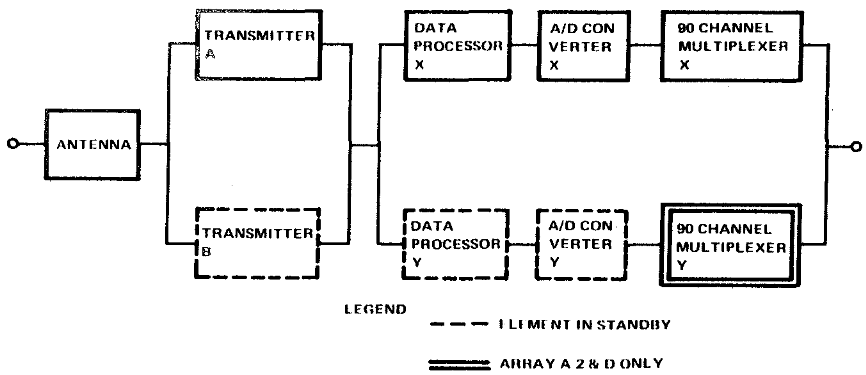
7759-6604

DOWNLINK ELECTRONICS RELIABILITY FEATURES

- FULL REDUNDANCY FOR EXPERIMENT SCIENCE DATA HANDLING
- TRANSMITTER IS STANDBY REDUNDANT W/AUTOMATIC AND COMMANDABLE SWITCHOVER CAPABILITY
- DATA PROCESSOR, STANDBY REDUNDANT
- MULTIPLEXER PARTIALLY REDUNDANT FOR CRITICAL HOUSEKEEPING STATUS DATA
- REDUNDANT A/D CONVERTERS
- COMPLETE MULTIPLEXER REDUNDANCY FOR ARRAY A-2 & D

7759-6605

CENTRAL STATION DOWNLINK ELECTRONICS SIMPLIFIED RELIABILITY BLOCK DIAGRAM



7759-6606

POWER SUBSYSTEM

- POWER CONDITIONING UNIT, STANDBY REDUNDANT WITH AUTOMATIC AND COMMANDABLE SWITCHOVER CAPABILITY
- POWER DISTRIBUTION UNIT, SELECTED PIECE-PART REDUNDANCY TO PRECLUDE SINGLE POINT FAILURE SOURCES
- RTG HAS LATTICE NETWORK REDUNDANCY

7759-6607

FAILURE MODES, EFFECT, AND CRITICALITY ANALYSES

- IDENTIFY ALL SINGLE POINT FAILURES
- ELIMINATE OR REDUCE SINGLE POINT FAILURES
- DESIGN TO MINIMIZE THE RISK OF SINGLE POINT FAILURES (I.E., LOW PROBABILITY OF OCCURRENCE)
- EVALUATE CRITICIALITY OF ALL FAILURE MODES TO ESTABLISH PRIORITY FOR RELIABILITY ENHANCEMENT (I. E., REDUNDANCY SIMPLIFICATION, STRESS DERATING, ADDITIONAL PROCESS CONTROL)

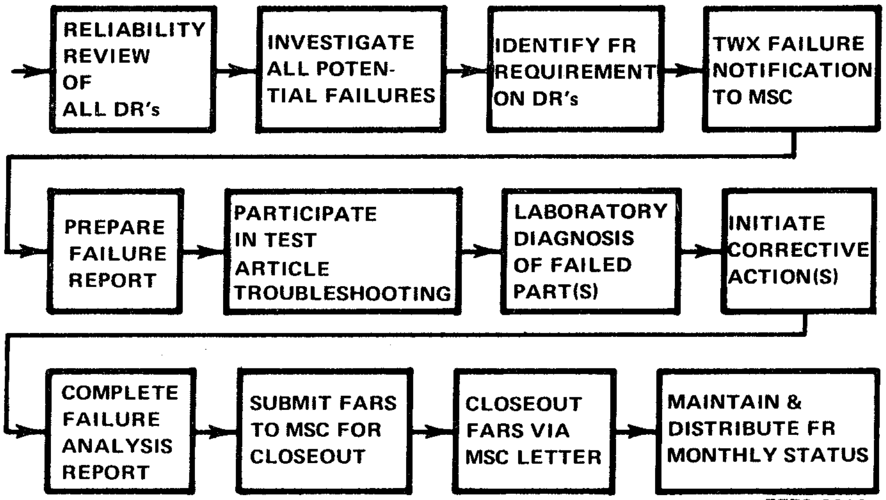
7759-6608

SUBCONTRACTOR CONTROL

- REVIEW & APPROVE SUBCONTRACTOR RELIABILITY PROGRAM PLAN
- MAINTAIN SUBCONTRACTOR RELIABILITY LIAISON
- PROVIDE TECHNICAL DIRECTION ON ALL RELIABILITY ACTIVITIES
- REVIEW & APPROVE ALL PARTS & MATERIALS SELECTED
- CONDUCT PERIODIC RELIABILITY PROGRAM REVIEWS
- REVIEW & APPROVE FAILURE ANALYSIS REPORTS

7759-6609

ALSEP FAILURE REPORTING & CORRECTIVE ACTION SYSTEM



7759-6610

PARTS AND MATERIALS PROGRAM

- DEVELOP AND PUBLISH AN APPROVED PARTS AND MATERIALS LIST FOR ALSEP USAGE
- ESTABLISH PART SELECTION PREFERENCE AND HI-REL REQUIREMENTS
- SELECT PARTS

7759-6611

PARTS AND MATERIALS PROGRAM (CONT')

- PREPARE SPECIFICATION CONTROL DRAWINGS
- PARTICIPATE IN FAILURE ANALYSIS ACTIVITIES
- CONDUCT PART EVALUATION TESTS
- APPROVE SUBCONTRACTOR PARTS AND MATERIALS SELECTIONS
- CONDUCT SCREENING AND BURN-IN

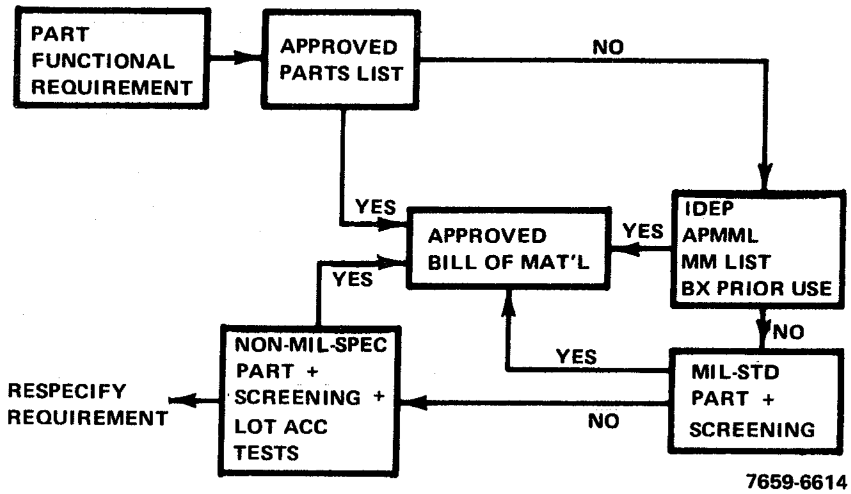
7759-6612

HOW HIGH IS "HI-REL"

- NASA/APOLLO AND MINUTEMAN
- NASA/MSFC, JPL
- MIL-ER AND MIL-TX SERIES
- INDUSTRY HI-REL (MEG-A-LIFE, SURE, ETC)
- MIL SPEC AND BURN IN
- NON-MIL SPEC AND BURN IN AND LOT ACCEPTANCE.

7759-6613

PARTS SELECTION FLOW



7659-6614

PARTS APPLICATION ANALYSES

- COMPUTERIZED (ECAP) CIRCUIT ANALYSES
- PART DERATING
  - CAPACITORS-ELECTROLYTIC-60% VOLT
  - RESISTORS 50% POWER
  - SEMICONDUCTORS 50% VOLTAGE
    - 50% CURRENT
    - $T_J = 140^{o}C$ MAX
  - TRANSFORMERS, & COILS 15^0 C RISE

7759-6615

TYPES OF PARTS TESTS

. QUALIFICATION
. LOT ACCEPTANCE
  GROUP "A"
    100% - FUNCTIONAL
    & ENVIRONMENTAL
    (NON-DESTRUCTIVE)
  GROUP "B"
    SAMPLE
    MECHANICAL
    ENVIRONMENTAL
  GROUP "C"
    SAMPLE
      LIFE
      GROUP "B"

7759-6616

TYPES OF PARTS TESTS (CONT')

. SCREENING & BURN IN
  100%
  EXERCISE RATED STRESSES
  TIME COMPATIBLE WITH INFANT MORTALITY
  DELTA LIMITS
  LOT REJECTION CRITERIA

7759-6617

% "HI-REL" PARTS IN CENTRAL STATION

			QTY	%	
CAT	1	NAA/APOL/MM	270	8.9	86.8
	2	NASK/MSFC/JPL	147	4.8	
	3	ER ETX	1071	35.2	
	4	INDUS HI-REEL	1153	37.9	
	5	MIL + SCREEN	244	8.0	13.2
	6	NON-MIL + SCREEN	159	5.2	
		TOTAL	3044	100.0	

7759-6618

SIGNIFICANT DESIGN IMPROVEMENTS

1. MULTIPLEXER
   REPLACED EPOXY SEMICONDUCTORS WITH HERMETIC-SEALED DEVICES.
   REDESIGNED MULTIPLEXER WITH MOS FETS, COMPLETELY REDUNDANT (A2 ALSEP)
   REDESIGNED A/D CONVERTER.
   INTEGRATED SYSTEM (ARRAY D)

2. RECEIVER, COMPLETELY REDUNDANT (ARRAY D)

3. SOLID STATE TIMER (A2 & ARRAY D)

7759-6619

SOLID STATE TIMER

- RELIABILITY - 996 FOR 2-YEAR OPERATION
- DESIGNED TO PREVENT PREMATURE SYSTEM SHUTDOWN
- REDUNDANT THREE-MONTH COUNTERS
- POWER INTERRUPT CAPABILITY FOR 2 MINUTES WITHOUT RESETTING COUNTERS

7759-6620

A-2 MULTIPLEXER PART COUNT

PART TYPE	OLD DESIGN	A-2 DESIGN	PERCENT PART REDUCTION CHANGE
J-FET	160	---	-NA-
MOS-FET	---	17	-NA-
MOS INTEGRATED CIRCUIT	---	8	-NA-
BIPOLAR INTEG CCT	22	---	-NA-
TRANSISTORS	191	4	98%
DIODES	326	4	99%
CAPACITORS	163	2	99%
RESISTORS	33	33	0%
THERMISTOR	1	1	0%
TOTAL	896	69	>92%

7759-6621

PARTS RELIABILITY IMPROVEMENTS

ITEMS	PROBLEMS AND SOLUTIONS
TYPE 2N4012 TRANSISTORS, TRANSMITTER POWER AMPLIFIER	SHORT LIFE LEAKAGE FAILURE MODE ELIMINATED BY ALTERNATE SOURCE EQUIVALENT TYPE, QUALIFIED FOR UNIQUE ALSEP APPLICATION
DUAL TRANSISTOR FLATPACKS	POTENTIAL INTERNAL WIRING DEFECTS PER NASA ALERT. ALSEP PARTS RETURNED TO VENDOR FOR X-RAY SCREENING PRIOR TO FLIGHT USE
MAGNETIC LATCHING RELAYS	LOOSE GETTER PARTICLES CITED PER NASA ALERT. BENDIX "NEW TECHNOLOGY" TECHNIQUES DEVELOPED TO REMOVE SUSPECT UNITS

7759-6622

PARTS RELIABILITY IMPROVEMENTS (CONT')

ITEMS	PROBLEMS AND SOLUTIONS
CIRCUIT BREAKER RELAYS	OSCILLATING MODES DURING SLOW RISE LOADING CORRECTED BY ADDING BACKUP OVERLOAD RELAY TO ELIMINATE "CUT–THROAT" DESIGN
FET SEMICONDUCTORS	PREMATURE TURN OFF PROBLEM AT LOW TEMPERATURE IN MUX GATE CIRCUITS CORRECTED BY SELECTION OF FET FOR PINCH OFF VOLTAGES UNIQUE TO ALSEP APPLICATION
OPERATIONAL AMPLIFIERS	DEGRADATION OF A702A OP AMP IN CPLEE TRACED TO HIGH LEVEL TRANSIENTS. ELIMINATED BY CURRENT LIMITING RESISTORS

7759-6623

PARTS RELIABILITY IMPROVEMENTS (CONT')

ITEMS	PROBLEMS AND SOLUTIONS
PRINTED CIRCUIT BOARDS	MOUNTING OF LOGIC BOARDS IN CPLEE MODIFIED TO ELIMINATE BOWING AND STRESS ON SOLDERED CONNECTIONS
M1000-10172 THERMOSTATS	BxA EVALUATION TESTS TO VERIFY CONTACT RESISTANCE DEGRADATION CITED BY NASA ALERTS. GOLD CONTACTS AND STABILITY SCREENING TESTS IMPLEMENTED ON PARTS PRIOR TO FLIGHT USE

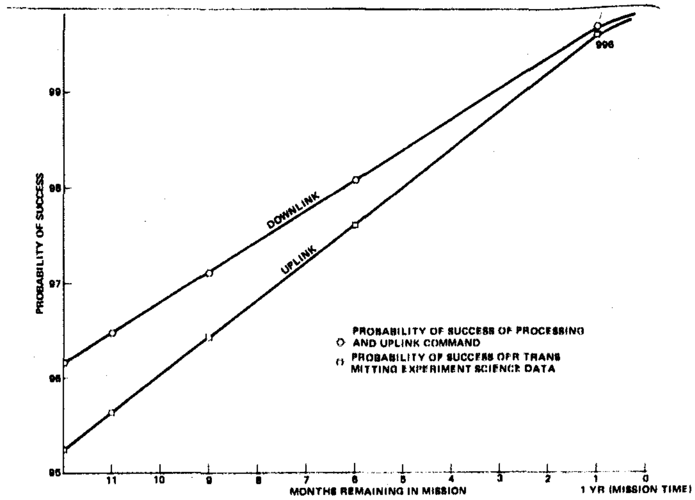
7759-6624

PARTS RELIABILITY IMPROVEMENTS (CONT')

ITEM	PROBLEMS AND SOLUTIONS
2N2222/ML 3C TRANSISTORS	MARGINAL INTERNAL WIRING CONDITIONS CITED BY NASA ALERT. ALSEP PROCUREMENT CHANGED TO ELIMINATE USE OF PARTS FROM SUSPECT SUPPLIER
OPERATIONAL	MOISTURE SUSCEPTIBILITY OF μ709 TYPES CITED BY NASA ALERT. ALSEP PROCUREMENT CHANGED TO μ741 TYPE RECOMMENDED BY ALERT.

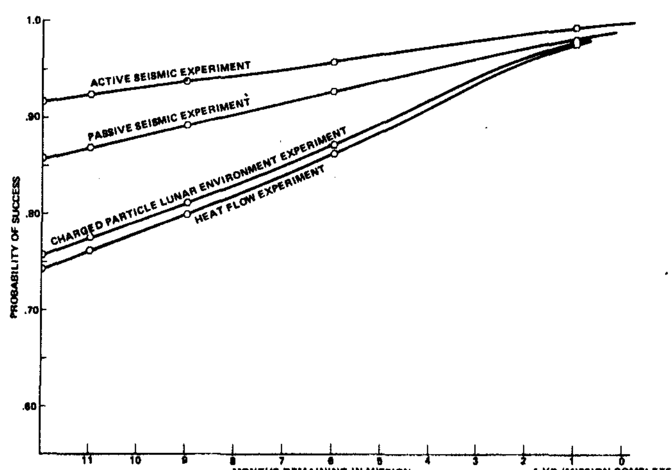
7759-6625

RELIABILITY OF ALSEP UPLINK & DOWNLINK ARRAY A,B,& C



7759-6626

PROBABILITY OF SUCCESSFULLY RECEIVING CFE EXPERIMENT DATA



7759-6627

Section 15

Dust Detector Experiment

DUST DETECTOR EXPERIMENT HISTORY

SEP 65	DR. B.J. O'BRIEN PROPOSAL (ACCEPTED AS ALSEP HOUSEKEEPING) 3 RADIATION - RESISTANT SOLAR CELLS AND 3 THERMISTORS, 0.3 LB 0.5 WATT, 10 BITS/SECOND
SEP 68	PROPOSAL WITHDRAWN
	DTREM I PROPOSED
DEC 68	DTREM I ASSIGNED TO EASEP
	DTREM II ASSIGNED TO APOLLO 12 AND UP. RETROFIT TO APOLLO 14 ONLY.
JULY 69	DTREM I DATA, O'BRIEN REPROPOSAL
NOV 69	MSFEB APPROVES M515-LUNAR DUST EXPERIMENT

7759-6700

DUST DETECTOR FLIGHT ASSIGNMENT

		P.I.	CO-P.I.
APOLLO 11	DTREM I	NONE	
12	DDE	O'BRIEN	FREDEN
13	DDE	FREDEN	O'BRIEN
14	DTREM II	FREDEN	O'BRIEN
15	DTREM II	FREDEN	O'BRIEN
16	NONE		

7759-6701

DUST DETECTOR EXPERIMENT

OBJECTIVE:	MEASURE EAST, WEST, HORIZONTAL DUST TO $\pm$ FEW PER CENT
METHOD:	CELL ENERGY BALANCE

$$\epsilon \sigma T^4_{CELL} = \alpha S. \cos \phi + \text{SMALL ERRORS}$$

MEASURE CELL CURRENT AND TEMPERATURE TO GET α/ϵ FOR DUSTY CELL.

CELLS ARE UV AND PROTON RADIATION RESISTANT.

7759-6702

DTREM II OBJECTIVES

FREDEN — PROTON DOSE (DAMAGE) TO SOLAR CELL IN THREE ENERGY INTERVALS.

BARE CELL	$0 \rightarrow \infty$	MEV PROTONS
6 MIL CELL	$4.5 \longrightarrow$	
20 MIL CELL	9 MEV $\longrightarrow$	

O'BRIEN — MEASURE HORIZONTAL DUST TO $\pm$ FEW %.

HICKSON
(1) MEASURE LUNAR SURFACE BRIGHTNESS TEMPERATURE (TO $\pm$ 1 KELVIN AT NIGHT) =FOURTH ROOT OF ENERGY FROM SURFACE

(2) GET RANGE OF LUNAR SURFACE THERMAL INERTIA PARAMETER, $\gamma = 1/\sqrt{kpc}$

(3) MEASURE ANGULAR DEPENDENCE OF LUNAR SURFACE IR EMISSION. (NON-LAMBERTIAN EMISSION)

7759-6703

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P J HICKSON ** DTREM I TEMPERATURES USING CINDSN **                                DATE 031370        PAGE   130

-- PAUL J. HICKSON --  DTREM I (EASEP/APOLLO 11) LUNAR SURFACE (IR) BRIGHTNESS TEMPERATURE USING A NICKEL THERMOMETER

SUN ELEVATION=   61.29     GMT=207 13  0     T(LIT LS)= 231.59 F     T(DARK LS)= -99.67 F     T(DTREM-CALC)=   9.96 F
TOTREM=331.15   FDTREM=136.90   CDTREM=  58.00     FDARE= 192.56   F20MIL= 188.96     FLITLS= .35862   FDRKLS= .00253
                                       FESOLPAN= 196.50 FWSOLPAN= 168.30        (FEXP= .55287)

                          -32.6  -33.8  -35.6  -38.6  -29.1  -21.3  -19.9
                          -29.7  -32.0  -34.5  -39.1  -28.2  -20.2  -19.0
                          -23.4  -23.6                       -11.9  -13.0
                          -18.0  -17.8                        -6.6   -8.2
                          -11.2  -10.6  -10.6  -12.7   -4.9   -2.9   -3.5
                           -2.5   -2.6   -3.0   -2.8    -.3    1.9    2.4

                                         189.5  190.9  192.9
                                         189.3  191.1  192.7
                                         189.6  191.2  193.0

          EAST                                  SOUTH                                         WEST

-27.9  -22.6  -17.1  -10.3   -1.7     4.1    4.5    3.6    5.2    4.9    7.6    7.6     2.6   -3.8   -6.6  -13.3  -18.9  -19.6
-17.1  -14.2   -9.6   -3.0    7.1    17.1   15.1   14.0   17.8   11.8   15.2   18.1     6.5   -3.7   -9.5  -13.9  -17.5  -18.1
 -3.0   -1.2    2.6    9.4   21.9    36.9   36.6                        31.6   33.1    16.5    2.5   -4.9   -9.3  -11.7  -12.2
 14.1   15.2   18.2   24.6   37.1    55.0   55.1                        46.2   47.2    28.6   13.3    5.4    1.7    -.1    -.6
 39.9   40.0   41.8   46.9   60.8    73.1   74.9   77.8   83.8   72.5   63.5   62.0    44.5   31.7   24.3   21.7   21.5   21.5
 69.3   67.7   68.1   70.3   74.5    74.9   76.6   79.0   83.1   74.8   66.1   63.6    61.4   54.5   46.2   44.3   47.8   48.8

          EAST                                  NORTH                                         WEST

                           77.3   80.6   83.2   86.0   78.4   68.6   64.6
                           74.2   76.7   79.3   83.6   72.5   61.6   58.3
                           72.3   73.9                        50.2   49.6
                           72.0   73.6                        47.4   47.8

F(BACK)=  156.0            73.6   76.2   78.2   80.9   67.2   55.4   51.9
BRACKET F(SIDE)=  155.0    78.5   79.7   81.3   82.7   70.6   57.9   53.5
F(BOOM)=  144.6
                                  128.6  128.3  125.2  129.8  131.0
                                  119.2  124.9      126.4     120.6
                                  118.3  124.7      126.4     126.7
                                  125.4  125.1  122.5  127.0  127.7

  TOTAL HEAT INPUTS TO NICKEL SENSOR,(MILLIWATTS     SUN ELEVATION=   61.29     TIR=   233.64        TDET(NTL=0)=   124.37
       BLK SKY  LIT LS  DRK LS WS BRAC BK BRAC   BOOM     ESOLPAN WSOLPAN (1014)  (1015)  (1026)  (1036)
     -145.718 101.073    .053  15.119  10.070   7.137      3.015   6.798   -.794   1.937    .426    .313

         (1045)  (1044)  (1033)  (1023)  REF BRC  REF LS    ISW R SUN-TILT REF PAN
          .337  -2.497  -1.956  -1.796    .000    2.060     2.110   1.296    .000                      WTOTAL=   -.979

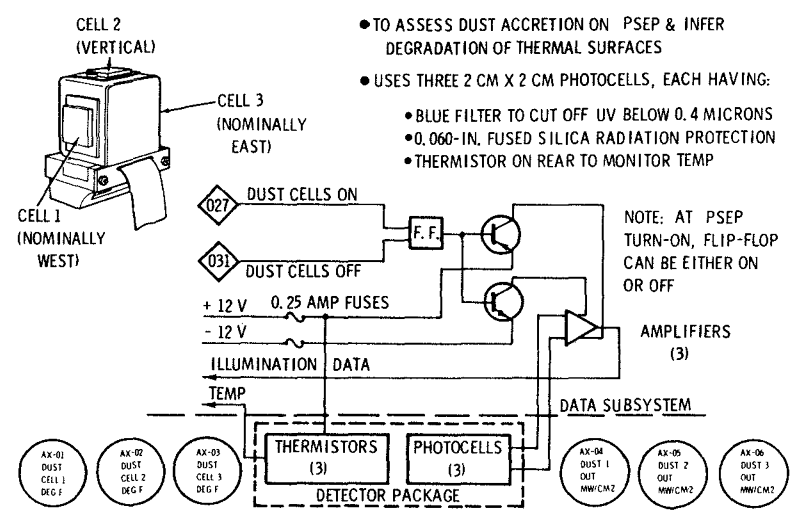
  TOTAL HEAT INPUTS TO NICKEL DETECTOR,(MILLIWATTS     SUN ELEVATION=   61.29
       BLK SKY  LIT LS  DRK LS WS BRAC BK BRAC   BOOM      ESOLPAN WSOLPAN TP BOLT BT BOLT TP WIRE BT WIRE
     -431.568 300.187    .156  44.490  29.908  21.196       8.959  20.189  -5.960  -5.956  -3.569  -3.561

       REF BRC  REF LS  ISW-R   SIDEDG SUN-TILT REF PAN
         .000    6.117   2.11    6.591   3.848    .000                                                 WTOTAL=  -6.469
```

7759-6704

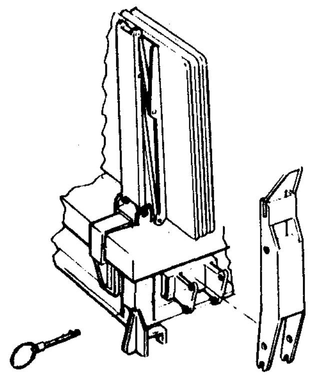
DUST DETECTOR

- TO ASSESS DUST ACCRETION ON PSEP & INFER DEGRADATION OF THERMAL SURFACES
- USES THREE 2 CM X 2 CM PHOTOCELLS, EACH HAVING:
  - BLUE FILTER TO CUT OFF UV BELOW 0.4 MICRONS
  - 0.060-IN. FUSED SILICA RADIATION PROTECTION
  - THERMISTOR ON REAR TO MONITOR TEMP



7759-6705

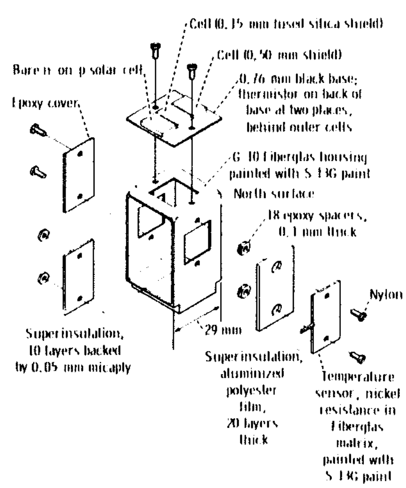
PULL-PIN FASTENERS



- SPRING-LOADED DETENT BALLS
- USED FOR SHEAR CONNECTIONS ON:
  - PSEP/LM INTERFACE
  - BOOM & HANDLE ASSEMBLY
  - SOLAR PANEL RESTRAINTS
  - ANTENNA TIE-DOWN

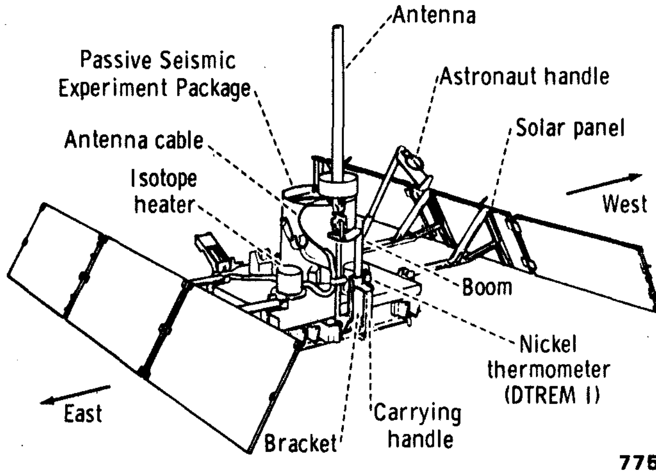
7759-6706

DTREM PACKAGE—APOLLO 11



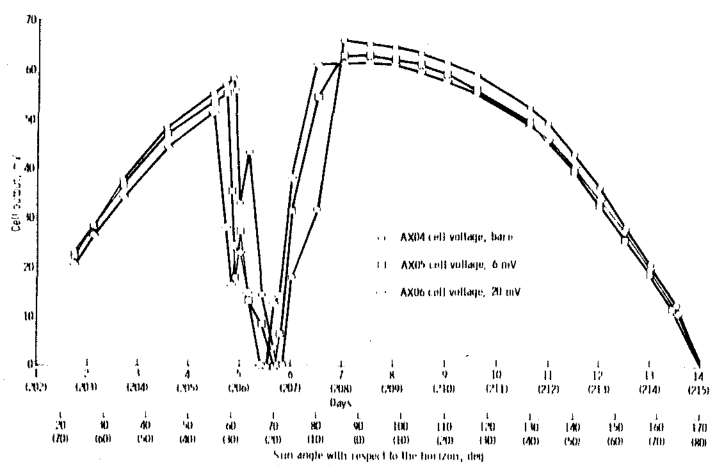
7759-6707

PSEP—GEOMETRY OF DTREM 1



7759-6708

DUST-DETECTOR SOLAR-CELL OUTPUT



7759-6709

15-5

R. Malley PT14

ALSEP DESIGN SUMMARY ADDENDA I-V

Presentation Material

BSR-2900

17 - 20 March 1970

NASA/MSC - Bendix Aerospace Systems Division

Bendix Aerospace Systems Division

Addendum I

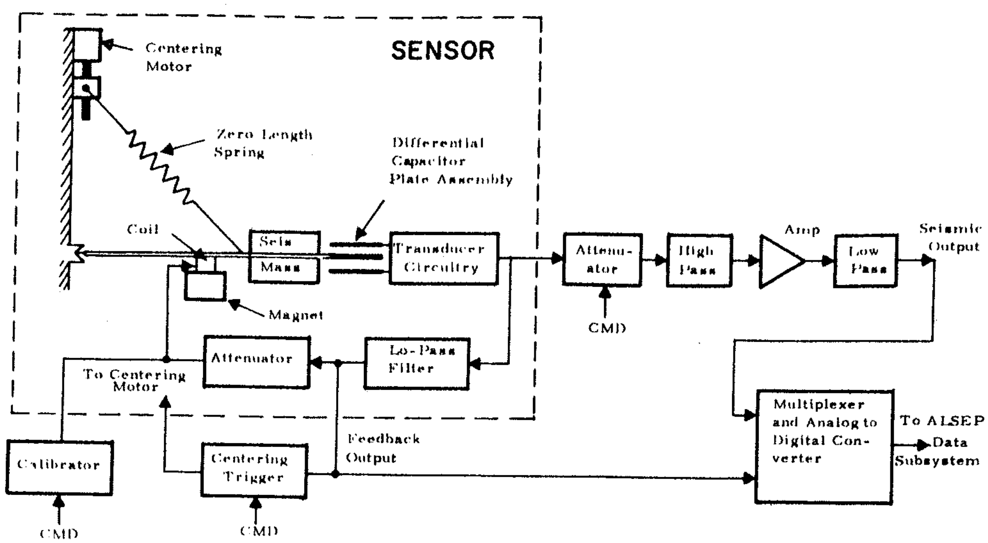
PASSIVE SEISMIC EXPERIMENT

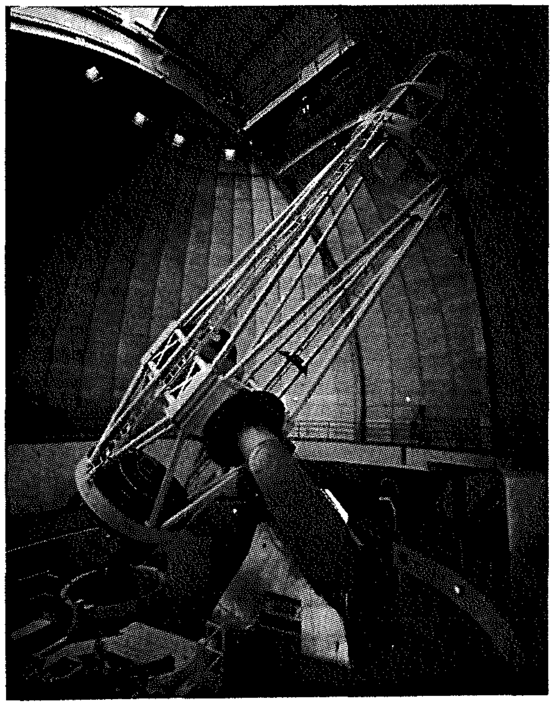
Presented by Dr. Gary Latham

Lamont Geological Observatory

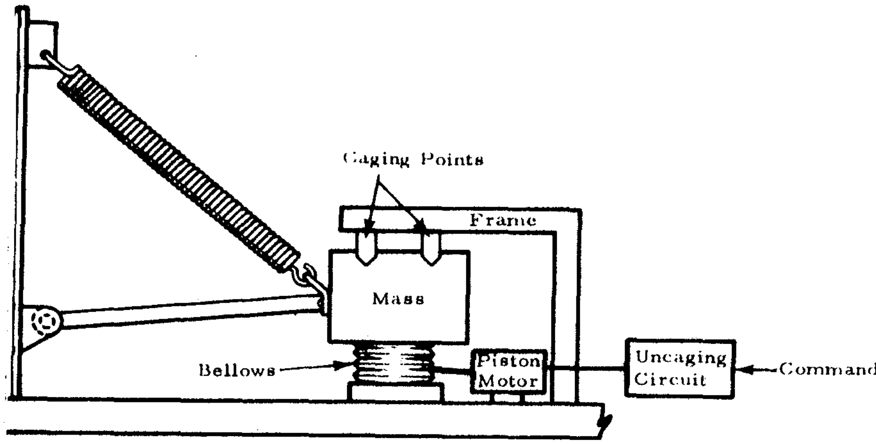
PSE SCIENTIFIC MEASUREMENTS

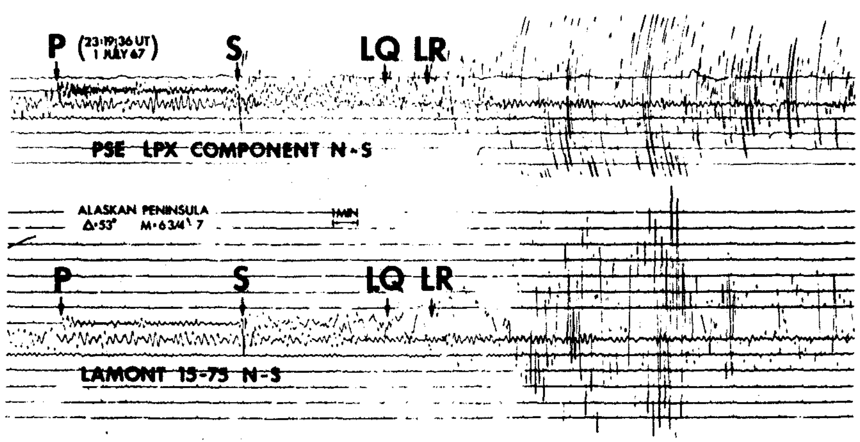
DATA CHANNEL	PARAMETER MEASURED	MINIMUM DETECTABLE SIGNAL	AT PERIOD
LPZ	VERTICAL GROUND MOTION	0.3 mμ, p-p	shorter than 15 sec.
LPX	HORIZONTAL GROUND MOTION	0.3 mμ, p-p	shorter than 15 sec.
LPY	HORIZONTAL GROUND MOTION	0.3 mμ, p-p	shorter than 15 sec.
SPZ	VERTICAL GROUND MOTION	0.1 mμ, p-p	0.1 sec.
Z - FB	VERTICAL COMPONENT OF GRAVITY	8 μgal	D C
X-FB	SURFACE TILT	0.01 sec. arc	D C
Y-FB	SURFACE TILT	0.01 sec. arc	D C
TEMP.	INSTRUMENT TEMPERATURE	0.2 deg C	D C





DIAGRAMMATIC SKETCH PSE UNCAGING MECHANISM





PSE PROBLEM AREAS

- <u>Long Period Vertical Seismometer</u>

  Natural period lengthened (60 sec instead of 15 sec).
  Acceptable operation achieved by removal of feedback filters.

- <u>Short Period Vertical Seismometer</u>

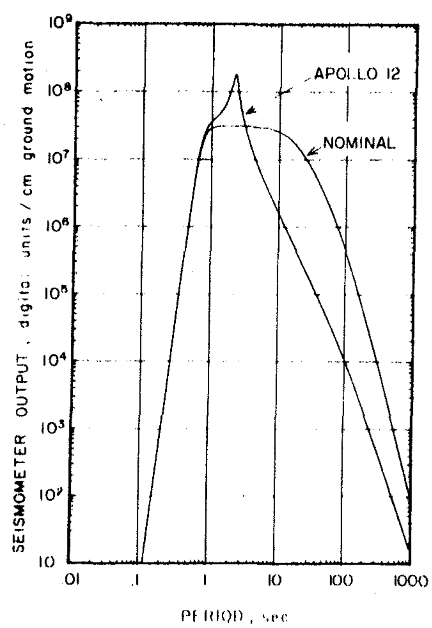
  1. Reduced calibration pulse amplitude.
     Calibration coil shorted - problem not electronic
  2. Lack of sensitivity to small signals.
     Mass rubbing frame. Delta rods broken.
  3. Noise pulses at output.
     Basic power variation (0.6 mv)

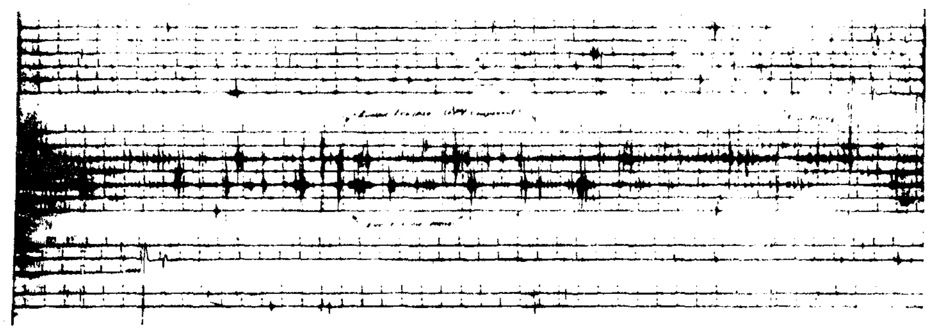
- <u>Thermal Control</u>

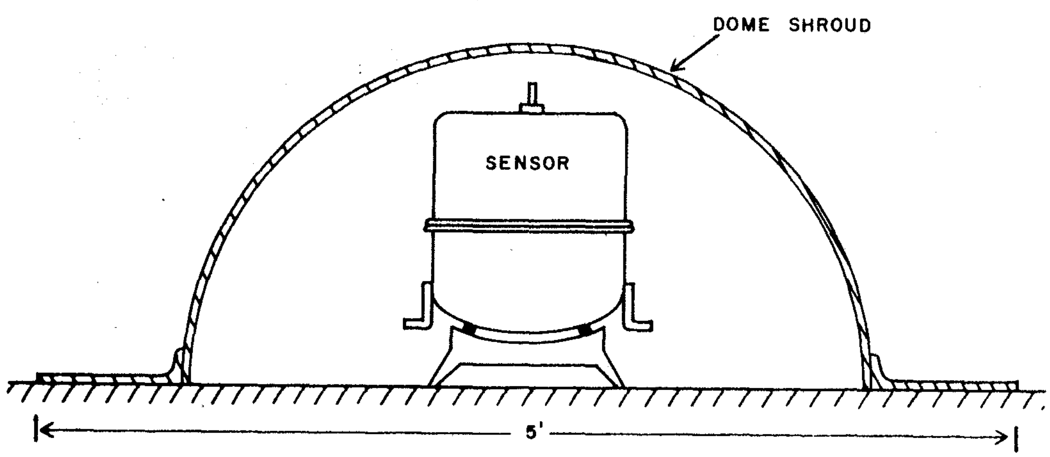
  Excessive temperature variation.
  Degraded thermal shroud. Have added motor heating at night.

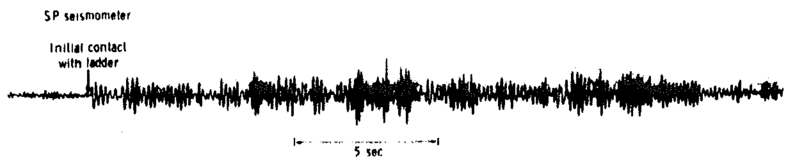
- <u>Seismic and Tidal Variations at Terminator Crossing</u>

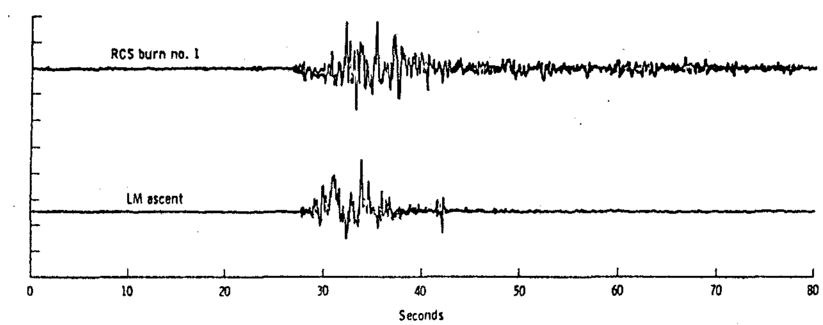
  Expansion and contraction of shroud couples mechanically to sensor.






DOME SHROUD
SENSOR
5'


SP seismometer
Initial contact
with ladder
5 sec


RCS burn no. 1
LM ascent
0
10
20
30
40
50
60
70
80
Seconds

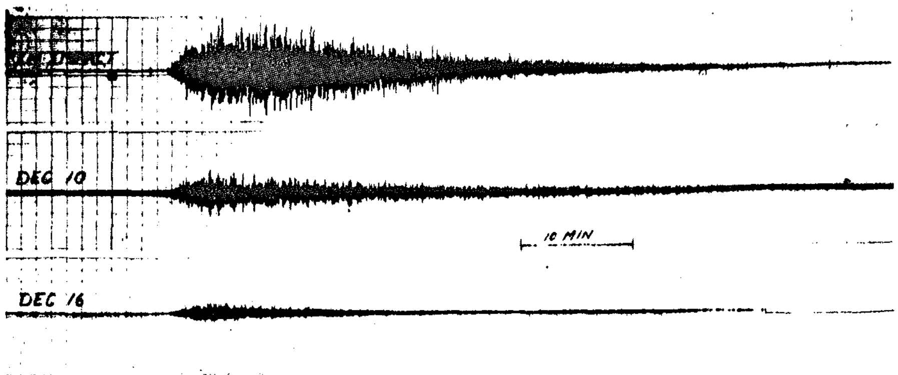
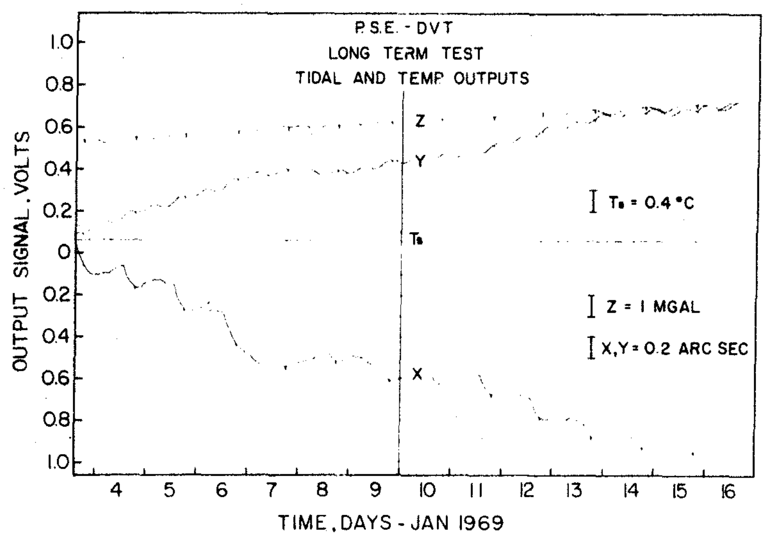


Figure [illegible]. Seismic signals received at the long period vertical component seismometer from the LM impact and from natural sources on December 1[illegible] and December 1[illegible], [illegible].

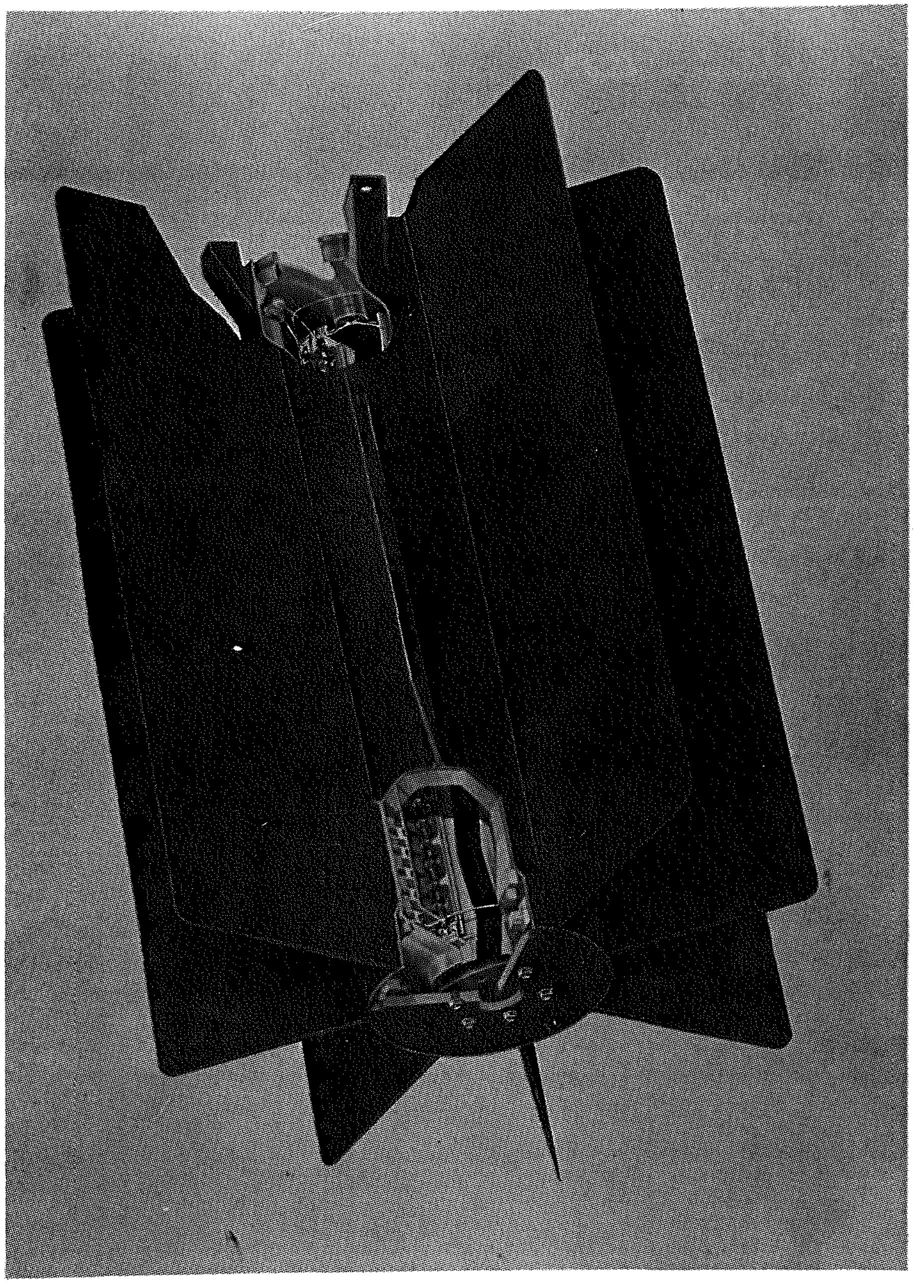


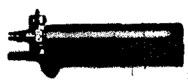
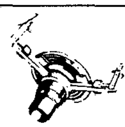
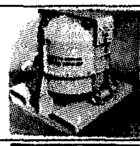
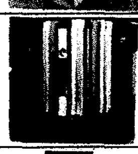
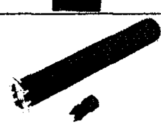
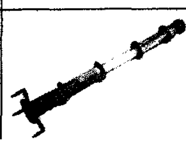
Addendum II

POWER SUBSYSTEM

Presented by A. Pitrolo

General Electric Company



	TITLE	PHOTO	PERTINENT FEATURES	USE	QUANITY FABRICATED
FLIGHT HARDWARE	GENERATOR ASSEMBLY (GA)		BERYLLIUM STRUCTURE WITH HIGH EMISSIVE RADIFRAX COATING 3N – 3P LEAD TELLURIDE ELEMENTS CONVERSION WELDED HERMETIC SEAL ARGON COVER GAS + 25 PSIA 442 COUPLES – 2 SERIES PARALLEL STRINGS TH = 1100°F/TC = 528°F POWER AT EOM (MIN): 63.5 WATTS FOR 1415 WATTS THERMAL INPUT WEIGHT: 28 LB WITH 10 – FT CABLE AND CONNECTOR TESTED TO SATURN V LAUNCH VEHICLE LOADS MAGNETIC FIELD FUELED 1 γ @ 3 METERS RELIABILITY 0.995 STORES WITHOUT CAPSULE UNLIMITED THERMAL CYCLES	ON LUNAR SURFACE	10
	GRAPHITE LM FUEL CASK (GLFC)		GRAPHITE STRUCTURE: PYRO CARB 406 BERYLLIUM HEAT SINK COATED WITH RHODIUM AND HIGH EMISSIVE RADIFRAX COATING ADJUSTABLE CAPSULE SUPPORT DESIGNED FOR EARTH ORBITAL, SUPERORBITAL RE-ENTRY NO FUEL RELEASE DURING RE-ENTRY ABORTS NO RELEASE MECHANISM REQUIRED TESTED TO SATURN V LAUNCH LOADS HIGH IMPACT CAPABILITY PREVENTS CAPSULE OR FUEL MELT WEIGHT: 26 LB	SUPPORTS HEAT SOURCE DURING EARTH TO LUNAR TRANSIT RE – ENTRY HEAT SHIELD	10
	FUEL CAPSULE ASSEMBLY (FCA)		PU – 238 MICROSPHERES (1480 ± 30 WATTS) SUPER ALLOY STRUCTURE (HAYNES) WITH HIGH EMISSIVE RADIFRAX OUTER COATING HELIUM VENT PROVIDED FUEL CONTAINMENT CAPABILITY-AT IMPACT LAUNCH TEMPERATURE: 1400°F RE – ENTRY TEMP. MAX. AVG: 2300°F TESTED TO SATURN V LAUNCH VEHICLE LOADS 2 – YEAR EARTH STORAGE CAPABILITY WEIGHT: 14.7 LB	HEAT SOURCE TO GENERATOR – LUNAR SURFACE	6
	FLIGHT HANDLING TOOL		LIGHTWEIGHT DESIGN (0.4 LB) TITANIUM GOLD – PLATED SURFACE TO REFLECT CAPSULE HEAT < 10 IN – LB OPERATING TORQUE	MOUNTS ONTO THE ALSEP FUEL TRANSFER ASSEMBLY TOOL USED BY ASTRONAUT TO REMOVE CAPSULE FROM GLFC FOR INSERTION INTO GA	12
SUPPORT HARDWARE	GENERATOR ASSEMBLY SHIPPING CONTAINER		PROVIDE GAS STORAGE ENVIRONMENT SHOCK ATTENUATED MOUNTINGS (<15G) PROVIDES UNLIMITED EARTH STORAGE OF GA REUSABLE	EARTH STORAGE CONTAINER FOR GENERATOR ASSEMBLY	6
	FUEL CAPSULE GROUND SHIPPING CASK		STAINLESS STEEL CONSTRUCTION WATER SHIELDED – 10 MREM/HR SURFACE TEMP < 180° F CAPSULE TEMP < 400° F COMPLIANCE TO AEC AND ICC REGULATIONS SHIPPING FIRE CAPABILITY QUALIFIED TO MIL STD 810A SPECIFICATIONS	STORES HEAT SOURCE ON EARTH	6
	TEST CONSOLE		ELECTRIC HEATER POWER SUPPLY: 0 – 1800 WATTS GENERATOR LOAD RESISTANCE: 0 – 20 Ω TEMPERATURE READ OUTS GENERATOR VOLTAGE, CURRENT, POWER READOUTS	OPERATES AND CHECKS OUT GENERATORS ENERGIZED EITHER WITH NUCLEAR HEAT SOURCE OR ELECTRIC HEAT SOURCE	10
	ELECTRIC FUEL CAPSULE SIMULATOR		SIMULATES HEAT SOURCE 1800 WATT CAPACITY DYNAMIC CAPABILITY (SATURN V ENVIRONMENT) AIR/VACUUM OPERATION WEIGHT/STIFFNESS SIMULATION	PERMITS TESTING OF GENERATORS AND GLFC'S	17
	GROUND HANDLING TOOL		TITANIUM/MELAMINE CONSTRUCTION LOCK DEVICE TO SECURE CAPSULE MAX GRIP TEMP < 125°F	HANDLES HEAT SOURCE ON EARTH	10

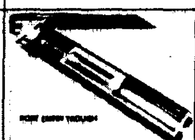
CAPSULE BACK PLATE LOCK CHECK TOOL		STEEL FITS CAPSULE BACK PLATE LATCH PLATES	ASSURES HEAT SOURCE IS PROPERLY LOADED INTO GLFC PRIOR TO LIFT-OFF	3
SLA HANDLING TOOL		TITANIUM/MELAMINE SAFETY LOCK MECHANISM FOR CAPSULE	USED FOR LOADING OF LOAD SOURCE INTO GLFC ON LAUNCH PAD PRIOR TO LIFT-OFF	6
PORT ENTRY TROUGH		ALUMINUM CONSTRUCTION FITS IN 10 IN. DIA. HOLE OF SATURN V ADAPTER WEIGHT < 20 LB HANDLE TEMPERATURES < 100°F	PERMITS HEAT SOURCE TO BE INSERTED THROUGH SATURN LM ADAPTER (SLA)	2
SLA TRANSFER CASK		MAX SURFACE TEMP < 90 °F SCREENED FOR HANDLING PROTECTION WEIGHT < 25 LB	PORTABLE SUPPORT STRUCTURE FOR CAPSULE AT LAUNCH SITE	8

Figure 2

SNAP-27 PROGRAM BACKGROUND

INITIAL STUDY

- FEASIBILITY STUDY FOR RTG IN LUNAR ROVING VEHICLE
- CONTRACT TO AEC (SLRV) 40 WATT GENERATOR
- STUDY RECOMMENDED BERYLLIUM FOR STRUCTURE

SNAP-27 (AEC)

PHASE IIA - TECHNOLOGY PROGRAM

PLAN TO START - SPRING 1965
ACTUAL START - AUGUST 1965
EIGHT MONTH PROGRAM

CONCEPTUAL DESIGN (50 WATT)
THERMOELECTRIC DEVELOPMENT PROGRAM (3M)

10-COUPLE MODULES
MAT'L COMPATIBILITY
MAT'L SELECTION

BERYLLIUM FABRICATION

PROCESS DEVELOPMENT
Y-12, SOLAR
PROOF GENERATOR (W/O T/E)

DEVELOPMENT PLAN

SURFACE EXPERIMENT PACKAGE STUDY (SEP)

STUDY FOR NASA - SNAP 27 CONCEPT
PARALLEL STUDY GIVEN TO RCA
DESIGN AND INTEGRATION STUDY
COMPLETE JULY 1965

GE SELECTED IN AUG/SEPT FOR ALSEP

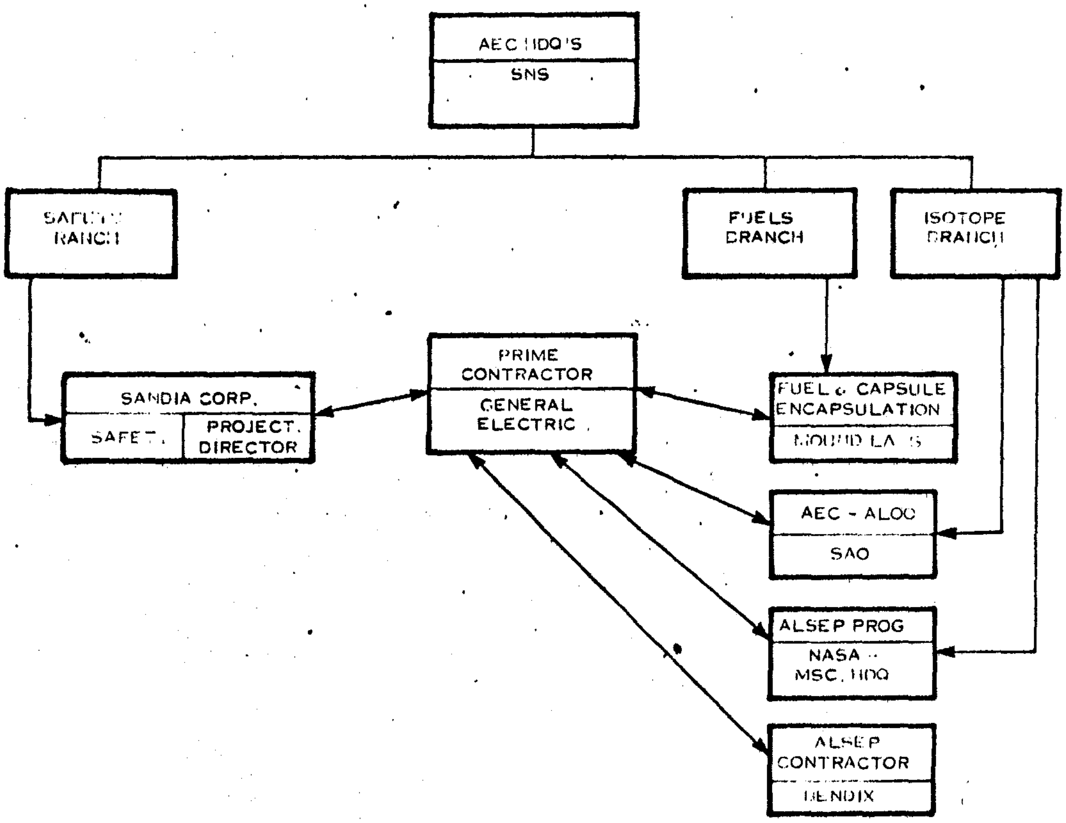
SNAP-27 PROGRAM

INITIATED IN SEPTEMBER 1965

STRUCTURED AS COMPONENT DEVELOPMENT EFFORT

PARALLEL DESIGN AND TECHNOLOGY DEVELOPMENT

SNAP 27 PROGRAM INTERFACES



SNAP-27 DESIGN AND PERFORMANCE CHARACTERISTICS

MISSION APPLICATION	POWER APOLLO LUNAR SURFACE EXPERIMENT PACKAGE (ALSEP)
CONVERSION CONCEPT	Pu^{238} FUELED THERMOELECTRIC SYSTEM USING LEAD-TELLURIDE ALLOY THERMOCOUPLES IN TWO SERIES PARALLEL STRINGS.
DESIGN LIFE	ONE YEAR LUNAR OPERATION PRECEEDED BY TWO YEARS EARTH STORAGE.

GENERATOR PERFORMANCE

OUTPUT POWER		
SPECIFIED (WATTS)	65 (BOM)*	63.5 (EOM)* MIN.
MEASURED (WATTS)	73.3 (BOM)	68.5 (EOM)**
OUTPUT VOLTAGE (NOMINAL)		16 VOLTS DC
CURRENT (NOMINAL)		4 AMPS
OVER-ALL EFFICIENCY (NOMINAL)		4.75%
AVERAGE HOT JUNCTION TEMPERATURE		1075°F (580°C)
AVERAGE COLD JUNCTION TEMPERATURE		525°F (271°C)
FUEL CAPSULE THERMAL OUTPUT (NOMINAL)		1450 WATTS

MECHANICAL CHARACTERISTICS

OVER-ALL DIAMETER OVER FINS	15.7 INCHES
OVER-ALL LENGTH	18.1 INCHES
NUMBER OF FINS	8
FIN RADIAL LENGTH	5.0 INCHES
FIN AXIAL LENGTH	18.0 INCHES

WEIGHT

GENERATOR ASSEMBLY (INCLUDES CABLE, CONNECTOR, AND INSTRUMENTATION)	28.2 POUNDS
RADIOISOTOPE FUEL CAPSULE ASSEMBLY	14.5 POUNDS
FUELED GENERATOR	42.7 POUNDS

* BEGINNING (OR END)-OF-MISSION
** 1485 WATT THERMAL INPUT, 12, 113 HOURS

SNAP-27 RTG DESIGN CONSTRAINTS

- GENERATOR STOWS IN LM INERT
- SYSTEM FUELED ON LUNAR SURFACE
- COMPATIBLE WITH SATURN V/ALSEP ENVIRONMENTS

VIBRATION: SINUSOIDAL

FREQUENCY (CPS)	QUAL VALUES
5-20	0.39" DA
20-35	7.8 ± 1 G 0 TO PEAK
35-100	10.4 ± 1 G 0 TO PEAK

3 OCTAVE/MINUTE SWEEP

RANDOM

FREQUENCY (CPS) 5 MIN/AXIS	QUAL VALUES G^2/CPS
23-80	0.224
80-120	12 DB/OCTAVE ± 1 DB
120-950	0.0444
950-1250	12 DB/OCTAVE ± 1 DB
1250-2000	0.0148

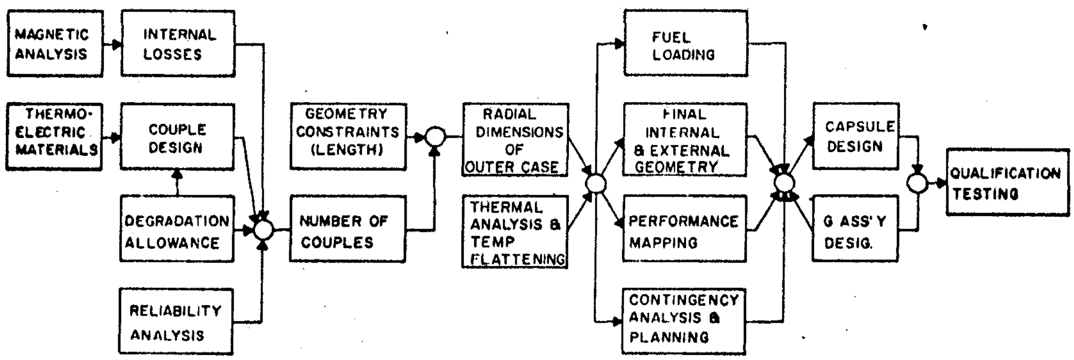
SHOCK - SAWTOOTH 11 MSEC USE 15G 3 SHOCK/AXIS

- FLANGE MOUNT

  6.500 INCH DIA BOLT CIRCLE
  8 HOLES .256 - .263 DIA .001R TRUE POSITION

- VOLTAGE CONTROL - 16 VOLTS ± .2 VOLTS
- START UP TEMPERATURE ≤ 1075°F
- COMPATIBLE WITH BENDIX CABLE
- BENDIX SUPPLIED CONNECTOR
- 6 TEMPERATURE SENSORS FOR DIAGNOSTICS
- FLOATING GROUND
- WEIGHT AND CG 1" DIA SPHERE ON GEOMETRIC CENTER 8.91 INCHES ABOVE MOUNTING FLANGE
- TWO YEAR INERT STORAGE

SNAP-27 IPU DESIGN AND DEVELOPMENT PROGRAM
SYSTEM ANALYSIS AND DESIGN



DEVELOPMENT TEST PROGRAM

GENERATOR ASSEMBLY

MATERIALS:
- COMPATIBILITY
- T/E INSULATION
- OUTER CASE & HOT FRAME COATINGS
- BE MATERIAL STRENGTH
- BN FRICTION TESTS

MFG. PROCESS:
- MACHINING TESTS
- SHRINK FIT
- FIN ATTACHMENT
- HERMETIC CLOSURE
- T/C ATTACHMENT

THERMOELECTRIC:
- 10 COUPLE MODULES
- 104 COUPLE MODULES

MAGNETIC:
- MOCK-UP, GA ASSEMBLY TEST

THERMAL/MECH:
- MOCK-UP
- PROOF MODEL NO. 1
- FOLLOWER PERFORMANCE
- FOLLOWER SPRING RELAX.

ENG. MODEL SERIES:
- MOD 5 SHOCK, VIBRATION
- MOD 6 LIFE
- MOD 7 PERFORMANCE
- MOD 8 SIMULATED MISSION

FUEL CAPSULE

MATERIALS:
- COATINGS AND LIFE TEST
- COMPATIBILITY
- IMPACT
- CREEP RUPTURE
- WELD TESTS
- BURST TESTS

COMPONENENT:
- LINER RUPTURE
- FILTER DEVELOP.
- SERIES I IMPACT
- SERIES II IMPACT
- VENTED DESIGN IMPACT

GENERATOR ASSEMBLY TEST PROGRAM

- ELECTRIC INSULATOR FRICTION COEFFICIENT MEASUREMENTS
- FOLLOWER PERFORMANCE TESTS
- HERMETIC SEAL DEFLECTION TESTS
- HERMETIC CLOSURE TRANSITION RINGS
- SHRINK FIT PERFORMANCE
- 10-COUPLE MODULE TESTS
- 104-COUPLE MODULE TESTS
- STRUCTURAL PROOF TESTS
- RADIATOR THERMAL PERFORMANCE TESTS
- MAGNETIC FIELD TESTS
- FREE CONVECTION AIR OPERATION TESTS
- OUTER CASE FIN AND TRANSITION BRAZE DEVELOPMENT
- HOT FRAME JOINING DEVELOPMENT
- HOT FRAME EMISSIVE COATING
- OUTER CASE AND FIN EMISSIVE COATING
- THERMAL INSULATION STABILITY TESTS
- ISOTHERMAL COMPATIBILITY TESTS
- INSULATION AND THERMOELECTRIC THERMAL CONDUCTIVITY TESTS
- THERMOELECTRIC PRODUCT SPECIFICATION DEVELOPMENT
- BERYLLIUM MATERIAL PROPERTIES TESTS
- ELECTRIC LEAD THRU DEVELOPMENT
- LIFE TEST OF FULL SIZE GENERATORS
- TRANSIENT START-UP CHARACTERISTICS OF RTG

CAPSULE AND FUEL TEST PROGRAM

- DEVELOPMENT TESTS
  - IMPACT TESTS (22)
  - DROP TEST
  - BURST PRESSURE TESTS
  - FATIGUE TESTS
  - CREEP RUPTURE TESTS
  - CRACK PROPAGATION TESTS
  - PENDULUM IMPACT TESTS
  - VIBRATION TEST (PART OF GLFC TEST)
  - RUPTURE DISC TESTS
  - PRD TESTS
  - CAPSULE/LM HARDWARE IGNITION TESTS
  - WELDED JOINT TESTS
  - COMPATIBILITY
  - COATING AND EMISSIVITY TESTS
- SAFETY TESTS
  - RADIANT HEAT TESTS
  - SOIL CONDUCTIVITY AND BURIAL TESTS
  - RADIATION LEVELS
- FUEL TESTS
  - COMPATIBILITY
  - SOLUBILITY
  - IMPACT

GENERATOR MATERIALS

OUTER CASE ASSEMBLY	- HOT PRESS Be CYLINDER - CROSS ROLLED SHEET Be FINS - SILVER BRAZE ALLOY - 19 - DL TRANSITION RINGS - SPRAY RADIFRAX COATING
COLD FRAME	- HOT PRESSED Be
THERMOELECTRICS	- PbTe AND Pb SnTe, COPPER
THERMOPILE INSULATION	- POWDERED MIN-K 1301 - PRESSED MIN-K (AFT SEAL)
FORWARD SEAL	- GOLD FOIL REFLECTING SURFACE (SPOT WELDED)
AFT SEAL	- IN 102
HOT FRAME	- IN 102 - INTERIOR COATED WITH RADIFRAX
SPRINGS	- INCONEL X
SHIMS	- ISOMICA
SPRING LOCK	- BERYLLIUM
HOT BUTTONS	- 1010 STEEL - 0.003" ARMCO IRON COATING
HOT SIDE INSULATOR	- BORON NITRIDE
INSULATOR SUPPORT STRUCTURE	- MOLY
COVER GAS	- ARGON
FOLLOWERS	- BERYLLIUM OXIDE

THERMOELECTRIC PROGRAM

1. SELECT BEST THERMOELECTRIC (T/E) MATERIALS

3N TYPE CANDIDATES	2P TYPE CANDIDATES
↓	↓
TPM 10 (PbTe) -3N-	TPM 15 (PbSnTe) -3P-

2. SELECT T/E OPERATING TEMPERATURES

   $T_H = 1100^{\circ}F$

   $T_C = 525^{\circ}F$

3. DETERMINE COUPLE EXTRANEOUS RESISTANCE FOR ELEMENT SIZE

   DESIGN N-LEG 1.70 m Ω

   P-LEG 3.0 m Ω

4. SIZE ELEMENT

   N LEG 0.207" DIA X 0.400 LONG

   P LEG 0.247" DIA X 0.400 LONG

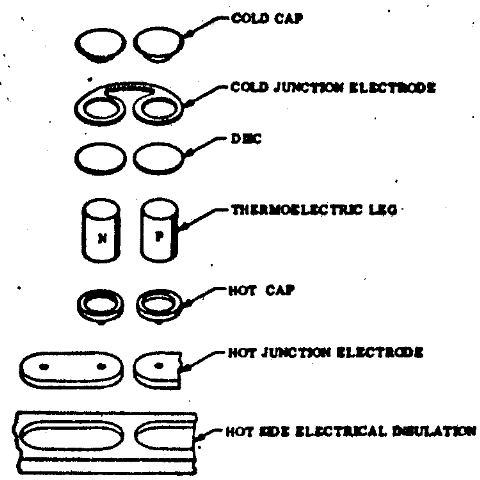
5. VERIFY T/E MATERIAL PERFORMANCE - TEST PROGRAM

   A. COMPATIBILITY OF T/E'S WITH ELEMENTS OF SNAP-27

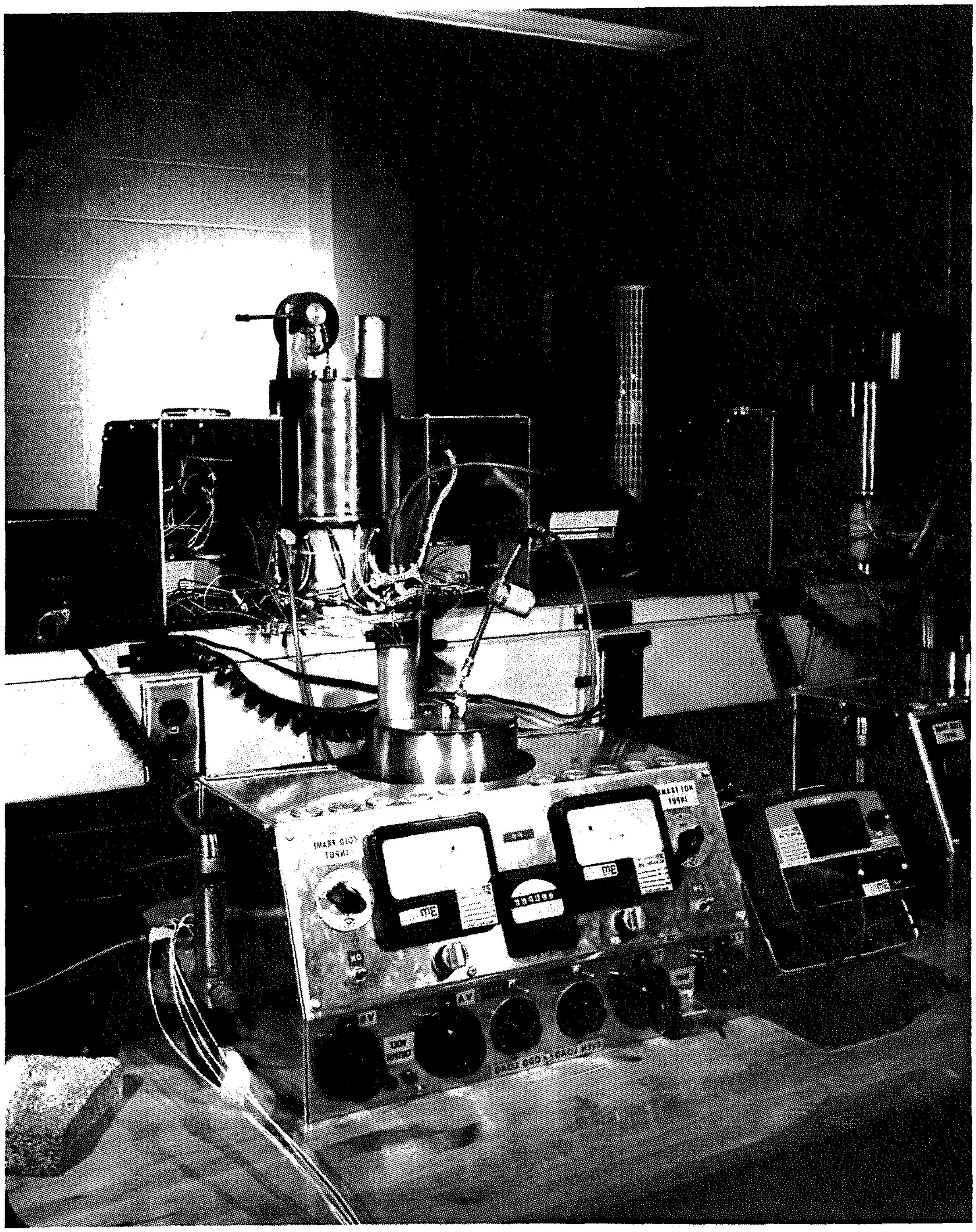
   B. T/E PROPERTY DATA - INDEPENDENT MEASUREMENTS BY BMI

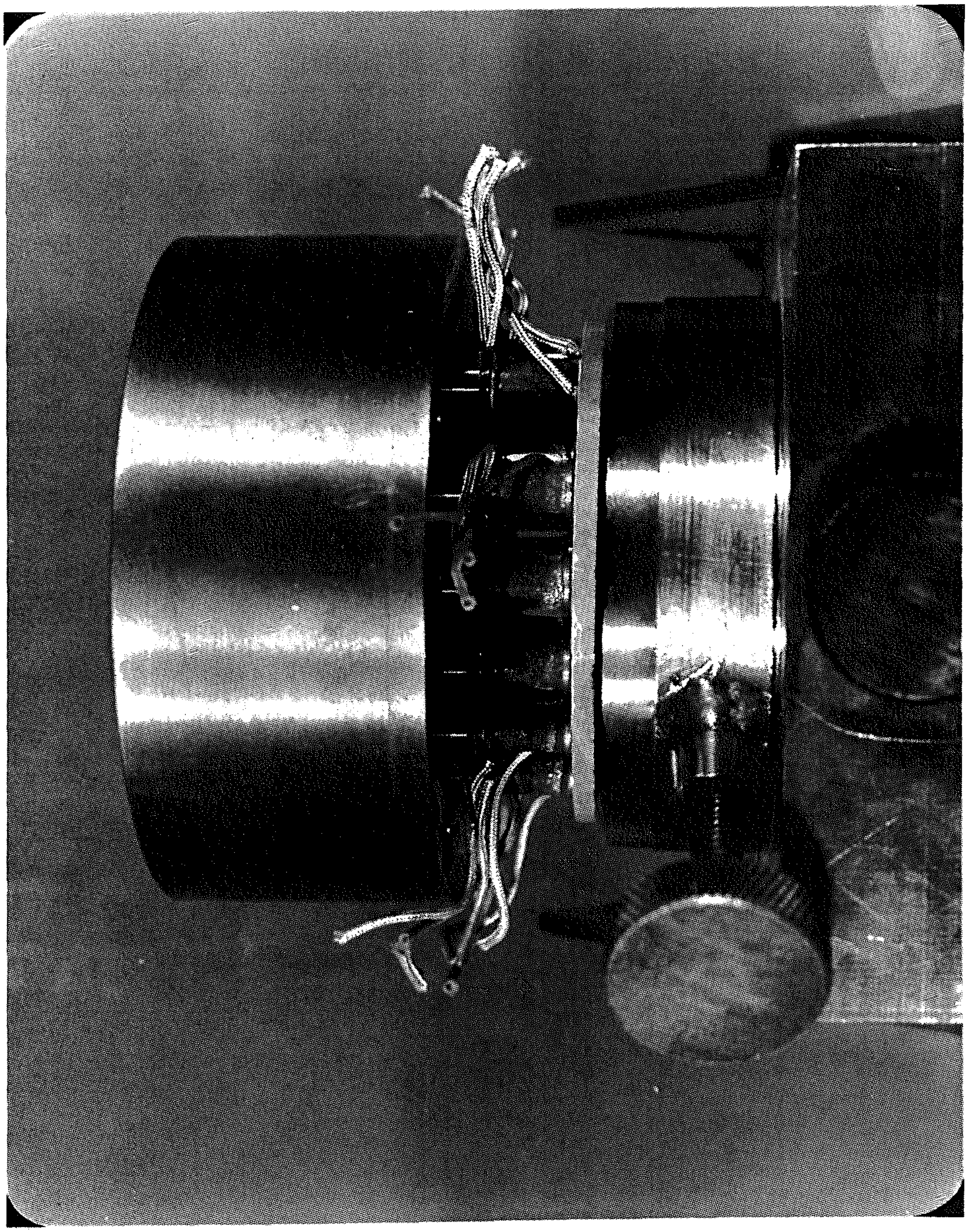
   C. SHORT AND LONG LIFE TEST PROGRAM WITH 19 FLAT PLATE MODULES

   D. LONG LIFE TEST PROG. WITH 15 QUARTER SIZE SNAP-27 GEN.



Couple Assembly





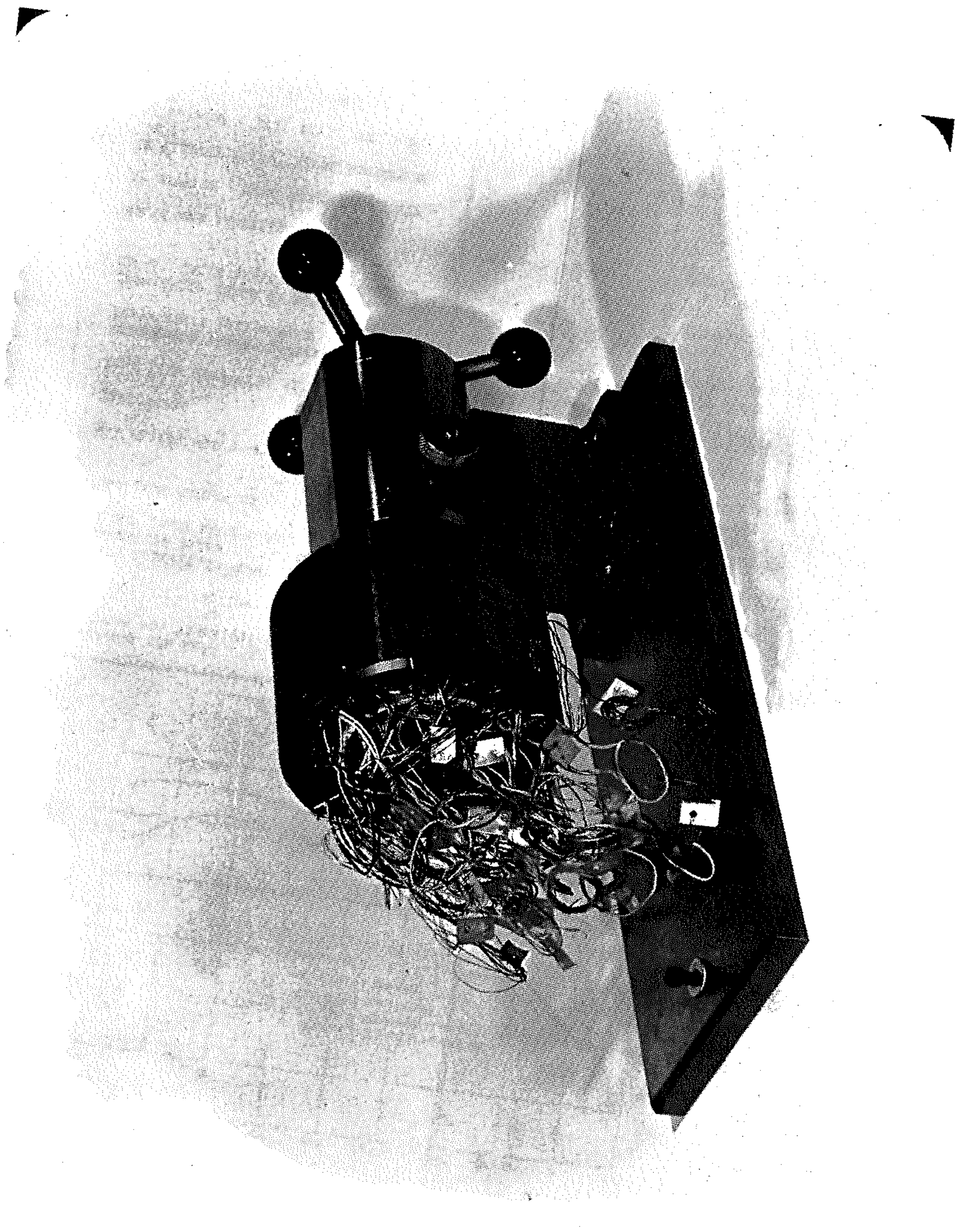
TEN - COUPLE TEST MATRIX

MODULE	TEST DESCRIPTION	HOT JUNC TEMP-T_H (°F)	COLD JUNC TEMP-T_C (°F)	GAS PRES. P_G (PSIA)	SPRING PRES. P_S (PSI)	TOTAL TIME ON TEST AT 9/5/69
B1	Short Term Stability	1100	525	25	150	Terminated at 2206 hr.
B2	Short Term Stability	1100	525	25	150	28,584 hr.
C3	Short Term Stability	1100	525	25	150	Terminated at 1832 hr.
C4	Short Term Stability	1100	525	25	150	28,2[illegible]9 hr.
C5	Off Design Hot Junction	1130	525	25	150	26,478 hr.
C6	Off Design Hot Junction	1130	525	25	150	26,395 hr.
C7	Off Design Hot Junction	1050	525	25	150	25,901 hr.
C8	Off Design Hot Junction	1050	525	25	150	25,684 hr.
C9	Off Design Hot Junction	1200	525	25	150	26,363 hr.
C10	Off Design Hot Junction	1200	525	25	150	Terminated at 23,997 hr. (7/19/69)
C11	Lower Gas Pressure	1100	525	25	150	24,397 hr.
C12	Lower Gas Pressure	1100	525	2.5*	150	Terminated at $\sim$6000 hr.
C13	Lunar Cycle	1100/1050	525/460	25	150	14,767 hr - terminated 9/12/68 after 36 cycles
C14	Increased Spring Pressure	1100	525	25	250	22,413 hr.
C15	Increased Spring Pressure	1100	525	25	250	23,099 hr.
C16	Lower Gas Pressure	1100	525	7**	150	17,785 hr.
C17	Lunar Cycle	1100/1050	525/460	25	150	23,197 hr-cycling terminated 4/19/67 after 29 cycles
C18	Off Design Cold Junction	1100	575	25	150	23,363 hr.
C19	Off Design Cold Junction	1100	625	25	150	22,868 hr.

Total Number Module Hours @ 9/5/69 - 393,588

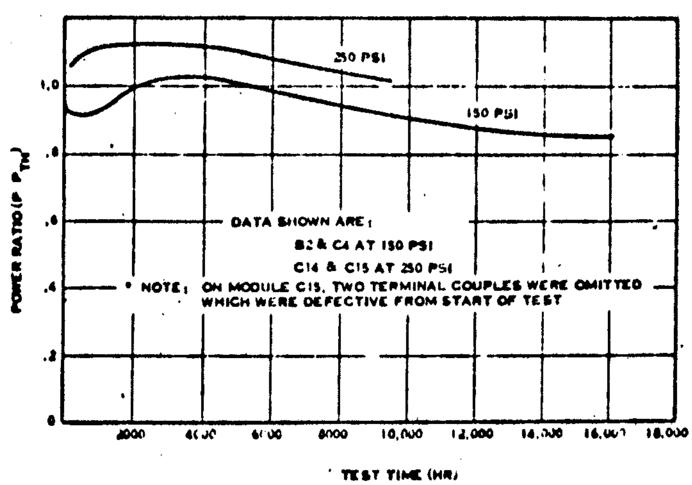
*Module was originally set at 0.5 psia; outgassing of the insulation increased pressure to 2.5 psia

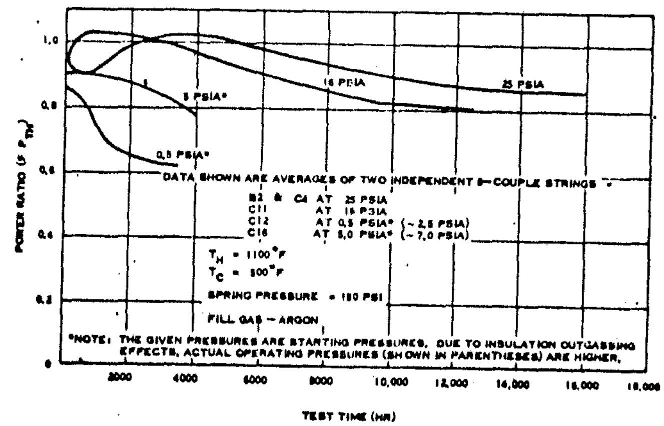
**Module was originally set at 5.0 psia; outgassing of the insulation increased pressure to 7.0 psia



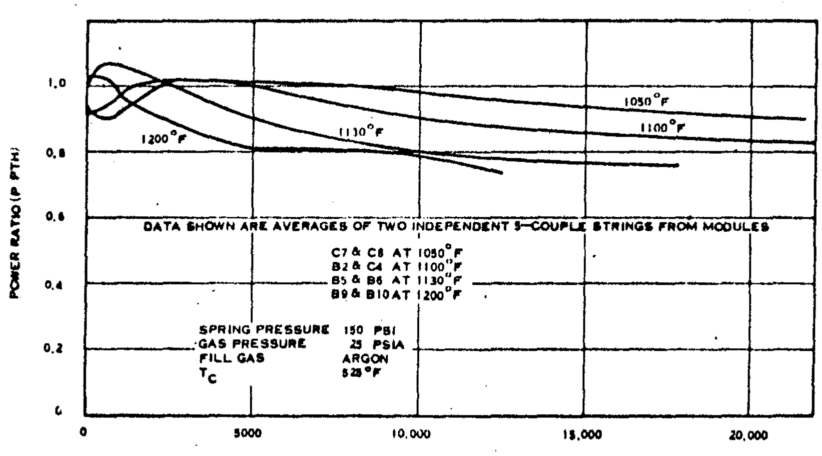
104-COUPLE TEST MATRIX

MODULE	TEST DESCRIPTION	HOT JUNC TEMP-T_H (°F)	COLD JUNC TEMP-T_C (°F)	TOTAL TIME ON TEST AT 3/1/70
104-B1	OFF DESIGN HOT JUNCTION	1030	525	12,058 HOURS
104-B2	EFFICIENCY TESTING WITH 4-ZONE HEATER	1070	525	22,475 HOURS
104-B3	IN STORAGE - TEST START POSTPONED			
104-B4	IN STORAGE - TEST START POSTPONED			
104-B5	IN STORAGE - TEST START POSTPONED			
104-B6	SHOCK AND VIBRATION	1100	525	TERMINATED 8/4/67 AT 2,413 HOURS
104-B7	ON-OFF CYCLE PERFORMANCE - CYCLING TERMINATED AFTER 17 CYCLES	1100	525	TERMINATED 10/19/67 AT 5,839 HOURS
104-B8	LUNAR CYCLE PERFORMANCE - CYCLING TERMINATED AFTER 20 CYCLES	1100/ 1045	525/ 460	TERMINATED 5/8/68 AT 9,451 HOURS
104-B9	LONG TERM STABILITY WITH ZENON GAS	1100	525	26,138 HOURS
104-B10	EFFICIENCY	1100	525	26,477 HOURS
104-B11	OFF DESIGN HOT JUNCTION	1130	525	TERMINATED 11/22/70 AT 24,090 HOURS
104-B12	LONG TERM STABILITY	1100	525	25,760 HOURS
104-B13	ON-OFF CYCLE PERFORMANCE - CYCLING TERMINATED AFTER 10 CYCLES, T_H REDUCED AFTER 2700 HOURS TO 1050°F	1100	525	25,833 HOURS
104-B14	REDUCED HOT JUNCTION	1050	525	25,566 HOURS
104-B15	REDUCED HOT JUNCTION, PRING PRESSURE 250 PSI	1050	525	23,107 HOURS

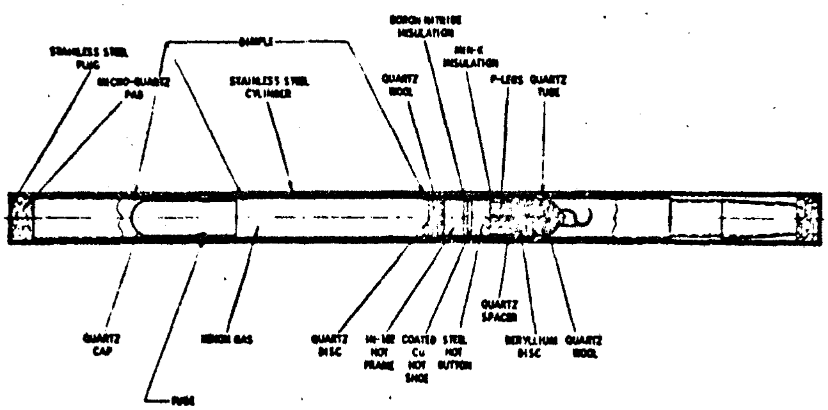




Influence of Gas Pressure



10-Couple Module Data Influence of Hot Junction Temperature



Compatibility Test Fixture Assemblies Nos. 11, 13, 15 and 17

SNAP-27 Isothermal Test Material

Description	Material	Size	Source	Processing
Hot Block	Inconel 102	0.375 L 0.70 D	Allegheney Ludlum	Will be cleaned and stored in bonded stock.
Electrical Insulation	Boron Nitride	0.075 L 0.70 D	Carborundum	Will be cleaned, baked, and stored in bonded stock.
Hot Shoe	110 Cu	0.075 L 0.70 D		Will be cleaned and stored in bonded stock.
Hot Junction Button	C1020 Steel	0.075 L 0.70 D		Will be cleaned and stored in bonded stock.
Cold Electrode	110 Cu	0.075 L 0.70 D		Cleaned and bonded to thermoelectrid legs.
Cold Block	Beryllium	0.070 L 0.070 D	G. E.	
Filler Pad	Quartz Wool		Engelhart	Will be baked and stored in bonded stock.
Spacers	Quartz Plate	0.0725 L 0.71 D	Engelhart	Will be cleaned and stored in bonded stock.
Thermal Insulation	MIN-K 1301	Powdered Form	Johns-Manville	Baked to remove bi binder and moisture, stored in closed container, and placed in bonded stock until used.
Quartz Tubes	Quartz	0.75 ± 0.03 ID	Engelhart	Will be assembled by the glass-blowing shop of Central Research, 3M Company.
Xenon Gas	Xenon		Matheson	Back filled to 6.3 lb/in.^{2} at room temperature.

SYSTEM DESIGN AND PERFORMANCE EVALUATION

DESIGN

NUMBER OF COUPLES 442

- END OF LIFE POWER 56.6 WATTS (CHANGED TO 63.5)
- ALLOWANCE FOR UP TO ONE STRING FAILURE (9mΩ/COUPLE)
- ALL COUPLES LADDERED FOR INCREASED RELIABILITY
- HEAT FLOW TO THERMOELECTRICS SELECTED FOR MAXIMUM EOM EFFICIENCY AND OUTPUT OF 16 VOLTS
- SYSTEM CHARACTERISTICS DETERMINED FOR ON AND OFF DESIGN PERFORMANCES AND MANUFACTURING TOLERANCE RANGES.

HARDWARE BUILT

- THREE ENGINEERING PROTOTYPES (2 GE, 1 BENDIX)
- TWO QUALIFICATION UNITS (1 GE, 1 BENDIX)
- FIVE FLIGHT UNITS

TEST PROGRAM

- LIFE TEST UNDER LUNAR CONDITIONS 28,000 HOURS
- PERFORMANCE AFTER QUAL DYNAMIC TESTS
- PERFORMANCE CHARACTERISTICS OF ALL SYSTEMS/THERMAL VACUUM
- MAGNETIC MEASUREMENTS
- TRANSIENT START-UP CHARACTERISTICS

SNAP-27 IPU THERMAL PROGRAM

TEST

- THERMAL MOCK-UP GENERATOR
  - ALUMINUM-12 AND 6 FIN
  - AIR AND THERMAL VACUUM
  - FIN TEMPERATURE MAPPING
  - AXIAL AND CIRCUMFERENTIAL GRADIENTS
  - VERIFICATION OF ANALYTICAL TOOLS
  - INTERFACE BOUNDARIES
- FOLLOWER-COLD JUNCTION Δ T
  - BeO, Be FOLLOWERS
- ENGINEERING PROOF MODEL #1
  - TEMP DISTRIBUTIONS
  - Δ T THRU SHRINK FIT
- SHRINK FIT THERMAL TEST
  - Δ T THRU SHRINK FIT
- FUEL AND FUEL CAPSULE Δ T
  - FUEL PROPERTIES
  - LINER TEMPERATURES
- THERMOPILE INSULATION THERMAL CONDUCTIVITY
- COATING DEVELOPMENT
  - HI AND LOW EMISSIVE COATINGS

ANALYSIS

FINS

OPTIMIZATION TAKE-OFF OF FIN DESIGN

IPU

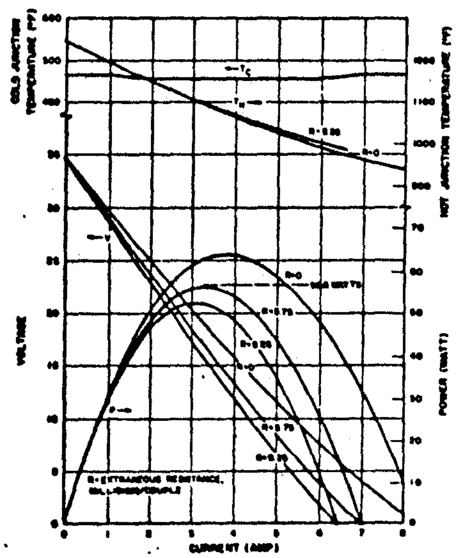
(TWO-PROBLEM SOLUTION)
TEMPERATURE DISTRIBUTION
LOCATION OF KEY PARTS
FUEL LOADING
SYSTEM PERFORMANCE

IPU

(3 DIMENSIONAL-22° THERMAL MODEL)
CHECK ON ORIGINAL ANALYSIS
VARIABLE MATERIAL PROPERTIES
VARIABLE SINK AND FUEL LOADING
SUPPORT COMING TEST PROGRAM

FUEL CAPSULE

TEMPERATURE DISTRIBUTION



Lunar Night Sink Temperature,
Q = 1200 watts

COMPONENTS OF THERMAL SYSTEM

- RADIATOR
  - OUTER CASE
  - FINS
- COLD FRAME
- BeO FOLLOWERS
- THERMOELECTRICS
- THERMOPILE INSULATION MIN-K
- THERMOPILE COVER GAS
- END ENCLOSURE INSULATION MIN-K
- END SEALS
- ALSEP BASEPLATE
- HOT FRAME
- ELECTRICAL INSULATORS
- HEAT SOURCE
- HEAT SOURCE BACKPLATE

RADIATOR

OUTER CASE/FIN ASSEMBLY

- DEFINE CONSTRAINTS
- DETERMINE RANGE OF HEAT REJECTION
- PERFORM OPTIMIZATION STUDIES
  - THERMAL SURFACES
  - NUMBER OF FINS
  - FIN SIZE
  - LUNAR SINK
  - EFFECTS OF ALSEP BASEPLATE
- TEST PROGRAM
  - VERIFY ANALYTICAL TECHNIQUES

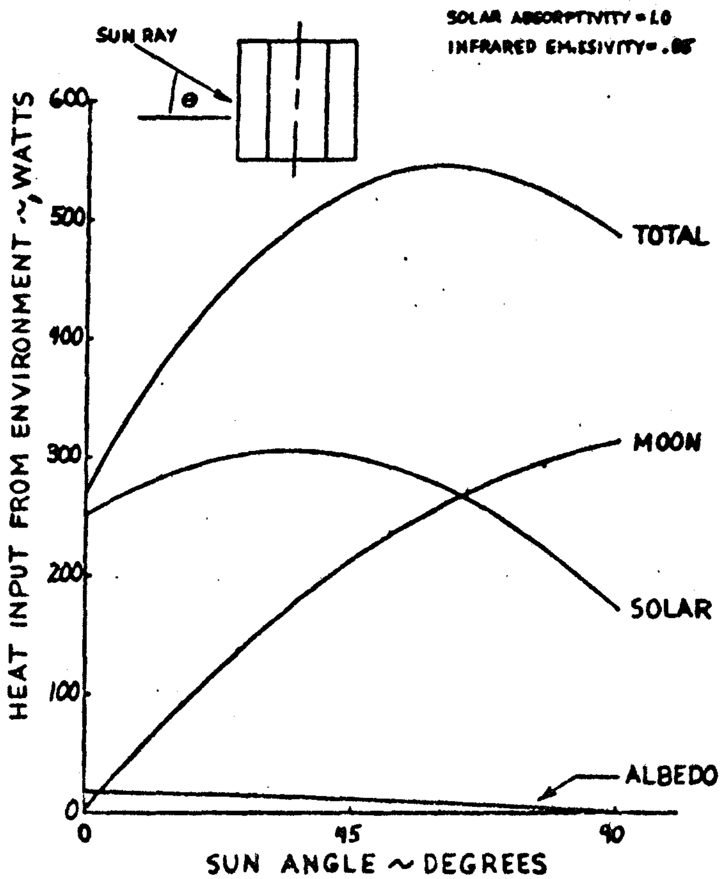
    ALUMINUM STRUCTURE WITH 12 AND 6 FINS
  - MEASURE PERFORMANCE OF COATED OUTER FRAME/ COLD FRAME UNIT - MOD 1
  - DEVELOP OUTER SURFACE COATINGS

    RADIFRAX
  - ASSESS LONG TERM PERFORMANCE

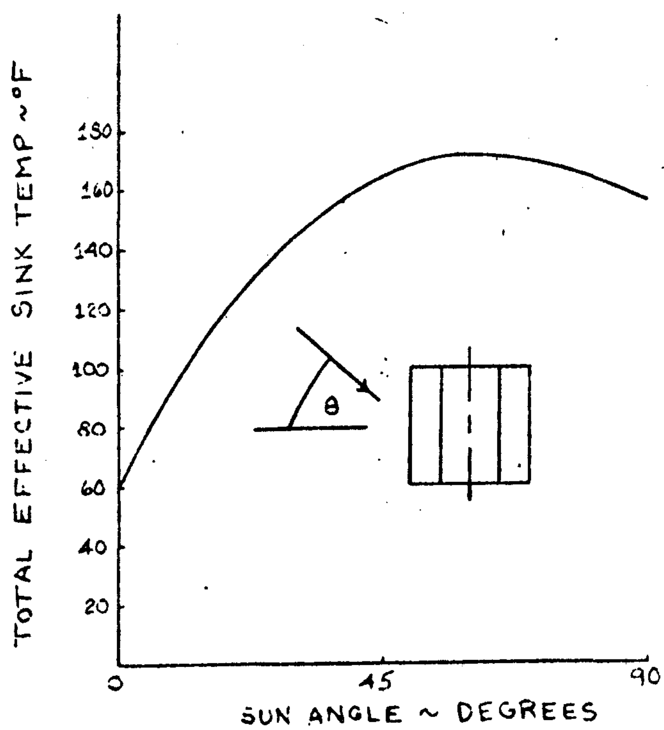
    COATING SAMPLES

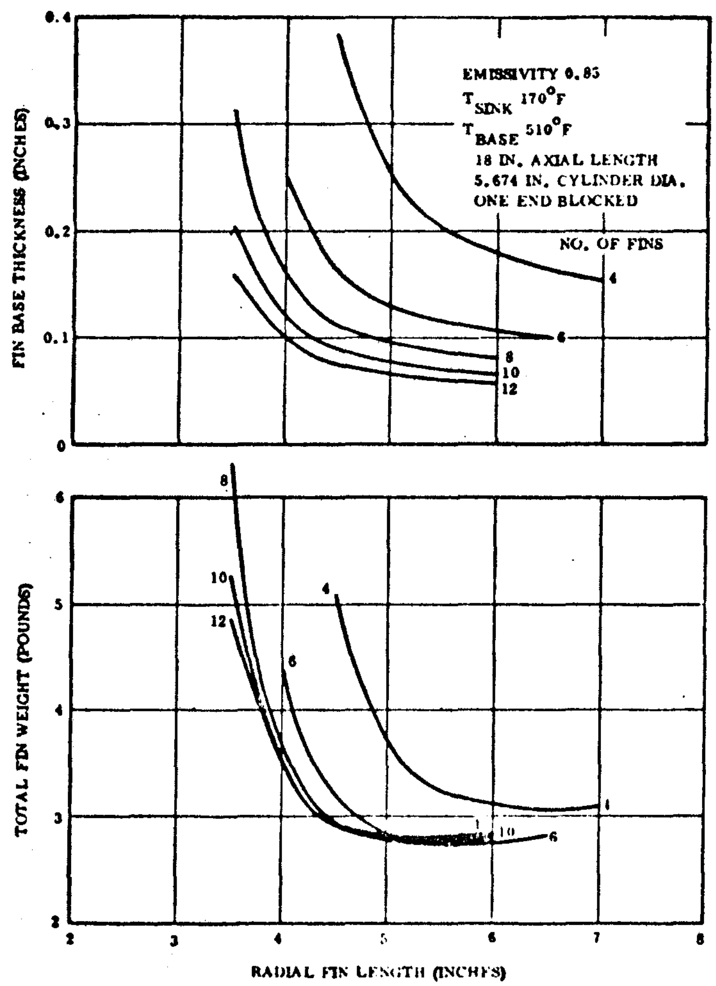
MOD 5 GENERATOR	12,165 HOURS
MOD 8B GENERATOR	8,340 HOURS
MOD 10 GENERATOR	10,000 HOURS

HEAT LOAD IMPOSED ON A DEPLOYED
SNAP-27 BY THE LUNAR ENVIRONMENT

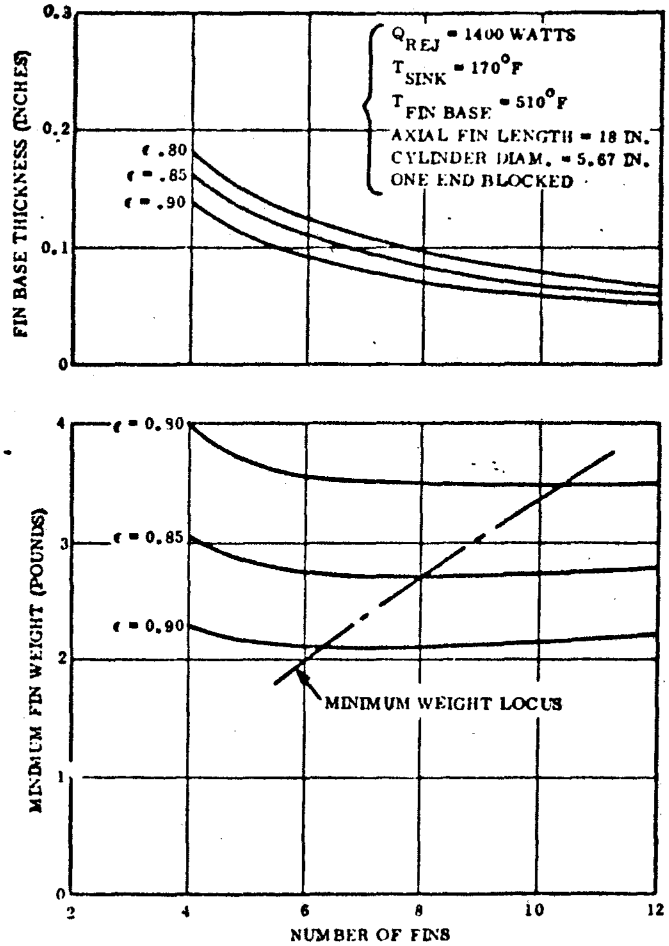


LUNAR SINK TEMPERATURE
FOR A DEPLOYED SNAP-27

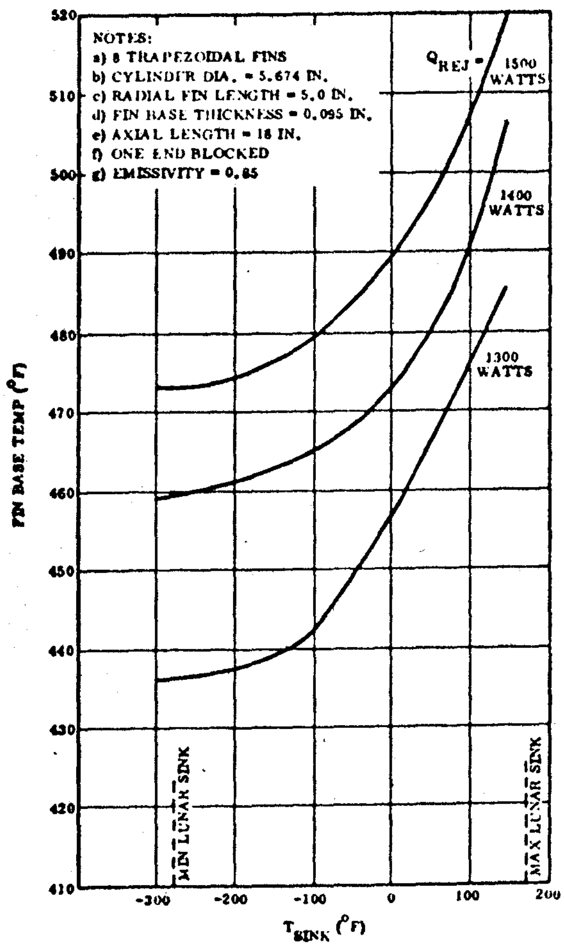




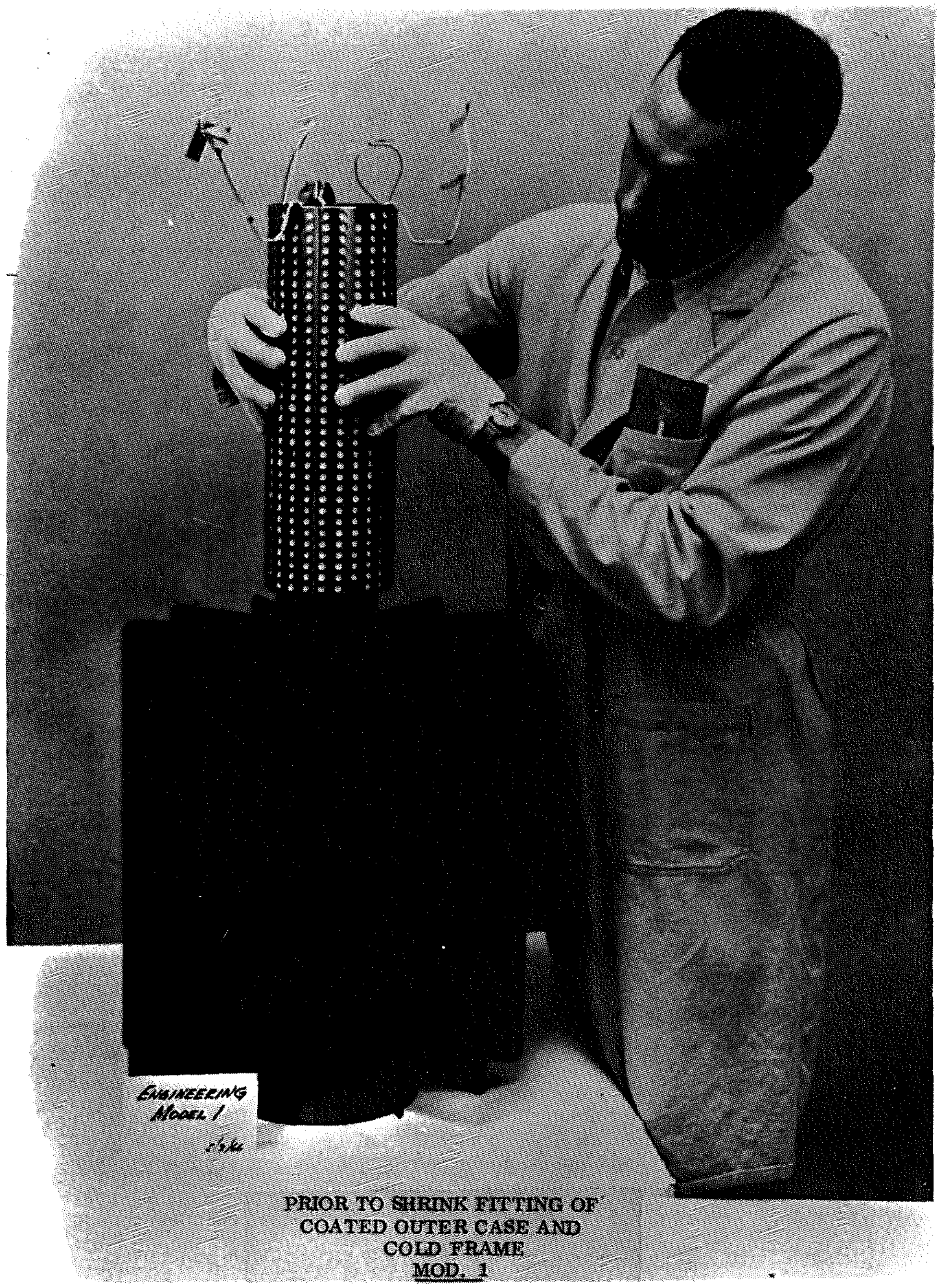
· in Parametric Analysis, 1400 Watt Heat Rejection



Minimum Fin Weight and Thickness Variation with Number of Fins and Fin Emissivity



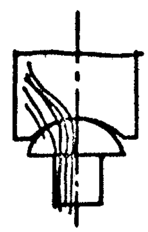
SNAP-27 Operational Fin Base Temperature for Reference Design



PRIOR TO SHRINK FITTING OF
COATED OUTER CASE AND
COLD FRAME
MOD. 1

BeO FOLLOWERS

- MINIMIZE TEMPERATURE DROP FROM COUPLE TO OUTER CASE
- DEVELOP ANALYTICAL MODEL CONSIDERING:



  - SPHERICITY
  - GAP (CLEARANCE)
  - PRESSURE
  - GAS

- VERIFY BY TESTS
  - COMPONENT TESTS
  - QUALITY CONTROL (DIMENSIONS) ESTABLISHED
  - SYSTEM ΔT 20-25° FROM COPPER CAP TO FIN BASE
  - BeO FOLLOWERS SUPERIOR

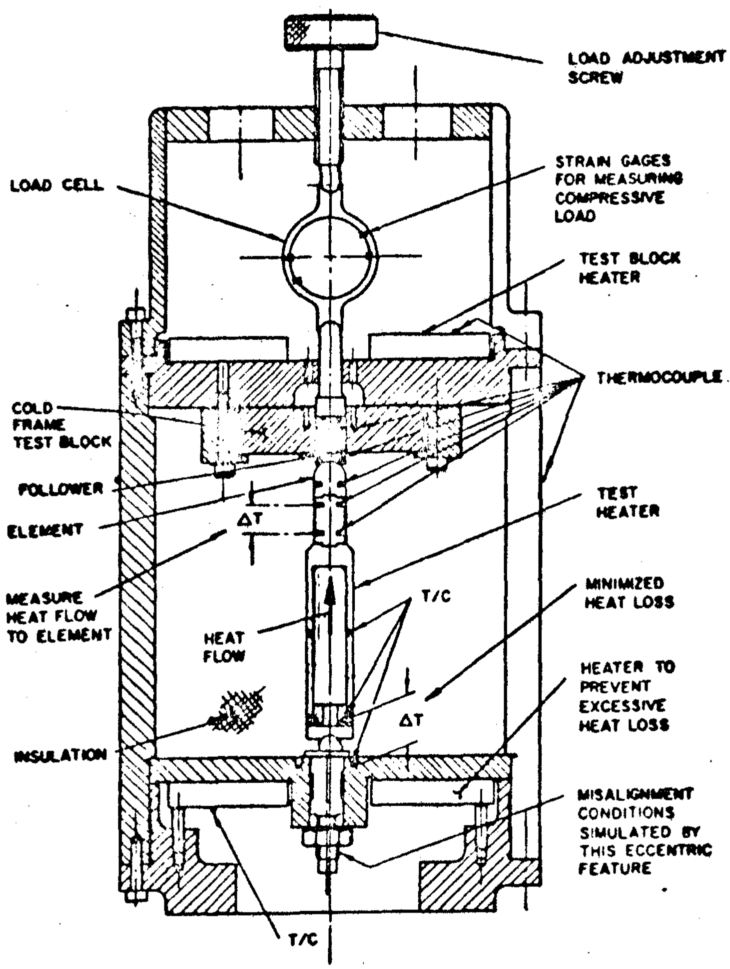


FIGURE 3-1 - FOLLOWER THERMAL CONDUCTANCE TEST UNIT SCHEMATIC

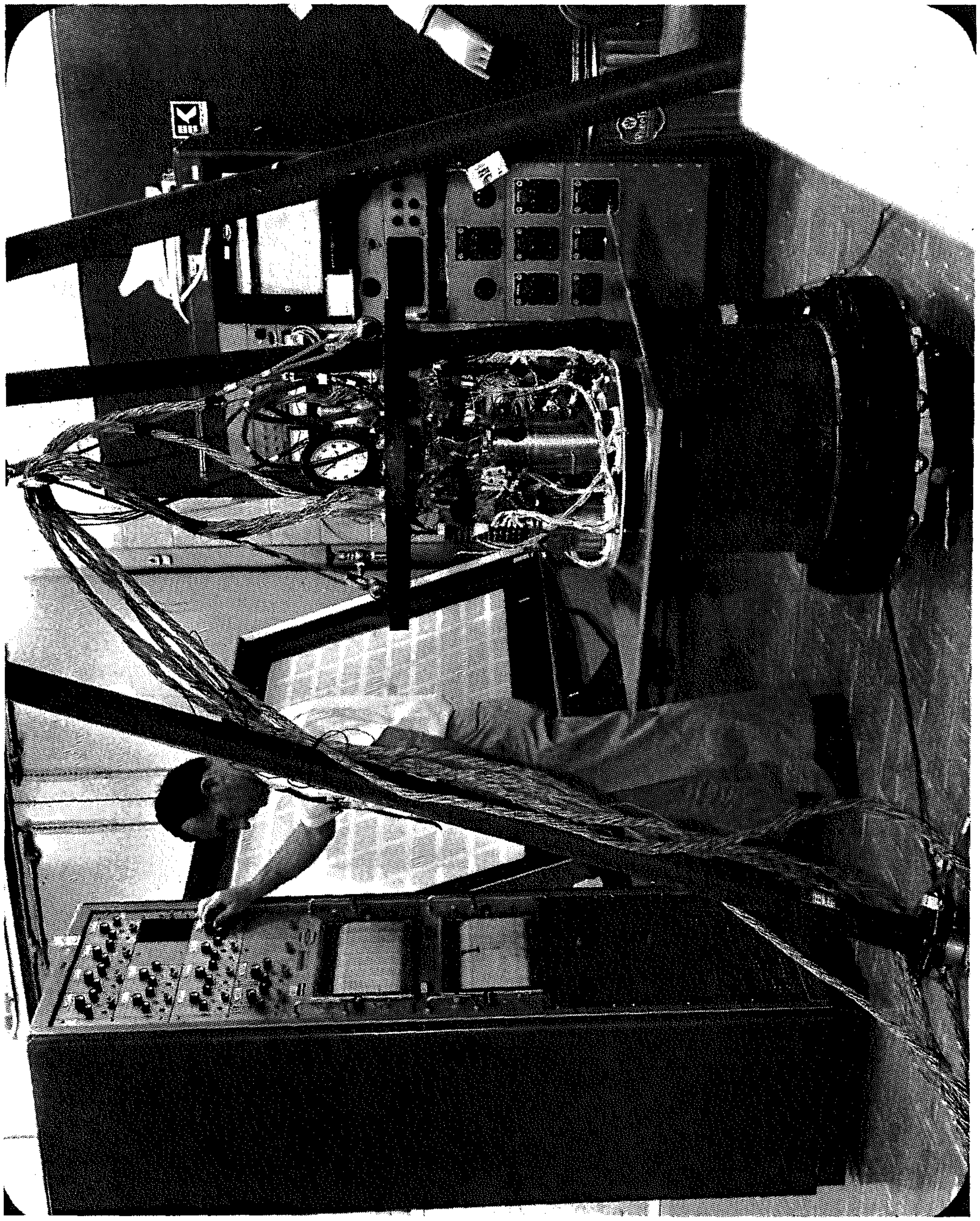


Table 1-1 Summary of Test Results

	Follower Material and Test Fixture	Radial Tolerance ΔR of Spherical Seat at Operating Temperature	Spherical Deviation: Cap	Spherical Deviation: Follower	Surface Roughness: Cap	Surface Roughness: Follower	Temperature Difference Across Spherical Interface*	Radial Tolerance Between Follower and Cold Frame At Operating Temperature	Temperature Difference Between Follower and Cold Frame Including Temperature Gradient Within Follower *	Total Temperature Difference Between Cold Cap and Cold Frame*	Remarks
		mils	μ"	μ"	μ"	μ"	^{o}F	mils	^{o}F	^{o}F	
1	Be-00	0	300	1000	8.5	11	27.0	.1	6.5	33.5	
2	Be-22	0	300	1500	7	8	45.5	.2	7.1	52.6	
3	Be-33	0	500	600	14	14	21.4	.2	7.1	28.5	
4	Be-22	0	300	1500	7	8	21.0	.2	6.5	27.5	With .0015 lead between spherical
5	Be-33	0	500	600	14	14	16.0	.2	8.0	24	
6	BeO-00	4.3	700	80	14	14	9.0	.45	11.5	20.5	
7	BeO-22**	1.0	950	40	12	8	8.5	.55	8.9	17.4	
8	BeO-33	0	150	450	8	10	5.7	.55	10.5	16.2	

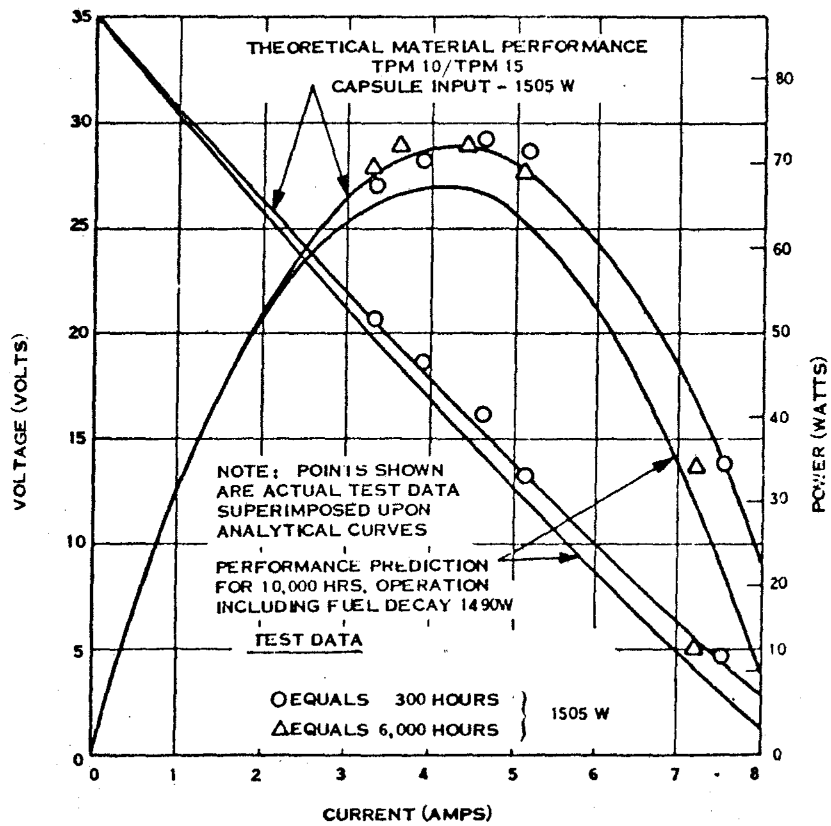
* At nominal heat flow of 1.415w and 6 lb. vertical load, normalized to 500^{o}F gap temperature.

** These data are not very conclusive, since taken at too high heat fluxes and temperature differences.

OTHER KEY DEVELOPMENT THERMAL SYSTEM TESTS

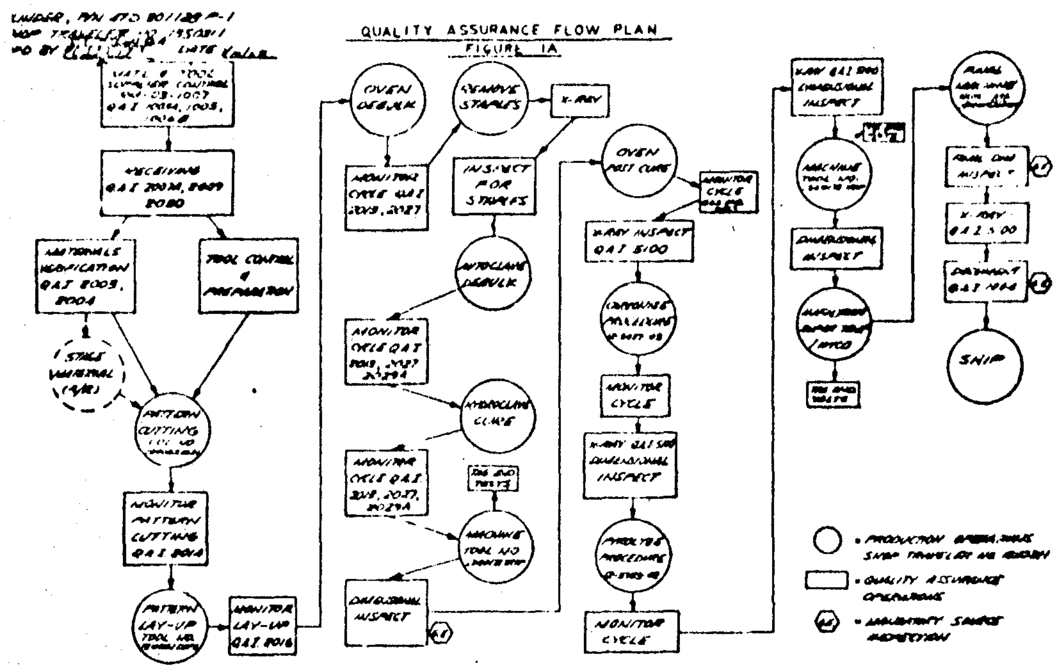
1. BORON NITRIDE COEFFICIENT OF FRICTION
2. HOT FRAME THERMAL COATINGS
3. FORWARD END SEAL THERMAL SURFACE (LOW e)
4. THERMAL CONDUCTIVITY OF MIN-K
5. OUTER CASE THERMAL COATINGS

MOD 10 - THEORETICAL VERSUS ACTUAL PERFORMANCE



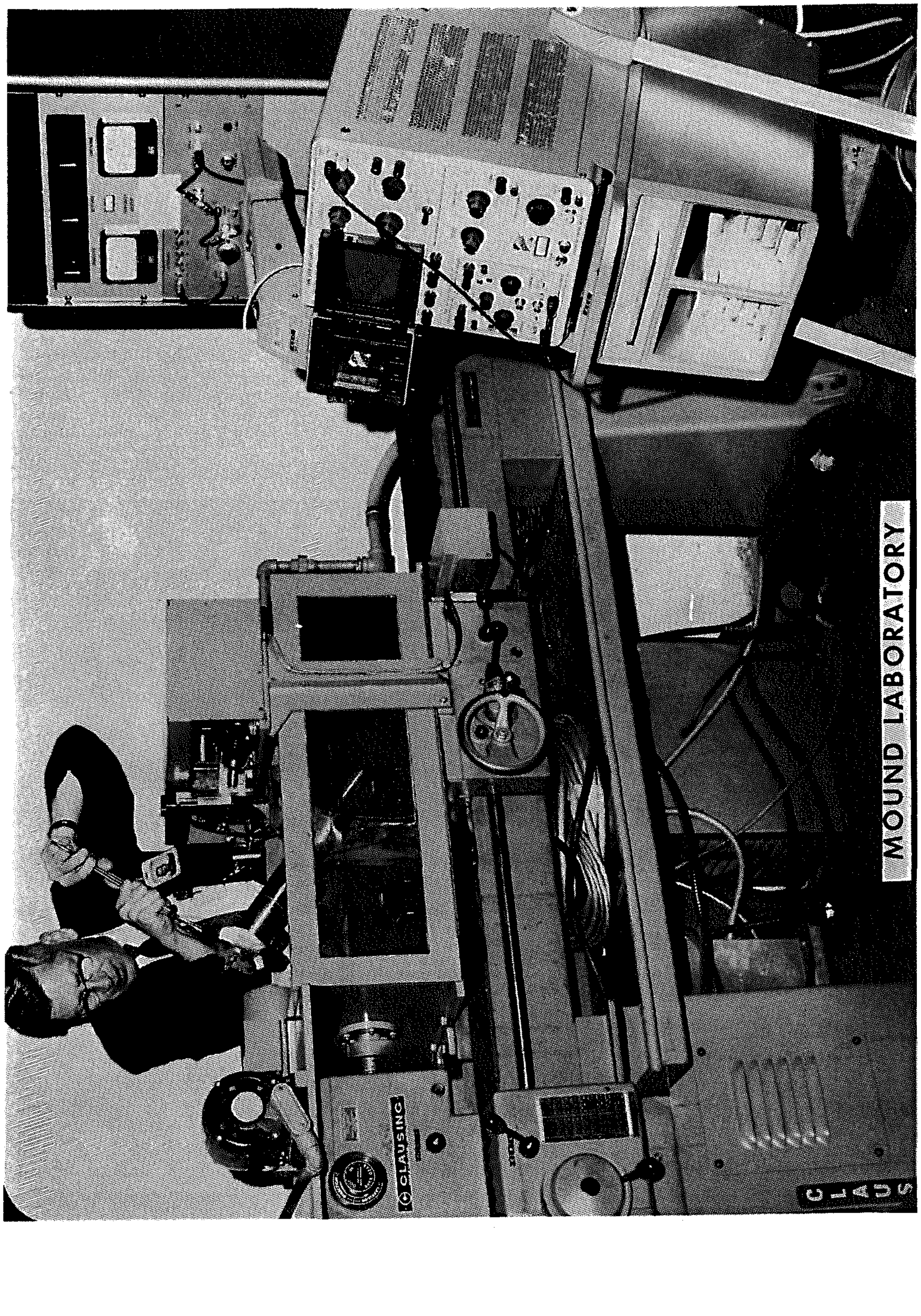
QUALITY ASSURANCE FLOW PLAN

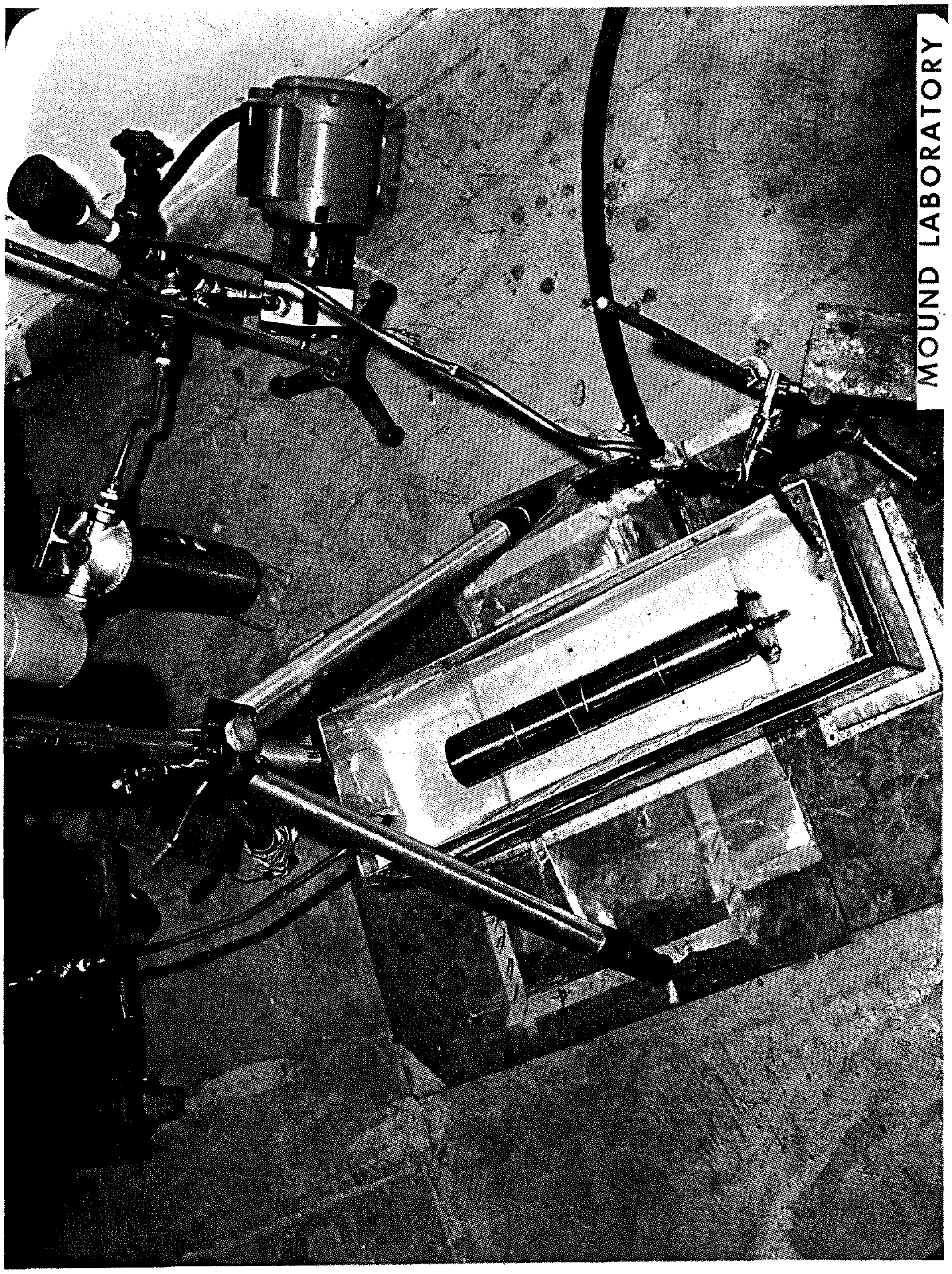
FIGURE 1A



CAPSULE FUEL LOADING

FLIGHT	THERMAL LOAD (WATTS)
1	1487
2	1485
3	1479
4	1483
BACK UP	1485
QUAL UNIT	1484


MOUND LABORATORY
CLAUSING
CLAUS


MOUND LABORATORY

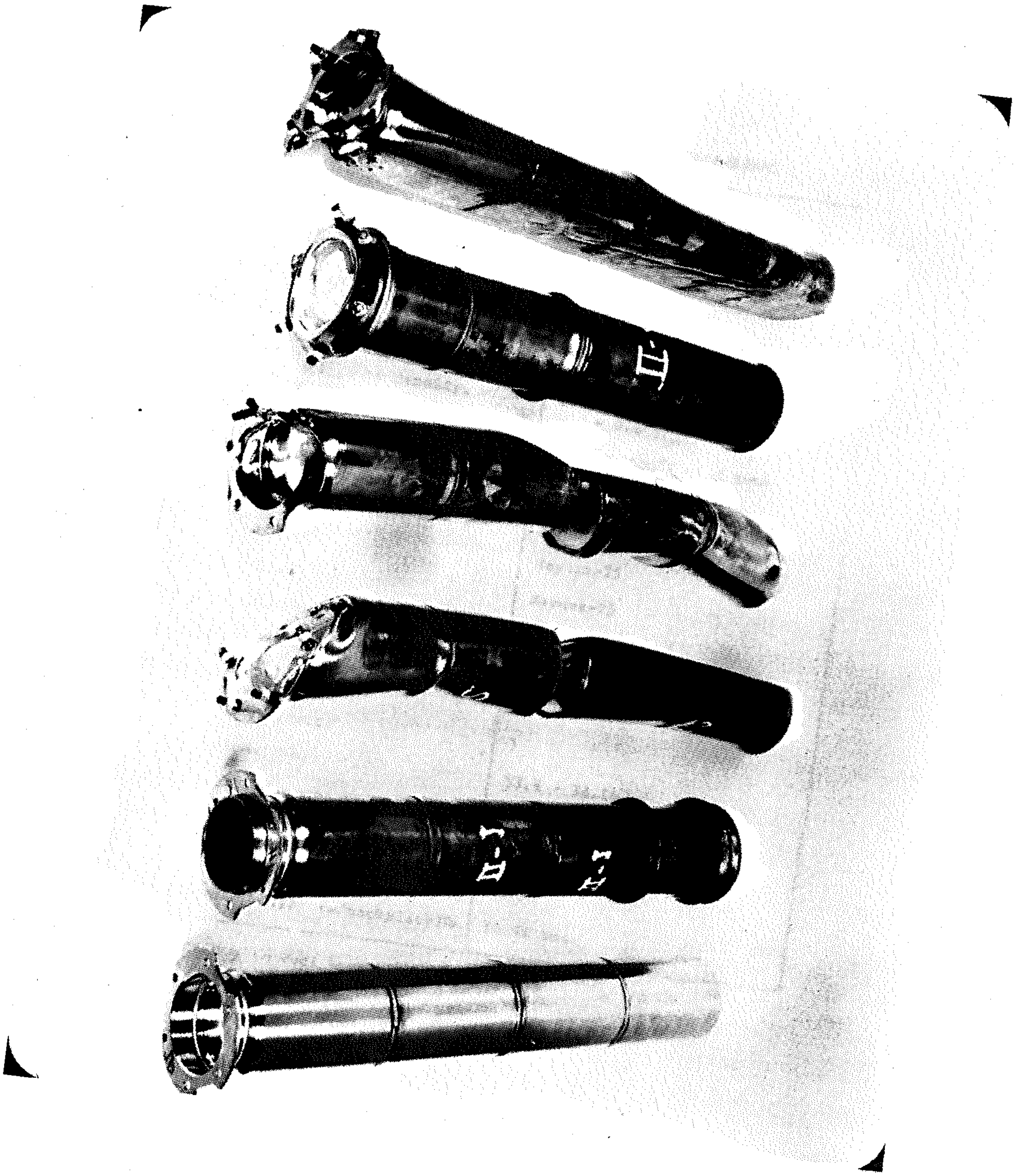
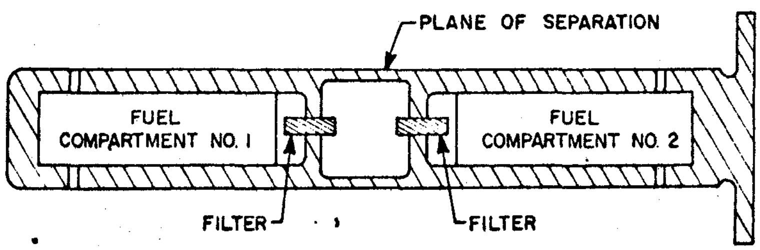


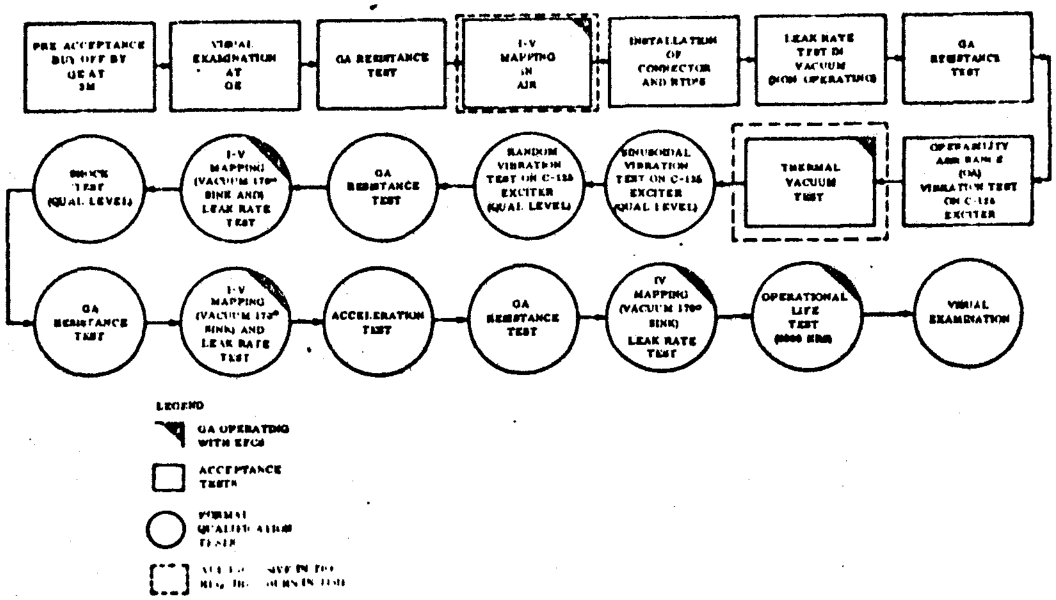
TABLE 2-2. FUEL CAPSULE DESIGN PARAMETERS

Thermal loading, watts	1480 ± 30
Fuel form	$Pu^{238}O_2$ microspheres 50 - 250 μ dia
Fuel geometry	Cylindrical annulus
Fuel specific power, w/g	0.400 ± 0.01
Physical density range of fuel particles, g/cm^3	9.1 - 10.3
Effective fuel power density, w/cm^3	2.6 + 0.2 - 0.1
Fuel conductivity (effective) Btu/hr/ft°F (in helium)	0.62 @ 1400°F clad temp
Fueled length, in.	13.76
Capsule OD (nominal, uncoated), in.	2.509
Capsule material	Haynes-25
Liner material	Haynes-25
Emissive coating	RC-356
Emissivity (minimum)	0.85
Mission time, years	1
Storage time, years	2
* Fuel volume, $in.^3$	33.9 - 38.14
* Fuel annulus width, in.	0.407 - 0.475
Liner assembly void volume, $in.^3$	17.65
Total void volume, $in.^3$	40.3
Total capsule weight (w/backplate)lb.	15.46 max.

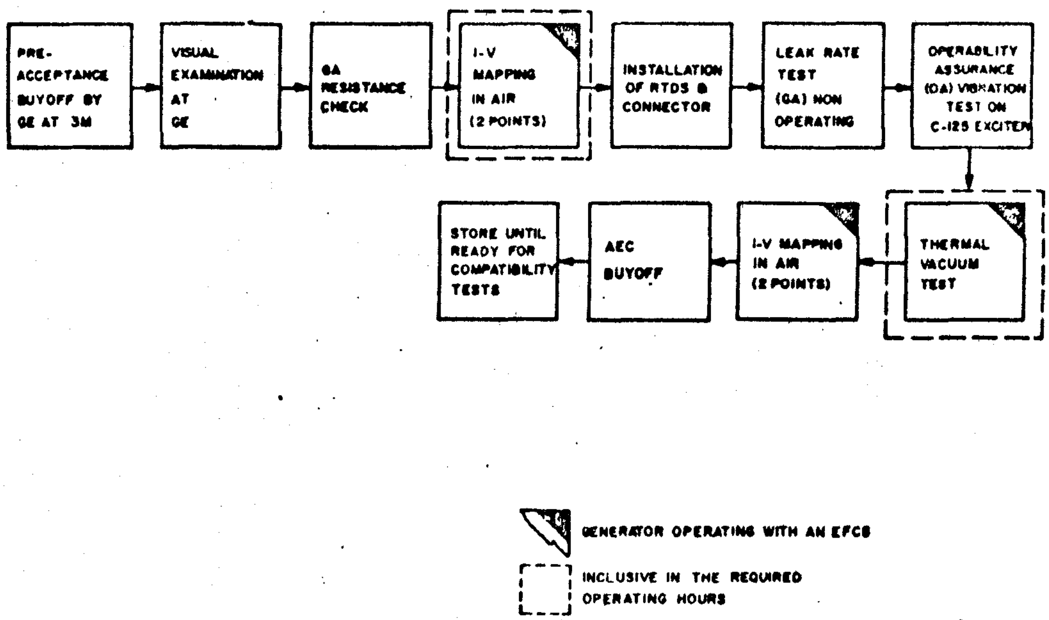
* Range due to fuel power density variance

FUEL CAPSULE ASSEMBLY DESIGN FEATURES





GA Model No. 10 Test Flow Chart



Flight GA Test Flow Chart

SUMMARY OF SNAP-27 FLIGHT GENERATOR TEST RESULTS

OPERATING CONDITIONS			GENERATOR POWER OUTPUT (WATTS)				
POWER INPUT (WATTS)	EQV. LOAD	SINK TEMP. (^{o}F)	MOD 13 GA S/N 6320006	MOD 19 GA S/N 6320009	MOD 21 GA S/N 6320011	MOD 22 GA S/N 6320012	MOD 23 GA S/N 6320013
1505	16 VOLTS	+170	69.8	69.1	68.2	68.3	70.7
1455	16 VOLTS	+170	67.1	67.5	66.0	66.2	67.9
1415	16 VOLTS	+170	64.3	64.7	63.2	63.2	65.0
1505	16 VOLTS	-280	72.5	72.9	71.3	71.3	72.9
1455	16 VOLTS	-280	68.8	68.8	66.7	67.3	68.9
1415	16 VOLTS	-280	65.3	65.3	64.0	64.1	65.1
1450	4.7 OHMS	AMBIENT	69.6	69.7	67.9	69.1	70.2
Total Accumulated Operational Time (Air and Vacuum) (Hours)			550	593	581	640	571
Operational Time in Vacuum (Hrs)			240	264	256	303	233
Final GA Leak Rate in std cc/sec of Argon while Operating in a +170°F Sink at 4.7 ohm load			2.50×10^{-6}	4.36×10^{-7}	1.09×10^{-6}	3.7×10^{-7}	Less Than 3.92×10^{-7}
Storage Container Serial No.			6287007	6287004	6287006	6287005	6287003
Total Weight (Pounds) (Less Protective Cable Sleeving)			27.83	27.77	27.96	27.86	27.80

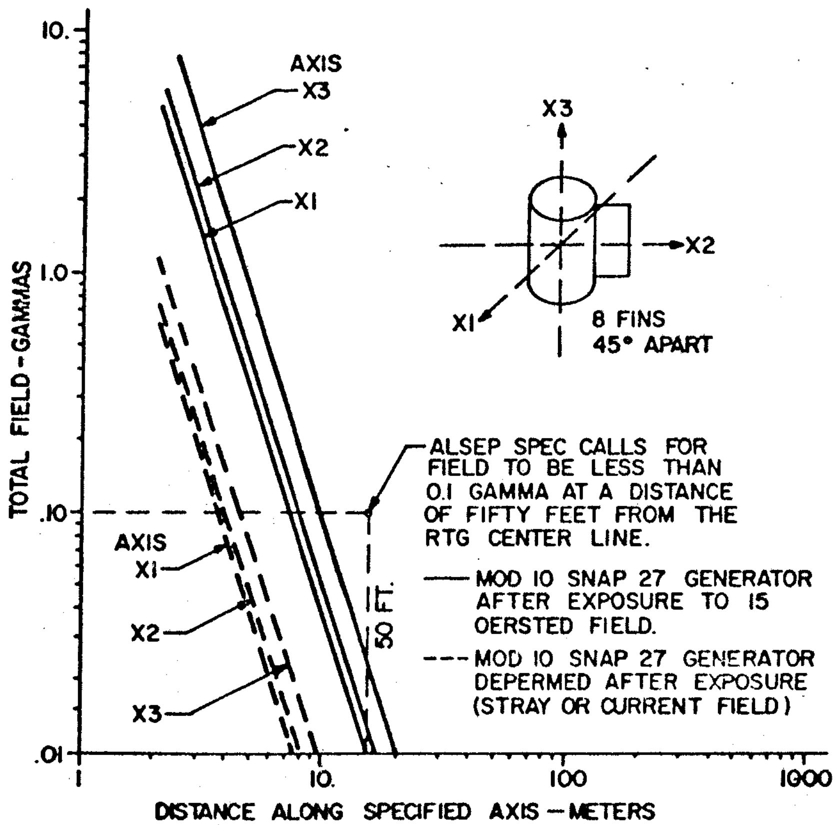
GENERATOR TEST PERFORMANCE SUMMARY

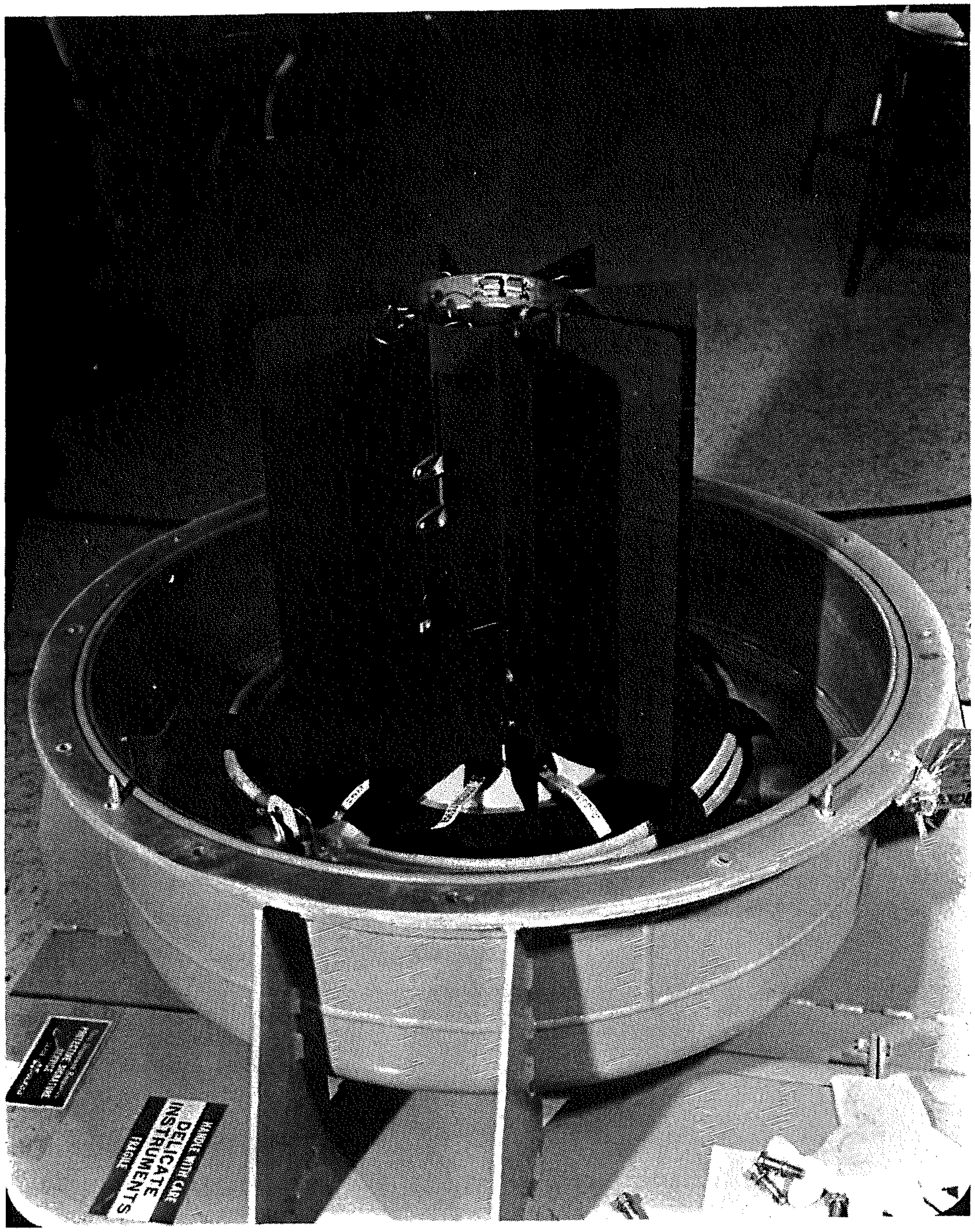
GENERATOR	TOTAL ACCUM TEST TIME (HRS)	POWER OUTPUT WATTS BOL		HEAT INPUT WATTS	POWER OUTPUT WATTS EOL	
		LUNAR DAY	LUNAR NIGHT		LUNAR DAY	LUNAR NIGHT
MOD 5 (1)	12,165	70.8	73.0	1500 AFTER 10000 HRS REDUCED TO 1485 WATTS	66.6	68.7
MOD 8B (1)	8,341	65.0	66.0	1415	62.0	62.9
MOD 10 (2)	7,697	71.2	73.3	1505	71.5	73.1
	10,244			1505	71.52 @ 49°F - sink	
	30,750					

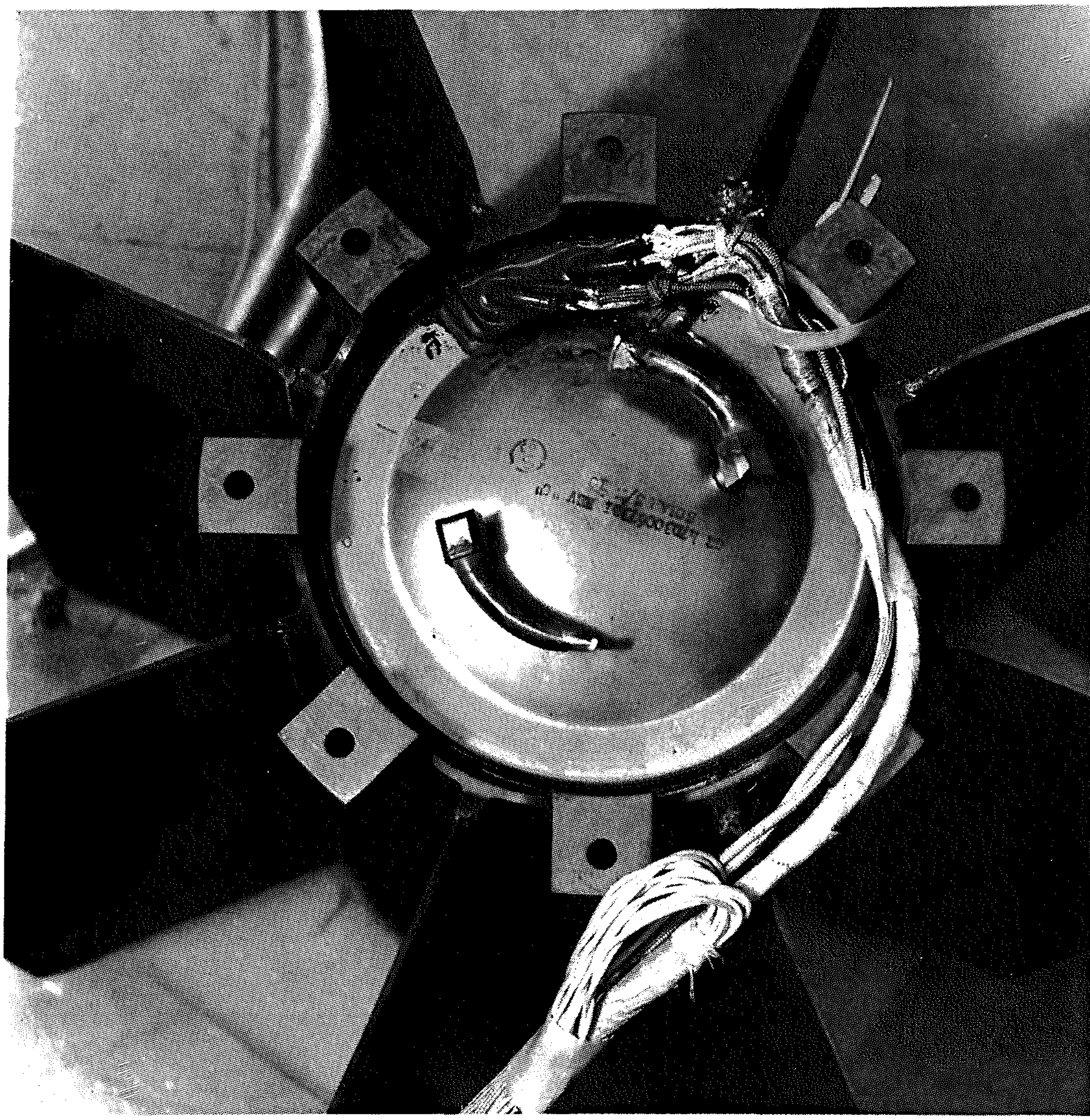
(1) ENGINEERING DEVELOPMENT GENERATORS

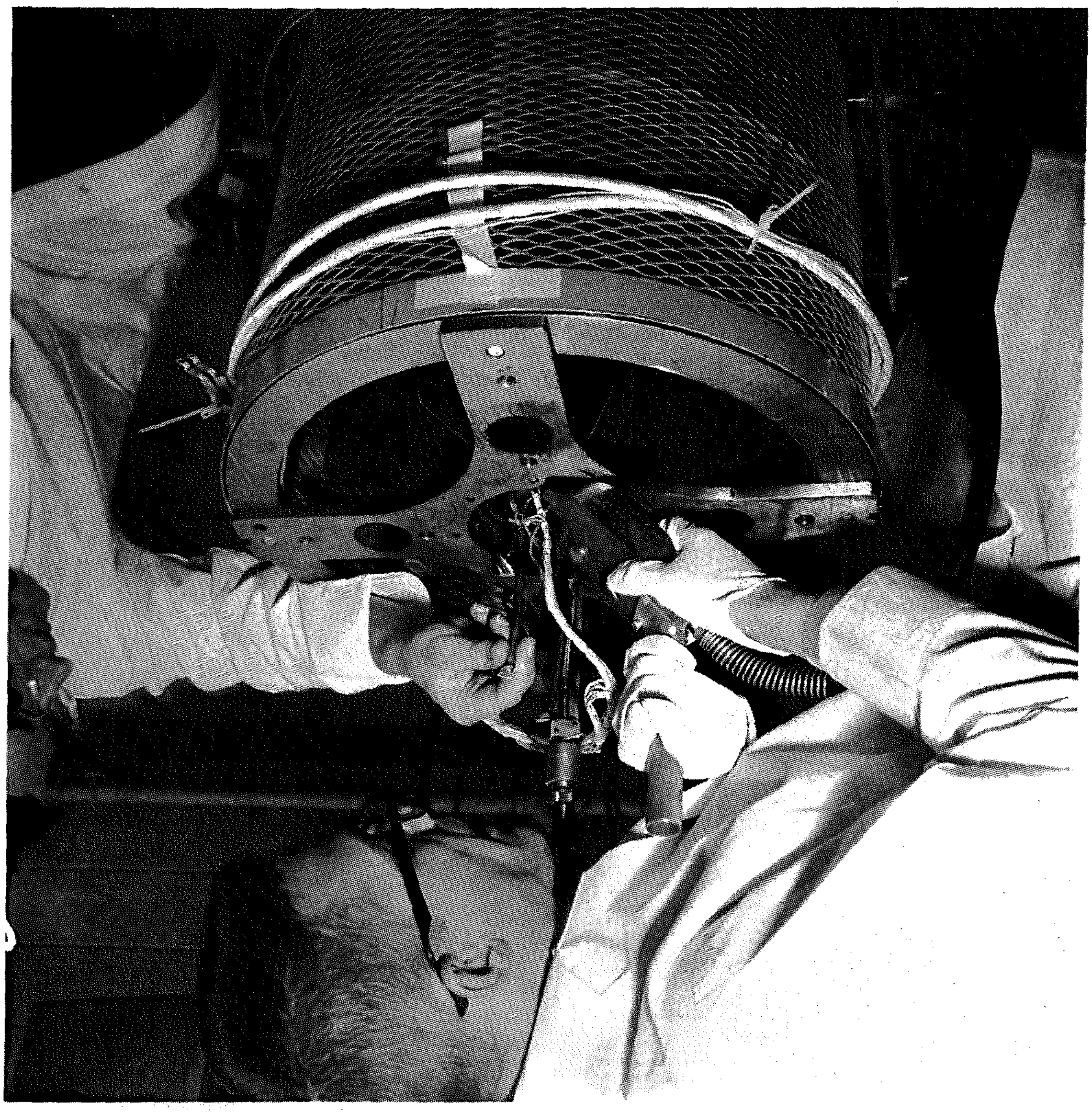
(2) PRIME FLIGHT QUALITY - IDENTICAL TO FIVE DELIVERED FLIGHT UNITS

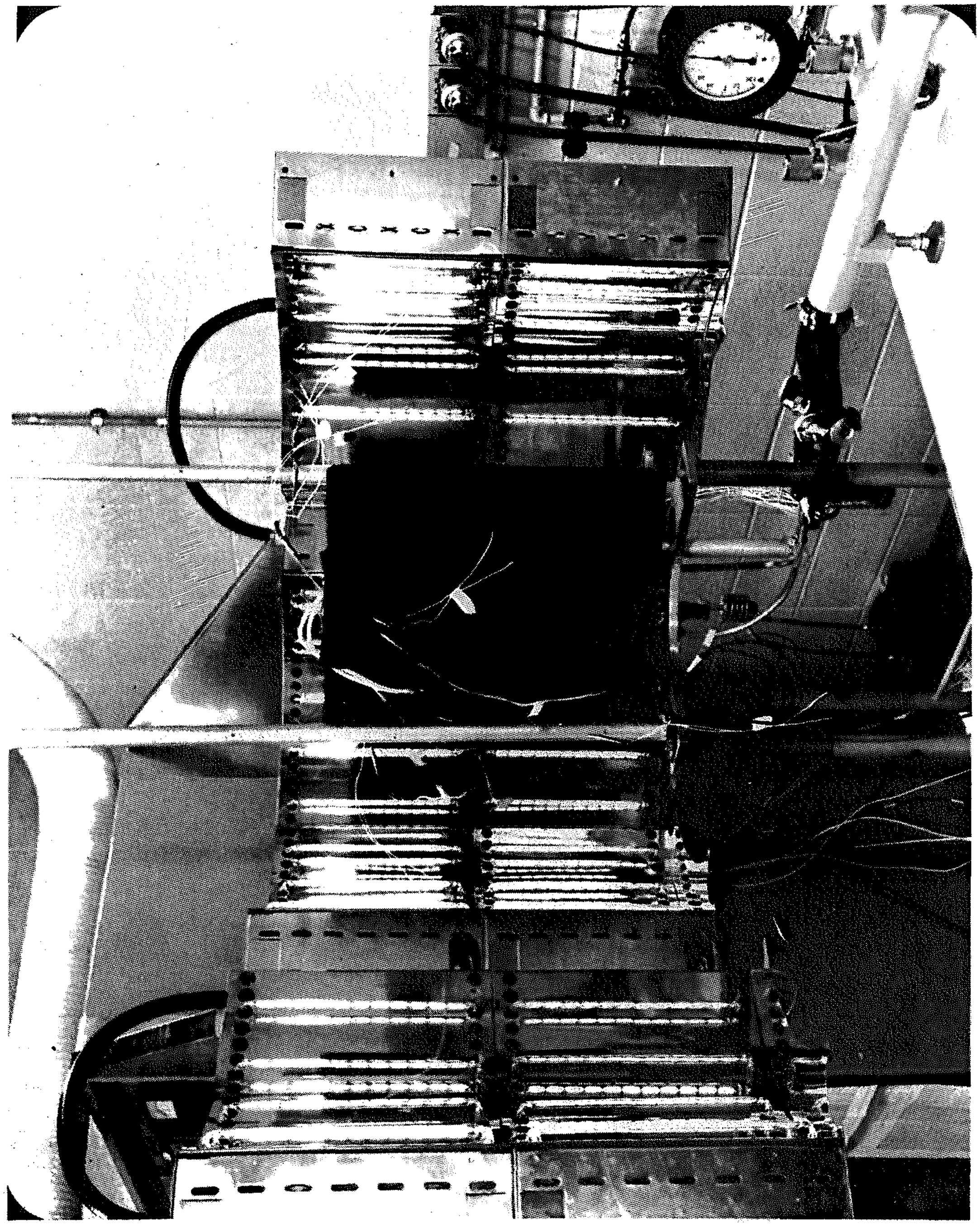
MAGNETIC FIELD MEASUREMENTS ON SNAP-27 GENERATOR

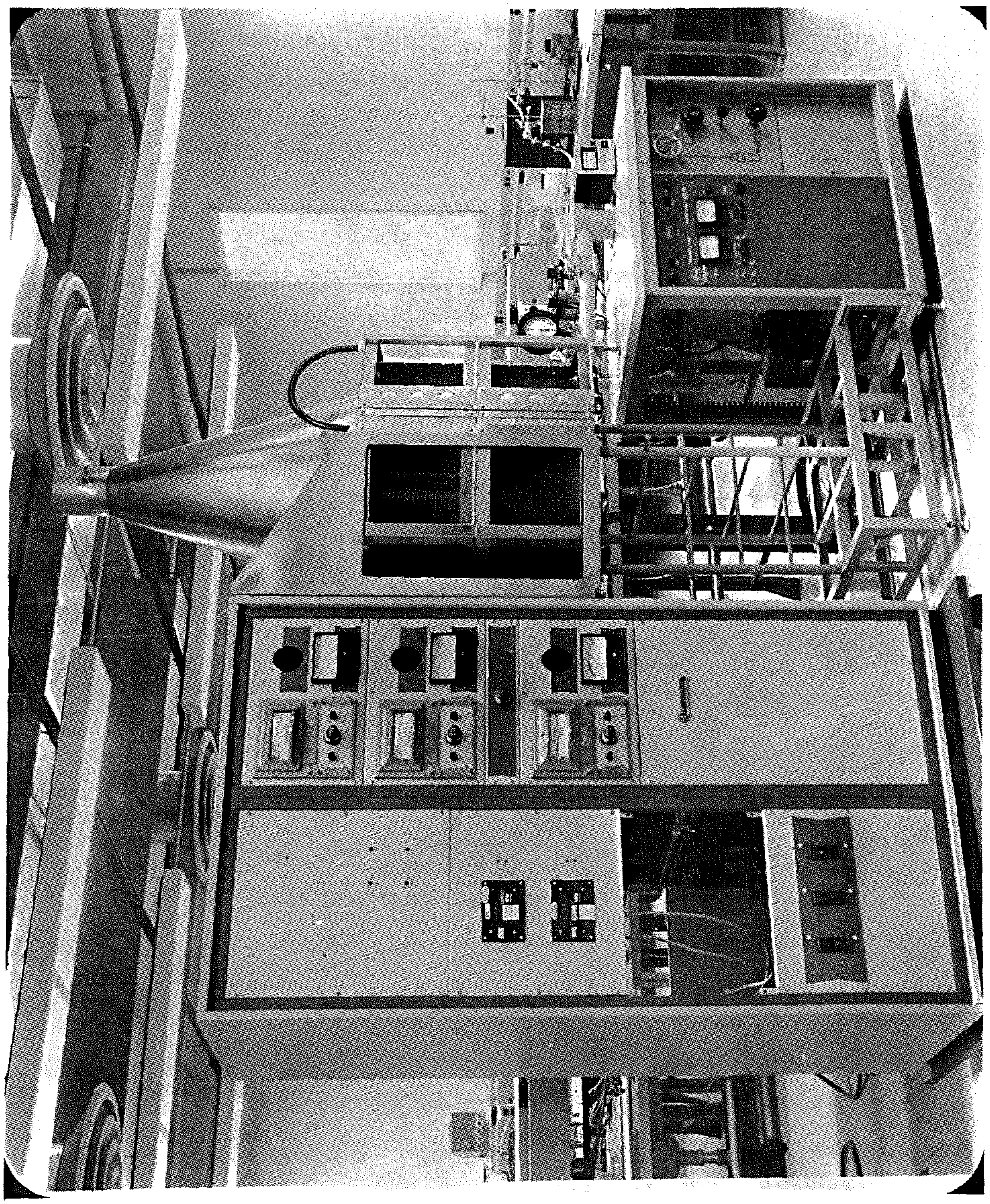


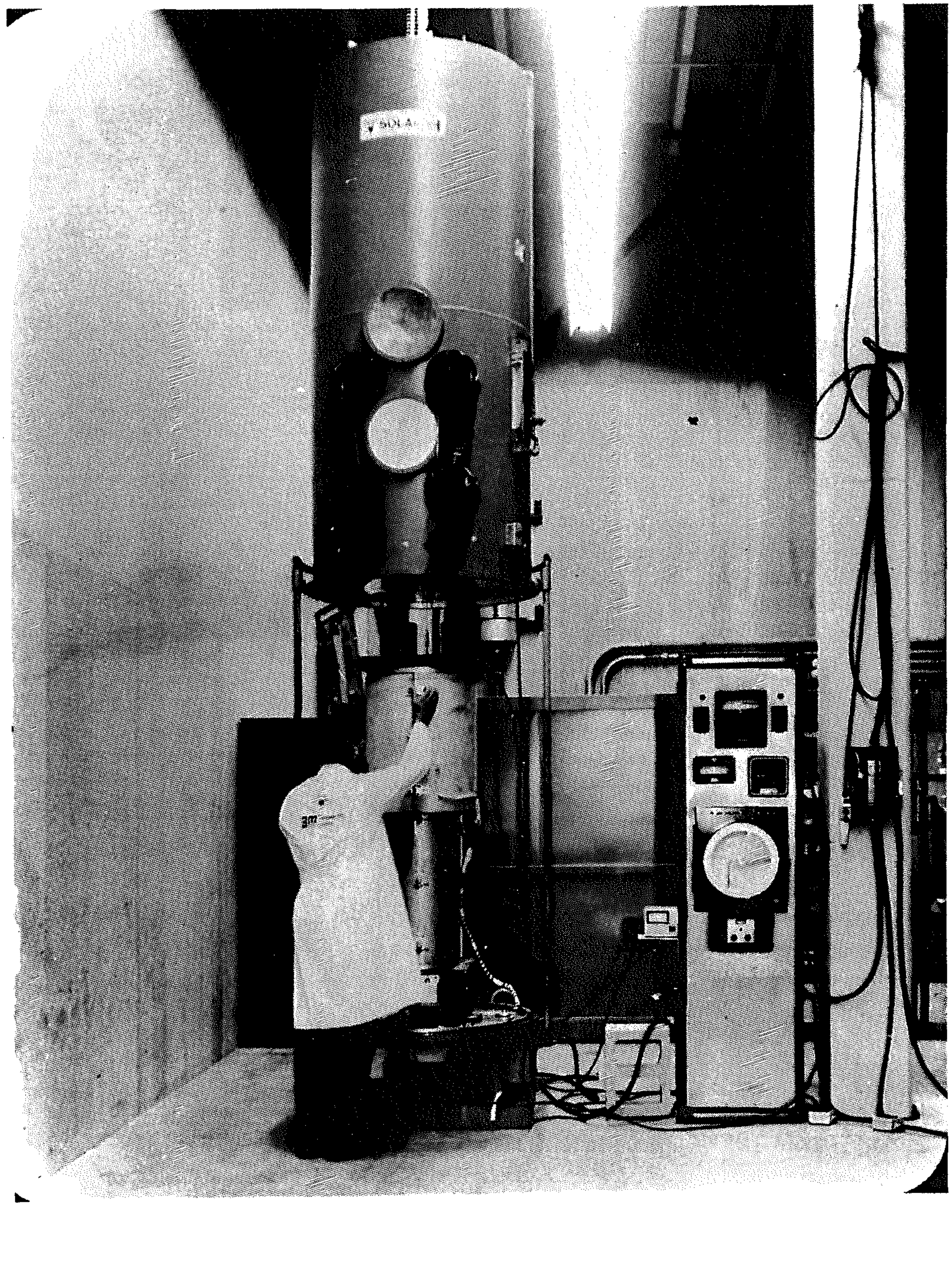

HANDLE WITH CARE
DELICATE
INSTRUMENTS
FRAGILE

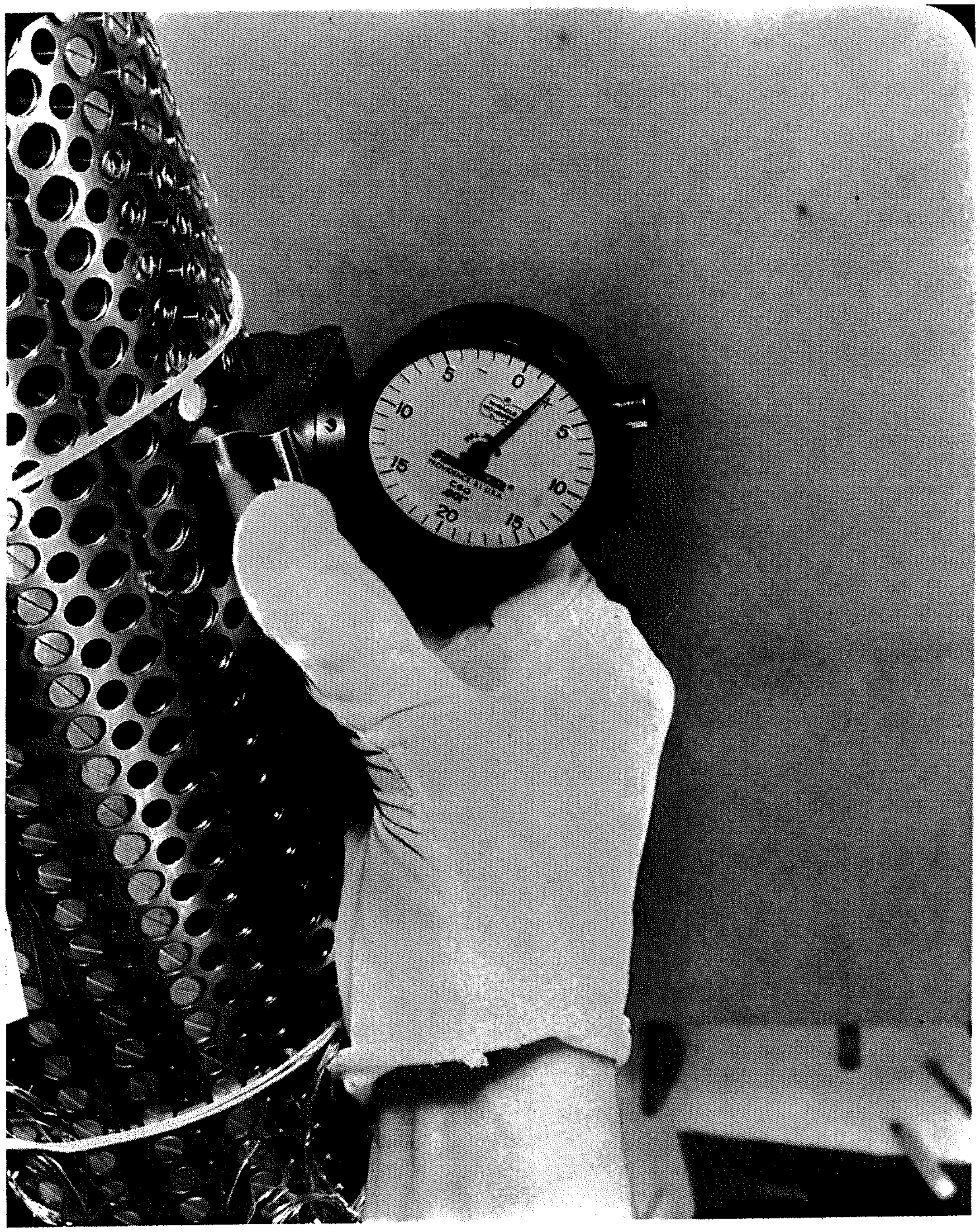


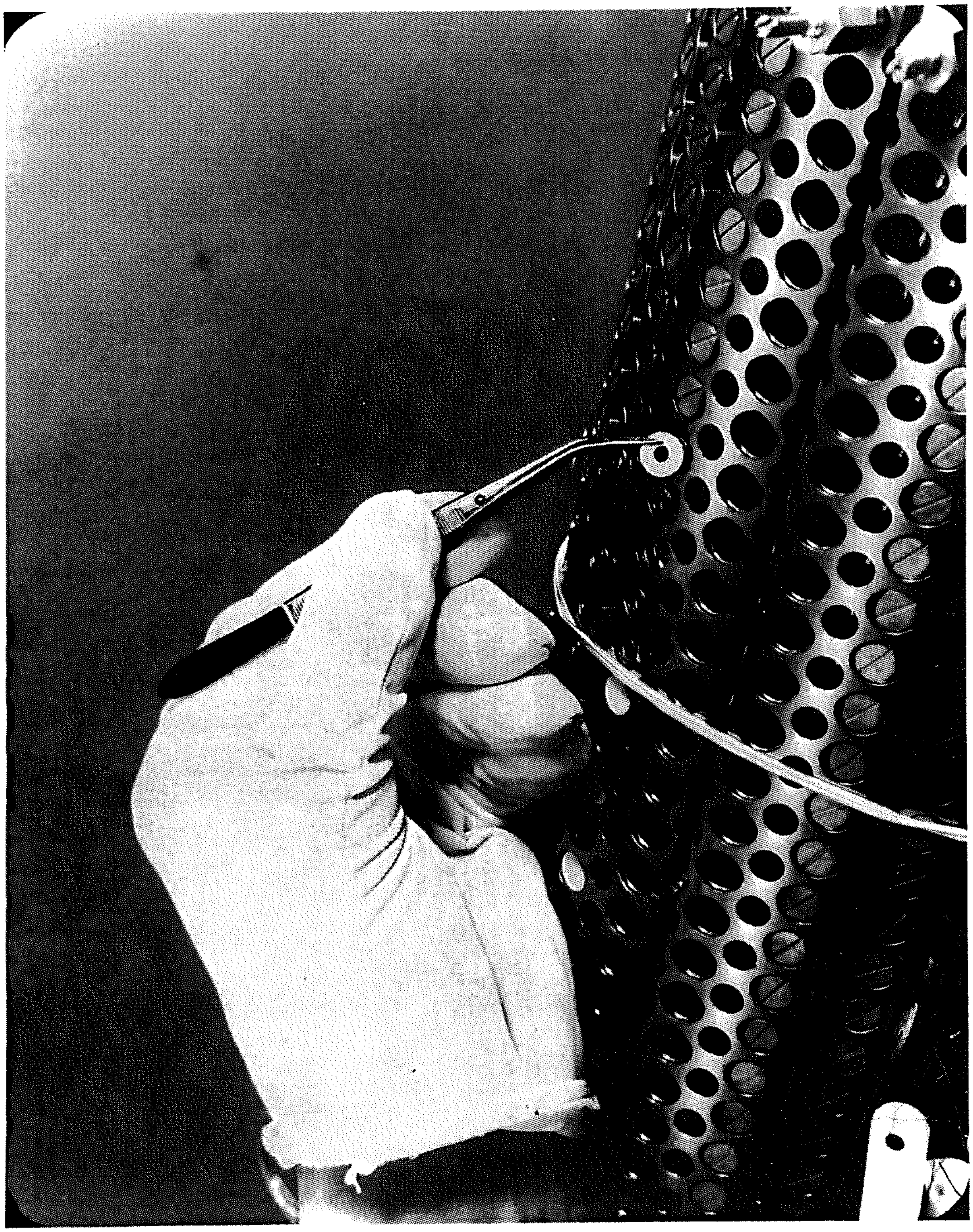


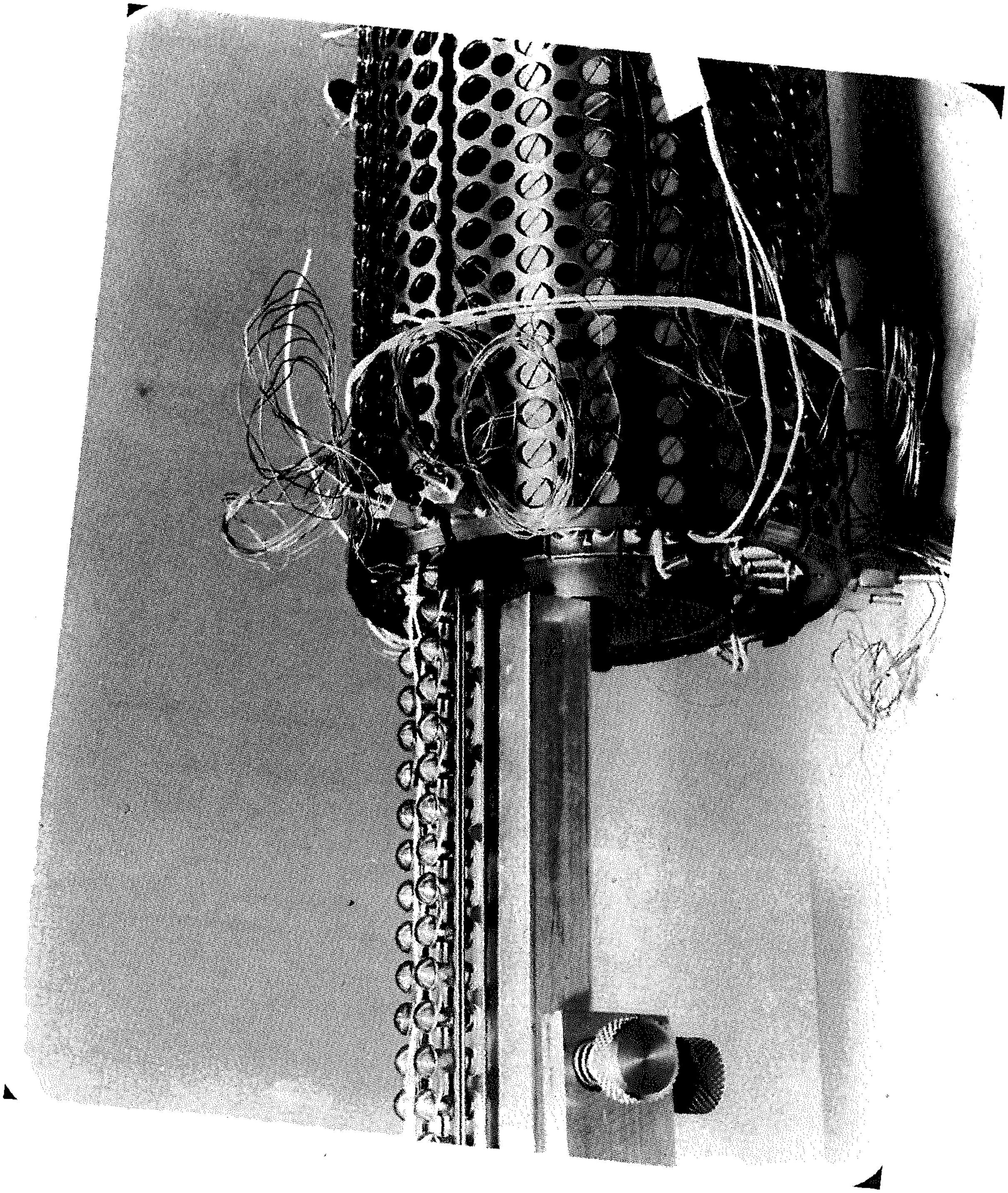


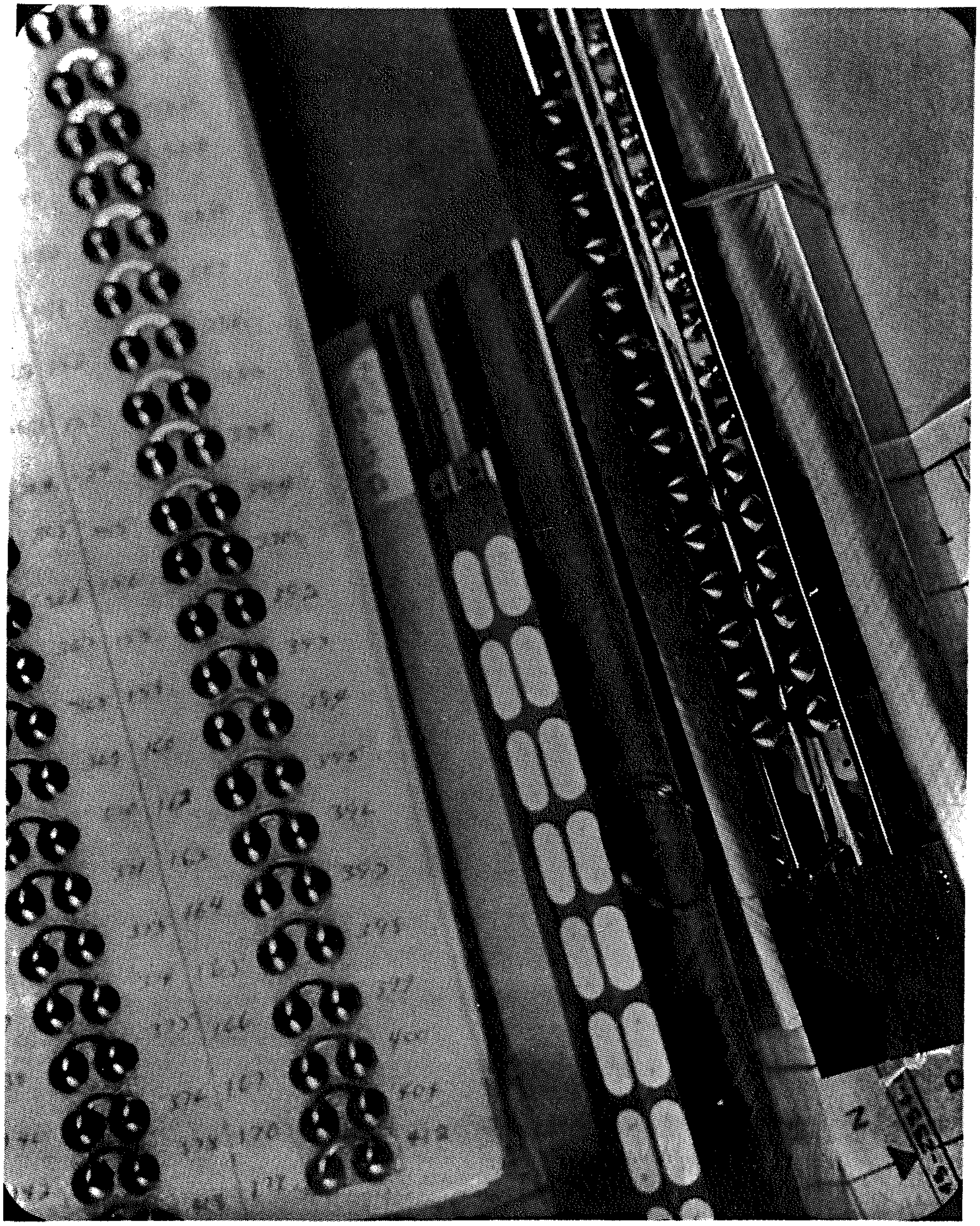


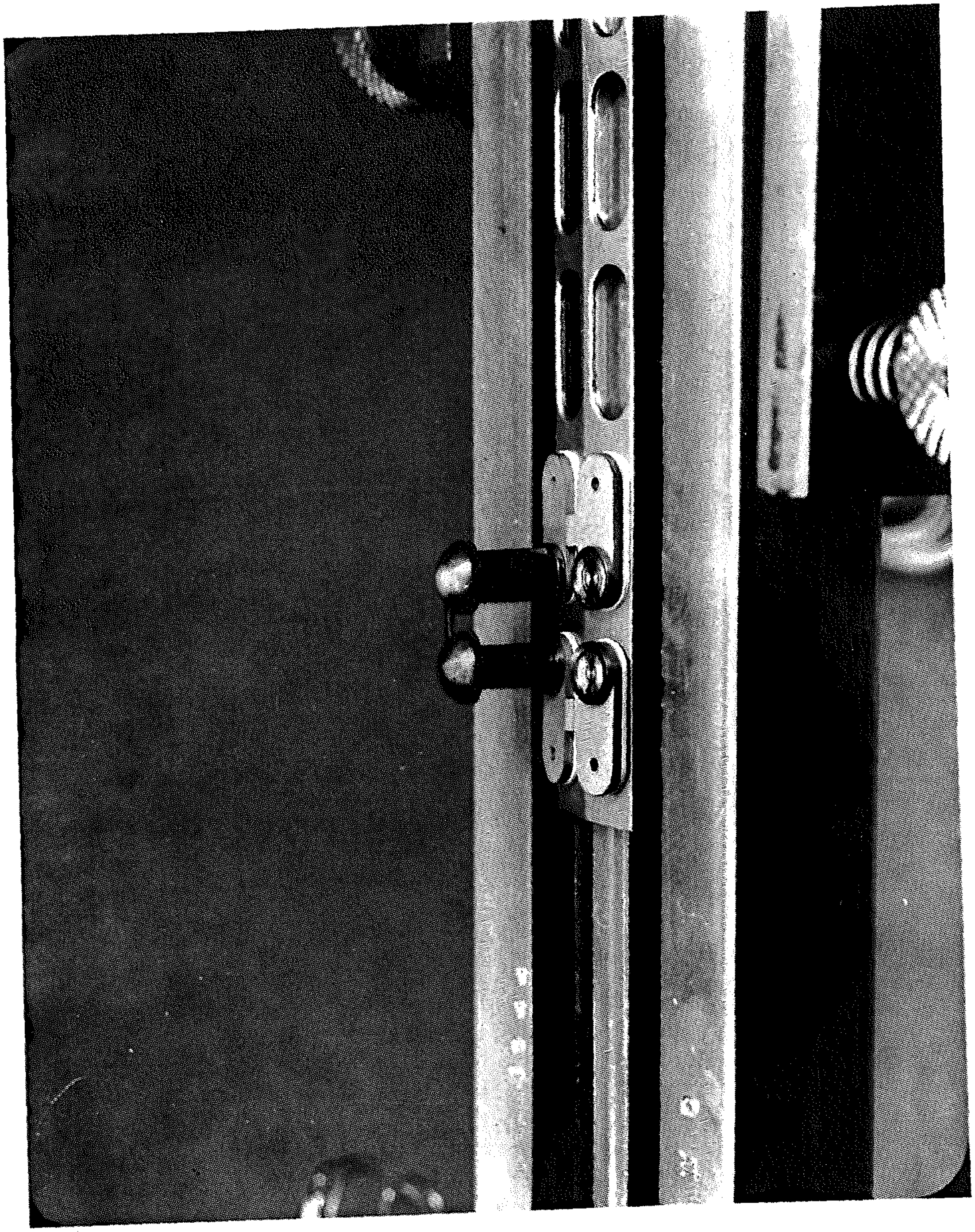


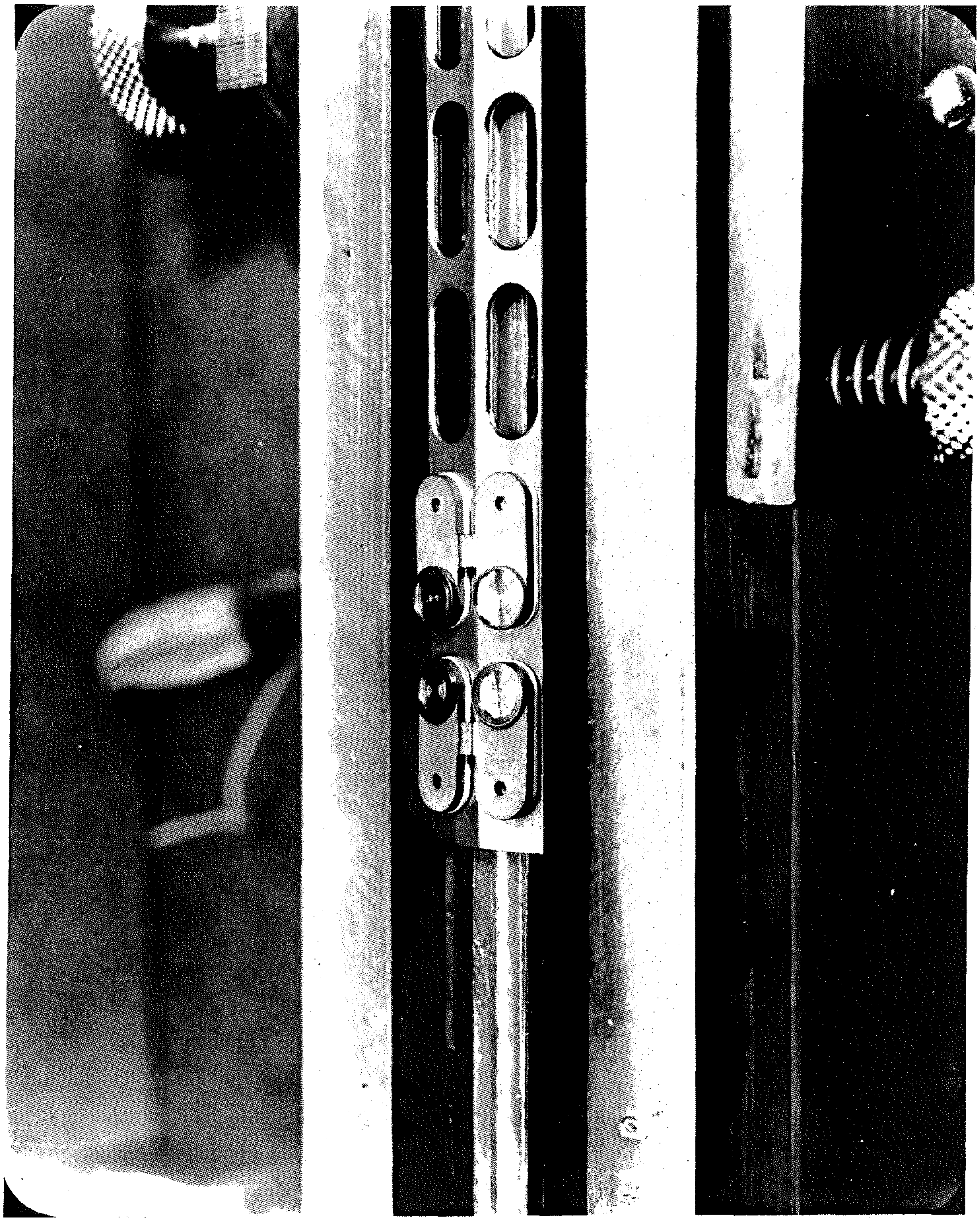

5 0 10 5 15 10 20 15

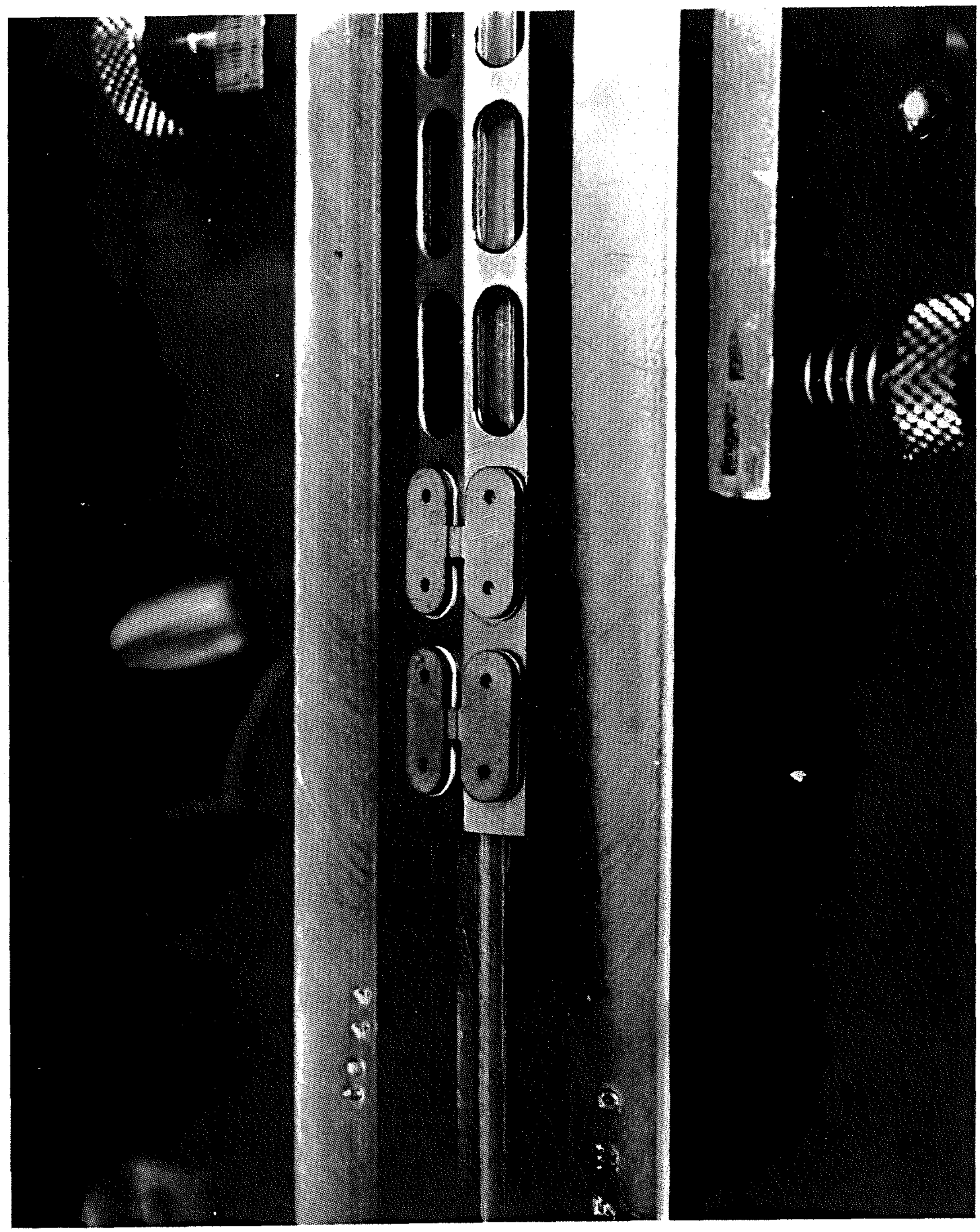


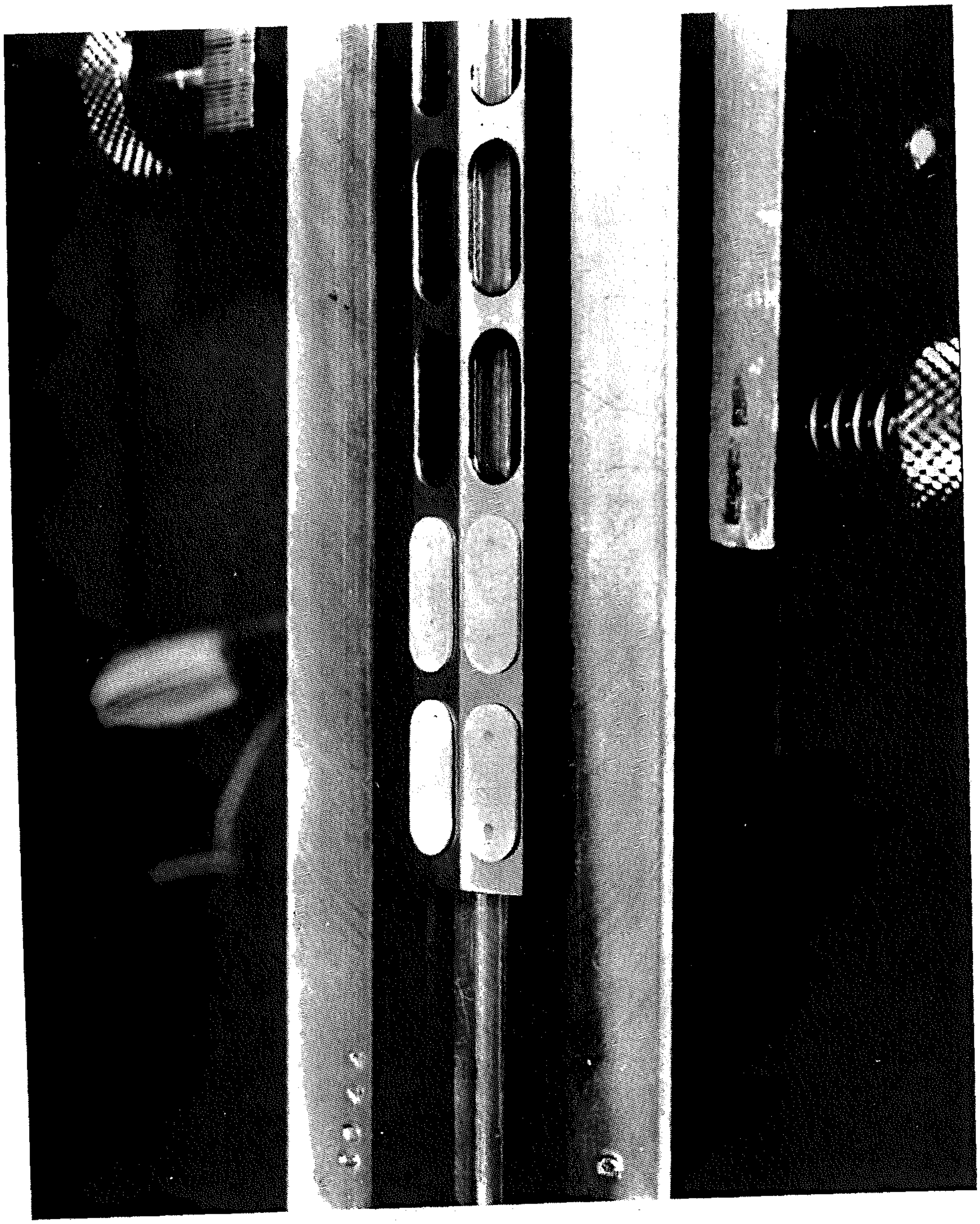


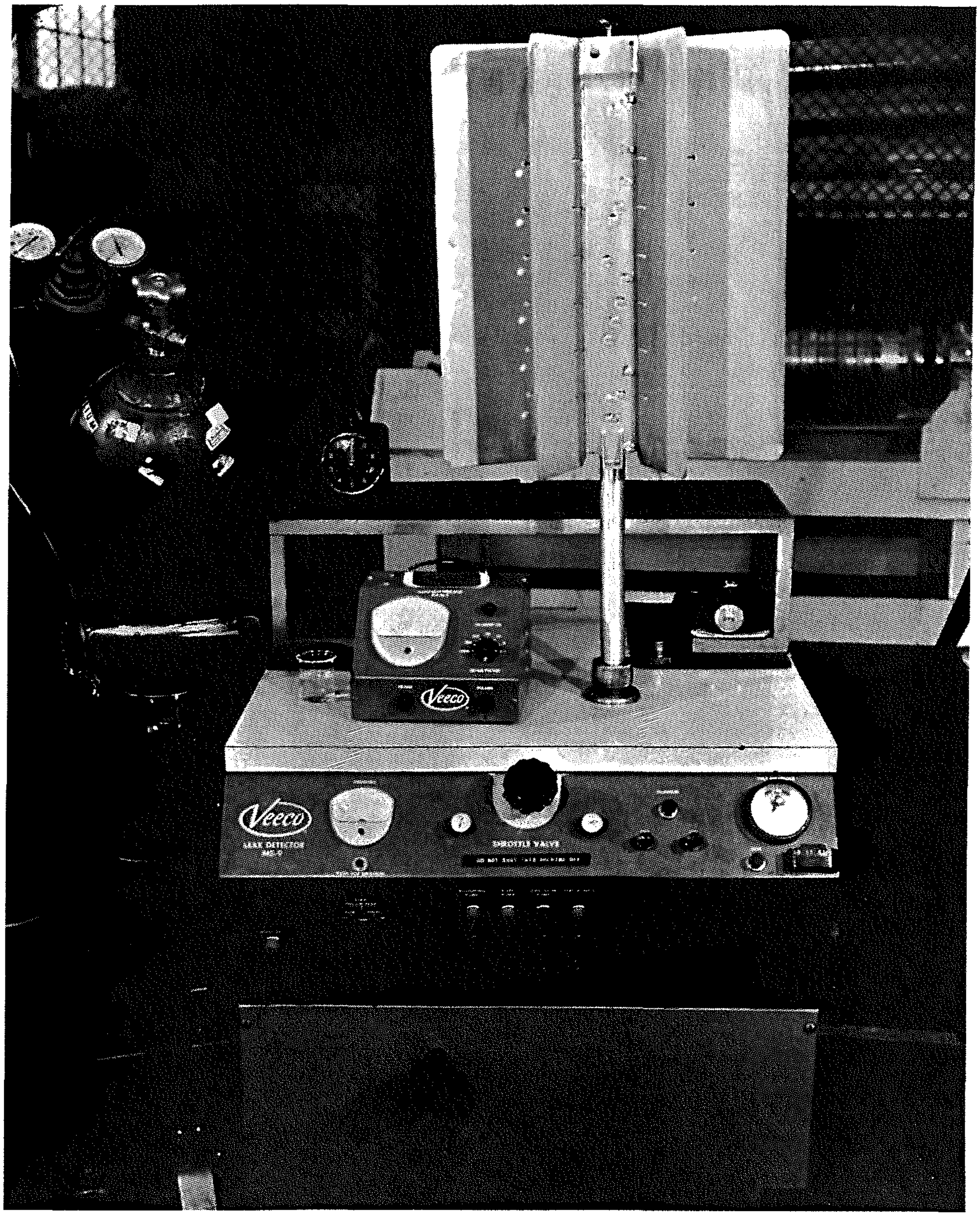


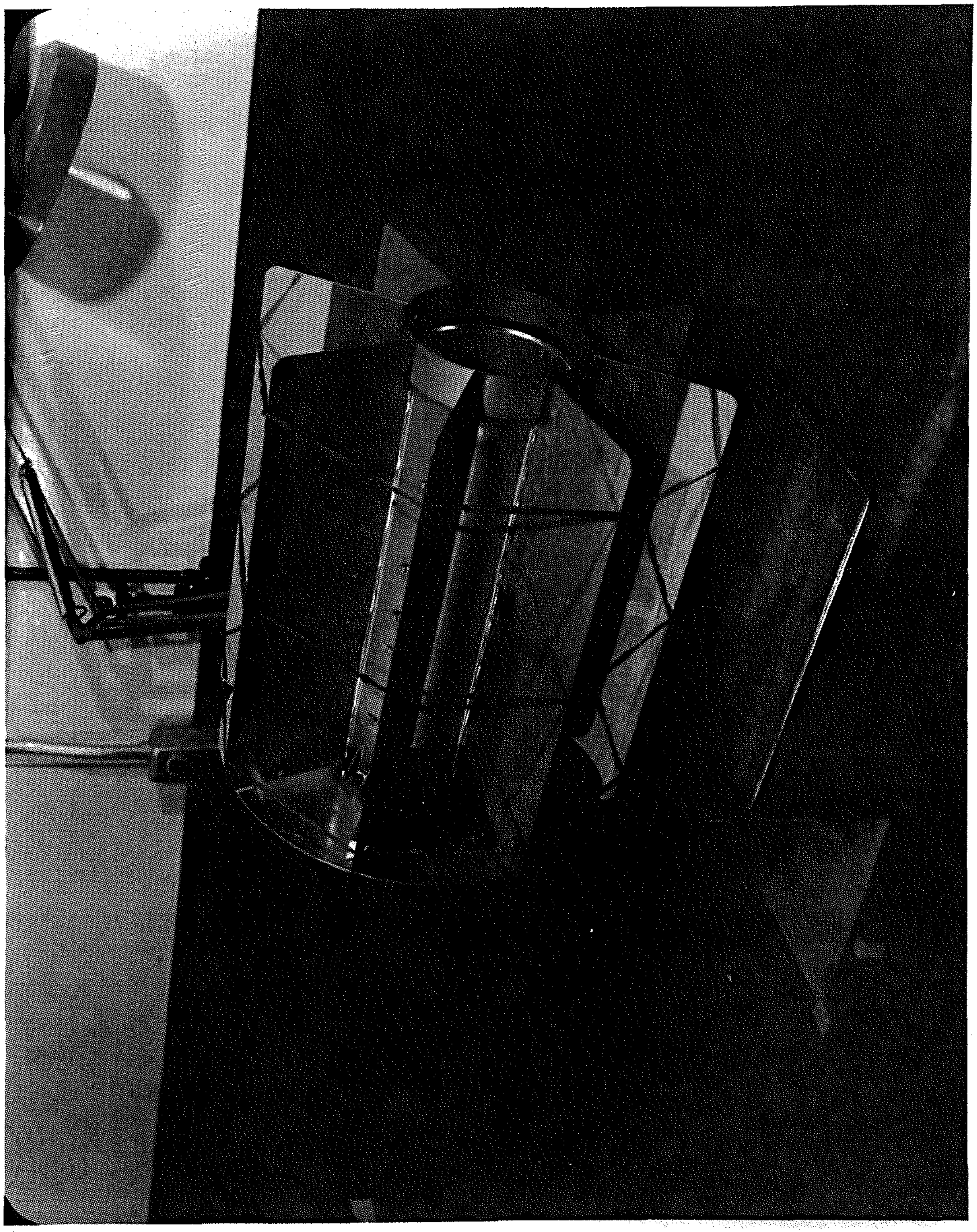


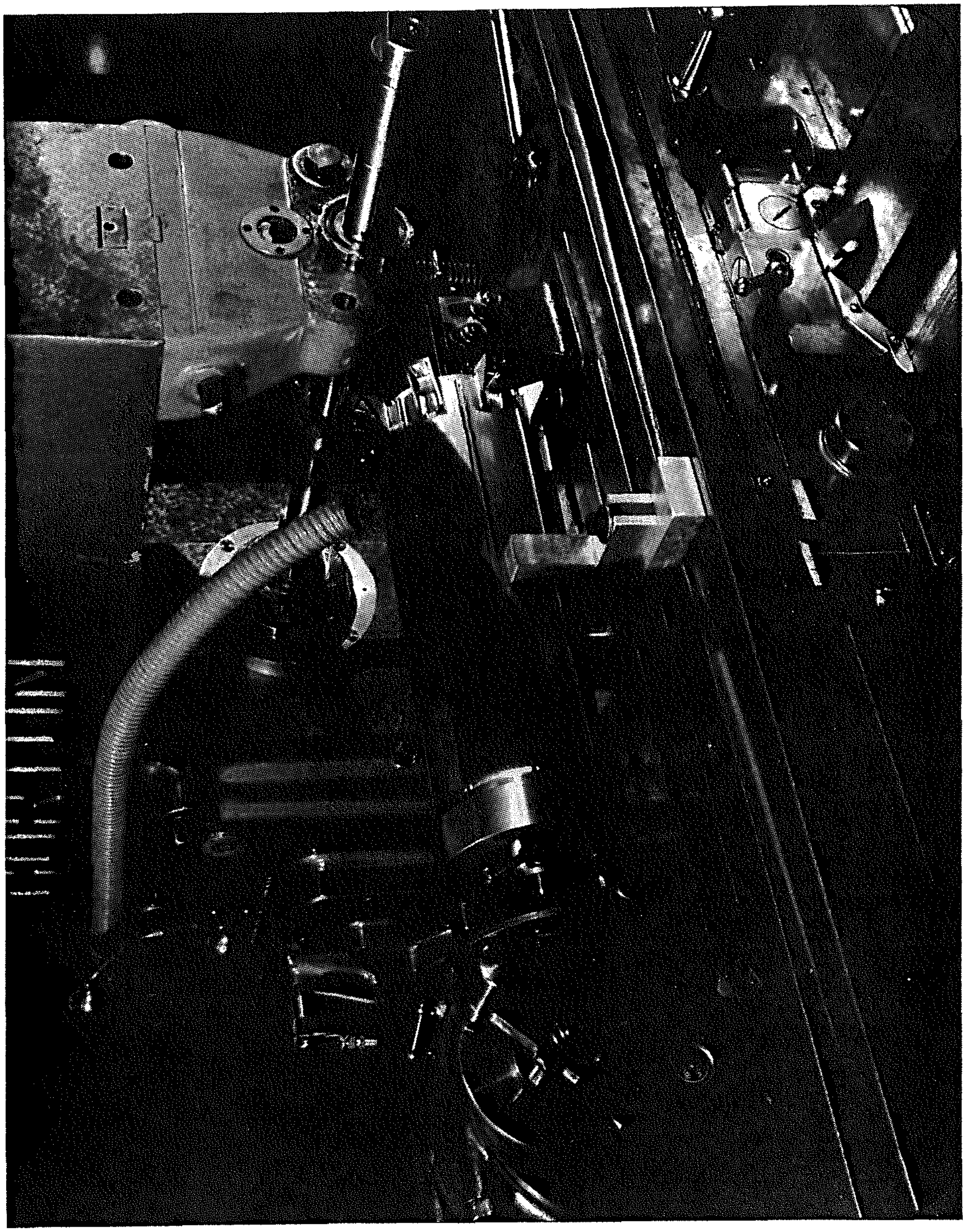


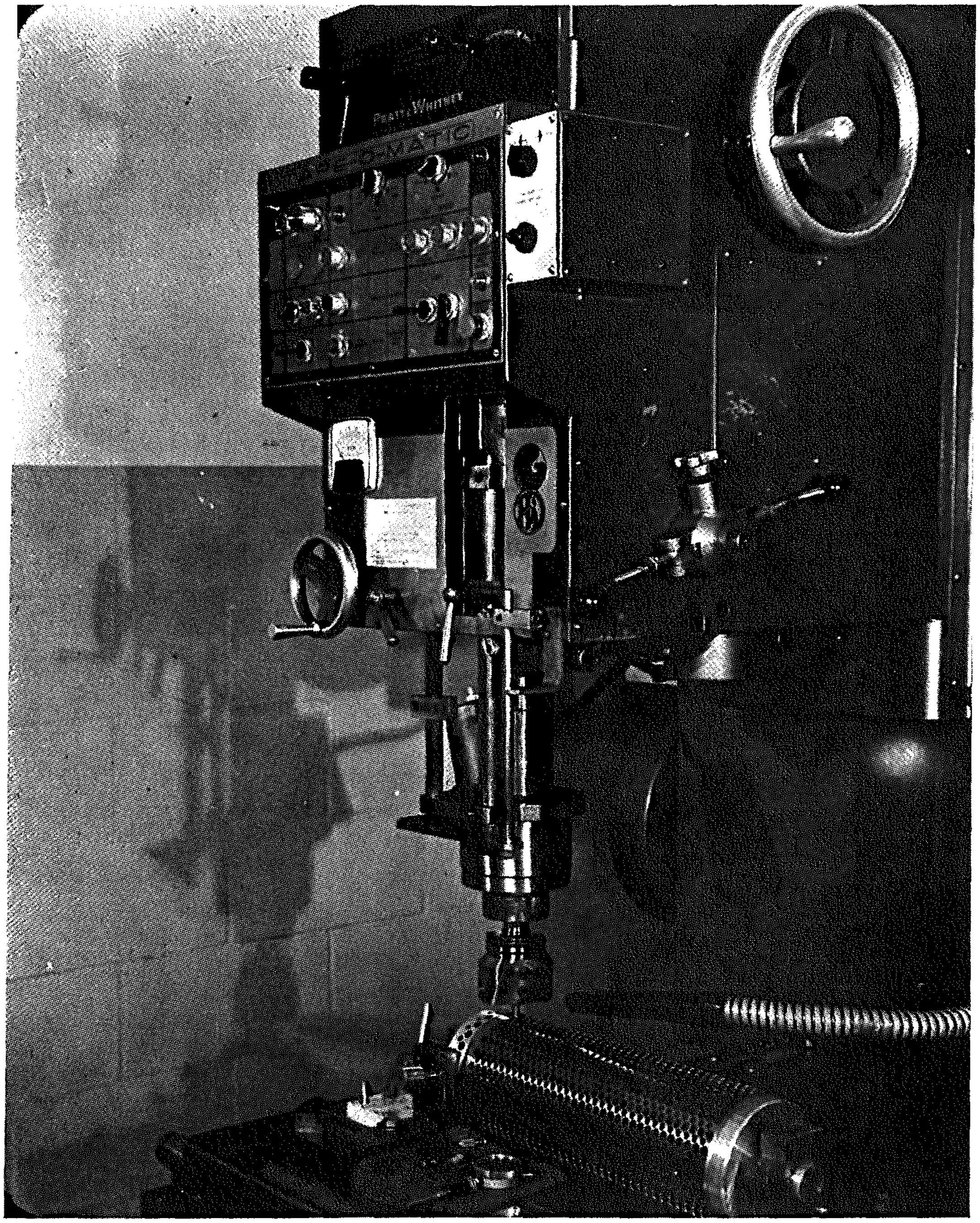





Veeco
Veeco







STRUCTURAL DESIGN

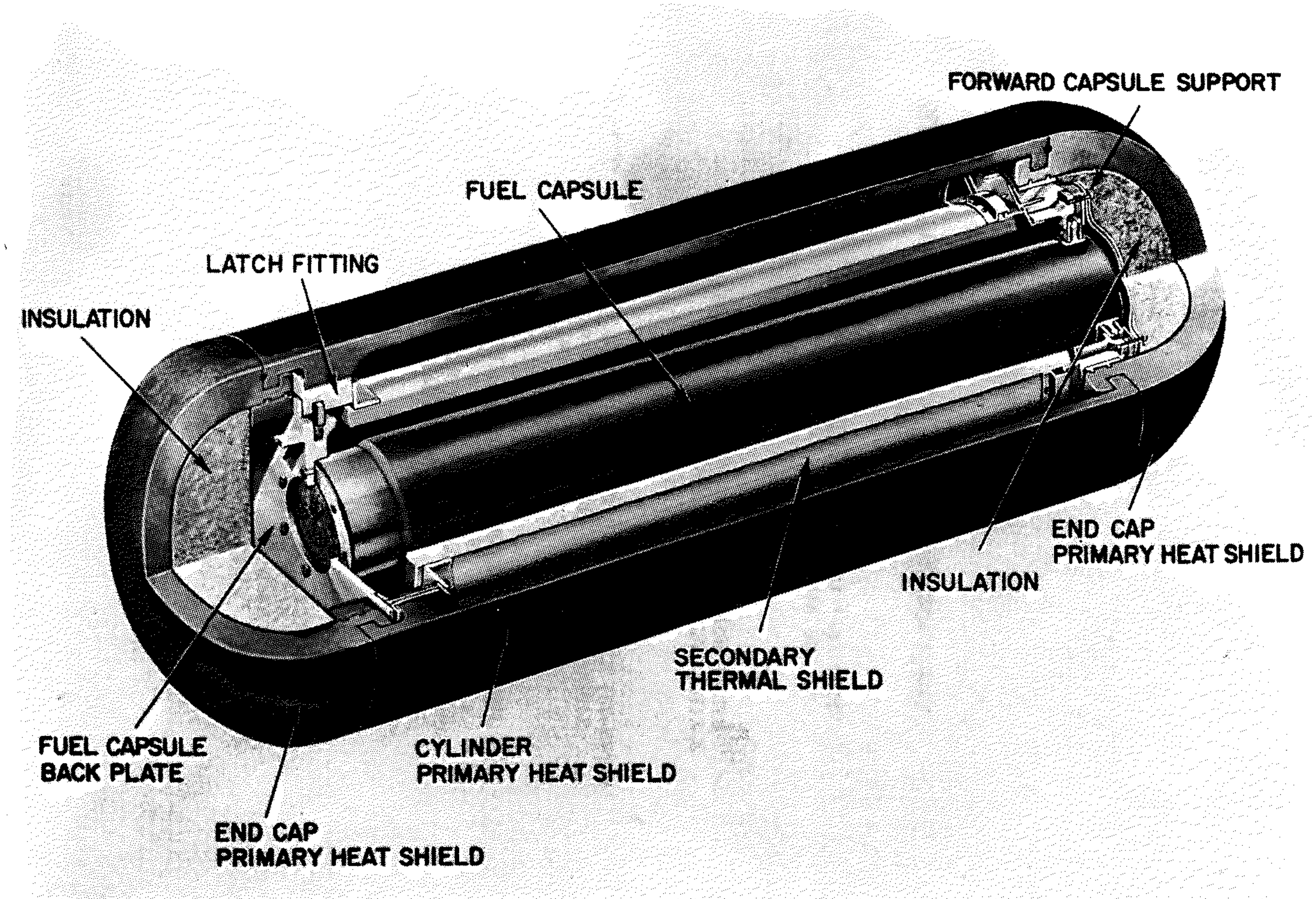
ITEM	MARGIN	COMMENTS
MOUNTING LUGS	0.30	45 G STATIC
COLD FRAME	6.17 >. LARGE	SHRINK FIT FOLLOWER SHEAR
FINS	>> LARGE	45 G STATIC
FOLLOWER SPRINGS	NOT CRITICAL	DESIGN FOR 16.4% RELAXATION AFTER TWO YEARS OPERATION
HOT FRAME	0.15	BASED ON SPRING PRESSURE AND INTERNAL GAS PRESSURE LOAD OF 60 PSI
HERMETIC SEAL - AFT - FWD.	3.00 0.06	DESIGNED FOR MINIMUM THERMAL LEAK - SUBJECTED TO COMPONENT TEST
TRANSITION RING BRAZE IN CASE RING SEAL WELD	 LARGE LARGE 1.5	
OUTER CASE	AMPLE	ANALYSIS COMPLEX - SYSTEM PROVEN BY RIGOROUS TESTS

GENERATOR ASSEMBLY STRUCTURAL ANALYSIS

ITEM	LOAD
MOUNTING LUGS	G-LOADS, 3 AXIS
COLD FRAME	SHRINK FIT STRESSES FOLLOWER SPRING SHEAR
OUTER CASE	LATERAL AND AXIAL LOADS SHRINK FIT THERMAL STRESS
FINS	LATERAL LOAD THERMAL STRESS
FOLLOWER SPRING	SPRING RELAXATION
HOT FRAME	PRESSURE (GAS) COMPRESSION LOAD OF T/E ELEMENTS
HERMETIC SEALS	PRESSURE DEFLECTION
TRANSITION RING BRAZE AND WELD	PRESSURE LOAD

GRAPHITE LM FUEL CASK

<u>GLFC</u>


FORWARD CAPSULE SUPPORT
FUEL CAPSULE
LATCH FITTING
INSULATION
END CAP
PRIMARY HEAT SHIELD
INSULATION
SECONDARY
THERMAL SHIELD
FUEL CAPSULE
BACK PLATE
CYLINDER
PRIMARY HEAT SHIELD
END CAP
PRIMARY HEAT SHIELD

GLFC REQUIREMENTS

OPERATIONAL:

- SUPPORT FUEL CAPSULE FROM LAUNCH TO LUNAR SURFACE
- REJECT CAPSULE HEAT OF 1500 WATTS TO MAINTAIN CLAD TEMPERATURE OF $< 1450^{o}F$
- ALLOW FOR CAPSULE INSERTION ON THE PAD AND REMOVAL ON THE LUNAR SURFACE

SAFETY:

- CONTAIN FUEL TO GROUND IMPACT (RE-ENTRY ABORT) i.e., MAINTAIN FUEL CAPSULE INTEGRITY
- MINIMIZE RELEASE OF HAZARDOUS FUEL FOR ANY OTHER SYSTEM ABORT, e.g., LAUNCH VEHICLE EXPLOSION, FIREBALL, BURIAL, ETC.

GLFC DESIGN RESTRAINTS

- CYLINDRICAL SHAPE 8" OD X 23" LONG
- WEIGHT $\leq$ 40 POUNDS WITH FUEL CAPSULE
- PAD COOLING TO $<$ 350°F
- THERMAL OUTPUT $<$ 1530 WATTS
- ATTACHMENT BAND LOADS TO 900 POUNDS
- DEPLOYMENT LOAD LIMITS

LOCKING SPLINE PULL	20 POUNDS
DOME ROTATION	80 IN.LBS.

GLFC ENVIRONMENTS

NORMAL OPERATION

- SURFACE TEMPERATURE: AIR - 125°F TO 700°F
  VACUUM - LESS THAN 835°F
- CAPSULE TEMPERATURE: 1450°F
- DYNAMIC ENVIRONMENT: VIBRATION SINE 3G to 100 HZ
  RANDOM $0.15G^2$/Hz TO 2000 Hz
  SHOCK 15 G
  QUASISTATIC LOAD 60 G

PAD ABORT

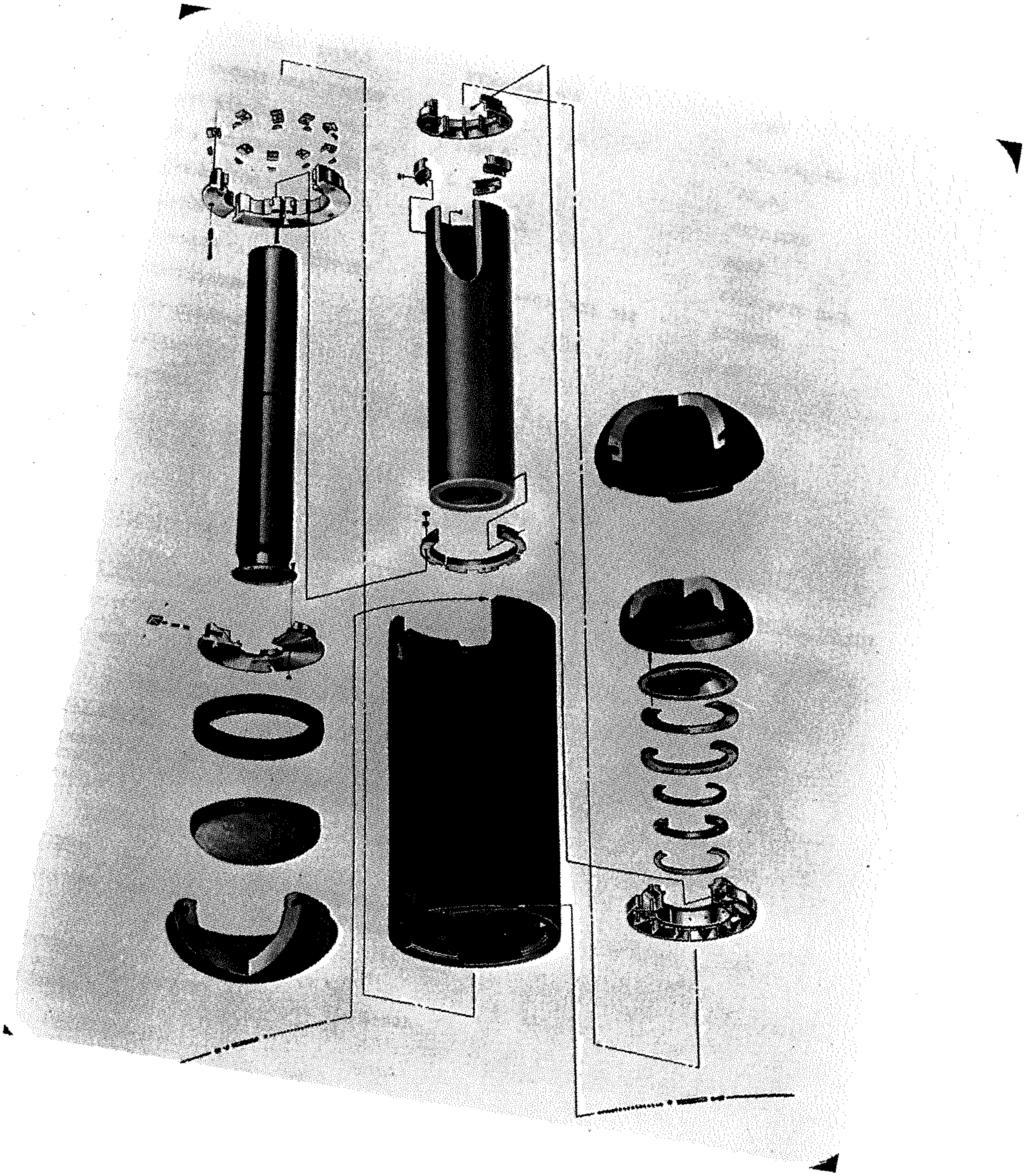
- BLAST: 20% YIELD SIVB
  STATIC OVERPRESSURE 525 PSI
  STATIC IMPULSE 2.1 PSI SECONDS
- FRAGMENTATION: SHEETS 1 IN^2 TO 200 FT^2 300 FPS TO 3500 FPS
  COMPONENTS 1 LB TO 200 LBS, 100 FPS TO 300f FPS
- FIREBALL: 5000°F MAX. TO 12 SECONDS
  1875°F AFTERFIRE FOR 1 HOUR

RE-ENTRY

- EARTH ORBITAL: INITIAL VELOCITY 25,708 FPS
  MAX. HEATING RATE 110 BTU/FT^2·SEC
  DURATION 6600 SECONDS
- SUPERORBITAL: INITIAL VELOCITY 36,333 FPS
  INITIAL 6-1/4° TO 38°
  MAX. HEATING RATES 6-1/4°-480 BTU/FT^2·SEC
  38° - 1900 BTU/FT^2·SEC
  DURATION 6-1/4° - 170 SECONDS
  38° - 35 SECONDS

IMPACT

- GLFC: TERMINAL VELOCITY 300 FPS, TEMPERATURE OF FCA 1850°F



GLFC MATERIALS

ITEM	MATERIAL	COATING
PRIMARY HEAT SHIELD	PYROCARB 406	NONE
SECONDARY HEAT SHIELD	Be	Ag, Rh, RC-165
SHS ATTACHMENT RINGS	INCO X	Al_2O_3
SHS ATTACHMENT BOLTS	L 605	OXIDIZED
INSULATION	FIBERFRAX	NONE
LATCH FITTING	Ti	CARBONATE BATH
FORWARD CAPSULE SUPPORT	Ag, Ti, L-605, CKS 302	LITHOID
DOME COVER	Ti	NONE
CAPSULE/BACKPLATE	L-605	OXIDIZED
SPLINE LOCK	Ti, Ta, Al_2O_3	NONE
CAPSULE	L-605	RC-356

GLFC WEIGHTS

DESCRIPTION	MATERIAL	CALCULATED NOMINAL WEIGHT
GRAPHITE PRIMARY SHIELD		
CYLINDER	PYROCARB	7.90
END CAPS	PYROCARB	6.16
RETAINER	PYROCARB	.43
TOTAL GRAPHITE		14.49
SECONDARY SHIELD		
CYLINDER	BERYLLIUM	5.62
COATINGS	Rh, Ag, R161	.30
ATTACHMENTS	INOX, Ti L605	1.57
TOTAL SECONDARY SHIELD		7.49
INSULATION		
INSIDE END CAPS	FIBER-FRAX	.87
OTHER		
LATCH FITTING	Ti	.98
FORWARD CAPSULE SUPPORT	Ti, L-605	1.27
DOME COVER	Ti	.43
SUBTOTAL		25.54
CAPSULE/BACK PLATE	L-605	14.80
TOTAL WEIGHT		40.33
RANGE		38.89 TO 41.04

SUMMARY OF ACTUAL GLFC WEIGHTS

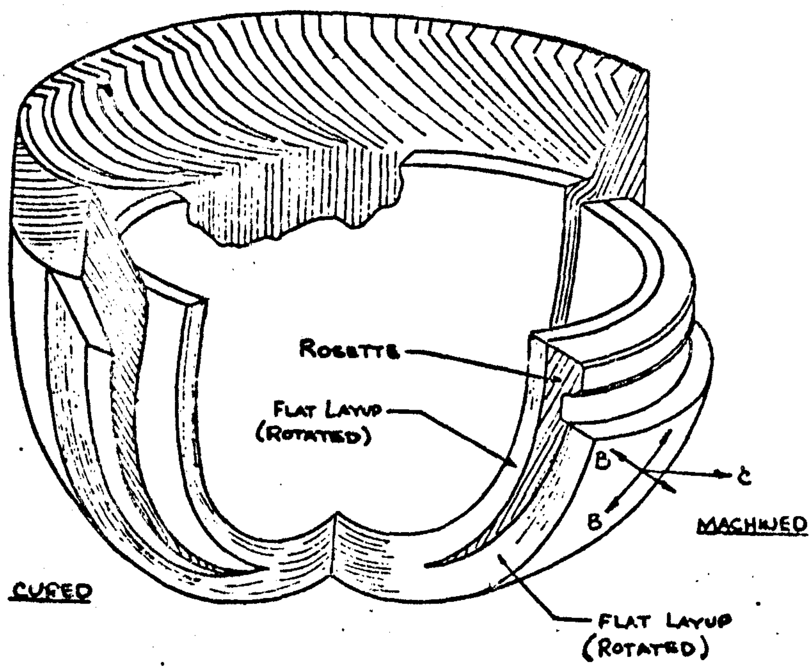
SYSTEM	FCA (LBS)	GLFC HARDWARE (LBS)	GLFC TOTAL W/FCA (LBS)
QUAL	14.8	25.55	40.35
FLIGHT 1	14.8	25.60	40.40
FLIGHT B/U	14.6	25.40	40.00
FLIGHT 2	14.7	24.85	39.55
FLIGHT 3	14.1	25.44	39.54
FLIGHT 4	14.4	25.00	39.40

SNAP 27

PYRO-CARB 406

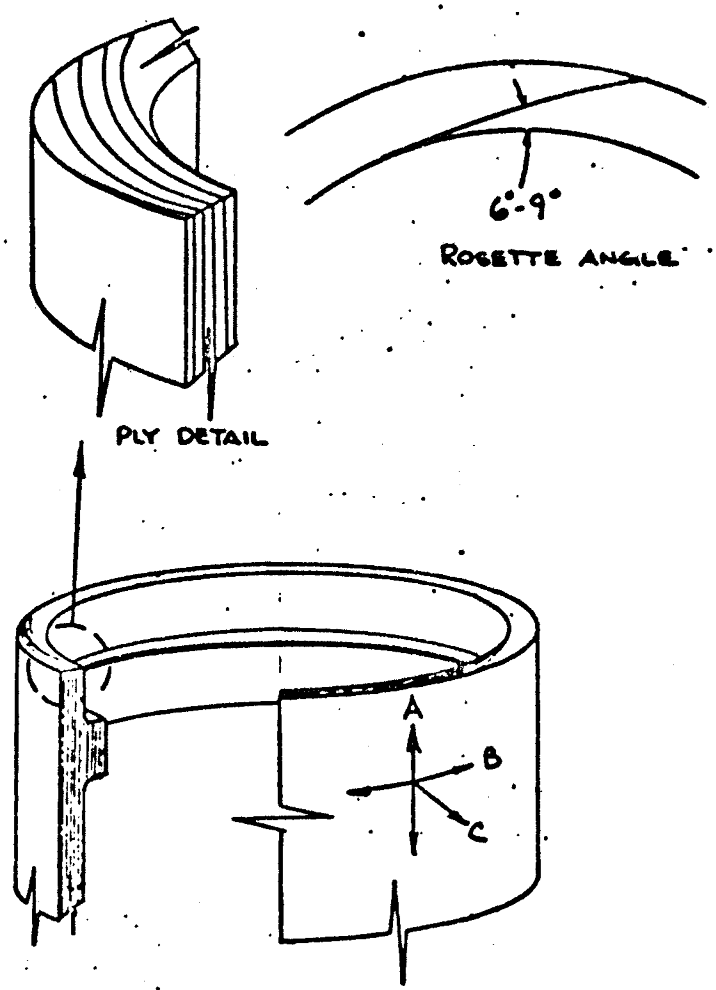
5

PYROCARB "406"



PLY ORIENTATION - END CAP

PYROCARB "406"



GLFC/FCA RE-ENTRY PROGRAM

SAFETY CRITERIA

CONTAINMENT OF FUEL TO POINT OF GROUND IMPACT

ABORT REGIME

EARTH ORBITAL DECAY
ABORT IN TRANSLUNAR TRAJECTORY

$6.25^\circ \rightarrow 38^\circ$ DFH (MOST PROBABLE)
38 - 90° DFH (POSSIBLE)

ATTACHED TO LM TO POINT OF RELEASE
CASK EITHER SPINNING OR ORIENTED

PROGRAM

CHARACTERIZE MATERIALS/MATERIAL BEHAVIOR BY TEST
INCORPORATE MAXIMUM DESIGN CAPABILITY

FUEL CAPSULE TEMPERATURE < MELT
NO STRUCTURAL FAILURE OF GRAPHITE

ASSESS GLFC/FCA IN WORST (LIMIT) CASES
DETERMINE MOST REASONABLE RE-ENTRY CONDITIONS

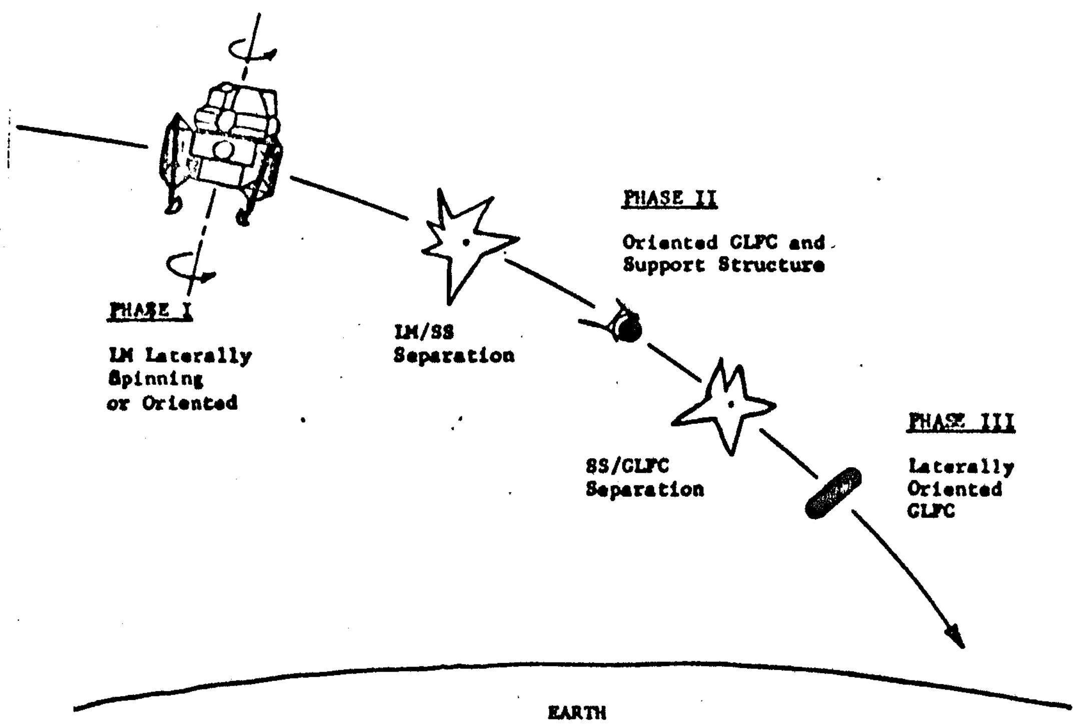
LM CONFIGURATION
LM BREAK-UP
GLFC/SUPPORT STRUCTURE INTERACTIONS

GRAPHITE MATERIAL CHARACTERIZATION PROGRAM

ROOM TEMPERATURE - TO $4500^\circ F$
AB PLANE AND C DIRECTION

PROPERTIES	
. TENSILE σ, E . SHEAR σ . FLEXURE σ . COMPRESSION σ, E	. STRENGTH FOR DESIGN ALLOWABLES
. EXPANSION . CONDUCTIVITY . SPECIFIC HEAT	. THERMAL DATA FOR THERMAL STRESS CALCULATIONS
. ARC JET TESTS . TUNNEL TESTS	. ABLATION RECESSION CHARACTERISTICS FOR RE-ENTRY PERFORMANCE
. REFLECTOMETER TEST TOTAL HEMISPHERICAL TEST COATINGS DEVELOPMENT	. EMITTANCE PROPERTIES FOR THERMAL CONTROL
. WEIGHT LOSS TESTS . OXIDIZED FLEXURE TESTS	. OXIDATION PROPERTIES FOR ON-PAD AIR EXPOSURE
. AIR, VACUUM STEADY STATE AND NON-STEADY STATE TESTS OF MATERIALS IN CONTACT	. COMPATIBILITY INFORMATION FOR DESIGN AND SAFETY INTEGRITY
. REPRESENTATIVE SAMPLE DEVELOPMENT . DENSITY GRADIENT TECHNIQUES . PROCESS DEVELOPMENT FOR QC CONTROL	. SPECIFICATIONS

RE-ENTRY SEQUENCE



RE-ENTRY CASES EVALUATED

REFERENCE CASES

- FREE AND UNENCUMBERED GLFC

LIMIT CASES

- ULTRA-CONSERVATIVE
- GLFC FOLLOWS IN TRAJECTORY AFTER SEPARATION
- AUGMENTED HEATING (FACTOR OF 5)
- TWO CONDITIONS
  - MAXIMUM HEATING (GLFC IN ITS OWN FLOW)
  - THERMAL SHOCK (GLFC HEATING IS 0 TO POINT OF MAXIMUM LM HEATING)

MISSION ABORT CASES

- GLFC AND SS HEATING WHILE ON LM IN THE LM FLOW
- GLFC AND SS FOLLOW ITS OWN TRAJECTORY AFTER SEPARATION FROM LM
- GLFC FOLLOWS ITS OWN TRAJECTORY AFTER SS MELTS

GLFC WITHOUT HEAT SHIELD

RE-ENTRY MODES FOR ALL CASES

- SIDE-ON STAGNATED
- PLANAR TUMBLE
- SPIN

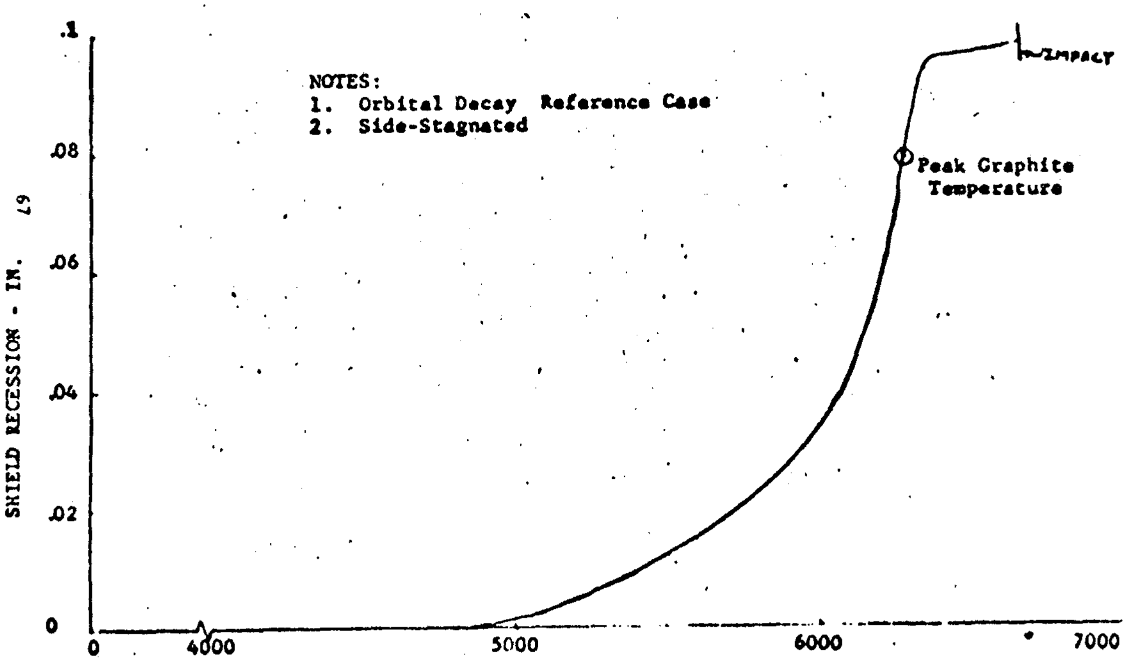
TABLE P4-3. GLFC MISSION ABORT THERMAL RESULTS

Boundary Case	One-D or Two-D	Graphite O.D. Max Temp (°F)	Graphite O.D. Time (Sec)	Graphite O.D. Alt (KFt)	Graphite I.D. Max Temp (°F)	Graphite I.D. Time (Sec)	Graphite I.D. Alt (KFt)	Beryllium [illegible] Max Temp (°F)	Beryllium Time (Sec)	Beryllium Alt (KFt)	Beryllium Max Avg Temp (°F)	Clad Max Temp (°F)	Clad Time (Sec)	Clad Alt (KFt)	Clad Max Avg Temp (°F)	Stagnation Point[3] Recession (inches) Total (inches)	Stagnation Point Recession At Pk Temp (inches)	Comments
Earth Orbit Decay, Upper Altitude[2] (.1)[3]	Two-D	3070	6610	196	2960	6610	196	1964	5564	150	1600	1046	6020	96	1600	---	---	GLFC does not separate from HS
Earth Orbit Decay, Upper Altitude[2] (8)[3]	Two-D	2960	6406	167	2640	6446	167	1966	6060	153	1520	1010	6068	115	1670	---	---	GLFC separation from HS at 6106 sec, 206 Kft.
Earth Orbit Decay, Lower Altitude[2] (.1)[3]	Two-D	2260	6370	204	2725	6370	204	1611	6456	137	1475	1566	6600	97	1600	---	---	GLFC separation from HS at 6370 sec, 204 Kft.
Earth Orbit Decay, Upper Altitude[2] (8)[3]	Two-D	2200	6370	204	2730	6070	204	1611	6480	137	1475	1566	6600	97	1600	---	---	See Note 1; GLFC separation from HS at 6046 sec, 210 Kft.
0.25°[3] Superorbital, Lower Altitude	One-D	5000	75	196	3400	86	104	2017	140	137	3000	1969	200	90	1919	0.000	0.0100	GLFC separation from LM and HS at 71 sec, 196 Kft.
30° Superorbital, Upper Altitude	One-D	1900	92	137	2520	27	108	1640	100	48	1636	1650	240	35	1650	0.0346	0.0120	GLFC separation from LM and HS at 13.7 sec, 230 Kft.
30° Superorbital, Lower Altitude	One-D	5000	21	140	3540	26	100	1630	120	97	1606	1640	220	30	1640	0.0610	0.0070	GLFC separation from LM and HS at 16.3 sec, 300 Kft.
30° Superorbital, Upper Altitude	One-D	2200	12	153	3300	17	92	1400	110	90	1607	1900	270	90	1900	0.0256	0.0060	GLFC separation from LM and HS at 7.35 sec, 250 Kft.
30° Superorbital, Lower Altitude	One-D	6100	12	156	3000	17	92	1400	115	60	1650	1900	270	90	1940	0.0047	0.0000	GLFC separation from LM and HS at 8.56 sec, 180 Kft.

Notes:

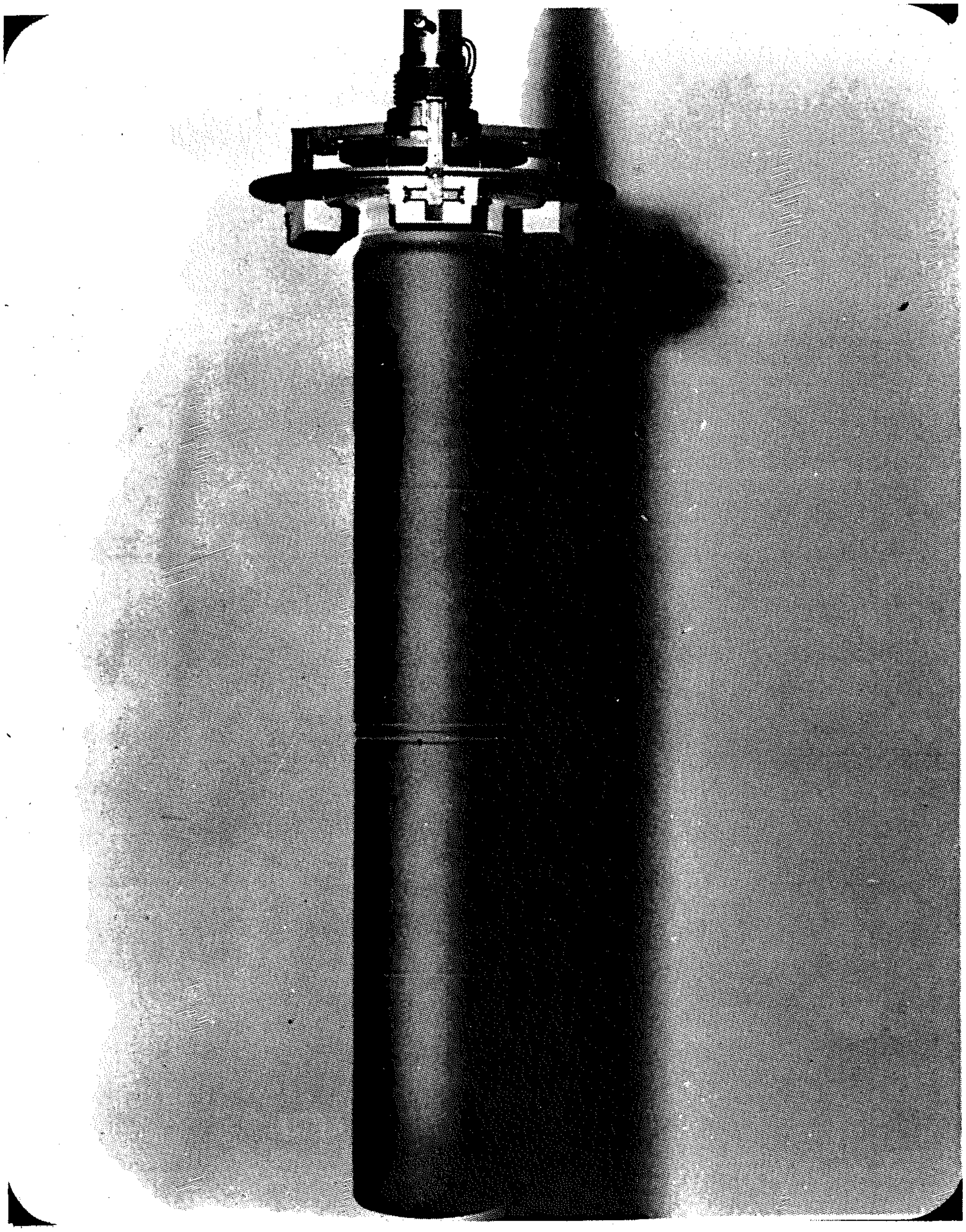
1. The Two Lower Altitude Cases Are Similar in Temperature Because of the Very Short Times for the GLFC/HS Flight
2. Denotes Upper or Lower Limit of LM Breakup Altitude
3. Denotes Stagnation Heating Rate Multiplier in Transition Area.

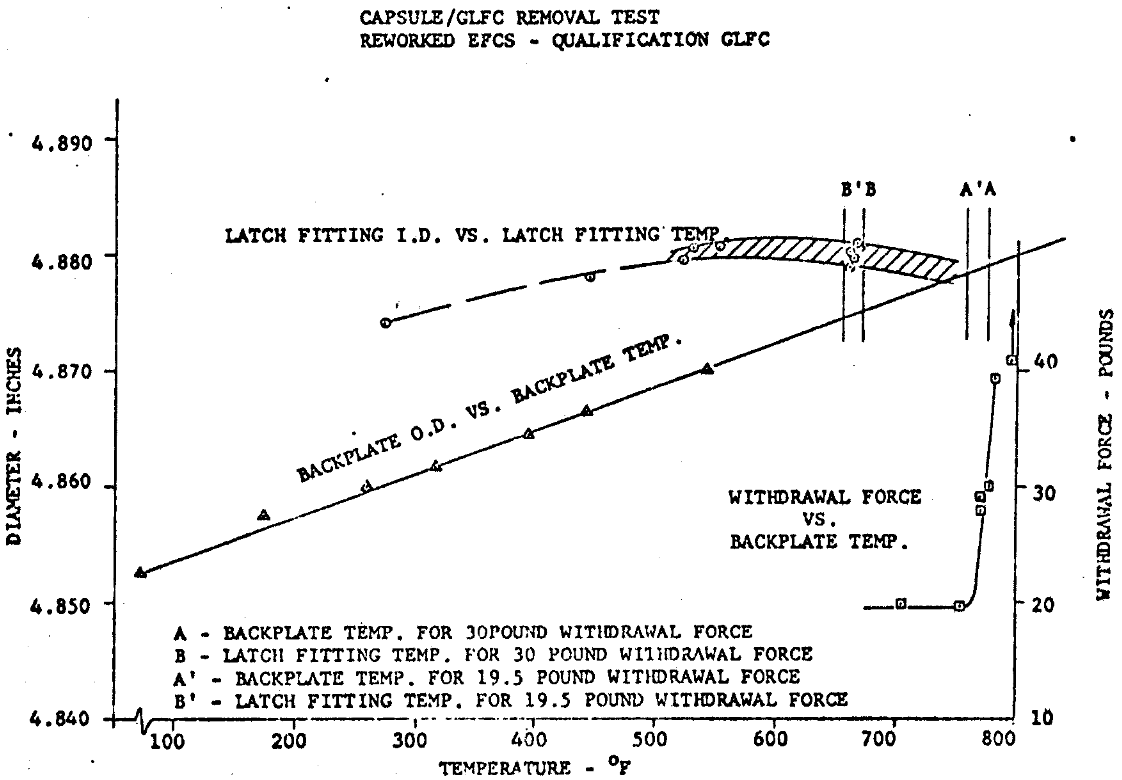
SNAP-27 SHIELD RECESSION HISTORY

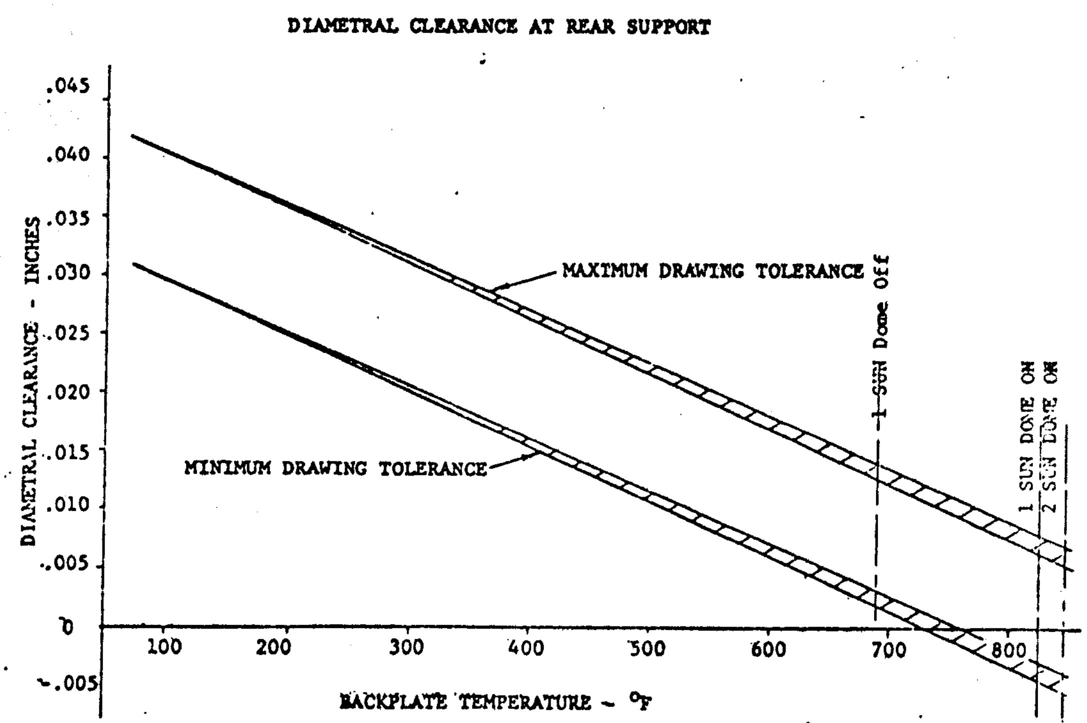


MAXIMUM HEAT SHIELD ABLATION

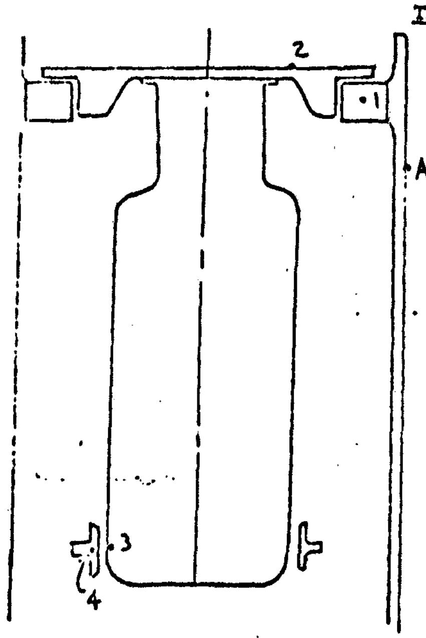
	ABLATION (INCHES)
• FREE GLFC (REFERENCE CASE)	
EARTH ORBITAL SIDE-ON STAGNATED	0.098
• LM TRAJECTORY (LIMIT CASE)	
EARTH ORBITAL SIDE-ON STAGNATED	0.238 (.141 AT MAXIMUM HEATING)
• MISSION ABORT CASE	
EARTH ORBITAL SIDE-ON STAGNATED	$<$0.098




CAPSULE/GLFC REMOVAL TEST
REWORKED EFCS - QUALIFICATION GLFC
LATCH FITTING I.D. VS. LATCH FITTING TEMP
BACKPLATE O.D. VS. BACKPLATE TEMP.
WITHDRAWAL FORCE VS. BACKPLATE TEMP.
B'B
A'A
DIAMETER - INCHES
WITHDRAWAL FORCE - POUNDS
TEMPERATURE - °F
A - BACKPLATE TEMP. FOR 30POUND WITHDRAWAL FORCE
B - LATCH FITTING TEMP. FOR 30 POUND WITHDRAWAL FORCE
A' - BACKPLATE TEMP. FOR 19.5 POUND WITHDRAWAL FORCE
B' - LATCH FITTING TEMP. FOR 19.5 POUND WITHDRAWAL FORCE

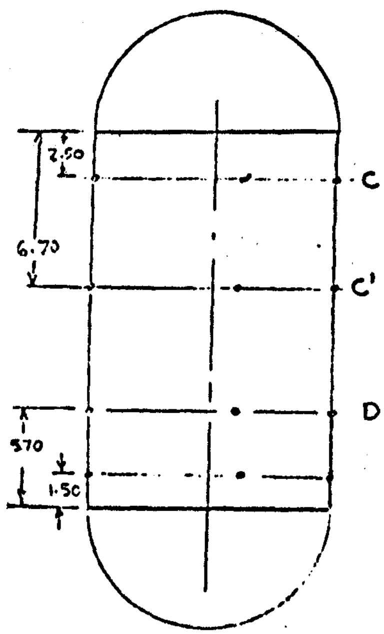

DIAMETRAL CLEARANCE AT REAR SUPPORT
MAXIMUM DRAWING TOLERANCE
MINIMUM DRAWING TOLERANCE
1 SUN Dome Off
1 SUN DOME ON
2 SUN DOME ON
DIAMETRAL CLEARANCE - INCHES
BACKPLATE TEMPERATURE - °F

TEMPERATURE PROFILES



ITEM	2 SUN °F	MAXIMUM POSSIBLE TEMPERATURE	DOME OFF -30 MIN
A. CONTROL POINT	710	675	648
1. LATCH RING	734	705	683
2. BACKPLATE	828	823	690
3. CAPSULE DOME	1420	1415	1392
4. IMPACT RING	1136	1124	1085

SNAP-27 GLFC ANOMALY TEMPERATURES



	2 SUNS LUNAR SURFACE	MAX. POSSIBLE TEMPERATURES
ROW C	710 °F	675 °F
ROW C[1]	797 °F	774 °F
ROW D	807 °F	790 °F
ROW E	712 °F	690 °F
TOTAL CYLINDER	756 °F	735 °F

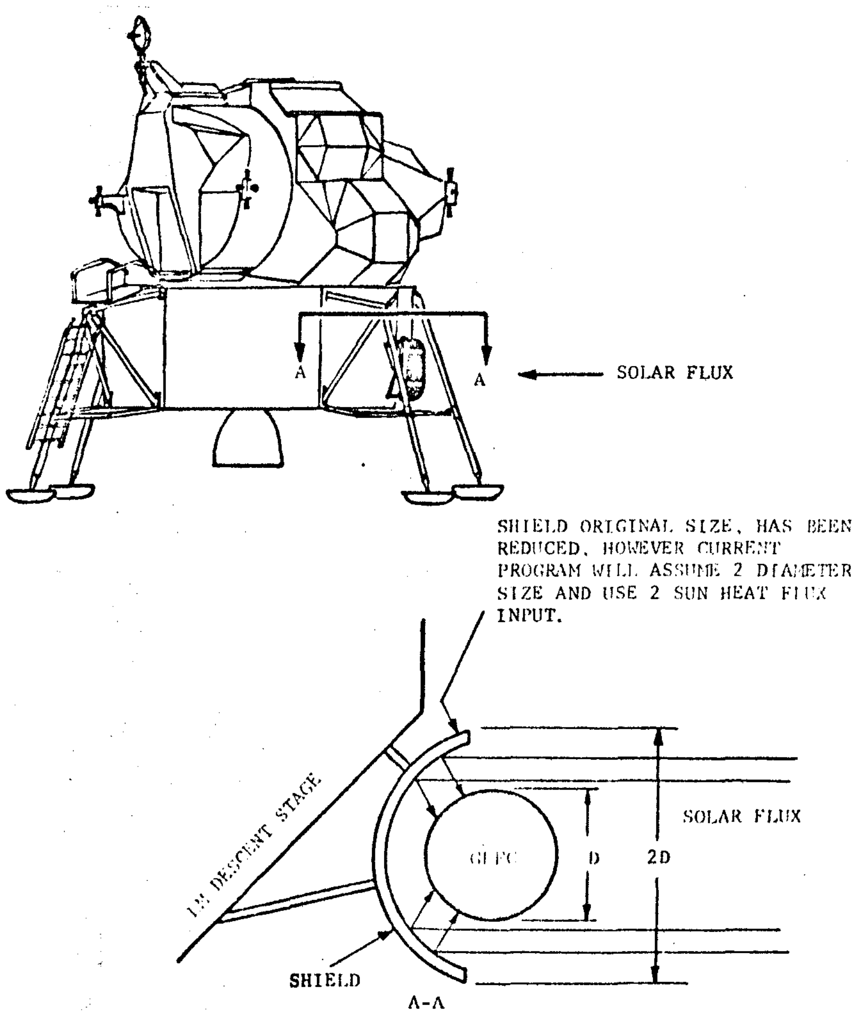
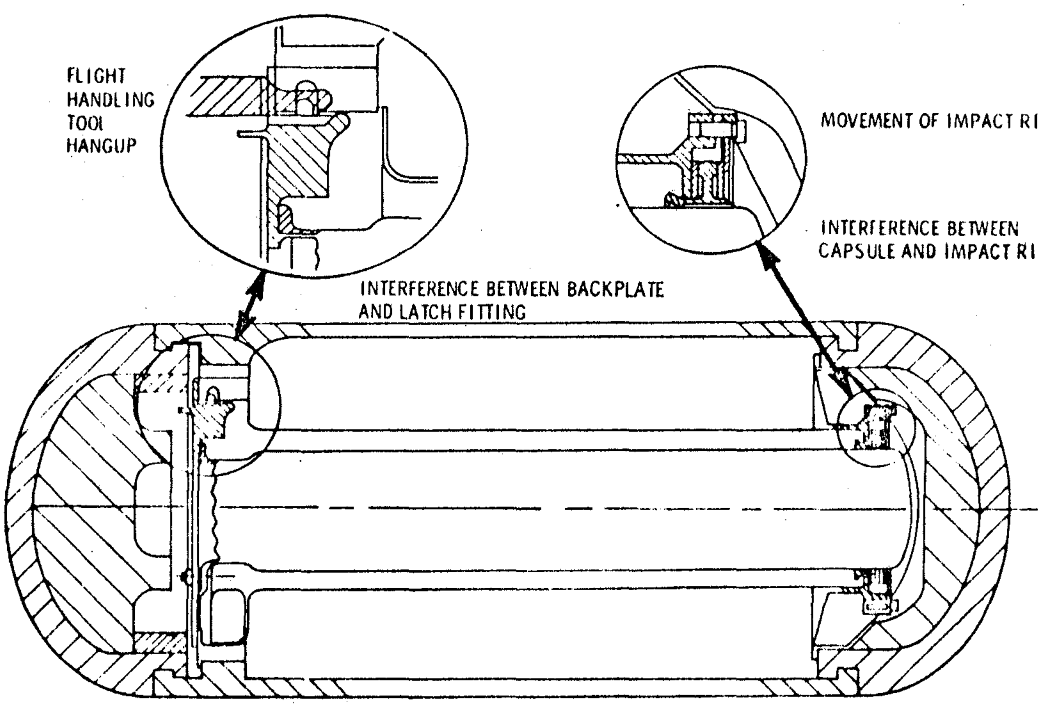
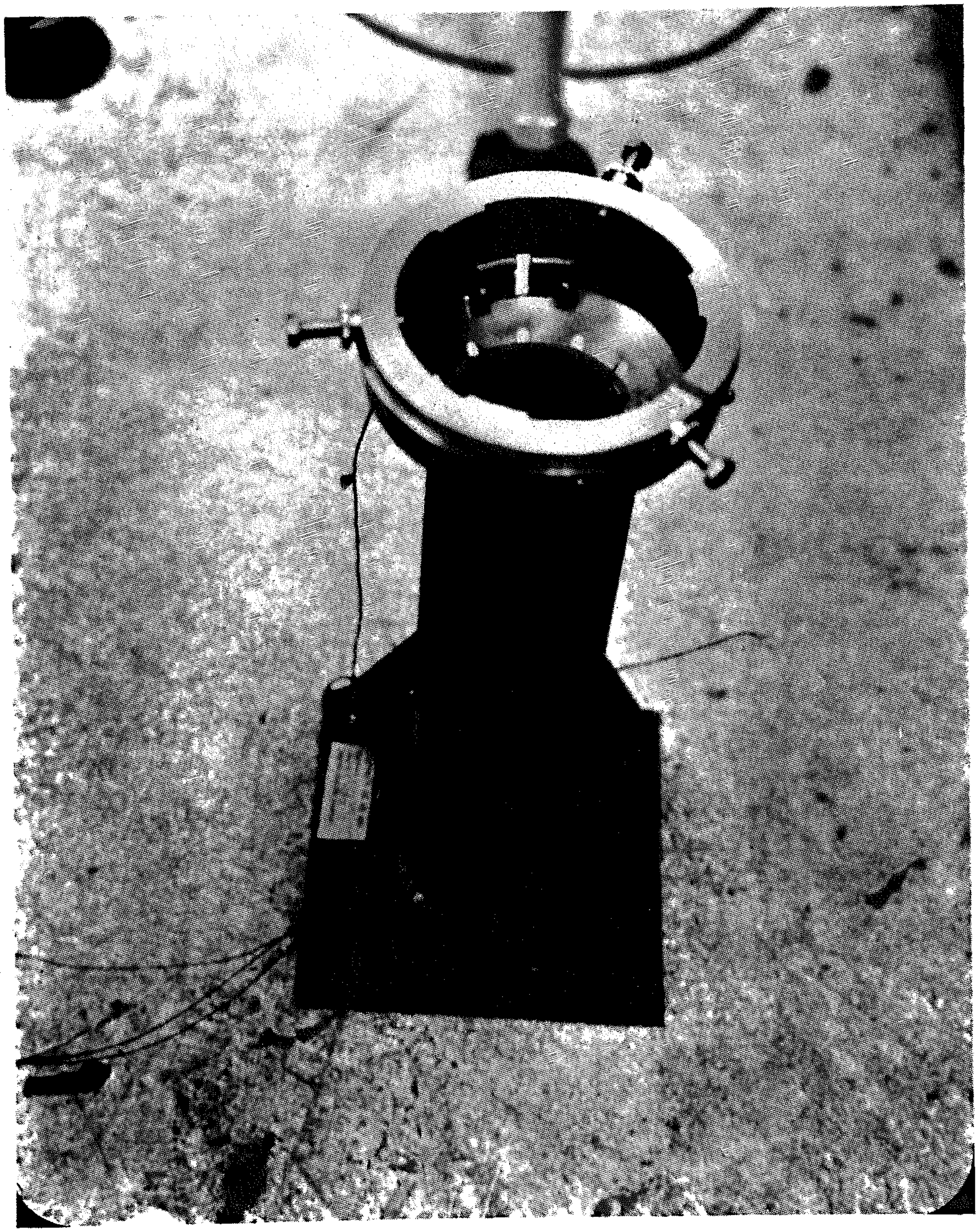


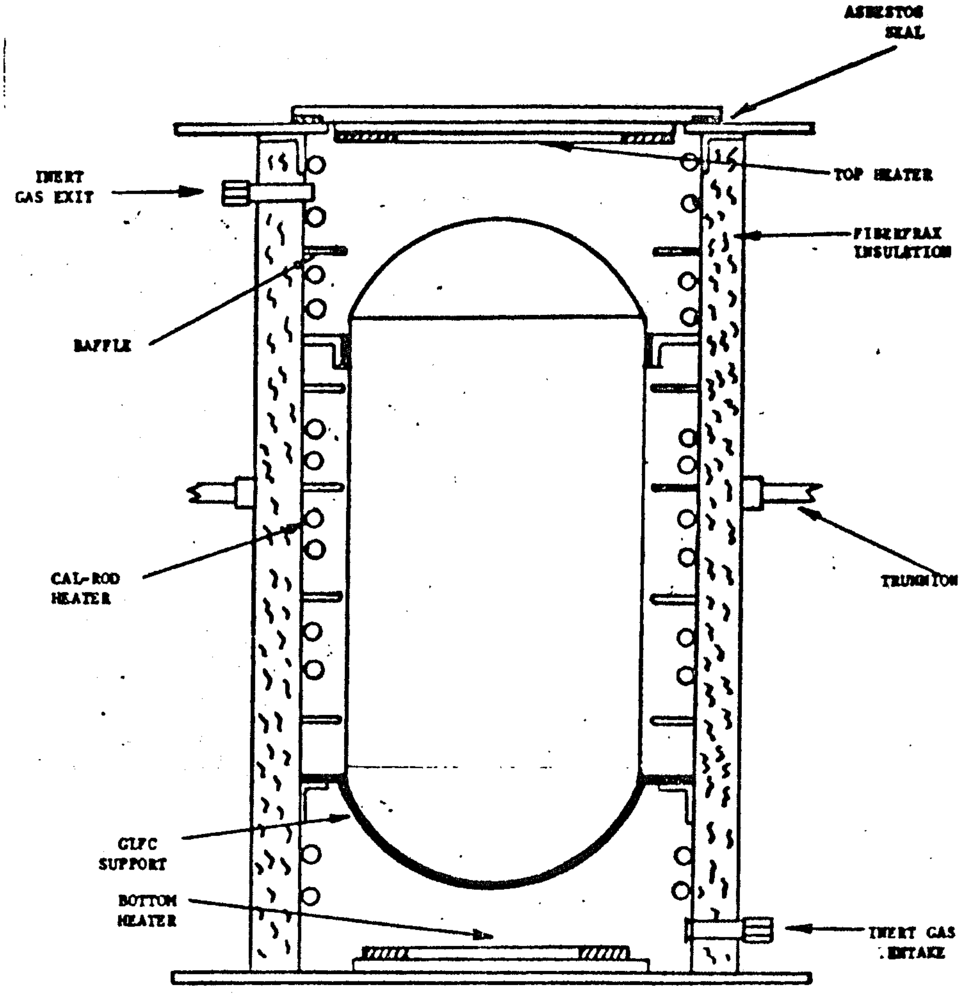
FIGURE 2-4. WORST CASE GLFC LUNAR ENVIRONMENT

SPACE SYSTEMS (NSP) SPACE DIVISION

POTENTIAL PROBLEM AREAS OF CAPSULE REMOVAL

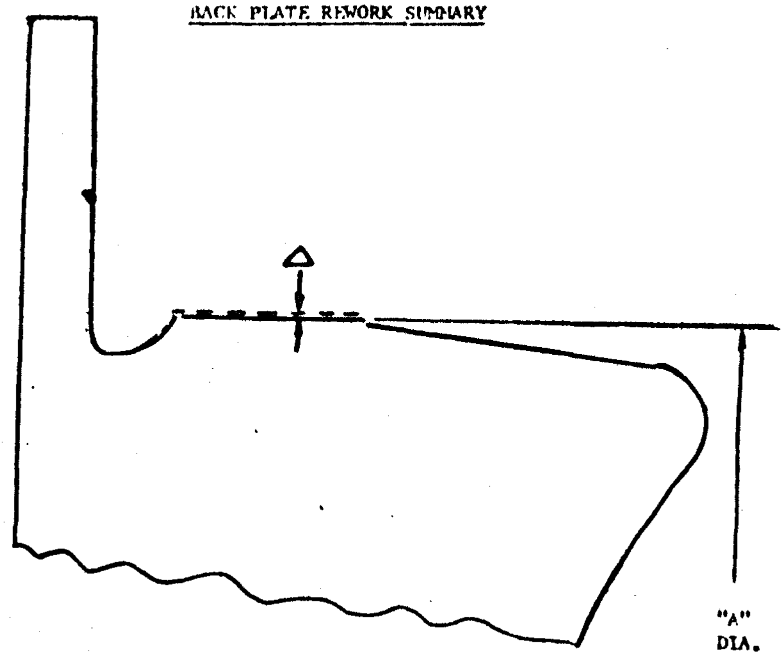




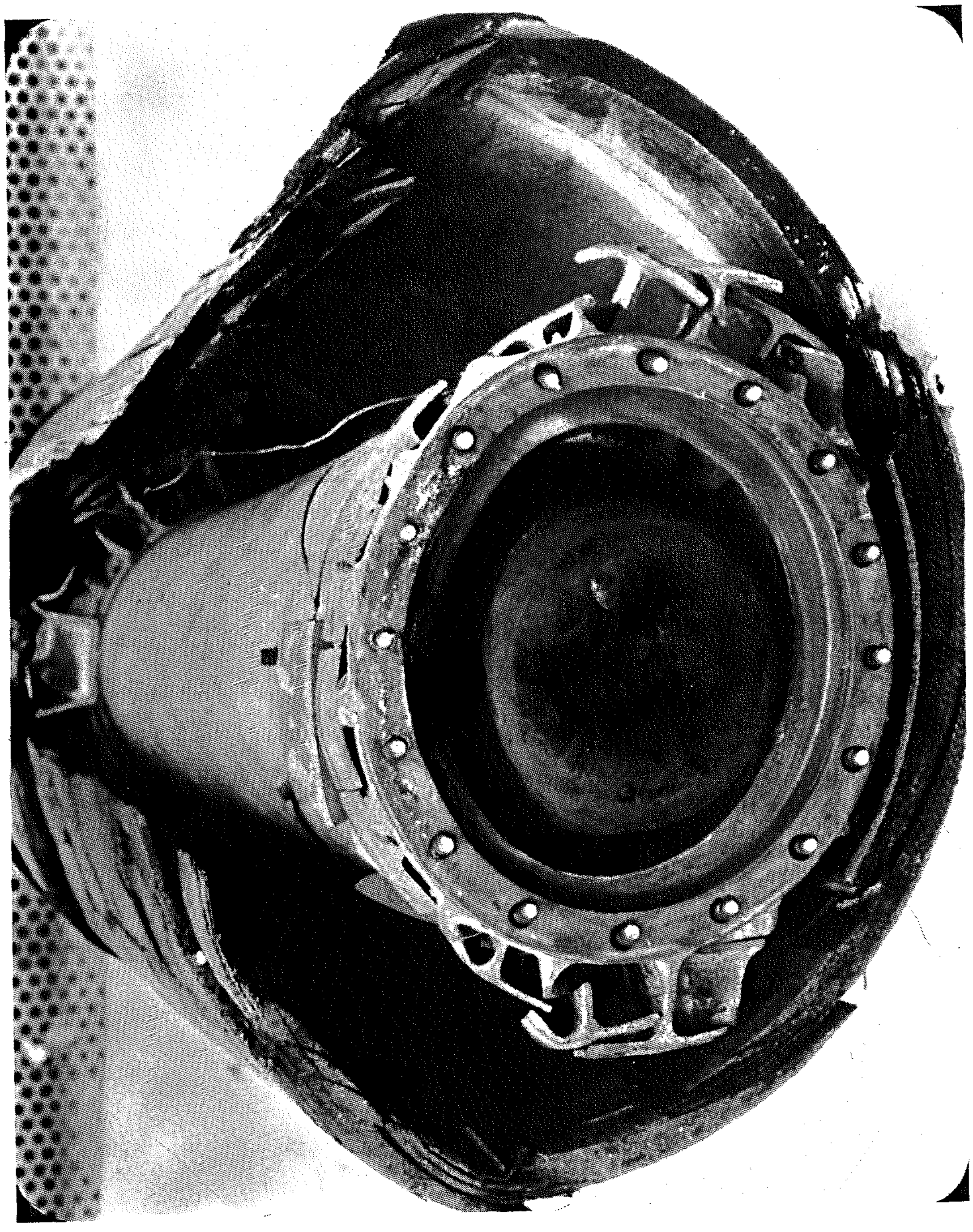


GLFC
CONTROLLED ATMOSPHERE
THERMAL TEST FIXTURE

BACK PLATE REWORK SUMMARY



CAPSULE NO.	"A" DIA.		MIN Δ (DIA)
	BEFORE	AFTER	
QUAL FCA #4	4.8501-4.8532	4.8454-4.8455	.006
FLT 2 FCA #2	4.8558-4.8570	4.8520-4.8525	.004
BACKUP FCA #6	4.8488-4.8519	4.8500-4.8519	.000
FLT 3 FCA #7	4.8525-4.8536	4.8532	.000
FLT 4 FCA #5	4.8535-4.8540	4.8538	.000



GLFC IMPACT TEST

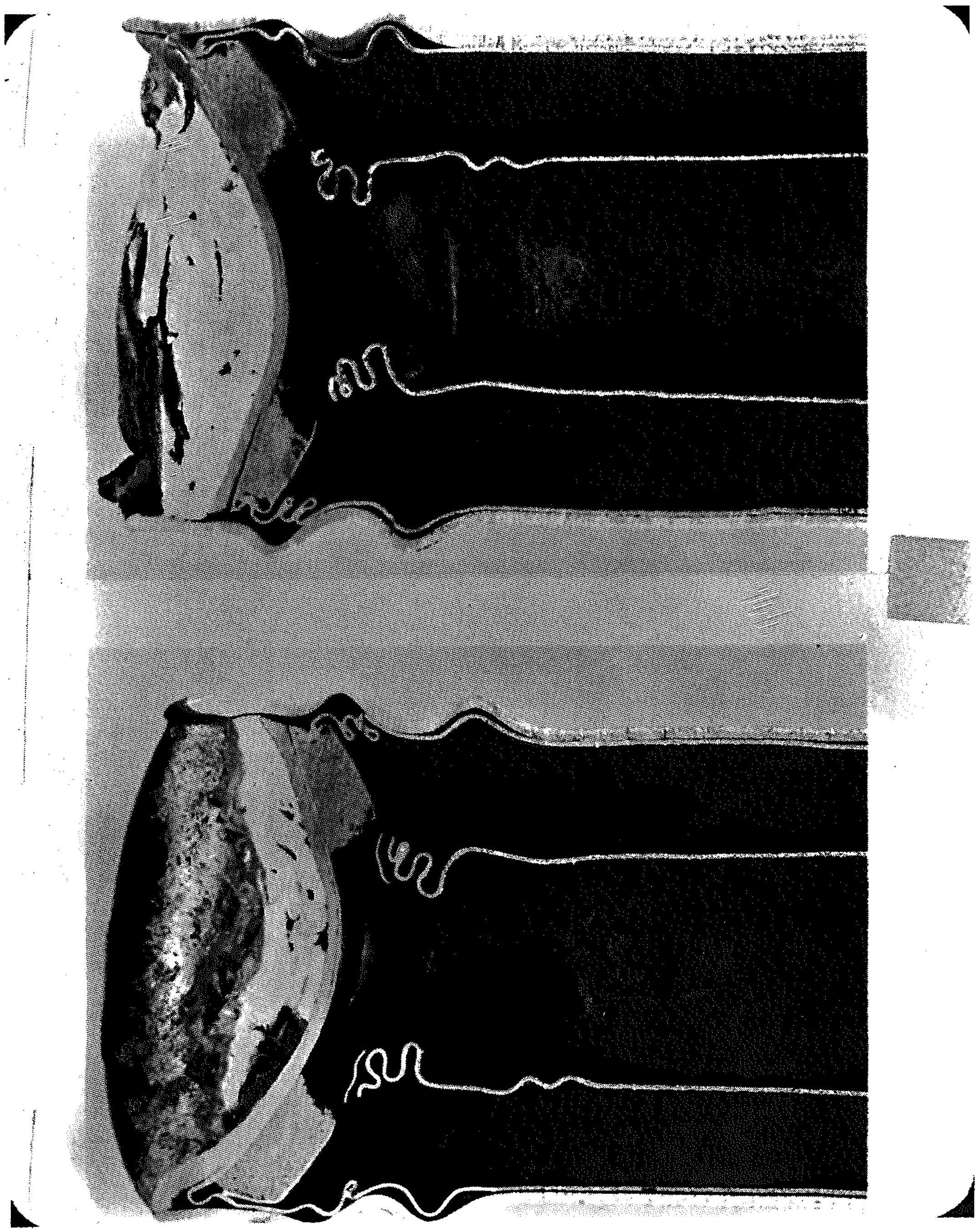
IMPACT RESPONSE OF GLFC/CAPSULE

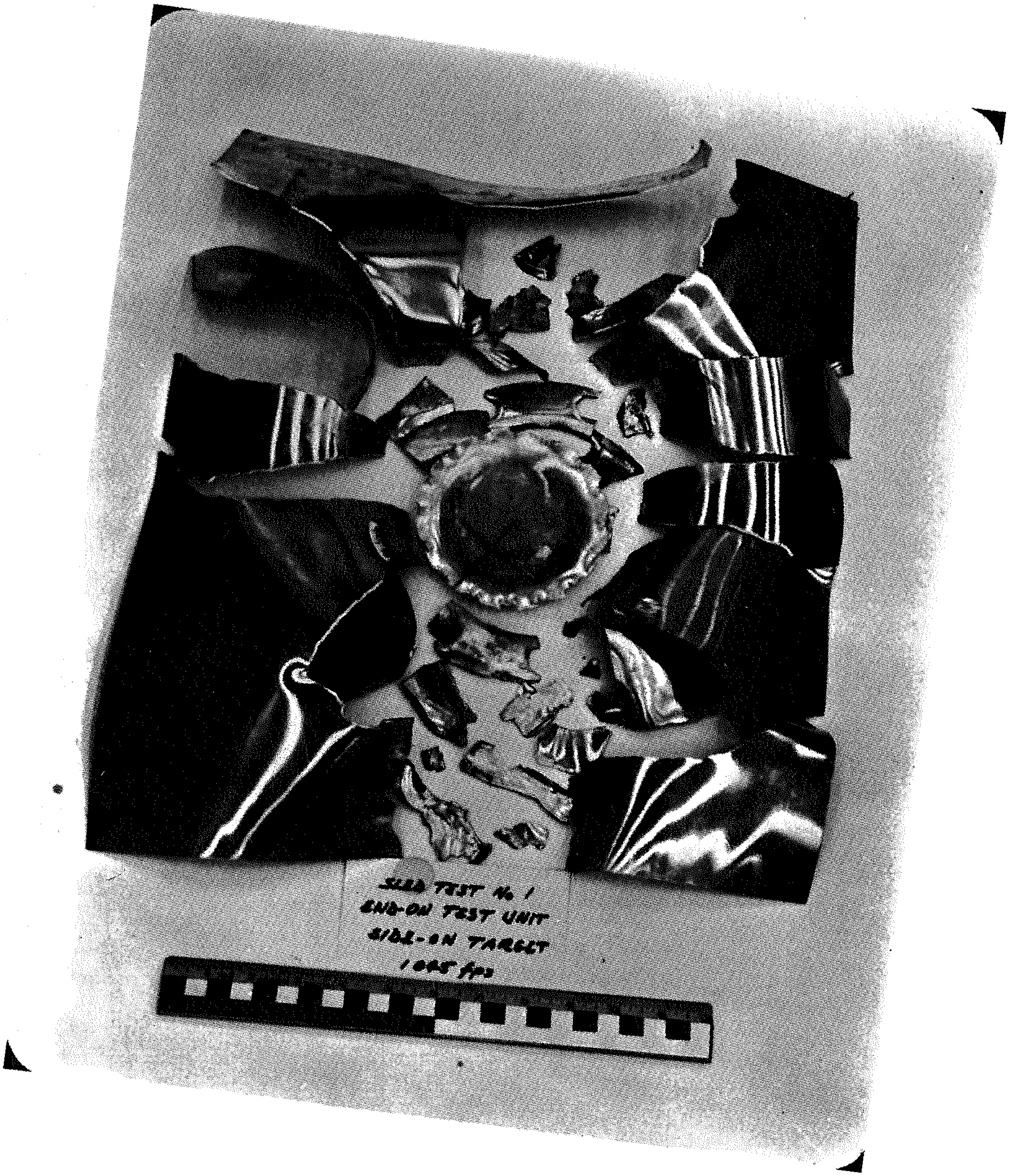
TEST CONDITIONS

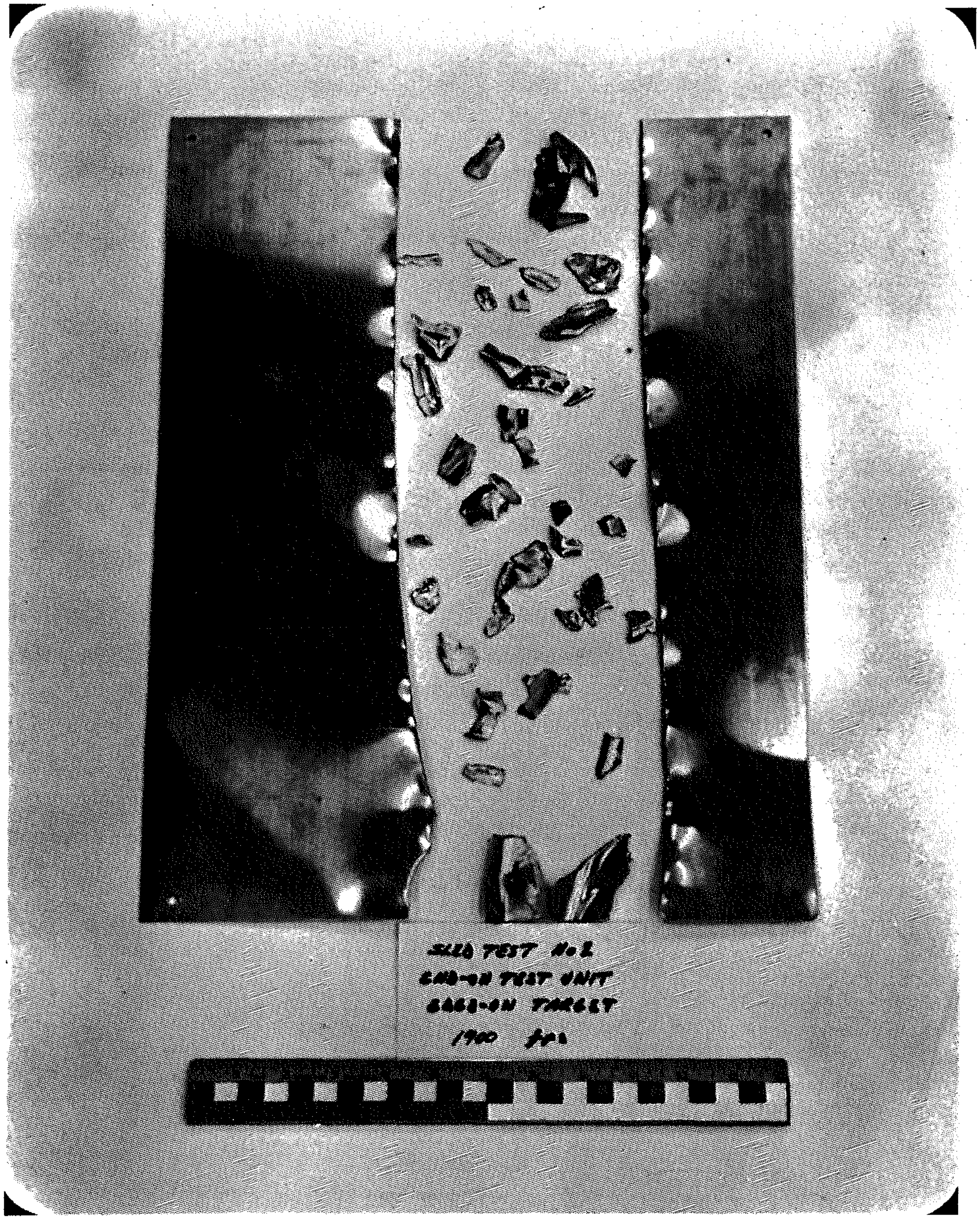
Capsule temperature: equivalent re-entry
11,000 ft. altitude above terrain
Concrete target

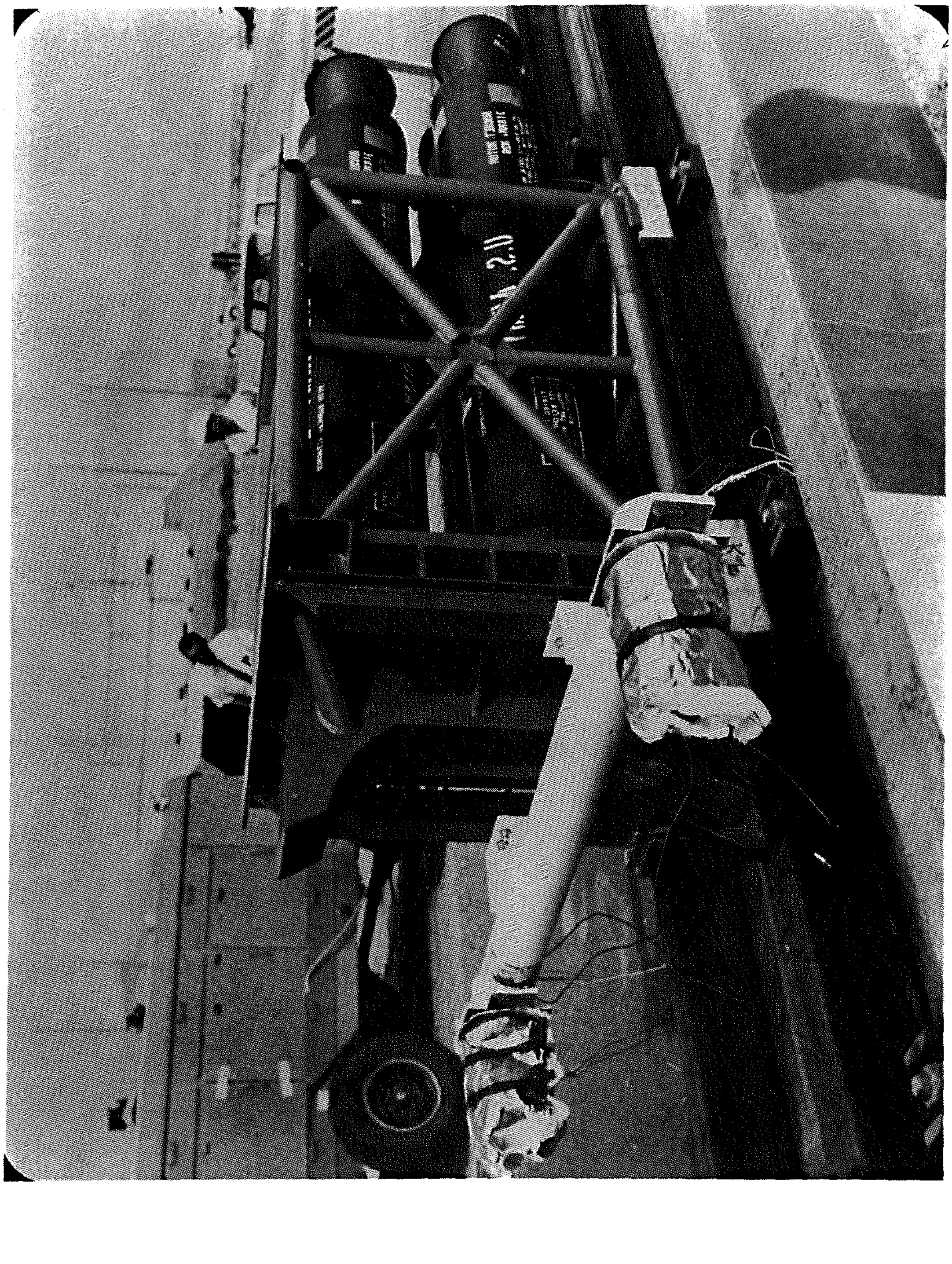
DATA OBTAINED

Random tumbling mode
Terminal velocity = 295 fps
Maximum velocity = 304 fps
Capsule temperature at release = 1890°F
Caliche soil impact




SLED TEST No 1
END-ON TEST UNIT
SIDE-ON TARGET


SLED TEST No 2
END-ON TEST UNIT
EDGE-ON TARGET
1900 fps



GLFC BLAST TEST

PURPOSE

Realistic evaluation of blast capability
Comparison with analysis

TEST CONDITIONS

600 psi static overpressure
2.2 psi-sec impulse

TEST SPECIMEN

Actual GLFC
Actual Capsule heated
Simulated fuel
Fully instrumented
Bendix mount

TEST SET-UP

Shock tunnel
- 2 ft diameter
- Pressurized to sea-level
- C-4 plastic explosive

RESULTS

157 fps velocity
GLFC cylinder completely destroyed
SHS found 750 ft from tunnel
GLFC end caps essentially intact

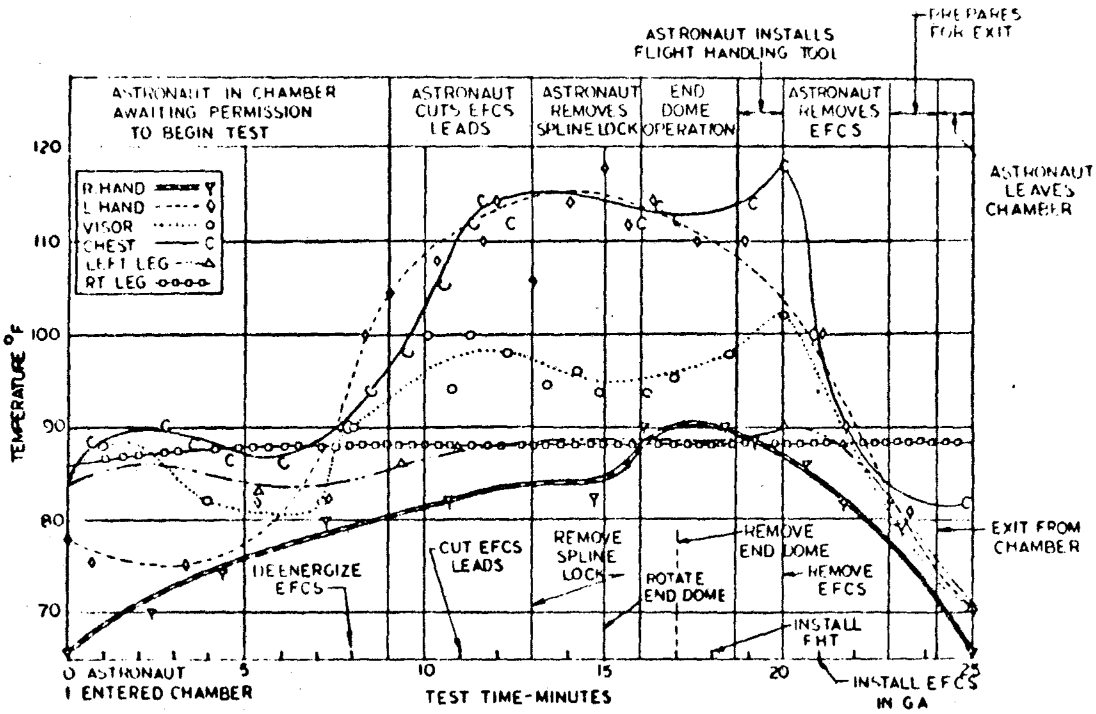
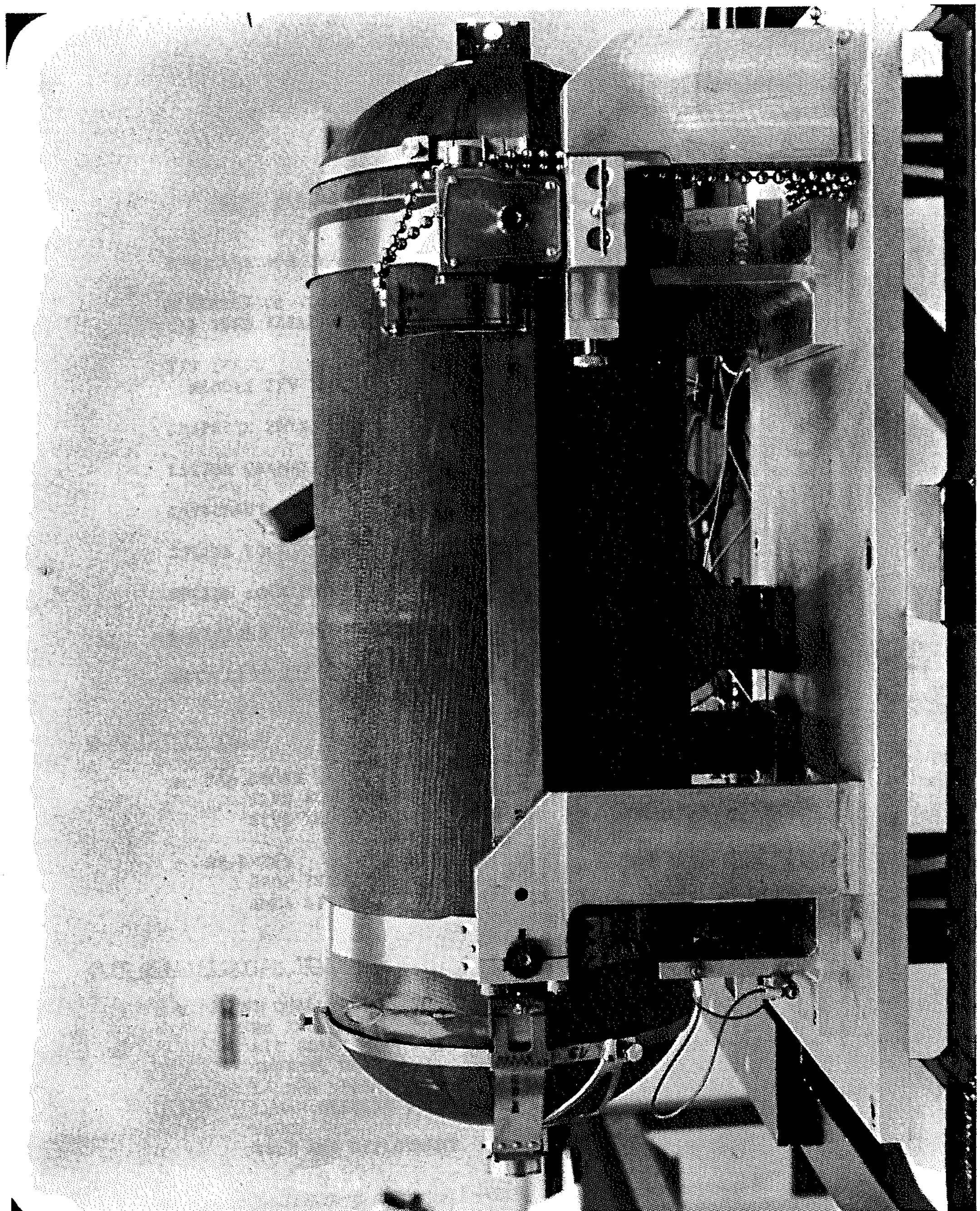


FIG 7 GLFC OPERATIONAL TESTS ASTRONAUT SPACE SUIT TEMPERATURES



GLFC TEST PROGRAM - DEVELOPMENT TESTS

PYROCARB 406 CHARACTERIZATION

6 SERIES OF VIBRATION TEST (1 HOT) (MOST WITH BENDIX HARDWARE)
3 TEST SERIES AT BENDIX

T/V TESTS 4 DAYS
BENDIX T/V TESTS

GRAPHITE EMISSIVITY AND COATING

LITTON CHAMBER FUNCTIONAL TESTS

ASTRONAUT LIVE DEPLOYMENT TESTS

SPLINE LOCK/GRAPHITE OXIDATION TESTS

SPLINE LOCK PULL TESTS

MATERIALS COMPATIBILITY TESTS

BERYLLIUM SHS COATING EMISSIVITY TESTS

GLFC SAFETY TESTS

- o PAD ABORT TESTS
  - SIVB BLAST TEST
  - SIVB FRAGMENTATION TESTS
- o RE-ENTRY
  - DROP TEST (TO TERMINAL VELOCITY)
  - AMES ABLATION AND Ti BAND TESTS

GLFC QUALIFICATION TESTS

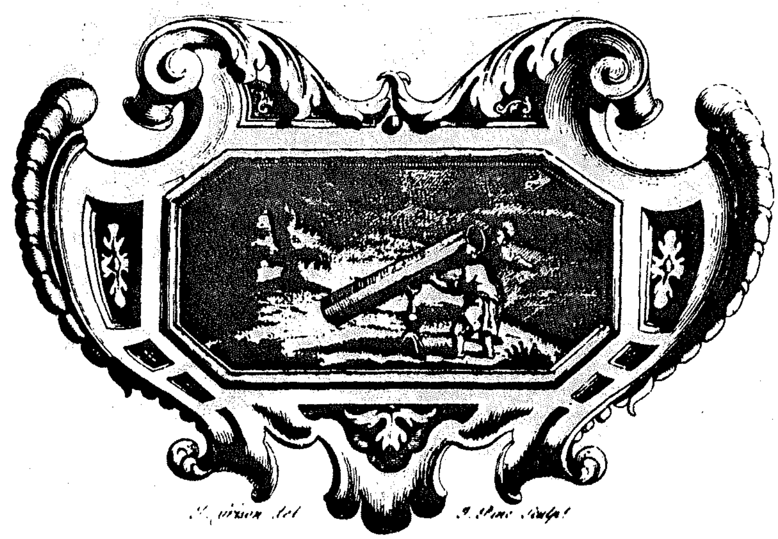
- o JOINT QUAL WITH BENDIX HARDWARE
  - OA TEST
  - AIR SOAK
  - THERMAL VACUUM
  - LAUNCH VIBRATION
  - LUNAR DESCENT VIBRATION
  - SHOCK
  - TILT AND DEPLOYMENT

Addendum III

LASER RANGING RETRO-REFLECTOR EXPERIMENT

Presented by Dr. J. Faller

Wesleyan University



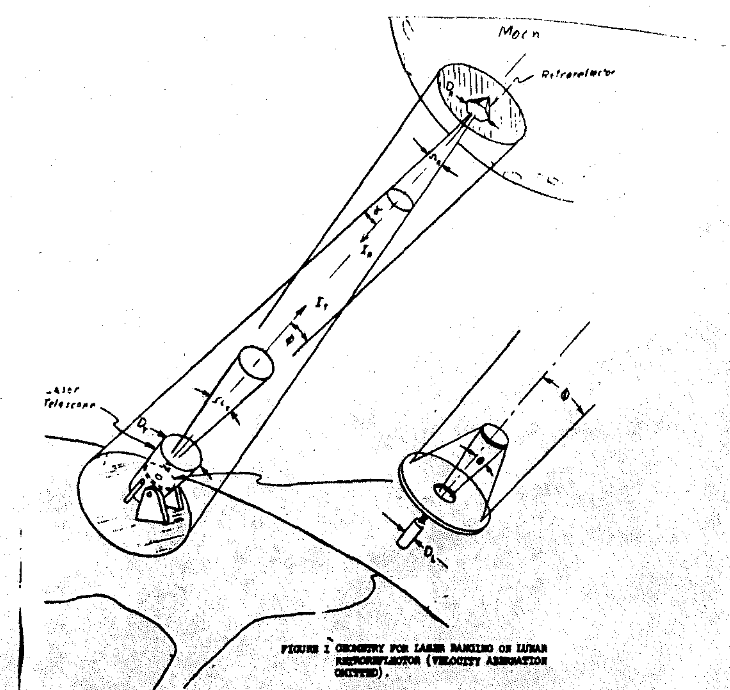


FIGURE 1 GEOMETRY FOR LASER RANGING ON LUNAR RETROREFLECTOR (VELOCITY ABERRATION OMITTED).

LUNAR ORBIT

Quantity	Present Accuracy About:	1.5 M Range Uncertainty Accuracy:	Time:	0.15 M Range Uncertainty* Accuracy:	Time:
Mean Distance	500 M	250 M	1 yr	75 M	0.5 yr
				25 M	1 yr
Eccentricity	1×10^{-7}	4×10^{-8}	1 yr	1.5×10^{-8}	0.5 yr
				4×10^{-9}	1 yr
Angular Position of Moon with respect to Perigee	2×10^{-6}	4×10^{-7}	1 yr	1.5×10^{-7}	0.5 yr
				4×10^{-8}	[illegible] yr
Angular Position of Moon with respect to Sun	5×10^{-7}	4×10^{-7}	1 yr	1.5×10^{-7}	0.5 yr
				4×10^{-8}	1 yr
Time Necessary to check predictions of Brans-Dicke Scalar-Tensor Gravitational Theory	-	25 years		8 years	

* 3 observing stations are assumed for periods longer than 1/2 year.

LUNAR PROPERTIES

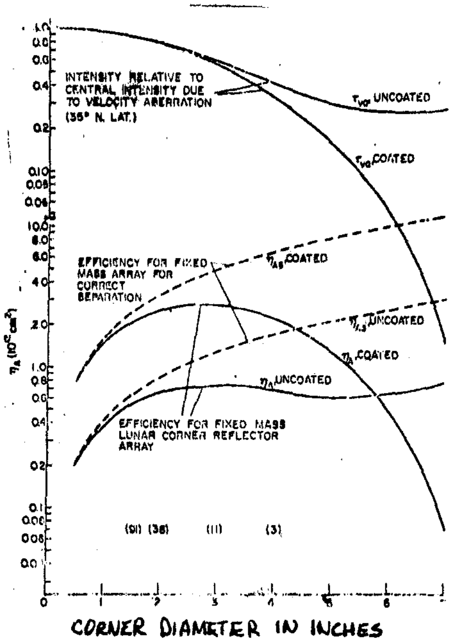
Quantity	Present Accuracy About:	1.5 M Range Uncertainty Accuracy:	Time:	0.15 M Range Uncertainty* Accuracy:	Time:
Libration Parameters					
$\beta = \frac{C-A}{B}$	1×10^{-5}	3×10^{-7}	4 yr	3×10^{-7}	0.5 yr
				3×10^{-8}	4 yr
$\gamma = \frac{B-A}{C}$	5×10^{-5}	2×10^{-6}	1.5 yr	1.5×10^{-6}	0.5 yr
				2×10^{-7}	1.5 yr
Coordinates of Retroreflector Package with respect to Center of Mass					
X_1	500 M	250 M	1 yr	75 M	0.5 yr
				25 M	1 yr
X_2	200 M	70 M	1 yr	40 M	0.5 yr
				7 M	1 yr
X_3	200 M	50 M	3 yr	50 M	0.5 yr
				5 M	3 yr

GEOPHYSICS

Quantity	Present Accuracy (Est)	1.5 M Range Uncertainty	0.15 M Range Uncertainty
Rotation Period of Earth	5×10^{-3} sec	10×10^{-3} sec	1×10^{-3} sec
Distance of Station from Axis of Rotation	10 M	3 M	0.3 M
Distance of Station from Equatorial Plane*	20 M	6 to 20 M†	0.6 to 2 M†
Motion of the Pole*	1 to 2 M	1.5 M	0.15 M
East-West Continental Drift Rate Observable in 5 years*	30 to 60 cm/yr	30 cm/yr	3 cm/yr
Time for Observing Predicted 10 cm/yr Drift of Hawaii toward Japan*	15 to 30 yr	15 yr	1.5 yr

* 3 or more observing stations are required

† Depending on latitude of station



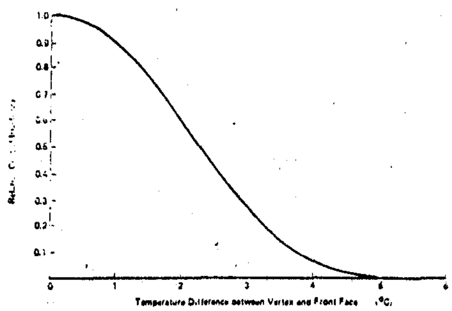
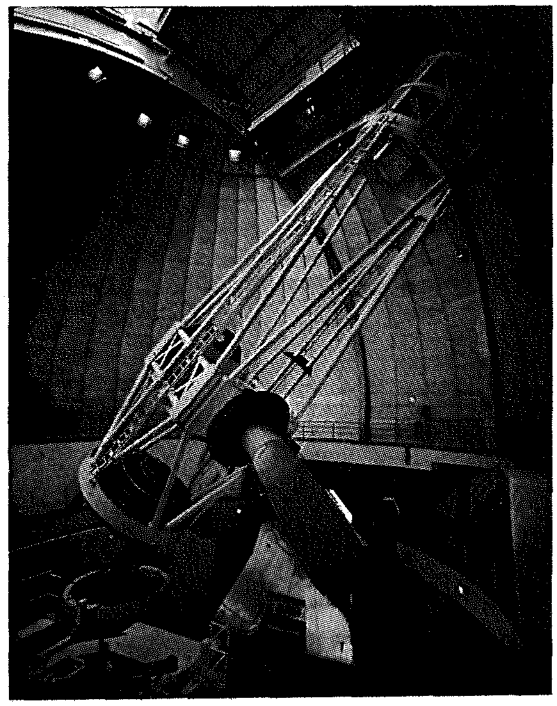
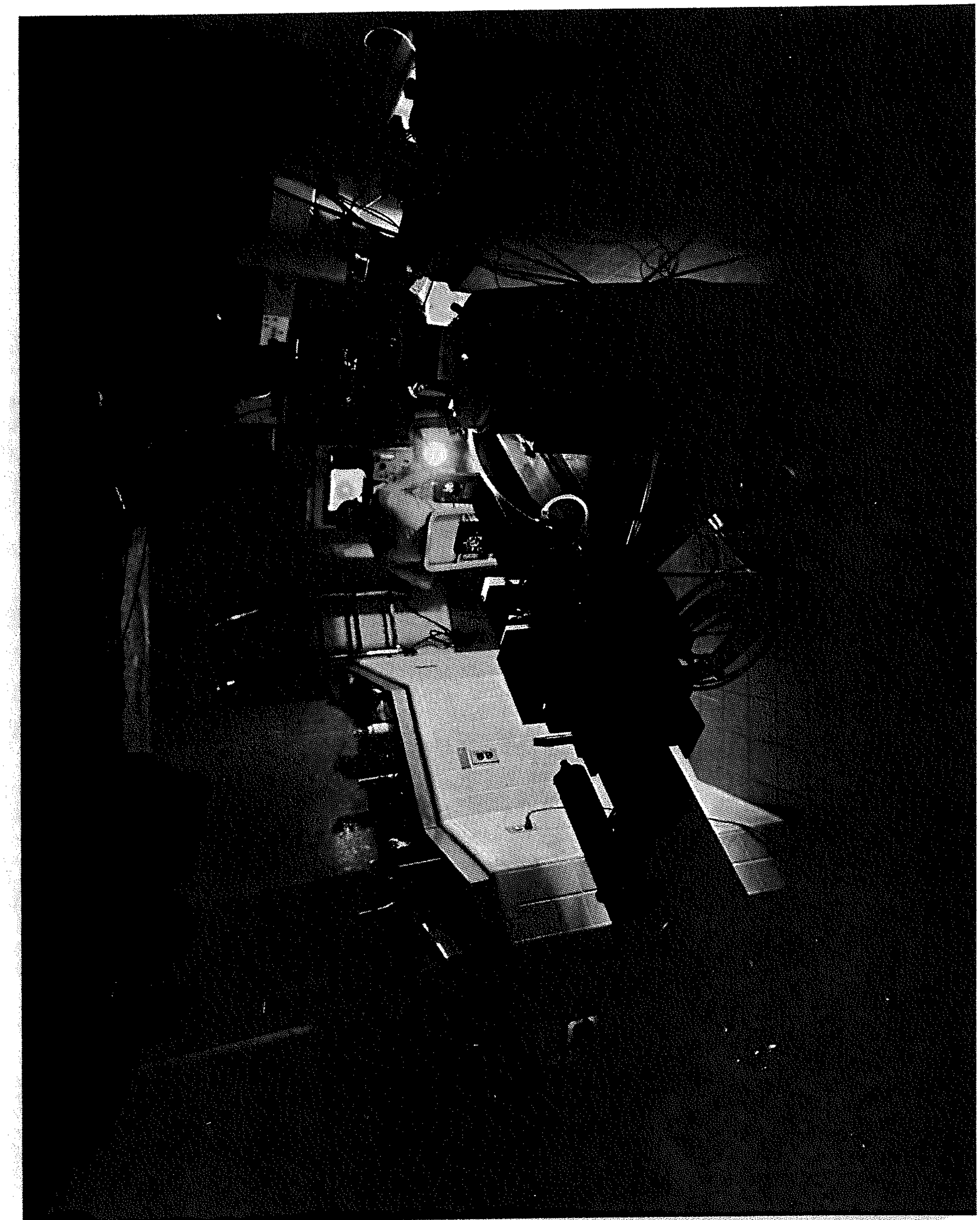
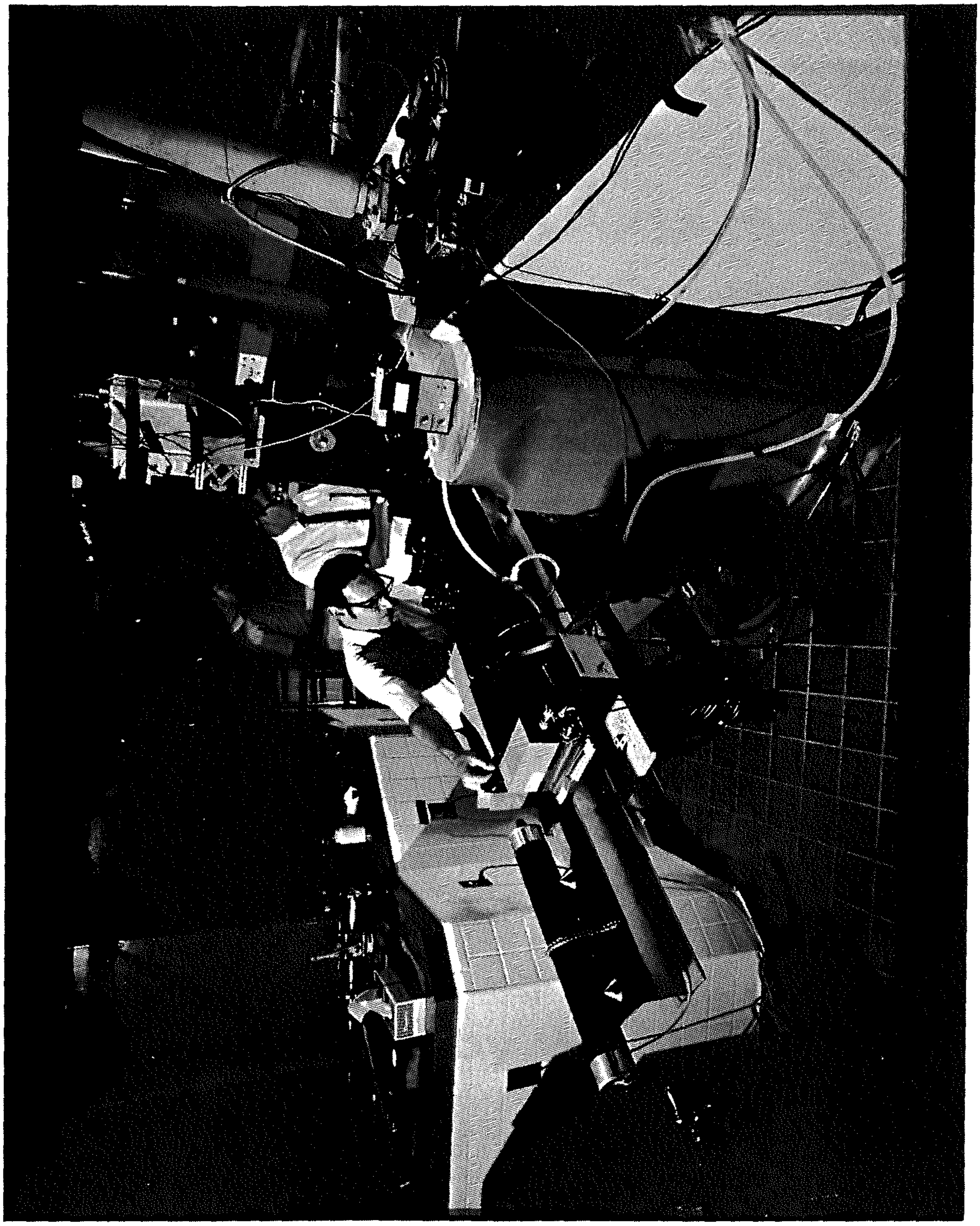


FIGURE 2 RELATIVE CENTRAL IRRADIANCE AS A FUNCTION OF TEMPERATURE DIFFERENCE (LINEAR GRADIENT)





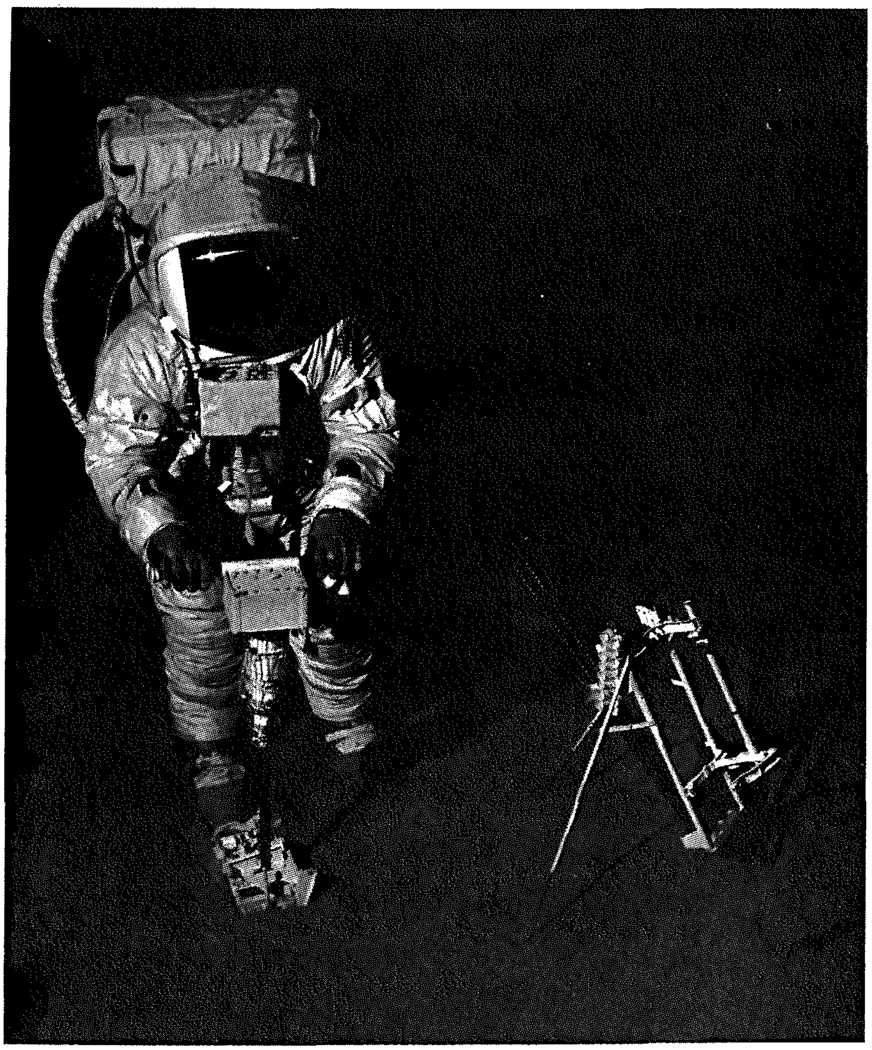


Addendum IV

APOLLO LUNAR SURFACE DRILL

Presented by W. Britton

Martin - Marietta Company



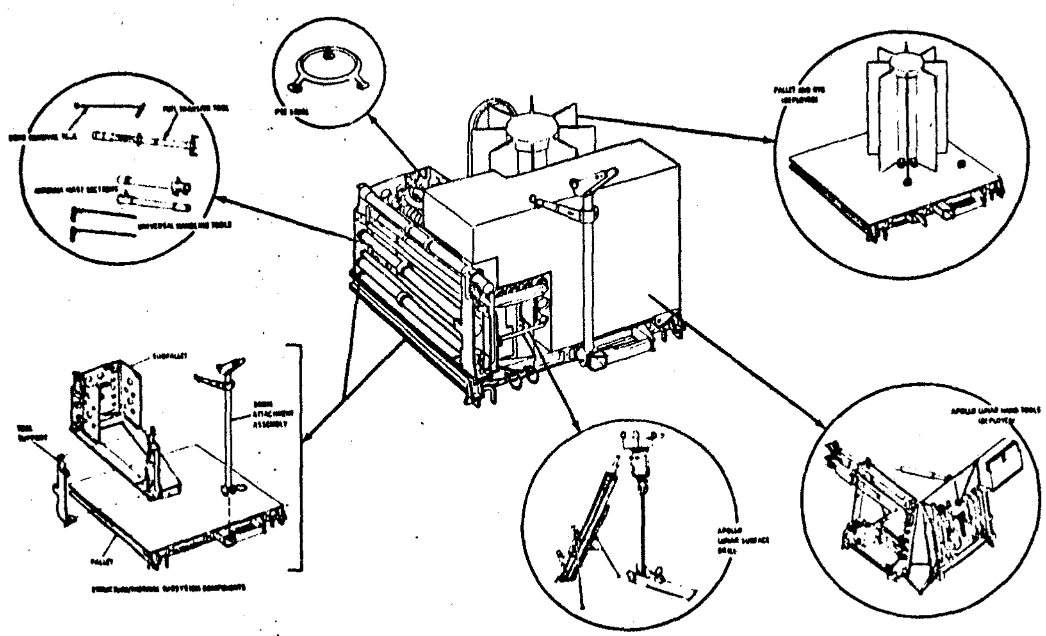
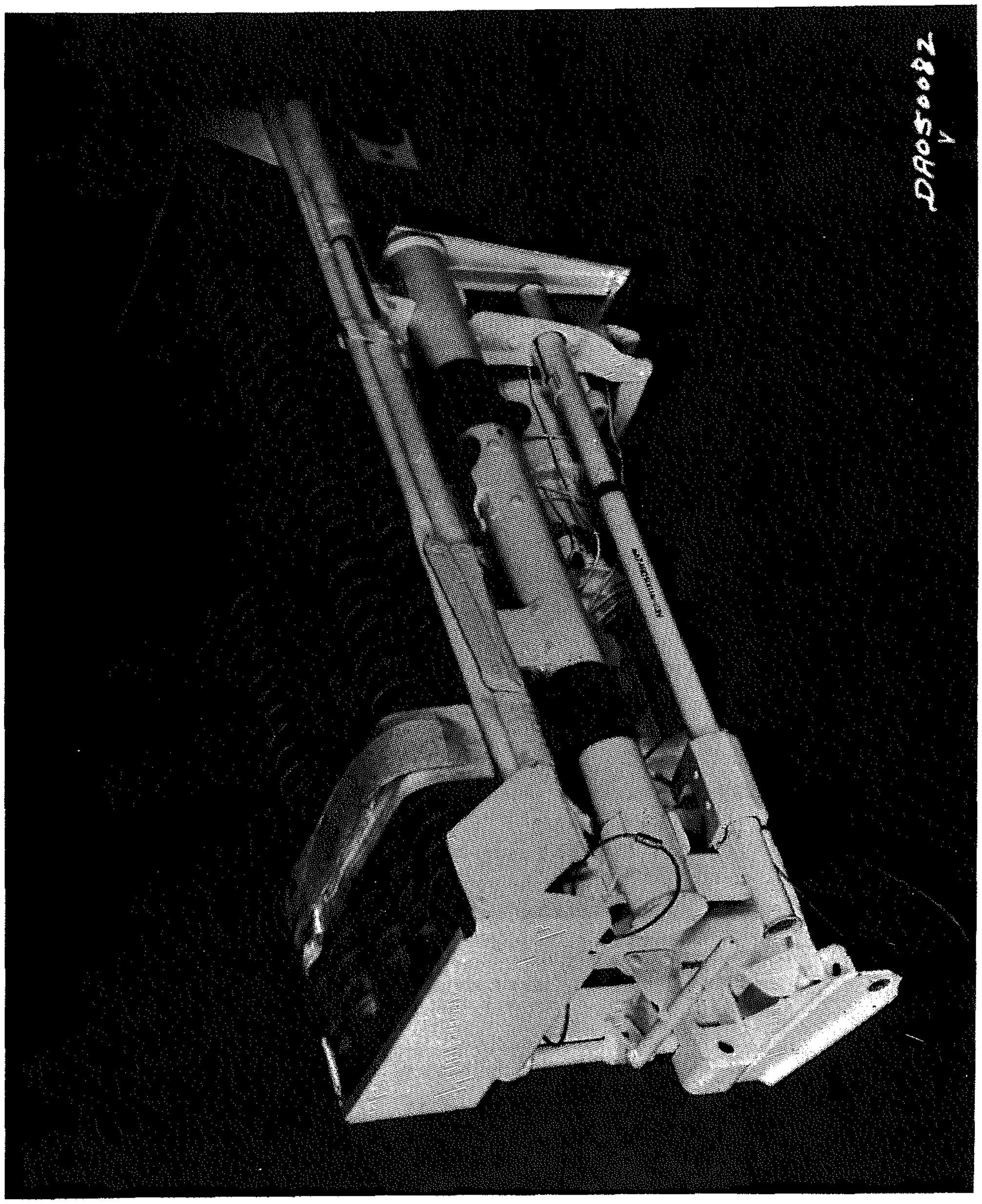


Figure II-3 ALSEP Subpackage No. 2/ALSD/ALHT Carrier Interface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APOLLO LUNAR SURFACE DRILL

MARTIN MARIETTA
DENVER DIVISION

OBJECTIVE -

(1) DRILL TWO (2) 1-1/8 INCH DIAMETER HOLES EACH TO A DEPTH OF TEN-FEET IN SUPPORT OF HEAT FLOW EXPERIMENT (HFE)

(2) DRILL ONE 1-INCH DIAMETER HOLE TO A DEPTH OF EIGHT-FEET TO OBTAIN SUB-SURFACE CORE SAMPLES.

PERFORMANCE REQUIREMENTS -

(1) STOWED ON ALSEP IN SEQ BAY IN TRANSIT
(2) DRILL TWO HOLES FOR HFE IN THIRTY MINUTES
(3) DRILL ONE HOLE FOR CORE SAMPLES IN TWENTY-FIVE MINUTES
(4) ALSD SHALL NOT EXCEED 31.0 POUNDS
(5) OPERABLE BY ONE ASTRONAUT UNDER 1/6-G ENVIRONMENT
(6) EXPOSED SURFACES OF ALSD SHALL NOT EXCEED 250°F

DESIGN REQUIREMENTS

MARTIN MARIETTA
DENVER DIVISION

ELECTRICAL - PROVIDE SUFFICIENT ENERGY TO DRILL THREE SUB-SURFACE HOLES IN A LUNAR ENVIRONMENT.

ESTIMATED POWER REQUIREMENT = 150 WATT-HOURS
AVAILABLE POWER = 300 WATT-HOURS

THERMAL - WITHSTAND TRANS-LUNAR SEQ-BAY TEMPERATURES OF 20-160°F
OPERATE AT LUNAR SUN ANGLES OF 7 TO 45 DEGREES ABOVE THE HORIZON.

LOW TEMPERATURE DESIGN MARGIN (BATTERY) $\Delta = 30°F$
HIGH TEMPERATURE DESIGN MARGIN (BATTERY) $\Delta = 35°F$

MECHANICAL - WITHSTAND LAUNCH AND BOOST, AND LUNAR DESCENT MECHANICAL ENVIRONMENTS OF VIBRATION, SHOCK, AND ACCELERATION.

QUAL. UNIT RECEIVED DOUBLE EXPOSURE TO QUAL-LEVEL ENVIRONMENTS INCLUDING SINUSOIDAL VIBRATION.

DRILL THREE SUB-SURFACE HOLES IN A LUNAR ENVIRONMENT

QUAL. UNIT EXPOSED TO 4 COMPLETE DRILLING MISSIONS.

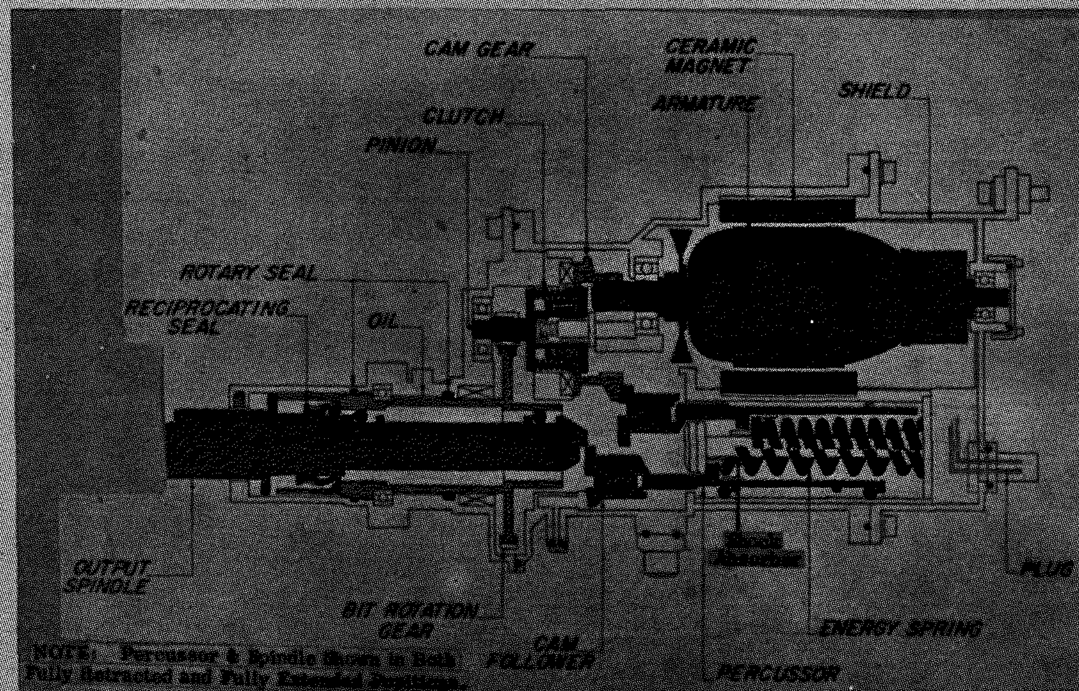


Figure III-10. Simplified Power Head Internal Components

DEVELOPMENT (INITIAL CONTRACT)

- POWER HEAD PERCUSSIVE ENERGY
- CORE BIT OPTIMIZATION
- CORE STEM OPTIMIZATION
- HOLE CASING OPTIMIZATION
- BATTERY CELLS
- HIGH & LOW TEMPERATURE OPERATION
- VACUUM OPERATION
- HUMAN ENGINEERING
- FINAL SIMULATED LUNAR SURFACE DRILLING (SYSTEM LEVEL)
- FIELD TESTS (DEATH VALLEY & BAKERSFIELD)

QUALIFICATION (INITIAL CONTRACT)

- VIBRATION (SINUSOIDAL & RANDOM)
- SHOCK
- ACCELERATION
- ELECTROMAGNETIC INTERFERENCE
- THERMAL-VACUUM
- SIMULATED LUNAR SURFACE OPERATION (1/6-G & SPACESUIT)

DEVELOPMENT (MODIFICATION CONTRACT)

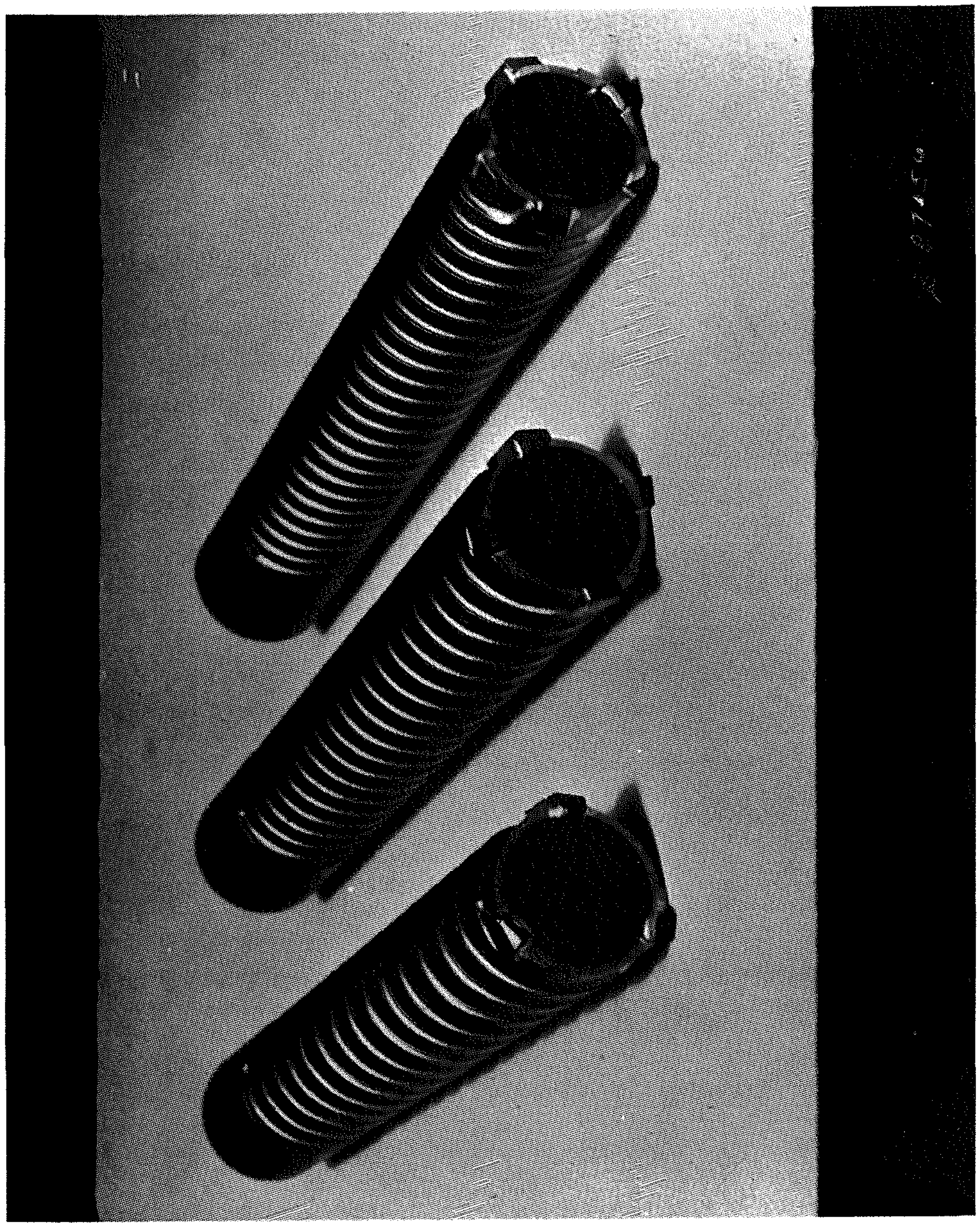
- BORON-FILAMENT/FIBERGLAS BORE STEM TEST
- BORE BIT TESTS
- QUICK RELEASE ADAPTER
- SIMULATED LUNAR SURFACE DRILLING (SYSTEM LEVEL)

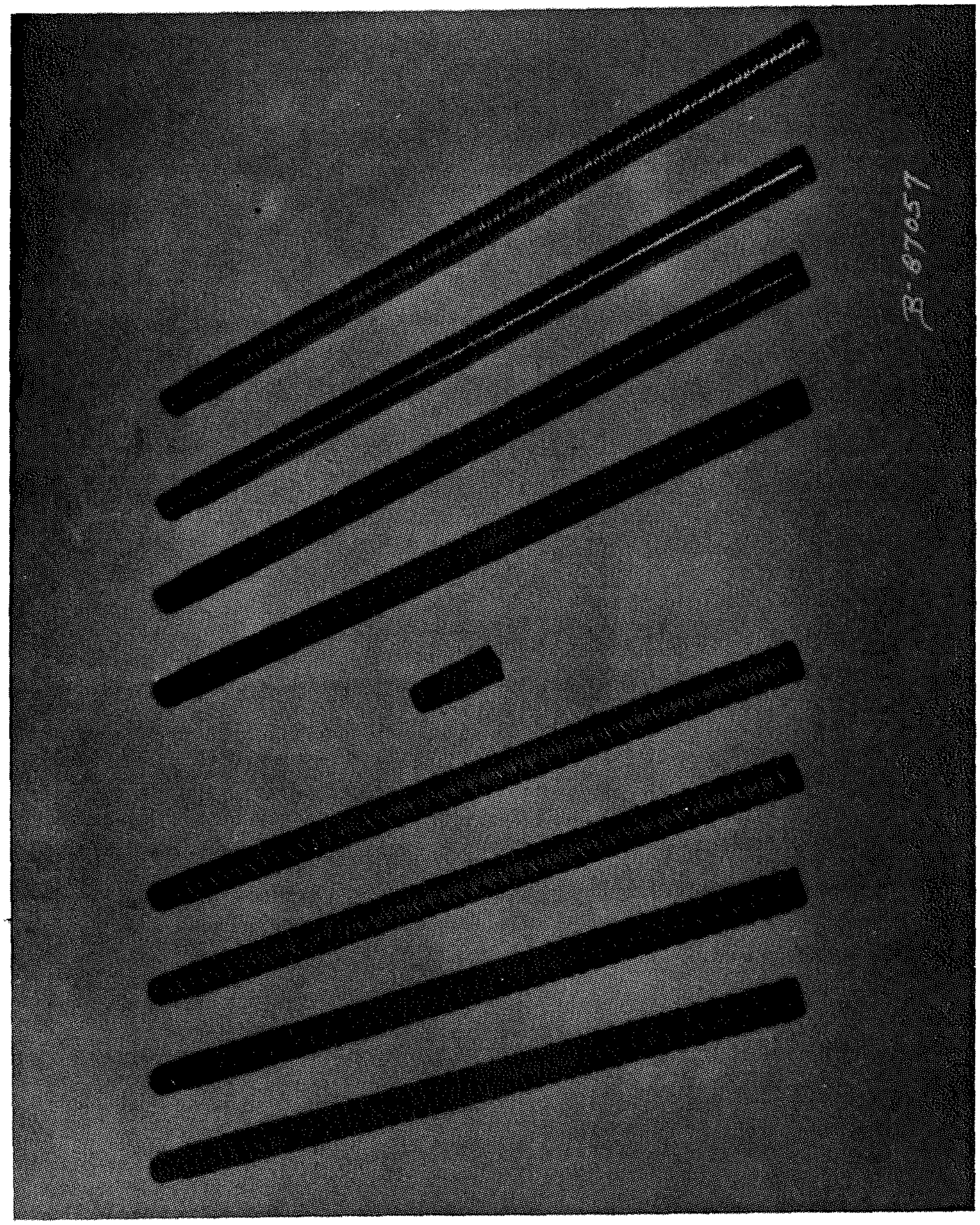
QUALIFICATION (MODIFICATION CONTRACT)

- VIBRATION (SINUSOIDAL & RANDOM)
- SHOCK
- OPERATION IN SIMULATED LUNAR SURFACE

ACCEPTANCE


ALSD
TEST
FACILITY

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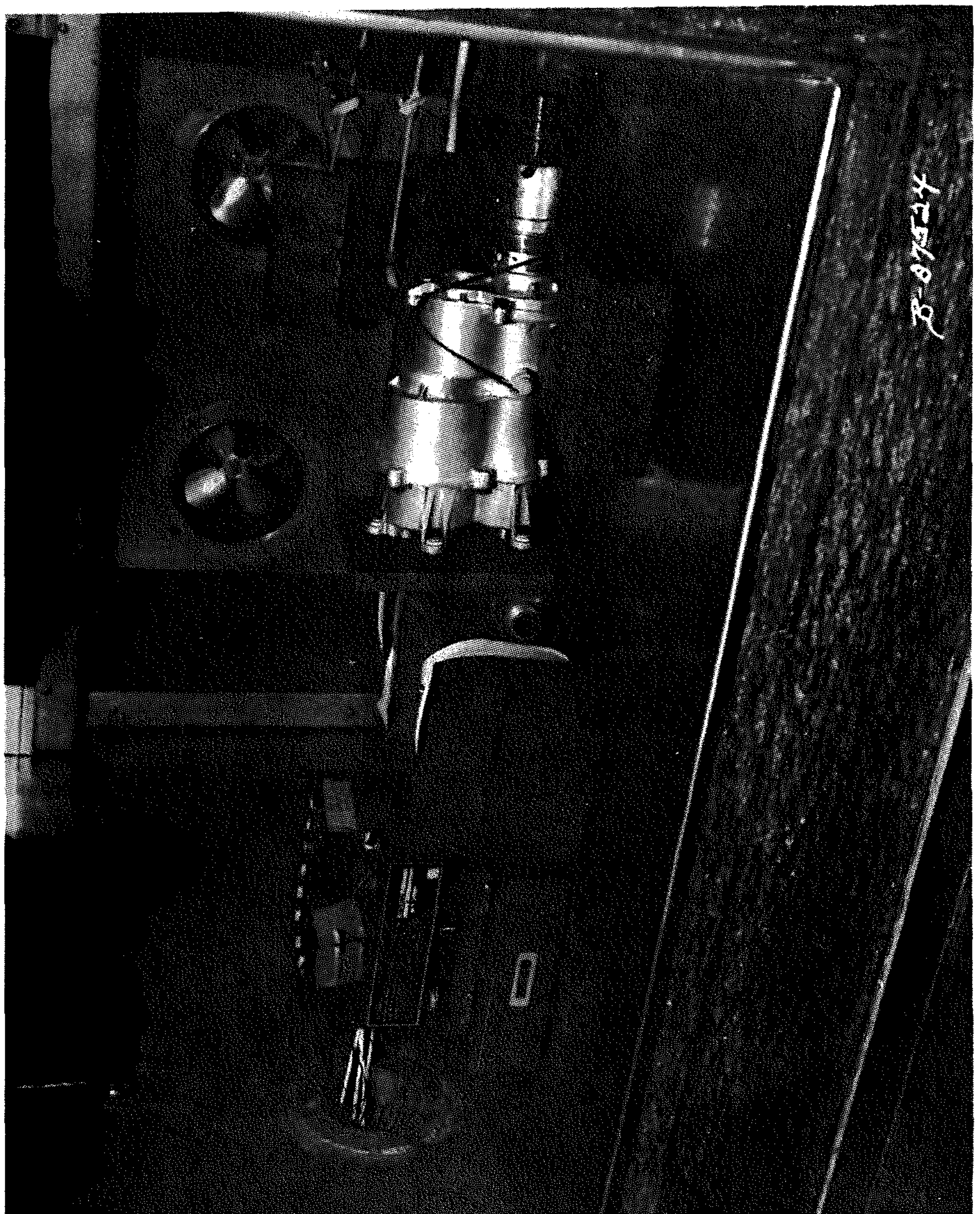

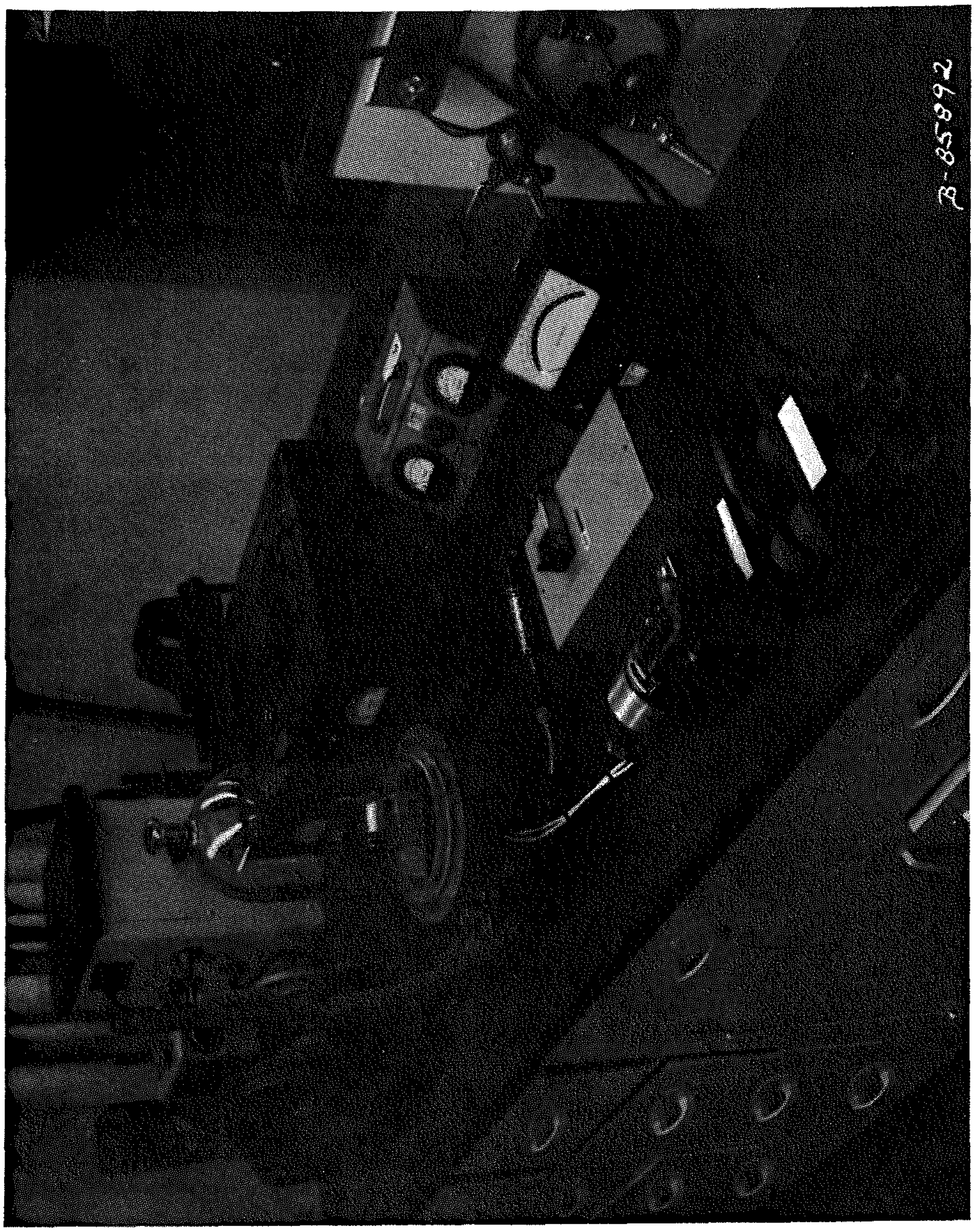
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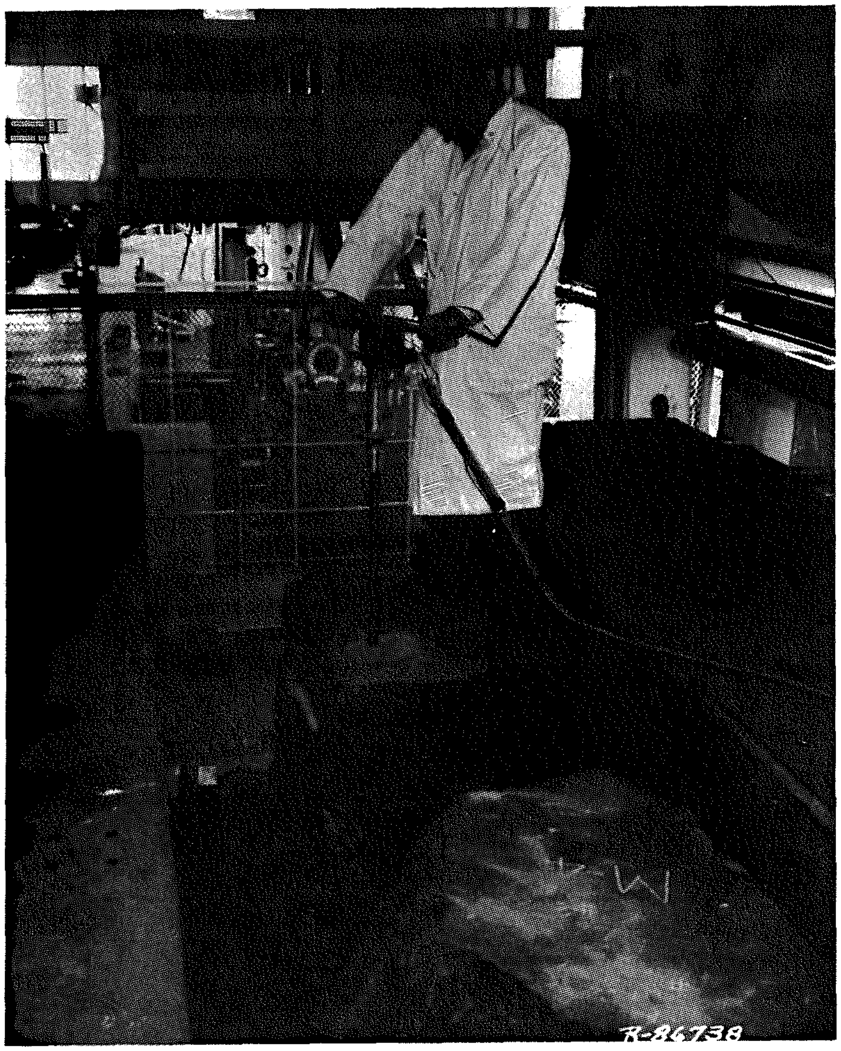

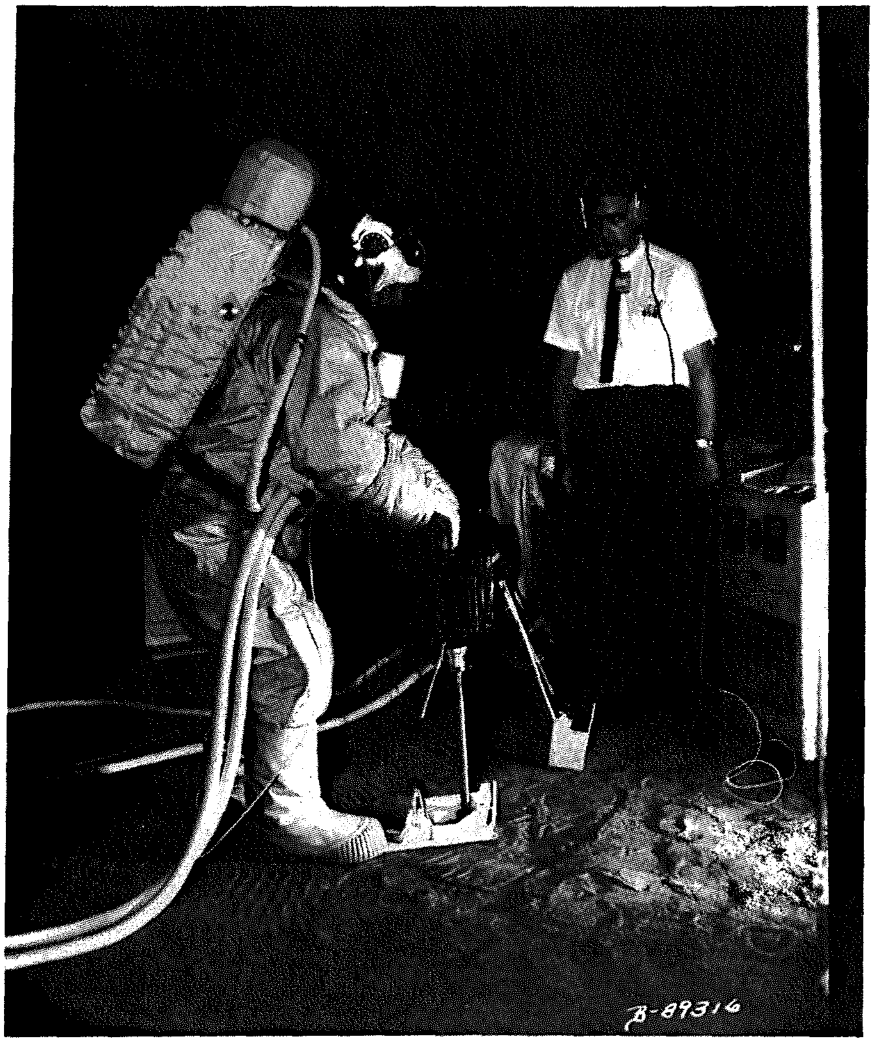
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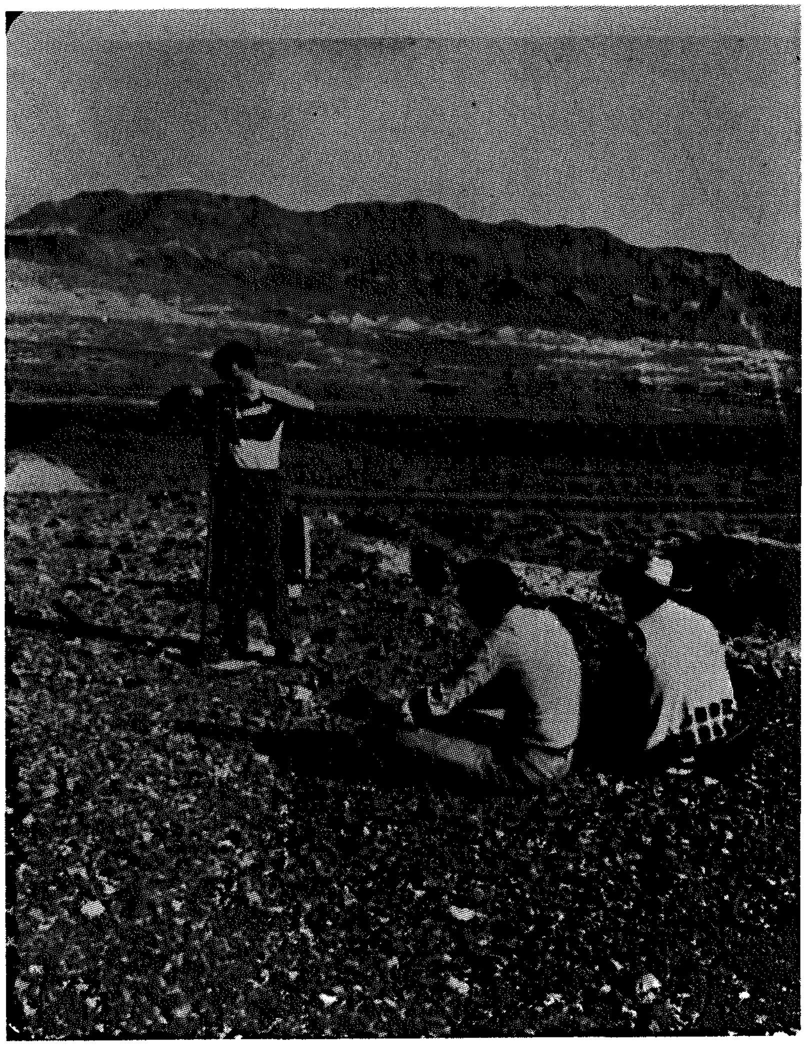

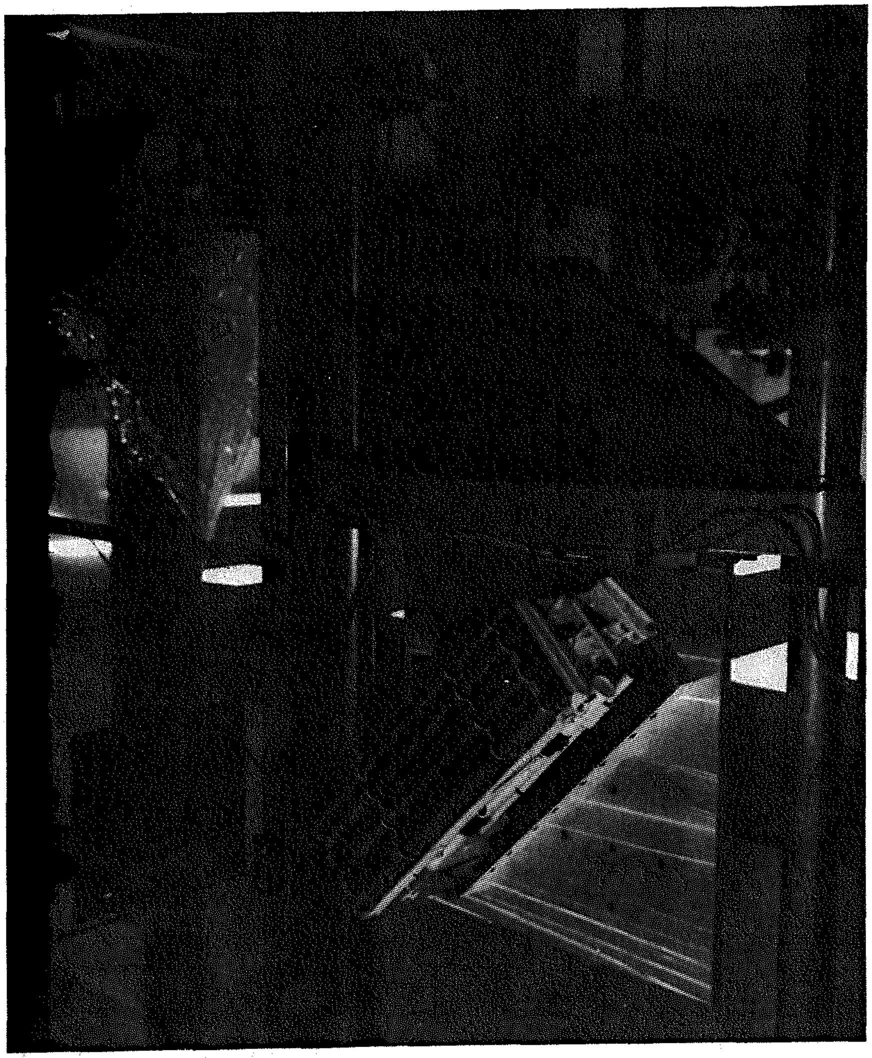

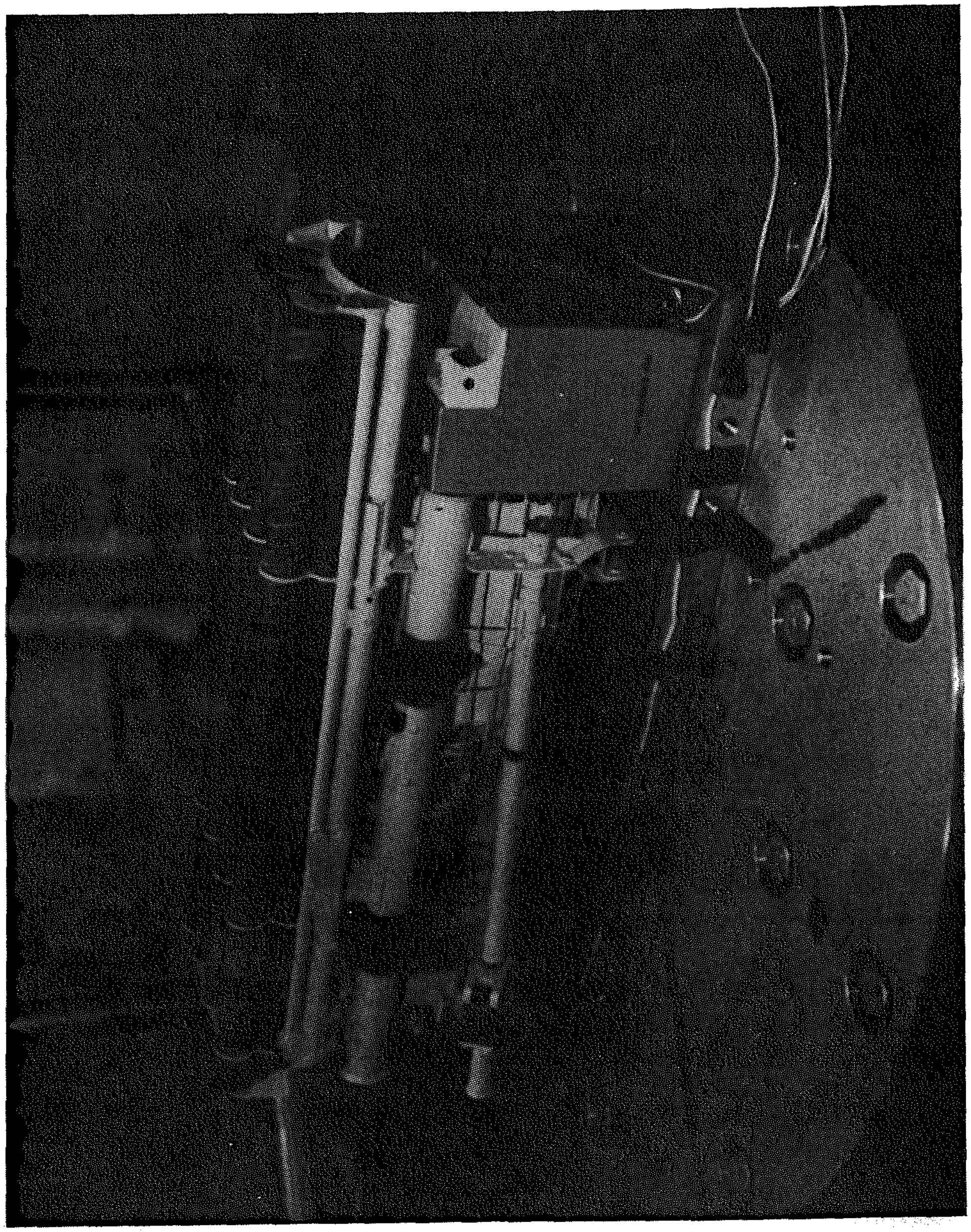

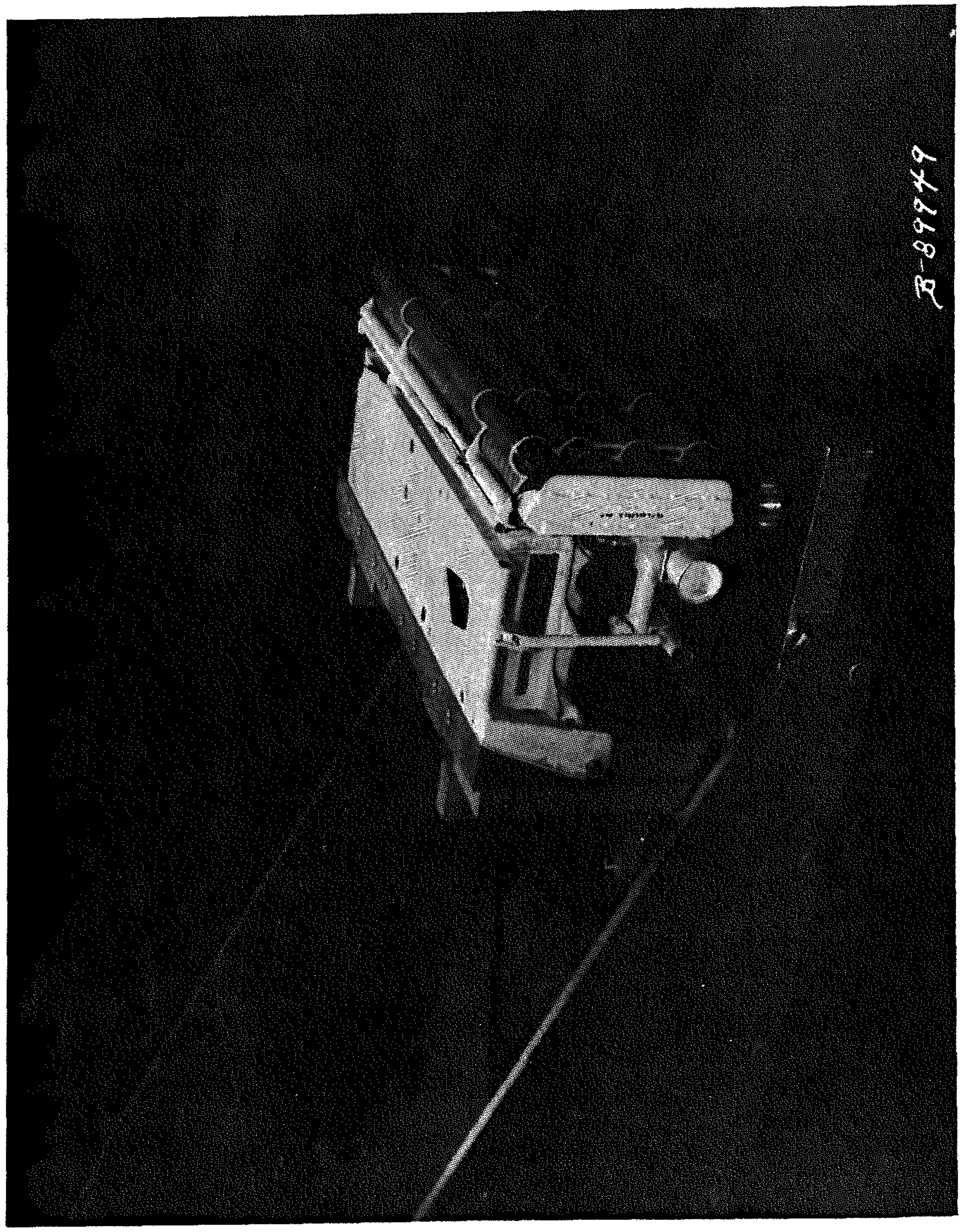
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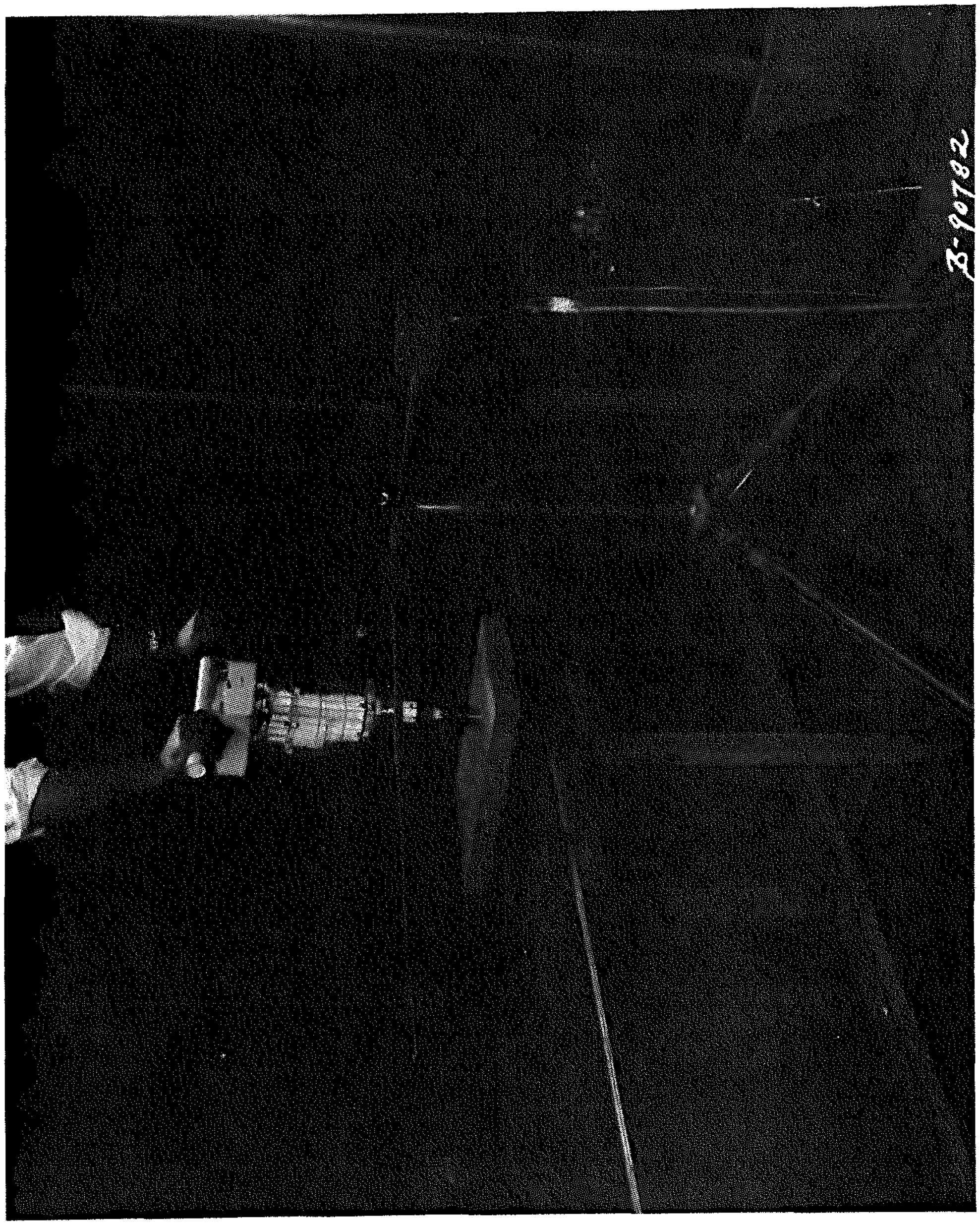
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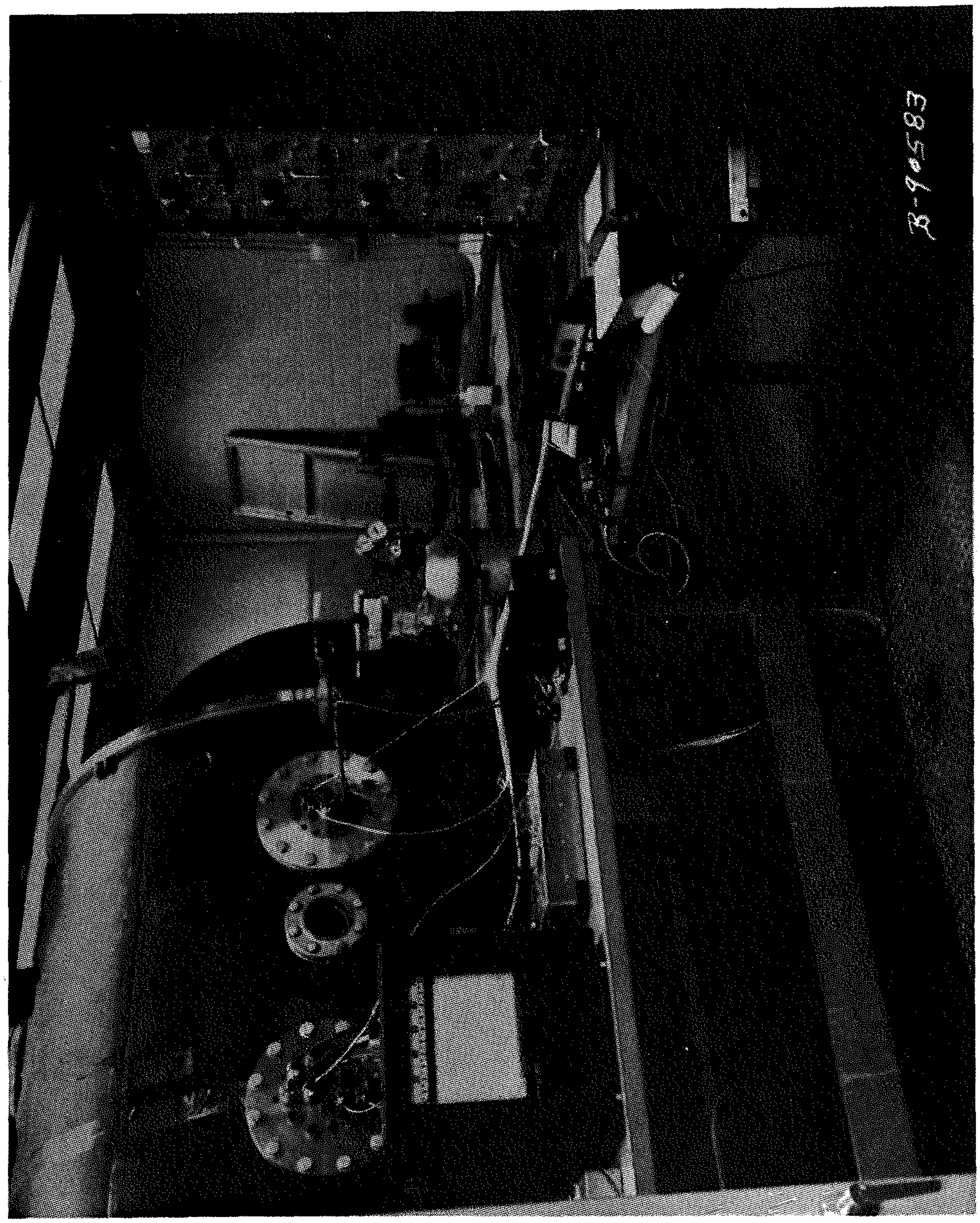
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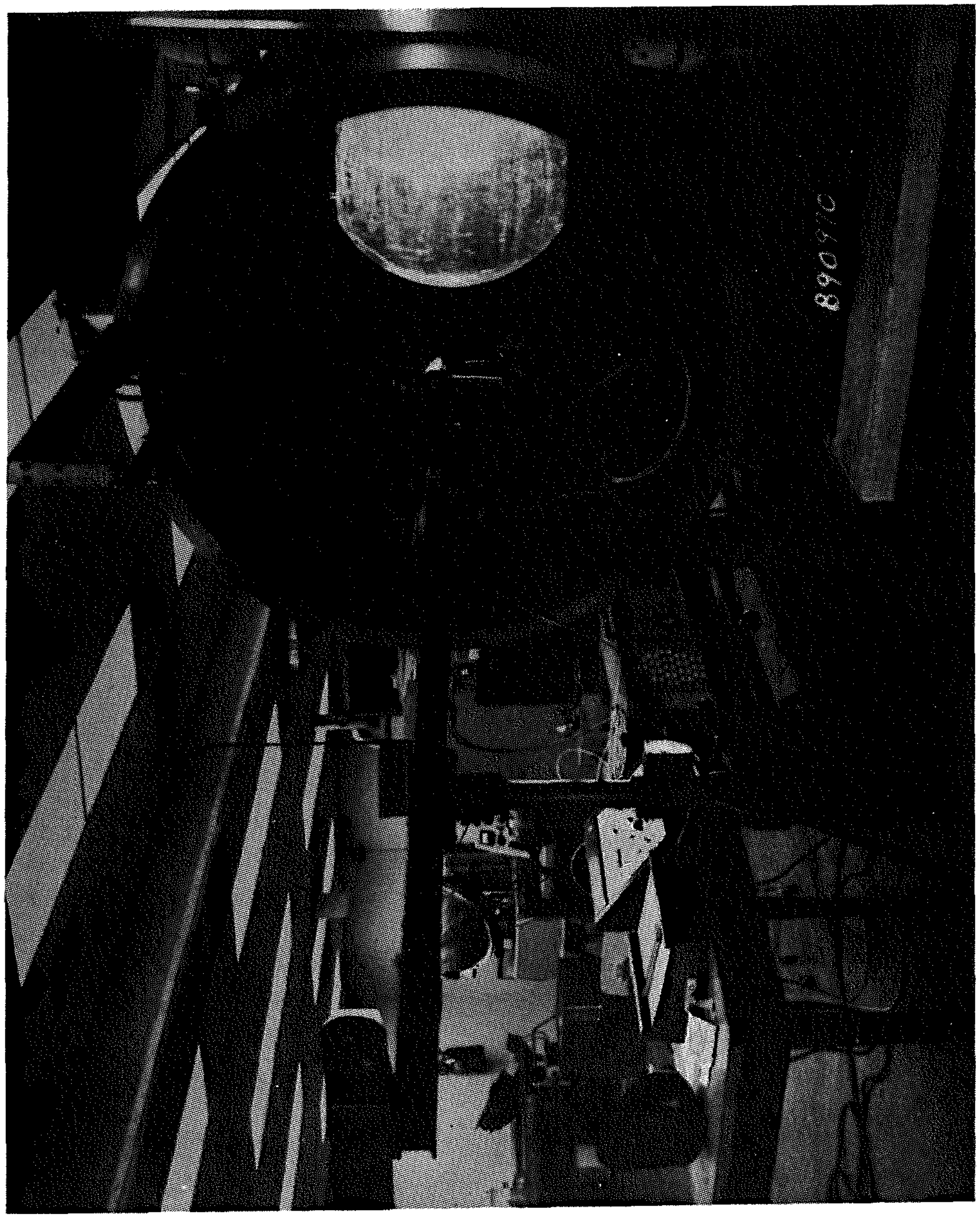

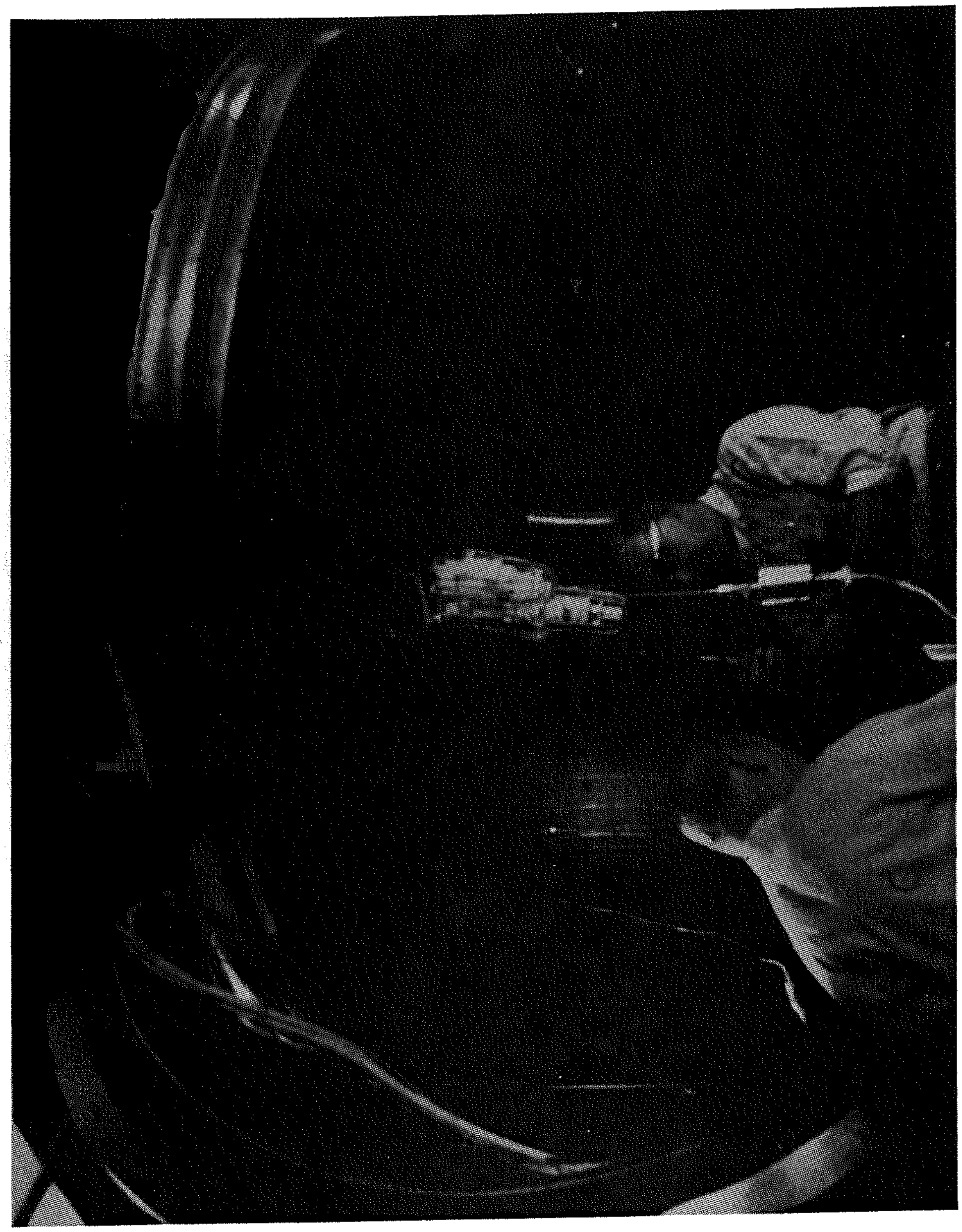

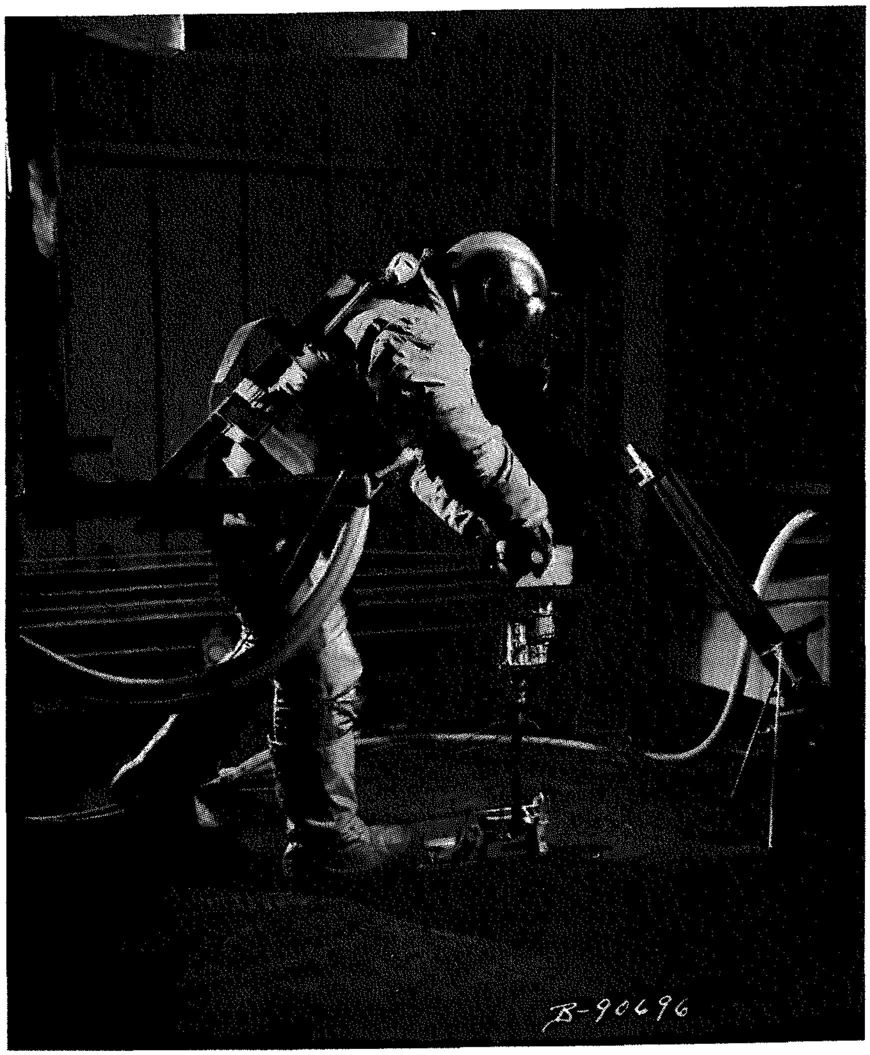
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DEMONSTRATED DESIGN MARGINS	MISSION REQUIREMENTS	OVER-TESTS
1. ENVIRONMENTS		
VIBRATION	1 EXPOSURE TO FLIGHT LEVEL	2 EXPOSURES TO QUALIFICATION LEVEL, 1 EXPOSURE TO FLIGHT LEVEL, PLUS LOW FREQUENCY OVER-TESTS
THERMAL - VACUUM	1 EXPOSURE TO NOMINAL MISSION CYCLE	1 EXPOSURE TO HIGH THERMAL EXTREMES, 1 EXPOSURE TO LOW THERMAL EXTREMES, NON-PRESSURIZED POWER HEAD OPERATION IN VACUUM.
2. DRILLING OPERATIONS		
SYSTEM DEPLOYMENT	1 CYCLE	8-10 CYCLES
POWER HEAD	20 MINUTES POWER-ON TIME	120 MINUTES POWER-ON TIME
BATTERY	150 WATT-HOURS	300 WATT-HOURS (AVAILABLE)
BORE STEMS	1 HOLE TO A 3-METER DEPTH	4-6 HOLES TO A 3-METER DEPTH
CORE STEMS	1 HOLE TO A 2-METER DEPTH	4 HOLES TO A 2½-METER DEPTH
DRILL BITS	10-INCHES OF HARD ROCK DRILLING	50-60 INCHES OF HARD ROCK DRILLING.
ADAPTER	10 CYCLES OF OPERATION	50 CYCLES OF OPERATION

Addendum V

HEAT FLOW EXPERIMENT

Presented by Dr. M. Langseth

Lamont Geological Observatory

TABLE I: SURFACE HEAT FLOW FOR VARIOUS THERMAL HISTORIES OF THE MOON (AFTER FRICKER ET AL., 1967)

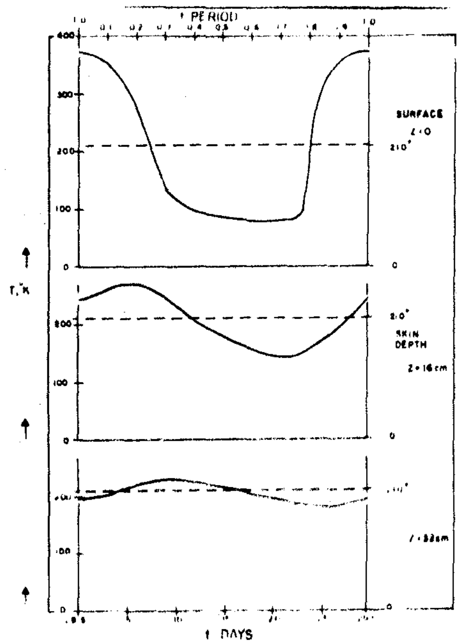
INITIAL TEMPERATURE	RADIOACTIVE ISOTOPE ABUND.	DEPTH TO FUSION	SURFACE HF CAL X 10^{-7}/cm^2sec^2
COLD 0° C	CHONDRITIC (80%) DIFFERENTIATED	560 km	2.75
COLD 0° C	TERRESTRIAL (80%) DIFFERENTIATED	620 km	2.58
WARM 500° C	CHONDRITIC (80%) DIFFERENTIATED	480 km	3.71
WARM 500° C	CHONDRITIC UNDIFFERENTIATED	300 km	3.30
WARM 500° C	CHONDRITIC (100%) DIFFERENTIATED	NO FUSION	3.94
YOUNG 2.5 x 10^9 WARM 500° C	CHONDRITIC (80%) DIFFERENTIATED	280 km	5.21

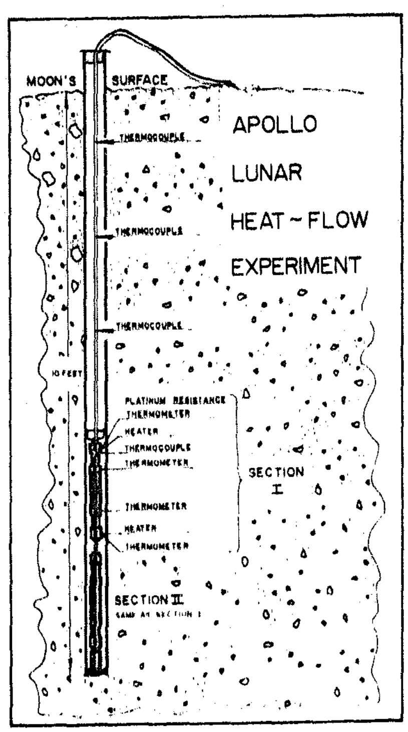
ABUNDANCES OF RADIOACTIVE ISOTOPES IN GRAM X 10^{-8}/GRAM

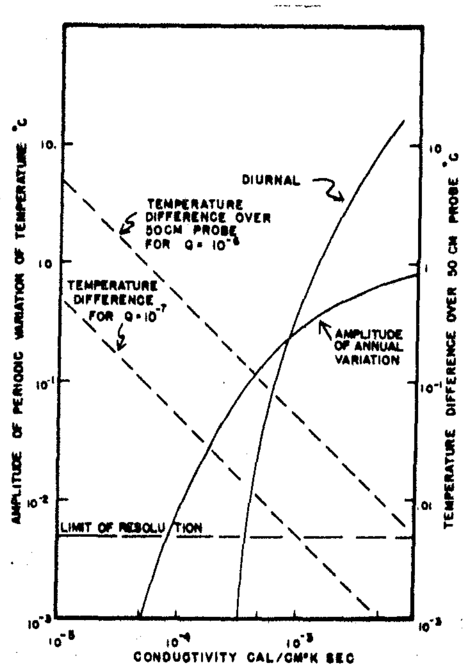
	U^{238}	U^{235}	Th^{232}	K^{40}
CHONDRITIC*	1.092	0.0079	4.4	9.52
TERRESTRIAL †	3.067	0.022	11.43	3.68

* MACDONALD (1959)
† WASSENBURG (1964)

$$HF_{DC} = -K \left. \frac{dT}{dx} \right|_{DC}$$


PERIOD
SURFACE
SKIN DEPTH
t DAYS


MOON'S SURFACE
APOLLO
LUNAR
HEAT ~ FLOW
EXPERIMENT
THERMOCOUPLE
THERMOCOUPLE
THERMOCOUPLE
10 FEET
PLATINUM RESISTANCE THERMOMETER
HEATER
THERMOCOUPLE
THERMOMETER
SECTION I
THERMOMETER
HEATER
THERMOMETER
SECTION II
SAME AS SECTION I



Specifications for Resolution, Accuracy, and Stability of Measurements of the Heat Flow Experiment

Measurement	Temperature of Probe in Lower 1 Meter of Bore Hole	ΔT in Lower 1 Meter of Bore Hole	Temperature of Thermocouples in Upper 2 Meters of Bore Hole	Conductivity
Range	200 to 250 K	±20 K	90 to 350 K	5 × 10 [illegible] to 1 × 10 [illegible] cal/°C-cm-sec
Resolution	0.1 K	0.001 K	0.5 K	±20%
Accuracy	±0.1K	±0.003 K	±0.5 K	±20%
Stability	0.1K/yr	0.003 K/yr	0.5 K/yr	—

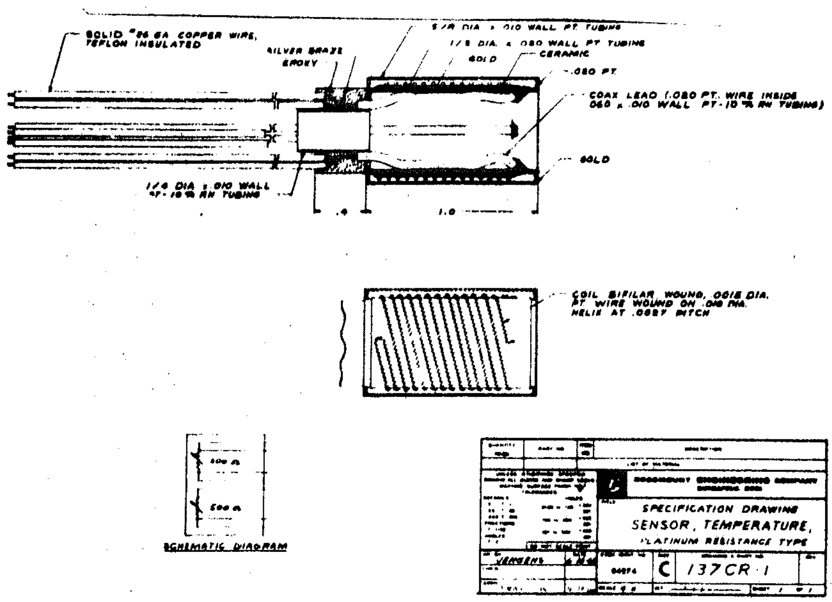


FIGURE 1 SCHEMATIC DIAGRAM OF PLATINUM RESISTANCE TEMPERATURE SENSOR

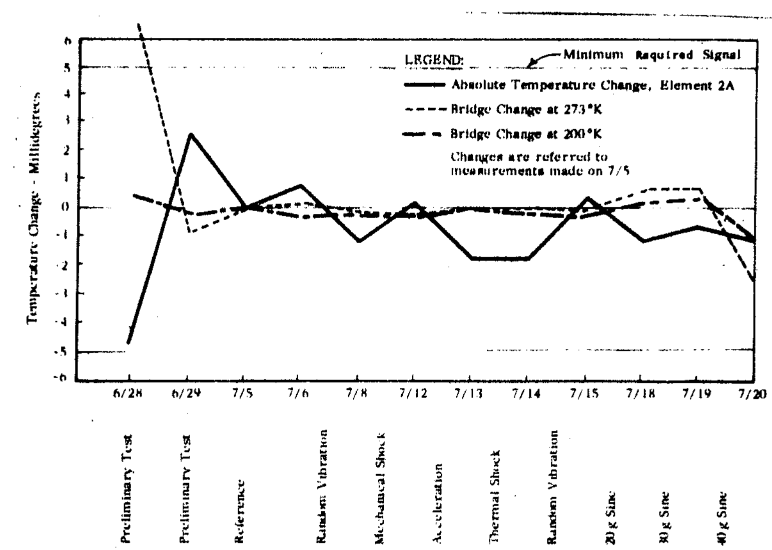
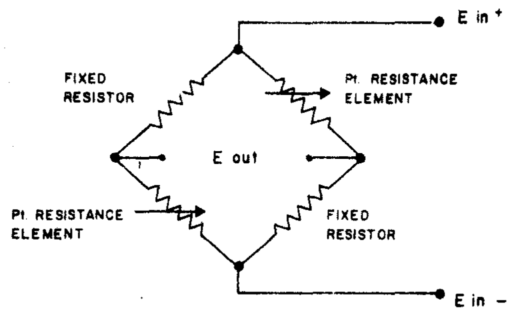
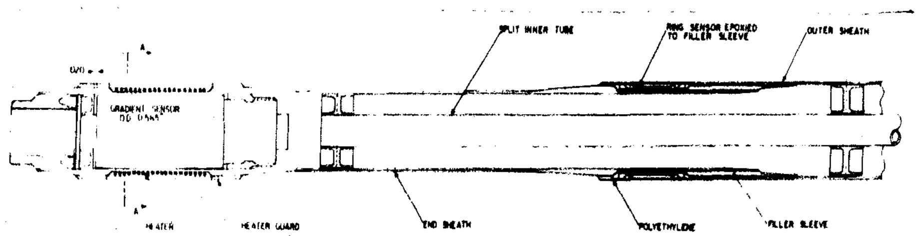


FIGURE 3 PLATINUM SENSORS 2A, 2B, 3A, & 3B PERFORMANCE - ROSEMOUNT DATA

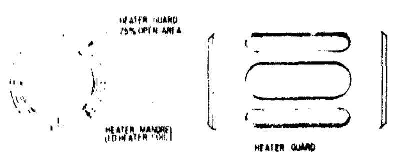


REFERENCE THERMOMETER

FIG. 2

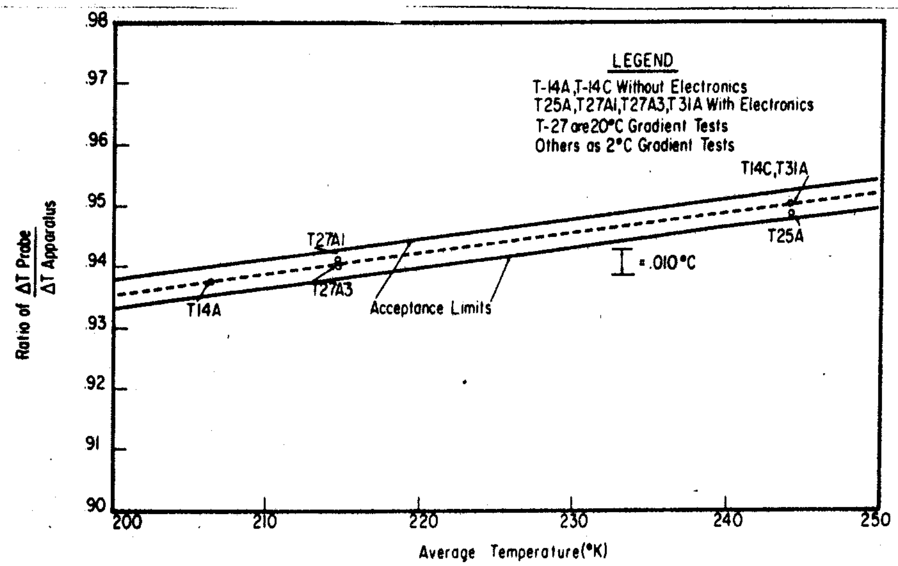


ENLARGED VIEW SENSOR SECTION
LEFT SIDE SHOWN-RIGHT SIDE SIMILAR

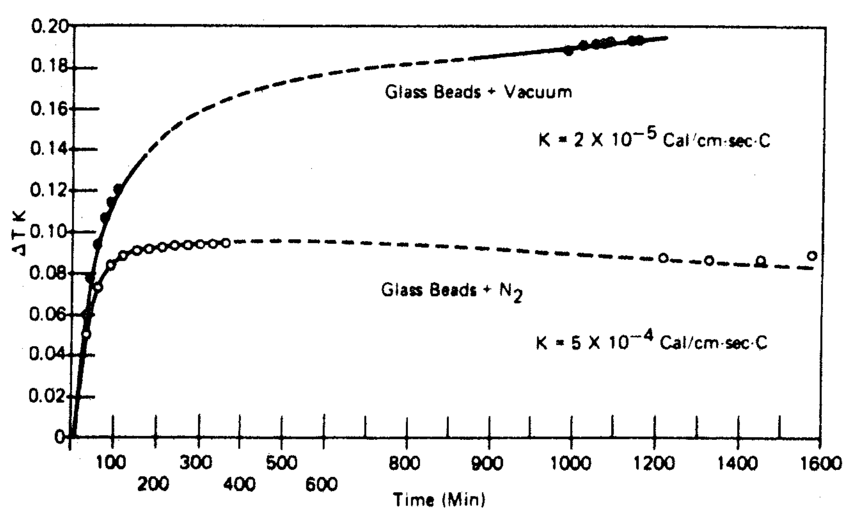


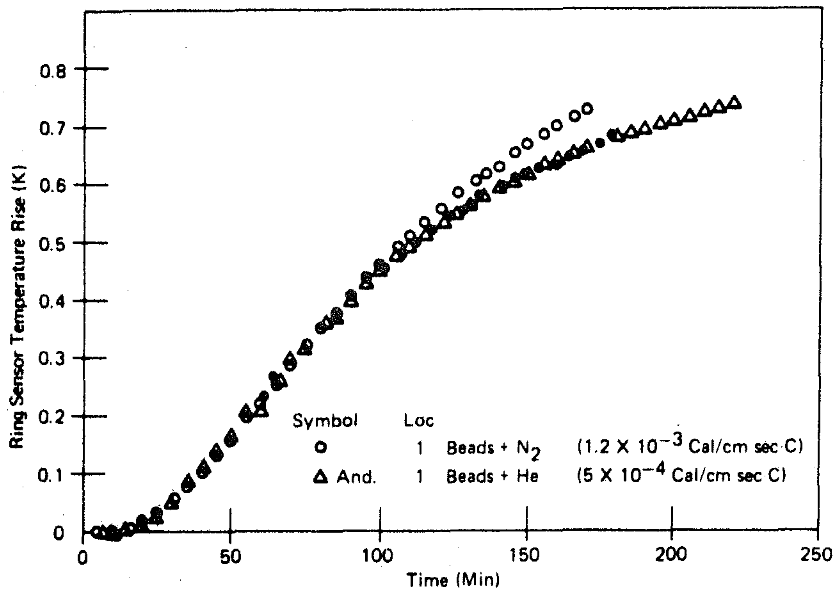
SECTION A-A

DETAIL OF SENSOR MOUNT

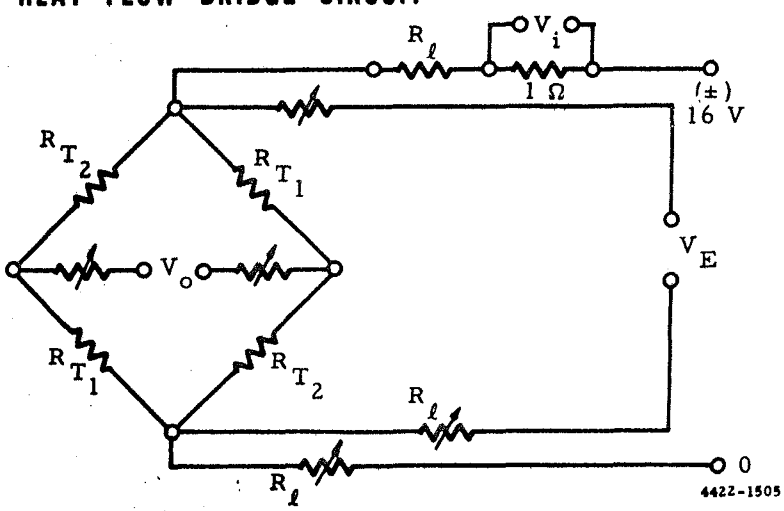


PROTOTYPE MODEL ACCEPTANCE TEST SHORTING RATIOS

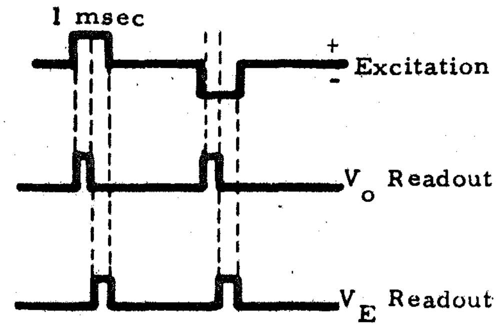




HEAT FLOW BRIDGE CIRCUIT



BRIDGE PULSE EXCITATION



$$V_o = \frac{V_o^+ - V_o^-}{2} \qquad V_E = \frac{V_E^+ - V_E^-}{2}$$

D. C. Offset is Cancelled
Each Sensor Sampled Every 7. 2 Minutes

BLOCK DIAGRAM OF HEAT FLOW ELECTRONICS