

RCA

J T Raleigh

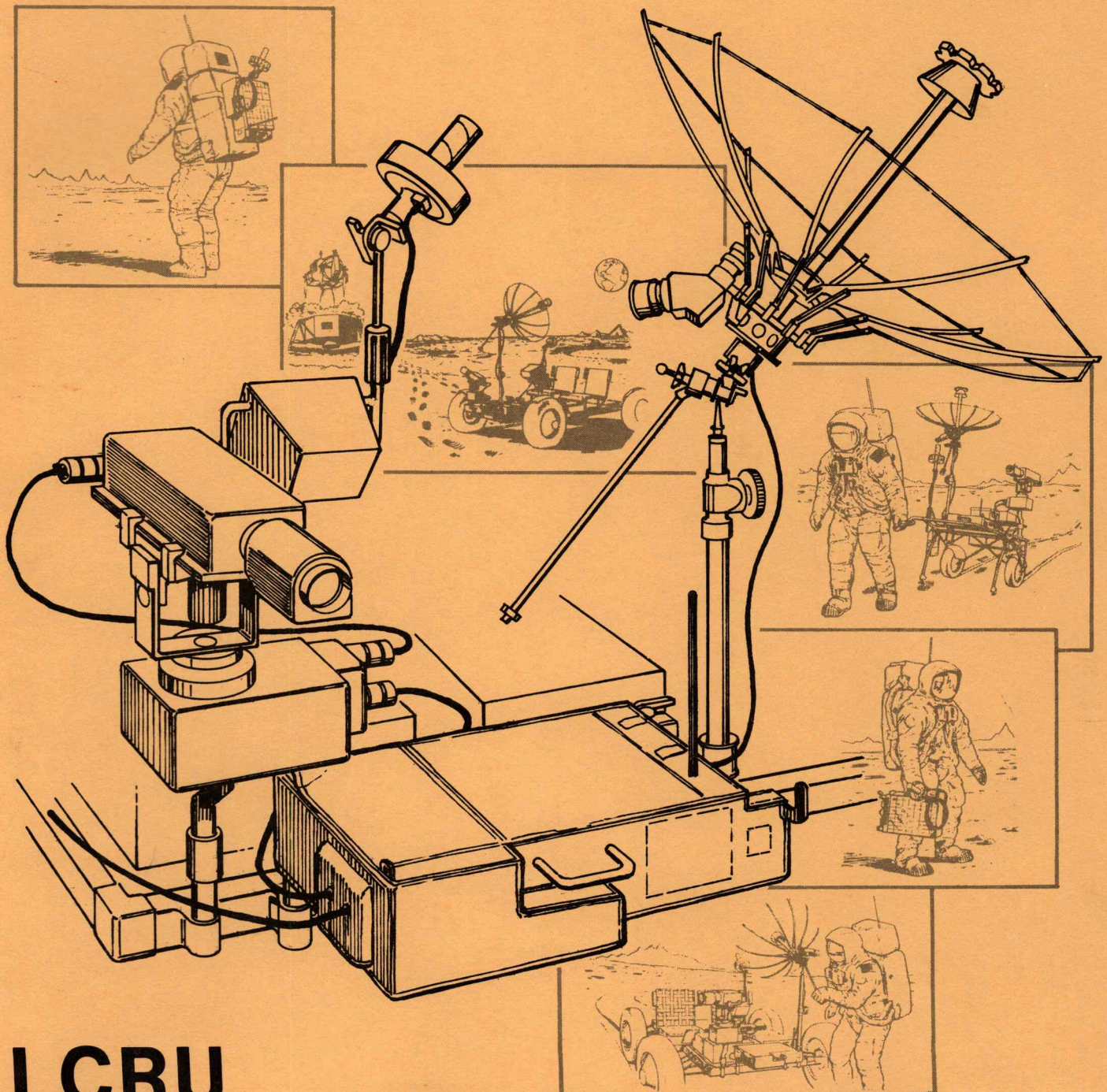
Lunar Communications Relay Unit (LCRU)

Critical Design Review Report

NASA/MSC, Houston, Texas

Sept. 15, 16, 17, 18, 1970

Volume 3



LCRU

LUNAR COMMUNICATIONS RELAY UNIT (LCRU)

CRITICAL DESIGN REVIEW

NASA/MSC HOUSTON, TEXAS

15, 16, 17 and 18 SEPTEMBER 1970

21 SEPTEMBER 1970 - DELTA CDR

VOLUME III

LUNAR COMMUNICATIONS RELAY UNIT (LCRU)

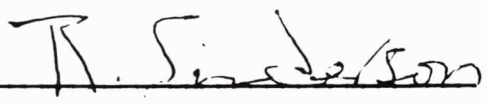
CRITICAL DESIGN REVIEW

NASA/MSC - HOUSTON, TEXAS

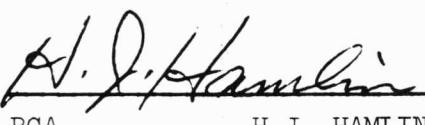
SEPTEMBER 15, 16, 17, 18, 1970



NASA W. SPEIER



NASA R. SINDERSON



RCA H.J. HAMLIN

These Minutes do not constitute contract change authorization. Changes to contract or schedule must be negotiated.

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AGENDA
LUNAR COMMUNICATIONS RELAY UNIT
CRITICAL DESIGN REVIEW
SEPTEMBER 15, 16, 17, 18, 1970

9/15/70

9:00 AM

General Session - Chairman: W. Speier - Minutes: A.M. Burke
Co-Chairman: H.J. Hamlin

- 1.0 GROUND RULES/INTRODUCTION W.M. Speier/
H.J. Hamlin
 - 1.1 Purpose
 - 1.2 What we were to do
 - 1.3 What you will see
- 2.0 MANAGEMENT OVERVIEW H.J. Hamlin
 - 2.1 Organization
 - 2.2 Schedule
 - Design Status
 - Manufacturing Status
 - Material Status
 - 2.3 Problems
- 3.0 SUBCONTRACT SUMMARY D.A. Orendac
- 4.0 CIRCUIT MARGIN SUMMARY B.M. Trachtenberg
- 5.0 CONFIGURATION OVERVIEW A.M. Burke
 - 5.1 LCRU Configuration - LRV
 - 5.2 LCRU Assembly Operations
 - 5.3 LCRU Configuration - Walk Mode
 - 5.4 Alternate Mode Capability
 - 5.5 Thermal Considerations
- 6.0 PERFORMANCE SUMMARY J.J. Connelly
 - 6.1 Design
 - 6.2 Weight Budget
 - 6.3 Power Budget



AGENDA

LUNAR COMMUNICATIONS RELAY UNIT

CRITICAL DESIGN REVIEW

SEPTEMBER 15, 16, 17, 18, 1970

9/15/70 Splinter Meeting
1:00 PM
to
9/16/70
5:00 PM
Room ()

7.0 ELECTRICAL DESIGN - Chairman: R. Sinderson - Minutes: V. Carita
Co-Chairman: J. Connelly

7.1 System Design B.M. Trachtenberg

7.1.1 Circuit Margins B.M. Trachtenberg
7.1.2 Signal Design B.M. Trachtenberg
7.1.3 Link Analyses B.M. Trachtenberg
7.1.4 Sub-System Configuration B.M. Trachtenberg

7.2 Electrical Interface Design

7.2.1 LCRU Design J.J. Connelly
7.2.2 EM Test Status J.J. Connelly
7.2.3 EMI & Grounding G. Houck

7.3 LCRU Internal Electrical Design

7.3.1 VHF Antenna Triplexer E. DeBaecke
7.3.2 S-Band Diplexers E. DeBaecke
7.3.3 VHF Receiver I. Grasheim
7.3.4 VHF Transmitter C. Montini
7.3.5 Down-Link Signal Processor
Including VCO's C. Montini
7.3.6 Voltage Regulator C. Montini
7.3.7 S-Band Transmitters V.J. Carita
7.3.8 S-Band Receivers H.E. Hawlk
7.3.9 Up-Link Signal Processor O. Ramanis
7.3.10 DC-DC Converter R. Erdman
7.3.11 Battery D.V. Howard
7.3.12 Low Gain Antenna D.V. Howard
7.3.13 High Gain Antenna F.J. Nangle

7.4 Integration Design

7.4.1 Case Electrical Integration
Signal Flow and Grounding H. Comfort
7.4.2 Control Panel H. Comfort
7.4.3 Cabling H. Comfort
7.4.4 LCRU Power Utilization H. Comfort

7.5 External Electrical Design H. Comfort

7.5.1 LCRU LRV TV Cables
7.5.2 HGA LGA Cables



AGENDA

LUNAR COMMUNICATIONS RELAY UNIT

CRITICAL DESIGN REVIEW

SEPTEMBER 15, 16, 17, 18, 1970

9/15/70 Splinter Meeting - Chairman: H. Schultz - Minutes: J. Liggett
1:00 PM Co-Chairman: J. Liggett
to
9/16/70 8.0 MECHANICAL DESIGN
5:00 PM
Room ()

8.1 Mechanical Interface Design R. Holston

8.1.1 LCRU/LRV
8.1.2 HGA/LRV
8.1.3 LCRU-LM-MESA
8.1.4 Battery - LM-MESA

8.2 LCRU Mechanical Design R. Holston

8.2.1 Subassembly Arrangement R. Holston
8.2.2 LCRU Weight Analysis R. Holston
8.2.3 Subassemblies L. Krawitz

8.2.3.1 VHF Receiver L. Krawitz
8.2.3.2 VHF Transmitter
8.2.3.3 VHF Triplexer
8.2.3.4 Down Link Signal Processor
8.2.3.5 Up Link Processor
8.2.3.6 Voltage Regulator
8.2.3.7 Battery
8.2.3.8 S-Band Receiver
8.2.3.9 S-Band Transmitters
8.2.3.10 Diplexer
8.2.3.11 VHF Antenna
8.2.3.12 DC-DC Converter L. Krawitz
8.2.3.13 Antenna Connector W. Babcock
8.2.3.14 High Gain Antenna W. Babcock
8.2.3.15 Low Gain Antenna W. Babcock

8.2.4 Case Design R. Holston
8.2.5 Cover Design
8.2.6 Wax Package Assembly
8.2.7 Control Panel Design
8.2.8 LCRU/LRV Mounting Design
8.2.9 HGA Mast and Interface Design
8.2.10 Stowage Container Design
8.2.11 Vibration and Stress Analysis



AGENDA
LUNAR COMMUNICATIONS RELAY UNIT
CRITICAL DESIGN REVIEW
SEPTEMBER 15, 16, 17, 18, 1970

9/16/70 Splinter Meeting - Chairman: E. Chimenti - Minutes: H. Rosenthal
9:00 AM Co-Chairman: G. Grube

to
9/16/70
5:00 PM

9.0 THERMAL DESIGN

9.1 Design Analyses

B. Shelpuk

- 9.1.1 Multinode Thermal Analysis
- 9.1.2 Component Hot-Spot Analysis
- 9.1.3 Parking Orientation Analysis
- 9.1.4 Walk Back Analysis
- 9.1.5 Phase Change Freezing Analysis
- 9.1.6 Phase Change Material Package Design

9.2 Thermal Design

G. Grube

- 9.2.1 Radiator
- 9.2.2 Thermal Blanket
- 9.2.3 Thermal Finishes
- 9.2.4 Component Temperatures

9.3 Thermal Testing

- 9.3.1 Test Approach
- 9.3.2 Test Results

9/16/70 Splinter Meeting - Chairman: J. Miller - Minutes: R. Virostek
9:00 AM Co-Chairman: R. Virostek

to
9/16/70
5:00 PM

10.0 TEST PROGRAM

- 10.1 Thermal
- 10.2 Engineering Model
- 10.3 DVT
- 10.4 QTP
- 10.5 ATP
- 10.6 Test Equipment Design
- 10.7 MSC/KSC Test Program
- 10.8 MSC Special Test Program



AGENDA

LUNAR COMMUNICATIONS RELAY UNIT

CRITICAL DESIGN REVIEW

SEPTEMBER 15, 16, 17, 18, 1970

9/16/70	Splinter Meeting - Chairman: D. Becker - Minutes: W. Carlino	
9:00 AM	Co-Chairman: W. Carlino	
to		
9/16/70	11.0 PROGRAM SUPPORT	
5:00 PM	11.1 Reliability	W. Carlino
Room ()		
	11.1.1 RCA Status	
	11.1.2 Subcontractor Status	
	11.1.3 Reliability Design Status	
	11.1.4 Parts Qual.	H. Farcus
	11.1.5 Parts Usage: APL, Derating	H. Farcus
	11.1.6 FMEA	H. Farcus
	11.2 Configuration Control	H. Yarbrough
	11.2.1 Program Control and Status	
	11.2.2 Response to MSC Con Con Comments	
	11.3 Quality Assurance	G. Floyd
	11.3.1 RCA Quality Program Status	
	11.3.2 Subcontractor Controls and Status	
	11.3.3 Equipment Flow Charts	

9/17/70	12.0 GENERAL SPLINTER & RID REVIEWS	
9:00 -	Chairman: W. Speier - Minutes: A.M. Burke	
10:00	Co-Chairman: H.J. Hamlin	
to		
1:00 -	12.1 Electrical Design Splinter Review	J.J. Connelly
5:00	12.2 Mechanical Design Splinter Review	J. Liggett
	12.3 Thermal Design Splinter Review	G. Grube
	12.4 Test Program Splinter Review	R. Virostek
	12.5 Program Support Splinter Review	W. Carlino

9/17/70	13.0 DEMONSTRATION	B.M. Trachtenberg/ J.J. Connelly
10:00 AM		
to		
12:00 AM		

9/18/70	14.0 CDR REVIEW BOARD	R. Johnston
9:00 AM		
to		
12:00		

9/18/70	15.0 MINUTES REVIEW AND SIGNOFF	W. Speier
1:00 -		R. Sinderson
ON		H.J. Hamlin
		A.M. Burke
		J.J. Connelly
		D. Orendac
		W. Carlino
		R. Virostek
		J. Liggett

AGENDA

LCRU CREW STATION REVIEW

MSC/BLDG. 5, SEPTEMBER 21, 1970

DELTA CDR

9/21/70

16.0

LCRU Crew Station Review

H.J. Hamlin

LCRU Lunar
Communications
Relay
Unit

CRITICAL DESIGN REVIEW

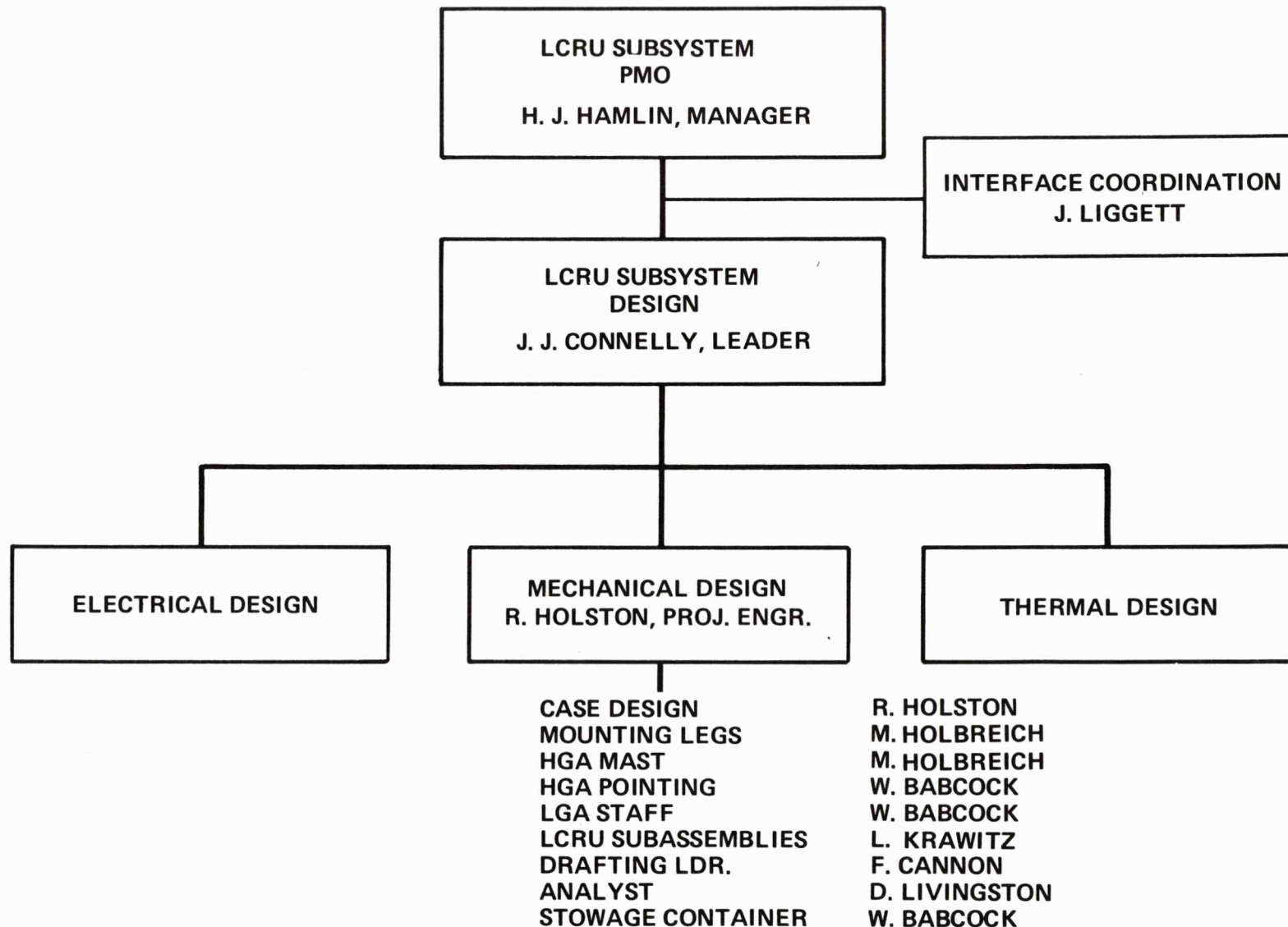
RCA

9-15-70 thru 9-18-70

8.0 MECHANICAL



LCRU MECHANICAL DESIGN ORGANIZATION



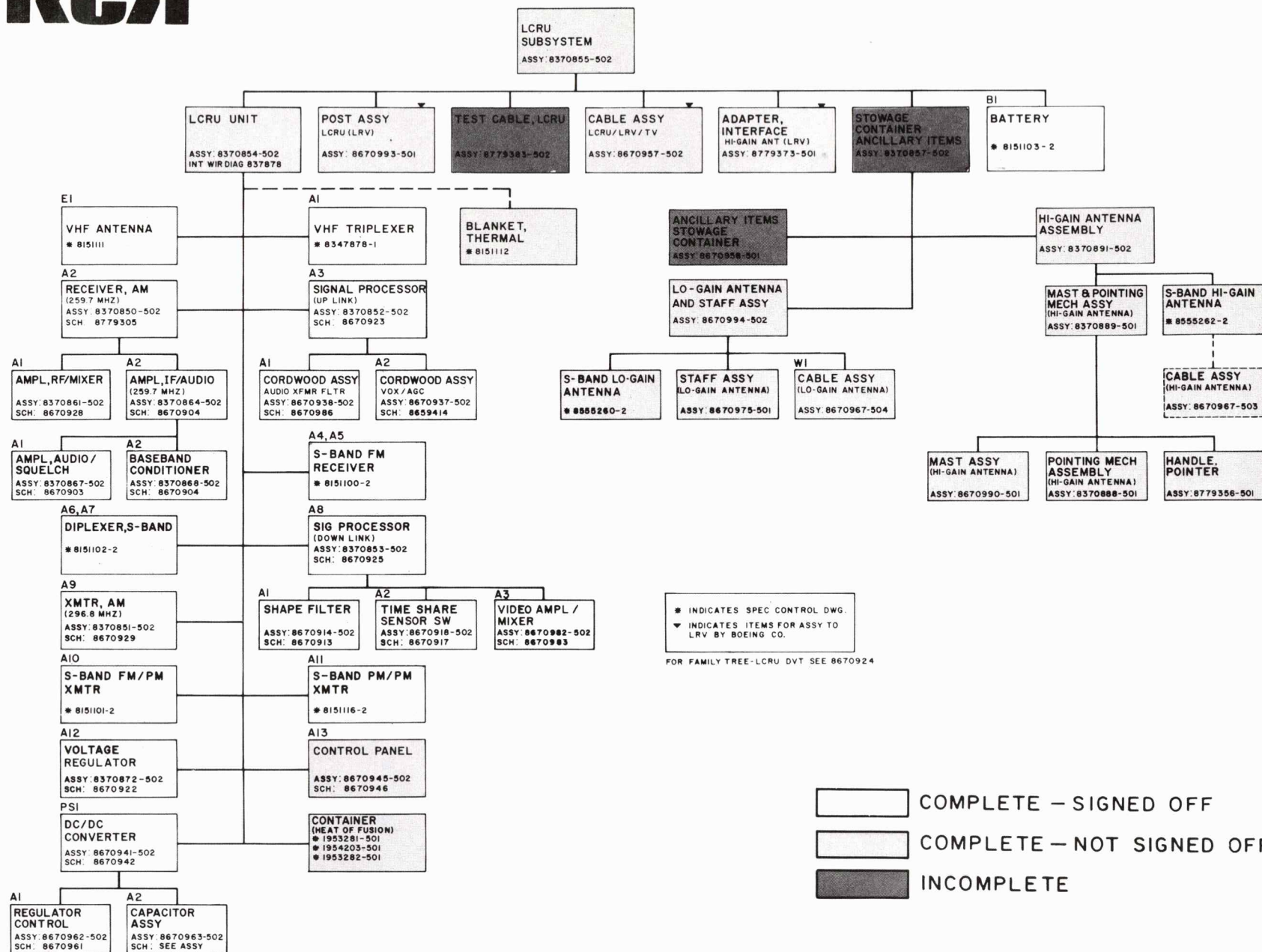


☐ COMPLETE — SIGNED OFF
☐ COMPLETE — NOT SIGNED OFF
☐ INCOMPLETE



LCRU DRAWING STATUS

FAMILY TREE-LCRU FLIGHT





ENGINEERING MODEL TEST PROGRAM

CONFIDENCE TESTING	1970					1971			
	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR
ANCILLARY ITEM STOWAGE CONTAINER									
1. PRE-ASSEMBLY			I						
2. INTEGRATION VERIFICATION			I						
3. RANDOM VIBRATION			I						
4. SHOCK				I					
5. LAUNCH DEPRESSURIZATION				I					
HYDRAULIC PRESSURE VESSEL									
1. LEAK RATE/PRESSURE VERIFICATION		I							
2. OVERPRESSURE VERIFICATION		I							
MESA VIBRATION - LCRU MOCK-UP									
1. RANDOM VIBRATION, E L/B			I						
HGA ASSEMBLY									
1. SINE VIBRATION, LRV MOUNT				I					
LGA ASSEMBLY									
1. SINUSOIDAL VIBRATION, LRV MOUNT					I				



LRV INTERFACE

PROBLEM AREAS

1. TO COMPLETE STRESS ANALYSIS AND WEIGHT REDUCTION RCA REQUIRES THE FOLLOWING:
 - A. FINAL LRV DYNAMIC ENVIRONMENT FROM MSC
 - B. COMPLETE RCA INHOUSE VIBRATION TESTS ON ENGINEERING MODEL. (SCHEDULED FOR SEPT, OCT 1970)
2. INTERFERENCE BETWEEN TV/LCRU/HGA - RCA MOCKUP EVALUATION
 - A. TV CAMERA INTERFERES WITH HGA DEPLOYMENT
 - B. TV CAMERA INTERFERES WITH LCRU REMOVAL FOR HAND CARRY
 - C. TV CAMERA INTERFERES WITH HGA AT LOW MAST EXTENSION
 - D. VHF ANTENNA INTERFERES WITH HGA AT LOW MAST EXTENSION AND LOW POINTING ANGLES



LM INTERFACE

- LCRU STOWAGE ICD LID 340-25162
- BATTERY STOWAGE ICD LID 340-25162
- ANCILLARY ITEM STOWAGE NEED REVISED ICE FOR NEW LOCATION (LM ERECTABLE LOCATION)
- STOWAGE CONTAINER DEPLOYMENT NOT REQUIRED – CONTENTS REMOVED DIRECTLY
- LCRU DEPLOYMENT LCRU DEPLOYED WITHOUT PALLET
- ENVIRONMENT ICD LIS 520-25163
NEED RESULTS OF MESA QUAL TEST
- RCA/GAC INTERFACE MEETING
8-25-70 GAC ACTION ITEMS
- POTENTIAL PROBLEMS VIBRATION
BATTERY REMOVAL

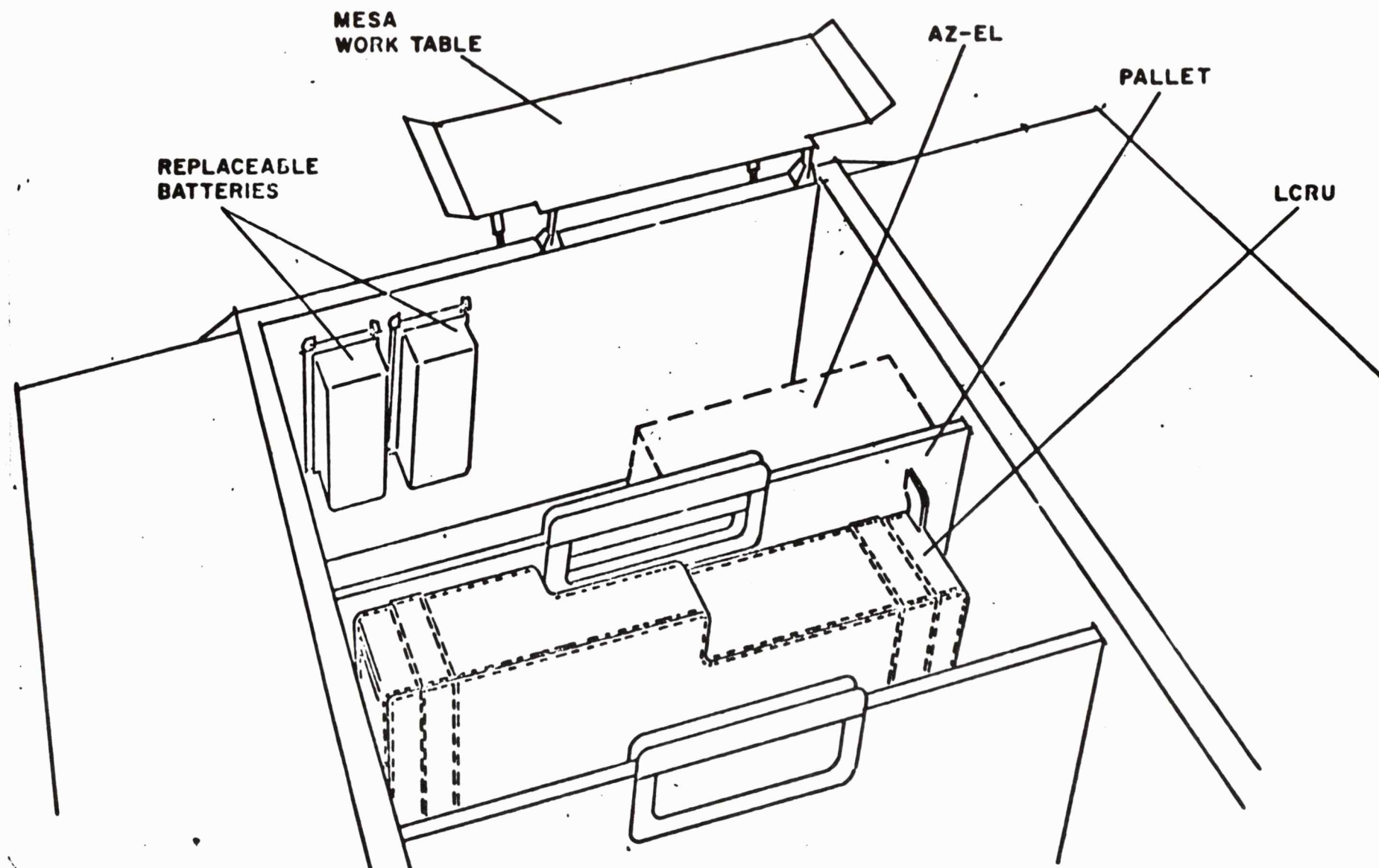
8-7

[illegible]

RCA

AZ-EL STORAGE ON PALLET & BATTERY

ATTACHMENT TO INSIDE WALL OF MESA





LM INTERFACE STOWAGE CONTAINER CONTENTS

- HGA ASSEMBLY (COMPLETELY PREASSEMBLED)

HGA
MAST
POINTING
CABLE

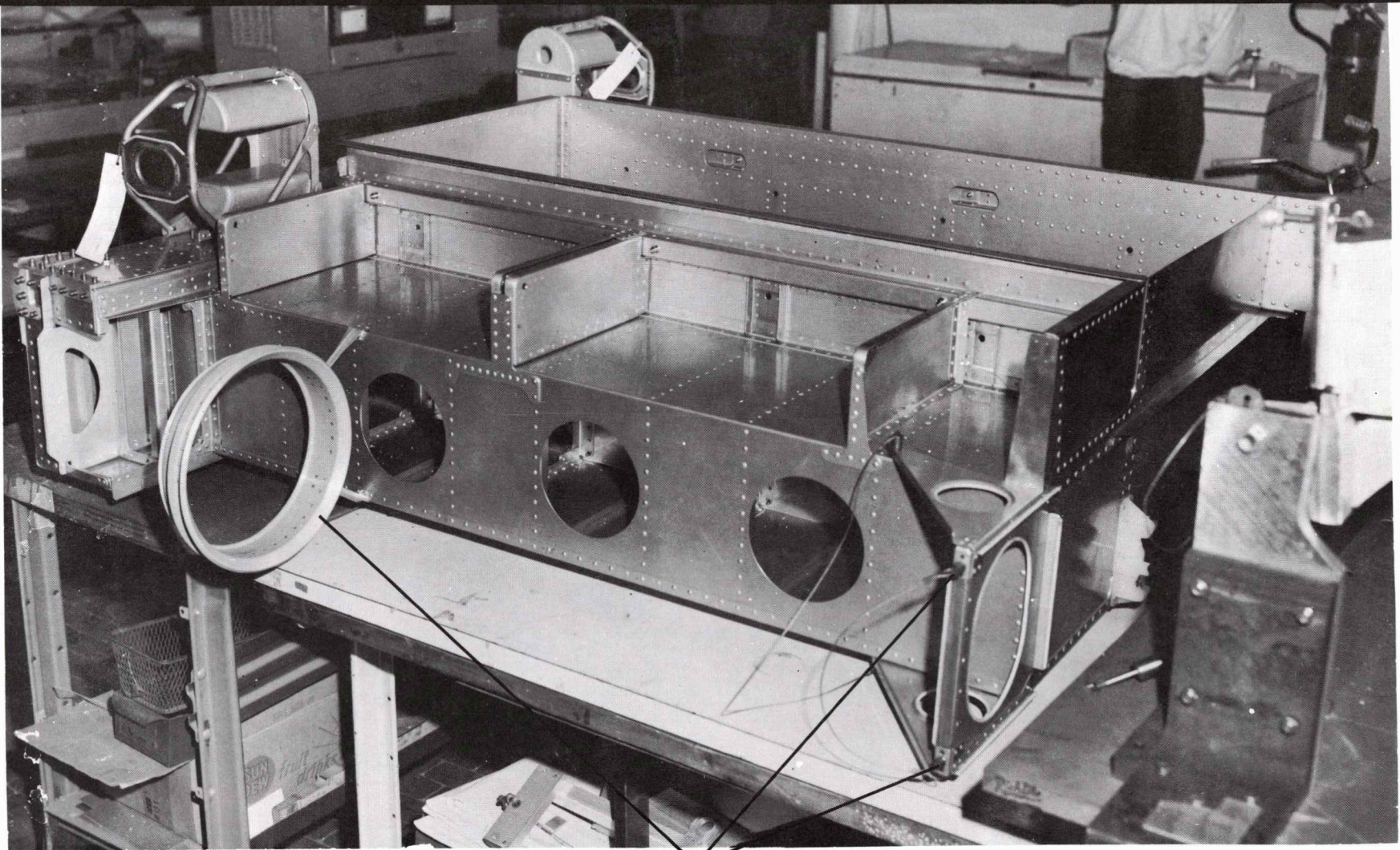
- LGA ASSEMBLY (COMPLETELY PREASSEMBLED)

LGA
STAFF
POINTING
CABLE

**NOTE: STOWAGE CONTAINER REMAINS IN MESA WHEN
CONTENTS ARE DEPLOYED**

RCA

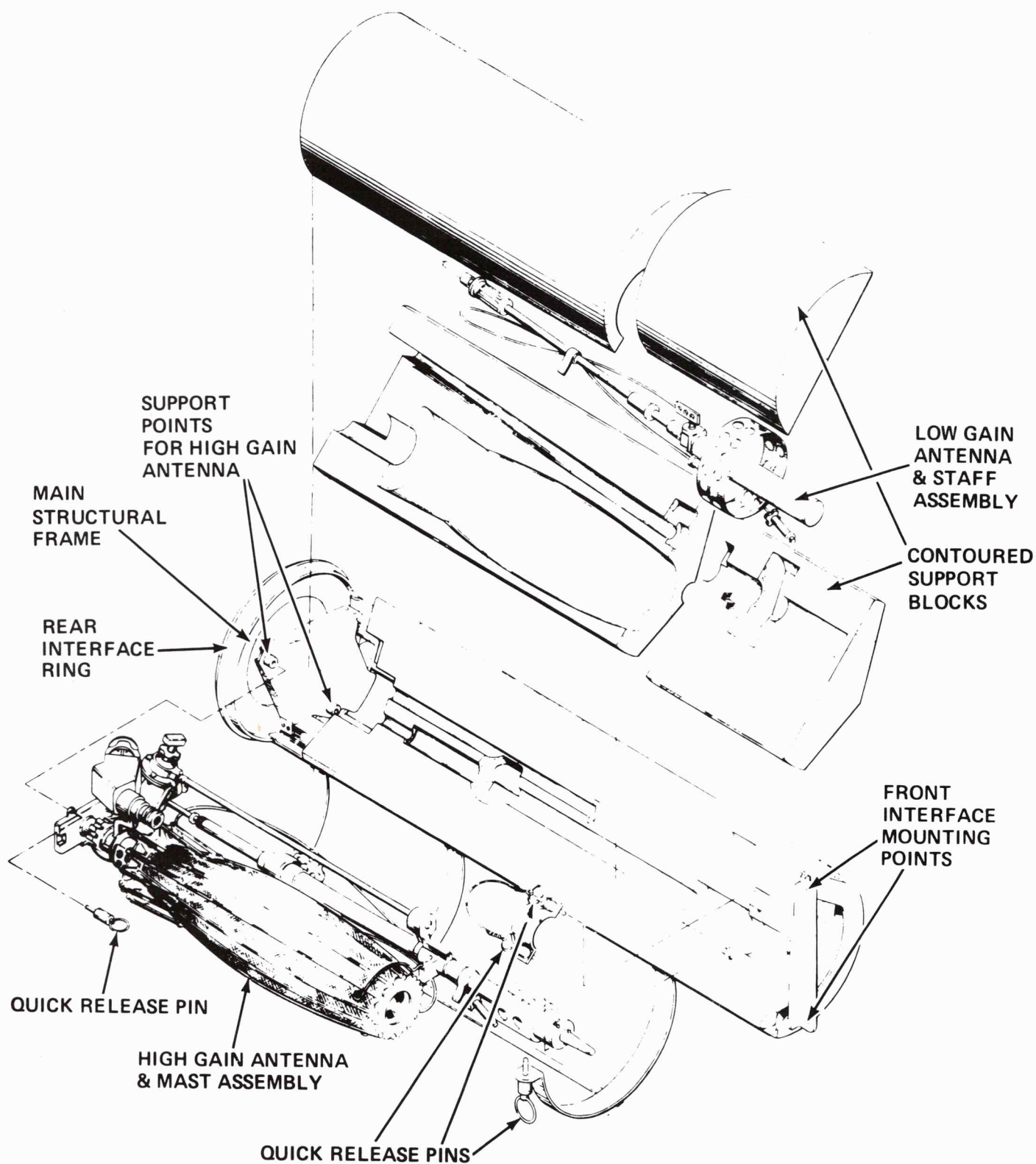
LM INTERFACE LCRU STOWAGE CONTAINER LOCATION



STORAGE CONTAINER
MOUNTING POINTS

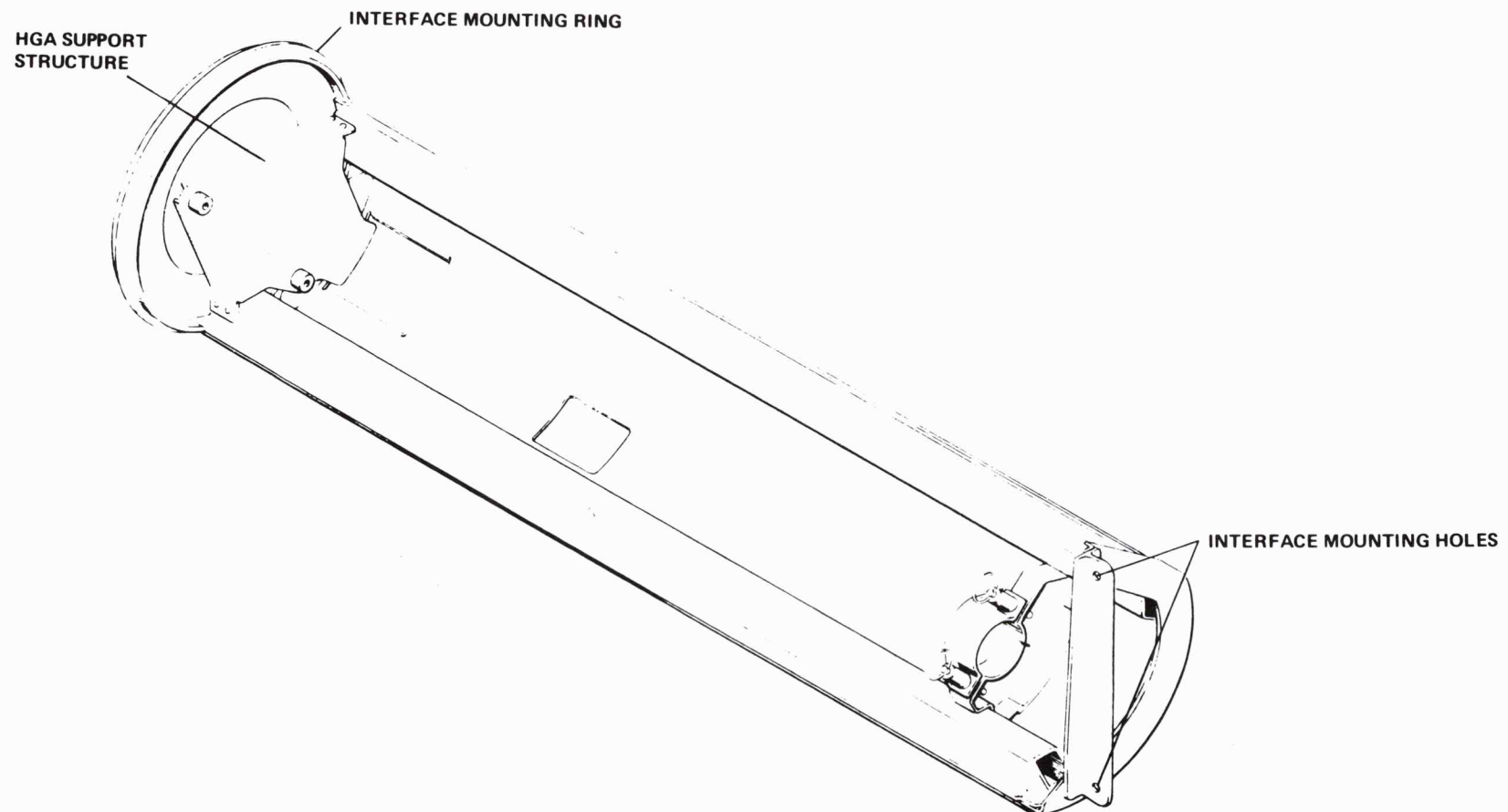


STOWAGE CONTAINER/ANCILLARY ITEMS CONFIGURATION



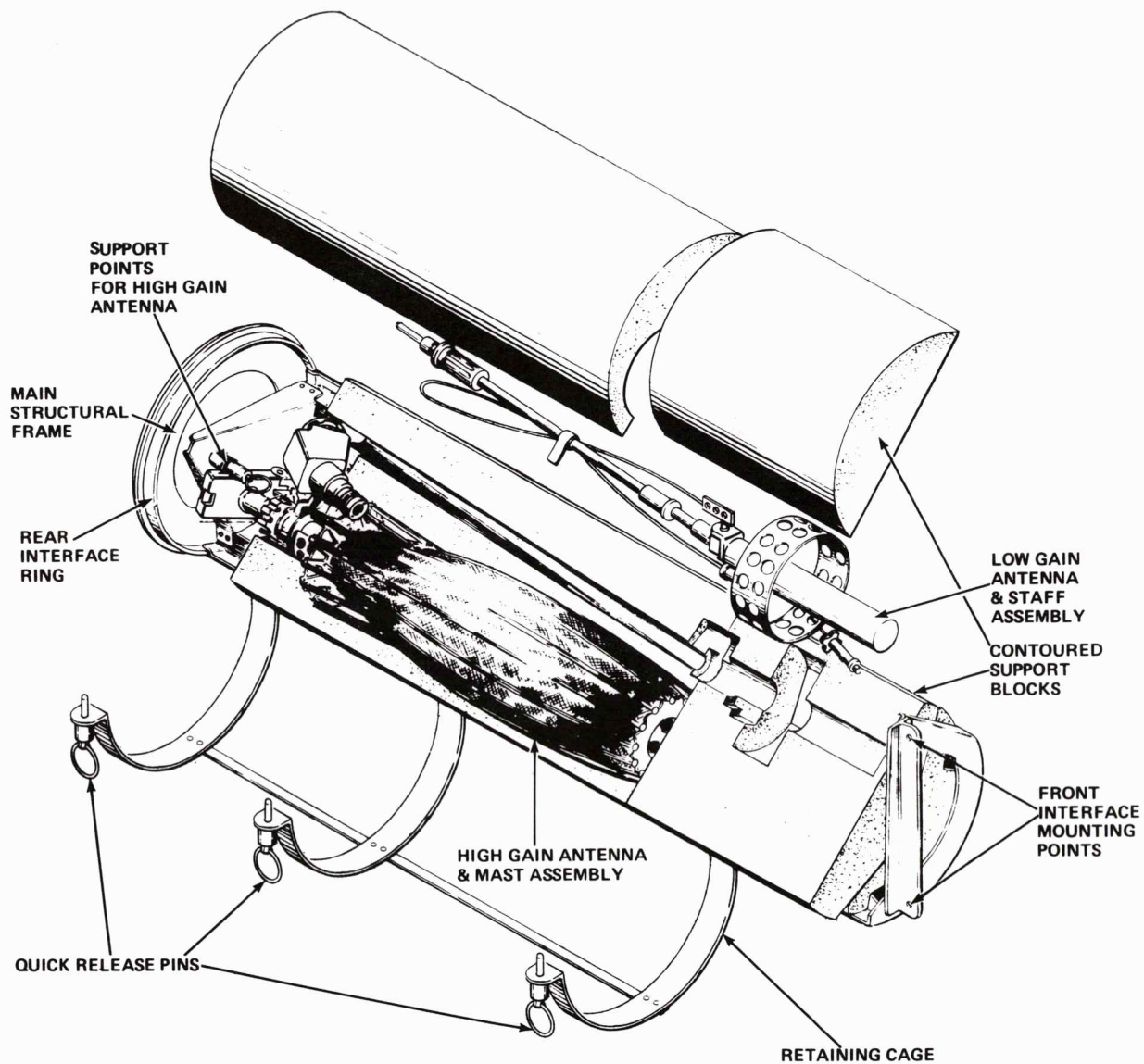


STOWAGE CONTAINER STRUCTURAL CONCEPT





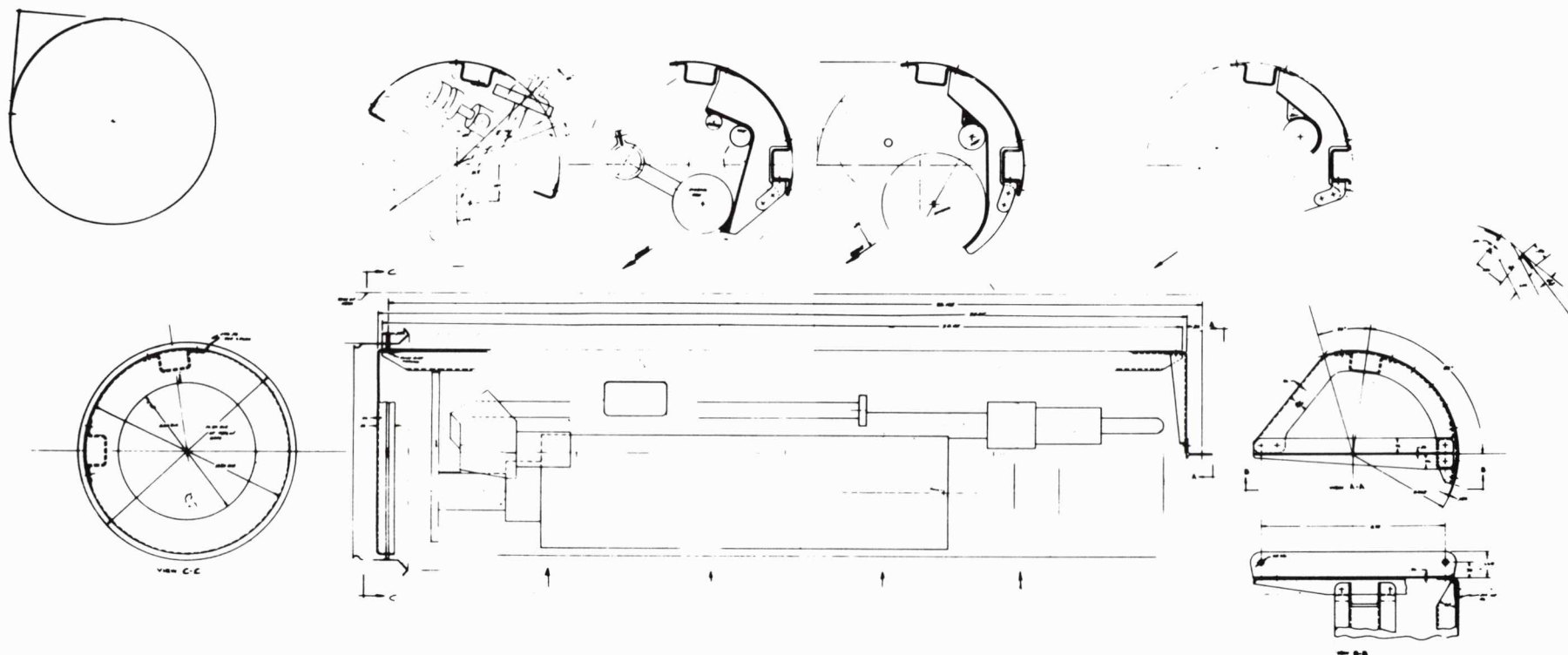
ANCILLARY ITEM STOWAGE CONTAINER HGA IN STOWED POSITION





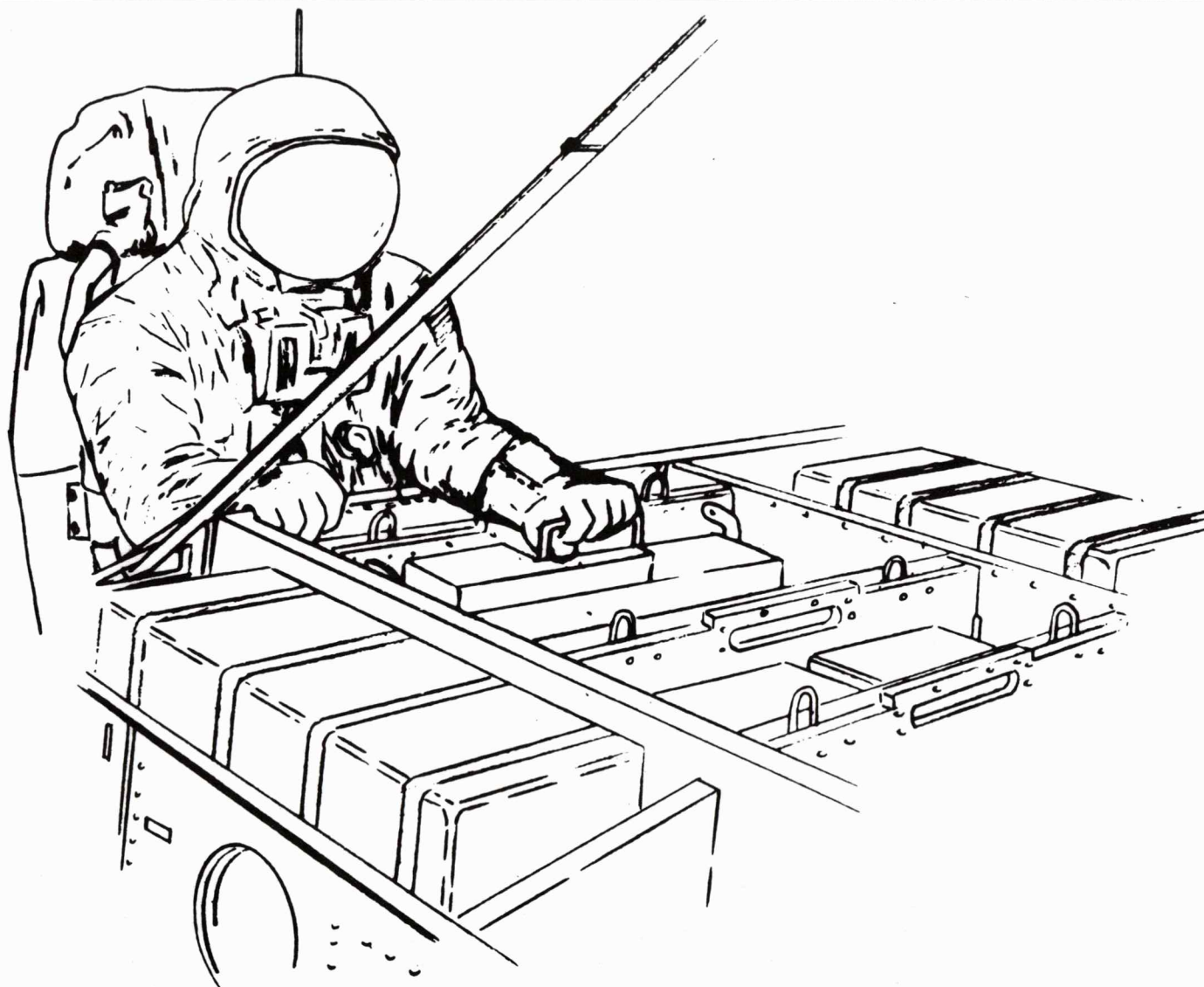


STOWAGE CONTAINER STRUCTURAL DESIGN





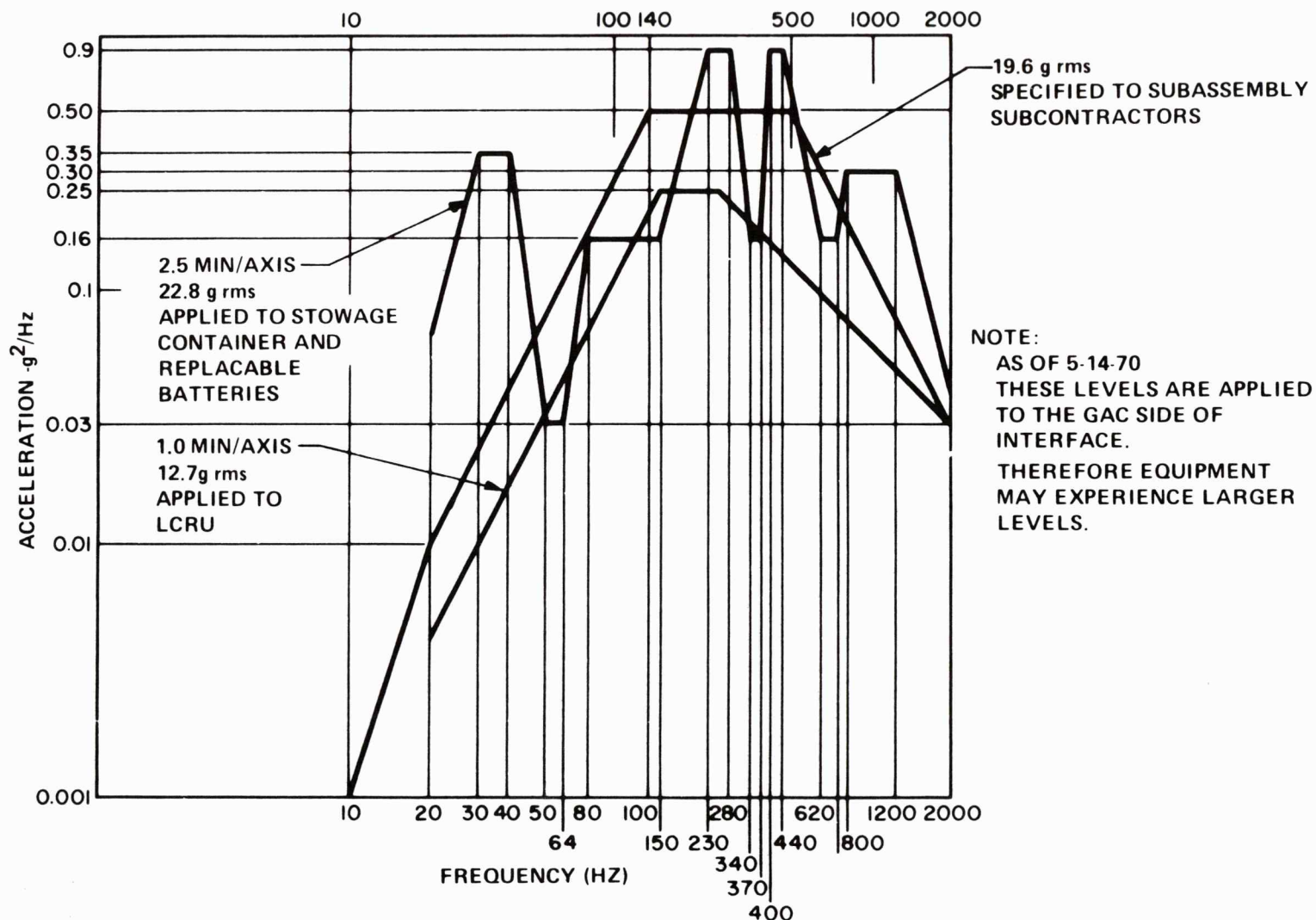
LCRU CASE REMOVAL PRIME MODE WITHOUT PALLET





ICD LIS 520-25163

LAUNCH AND BOOST RANDOM VIBRATION





LM INTERFACE

INTERFACE MEETING RCA/GAC 8-25-70

SUBJECT; LCRU BATTERIES AND ANCILLARY EQUIPMENT

MINUTES

I. BATTERY INTERFACE

- 1) GAC WILL UPDATE THE STOWAGE ICD SHOWING THE TRACK WITH SHIMS VS BATTERY INTERFACE. DUE AUGUST 31, 1970.
- 2) WITH THE PRESENT MOUNTING FIXTURE, IF THE BATTERY IS COCKED IN ANY DIRECTION UPON REMOVAL, IT WILL BIND. TO REMOVE THE BATTERY JIGGLING OR CAREFUL ALIGNMENT IS REQUIRED' RCA/GAC FEEL THIS MAY BE A POTENTIAL CREW PROBLEM AND SHOULD BE BROUGHT TO MSC'S ATTENTION.

II. ANCILLARY EQUIPMENT

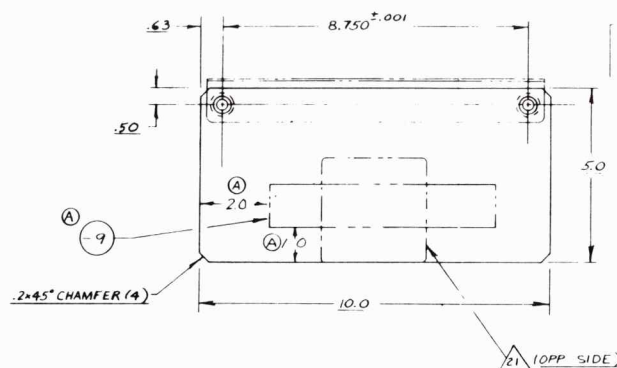
- 1) RCA STATED THAT AT A RCA/MSC MEETING A DECISION WAS MADE TO REMOVE THE ANCILLARY EQUIPMENT FROM ITS STORAGE CONTAINER WHILE STILL ON THE MESA. THE EMPTY CONTAINER WILL BE REMOVED TO GET AT THE EQUIPMENT STOWED BEHIND THE CONTAINER.
- 2) GAC WILL CHECK TO SEE IF THE S-BAND ANTENNA MATING TOOL IS AVAILABLE FOR USE. IF NOT AT LEAST THE DETAILED DRAWINGS WILL BE AVAILABLE TO RCA. PRINTS DUE AUGUST 31, 1970.

WITH THIS TOOL, RCA STATES THEY CAN COMPLY WITH THE INTERFACE.
- 3) ON THE STOWAGE ICD, GAC WILL CLARIFY THE FORCE REQUIRED TO REMOVE THE ANCILLARY EQ. CONTAINER AS: FRICTIONAL PLUS WEIGHT AND DIRECTION.
- 4) GAC WILL DETERMINE THE MAXIMUM ENVELOPE (WITHOUT STRUCTURAL IMPACT) THAT RCA CAN USE FOR THE ANCILLARY EQUIPMENT. DUE AUGUST 31, 1970.
- 5) GAC WILL UPDATE LID 340-25162 TO REFLECT RELOCATION OF ANCILLARY EQ. TO THE S-BAND ANTENNA STOWAGE LOCATION.
- 6) GAC PRESENTED RCA WITH DRAWINGS: LDW 340M15018 PG. 1, 2 & 3 AND LDW 380-54201 PG. 5.00. THESE DRAWINGS DEFINE THE MOUNTING HOOKS FOR THE S-BAND ANTENNA/ANCILLARY EQ.



ASSEMBLY (LSC 380-00370-51 I.C.F.) S-BAND ERECTABLE ANTENNA P-152935

STANDARD NOTES	
PLACE THIS SYMBOL & NOTE NUMBER NEAR DETAIL IN FIELD OF DRAWING. ADD REQUIRED DATA BELOW.	
1	HT. TR. TO ROCKWELL C. TO C.
2	STRESS RELIEVE
3	ANNEAL
4	CASE HDN. DEEP TO C. ROCKWELL C. TO C.
5	FLAME HARDEN EDGES
6	SANDBLAST
7	PERPENDICULAR WITHIN .0003 PER INCH OF LENGTH
8	DIAMETERS TO BE CONCENTRIC WITHIN .001 T.I.R.
9	SURFACE TO BE FLAT WITHIN .005 PER INCH OF LENGTH
10	USE STANDARD DRILL BAR OR PLATE ST.
11	TACK WELD OR WELD AS SHOWN
12	DRILL AND REAM ON ASSEMBLY
13	USE A COPY OF THIS DRAWING AS A FLAME CUT TEMPLATE
14	ASSEMBLE WITH a-HEX HEAD CAP SCREWS & NUTS b-SOCKET HEAD CAP SCREWS c-SELF TAPPING CAP SCREWS d-DOWELS
15	ATTACH LOOSE DETAILS WITH: a-CHAIN b-NYLON COVERED CABLE
16	SHIM AS NEEDED a-GYPSUM BASE b-PLASTIC c-METAL
17	POT PER STD DATA SD 166
18	IMPRESSION STAMP DETAIL NUMBER ON ALL DETAILS
19	STENCIL TOOL NUMBER, NAME & STATION MARKINGS; USE CONTRASTING COLOR
20	APPLY INTERCHANGEABILITY LABEL a-AREA b-PART
21	ATTACH NAMEPLATE NO. <u>10-179-5</u>
22	SUPPLY BOX AS PER STD DESIGN a-SD 99 b-SD 108
23	INSTALL AIR LINES PER SD 1410



-1 ASSEMBLY (SCALE 1/2)

-9 PHOTO-SENSITIVE LABEL
1 1/4 x 6 1/2, BLACK 1/8 LETTERS
ON SILVER BACKGROUND
(SCALE - FULL)

LSC 380-00370-51 ICF INSPECTION PROCEDURE
1. LOCATE LSC 380-00370-51 ICF AGAINST "T" MEMBER OF PARY 380-00370-51.
2. INSERT (2) P-152935-7 STEP PINS. THERE MUST BE NO BIND.

24	FINISHES a-HARD COAT b-CADMIUM PLATE c-ANODIZE d-THERMOGRAPHIC
25	PRINT PER SD 1480

TOOL AFFECTED		REVISIONS			
YES	NO	REVISION	DESCRIPTION	DATE	APPD

QTY REQ PER ASSY		PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL	STOCK SIZE (EA)
LIST OF MATERIALS					
UNLESS SPECIFIED OTHERWISE		LAYOUT BY	GRUMMAN AIRCRAFT ENGRG CORP		
DIM TOL SUR FIN		DRAWN BY	MANUFACTURING ENGINEERING		
1 PL DEC ± .060		3-3-66	BETHPAGE 61 N.Y.		
2 PL DEC ± .030		CHECKED BY	ASSEMBLY [LSC 380-00370-51 ICF]		
3 PL DEC ± .010 / 20 & OVER		J SMITH 3-3-66	S-BAND ERECTABLE ANTENNA		
4 PL DEC ± .005 (UP TO 20)		ENGRG APPD	MODEL SEE D/R ASSEMBLY		
ANGULAR ± 1.2°		C 470	CODE IDENT NO		
UNLESS SPECIFIED OTHERWISE		3-3-66	SIZE		
BREAK ALL SHARP CORNERS AND EDGES			26512 C P-152935		
			SCALE NOTED		
			SHEET		

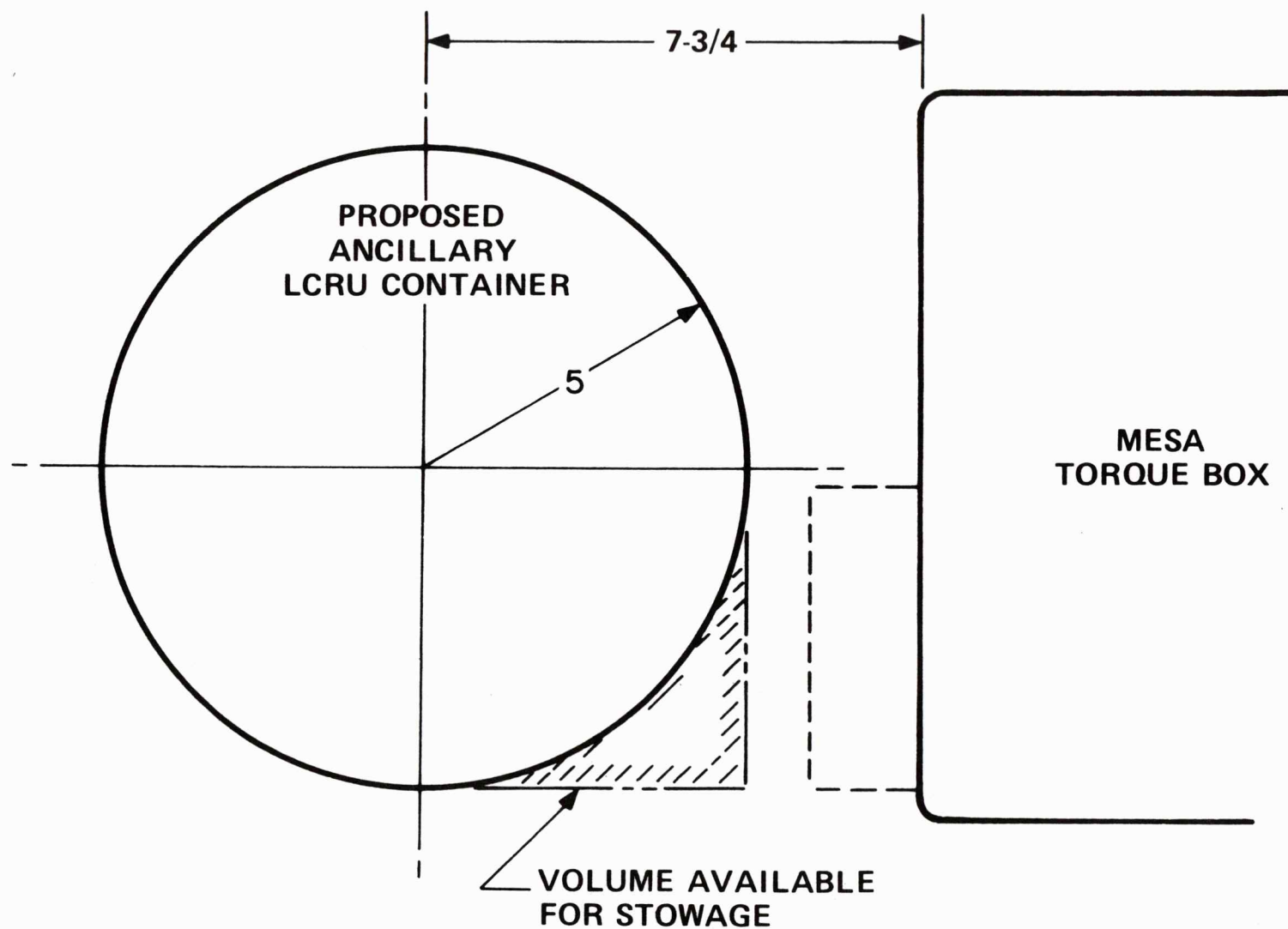


STANDARD SYMBOLS	
1	PLANE OR SURFACE OF REFLECTION (MIRROR, REFLECTOR, REFLECTING SURFACE)
2	RAY OR BEAM OF LIGHT
3	RAY OR BEAM OF SOUND
4	RAY OR BEAM OF HEAT
5	RAY OR BEAM OF ELECTRICITY
6	RAY OR BEAM OF MAGNETISM
7	RAY OR BEAM OF RADIATION
8	RAY OR BEAM OF PARTICLES
9	RAY OR BEAM OF SOUND
10	RAY OR BEAM OF LIGHT
11	RAY OR BEAM OF SOUND
12	RAY OR BEAM OF LIGHT
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74	RAY OR BEAM OF LIGHT
75	RAY OR BEAM OF SOUND
76	RAY OR BEAM OF LIGHT
77	RAY OR BEAM OF SOUND
78	RAY OR BEAM OF LIGHT
79	RAY OR BEAM OF SOUND
80	RAY OR BEAM OF LIGHT
81	RAY OR BEAM OF SOUND
82	RAY OR BEAM OF LIGHT
83	RAY OR BEAM OF SOUND
84	RAY OR BEAM OF LIGHT
85	RAY OR BEAM OF SOUND
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93	RAY OR BEAM OF SOUND
94	RAY OR BEAM OF LIGHT
95	RAY OR BEAM OF SOUND
96	RAY OR BEAM OF LIGHT
97	RAY OR BEAM OF SOUND
98	RAY OR BEAM OF LIGHT
99	RAY OR BEAM OF SOUND
100	RAY OR BEAM OF LIGHT

[illegible]



LM INTERFACE STOWAGE CONTAINER CROSS SECTION





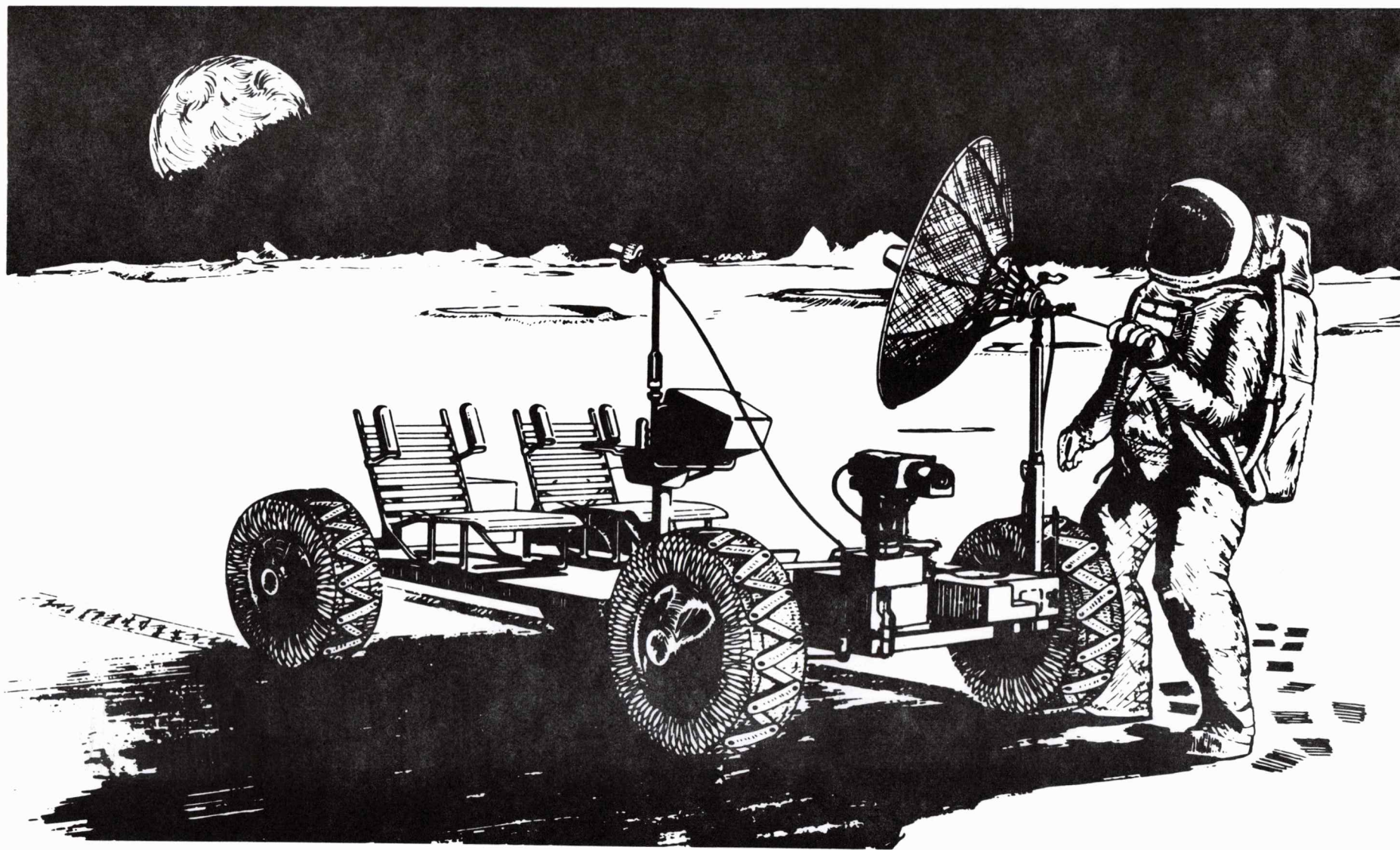
LM INTERFACE

POTENTIAL PROBLEMS

- IMPACT OF POTENTIAL INCREASED VIBRATION LEVELS AS A RESULT OF MESA TEST AND RCA TESTS
- LCRU BATTERY REMOVAL FROM MESA

RCA

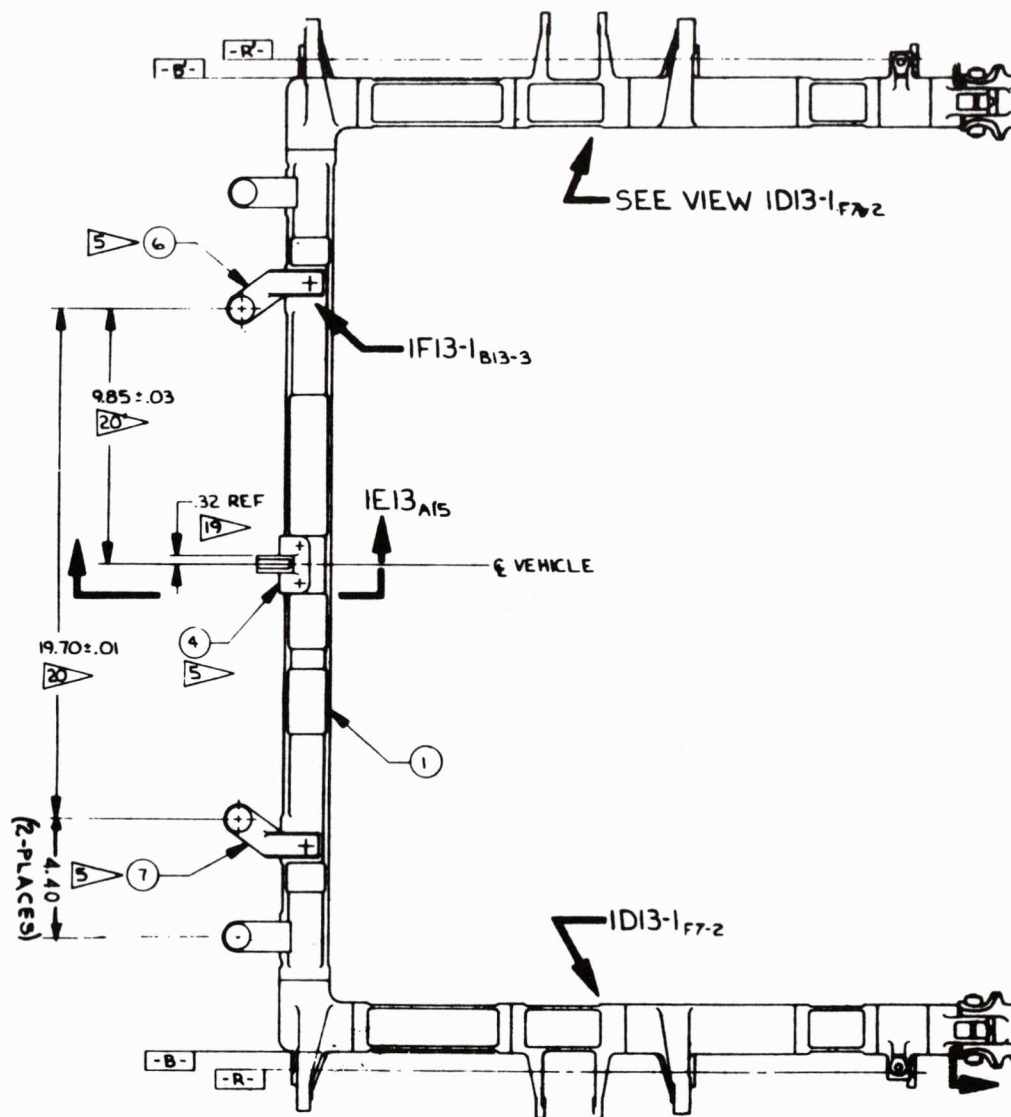
LRV INTERFACE





LRV INTERFACE MECHANICAL STATUS

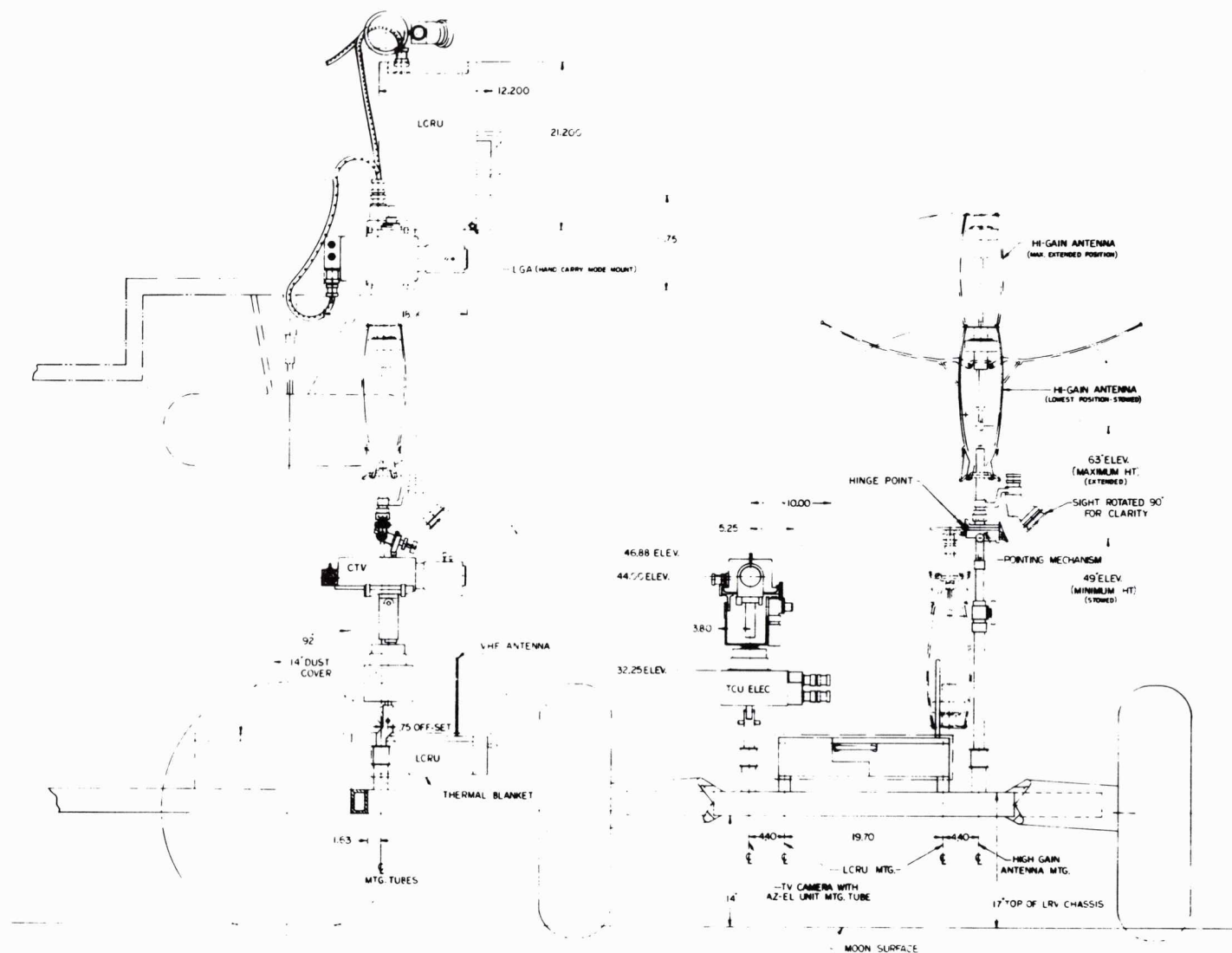
- | | |
|--|--|
| • INTERFACE DIMENSIONS
LRV MOUNTING TUBES | PER BAC CHASSIS DWG
NO CHANGE |
| • DEPLOYMENT PROCEDURE | COMPLETE PREASSEMBLY
OF HGA & LGA
MINIMUM CREW OPERATIONS |
| • BATTERY REPLACEMENT | PLUG IN MODULE |
| • LCRU HAND CARRY | HANDLE REVISED PER
CSR 8-17-70 |
| • VIBRATION ANALYSIS | HGA & MAST REVISED TO
E. M. CONFIGURATION
LCRU MOUNTING LEG PRELIMINARY
ANALYSIS COMPLETE |
| • VIBRATION TESTING | LCRU SUBSYSTEM MECHANICAL
MODEL AT BOEING KENT
FOR LRV VIBRATION TEST |
| • LGA AND MAST ASSEMBLY | E. M. COMPLETE W/MSC MAST
VIBRATION ENVIRONMENT NEEDED |
| • HGA AND MAST ASSEMBLY | E. M. COMPLETE
COMPLETE PREASSEMBLY
WITH MAST AND POINTING |
| • LCRU MOUNTING LEG | PREASSEMBLED TO LRV |





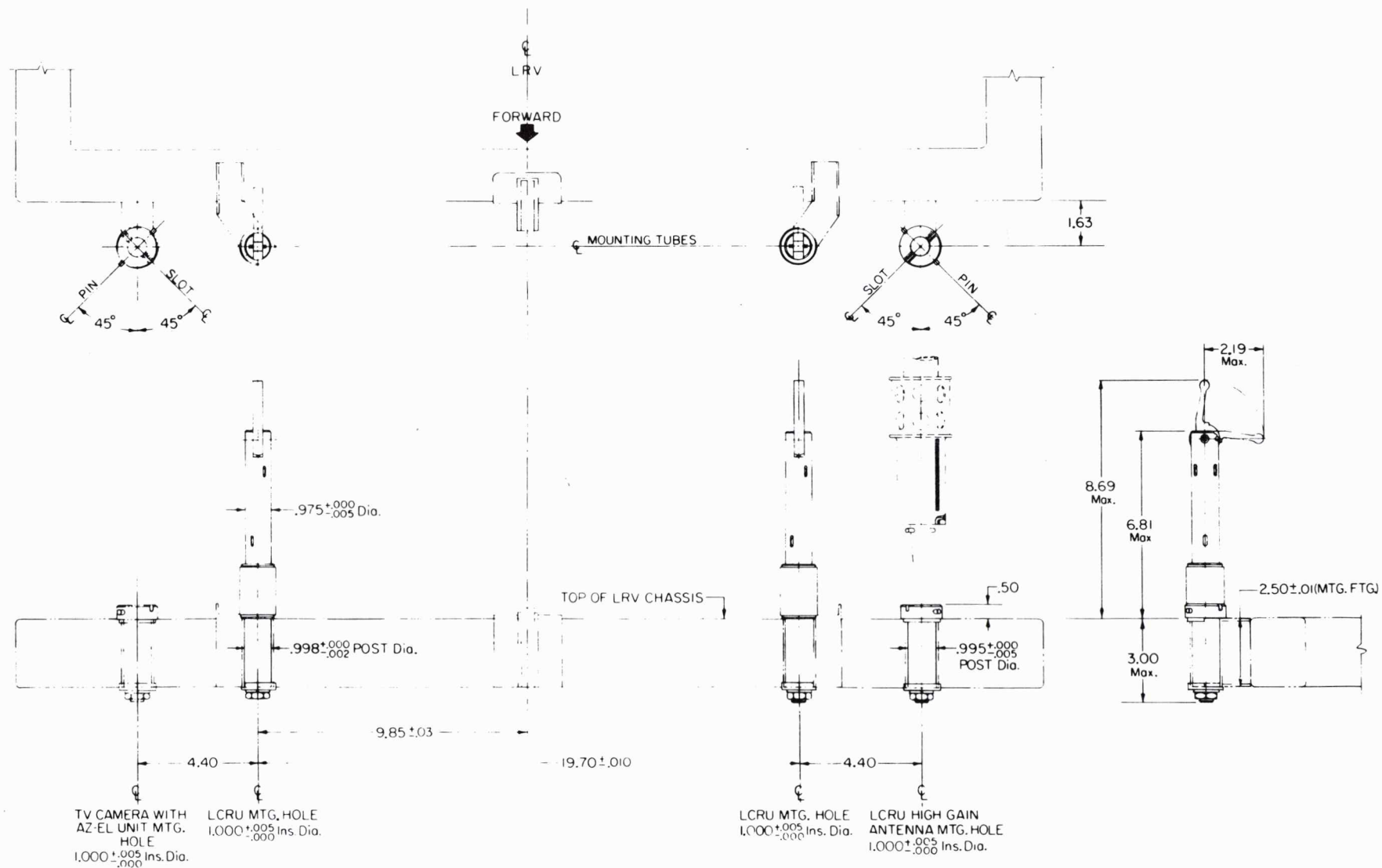
LCRU SUBSYSTEM/LRV INTERFACE

8-26



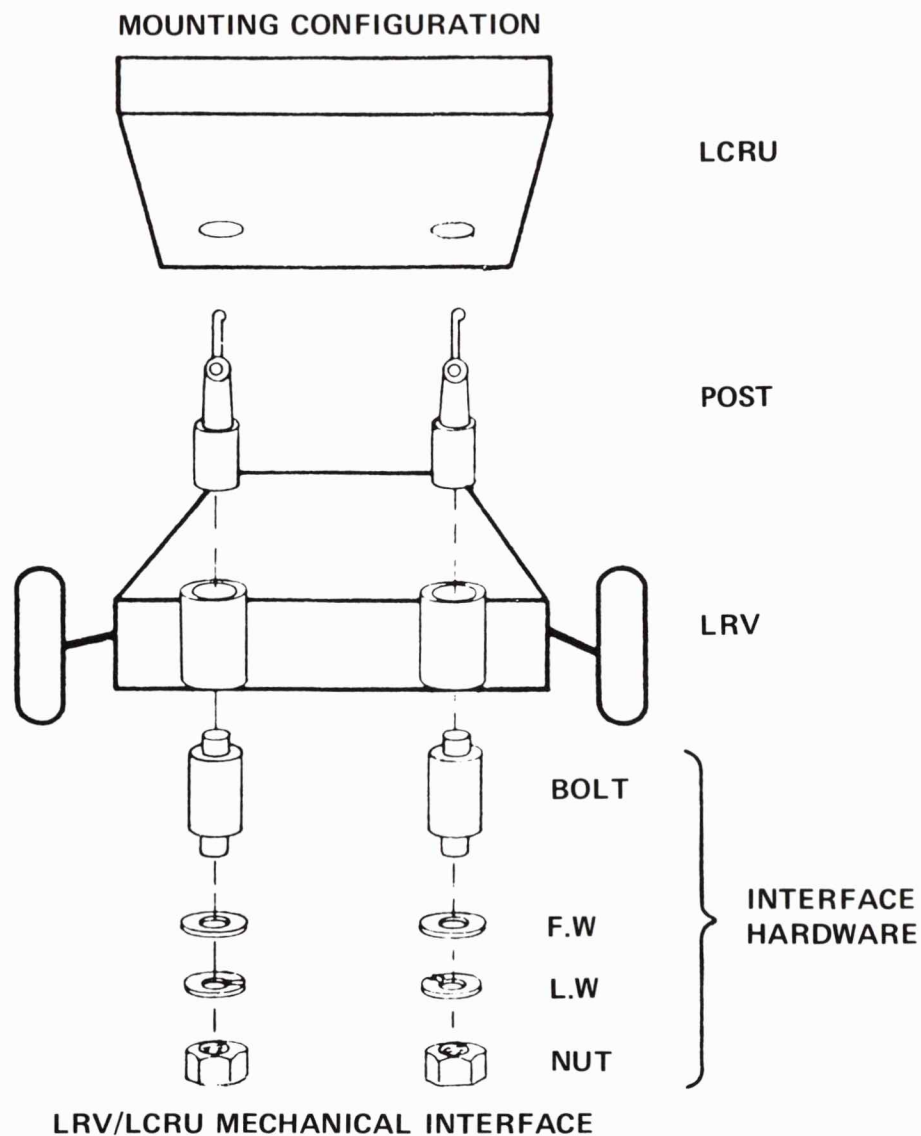
RCA

LCRU/LRV INTERFACE





LRV/LCRU MOUNTING INTERFACE TOLERANCE ANALYSIS

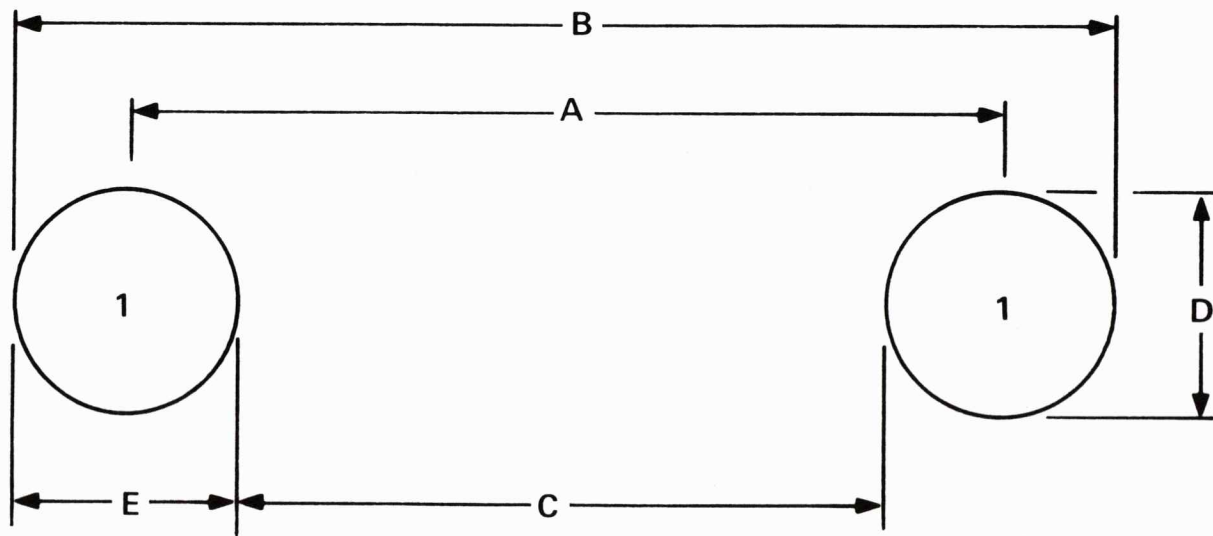




LCRU LRV INTERFACE TOLERANCE ANALYSIS

INTERFACE DIMENSIONS

	⌀ DISTANCE A IN.	DIAMETERS, D IN.
LRV TUBES	$19.700 \pm .010$	$1.000 \begin{smallmatrix} +.005 \\ -.000 \end{smallmatrix}$
LCRU HOLES	$19.700 \pm .010$	$1.000 \begin{smallmatrix} +.005 \\ -.000 \end{smallmatrix}$
BOLT	—	$0.998 \begin{smallmatrix} +.000 \\ -.002 \end{smallmatrix}$



DIMENSIONS REFERENCES



LCRU LRV INTERFACE TOLERANCE ANALYSIS

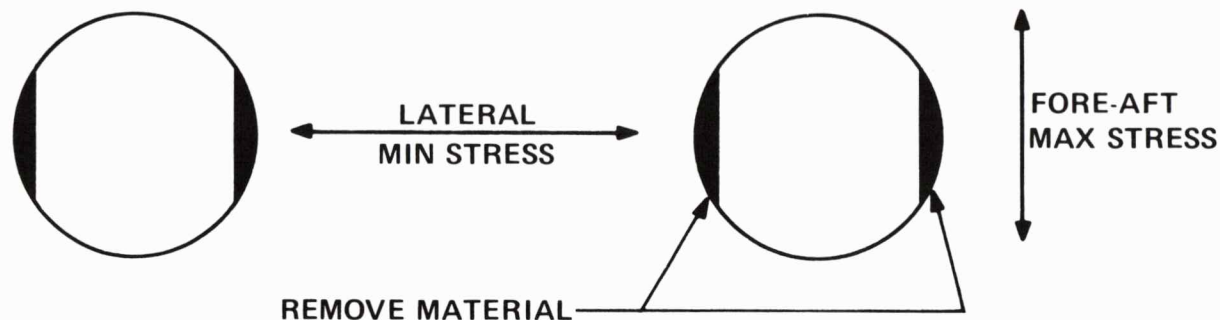
VARIABLES

- 1 LCRU HOLE DIA TOL
- 2 LCRU HOLE ϕ TOL
- 3 LRV HOLE DIA TOL
- 4 LRV TUBE ϕ TOL
- 5 BOLT DIA TOL
- 6 POST ASSY TIR
- 7 TEMPERATURE EFFECT

$\pm .024$ POTENTIAL INTERFERENCE

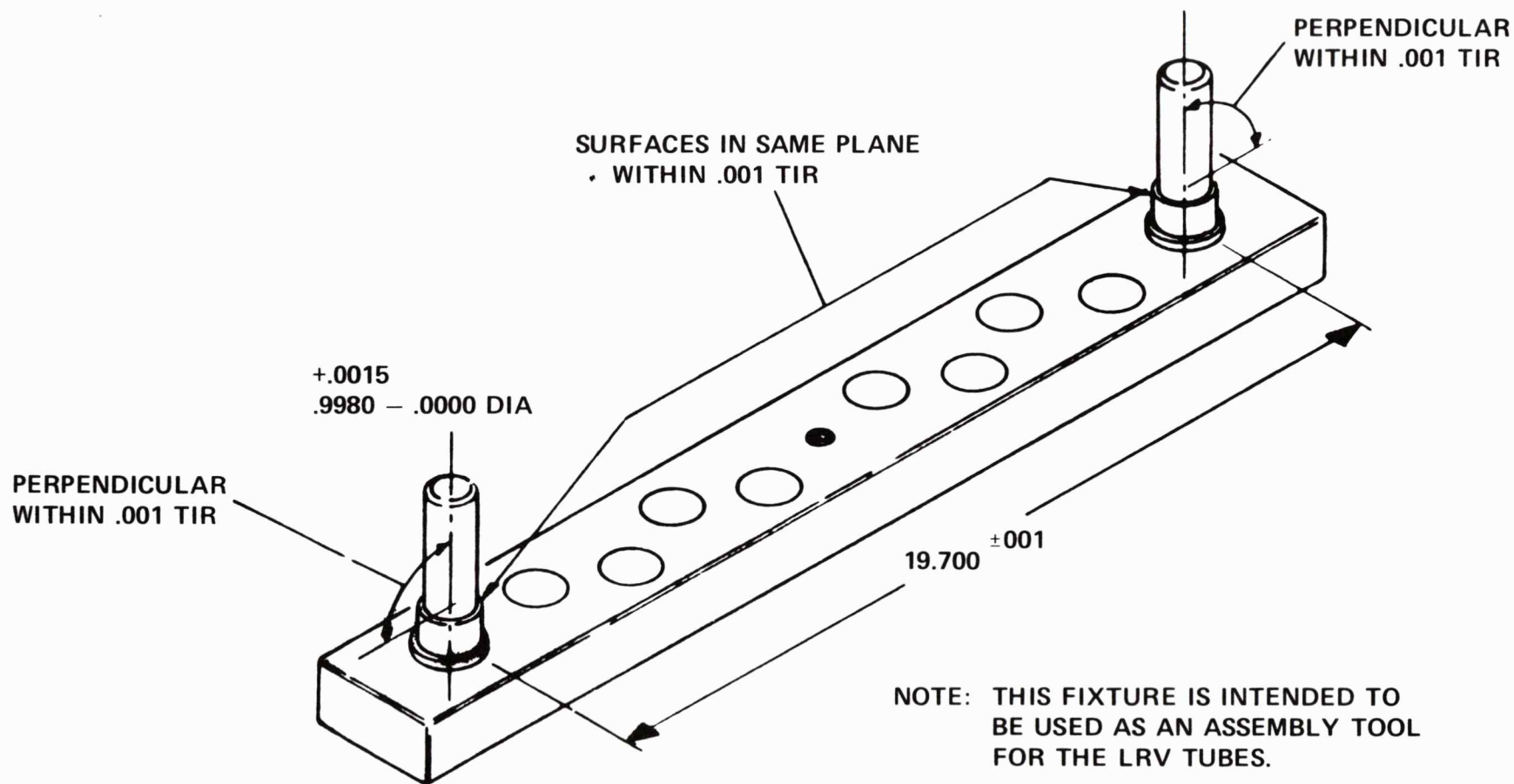
RECOMMENDATIONS

1. ASSEMBLE TUBES TO LRV WITH INTERFACE FIXTURE
RCA DWG NO. 8370835-501-X100
2. INSPECT FOR DIMENSIONS B, C, & D
3. REDUCE WIDTH OF UPPER PORTION OF POST





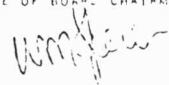
LCRU/LRV INTERFACE FIXTURE



REF: DWG. NO. 8370835-501-X100



LRV INTERFACE

TYPE OF REVIEW: IIC-CDR		REVIEW ITEM DISPOSITION		NUMBER: PCDR-13
VEHICLE:				COORDINATION:
DATE: 9/1/80		INITIATOR: T. H. Chase		ORGANIZATION: BOEING/PDS
		SYSTEM: LCRU		TEAM NAME: Mechanical
DISCREPANCY/PROBLEM		TITLE: LRV/LCRU Mounting Interface Tolerance Analysis		
The tolerance analysis used a value of 0.01 for the tolerance on the spacing of the holes on the LRV chassis on which the LCRU will be mounted. This is consistent with IRN R-6 of 13M07391, the controlling ICD. However, the use of RCA tooling to attach the holes should result in a lower tolerance by an order of magnitude.				
JUSTIFICATION: The tolerance analysis does not represent the actual configuration which will be controlled by the RCA tooling.				
RECOMMENDATION: The tolerance analysis should be repeated using a more realistic number for this tolerance. The ICD's and engineering drawings should be flagged to indicate that the dimensions are controlled by the jig.				
CONTRACTOR'S COMMENT: THE ASSEMBLY TOOL IS DESIGNED TO PRODUCE AN ASSEMBLY CONFIGURATION SAFELY WITHIN THE 0.01 TOLERANCE PERMITTED BY THE CONTROLLING I.C.D. HOWEVER, THE I.C.D., NOT THE ASSEMBLY TOOL, SETS THE CRITERIA FOR ACCEPTANCE. IF A CHANGE (AS RECOMMENDED BY THE REVIEWER) IS MADE IN THE BOEING ENGINEERING DRAWINGS AND THE CONTROLLING I.C.D, THE TOLERANCE ANALYSIS WILL BE REVISED ACCORDINGLY.				
TEAM CAPTAIN RECOMMENDATION				
CATEGORY	REMARKS			
ACTION				
SUSPENSE				
BOARD ACTION				
CATEGORY	REMARKS			
ACTION				
SUSPENSE				
ACTION	☐ Approved		SIGNATURE OF BOARD CHAIRMAN: 	
SUSPENSE	☐ Disapproved			

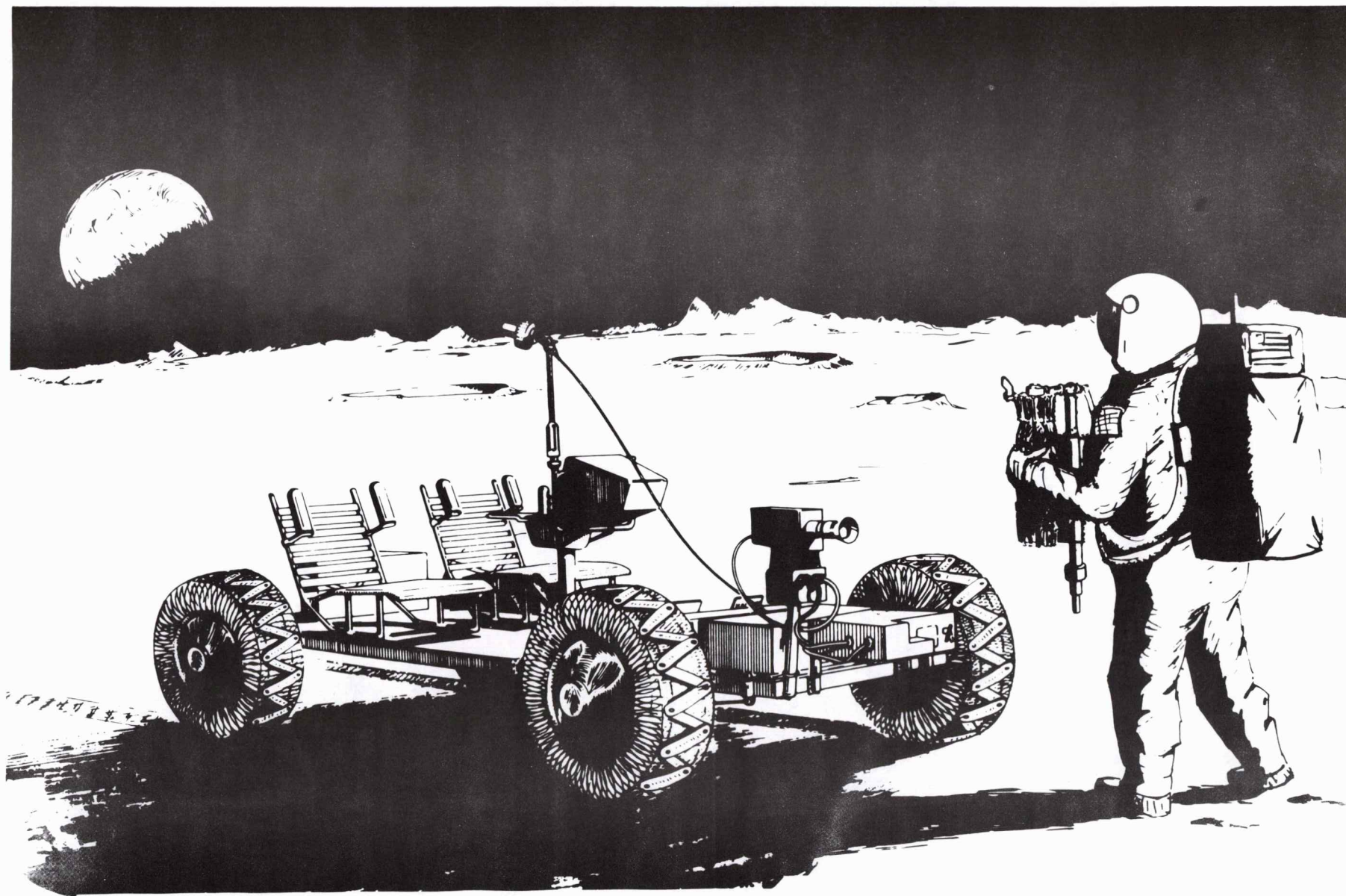


LRV INTERFACE DEPLOYMENT PROCEDURE

- MESA DEPLOYED
- LRV DEPLOYED
- DEPLOY LCRU ON LRV
- DEPLOY HGA ASSEMBLY ON LRV
- DEPLOY LGA ASSEMBLY ON LRV
- MATE ANTENNA AND TV/POWER CONNECTORS

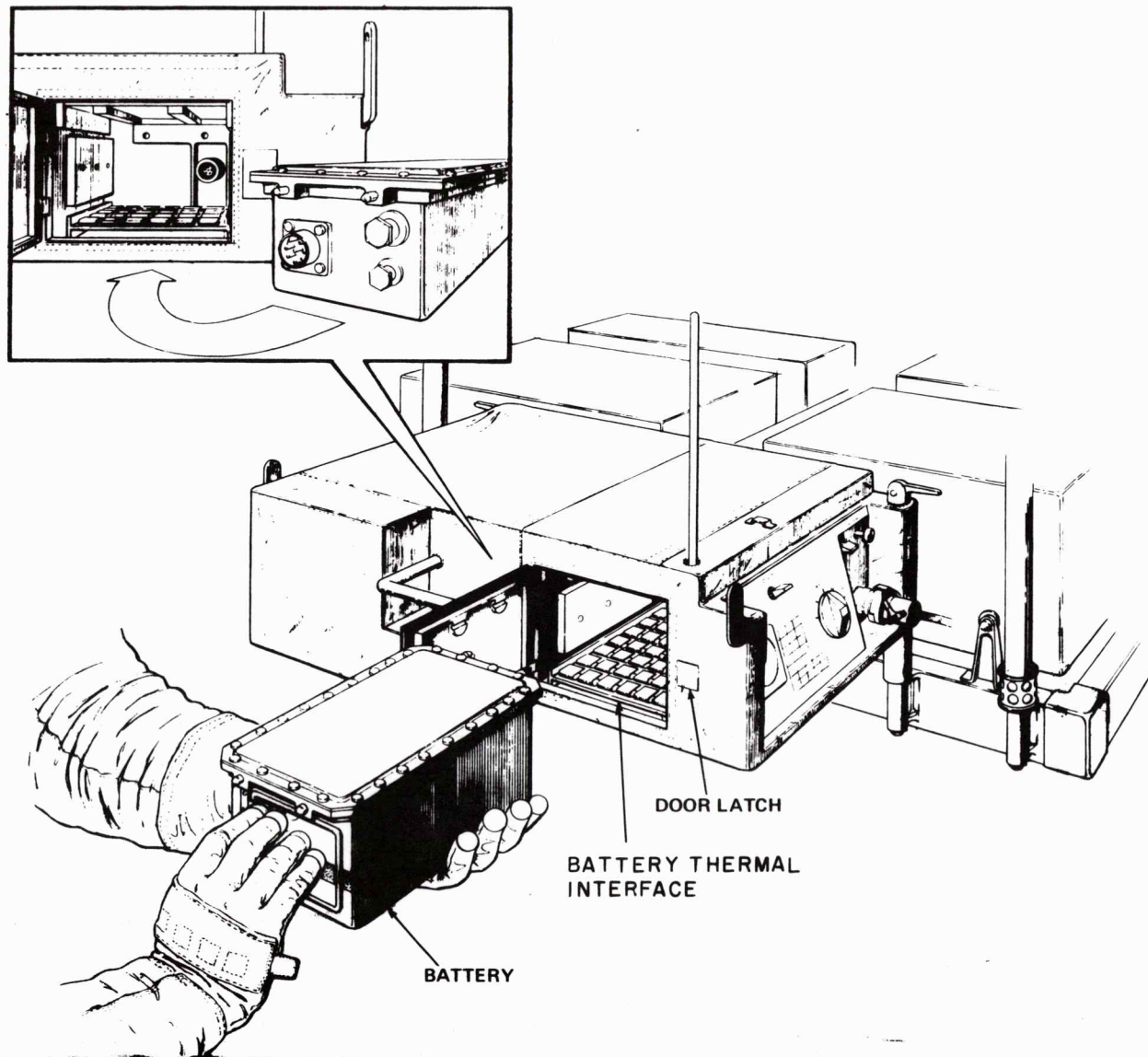
RCA

LRV INTERFACE HGA DEPLOYMENT



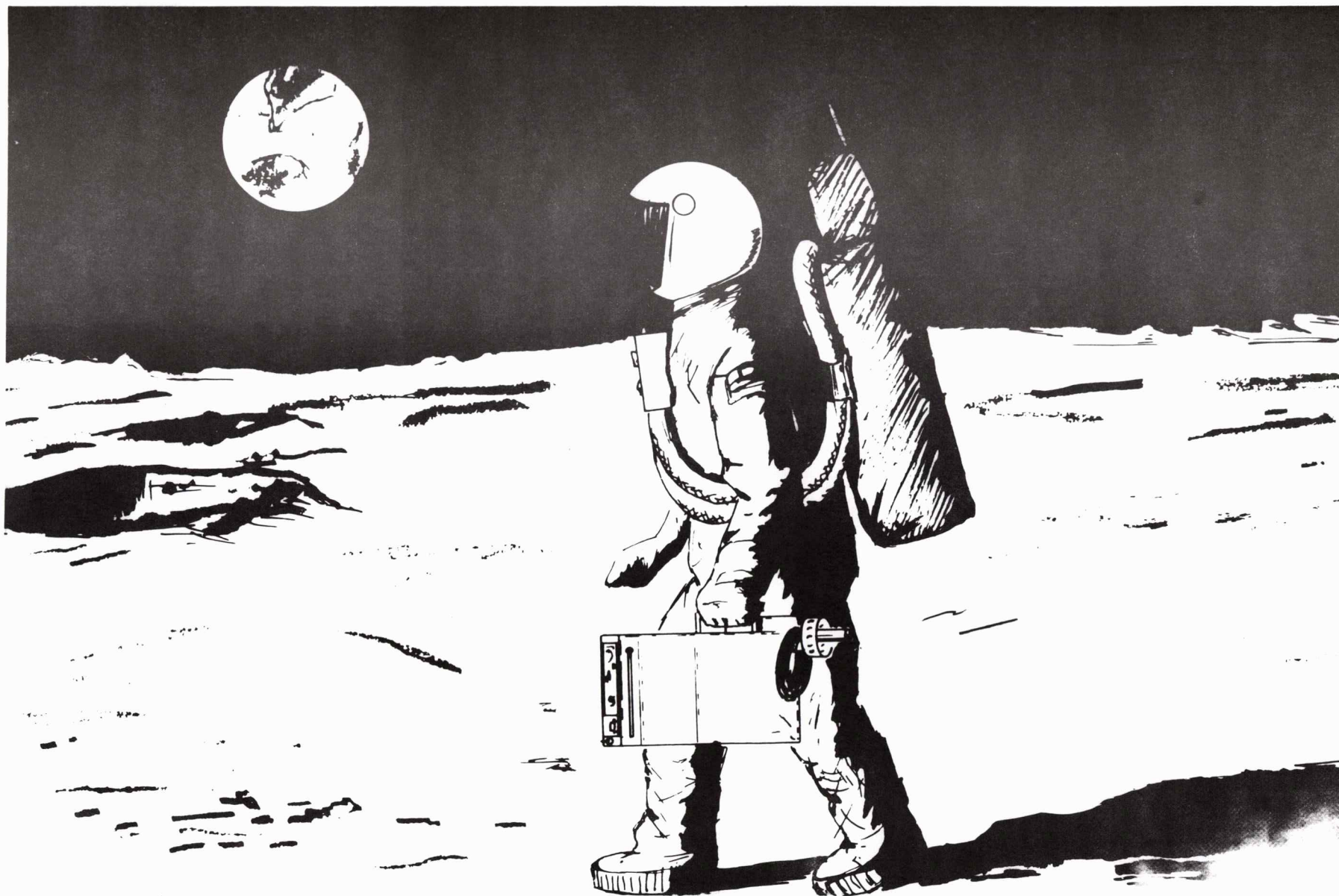


LCRU BATTERY REPLACEMENT



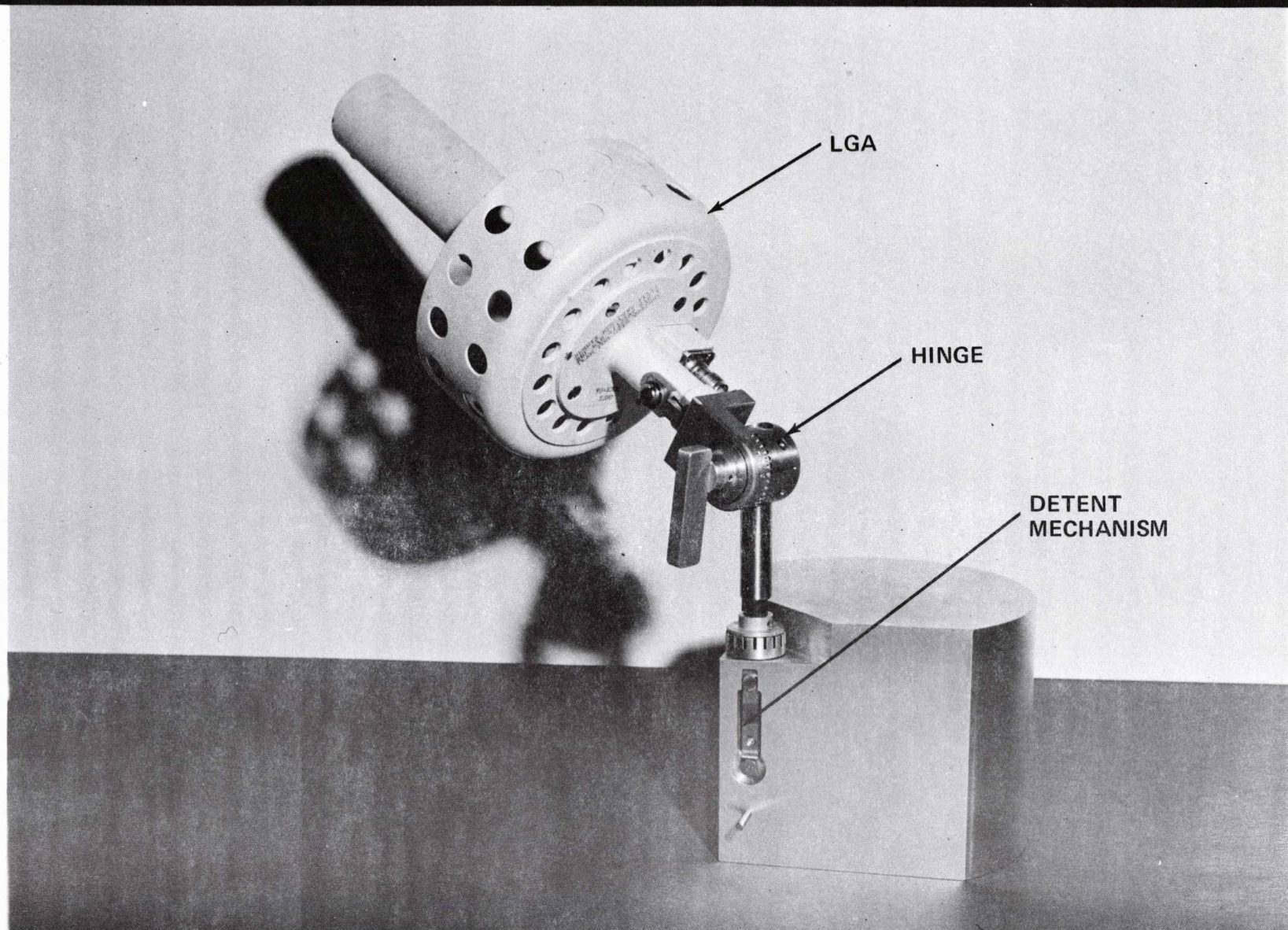
RCA

LCRU HAND CARRY MODE



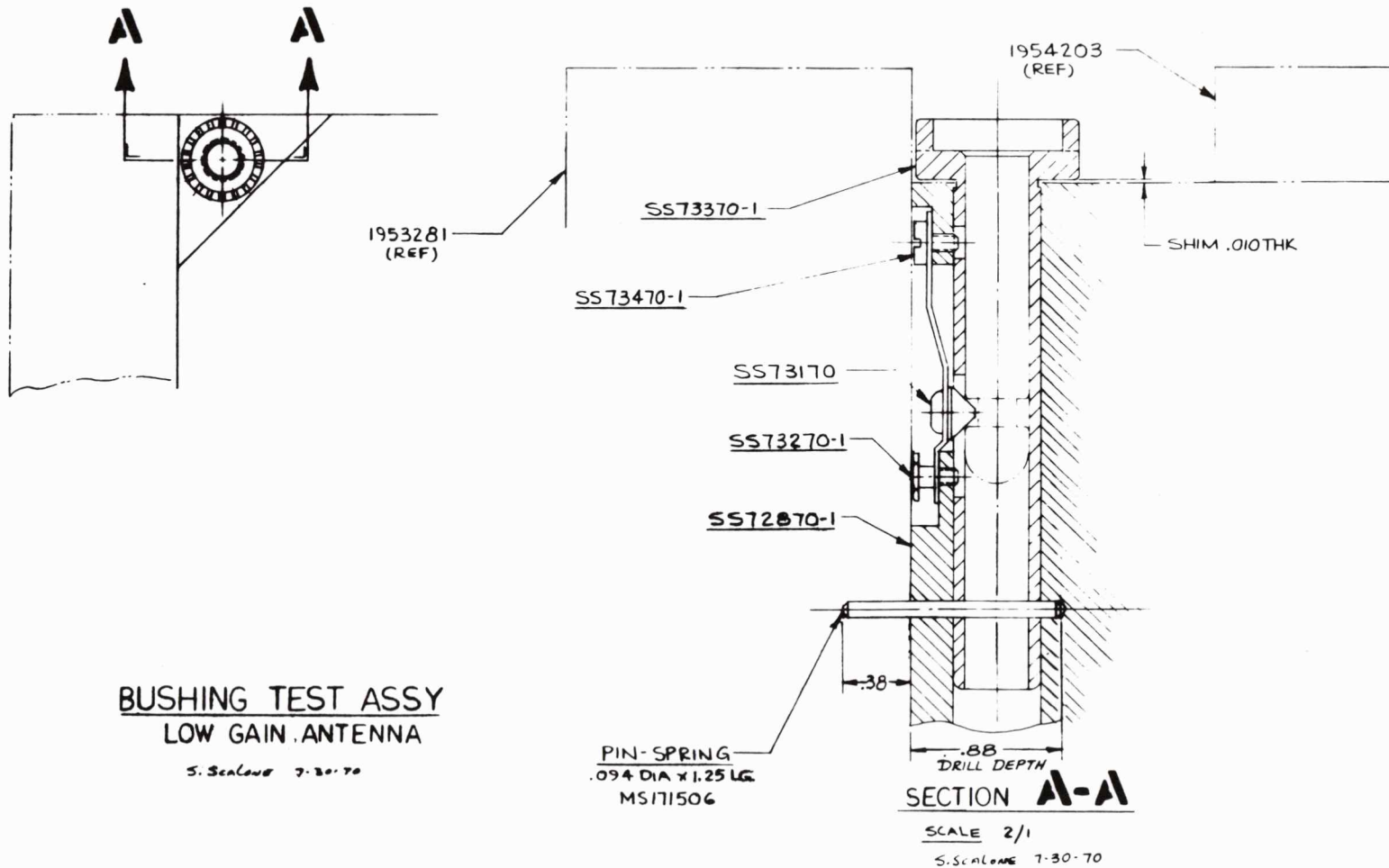


LCRU/LGA MECHANICAL INTERFACE





LGA-LCRU CASE INTERFACE HAND CARRY MODE





LCRU UNIT DESIGN

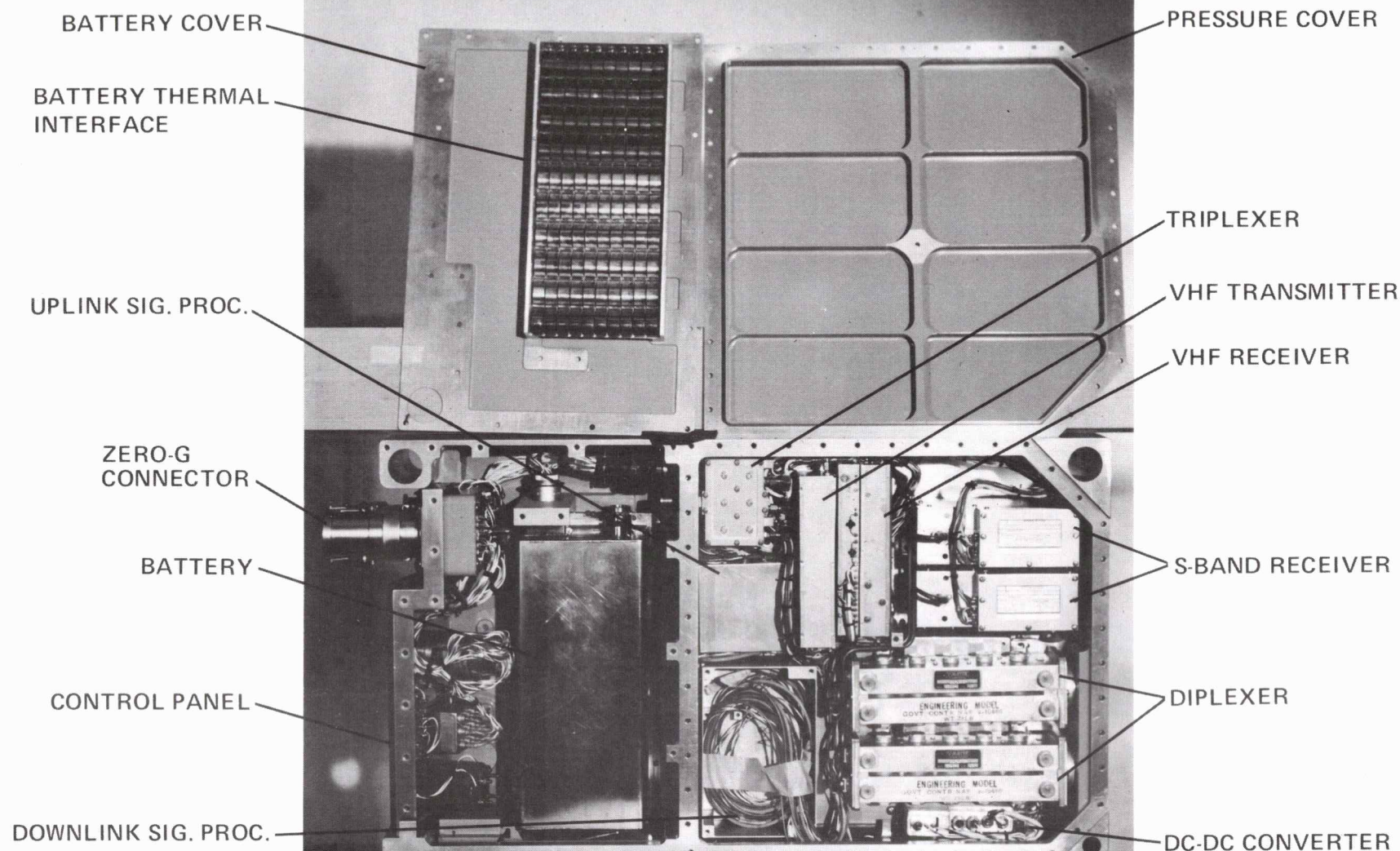
MECHANICAL DESIGN STATUS

- | | |
|--|--|
| • SUBASSEMBLIES | OUTLINE CHANGES
INTERNAL CONSTRUCTION DETAILS
THERMAL ANALYSIS |
| • LCRU CASE CONFIGURATION
AND PACKAGING | TOP ASSEMBLY DWG COMPLETE
BATTERY THERMAL INTERFACE
ADDED. |
| • CONTROL PANEL | REVISED TO PROVIDE INCREASED
CLEARANCE FOR ZERO-G
CONNECTOR. |
| • PRESSURIZATION DESIGN | 100% NITROGEN |
| • CASE STRESS ANALYSIS | PRELIMINARY DATA ON
PRESSURE TEST CASE |



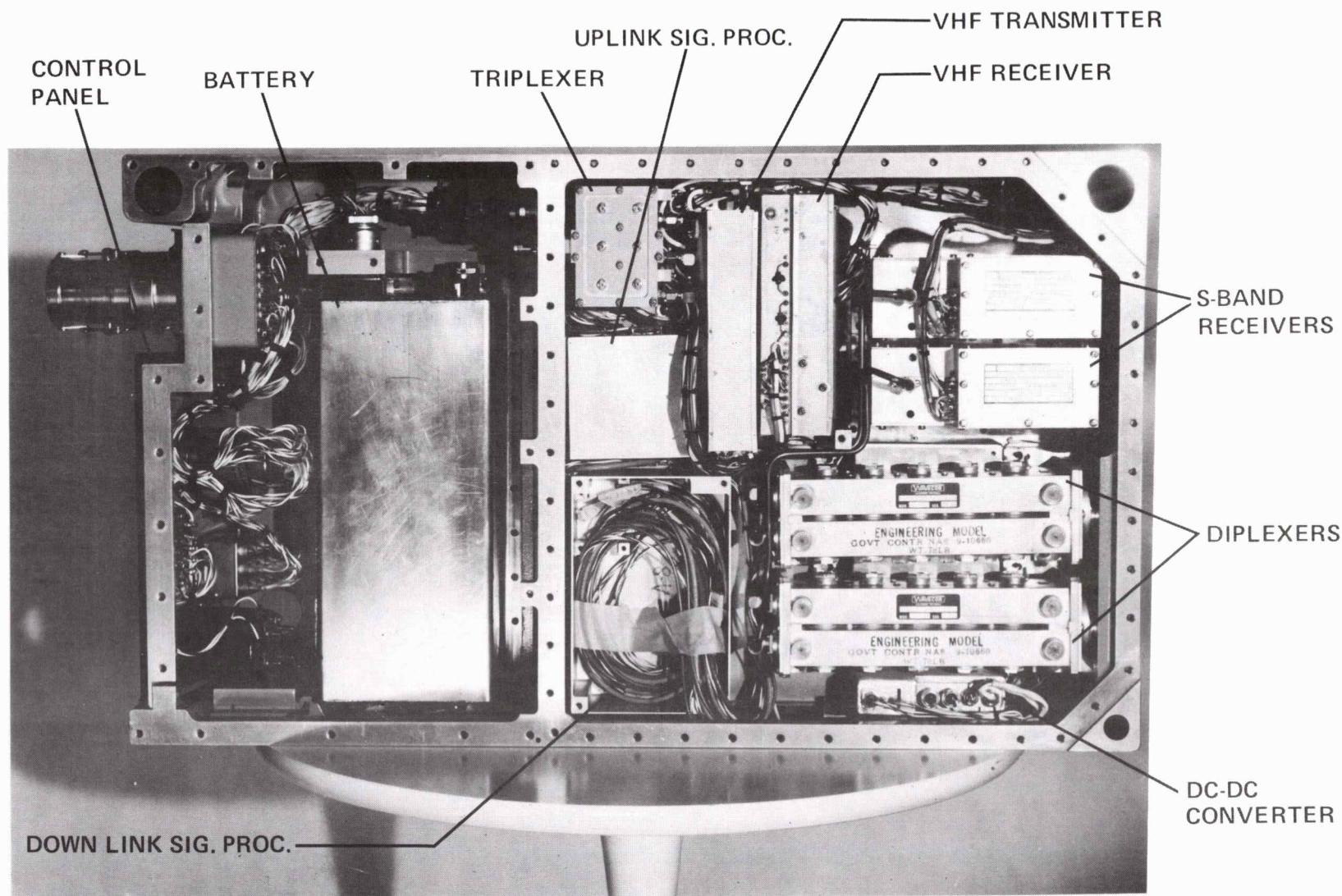
LCRU ENGINEERING MODEL BOTTOM VIEW (COVERS REMOVED)

8-40





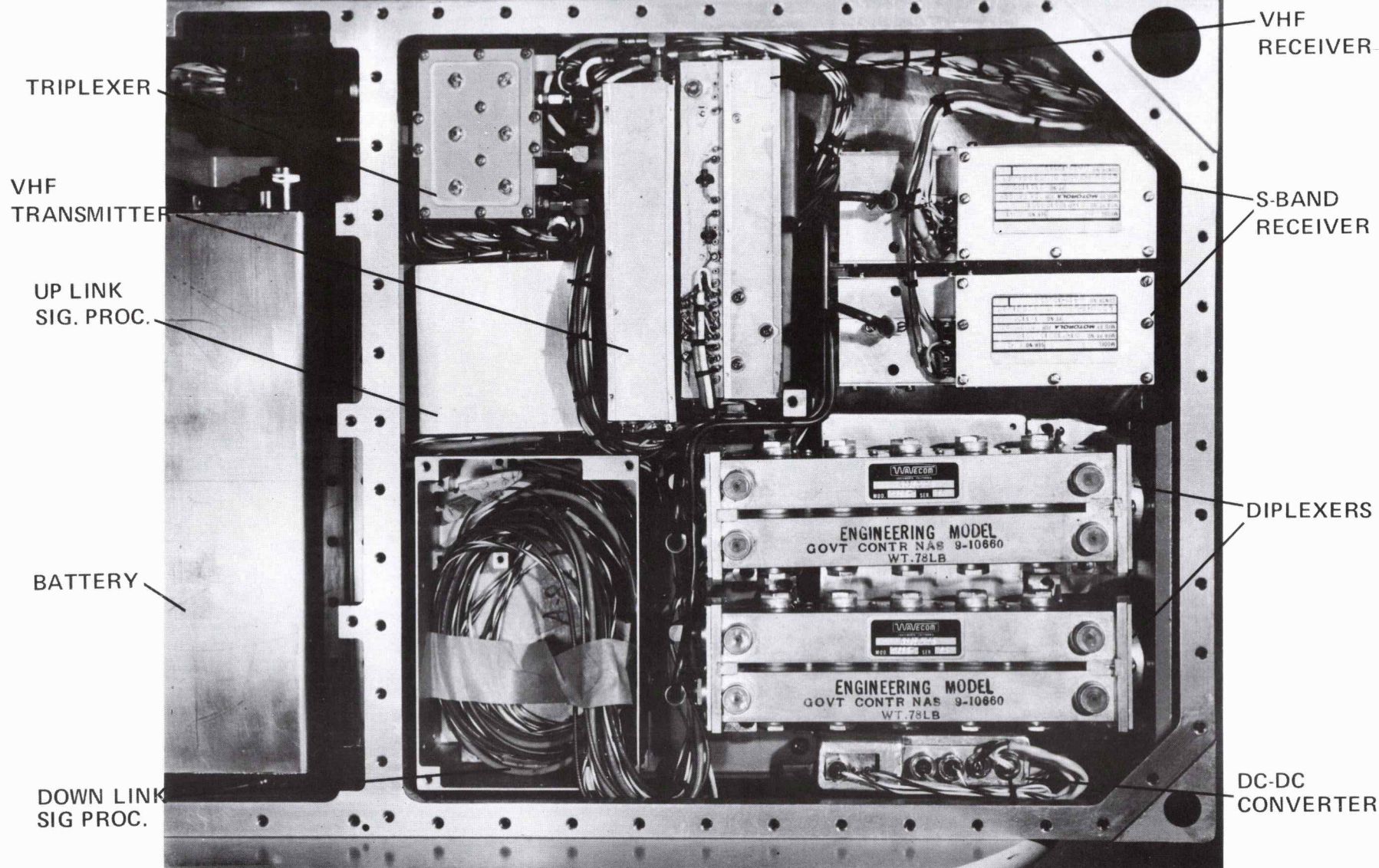
LCRU ENGINEERING MODEL BOTTOM VIEW (COVERS REMOVED)



RCA

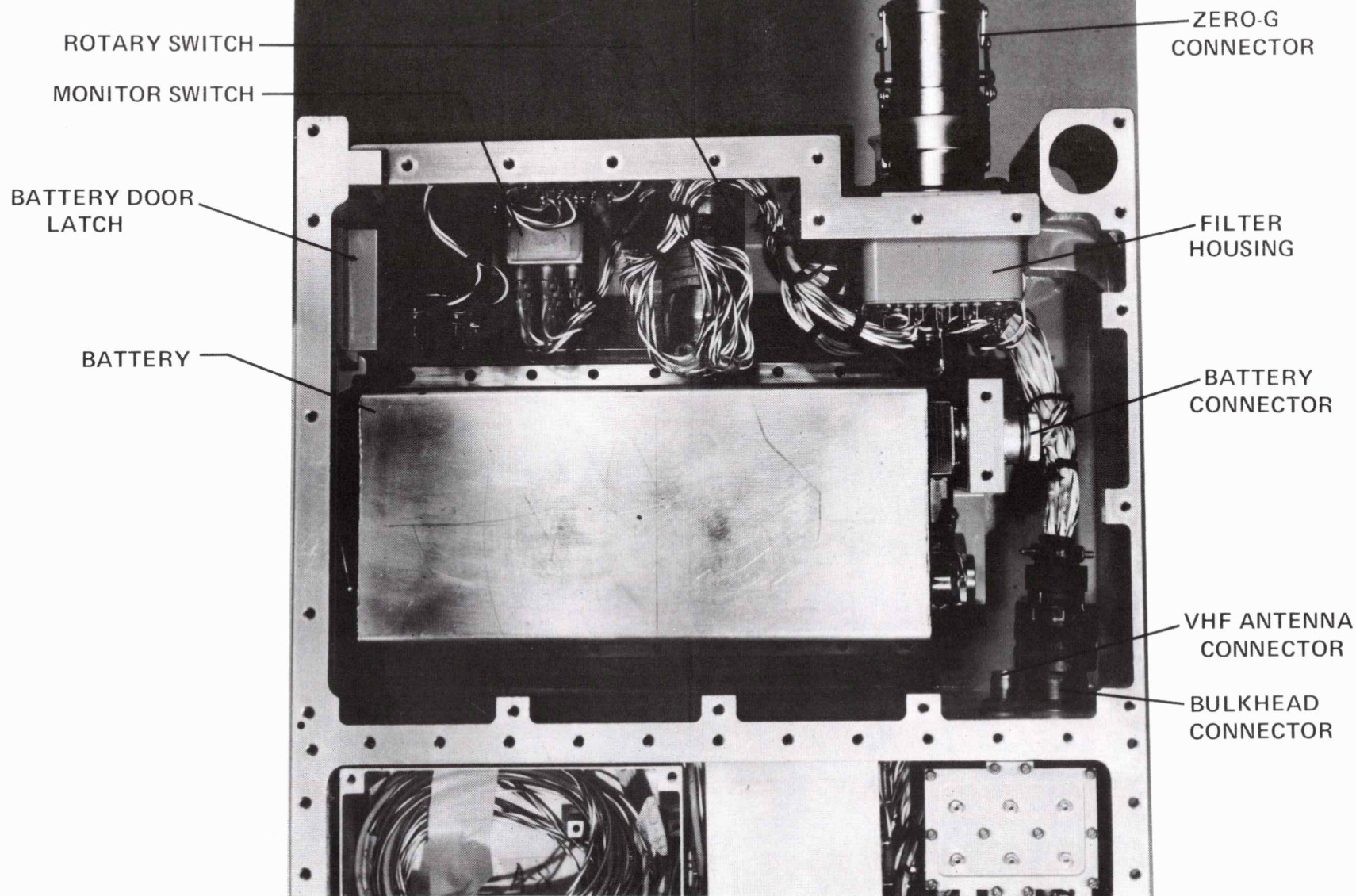
LCRU ENGINEERING MODEL BOTTOM VIEW (COVER REMOVED)

8-42



RCA

LCRU ENGINEERING MODEL BOTTOM VIEW (COVERS REMOVED)





COMPONENT TEMPERATURES

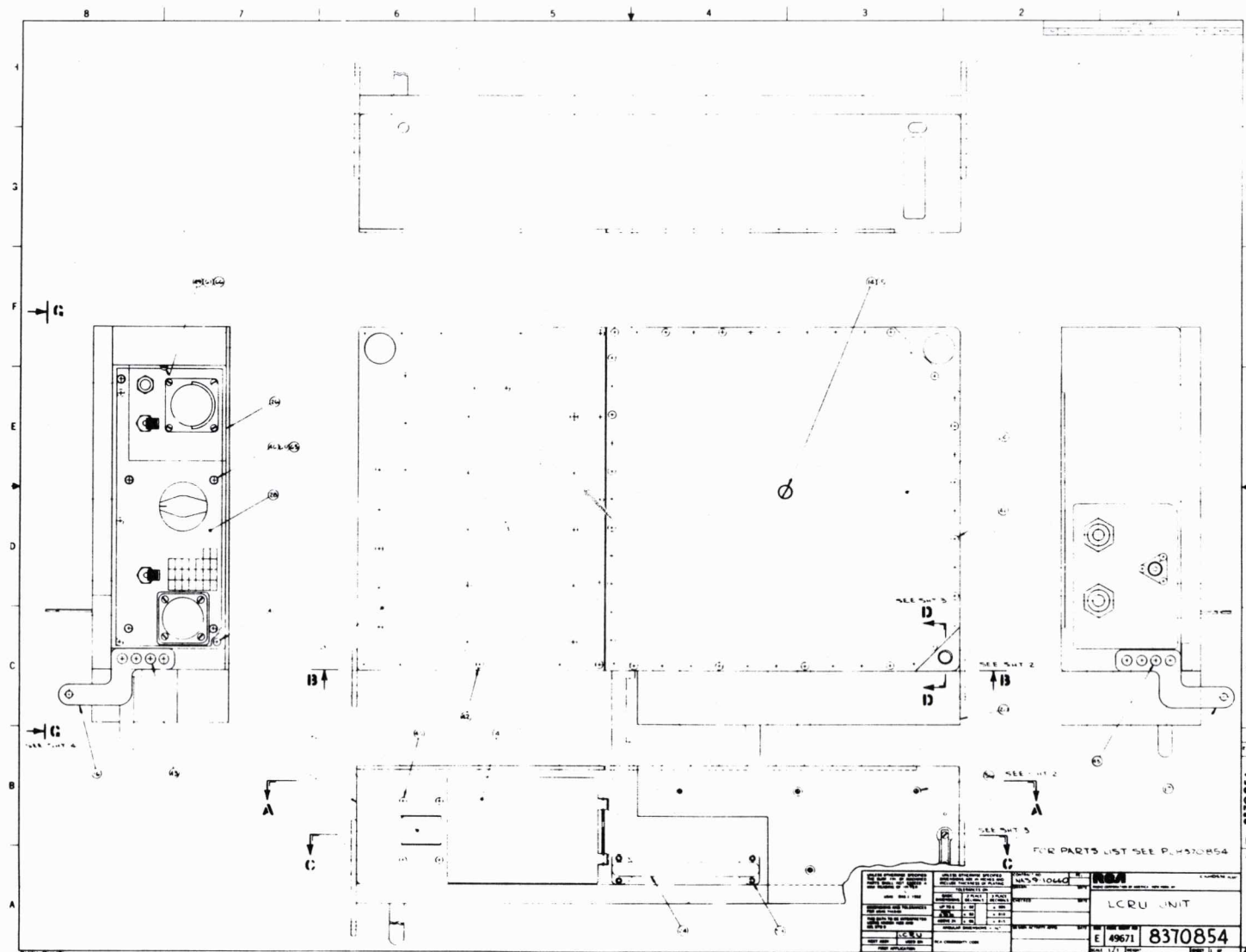
8-44

ITEM	VENDOR	COMPONENT	DISSIP. W.	θ c-j °C/W	ΔT c-j °C	LOCAL MODULE ΔT °C	LOCAL LCRU TEMP.* °C	ELEMENT TEMP. °C	LIMIT TEMP. °C
VHF Transmitter	RCA-CSD	Q4(2N3866)	.25	32	8	5	70	83	100
		Q5(2N3866)	.45	35.5	16	7	70	93	100
		Q6(2N3375)	.80	15	12	7	70	89	100
VHF Receiver	RCA-CSD	U1(LM101H)	.05	45	3	5	70	78	100
Voltage Regulator	RCA-CSD	VR1, VR2(UZ710)	.20	-	-	20	60	80	86
		Q1(5J1682H)	3.00	4.3	13	6	60	77	100
		Q2(2N2905)	.08	58	5	2	60	67	100
DC-DC Converter	RCA-CSD	Q1(1768-1030) Westing.	11.3	1.0	11	24	60	95	100
		T1(XT12434)	1.32	-	-	8	60	68	86
		C2(29F3292) GE	1.00	-	-	9	60	69	86
		C3(29F3292) GE	1.00	-	-	8	60	68	86
		CR1(1N3891)	1.36	2	3	8	60	71	100
		CR2(1N3910)	5.23	1	5	8	60	73	100
		Q2(2N2880)	.40	3.3	1	7	60	68	100
Up-Link Signal Processor	RCA-CSD	Z1-Z3(LM101H)	.05	45	3	0	70	73	100
Down-Link Signal Processor	RCA-CSD	Q1(2N2219A)	.22	50	11	6	70	87	100
14.5 KHz VCO	SOMEX	CR1(1N821)	.03	-	-	13	70	83	86
1.25 MHz VCO	SCI	Q2(2N2222A)	.06	83	5	14	70	89	100
		Q9(2N2501)	.08	145	12	11	70	93	100

* Worst Case Temperature at End of 3rd EVA.

RCA

LCRU UNIT 8370854 (SHEET 1 OF 4)

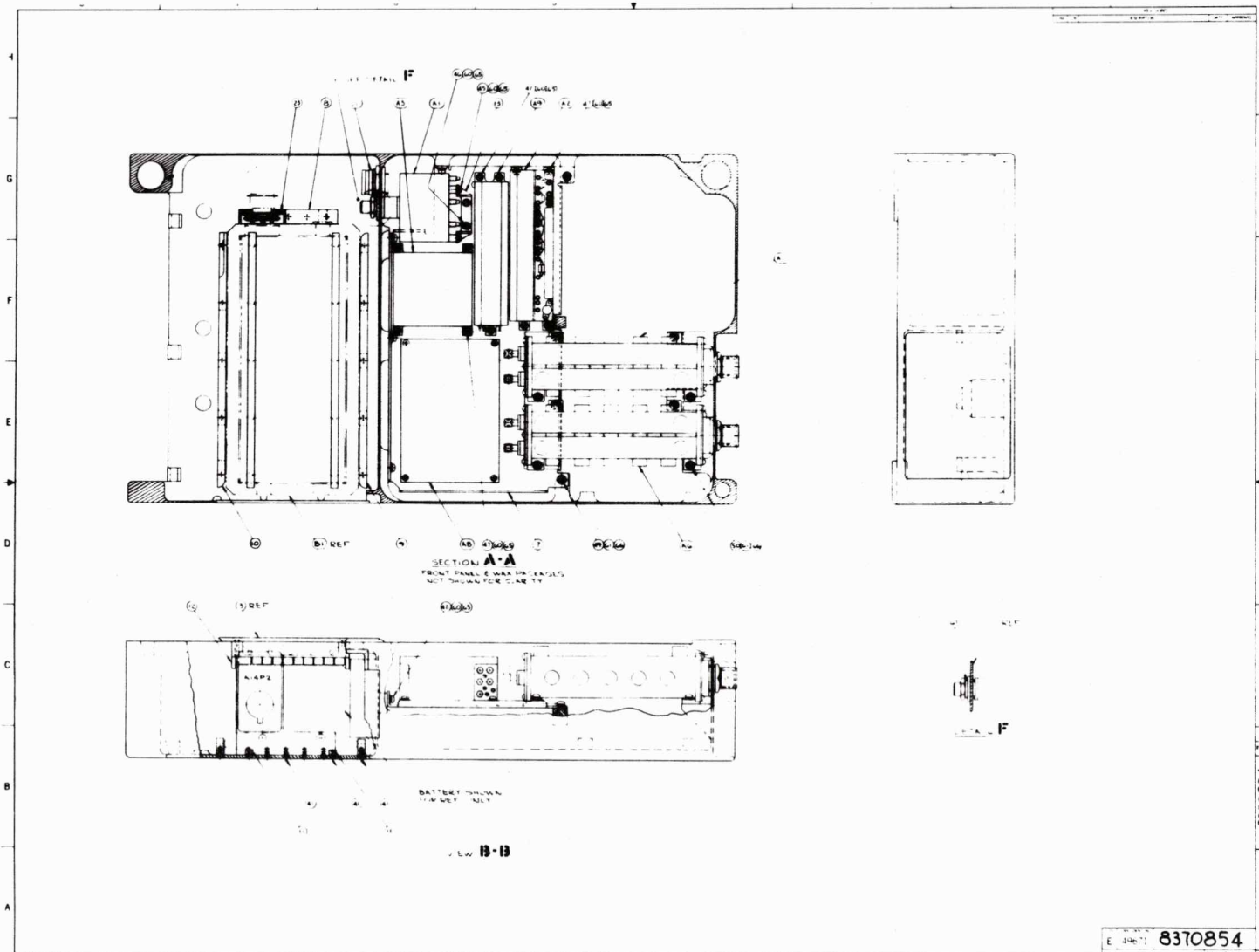


8-45

FOR PARTS LIST SEE PCH570854		RCA	
LCRU UNIT		8370854	
E 49671		8370854	

RCA

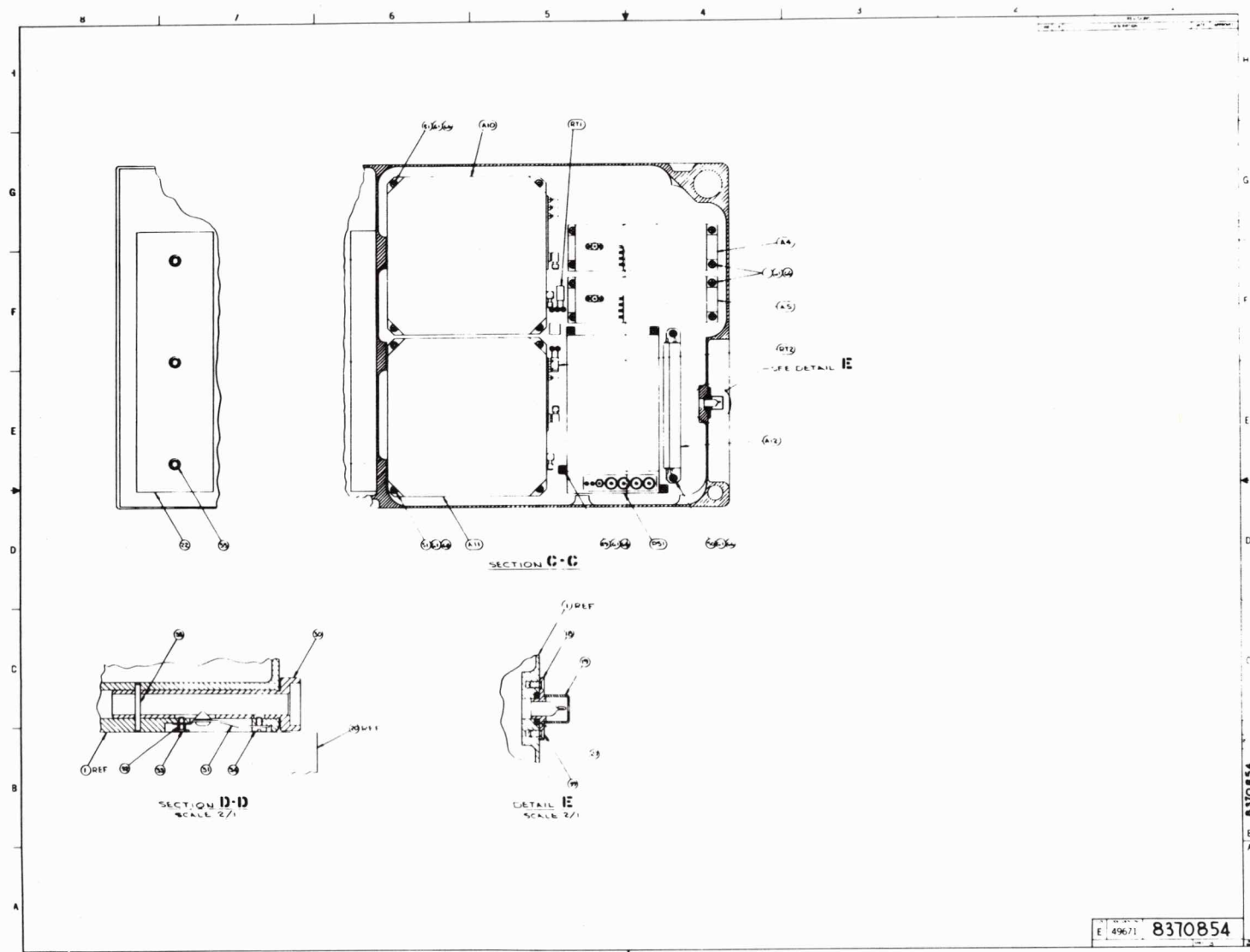
LCRU UNIT 8370854 (SHEET 2 OF 4)



RCA

LCRU UNIT 8370854 (SHEET 3 OF 4)

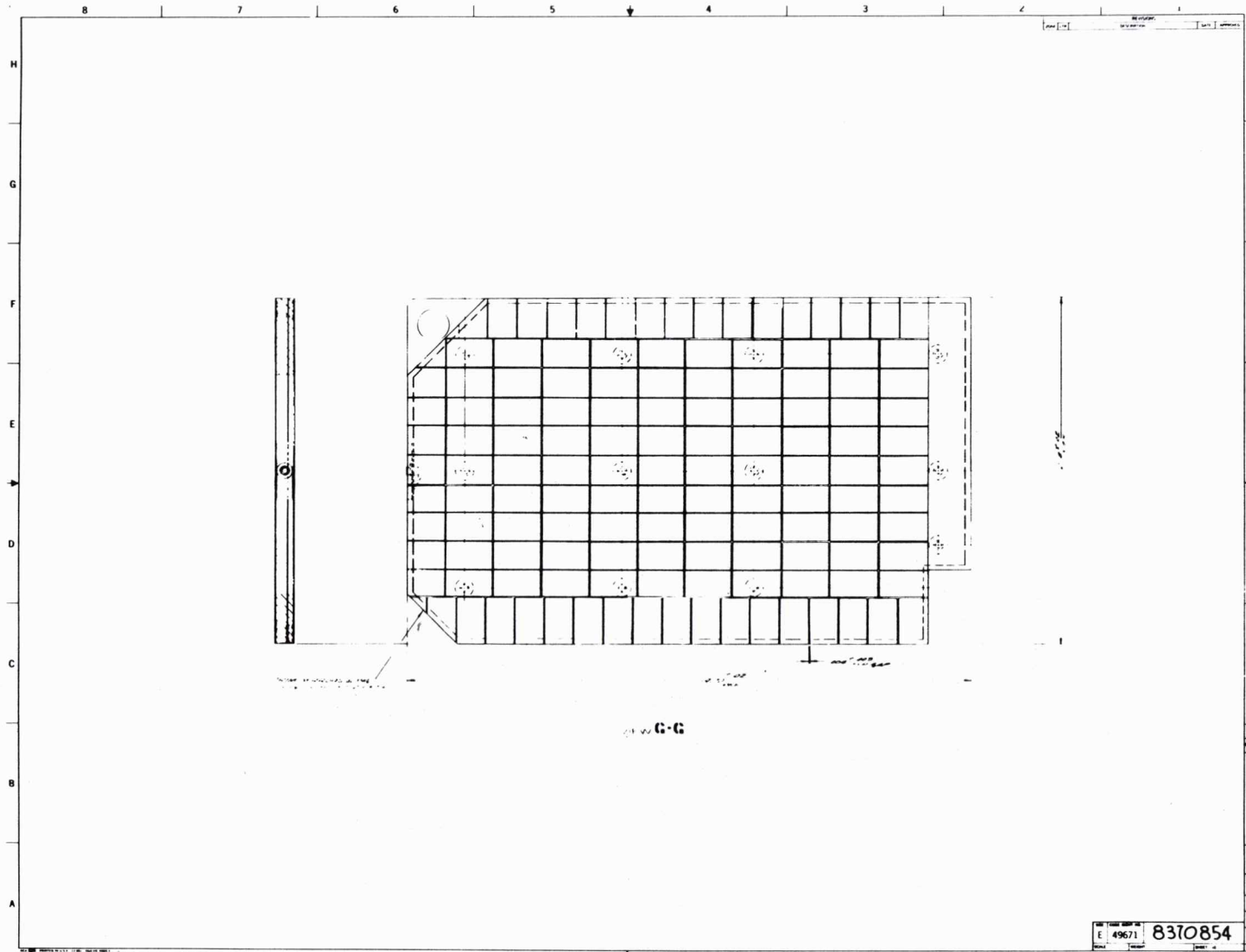
8-47



RCA

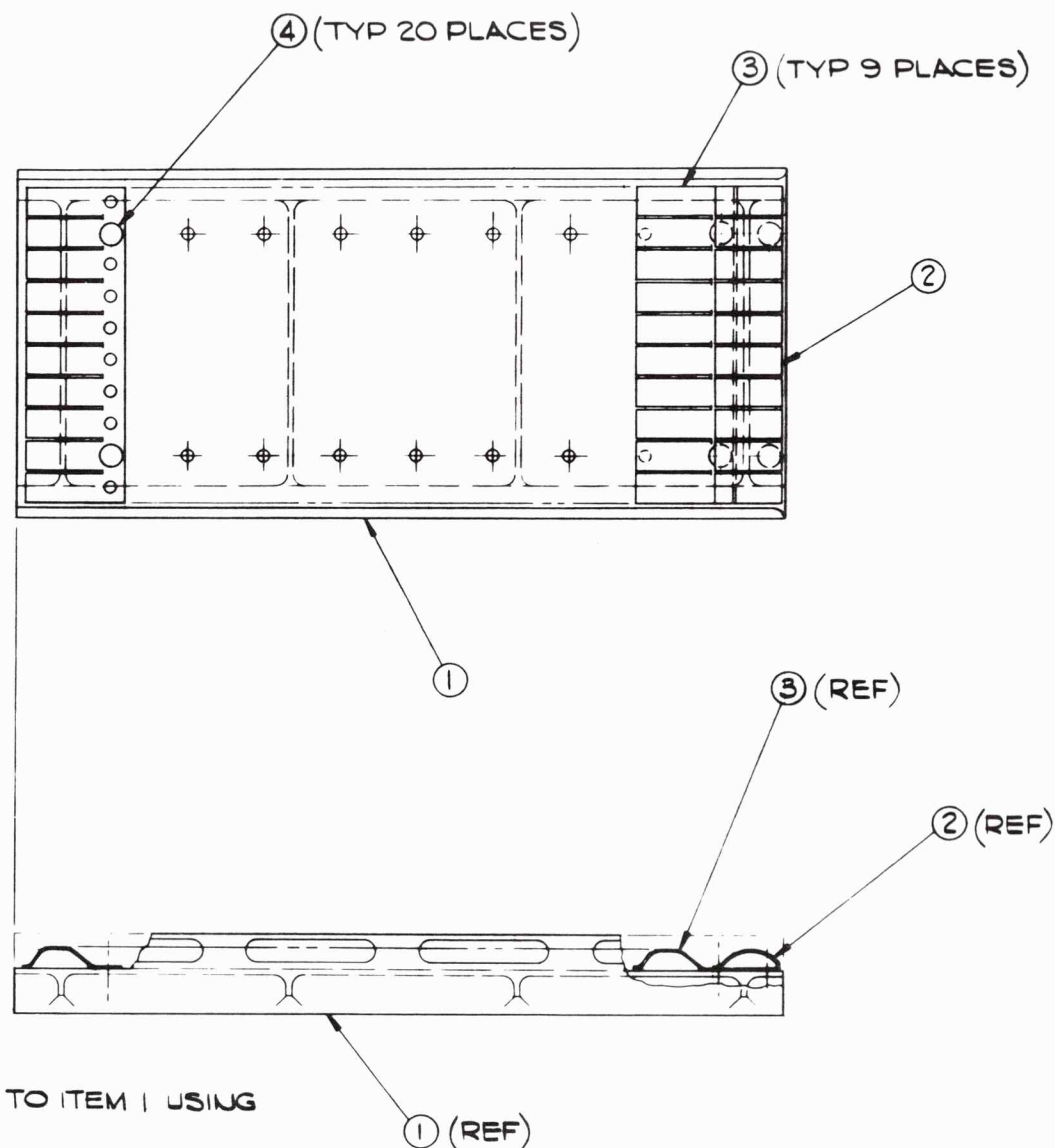
LCRU UNIT 8370854 (SHEET 4 OF 4)

8-48





LCRU BATTERY THERMAL INTERFACE 8670997

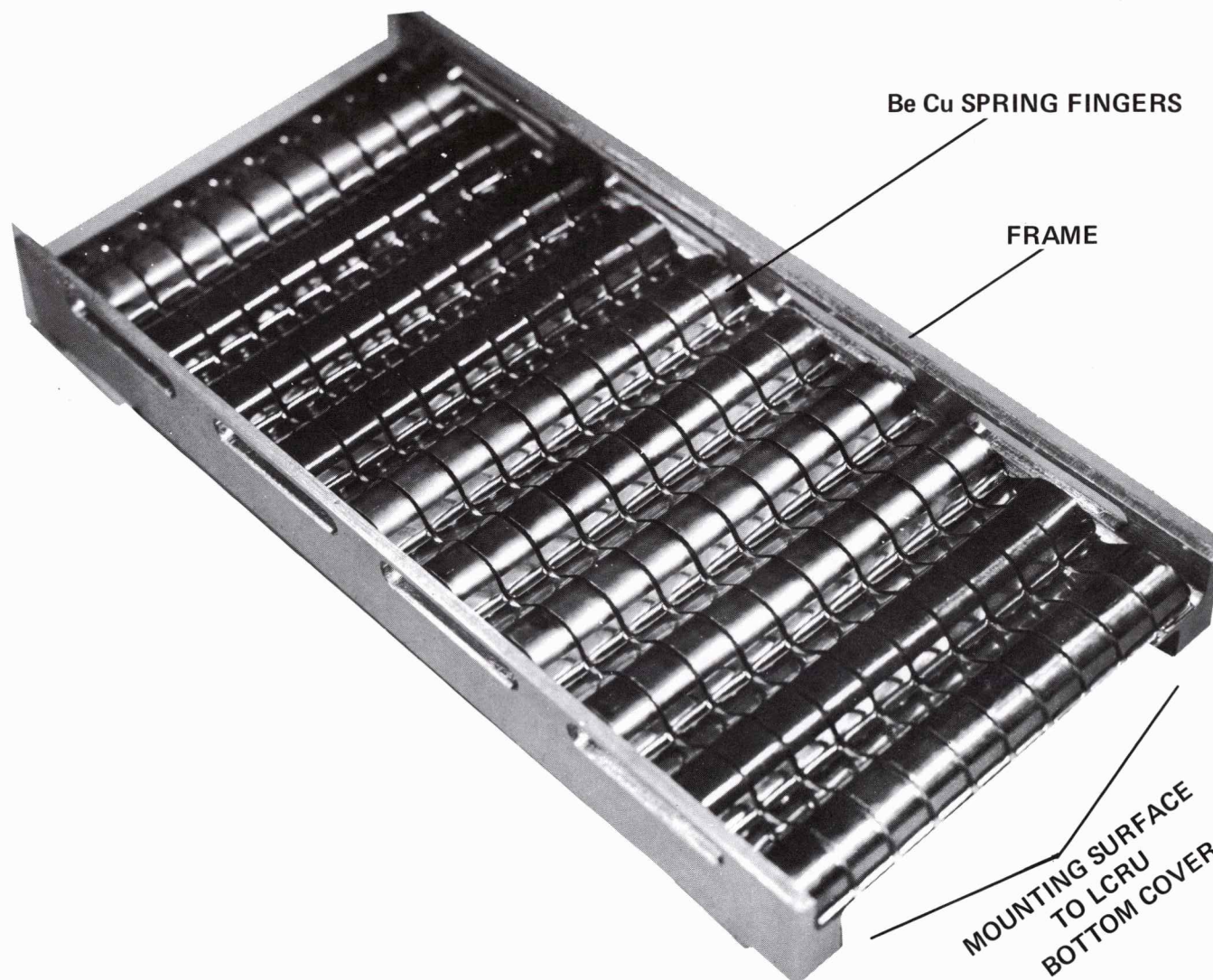


NOTES:

1. SOLDER ITEMS 2 & 3 TO ITEM 1 USING ITEM 5.



LCRU BATTERY THERMAL INTERFACE MECHANICAL MOCK-UP





LCRU MECHANICAL DESIGN

8-51

PROBLEM AREAS

IMPACT OF FINAL VIBRATION TESTING ON SUBASSEMBLIES.



LCRU UNIT WEIGHT ANALYSIS ENGINEERING MODEL

<u>ITEM</u>	<u>WEIGHT, LB.</u>
LCRU UNIT ENGINEERING MODEL	43.000
LESS: WAX PACKAGES THERMAL BLANKET BATTERY HEAT SINK VHF ANTENNA	
WAX PACKAGES	9.270
THERMAL BLANKET	.875
BATTERY HEAT SINK	.750
VHF ANTENNA	.250
TOTAL LCRU UNIT	<u>54.145</u>



LCRU UNIT WEIGHT ANALYSIS

ITEM	SUBASSEMBLY	WEIGHT, LBS.						
		PROP	TI-1	TI-2	PDR	TI-3	TI-4	CDR
1	VHF TRIPLEXER	0.30	0.30	0.30	0.30	PART OF	0.30	0.25
2	VHF TRANSMITTER	0.40	0.50	0.50	0.50	ITEM 30	0.50	0.40
3	VHF RECEIVER	0.50	0.50	0.50	0.50		0.50	0.40
4	PRI S BAND RECEIVER	1.50	1.50	1.50	1.50		1.50	1.40
5	SEC S BAND RECEIVER	NONE	1.50	1.50	1.50		1.50	1.40
6	FM/PM TRANSMITTER	3.12	2.62	2.62	2.62		2.62	2.67
7	PM/PM TRANSMITTER	3.12	2.62	2.62	2.62		2.62	2.64
8	DIPLEXER (1)	1.50	1.00	1.00	1.00		0.78	0.78
9	DIPLEXER (2)	1.50	1.00	1.00	1.00		0.78	0.78
10	UPLINK SIG. PROC.	0.30	0.50	0.50	0.50		0.50	0.30
11	DOWNLINK SIG. PROC.	0.30	0.80	1.00	1.00		1.00	1.00
12	DC-DC CONVERTER	NONE	NONE	2.50	2.50		2.00	2.00
13	VOLTAGE REGULATOR	0.20	0.25	0.25	0.25		0.25	0.25
14	BATTERY	9.25	9.40	9.40	9.40		9.00	9.00
15	WAX PACKAGES (3)	NONE	NONE	11.00	10.50	9.27	9.27	9.27
16	VHF ANTENNA	0.25	0.25	.19	0.25	PART OF	.25	0.25
17	CASE	15.80	14.00	14.00	14.00	ITEM 30	11.25	11.25
18	PRESS COVER						1.44	1.44
19	COVER						.60	0.60
20	RAILS (6)						.44	0.25
21	SHELF						.45	0.45
22	BATT. CONN. BRACKET						.28	0.28
23	FRONT PANEL						.50	0.50
24	TRIPLEXER BRACKET							0.01
25	DOOR AND LATCH						.45	0.45
26	PANEL OVERLAY						.13	0.13
27	CONTROL PANEL COMPONENTS		1.75	1.75	1.75		1.75	1.75
28	THERMAL BLANKET	1.66	1.66	2.10	2.10	0.88	0.88	0.88
29	INTERNAL CABLING, CONNECTORS AND HARDWARE	1.30	IN ITEM 17	1.00	1.00	1.00	1.00	1.00
30	MECHANICAL MOCK-UP LESS WAX PACKAGES AND THERMAL BLANKET					43.72		
31	BATTERY THERMAL INTERFACE							0.75
TOTAL		41.00	40.15	55.23	54.79	54.87	52.54	52.53

*ESTIMATED



LCRU ANCILLARY ITEM WEIGHT ANALYSIS

ASSEMBLY	WEIGHT, LBS.						
	PROP	TI-1	TI-2	PDR	TI-3	TI-4	CDR**
LCRU MOUNTING LEGS (2)	1.40	NO ESTIMATE PRESENTED ↓	2.00	1.20	2.00	2.00	1.75
HIGH GAIN ANTENNA ASSEMBLY							
HIGH GAIN ANTENNA	4.75		3.51	3.51	4.10	4.00	4.30
POINTING MECHANISM	1.16		0.60	0.60	0.80	0.78	
MAST			3.00	2.40	2.00	1.01	2.69
CABLE			0.66	0.66	0.66	0.66	0.56
LOW GAIN ANTENNA ASSEMBLY							
LOW GAIN ANTENNA	0.98		0.82	0.82	0.82	0.82	0.82
POINTING MECHANISM	0.74		0.44	0.44	0.44	--	--
STAFF ASSEMBLY			NONE	NONE	1.06	1.36	1.00
CABLE			0.76	0.76	0.87	0.87	0.68
POWER/TV INTERFACE CABLE	--		0.80	1.00	1.45	1.35	1.35
STOWAGE CONTAINER	3.80		5.70	5.70	7.00	7.00*	7.00*
TOTAL	12.83		18.31	17.11	21.42	20.97	20.15

*ESTIMATE - DESIGN INCOMPLETE

**WEIGHTS ARE ACTUALS FOR ENGINEERING MODEL ITEMS



LM INTERFACE

STOWED WEIGHT

	<u>WEIGHT, LB</u>				
	<u>PDR</u>	<u>TI-3</u>	<u>TI-4</u>	<u>ICD</u>	<u>CDR</u>
● LCRU UNIT	54.790	54.143	52.54	55.0	54.145
● STOWAGE CONTAINER W/CONTENTS	<u>17.106</u>	<u>17.965</u>	<u>17.62</u>	<u>18.0</u>	<u>18.995</u>
TOTAL	71.896	72.108	70.16	73.0	73.140

NOTE: 1. REPLACEABLE BATTERIES NOT INCLUDED
2. LCRU MOUNTING LEGS, POWER CABLE
AND MAST INSERT NOT INCLUDED IN TI-3,
4 AND CDR TOTAL.



LRV INTERFACE

LCRU/LRV STOWED WEIGHT

WEIGHT, LB

<u>ITEM</u>	<u>PDR</u>	<u>TI-3</u>	<u>TI-4</u>	<u>CDR</u>
● LCRU UNIT	54.790	54.143	52.540	54.145
● LCRU UNIT MOUNTING LEGS (2)	1.200	2.000	2.000	1.750
● HIGH GAIN ANTENNA	3.510	4.100	4.000	4.200
● HIGH GAIN ANTENNA POSITIONING MECHANISM	.600	0.800	0.780	1.860
● HIGH GAIN ANTENNA MAST	2.400	2.000	1.910	2.690
● INSERT FOR MAST				0.250
● LOW GAIN ANTENNA	.820	0.820	0.820	0.720
● LOW GAIN ANTENNA POSITIONING MECHANISM AND ARM/MAST	.440	1.500	1.360	1.000
● CABLES				
HIGH GAIN ANTENNA	.680	0.880	0.880	.620
LOW GAIN ANTENNA	.756	0.865	0.865	.680
POWER/TV INTERFACE	<u>1.000</u>	<u>1.450</u>	<u>1.350</u>	<u>1.350</u>
TOTAL	66.196	68.558	66.505	69.265

*WEIGHTS ARE ACTUALS FOR ENGINEERING MODEL ITEMS



LCRU HAND CARRY MODE

HAND CARRY WEIGHT

	<u>WEIGHT LB</u>			
	<u>PDR</u>	<u>TI-3</u>	<u>TI-4</u>	<u>CDR</u>
LCRU	54.790	54.143	52.540	54.145
LOW GAIN ANTENNA	.820	.820	.820	0.720
LOW GAIN ANTENNA POSITIONING MECHANISM AND ARM	.440	.440	.440	0.250
CABLE	<u>.756</u>	<u>.865</u>	<u>.865</u>	<u>0.680</u>
TOTAL	56.806	56.268	54.665	55.795
MOONWEIGHT	9.5	9.4	9.1	9.3

WEIGHTS ARE ACTUALS FOR ENGINEERING MODEL ITEMS



CONTRACT WEIGHT ADDITIONS LCRU (SHEET 1)

<u>ECP NO.</u>	<u>CCA</u>	<u>DESCRIPTION</u>	<u>Δ WEIGHT</u>	<u>ACCUM WT LBS</u>
SEC-0043A PAR 4, 5 CONTRACT BASELINE WEIGHT				50.00
2	1	S-BAND REDUNDANCY, VCO, DIPLEXER	24 OZ	51 LB 8 OZ
3	3	TV REMOTE CAPABILITY AND CONTROL PANEL CHANGE	8 OZ	52
4	4 ⁽²⁾	INTERNAL DC-DC CONVERTER	40 OZ	54 LB 8 OZ
6	5 ⁽²⁾	PHASE CHANGE MATERIAL (WAX) THERMAL DESIGN	11 LBS	65 LB 8 OZ
8	—	TNC CONNECTOR - DIPLEXER	2 OZ	65 LB 10 OZ
14	9 ^(A)	ICD LCRU ENVIRONMENTAL CRITERIA	POSSIBLE FUTURE	65 LB 10 OZ
15	9 ^(C) 9 ^(G)	LCRU/GCTA-ICD CHANGES ADD VIDEO AMP, REMOTE CONTROL OF VCO AND VHF XTMR CARRIER INHIBIT. DLSP, ULSP & DC WIRING MODIFICATION	7 OZ	66 LB 1 OZ
26	WAITING	PRESSURE SENSOR ADDITION	POSSIBLE 2 OZ	
16	NOT SUBMITTED (SHEET 2)	LCRU RIGID HANDLE & S BAND RECV SUBCARRIER SQUELCH ANCILLARY ITEMS	POSSIBLE 6 OZ 7 LB 12.4 OZ	73 LB 13.4 OZ
TOTAL Δ WEIGHT ADDITION			23 LB 13.4 OZ	
LCRU/LRV STOWED WEIGHT ACTUAL				69 LB 4.2 OZ
PRESENT SUBSYSTEM WEIGHT SAVING				4 LB 9.2 OZ

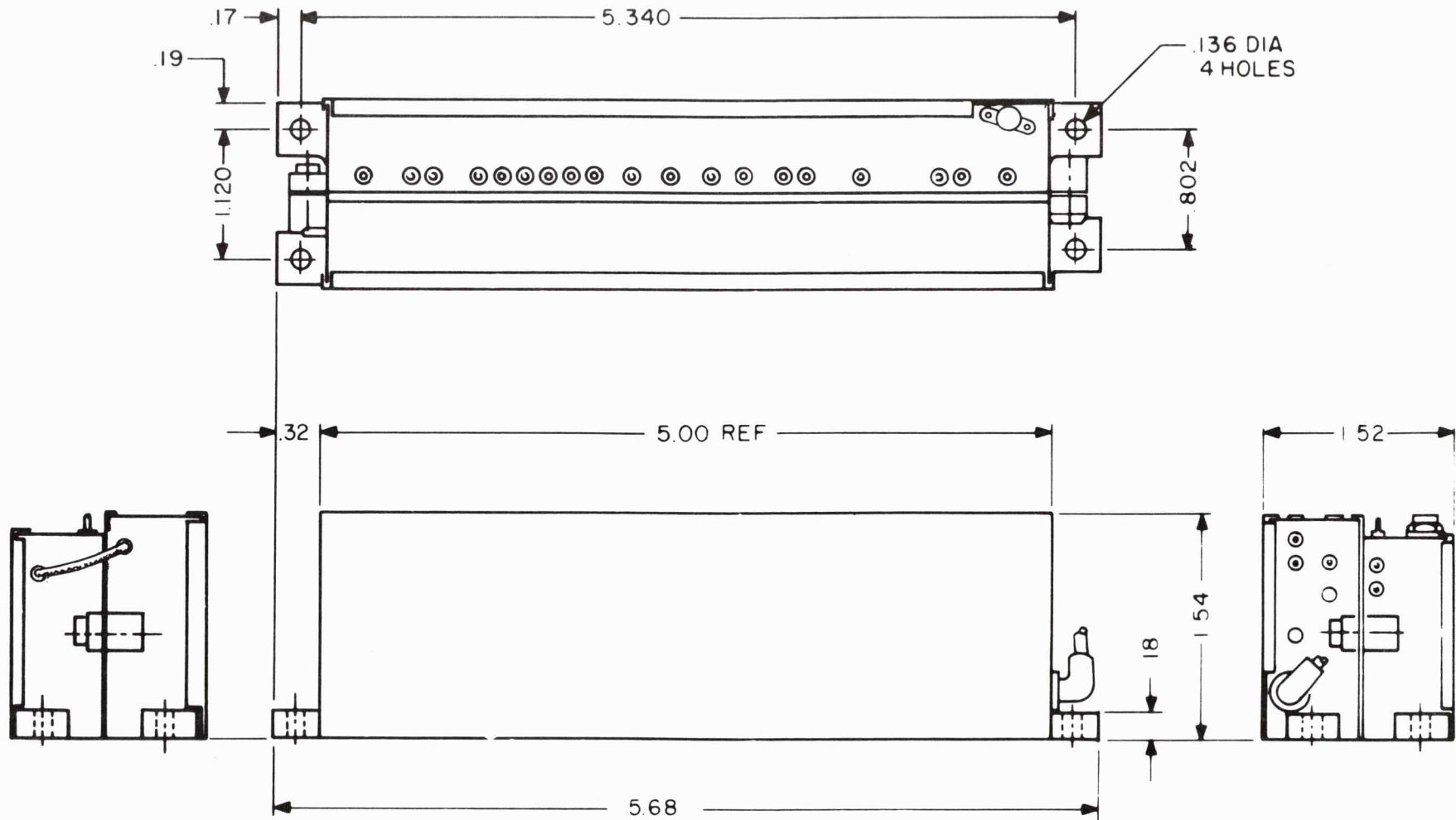


CONTRACT WEIGHT ADDITIONS - ANCILLARY (SHEET 2)

<u>ECP NO.</u>	<u>CCA</u>	<u>DESCRIPTION</u>	<u>Δ WEIGHT-OZ</u>
4	4 ⁽²⁾	DC-DC CONVERTER CABLE LCRU/LRV	13 OZ
5	4 ⁽¹⁾	LRV INTERFACE CHANGE HGA MAST & POSITIONING MECH. LRV POWER CABLE. LCRU LEGS	2 LB 2 OZ
8	—	TNC CONNECTOR-ANTENNA CABLES	2 OZ
17	—	LGA POINTING ASSM AND LRV INTERFACE	1 LB 3.2 OZ
18	9 ^(h)	HGA REAR MOUNTED OPTICAL SIGHT	12.8 OZ
19	11.2	CHANGE OF STOWAGE CONTAIN- ER LOCATION IN LM MESA AND PREASSEMBLY OR ANCILLARY ITEMS	2 LB 6.4 OZ
28	—	CSR LCRU/LRV SHORTEN HANDLES, HAND WHEEL TELE- SCOPING CONTROL, LENGTHEN HANDLE FOR RF CONNECTORS	5 OZ
TOTAL			7 LB 12.4 OZ

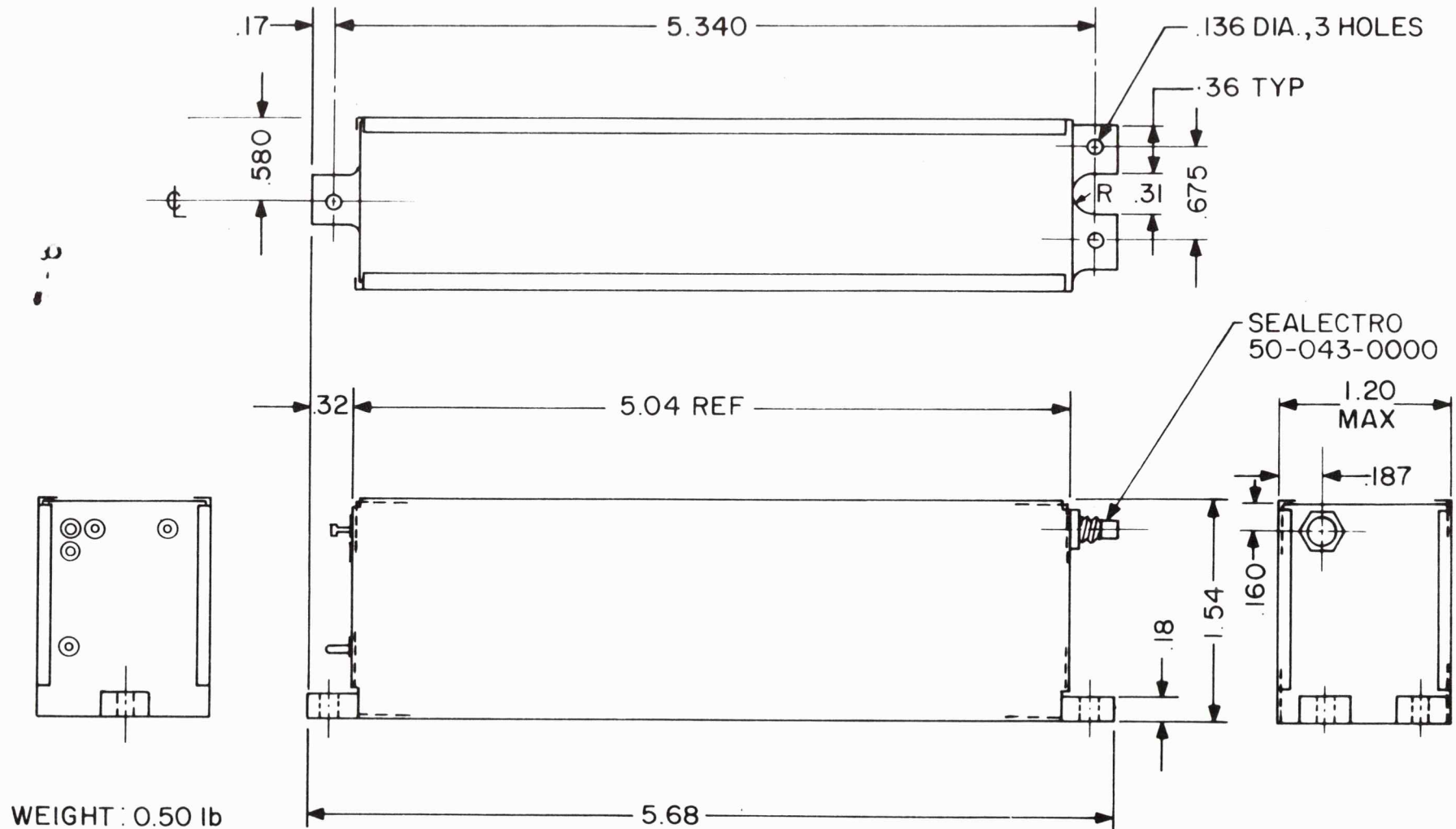
RCA

VHF RECEIVER



RCA

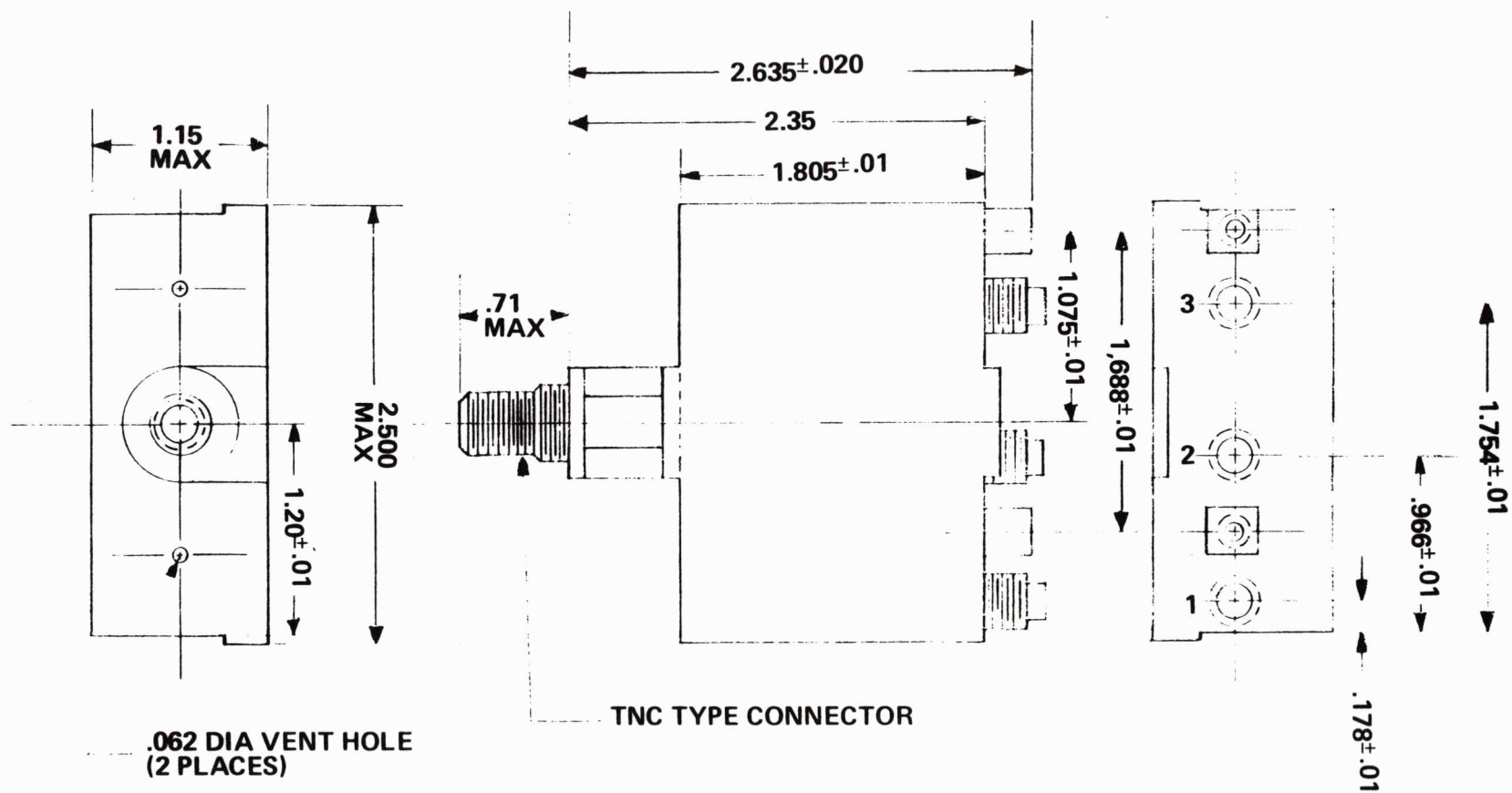
VHF TRANSMITTER





VHF TRIPLEXER

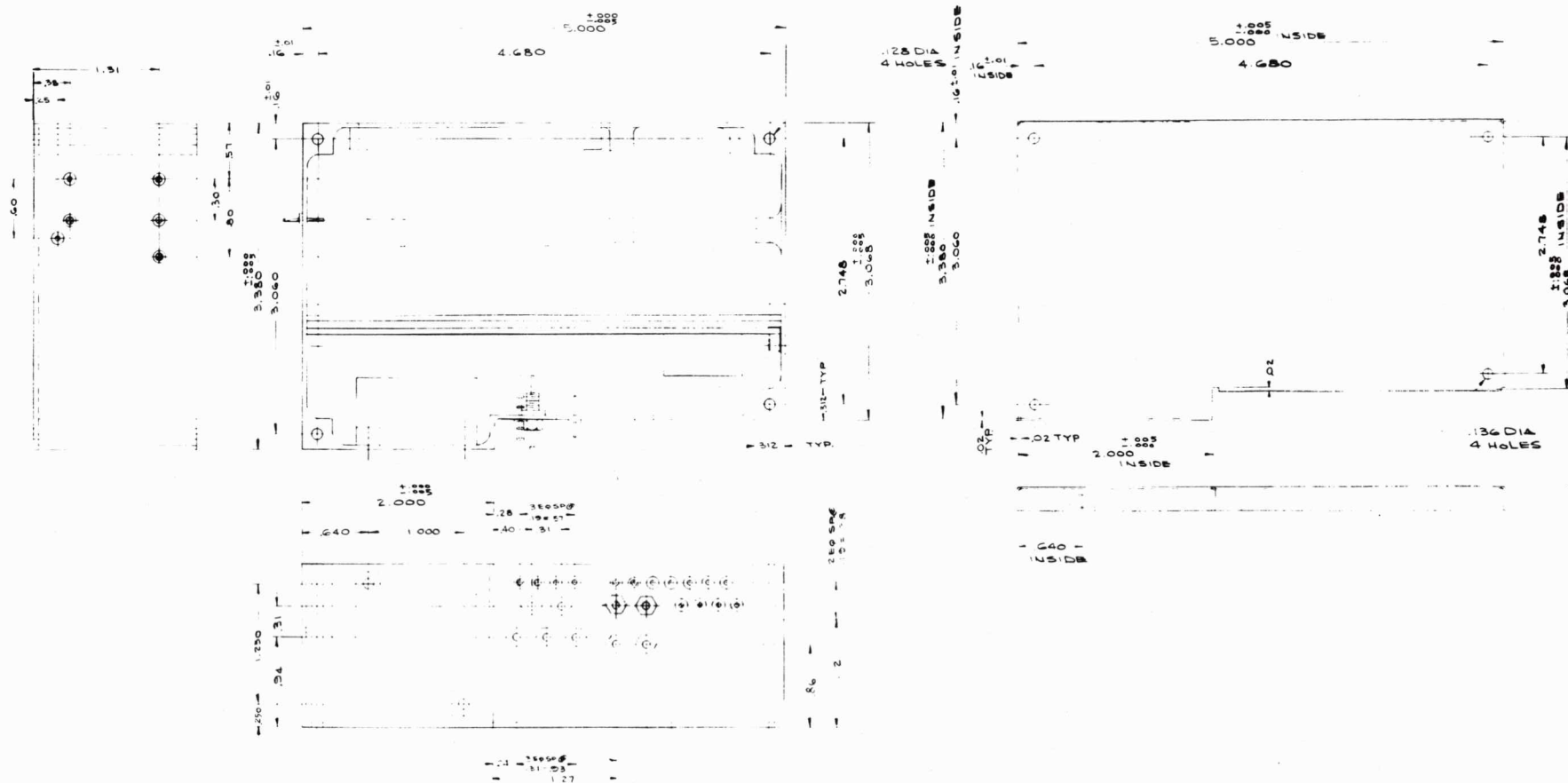
8-62



WEIGHT: 5 OZ. MAX.

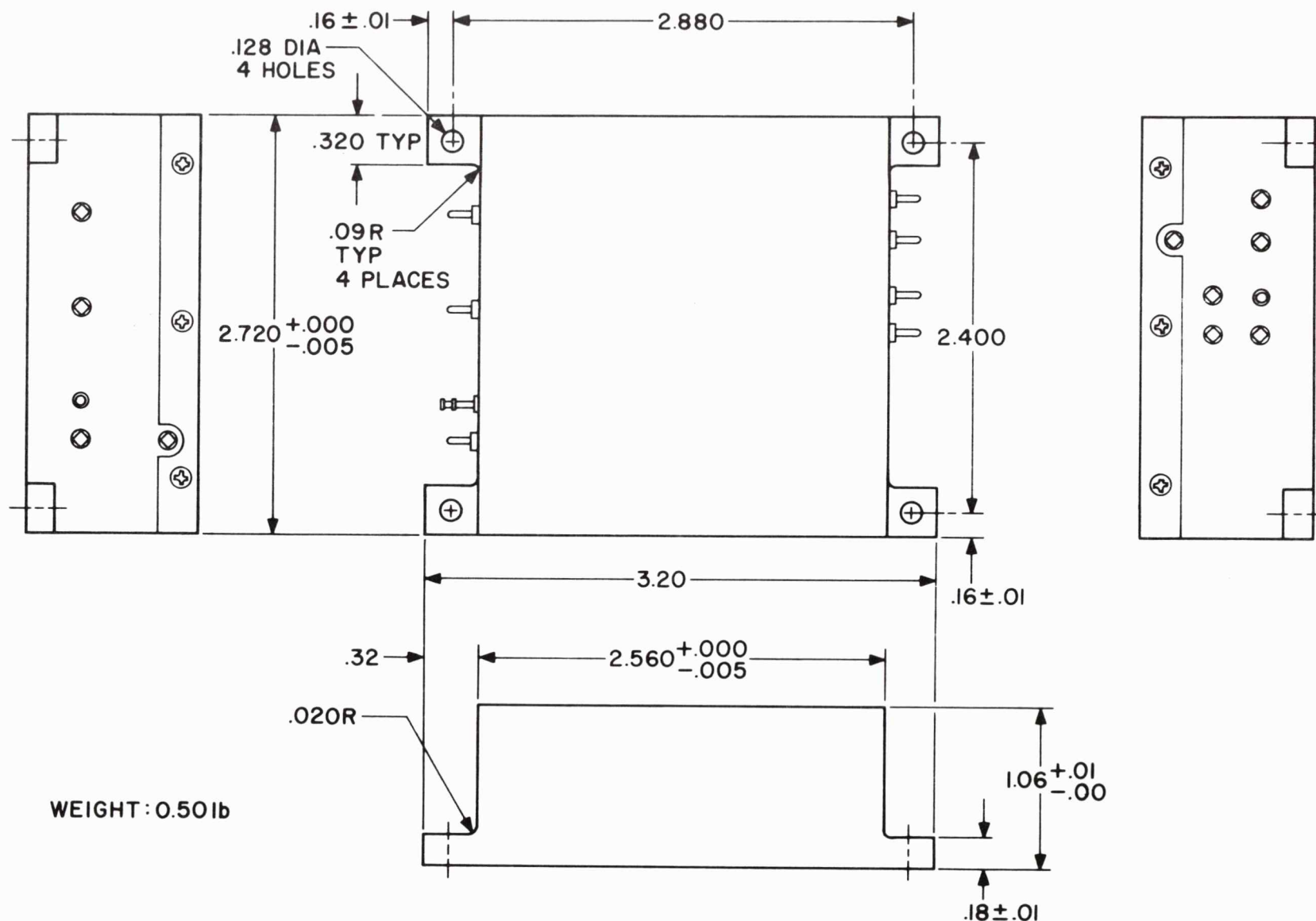


8-63



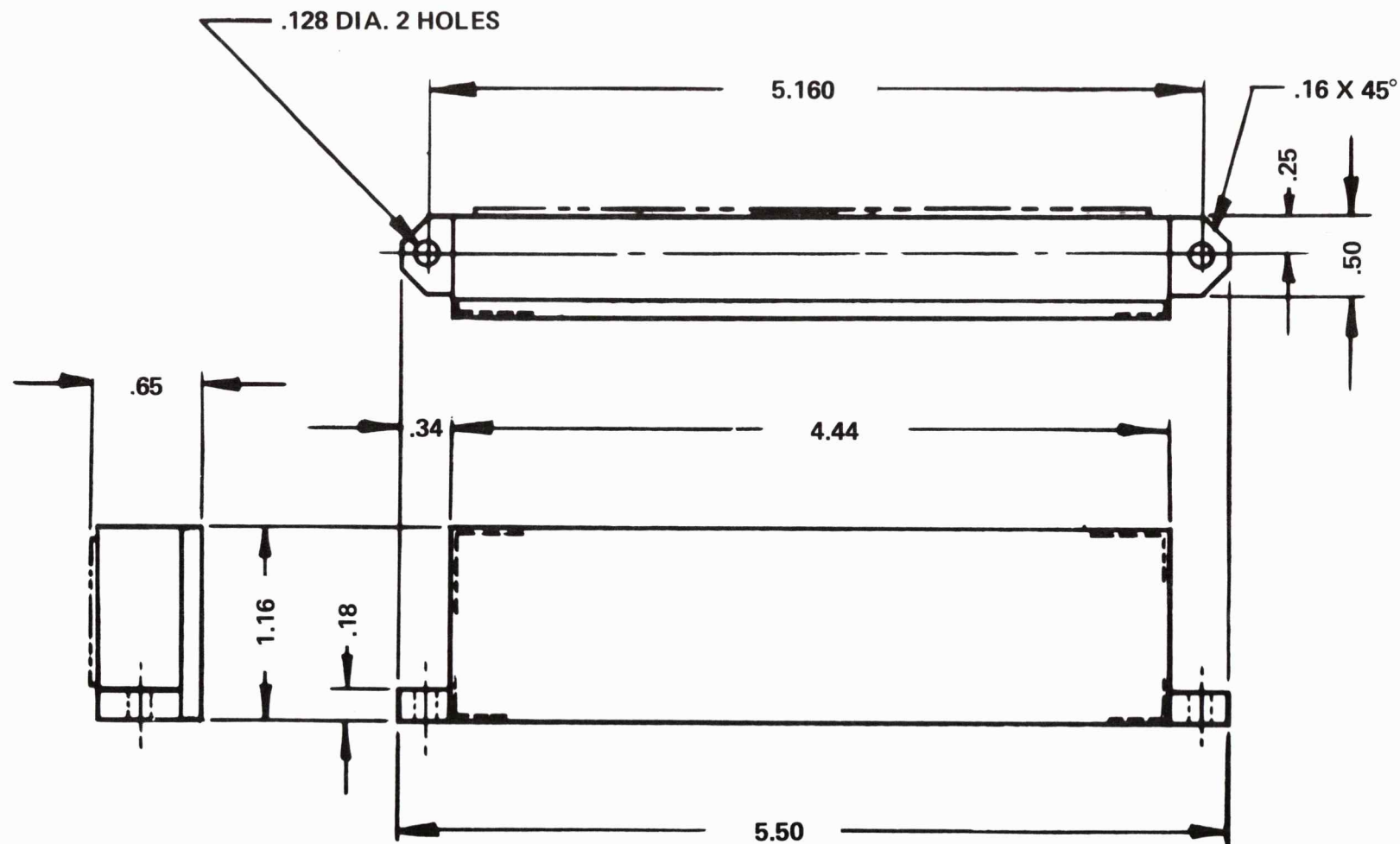
RCA

OUTLINE DRAWING SIGNAL PROCESSOR (UP LINK)



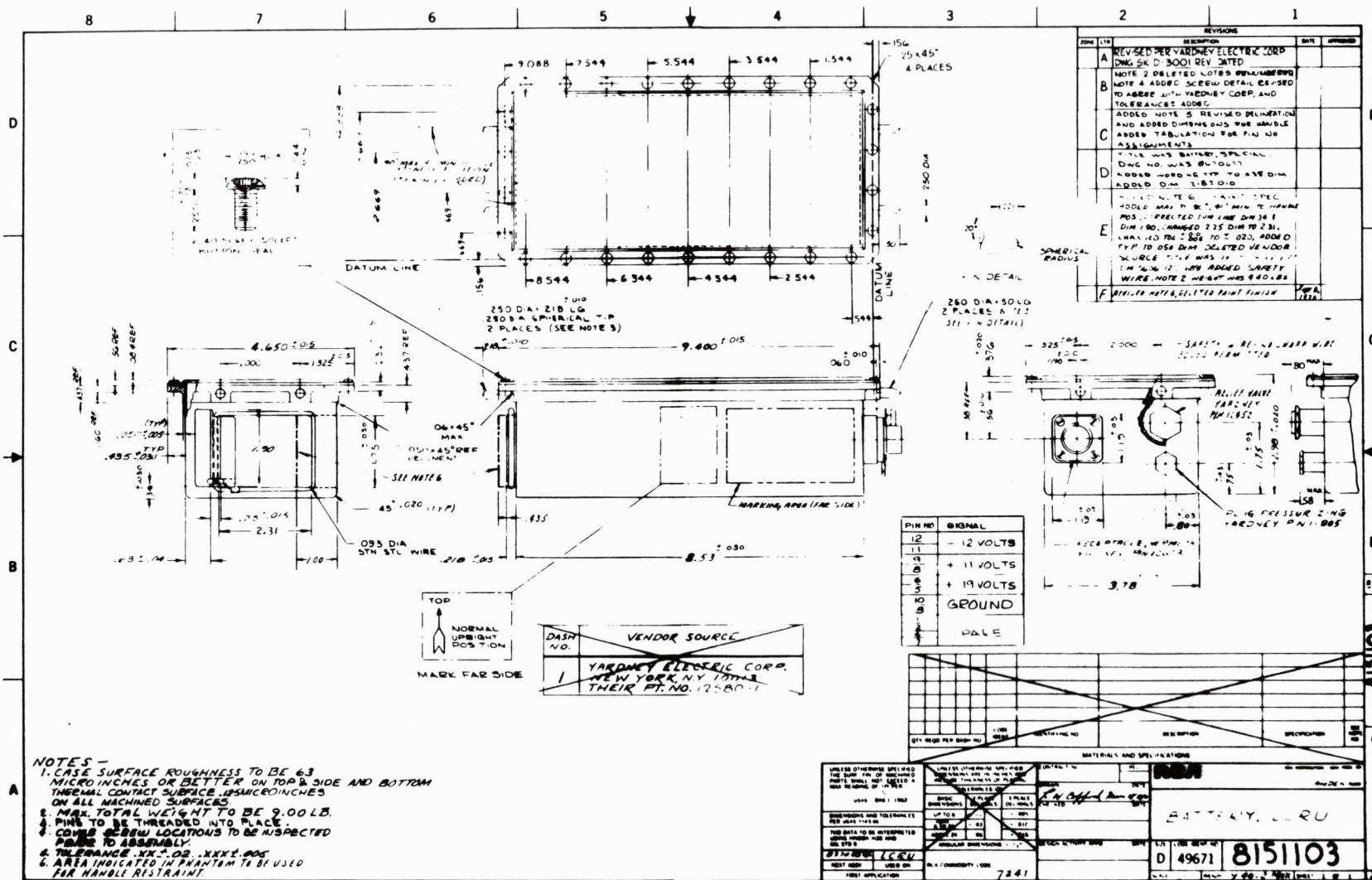


REGULATOR, VOLTAGE OUTLINE & MOUNTING



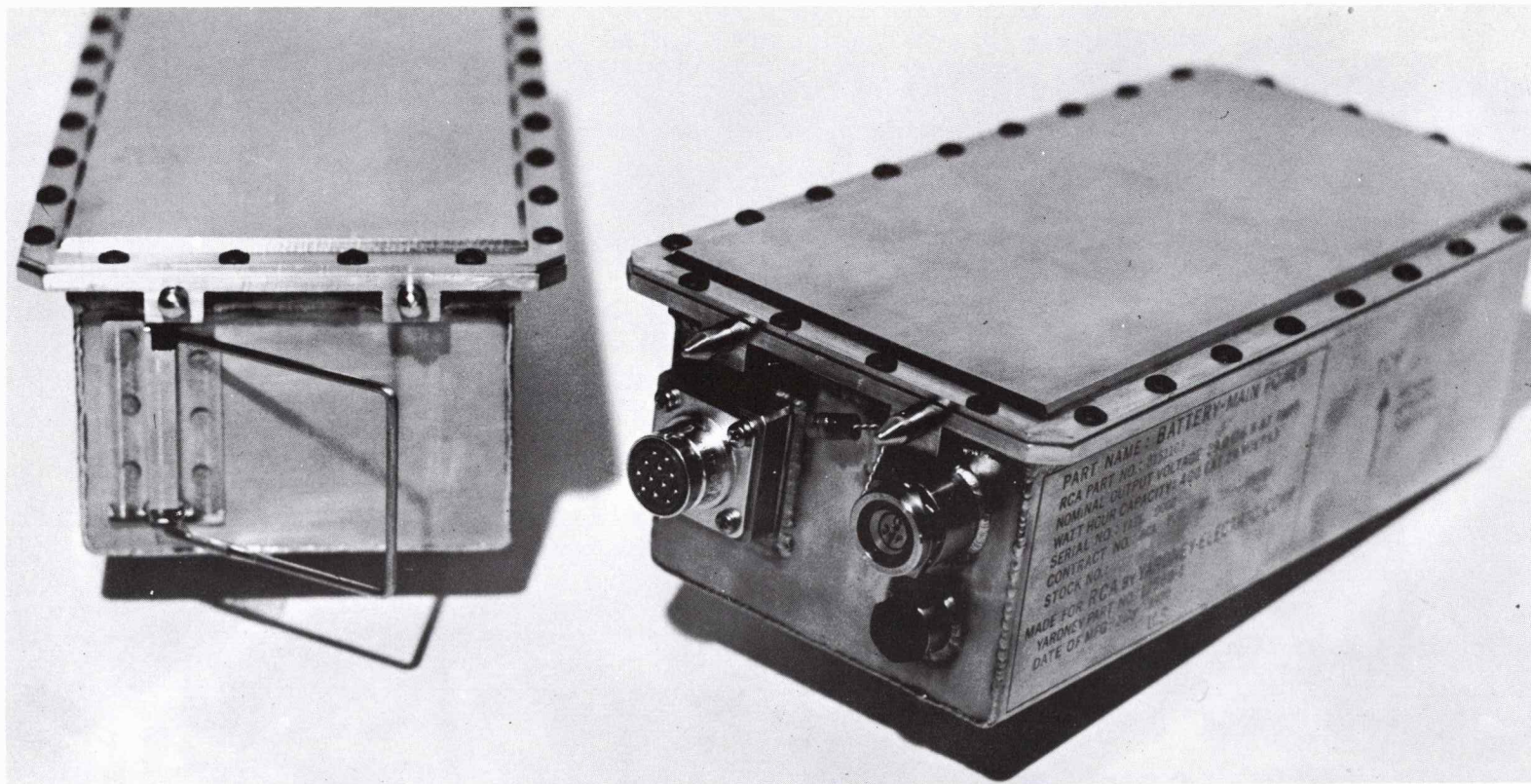
WEIGHT: 0.25 LB

8-66



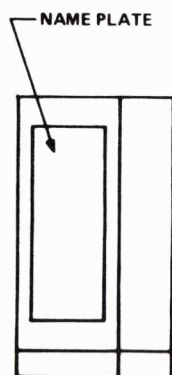
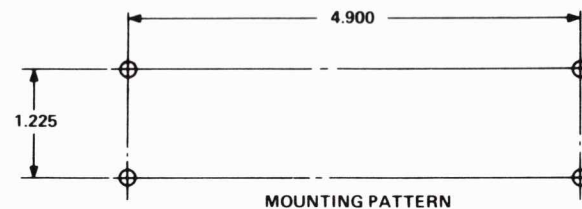
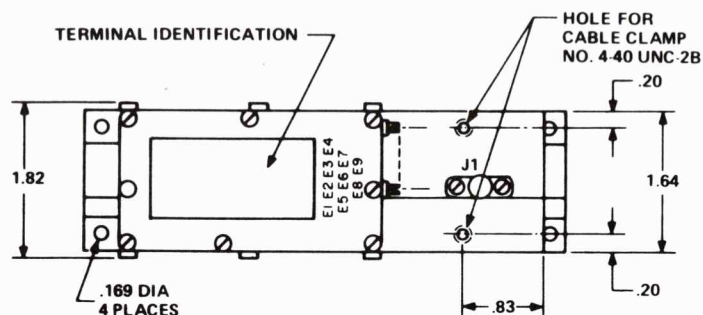
RCA

LCRU BATTERY ENGINEERING AND THERMAL MODELS

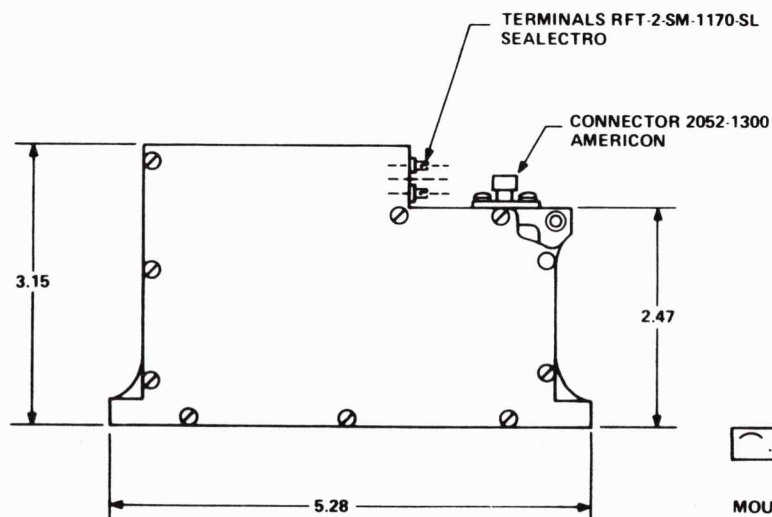




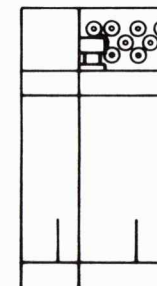
LCRU S-BAND RECEIVER



WEIGHT: 1.40 LB.



MOUNTING SURFACE

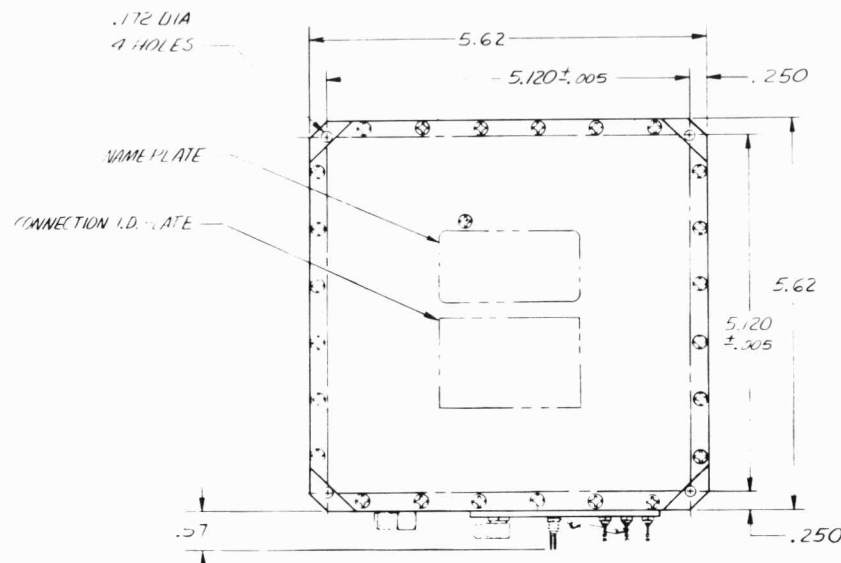


RCA

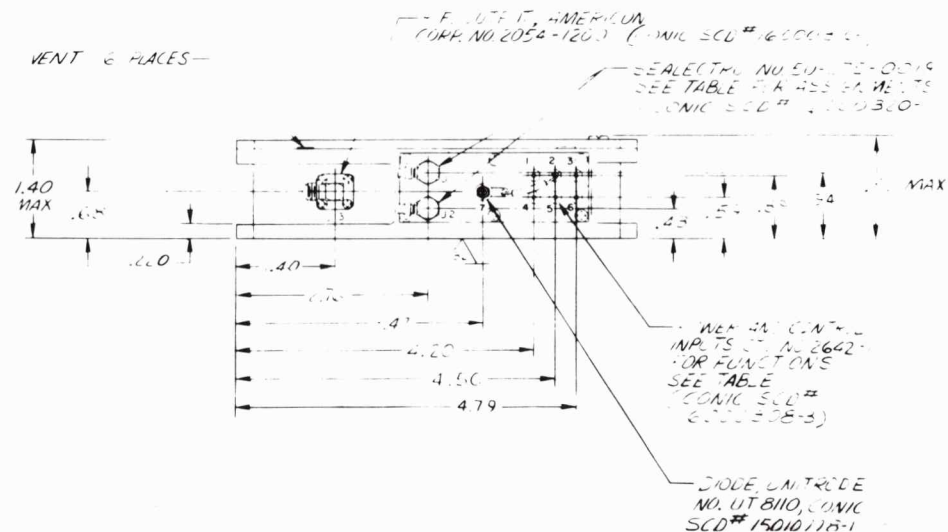
OUTLINE DRAWING TRANSMITTER LRSP FPT-1 12000700

WAVE FORM ASSIGNMENTS	
WAVEFORM DESIGN	FPT-1
11	WIDE BAND F.M. (VIDEO)
12	NARROW BAND P.M.
13	P.F. OUTPUT

POWER AND CONTROL INPUTS	
TERMINAL	FUNCTION
1	B+ 28V NOMINAL
2	B+ REDUNDANT
3	GND 28V RETURN
4	GND REDUNDANT
5	WIDE BAND F.M. CONTROL
6	NARROW BAND P.M. CONTROL
7	B+ (TEST ONLY)

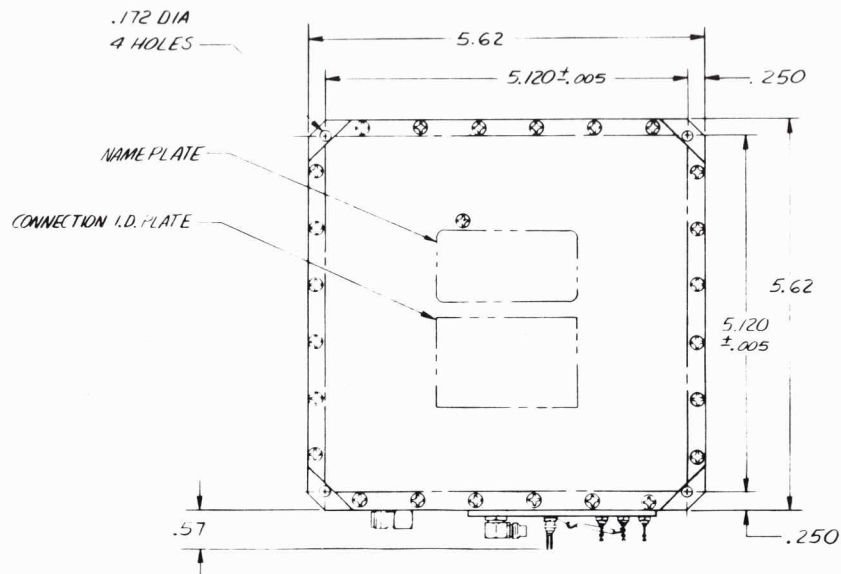


VENT 6 PLACES—



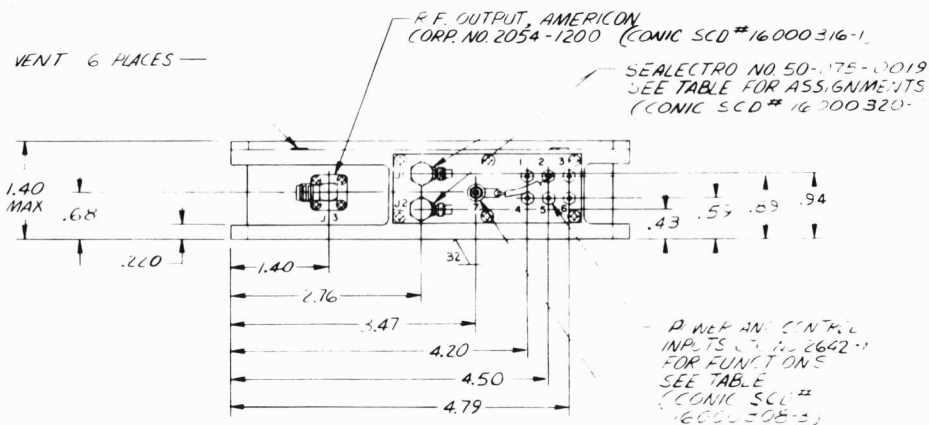
RCA

OUTLINE DRAWING TRANSMITTER LRSP SPT-3 12000734



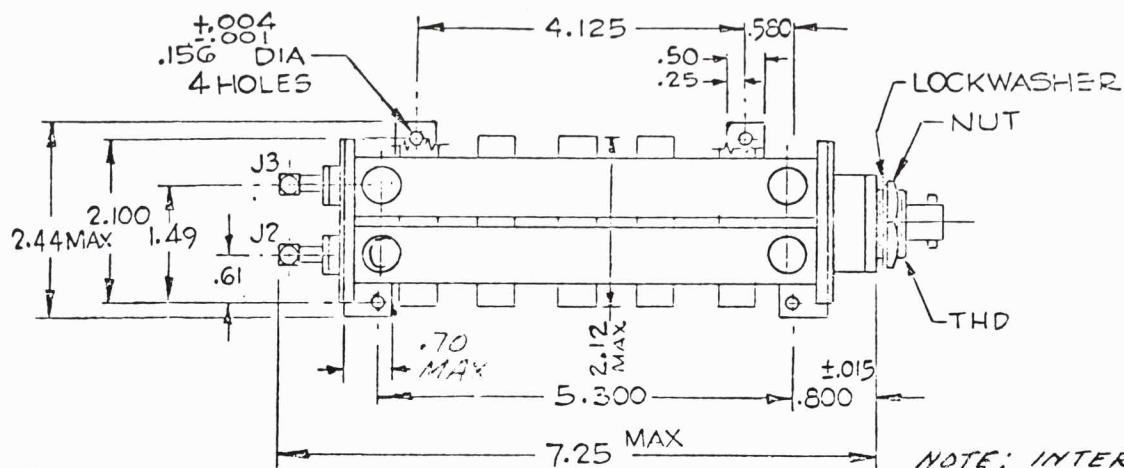
CONNECTOR ASSIGNMENTS	
CONNECTOR	SPT-3
J1	WIDE BAND P.M.
J2	NARROW BAND P.M.
J3	R.F. OUTPUT

POWER AND CONTROL INPUTS	
TERMINAL	FUNCTION
1	B+ 28V NOMINAL
2	B+ REDUNDANT
3	GND 28V RETURN
4	GND REDUNDANT
5	WIDE BAND P.M. CONTROL
6	NARROW BAND P.M. CONTROL
7	B+ (TEST ONLY)



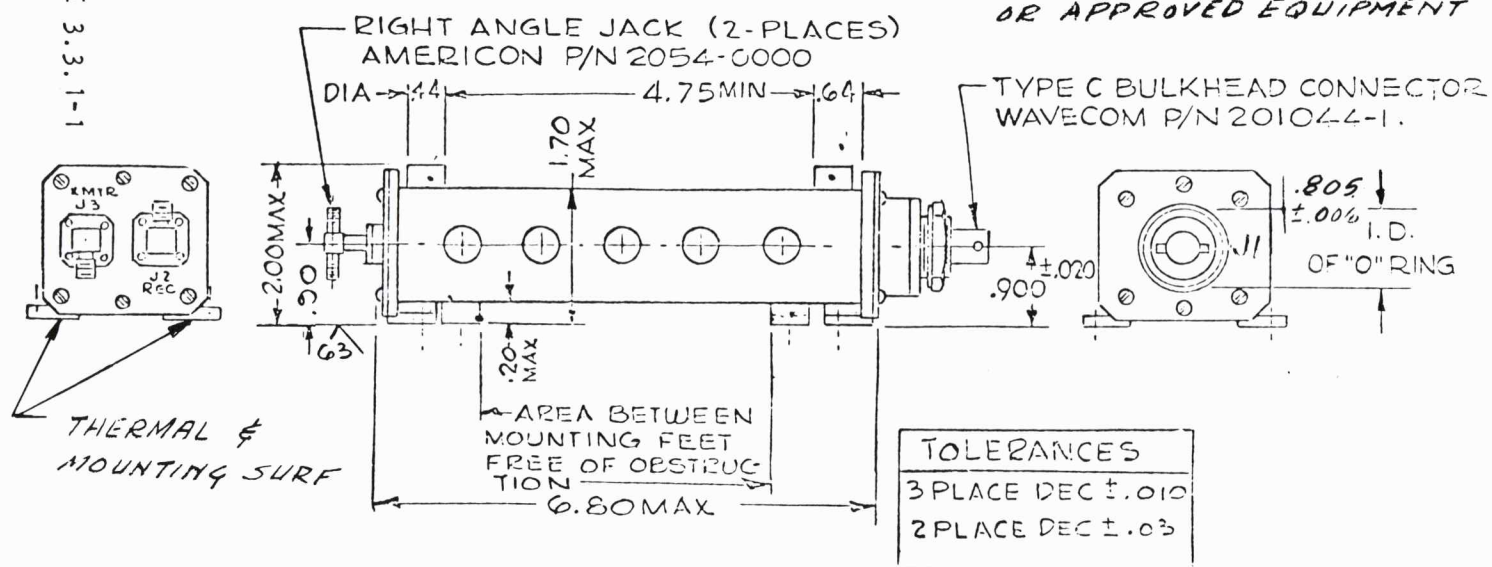
RCA

S BAND DIPLEXER



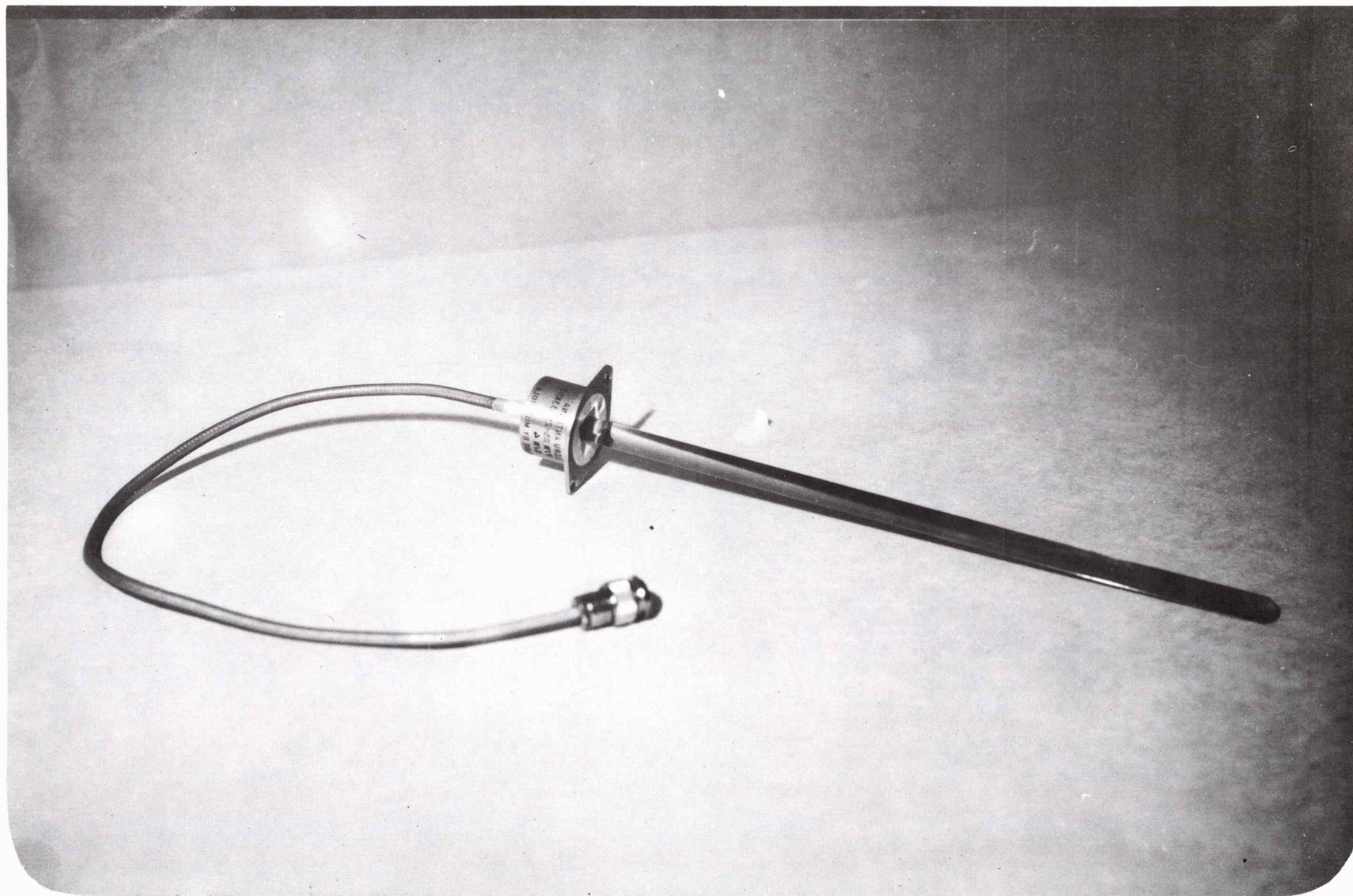
NOTE: INTERFACES BETWEEN SILVER & ALUMINUM TO BE COATED WITH 8533528 OR APPROVED EQUIPMENT

FIGURE 3.3.1-1



RCA

VHF ANTENNA FLIGHT MODEL

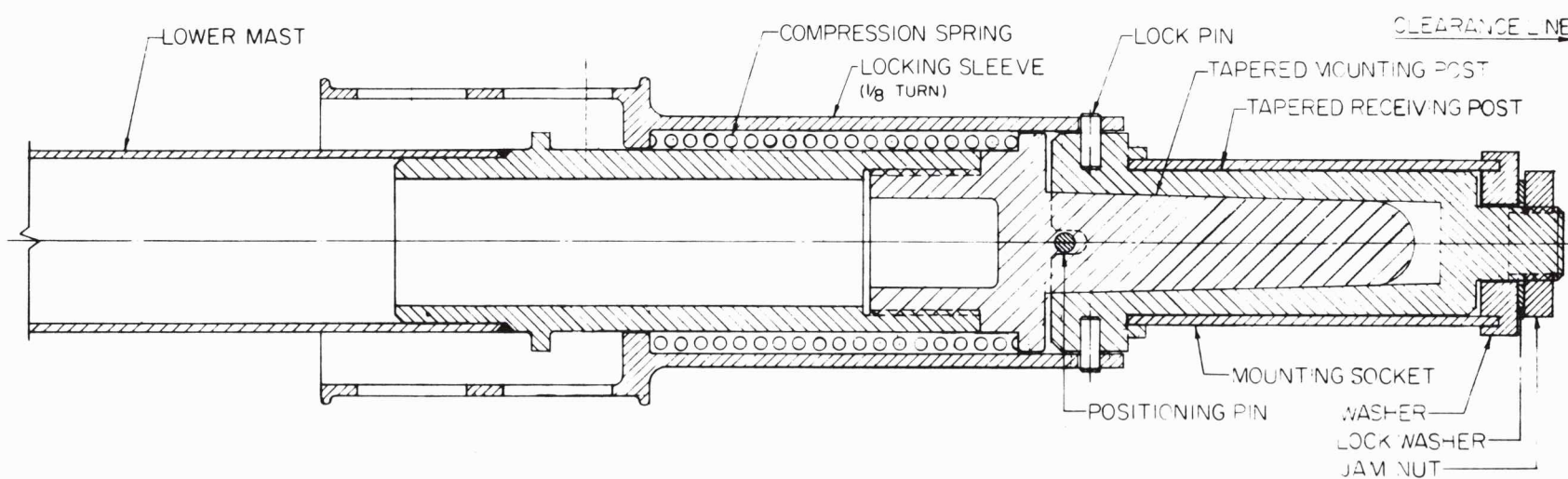


8-72





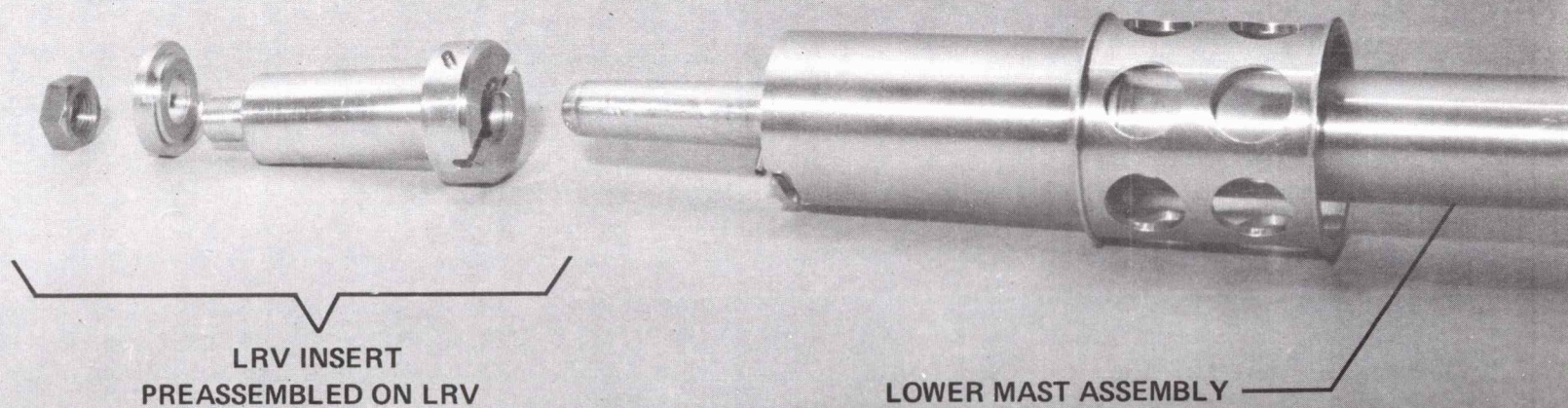
HGA MAST AND TV MOUNT LRV INTERFACE COUPLING





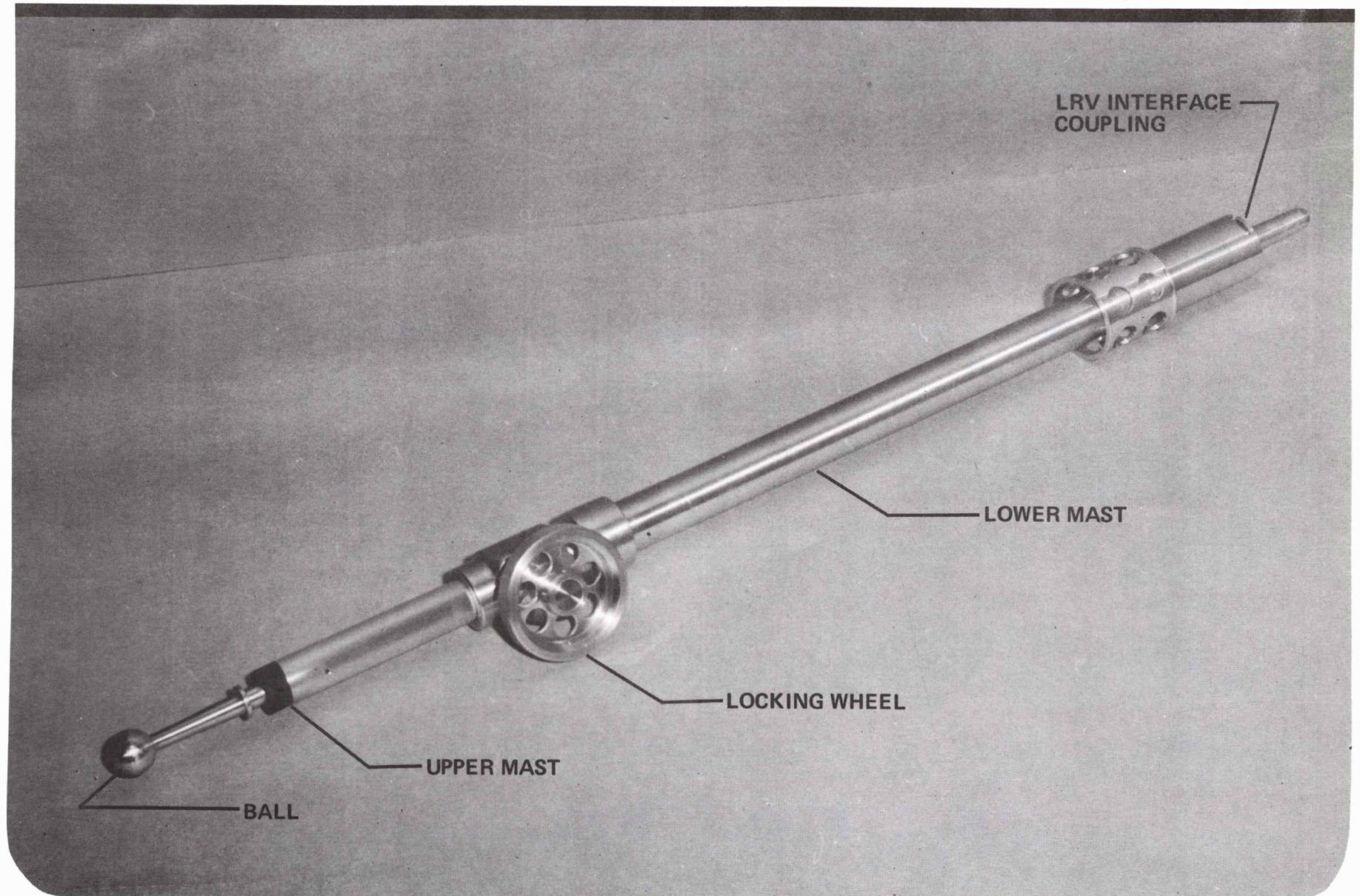
HGA MAST - TV MOUNT INTERFACE

8-75



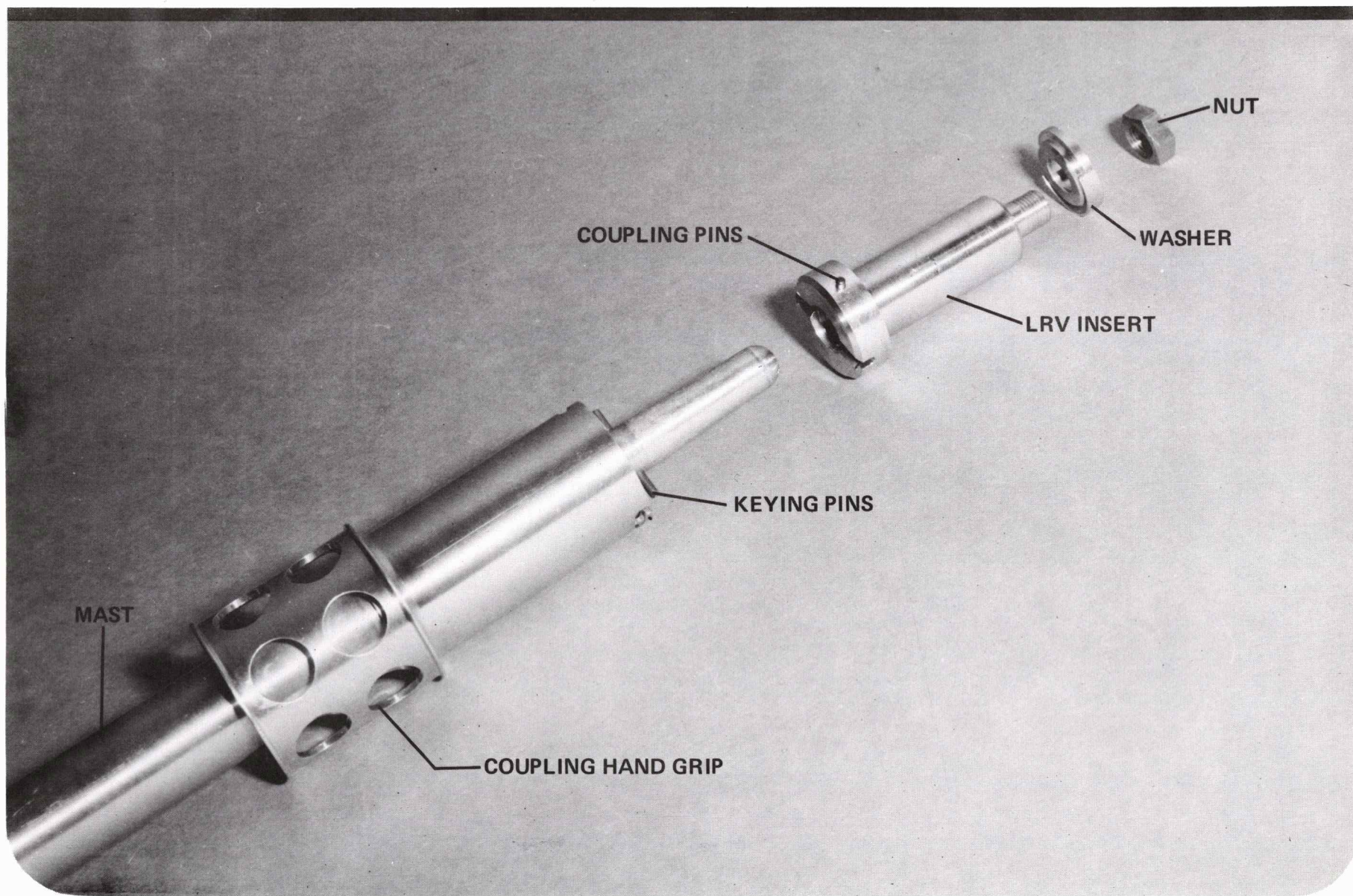
RCA

HGA MAST MECHANICAL MOCK UP



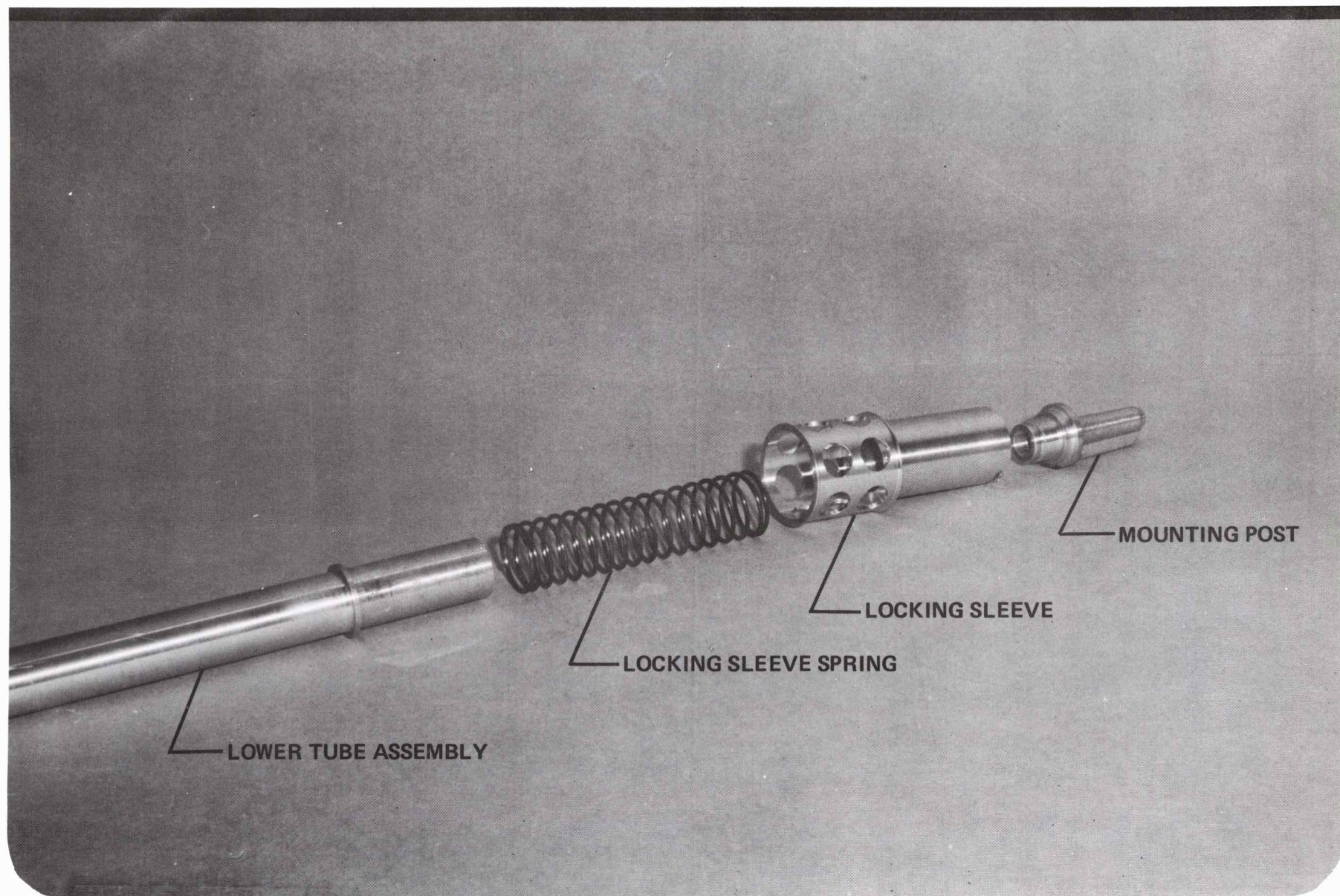


HGA MAST AND TV MOUNT LRV INTERFACE COUPLING



RCA

LOWER MAST ASSEMBLY HGA MECHANICAL MOCK-UP







CRITICAL DESIGN PARAMETERS

3.0 LB DESIGN GOAL

5.1.3 DEPLOYMENT CYCLES - 100

5.1.5 VIBRATION - LUNAR ENVIRONMENT

5.2.5.2 STOWED – 3.7 G 20 – 100 HZ

5.1.7 INTERFACE CHARACTERISTICS

5.1.7.2 SHIPPING CONTAINER - 5-1/2" DIA. X 24-2/4" LONG



WEIGHT SUMMARY

SPECIFICATION WEIGHT	3.5 LB
DESIGN GOAL	3.0 LB
CALCULATED WEIGHT (LESS OPTICAL SIGHT)	2.71 LB
MEASURED WEIGHT OF ENGINEERING MODEL	
ANTENNA (LESS SIGHT)	2.75 LB
MEASURED WEIGHT OF MOCK-UP OPTICAL SIGHT	1.29 LB
MEASURED WEIGHT OF SIGHT SUPPORT	.17 LB
TOTAL	4.21 LBS.



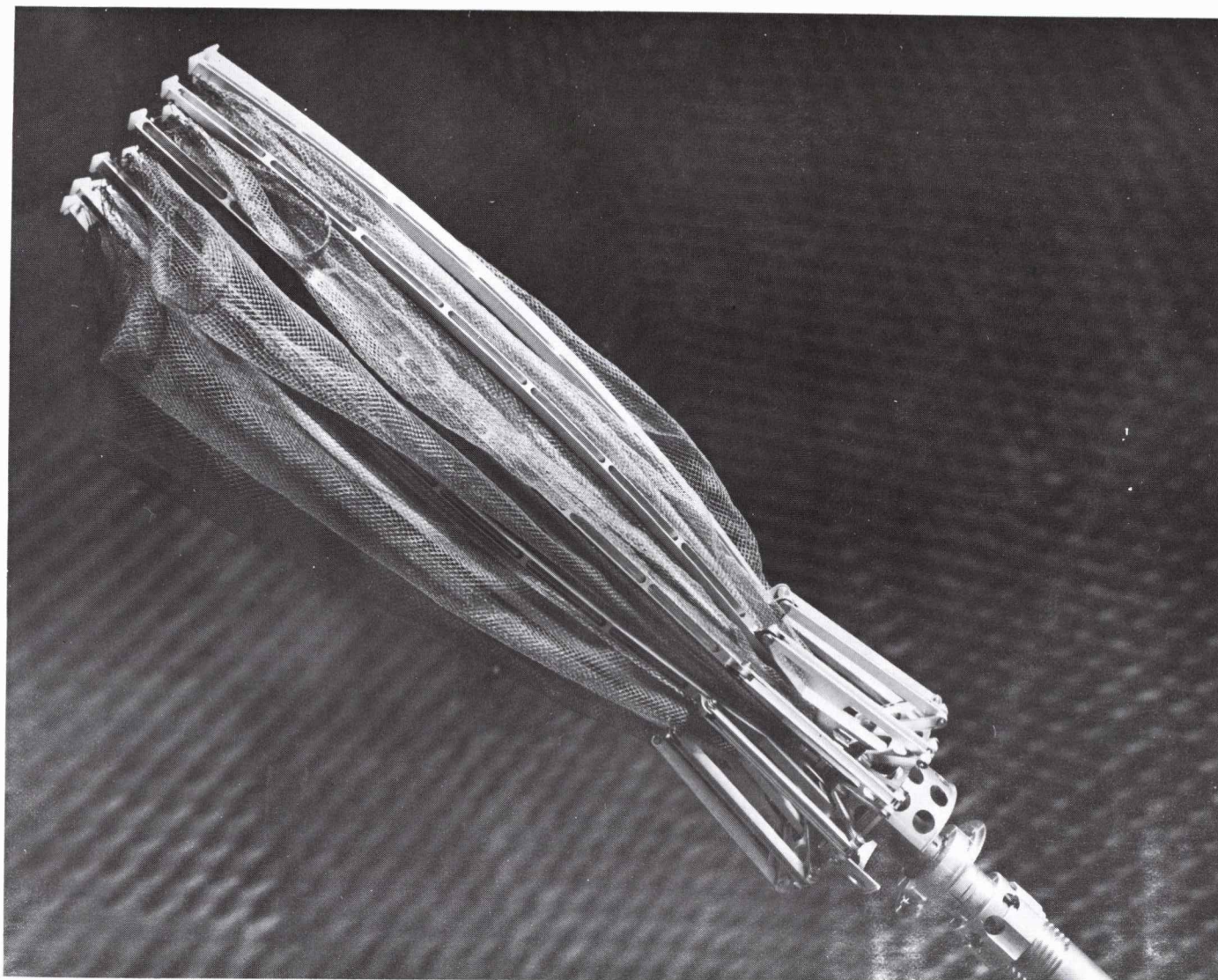
LCRU ANTENNA - WEIGHTS

(CALCULATED WITHOUT OPTICAL SIGHT)

		<u>WT PER</u>	<u>QTY</u>	<u>WT</u>
2)	ANTENNA SUPPORT	.1760	1	.1760
3)	INTERFACE NUT	.0385	1	.0385
4)	LOCKING CAM	.1163	1	.1163
5)	RIB LIFTER	.1891	1	.1891
6)	ANTENNA HUB	.1138	1	.1138
7)	SPECIAL NUT	.0374	1	.0374
8)	RIB	.0721	12	.8652
9)	RIB LIFTER LINK	.0145	12	.1740
10)	PIVOT PINS	.00263	36	.0946
13)	NON-METALLIC WASHER	.000247	24	.0059
14)	SPECIAL WASHER	.000312	36	.0112
15)	VLIER INSERTS	.0180	1	.0180
16)	BALL	.000288	14	.0040
17)	BALL	.000975	3	.0029
18)	PINS	.00022	86	.0190
26)	MESH GORE	.0102	12	.1224
27)	TEFLON TAPE	.00315	12	.0378
28)	GORE SEAM TUBE	.00423	12	.0508
29)	PERIMETER CABLE	.000659	12	.0079
31)	RIB TIP PROTECTOR	.000643	12	.0077
32)	CONNECTOR	.05	1	.0500
34)	FEED ASSEMBLY	.5666	1	.5666
			TOTAL	2.71 LB

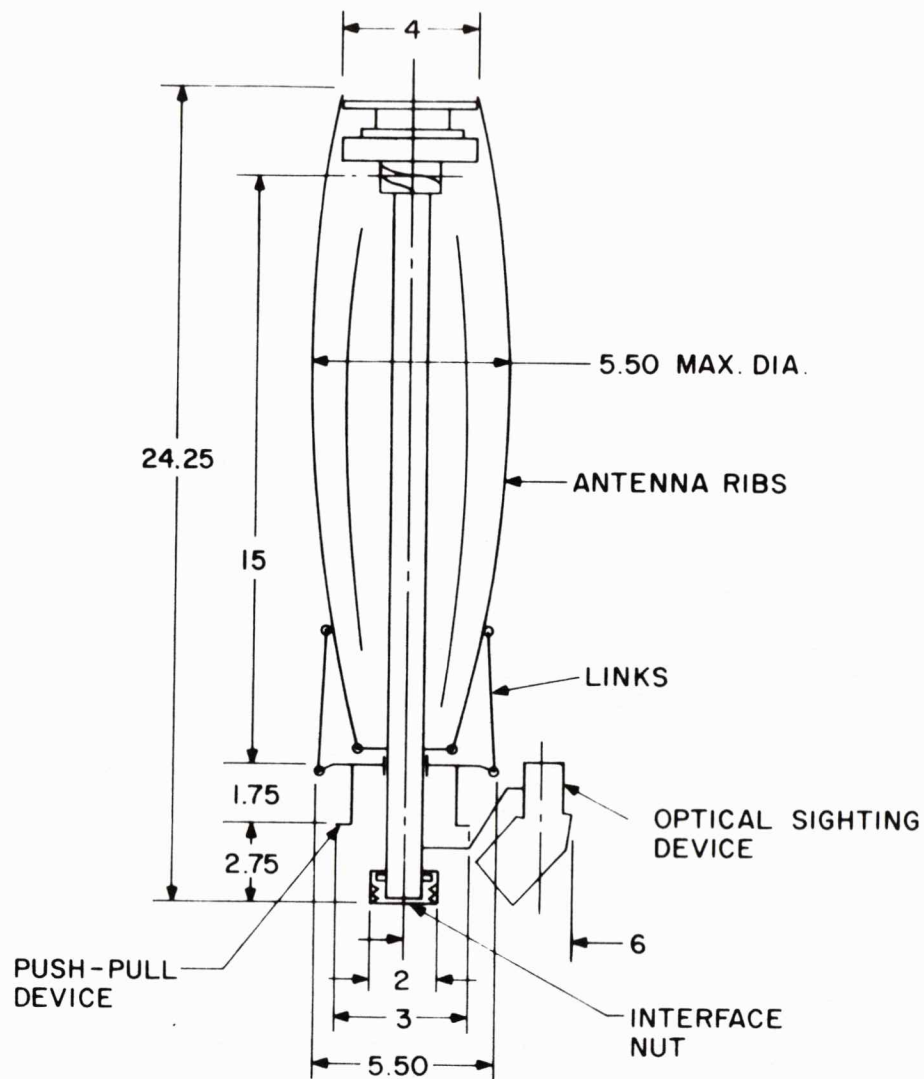
RCA

HGA ENGINEERING MODEL ON TEST RANGE



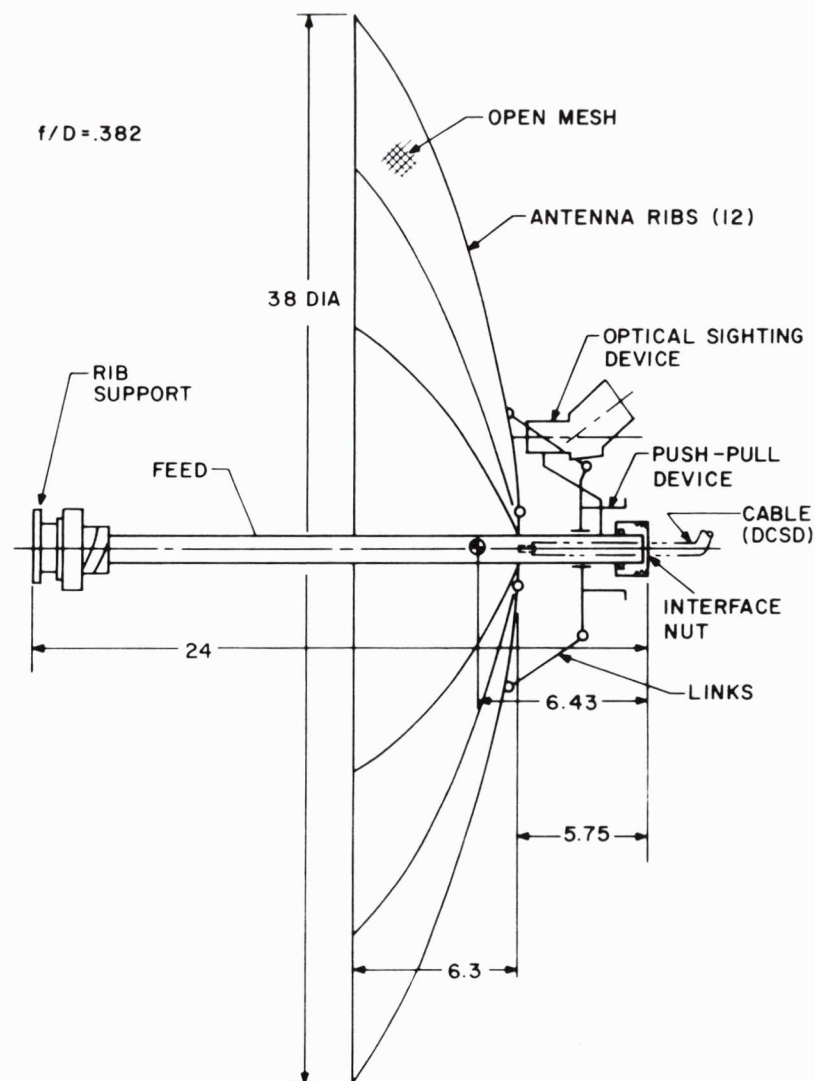


ANTENNA IN STOWED CONFIGURATION



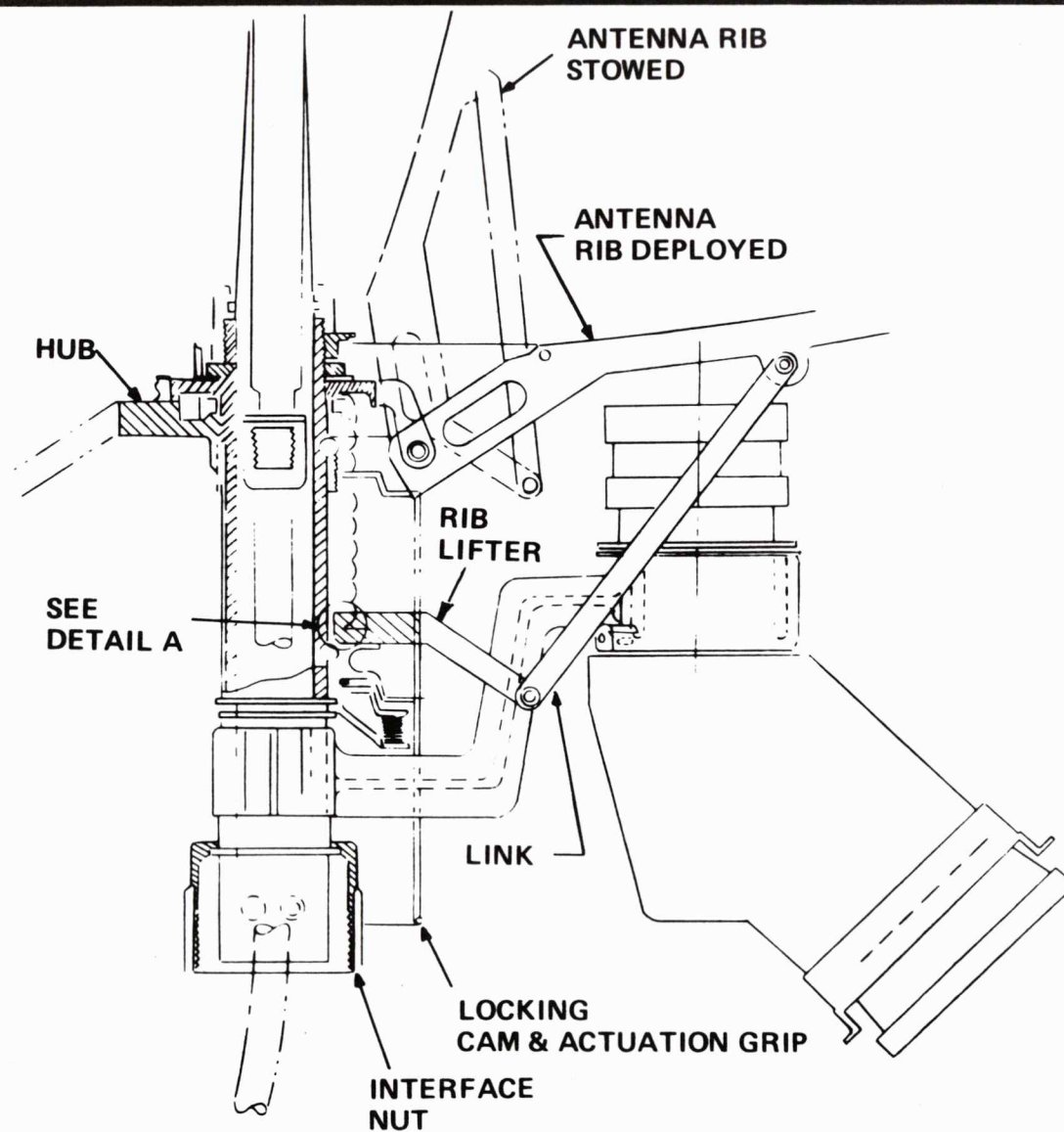


ANTENNA IN DEPLOYED CONFIGURATION





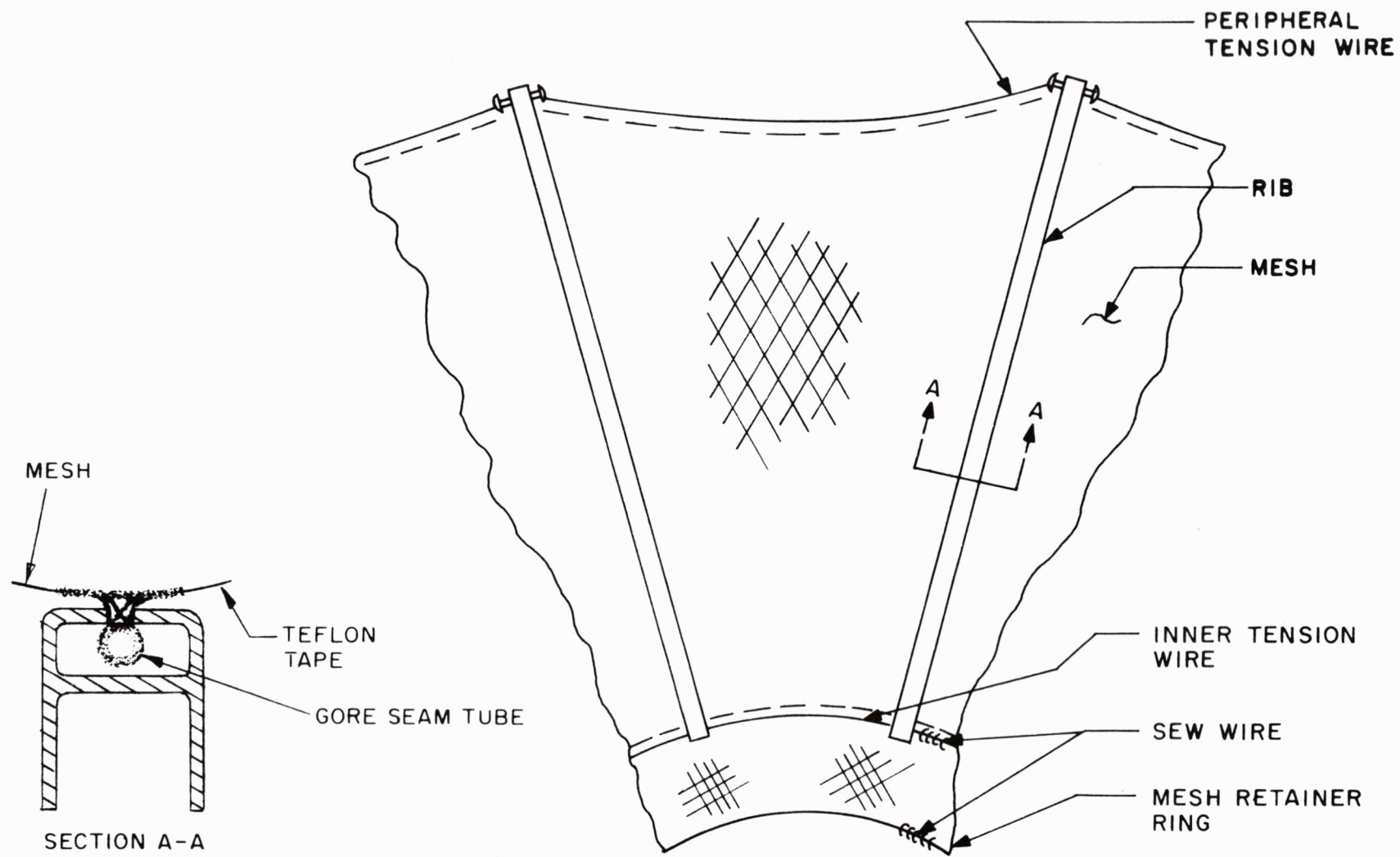
DEPLOYMENT MECHANISM & LOCKING DEVICE





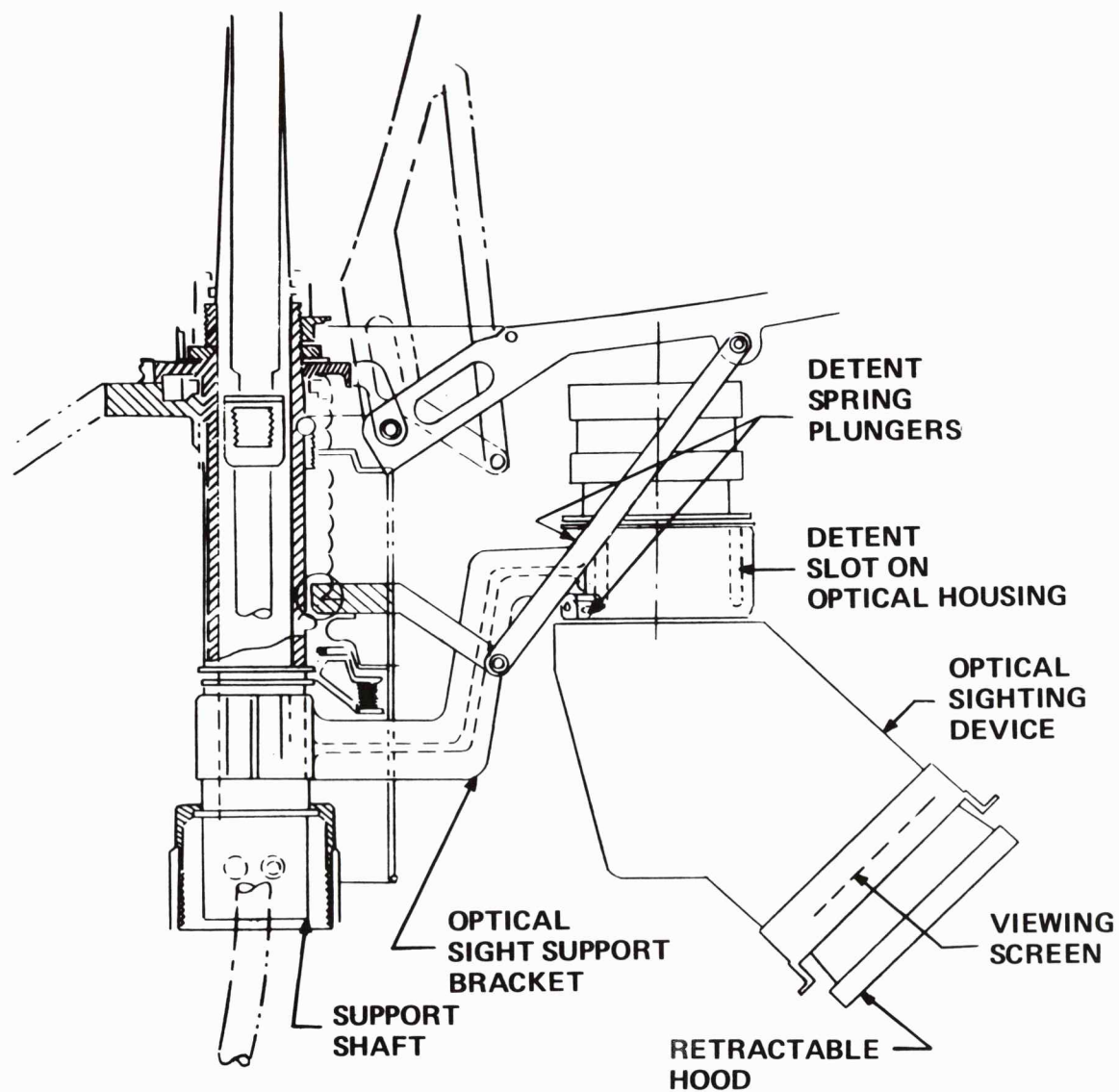
REFLECTOR CONSTRUCTION

8-87





OPTICAL SIGHT AND BRACKET





REAR-MOUNTED OPTICAL SIGHT LCRU BORESIGHT ANALYSIS

		<u>PEAK</u>	<u>1 RMS</u>
A.	RF BEAM SHIFT DUE TO FEED GRAVITY DISPLACEMENT	.143°	.048°
B.	THERMAL DISTORTION	.010°	.006°
C.	BEAM POSITION CENTER MEASUREMENT& BORESIGHTING ACCURACY	.200°	.067°
D.	FEED AXIS TO RF BEAM AXIS ALIGNMENT	.100°	.033°
E.	<u>OPTICAL DEVICE ACCURACY</u>		
	1. INTERNAL CENTERING OF LINE OF SIGHT	.150°	.050°
	2. MOUNTING INACCURACIES		
	a) SUPPORT AXIS ALIGNMENT TO FEED AXIS	.100°	.033°
	b) BRACKET MOUNTING ACCURACY TO SUPPORT AXIS	.250°	.145°
	c) BRACKET MOUNTING AXIS PARALLELISM TO OPTICAL MOUNTING AXIS	.250°	.145°
	d) BRACKET GRAVITY DISPLACEMENT	.053°	.018°
	3. ROTATIONAL ACCURACY	.114°	.038°
F.	RE-DEPLOYMENT ACCURACY	.100°	—
	1. RMS ERROR = $\pm .255^\circ$		
	3 ERROR + $\pm .765^\circ$		
	3 ERROR + ANTENNA SUPPORT DISPLACEMENT = $\pm .765^\circ$, $\pm .500^\circ$		
	ERROR (MAXIMUM = $\pm 1.265^\circ$ IN ALL DIRECTIONS.		
	THE MAXIMUM ERROR PERMITTED BY THE RCA SPECIFICATION 8555262 IS 0.8° .		



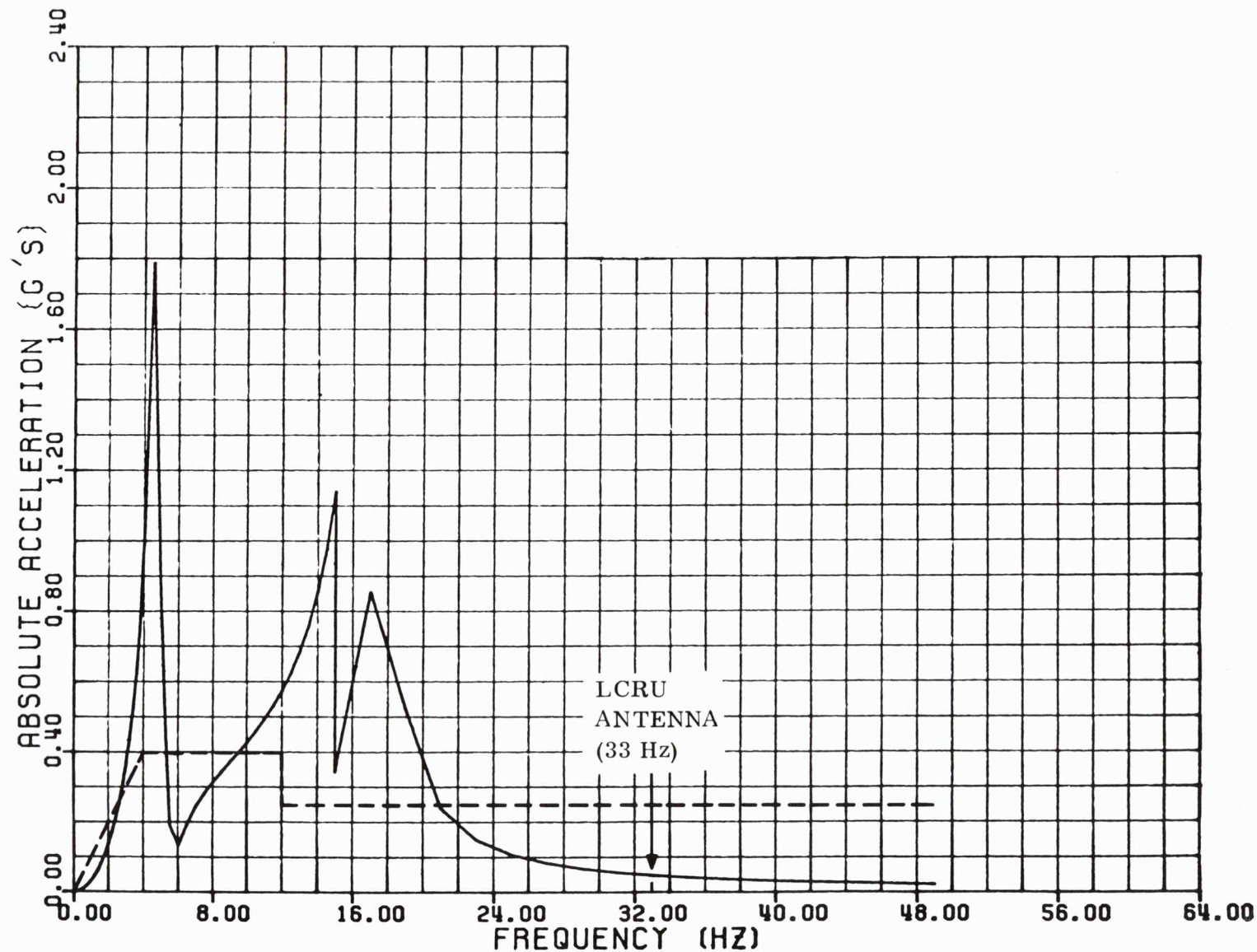
LCRU ANTENNA MATERIAL TEMPERATURES

<u>MATERIAL</u>	<u>ALLOWABLE TEMPERATURE</u>	<u>PEAK TEMP. EXPOSURE</u>
POLYURETHANE FOAM (E&C TYPE SH)	275° F CONTINUOUS 325° F SHORT TIME	270° F
GLASS-TEFLON LAMINATE PC BOARD	500° F	160° F
ALUM ALLOY STRUCTURE (CHROMATE IRIDITE FINISH)	400° F (1)	280° F
OPTICAL SIGHT	212° F	180° F
COAX CABLE CONNECTOR	(>200° F)	200° F

(1) TEMP. FOR 50% OF ROOM
TEMP. ULTIMATE STRENGTH

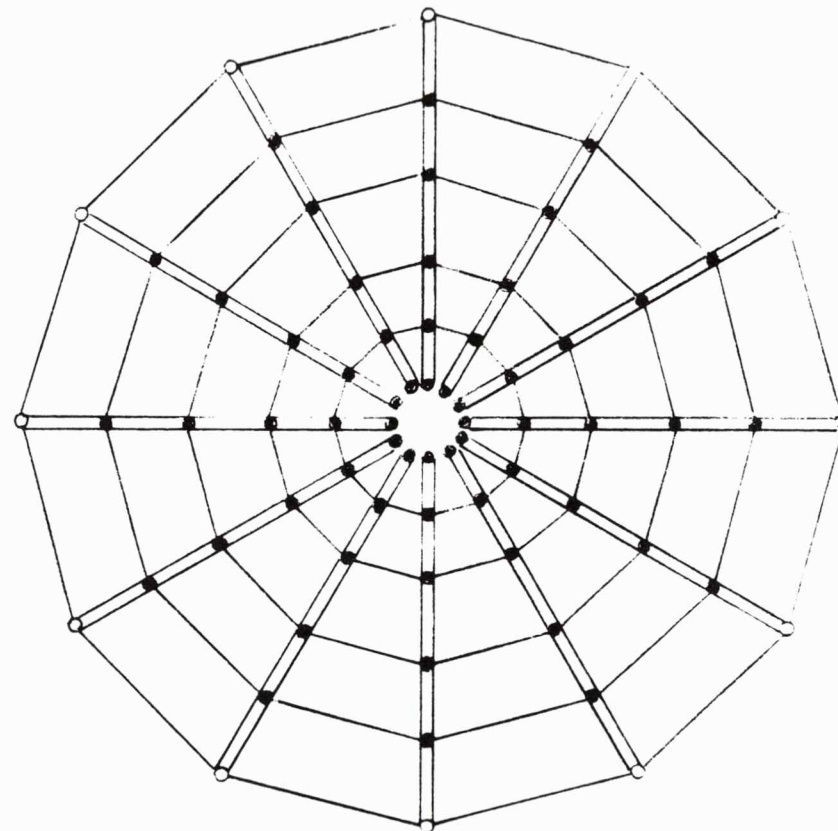
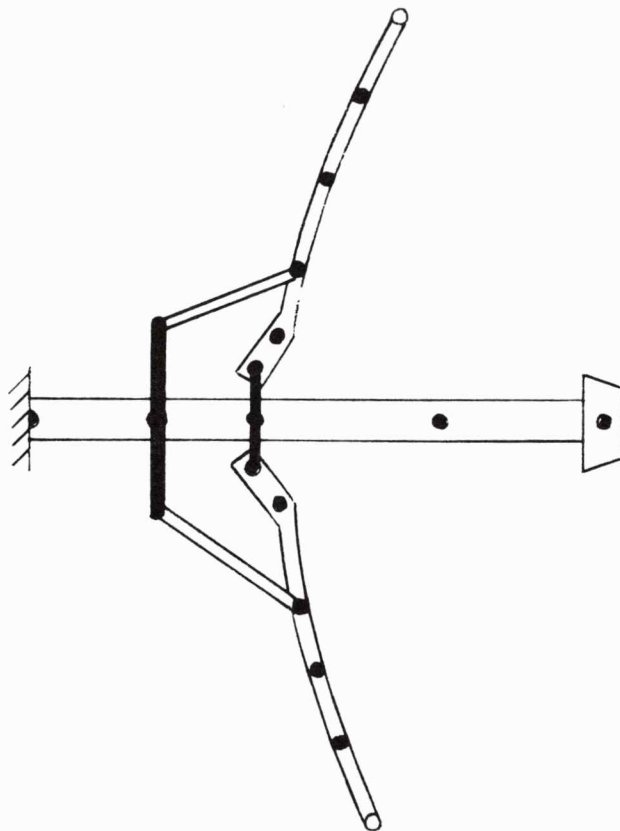


BOOM TRANSMISSIBILITY AT ANTENNA COUPLING





LCRU ANTENNA DYNAMIC ANALYSIS MODEL



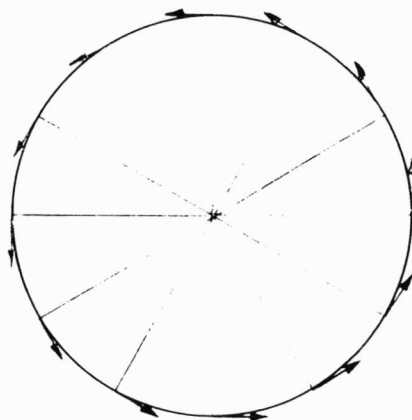
==== BEAM
—— BAR
—— RIGID CONNECTION

● MASS POINT
○ ELASTOMECHANIC POINT



LCRU ANTENNA PRINCIPAL MODE SHAPES

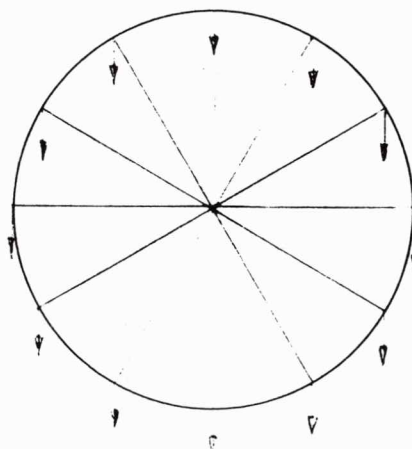
MODE 1 — 33 HZ



DESCRIPTION:

TORSION OF TOTAL DISH
ABOUT FEED AXIS

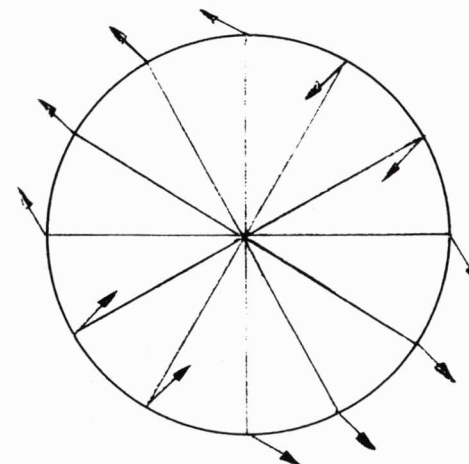
MODE 2 — 34 HZ



DESCRIPTION:

ROCKING ABOUT AN AXIS
PERPENDICULAR TO FEED.
MOTION OF DISH AS A UNIT.

MODE 3 — 35 HZ



DESCRIPTION:

ELLIPTICAL DEFORMATION
OF DISH CONTOUR.



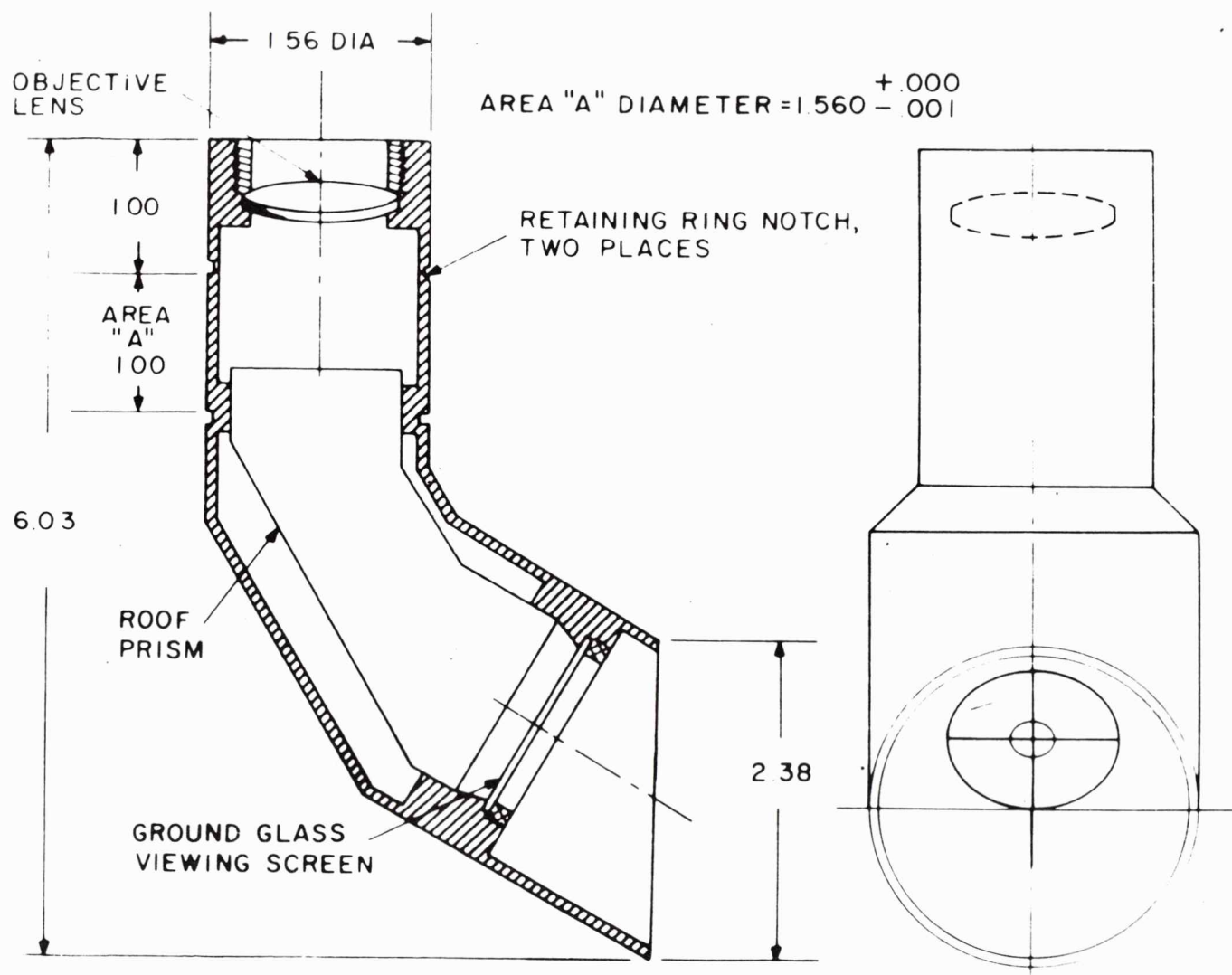
LCRU ANTENNA

MAXIMUM STRESSES IN MEMBERS

				WORST CASE	
PART	DEPLOYMENT STRESSES	DYNAMIC STRESSES	STOWAGE STRESSES	MAXIMUM STRESS (PSI)	F.S. - <u>YIELD</u> <u>ACTUAL</u>
2) ANTENNA SUPPORT	----	4920	----	4920	6.1
3) INTERFACE NUT	----	2920	----	2920	11
4) LOCKING CAM	134	----	324	324	107
5) RIB LIFTER	929	255	2226	2481	13
6) ANTENNA HUB	247	2060	98	2307	14
7) SPECIAL NUT	----	1180	----	1180	29
8) RIB	2040	3500	688	5540	5.3
9) RIB LIFTER LINK	30	72	57	129	332
10) PIVOT PIN	71	173	137	310	112
11) PIVOT PIN	114	255	162	417	83
12) PIVOT PIN	134	348	258	606	57
17) BALL	725	----	1737	1737	20
20) RETAINING RING	26	----	62	62	645
23) RF FEED ASSEMBLY	----	18078	----	18078	5.6
24) OPTICAL BRACKET	----	2630	----	2630	12
29) PERIMETER CABLE	5388	----	----	5388	5.5



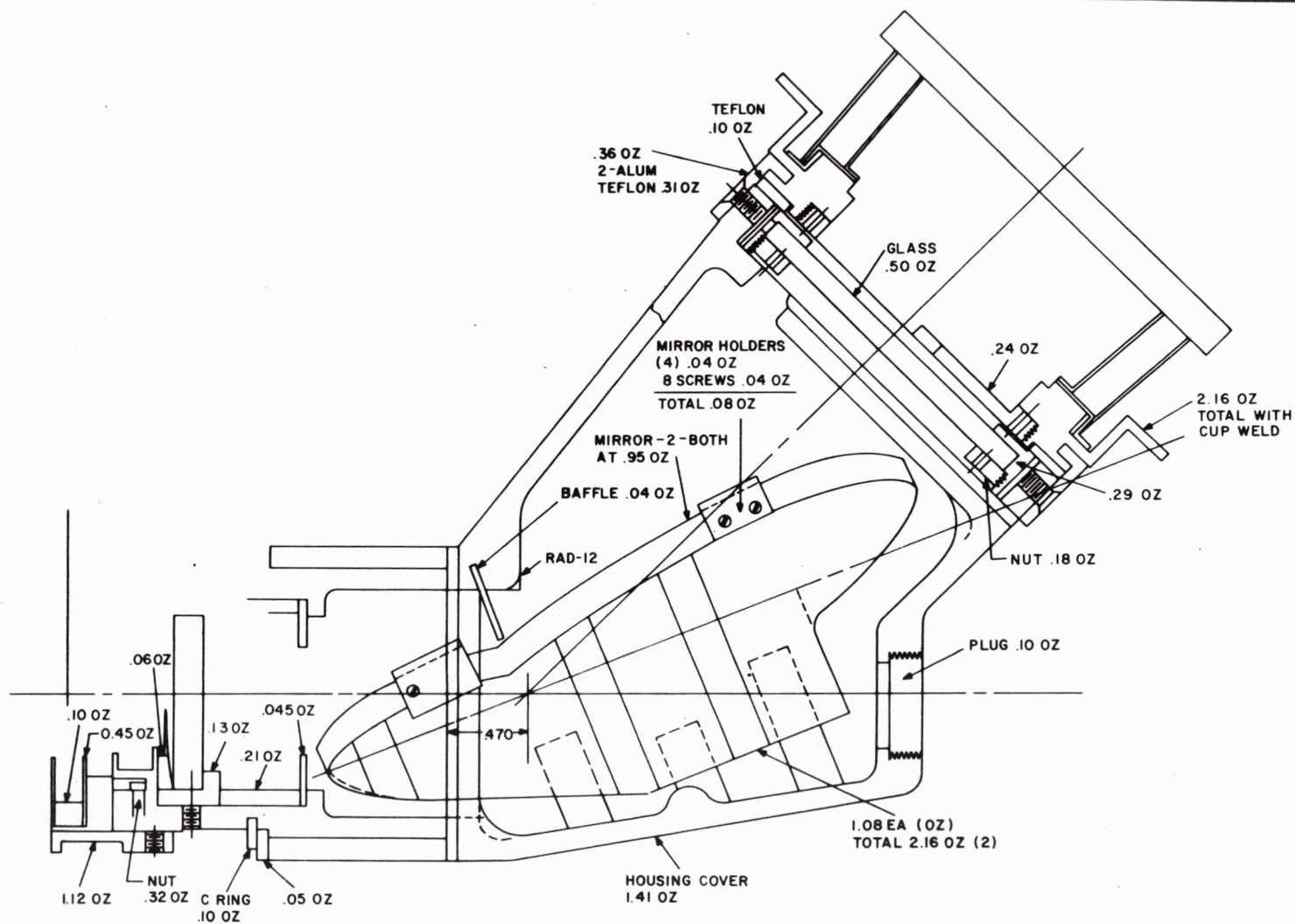
LCRU ANTENNA REAR MOUNTED OPTICAL SIGHT



RCA

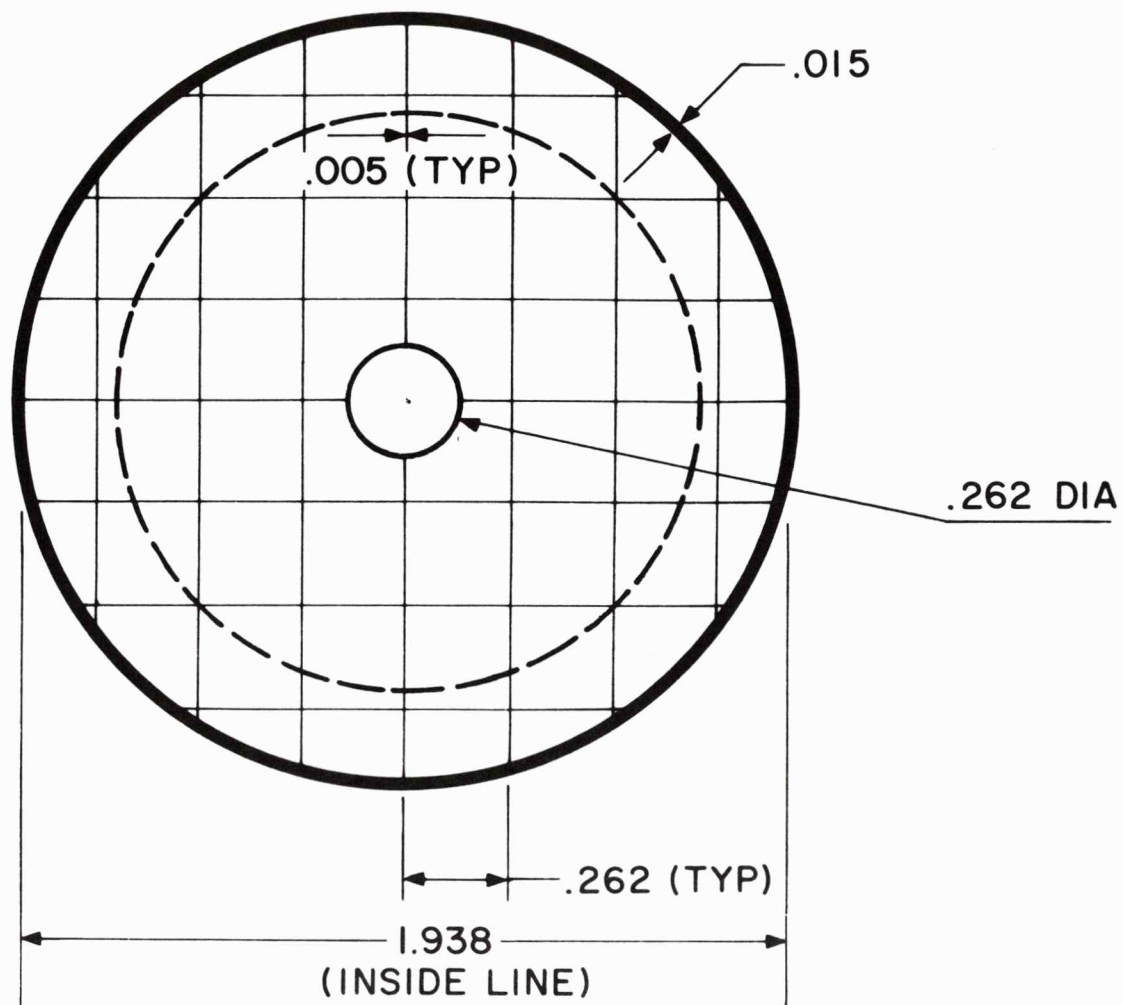
HGA SIGHT

96-8



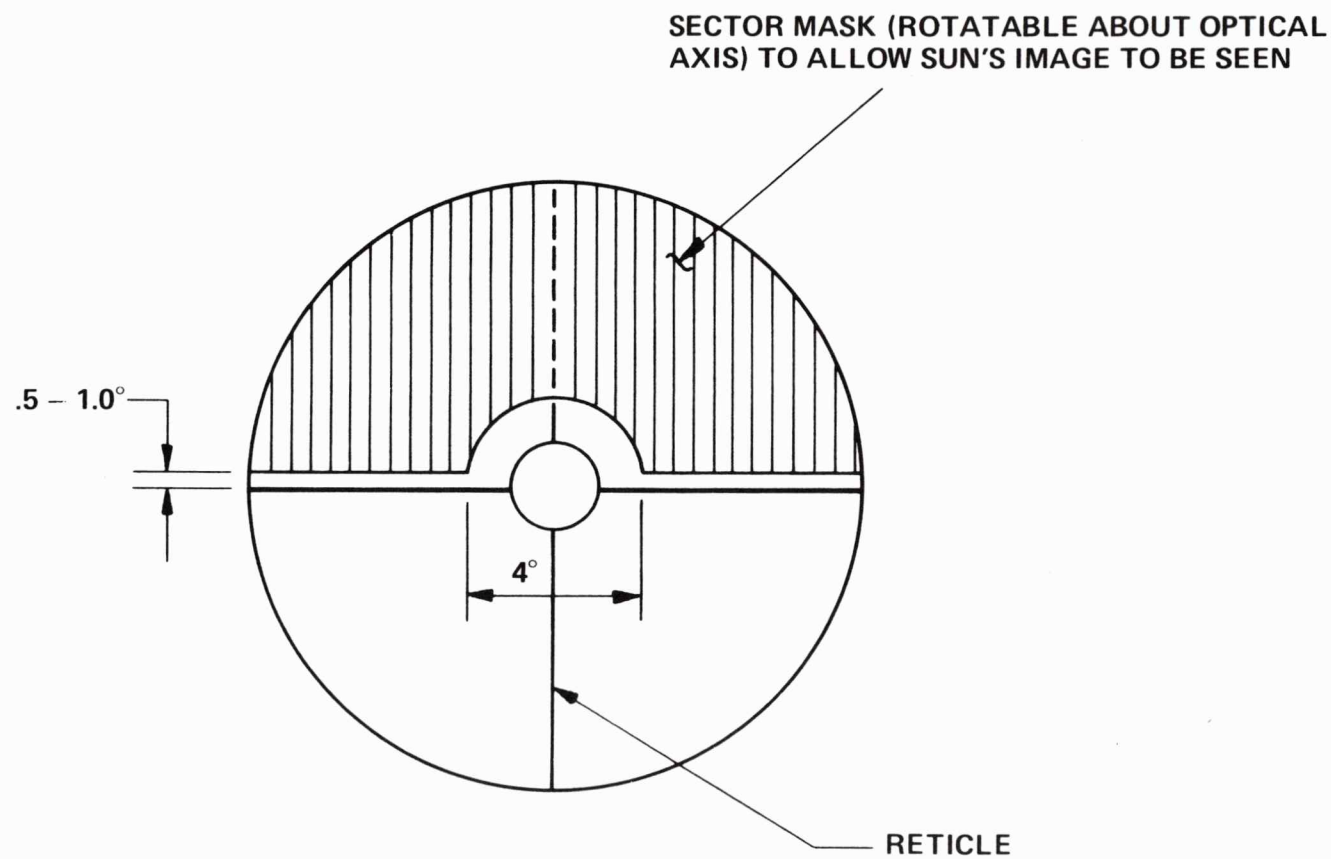
RCA

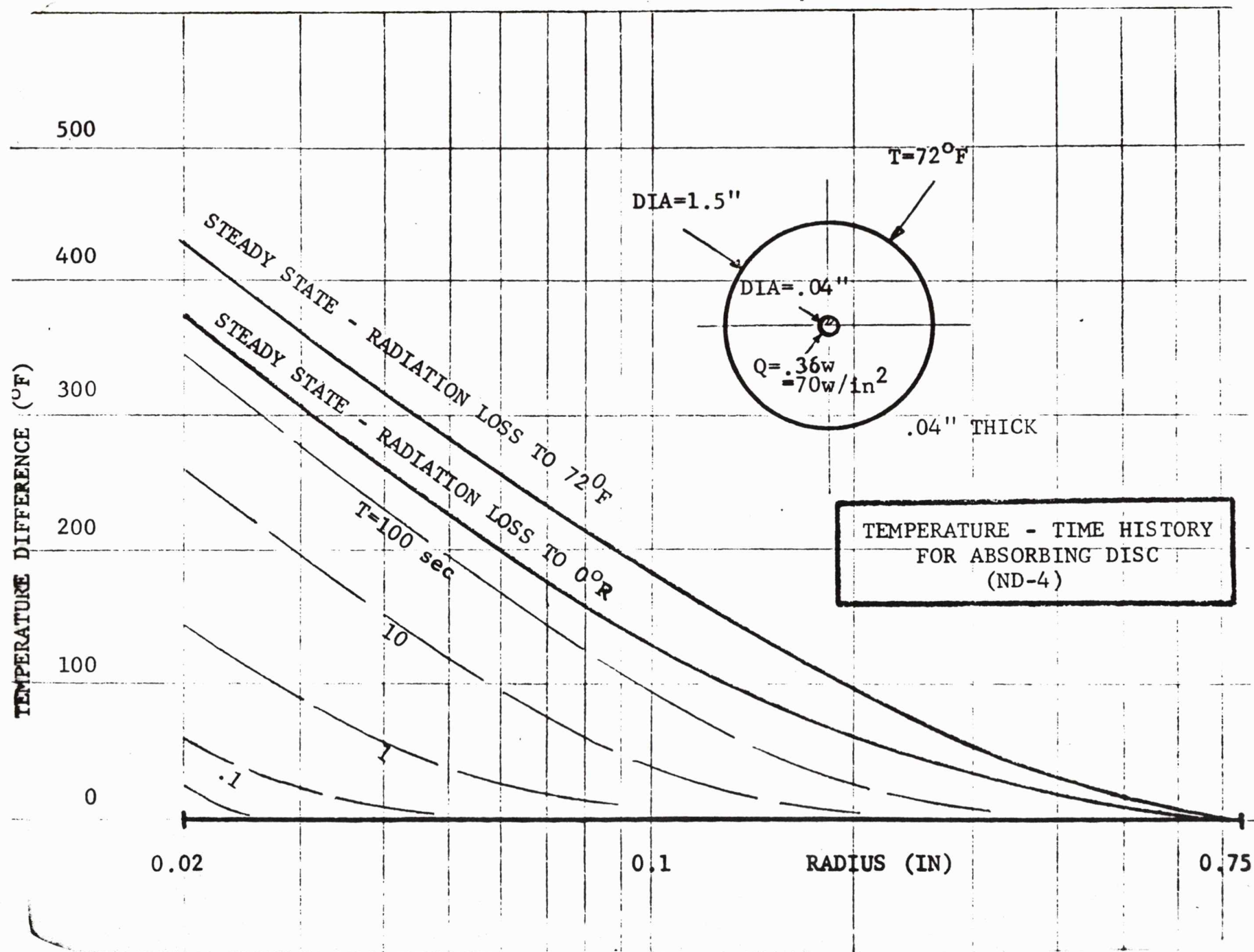
RETICLE





SECTOR MASK (Not to SCALE)

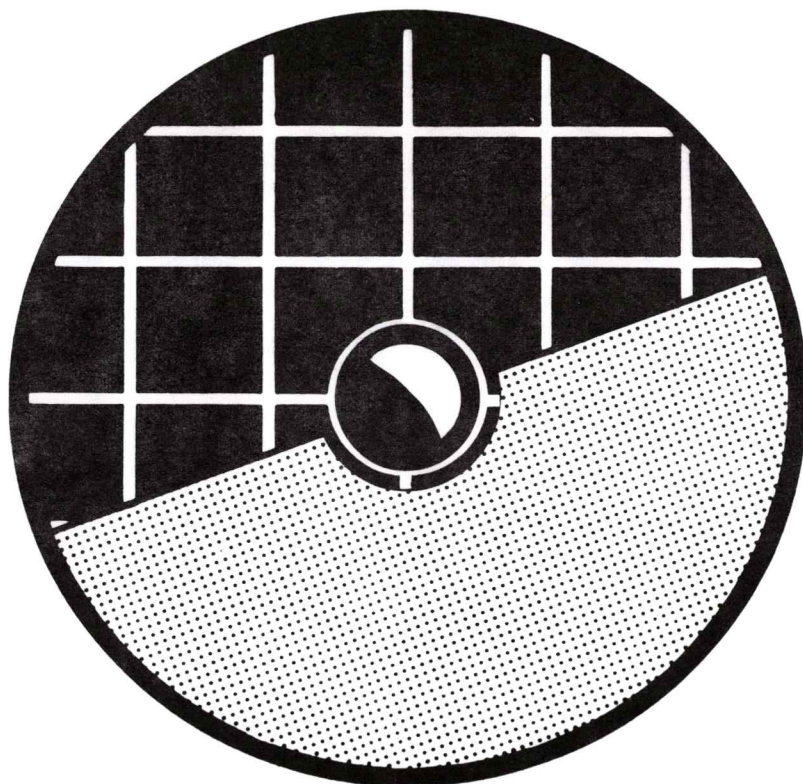




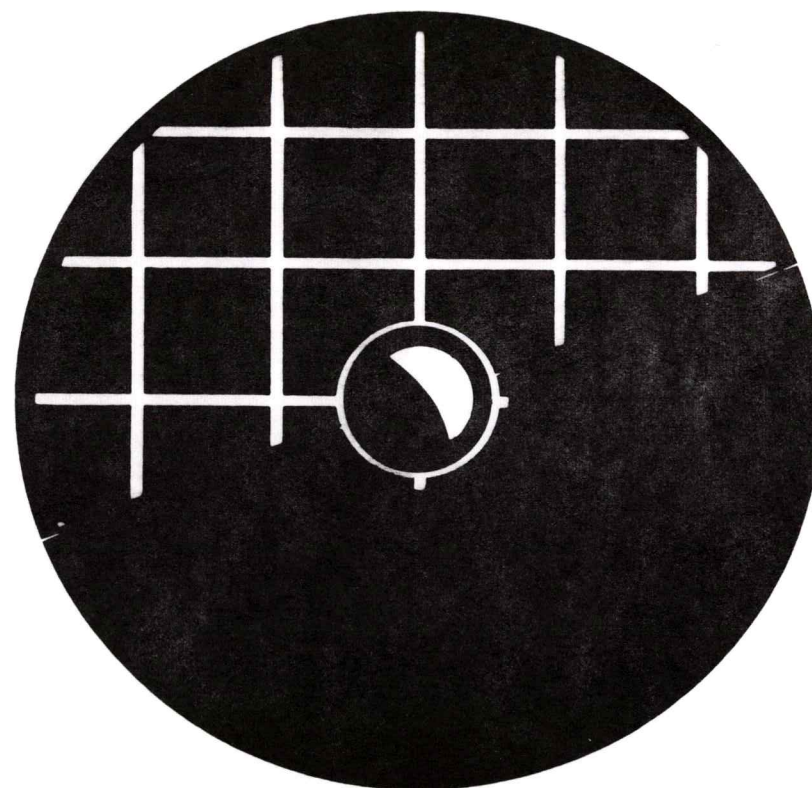
RCA

**HIGH GAIN ANTENNA SIGHT
SUN OUTSIDE FIELD OF VIEW**

8-100



ND4 FILTER SECTOR MASK

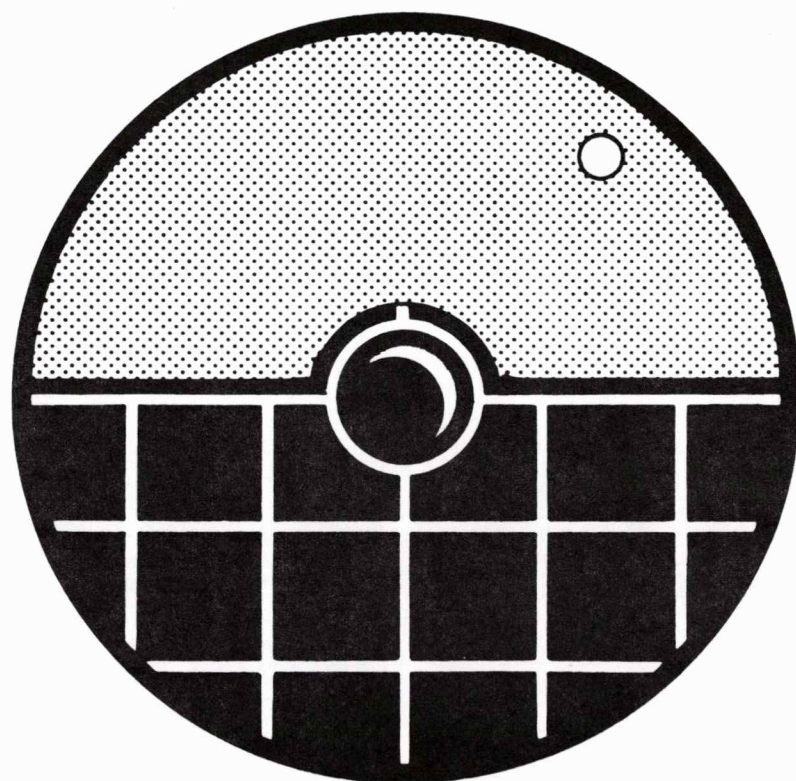


OPAQUE SECTOR MASK

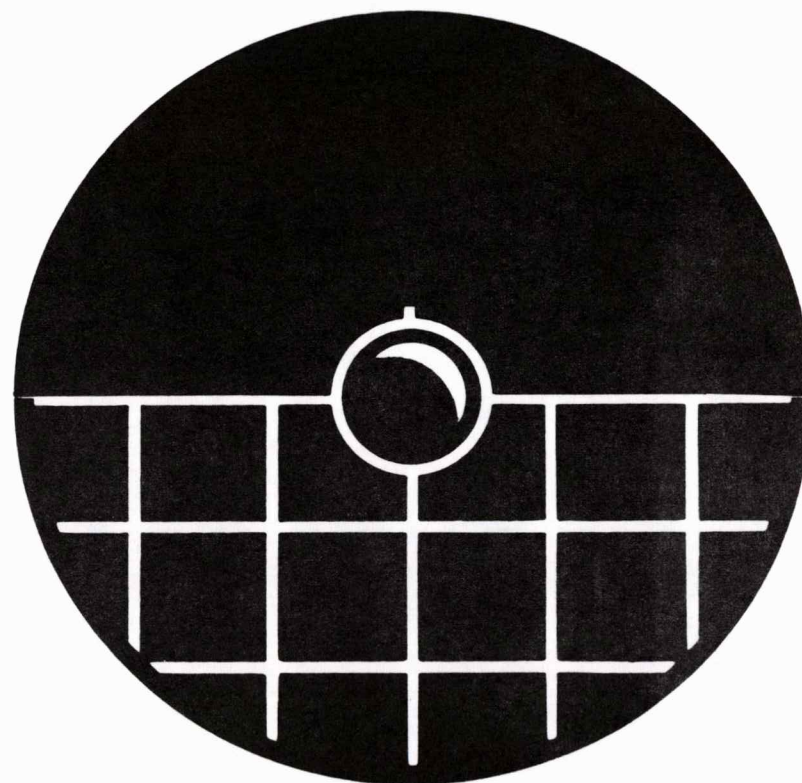
RCA

HIGH GAIN ANTENNA SIGHT
EARTH SUN ANGLE $> 4^\circ$

8-101



ND4 FILTER SECTOR MASK

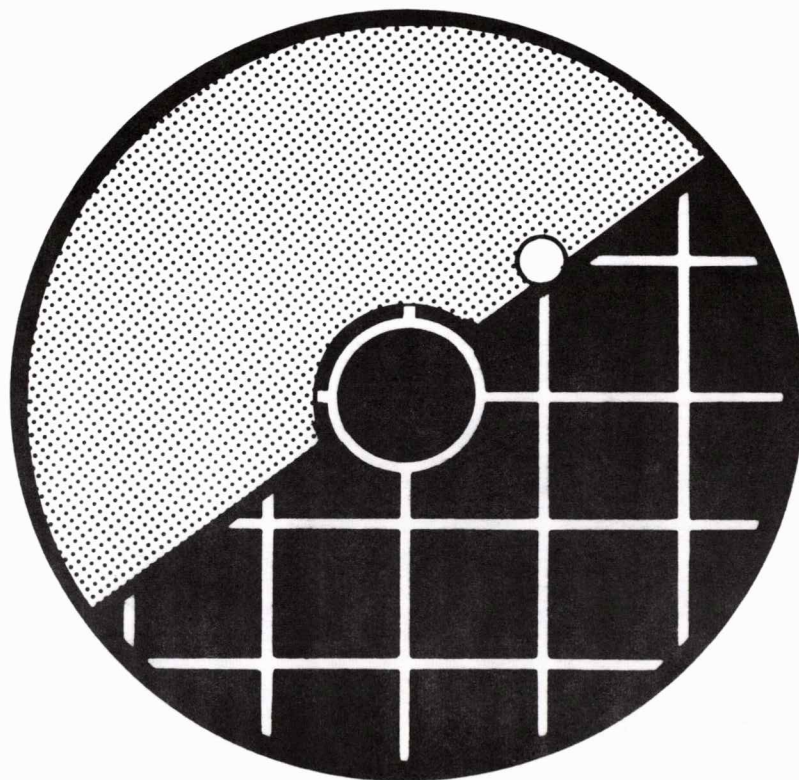


OPAQUE SECTOR MASK

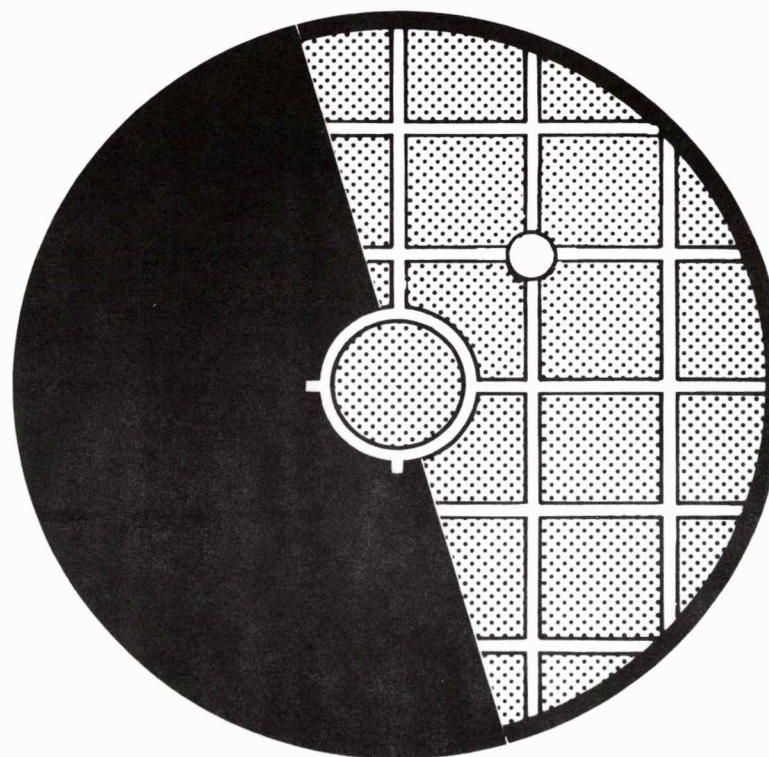


HIGH GAIN ANTENNA SIGHT EARTH SUN ANGLE $< 4^\circ$

8-102



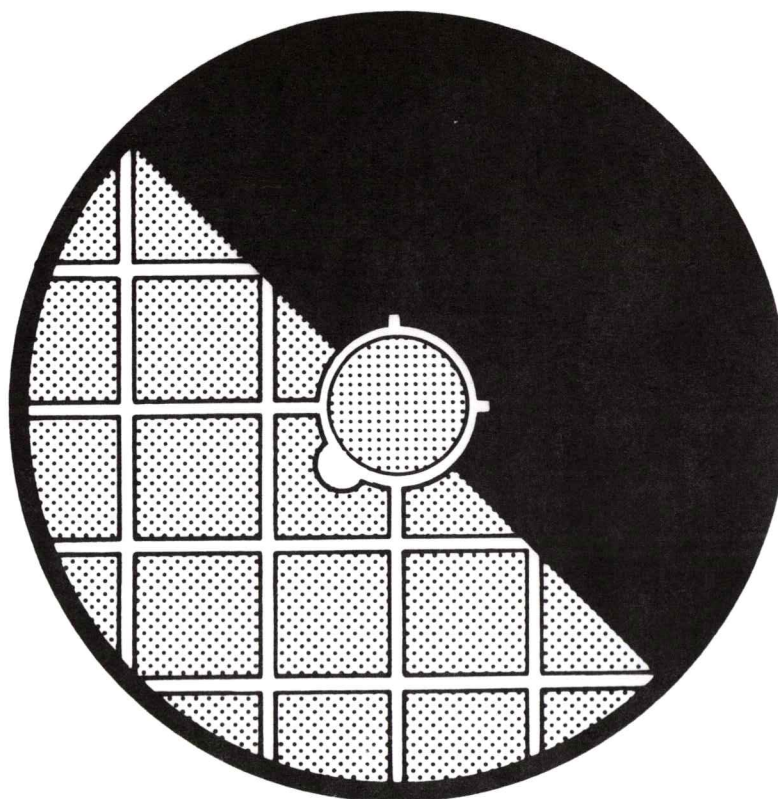
ND4 FILTER SECTOR MASK



OPAQUE SECTOR MASK
ND4 FILTER OVER LENS

RCA

HIGH GAIN ANTENNA SIGHT
SUN PARTIALLY ECLIPSED BY EARTH



OPAQUE SECTOR MASK
ND4 FILTER OVER LENS



SEAL REQUIREMENTS

1. EARTH ENVIRONMENT

- DUST EXCLUSION
- SALT EXCLUSION
- MOISTURE AVOIDANCE

2. BOOST/ASCENT

- DEPRESSURIZATION TOLERANCE

3. LUNAR ENVIRONMENT

- DUST EXCLUSION
- MOISTURE/ICE AVOIDANCE



SEALING PLAN

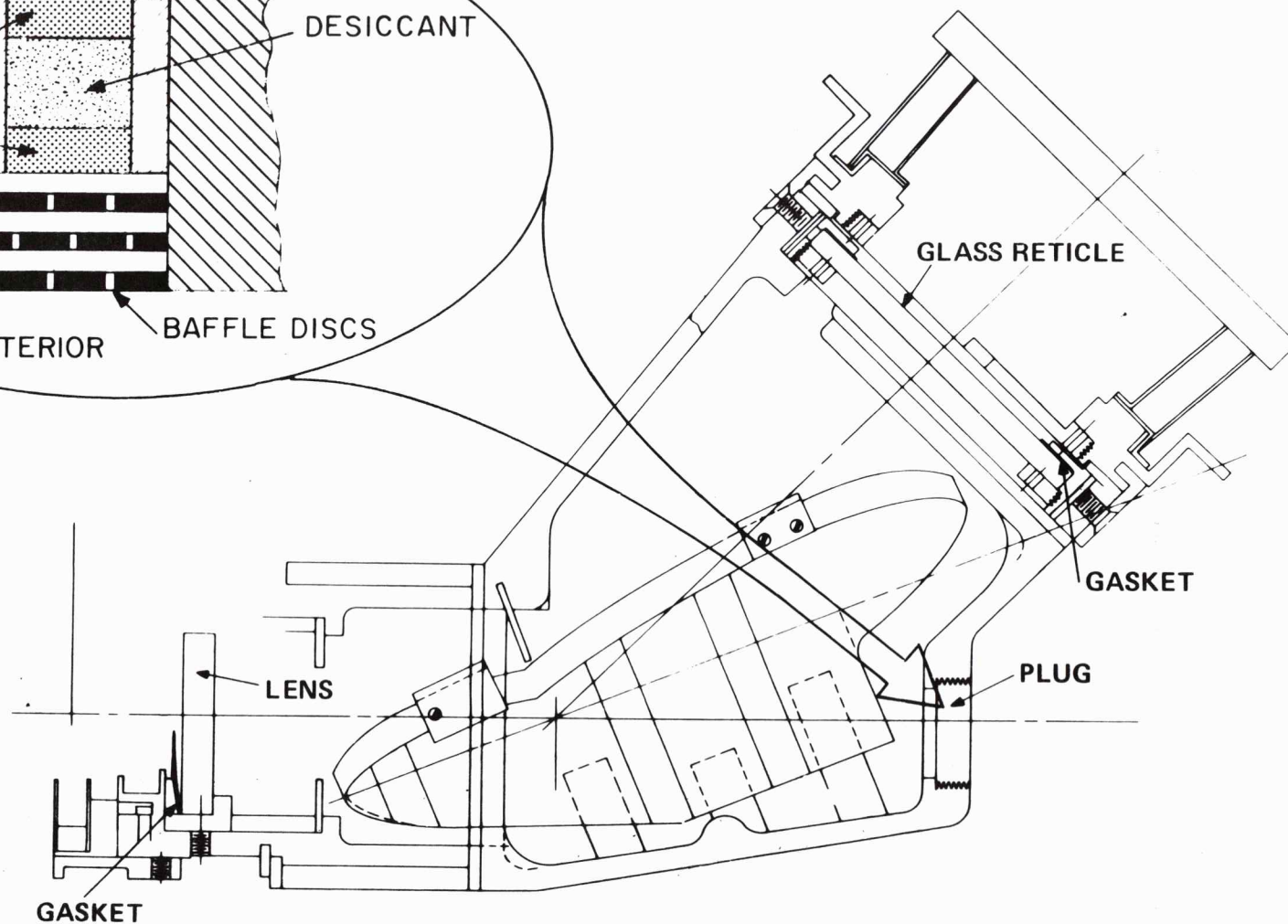
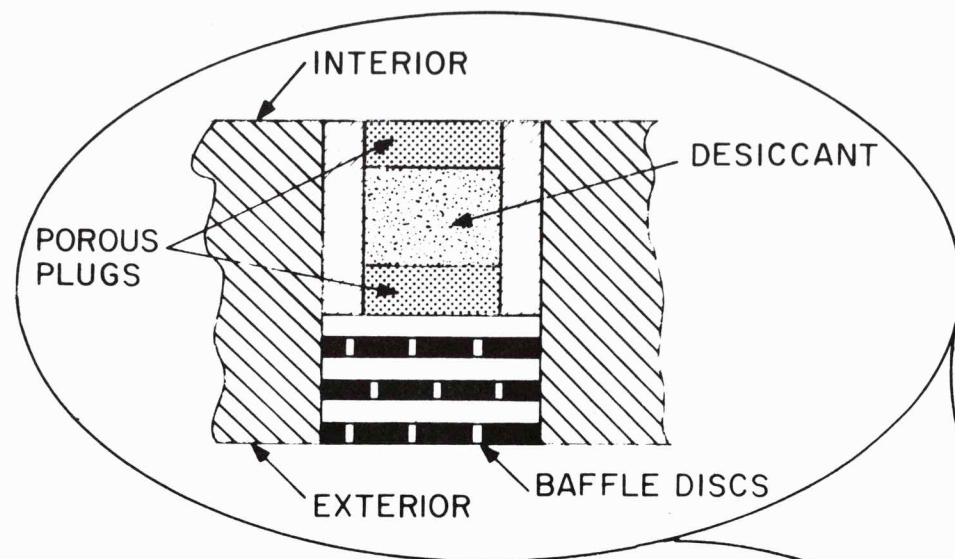
1. SEAL WITH GASKETS AT LENS AND RETICLE
2. PROVIDE POROUS PLUG WITH BAFFLE IN HOUSING WALL
3. ASSEMBLE IN CLEAN DRY ATMOSPHERE

FEATURES

- ALL GASKETS AND PLUGS WILL BE EFFECTIVE IN EXCLUDING DUST
- POROUS PLUG WILL PERMIT SMOOTH PRESSURE EQUALIZATION
- MOISTURE INFLOW IMPEDED BY DESICCANT IN PLUG
- MOISTURE DEPARTURE NOT IMPEDED



SEALING PLAN FOR HGA SIGHT



RCA OPTICAL SIGHT MOCK-UP WEIGHT SUMMARY

			<u>Wt/Oz</u>
<u>Reticle Assembly (total)</u>			.97
SK7019	Ring Clamp, Glass	.18	
SK7017	Ring Holder	.29	
	Reticle	.50	
<u>Lens (total)</u>			.31
<u>Mirror Assembly (total)</u>			3.19
SK7001	Mirror Assembly	2.16	
	Mirrors (2)	.95	
	Clips & Screws	.08	
<u>Baffle Assembly (total)</u>			2.33
SK7003	Washer	.06	
SK7004	Lens Holder	.13	
SK7005	Baffle, Light	.045	
SK7006	Spacer	.21	
SK7007	Clamp	.32	
SK7008	Holder	.27	
SK7009	Spacer	.10	
SK7010-1	Baffle	.03	
SK7010-2	Baffle	.045	
SK7011	Housing	1.12	
<u>Housing Assembly (total)</u>			10.88
SK7002	Cap	.10	
SK7024	Housing Body	9.29	
SK7029	Housing Cover	1.41	
SK7028	Baffle	.04	
SK7027-3	Shim	.04	
	"C" Ring	.10	
	Retainer Ring	.05	
<u>Shield Assembly (total)</u>			2.81
SK7023-501	Shield Assembly	2.16	
SK7021	Holder	.31	
SK7018	Ring Sector Mask	.24	
SK7020	Slide	.10	
TOTAL ASSEMBLY			20.64 oz. (1.29 lbs.)



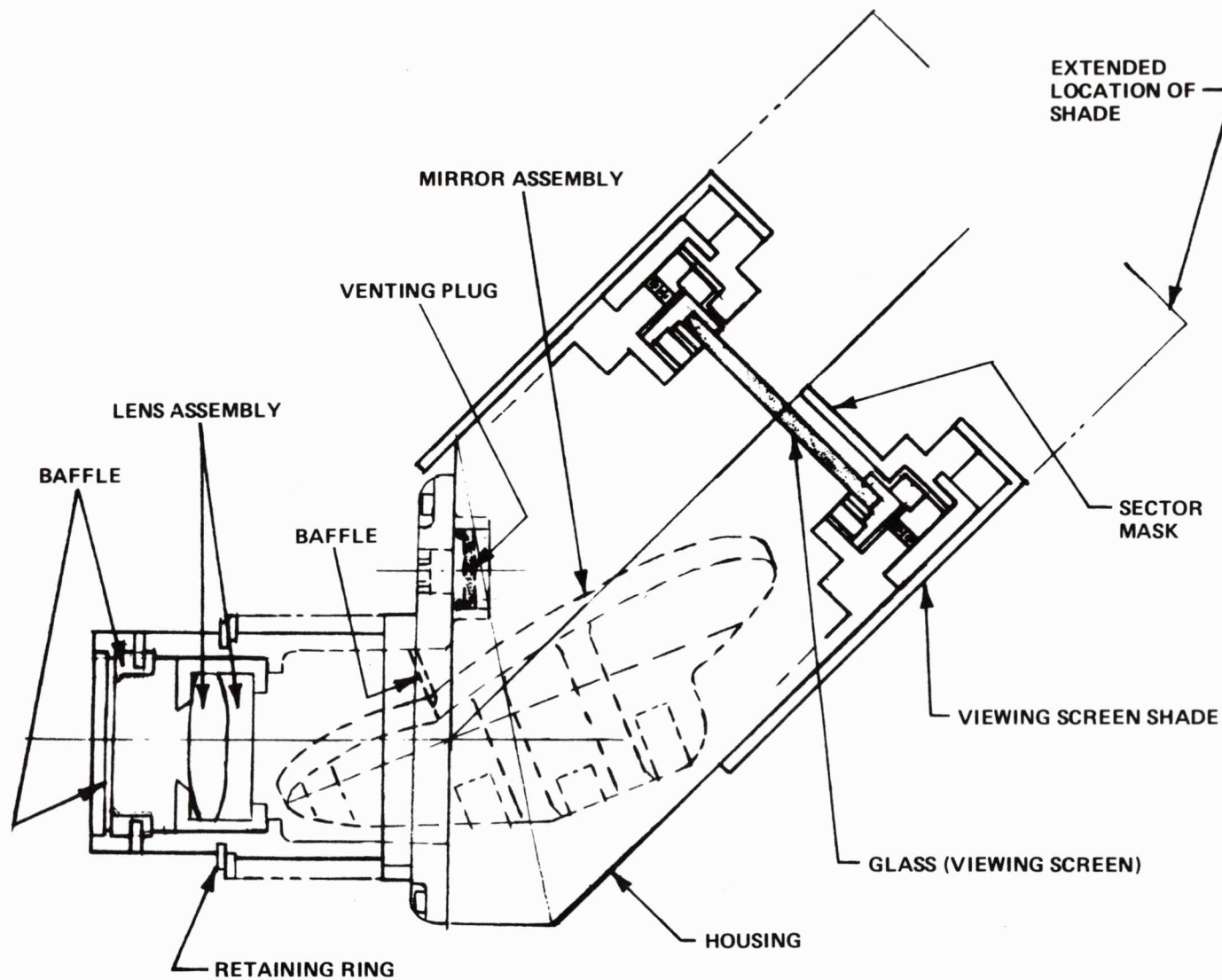
DESIGN CHANGES PLANNED — MOCK-UP/ENGINEERING MODELS TO DVT'S

1. SURFACES TO BE ROUNDED
2. SURFACE FINISH TO CHANGE (TO BLACK ANODIZE, PROBABLY)
3. LENS TO BE ACHROMAT WITH NO PLANAR SURFACE
4. SEAL SYSTEM TO BE INCORPORATED
5. BEARING SURFACE TO BE HARD COAT TREATED
6. EYE SHADE TO BE REDESIGNED TO AVOID SHARP EDGES AND TO IMPROVE RING SNUBBING
7. SECTOR MASK TO BE GLASS (ND 4), ATTACHED TO METAL RING
8. MIRRORS TO BE QUARTZ, WITH INVAR MOUNTING SLEEVES
9. BASIC REDESIGN OF HOUSING TO PROVIDE EFFICIENT INSERTION OF MIRRORS, TO PROVIDE IMPROVED LIGHT MASKING, AND TO PROVIDE MINIMUM UNIT WEIGHT.

1. **SPRAY TECHNIQUE FOR BLACK VELVET PAINT**
2. **RETICAL SURFACE GRINDING AND COATING**
3. **CEMENT EFFECTIVENESS VERIFICATION**
4. **TESTS OF STRUCTURAL STABILITY**

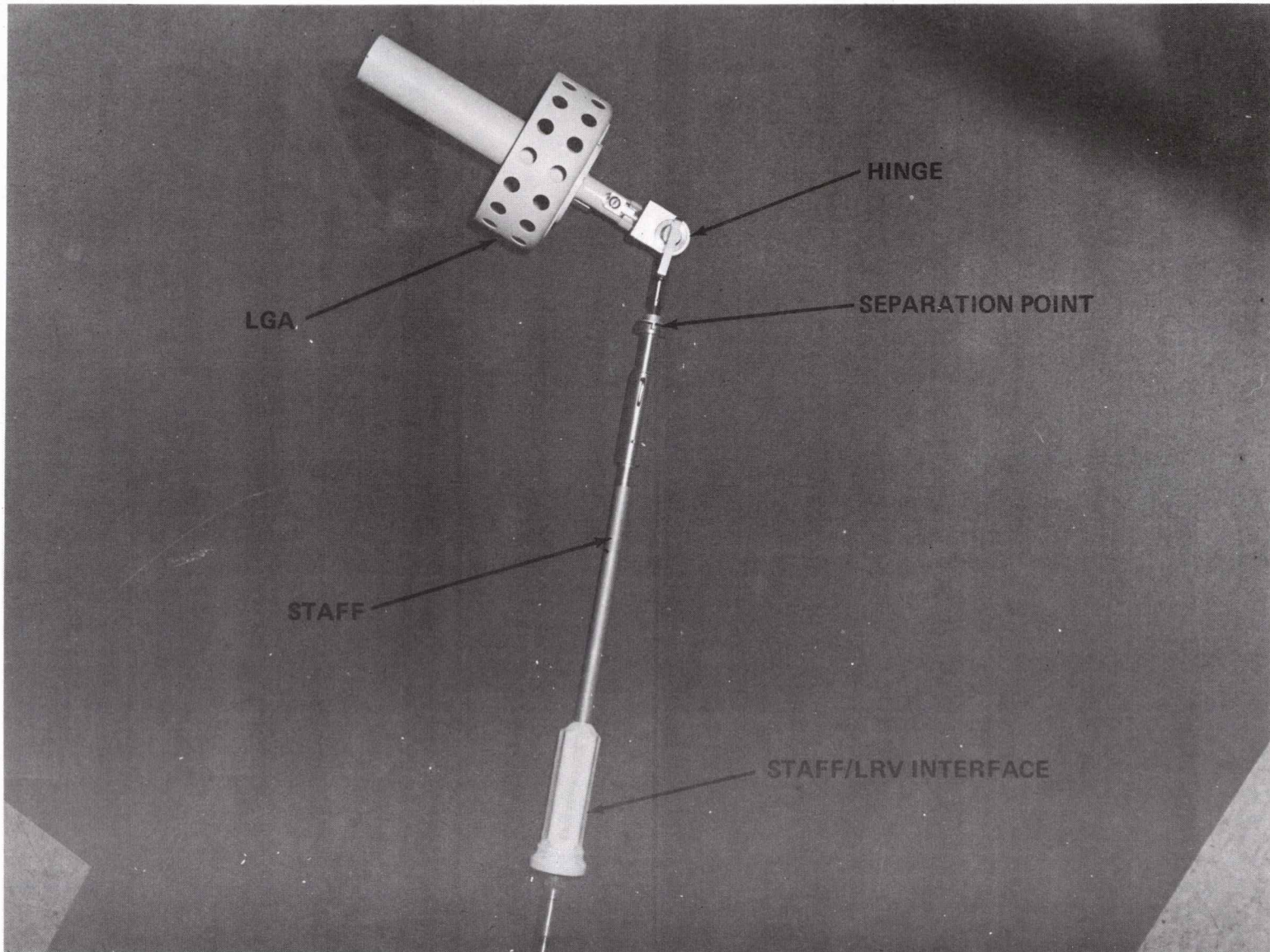


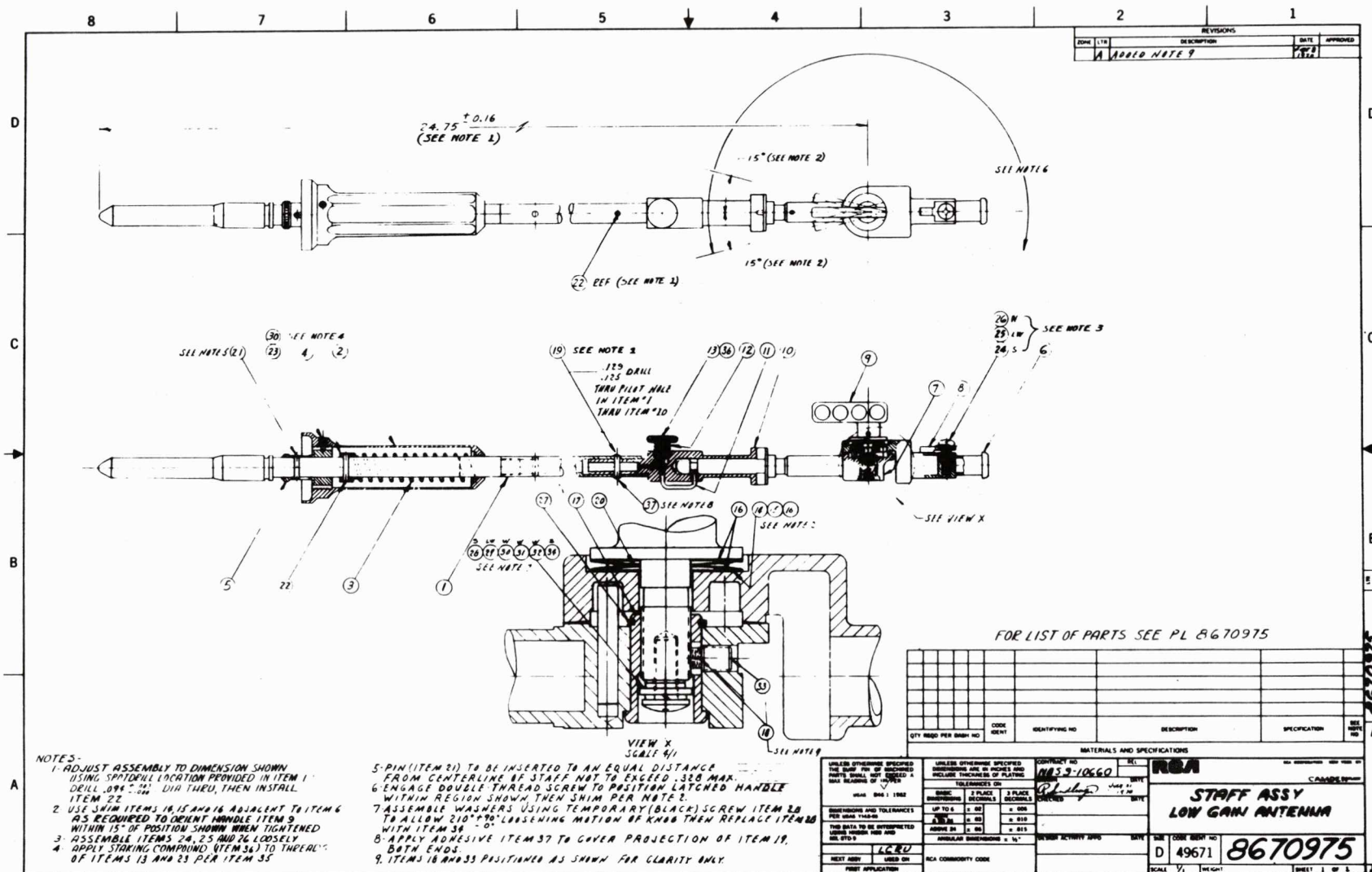
HGA SIGHT-DVT MODEL





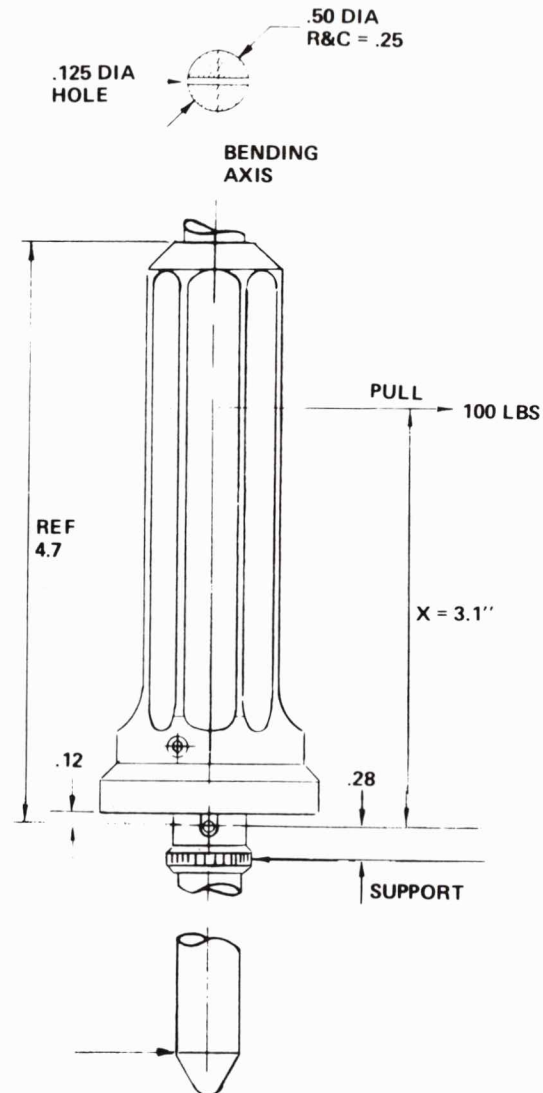
LCRU LGA AND STAFF ASSEMBLY MECHANICAL MOCK-UP







LGA STAFF STRENGTH



ALUM. 7075-T6@211° F

$$F_{tu} \ 88\% \times 75,000 = 66,000$$

$$F_{ty} \ 80\% \times 75,000 = 60,000$$

$$\frac{66,000}{1.5 \text{ F.S.}} = 44,000 \text{ p.s.i. allowable}$$

$$I_{.50 \text{ DIA}} = \frac{\pi}{4} R^4 = .785 \times .0039 = .00306$$

$$I_{\text{HOLE}} = \frac{bd^3}{12} = .125 \times .0104 = .00130$$

$$I_{\text{NET}} = .00176$$

$$S = \frac{Mc}{I}$$

$$44,000 = \frac{(100X) .25}{.00176}$$

$$X = \frac{44,000}{25} \times .00176 = 3.1"$$

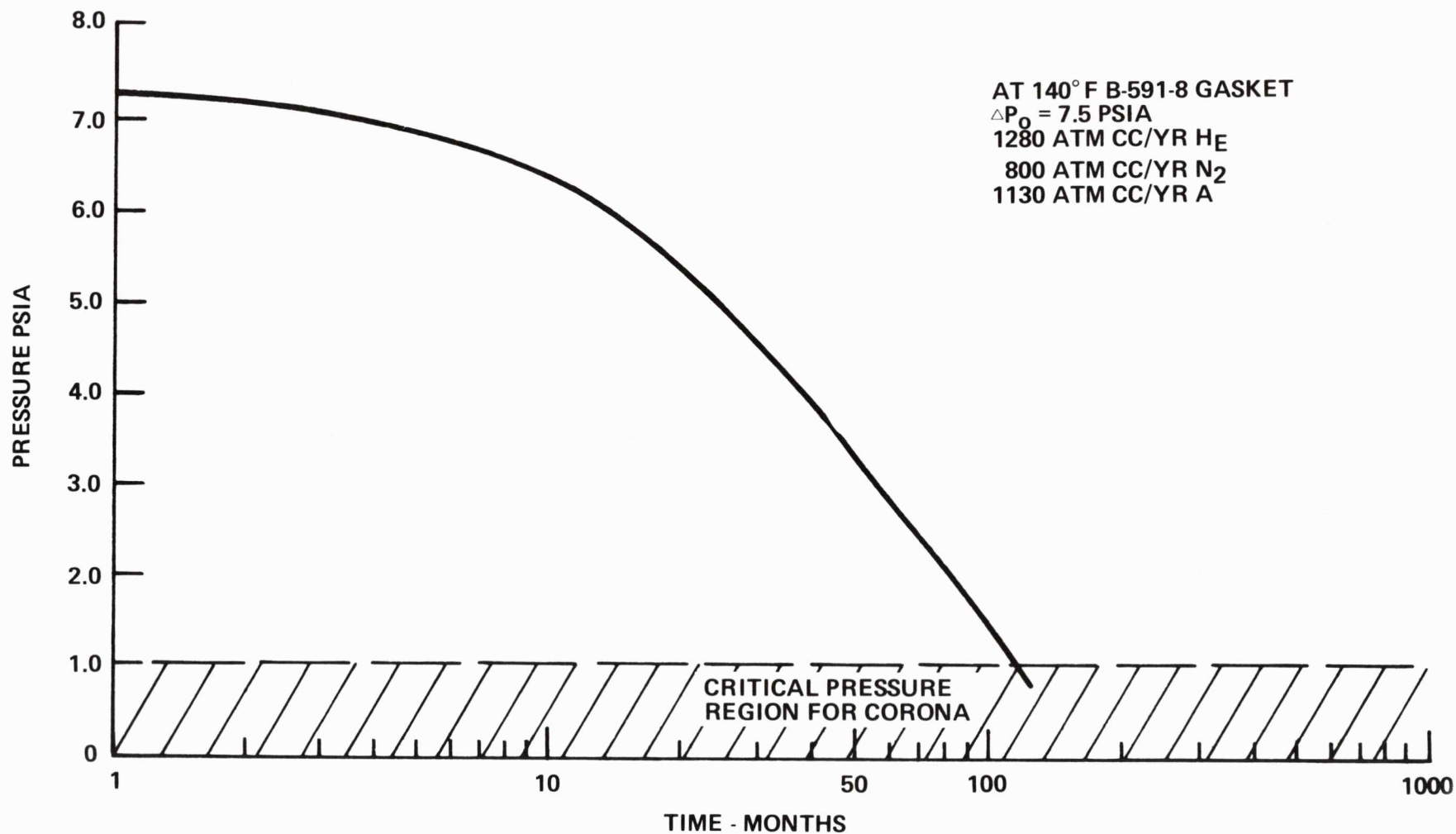


LCRU PRESSURIZATION DESIGN

- **GAS MIXTURE**
LEAK RATE CHECK WITH 10% N 90% A.
PURGE AND BACKFILL WITH 100% N – NO LEAK CHECK
- **PRESSURE**
7.5 PSIA
- **PRESSURE MONITOR – KULITE XT-190 SERIES PRESSURE SENSOR**
SPECIFICATION COMPLETE
PARTS ON ORDER 8553610
- **CASE STRUCTURAL DESIGN – NO CHANGE**
- **HYDRAULIC TEST CASE – PRELIMINARY TESTS COMPLETE**
- **PRESSURE PURGE VALVE – BEING INVESTIGATED TO REPLACE PINCH OFF TUBE.**
PARTS HAVE BEEN ORDERED.



LCRU CASE PRESSURE DROP





LCRU PRESSURIZATION DESIGN

ANALYTICAL ANALYSIS SEE HANDOUT - LCRU CASE PRESSURIZATION
STRESS ANALYSIS 6-30-70

CASE & COVER MATERIAL 6061-T6 AL

F_{ty} (TENSIL YIELD STRESS) FROM MIL-HDBK-5A = 35,000 psi

SAFETY FACTOR 1.5 APPLIED TO LIMIT LOAD

MAX PRESSURE LOADING 14.7 PSI EXTERNAL

S_{max} ALLOWABLE = (.98)(1.5)(35,000) = 22.2 x 10³ PSI

MAX TENSIL STRESS OCCURS AT TOP OF RIBS

PRESSURE TEST RESULTS (PRELIMINARY INFORMATION ONLY)

METHOD OF TEST - VACUUM AND HYDRAULIC

INSTRUMENTATION - "STRESS COAT" AND STRAIN GAGES

PRELIMINARY DATA - "STRESS COAT" CONFIRMS LOCATION OF HIGH
STRESSES ALONG EDGES OF WEBS.

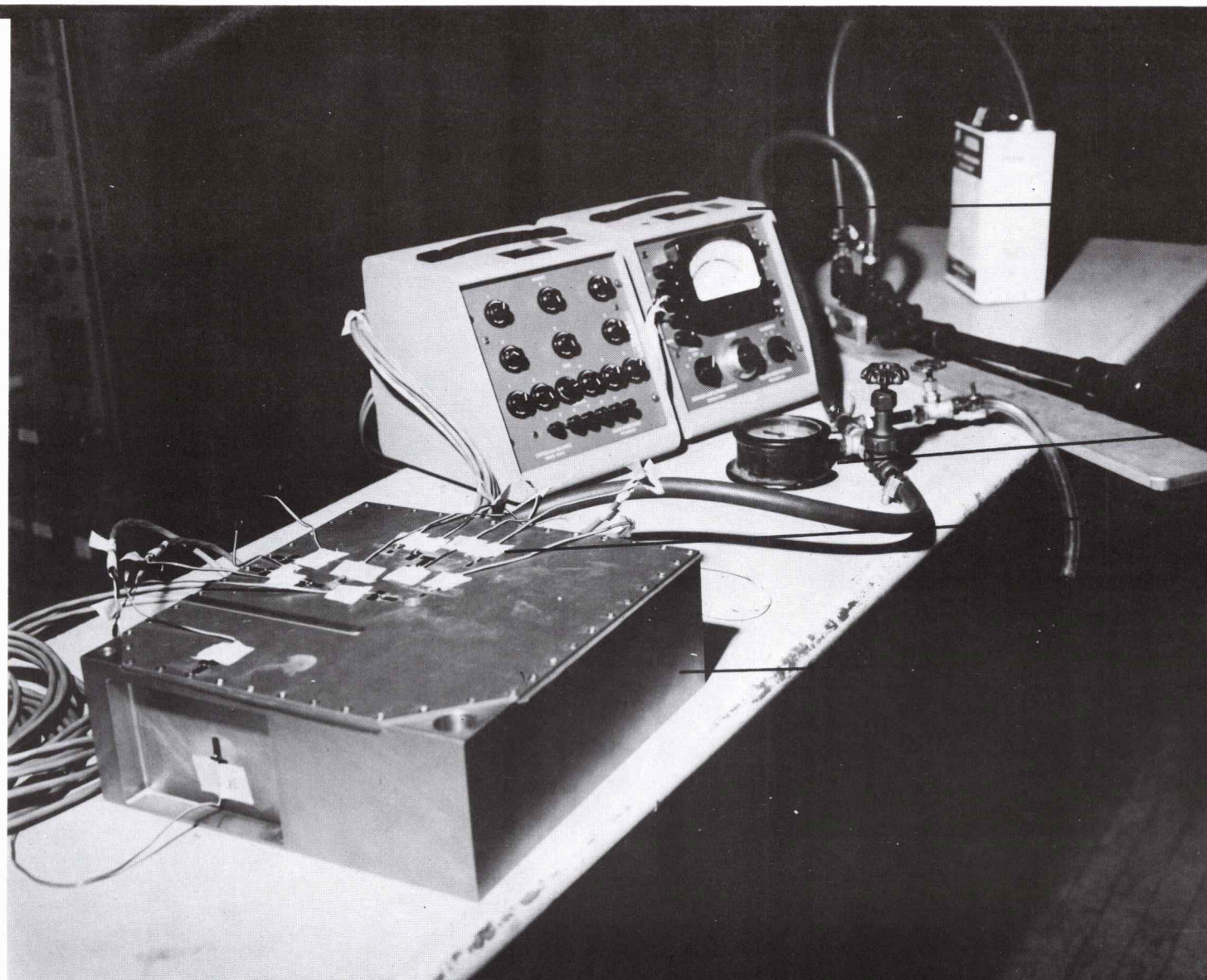
STRAIN GAGES INDICATORS 6,000 PSI

IN CENTER OF WEBS. (THIS IS LOW STRESS
AREA ACCORDING TO THEORY)

TEST TO BE COMPLETED BY NEXT TI



LCRU CASE PRESSURE TEST



WATER
SUPPLY

INSTRUMENTATION

PUMP

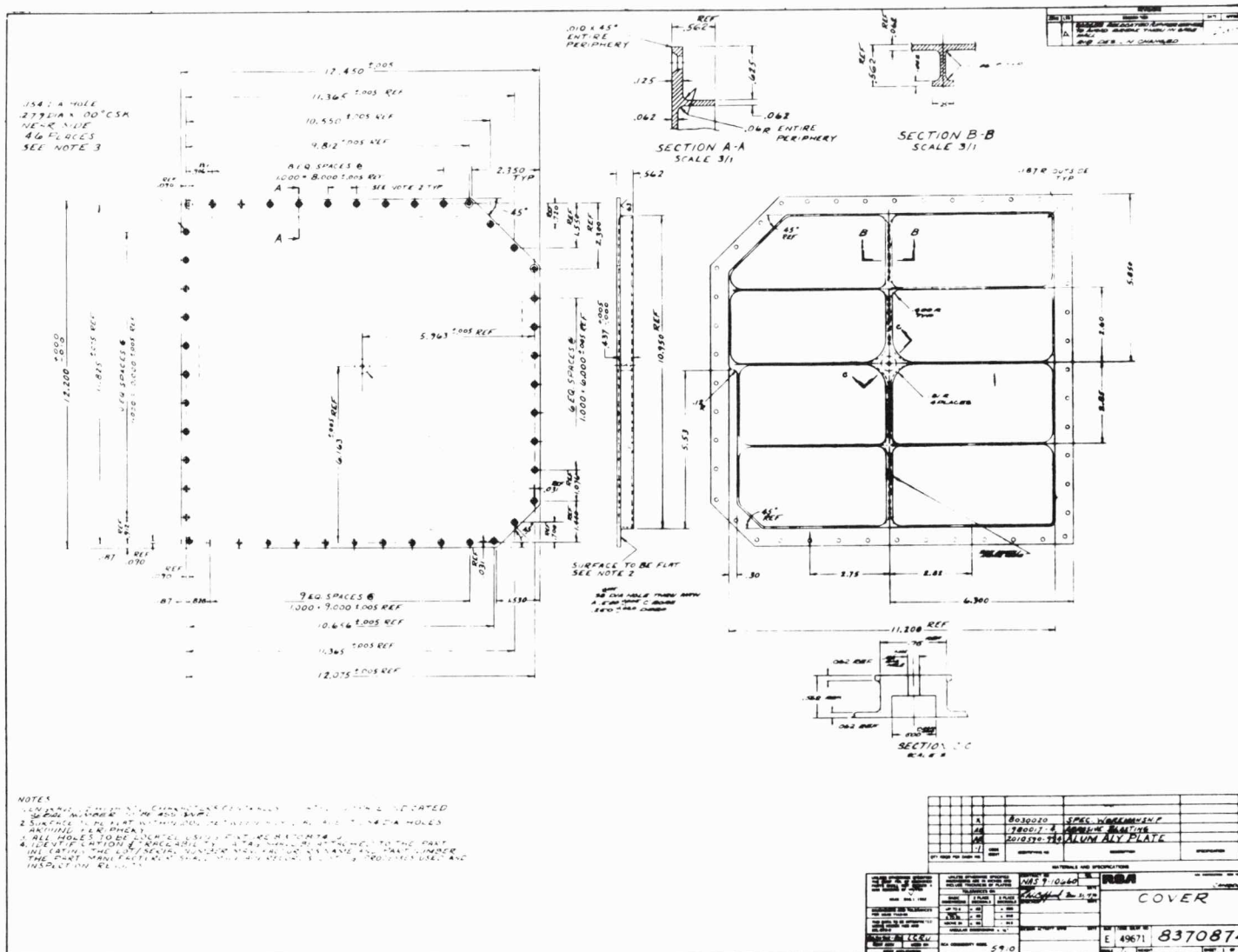
GAGE

STRAIN GAGES

LCRU PRESSURE
TEST CASE

REAL

COVER



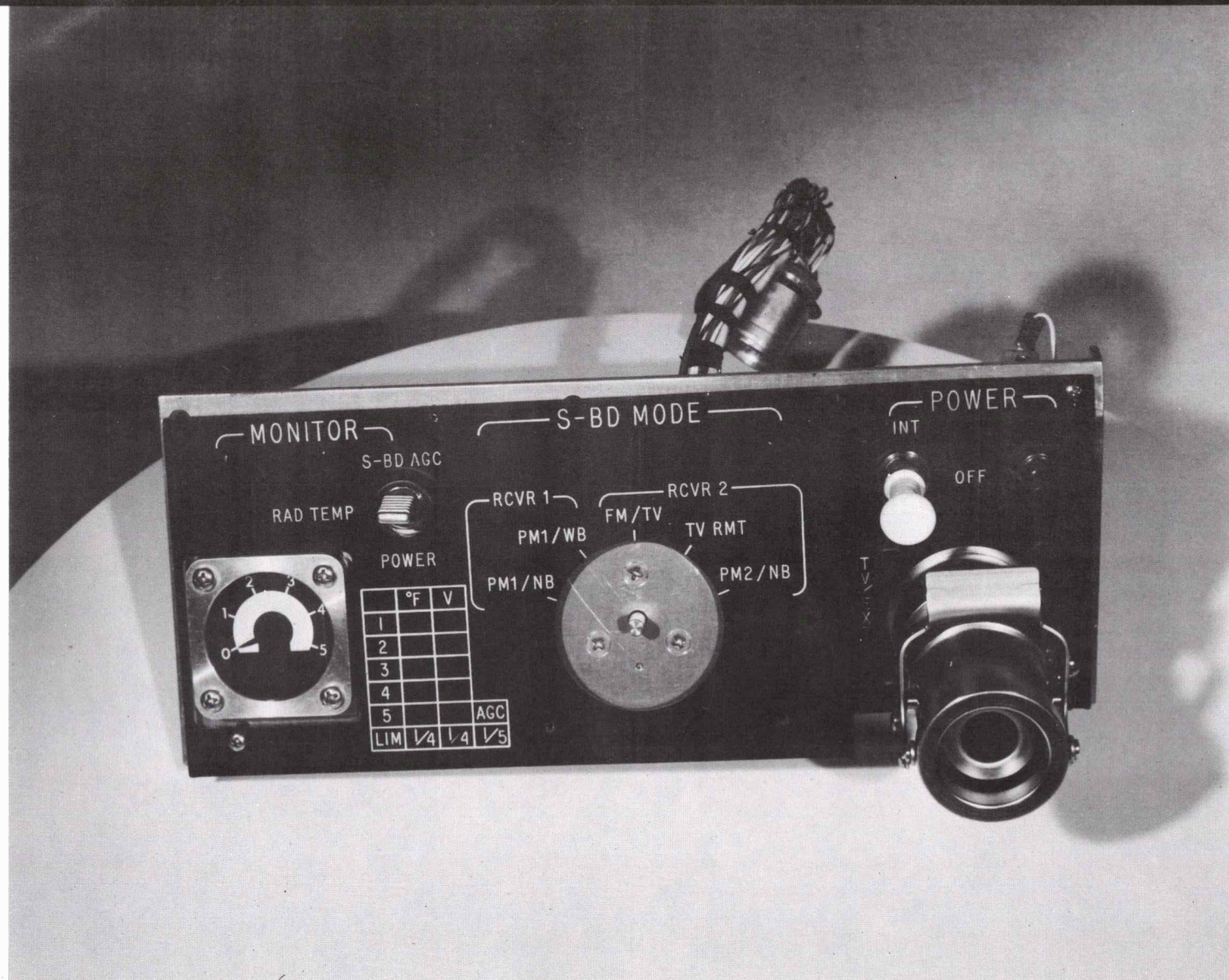


HANDLE-LCRU

[illegible]

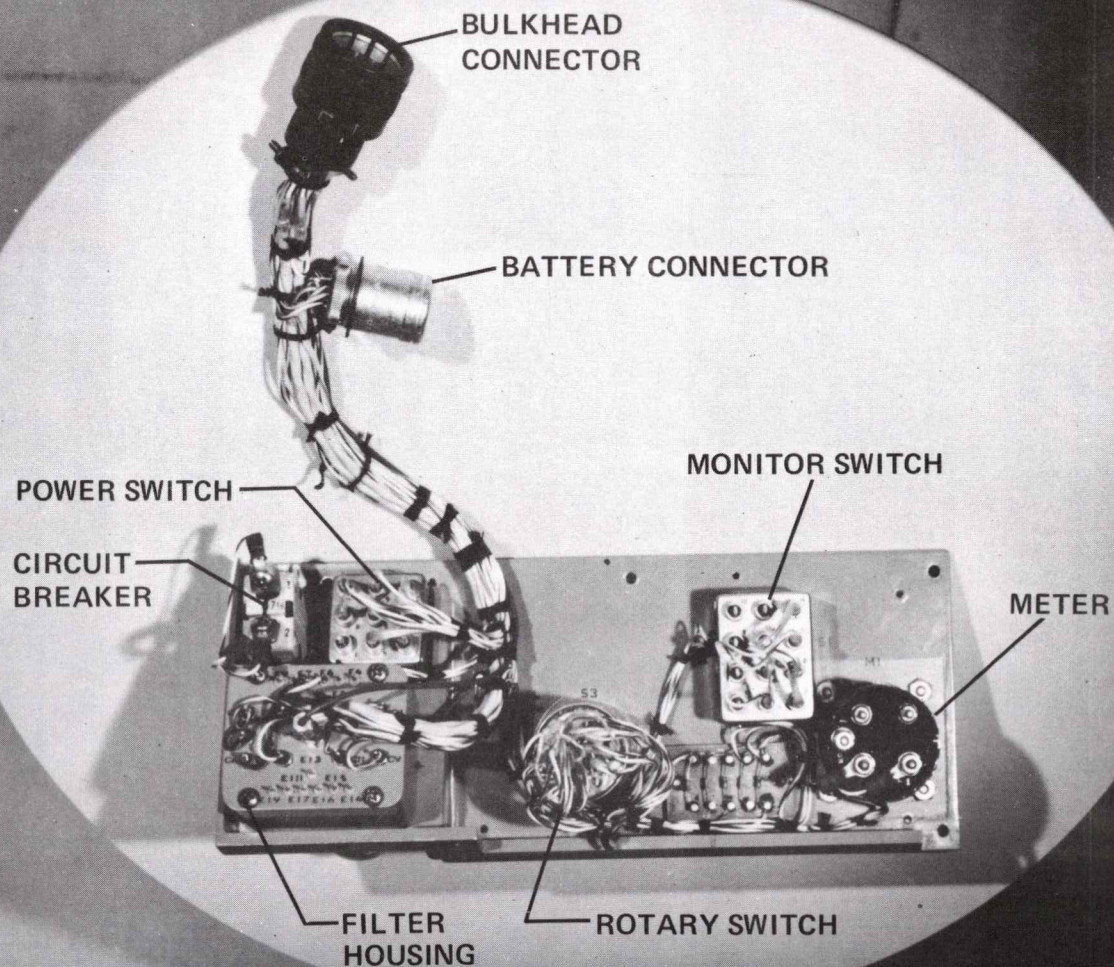
RCA

LCRU CONTROL PANEL ENGINEERING MODEL



RCA

LCRU CONTROL PANEL ENGINEERING MODEL

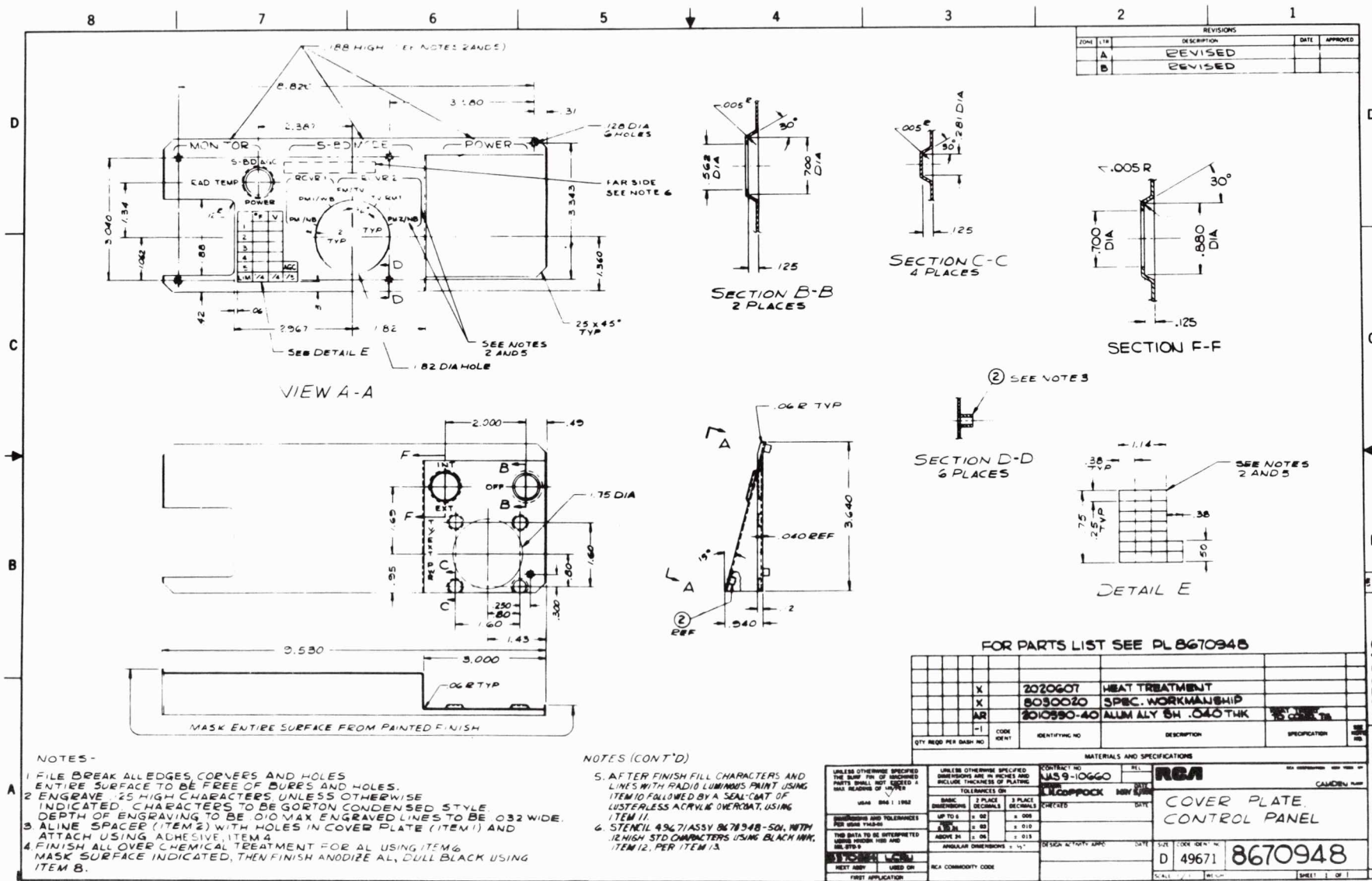


RCA

COVERPLATE — CONTROL PANEL

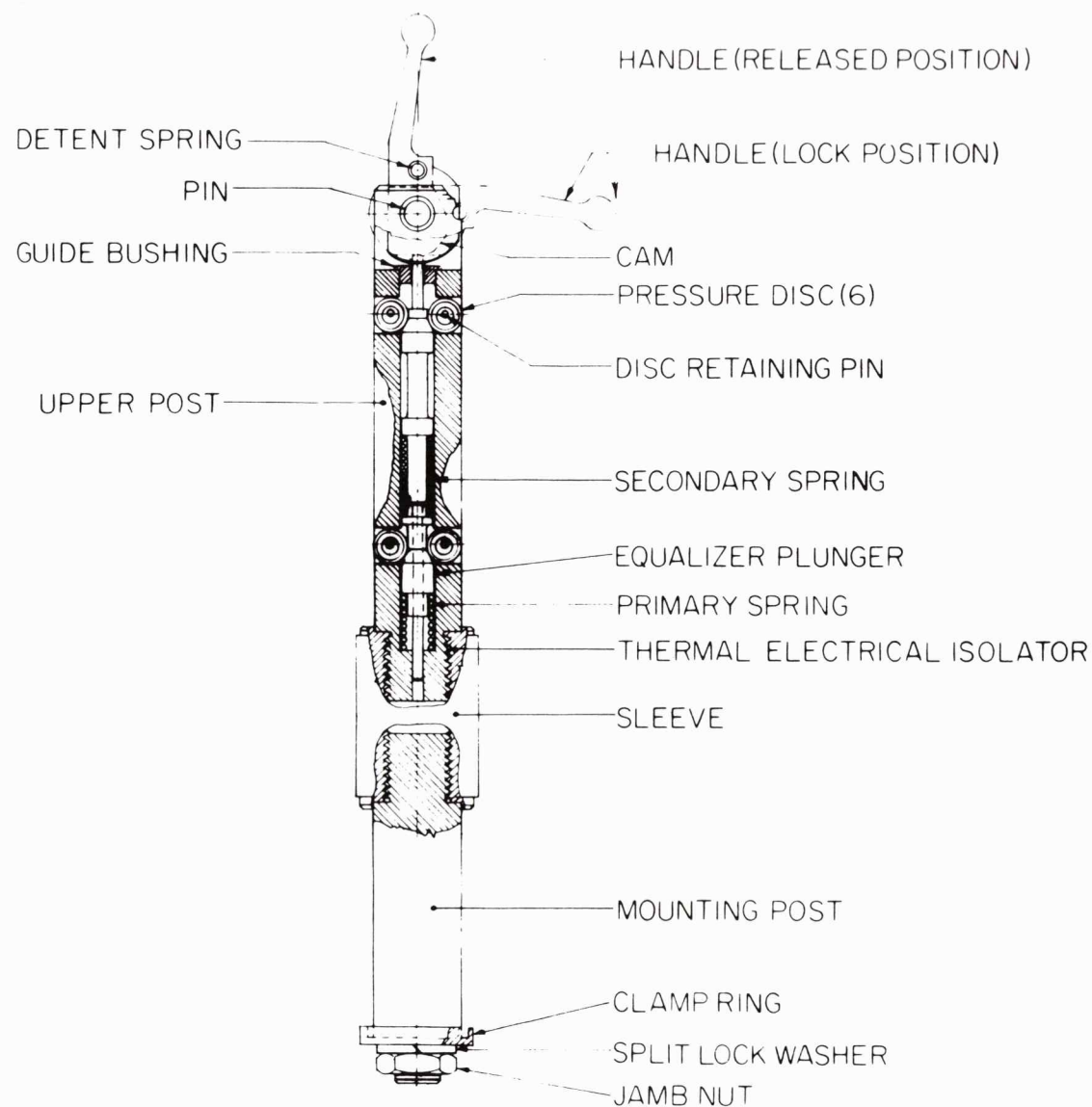
8670948

8-123



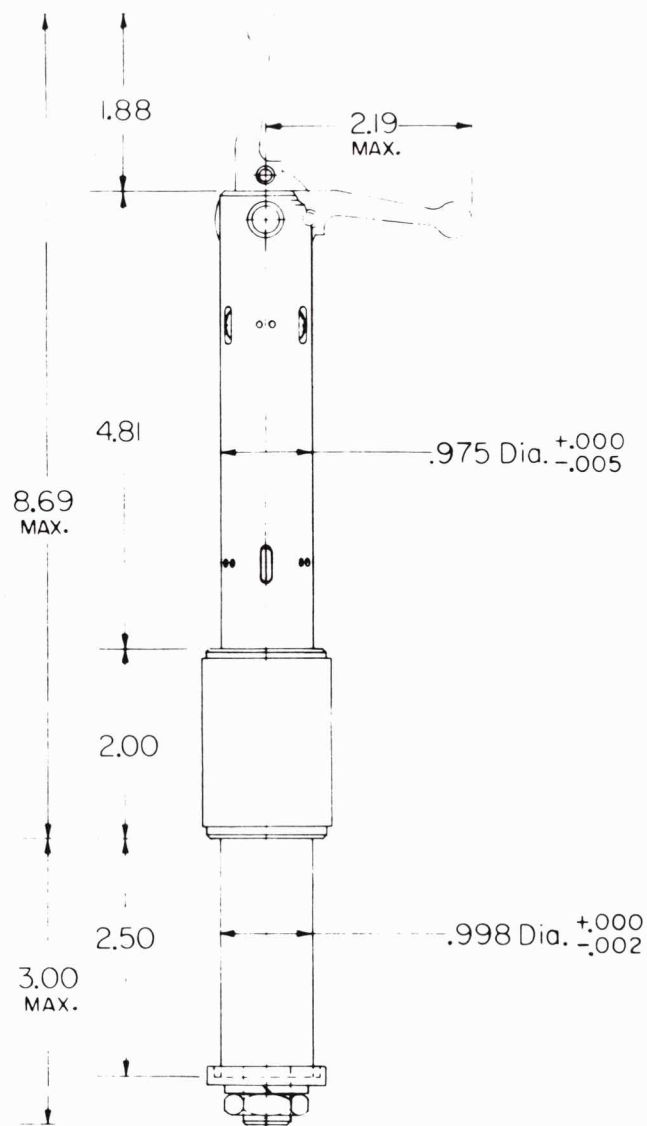


LCRU MOUNTING LEG





LCRU MOUNTING LEG OUTLINE





LCRU MOUNTING LEG VIBRATION ANALYSIS

ANALYTICAL STUDY SEE LCRU MOUNTING SYSTEM DESIGN STUDY 22 AUG. 1970

THIS ANALYSIS OBTAINS AN APPROXIMATE INDICATION OF THE RESPONSE OF THE LCRU ELECTRONICS CASE TO A SINUSOIDAL FORCING. ATTENTION IS GIVEN ONLY TO THE VIBRATION CHARACTERISTICS OF THE CASE MOUNTING POSTS; THE CASE MAY REALISTICALLY BE CONSIDERED A RIGID MASS, AND THE VEHICLE MOUNTING TUBES, WHILE NOT STRICTLY RIGID, ARE CONSIDERED SO IN THIS FIRST ANALYSIS.

THE MOUNTING POSTS ARE CONSIDERED AS A BI-LINEAR SPRING SYSTEM CONNECTING THE CASE MASS TO THE VEHICLE. AS THE CASE OSCILLATES WITH RESPECT TO THE VEHICLE, THE INDIVIDUAL SPRINGS ARE ABRUPTLY COUPLED INTO THE MOUNTING SYSTEM, RESULTING IN A NON-LINEAR SPRING RATE. PRINCIPLE DEFLECTION OF THE CASE IS RATIONALLY ABOUT THE VEHICLE; THIS LEADS TO A ONE-DIMENSIONAL STUDY. MINOR TRANSLATIONAL DEFLECTION IS TO BE NEGLECTED FOR SIMPLIFICATION.



LCRU MOUNTING LEG VIBRATION ANALYSIS

THE ANALYSIS IS TO BE CONTINUED UTILIZING THE BASIC RELATIONSHIPS AND SPRING CONSTANTS OBTAINED HERE.

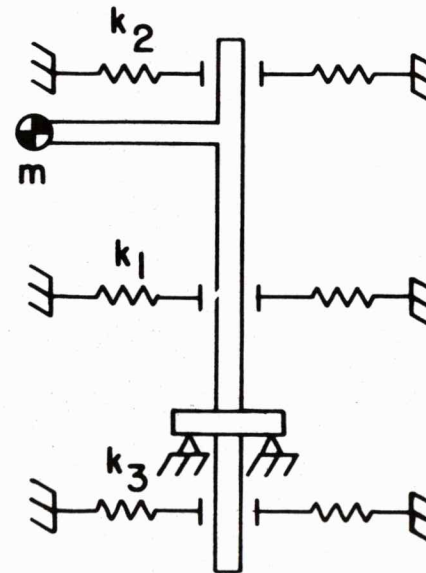
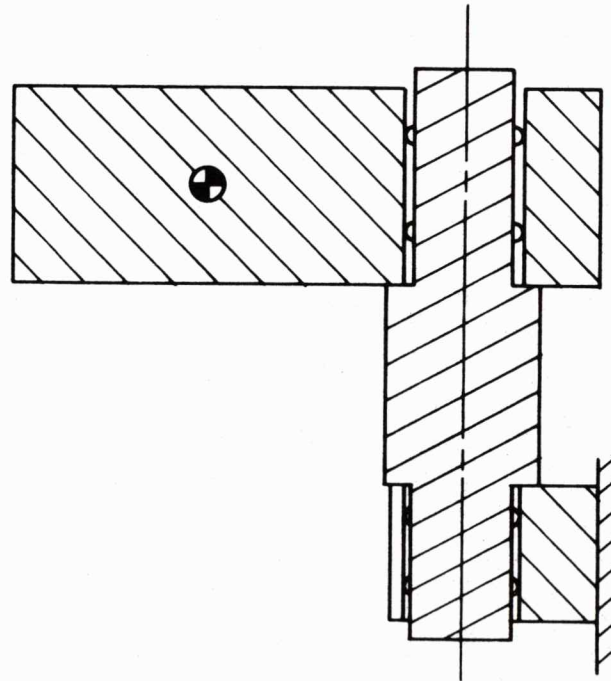
ONE BASIC MODIFICATION TO THE POST CONFIGURATION IS TO REPLACE THE LOWER SPRING/ROLLER POST ASSEMBLY WITH A BOLTED CLAMPING TO THE VEHICLE MOUNTING TUBE.

RESULTS OF THE CONTINUED ANALYSIS WILL INCLUDE THE FREQUENCY AT AN MAGNITUDE OF WORST VIBRATION RESPONSE FOR CHOSEN VALUES OF INPUT VIBRATION LEVEL AND DAMPING. BENDING MOMENTS IMPRESSED IN THE POST AT WORST VIBRATION RESPONSE WILL LEAD TO DETERMINATION OF POST STRESS. A CORRELATION OF VIBRATION RESPONSE AND POST STRESS TO POST CONFIGURATION WILL BE USEFUL FOR POSSIBLE WEIGHT REDUCTION.

THE GENERAL MAGNITUDE OF NATURAL FREQUENCY IS 12.6 HZ.



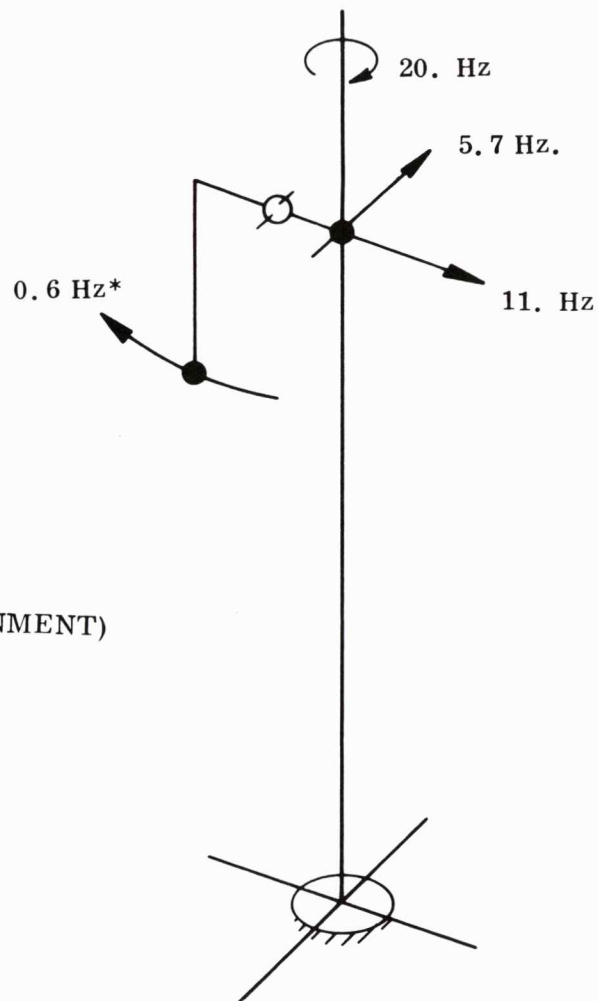
LCRU MOUNTING LEG VIBRATION ANALYSIS SPRING SYSTEM MODEL





LCRU HGA ANTENNA

APPROX. NATURAL FREQUENCIES (FIRST MODES)
FOR THE ANTENNA IN A TRAVELING CONFIGURATION

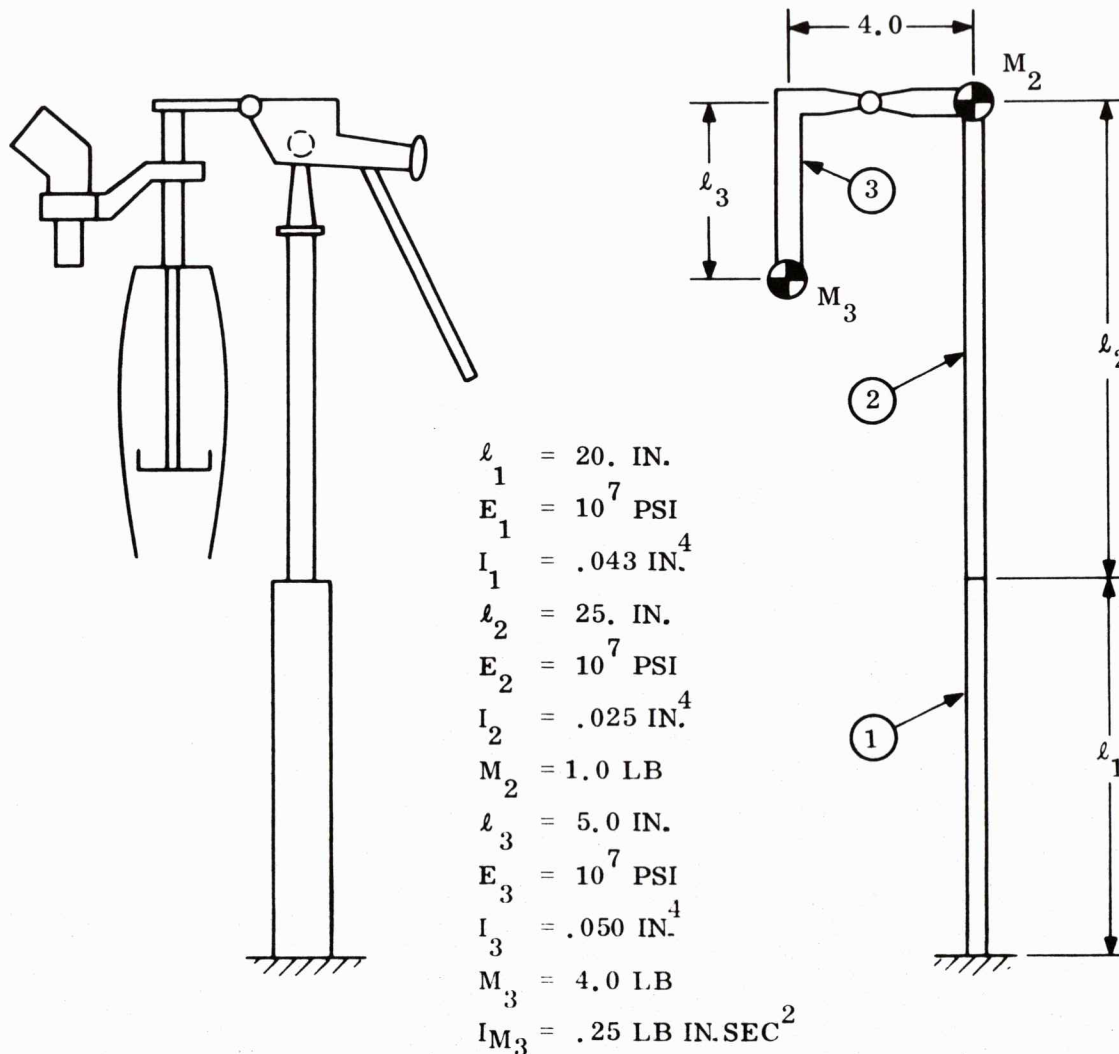


* LUNAR ENVIRONMENT
(1.4 Hz FOR EARTH ENVIRONMENT)



LCRU HGA ANTENNA

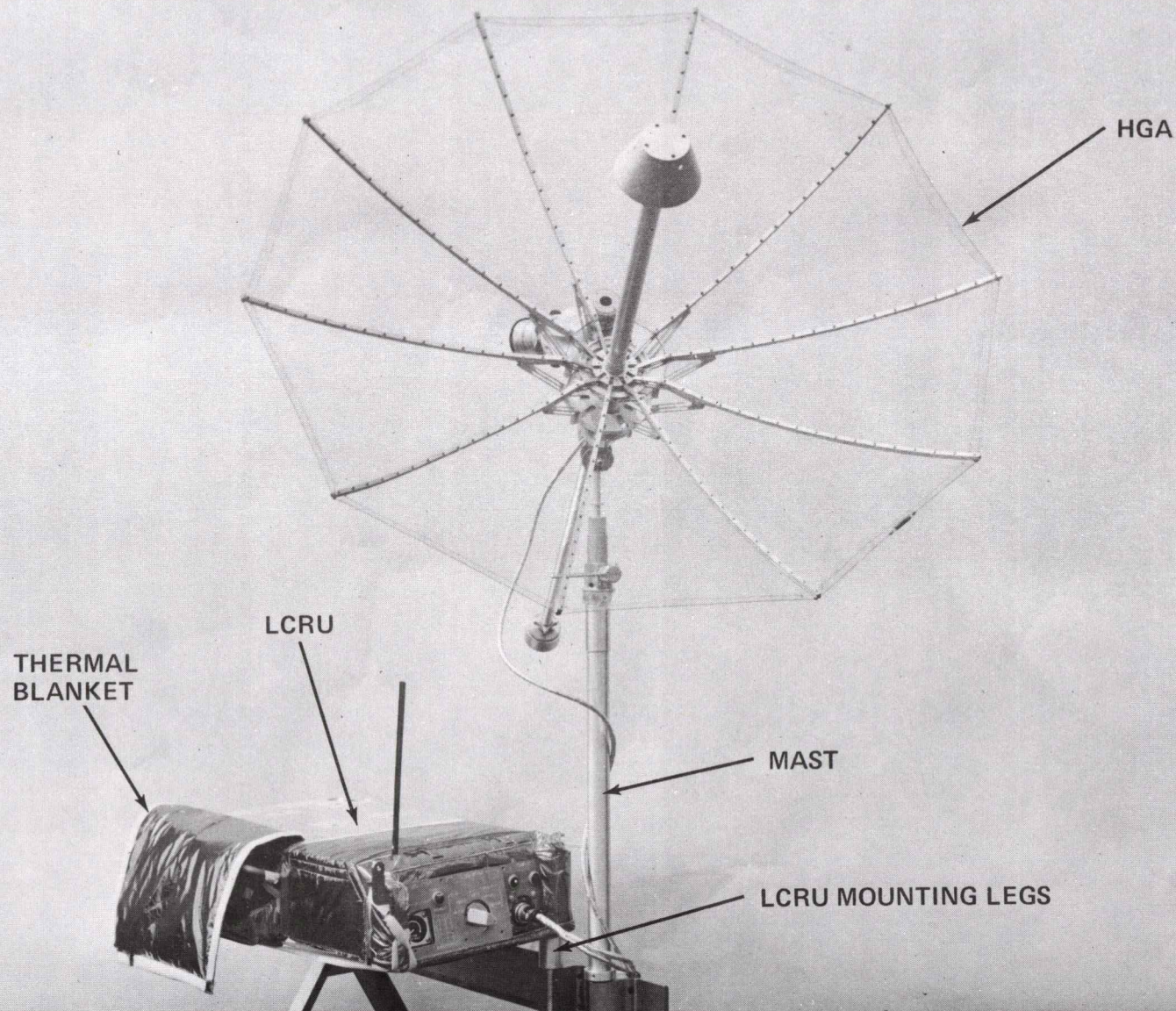
TRAVELING CONFIGURATION MODEL AND PARAMETER VALUES



RCA

LCRU SUBSYSTEM MECHANICAL MOCK-UP

8-131



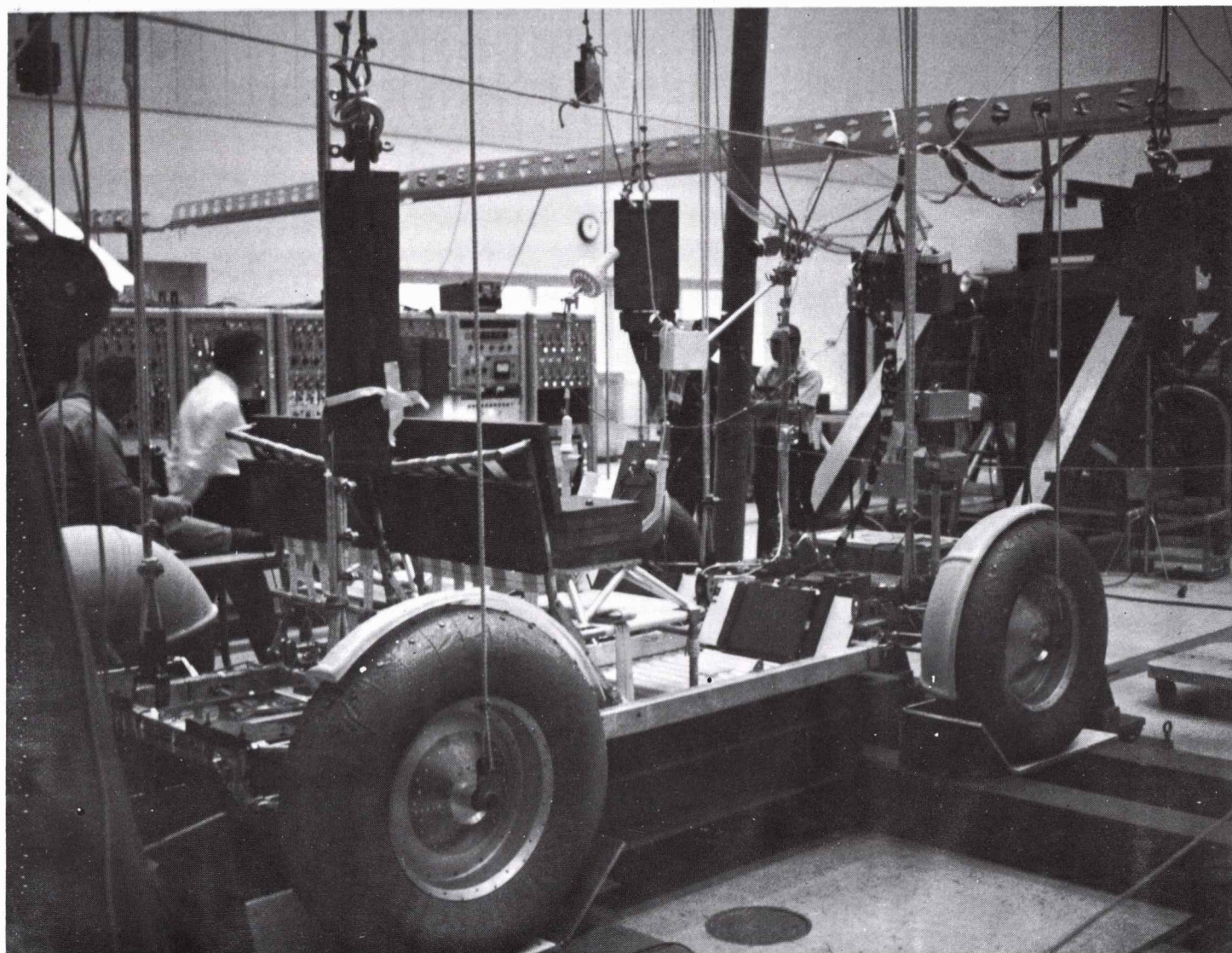


SEATTLE VIBRATION MODAL ANALYSIS PRELIMINARY RESULTS

NOTE: PURPOSE OF THIS TEST WAS TO DETERMINE THE VIBRATION MODES OF THE LUNAR ROVER VEHICLE CHASSIS AND ANCILLIARY EQUIPMENT. THIS WAS NOT A VIBRATION TEST AT DESIGN INPUT LEVELS TO DETECT FAILURES OR DETERMINE STRESS LEVELS.

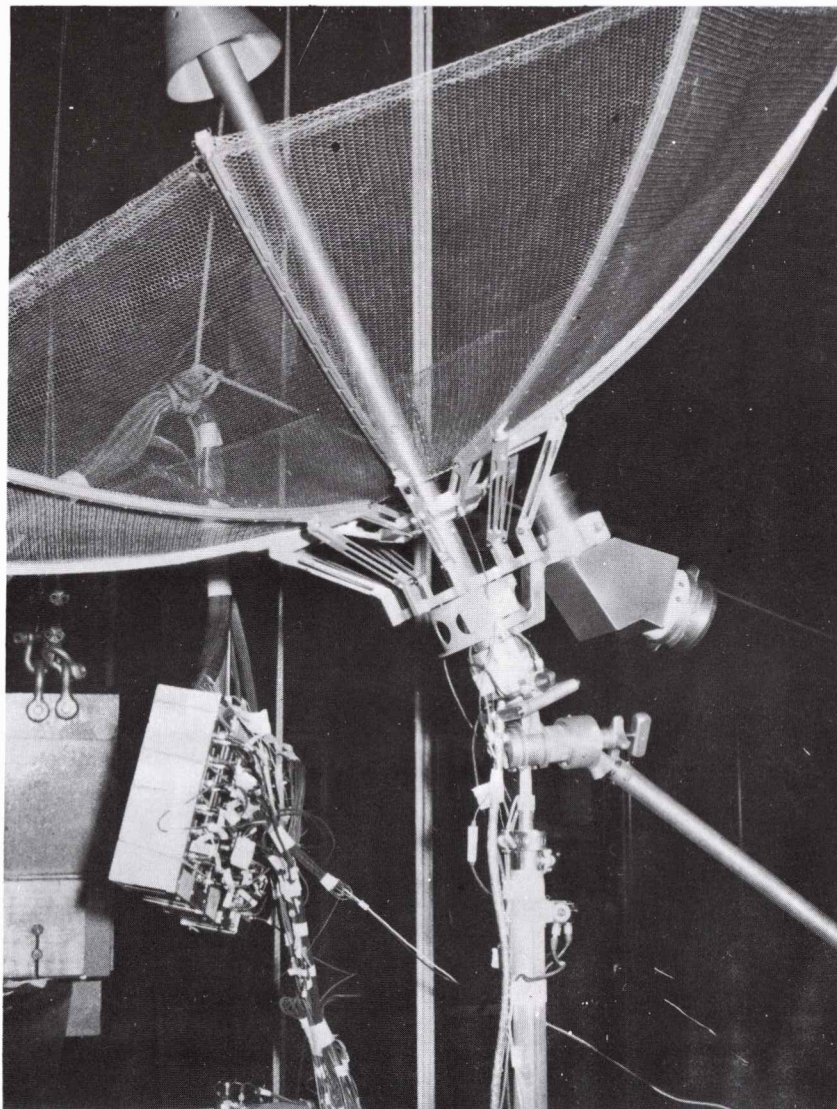
RCA

**LRV VIBRATION TEST
9-10-70
BOEING KENT, WASHINGTON**



RCA

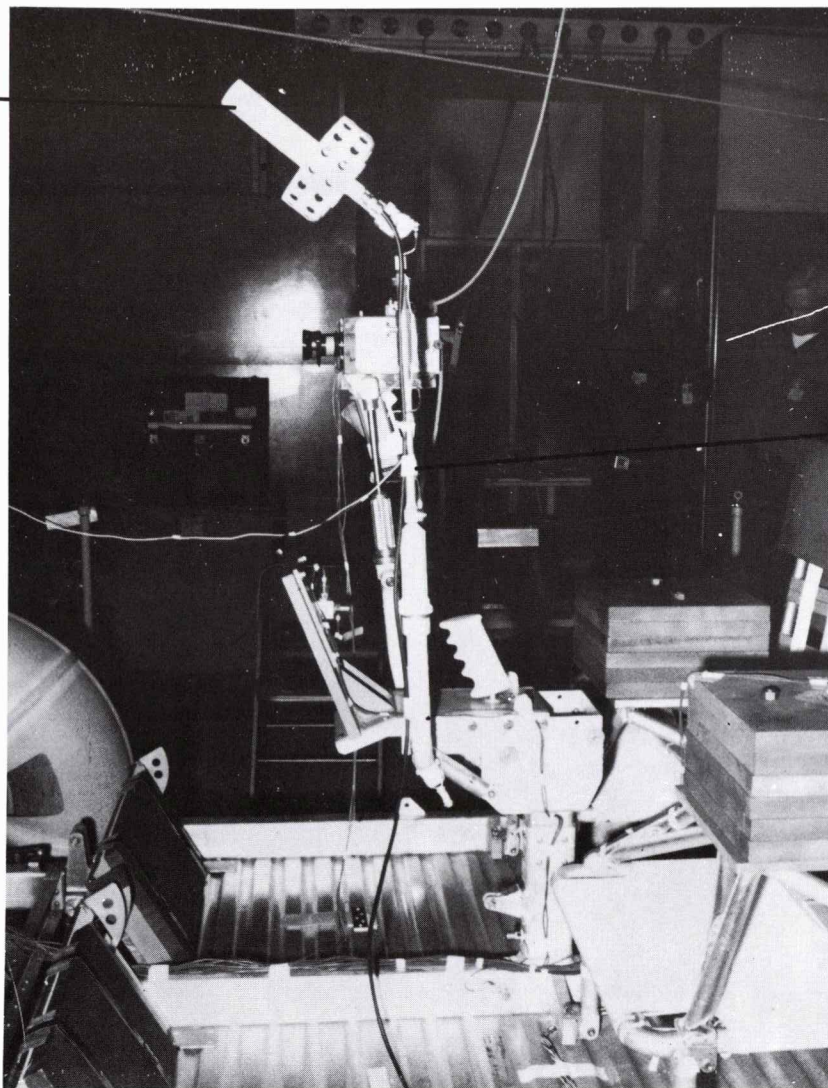
**LRV VIBRATION TEST
9-10-70
BOEING KENT, WASHINGTON**



RCA

**LRV VIBRATION TEST
9-10-70
BOEING KENT, WASHINGTON**

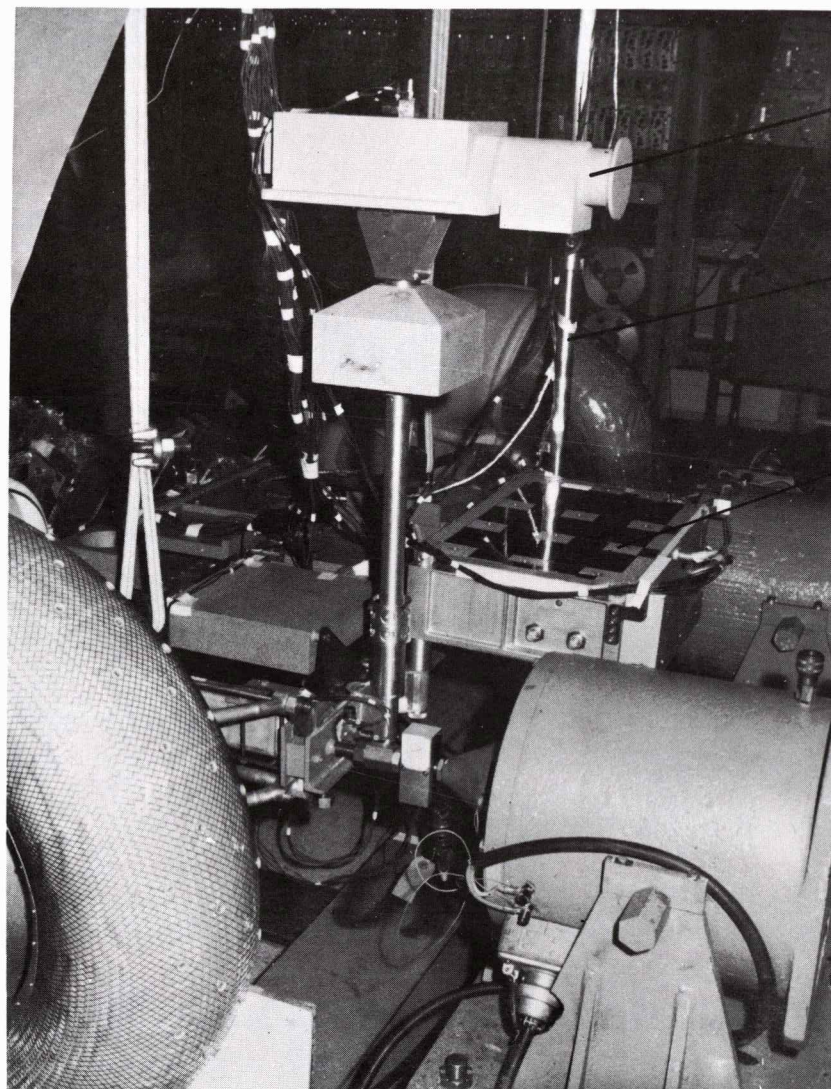
LGA



LGA STAFF

RCA

LRV VIBRATION TEST 9-10-70 BOEING KENT, WASHINGTON



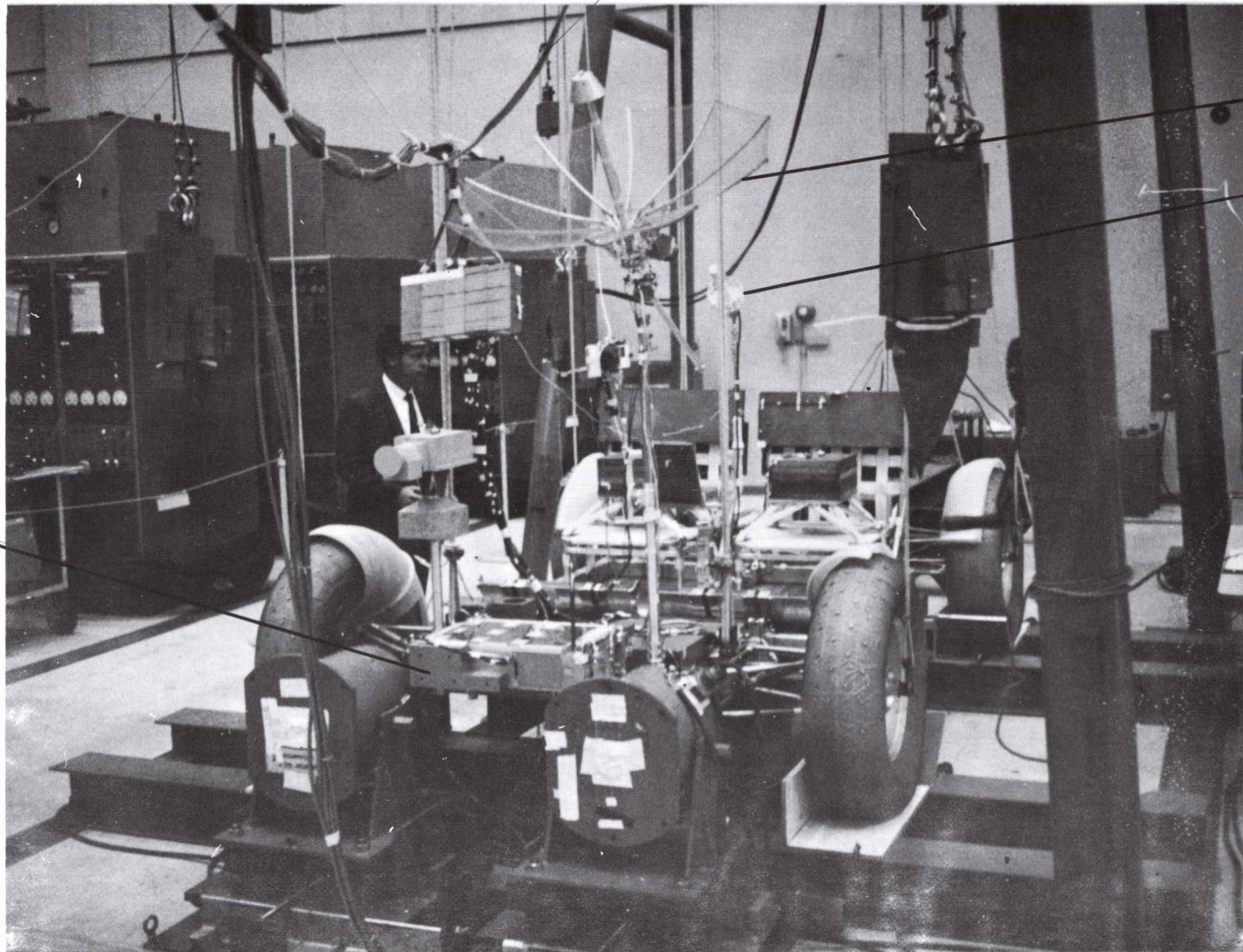
TV CAMERA

HGA MAST

LCRU

RCA

**LRV VIBRATION TEST
9-10-70
BOEING KENT, WASHINGTON**



RCA

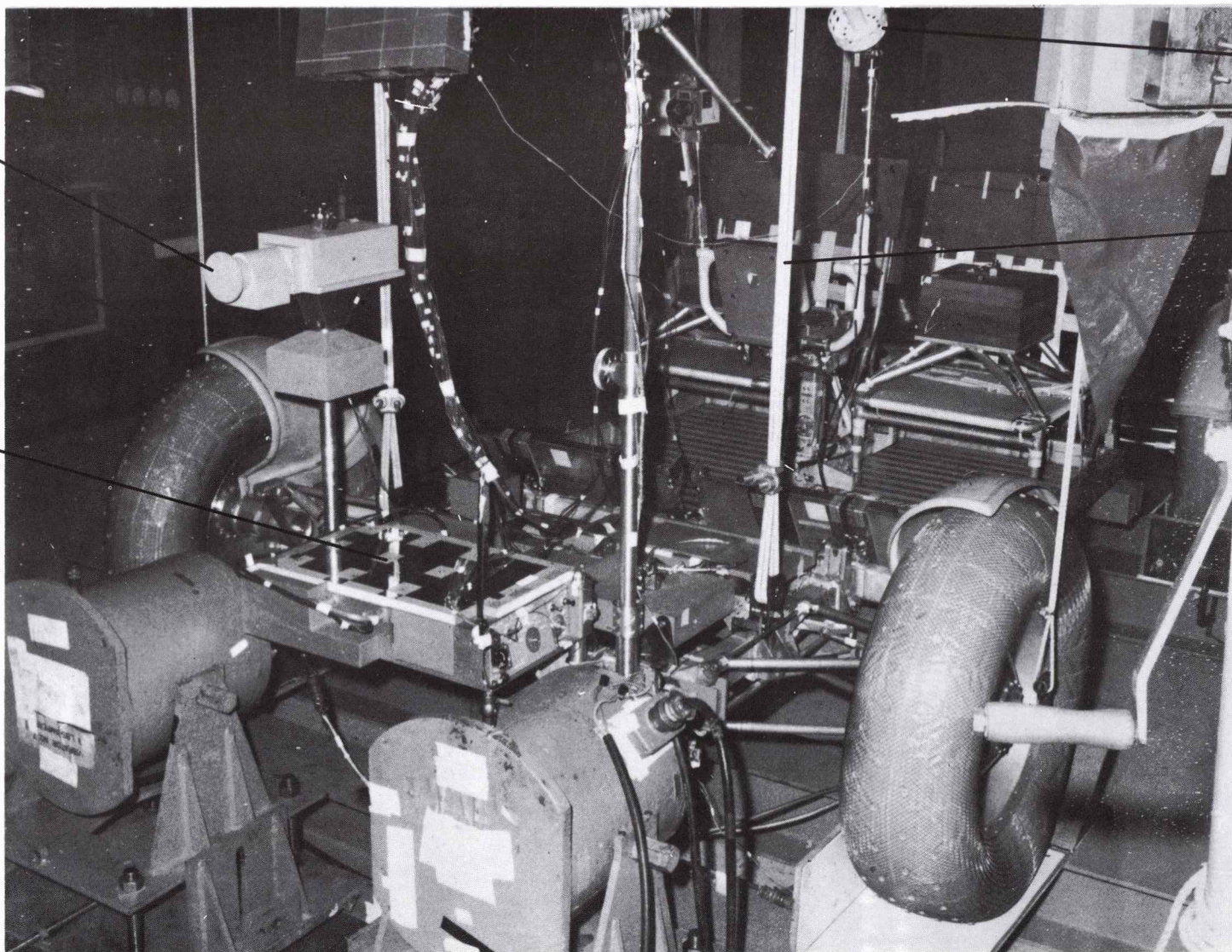
LRV VIBRATION TEST 9-10-70 BOEING KENT, WASHINGTON

TV
CAMERA

LCRU

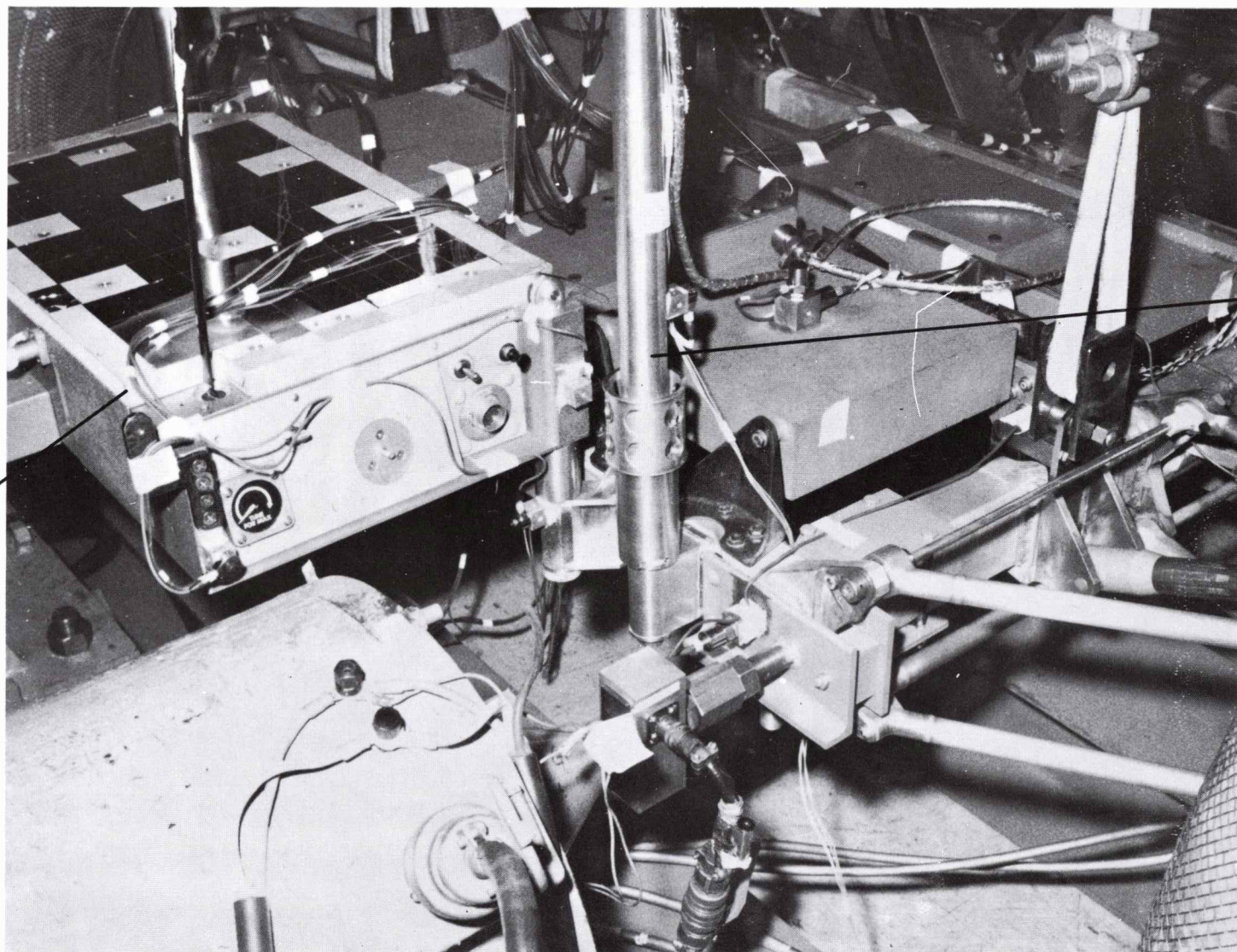
LGA

HGA
MAST



RCA

**LRV VIBRATION TEST
9-10-70
BOEING KENT, WASHINGTON**

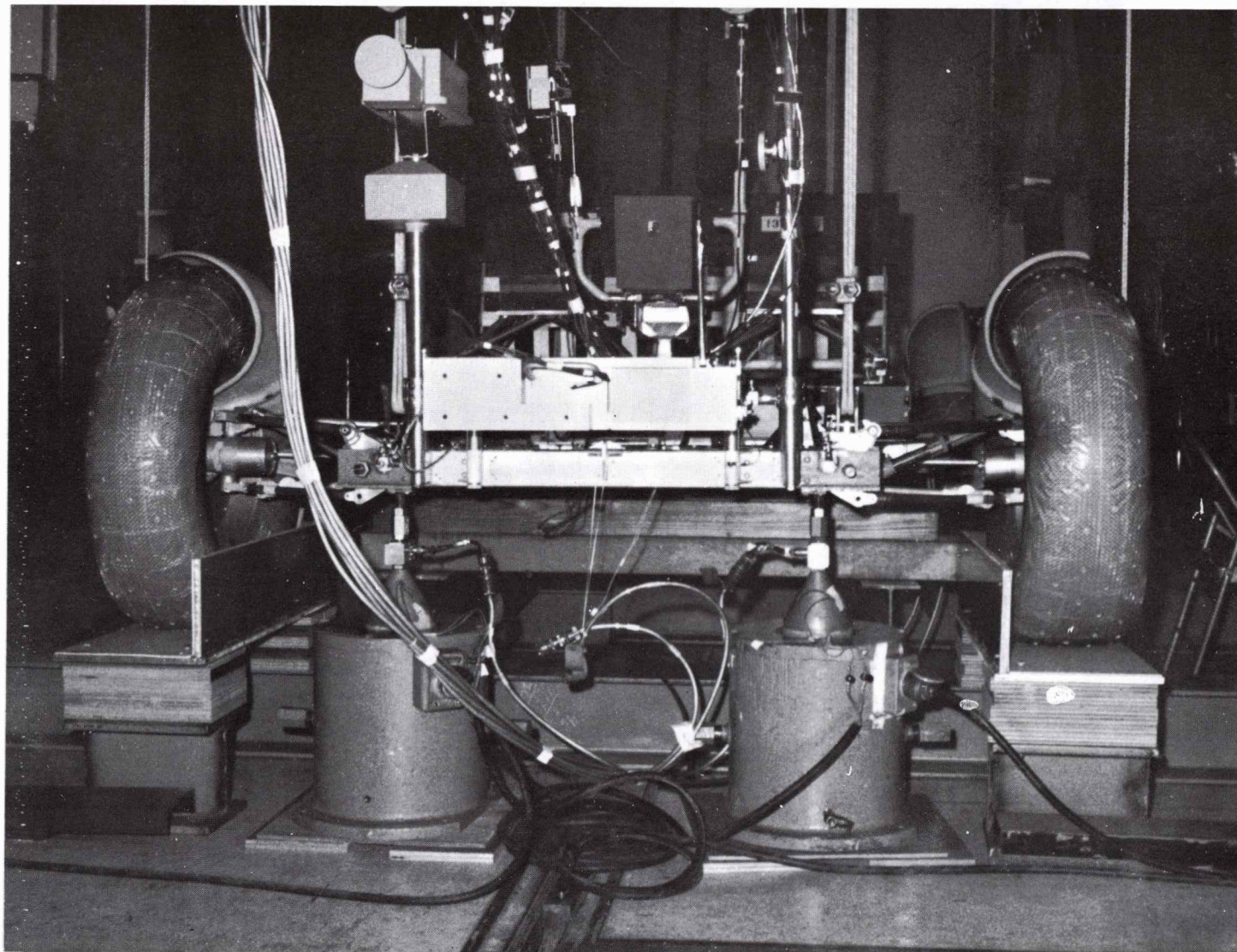


LCRU

HGA
MAST

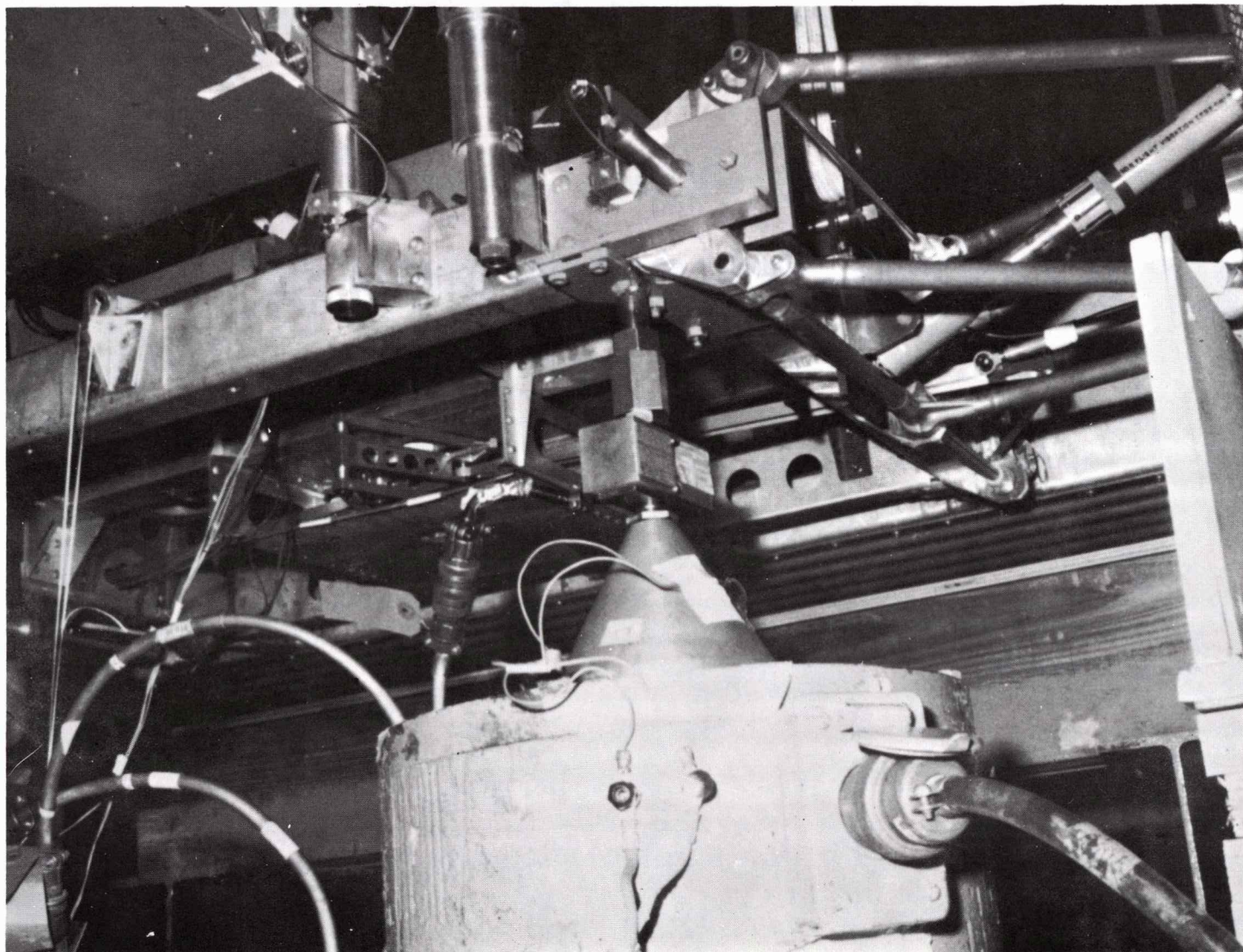
RCA

**LRV VIBRATION TEST
9-10-70
BOEING KENT, WASHINGTON**



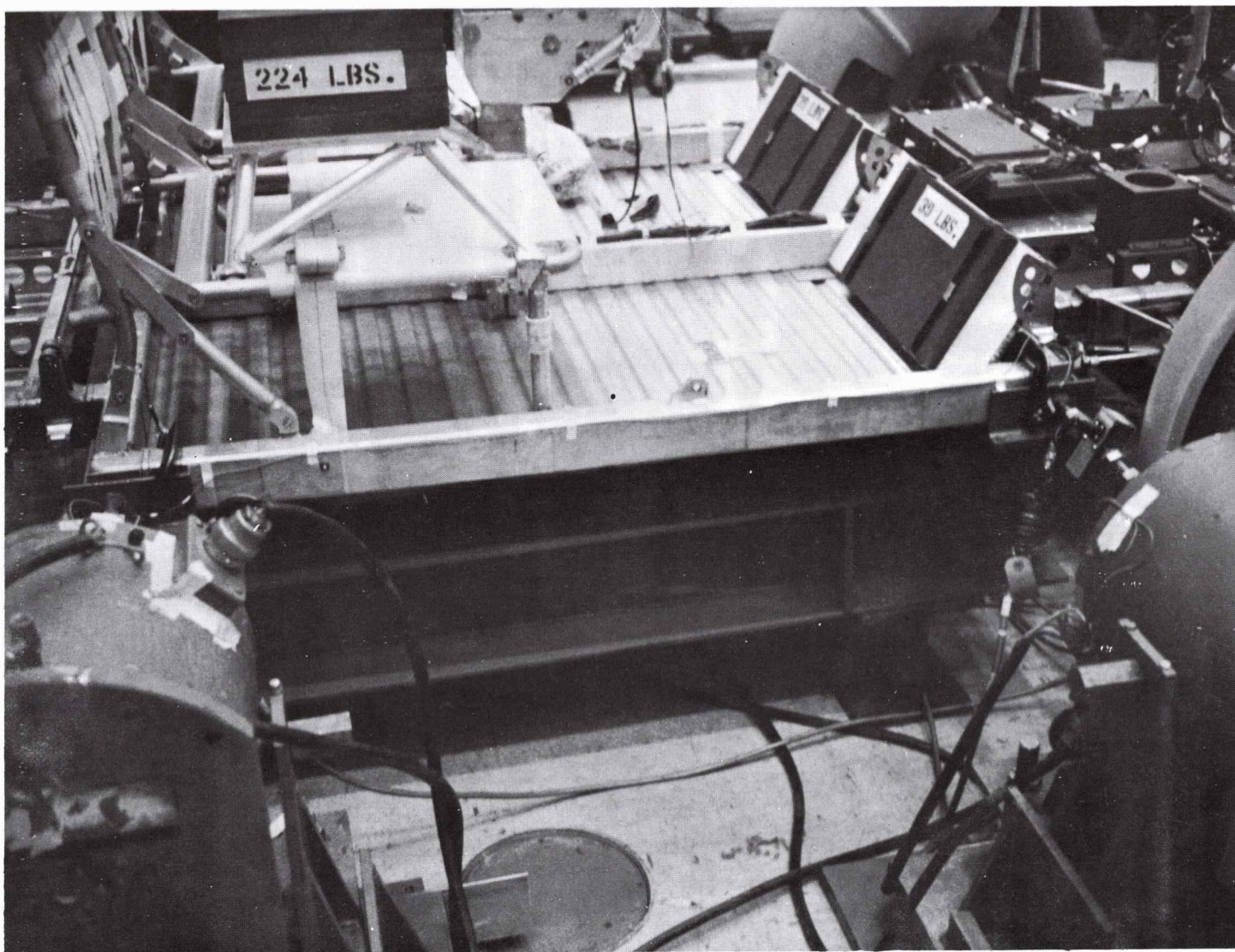
RCA

**LRV VIBRATION TEST
9-10-70
BOEING KENT, WASHINGTON**



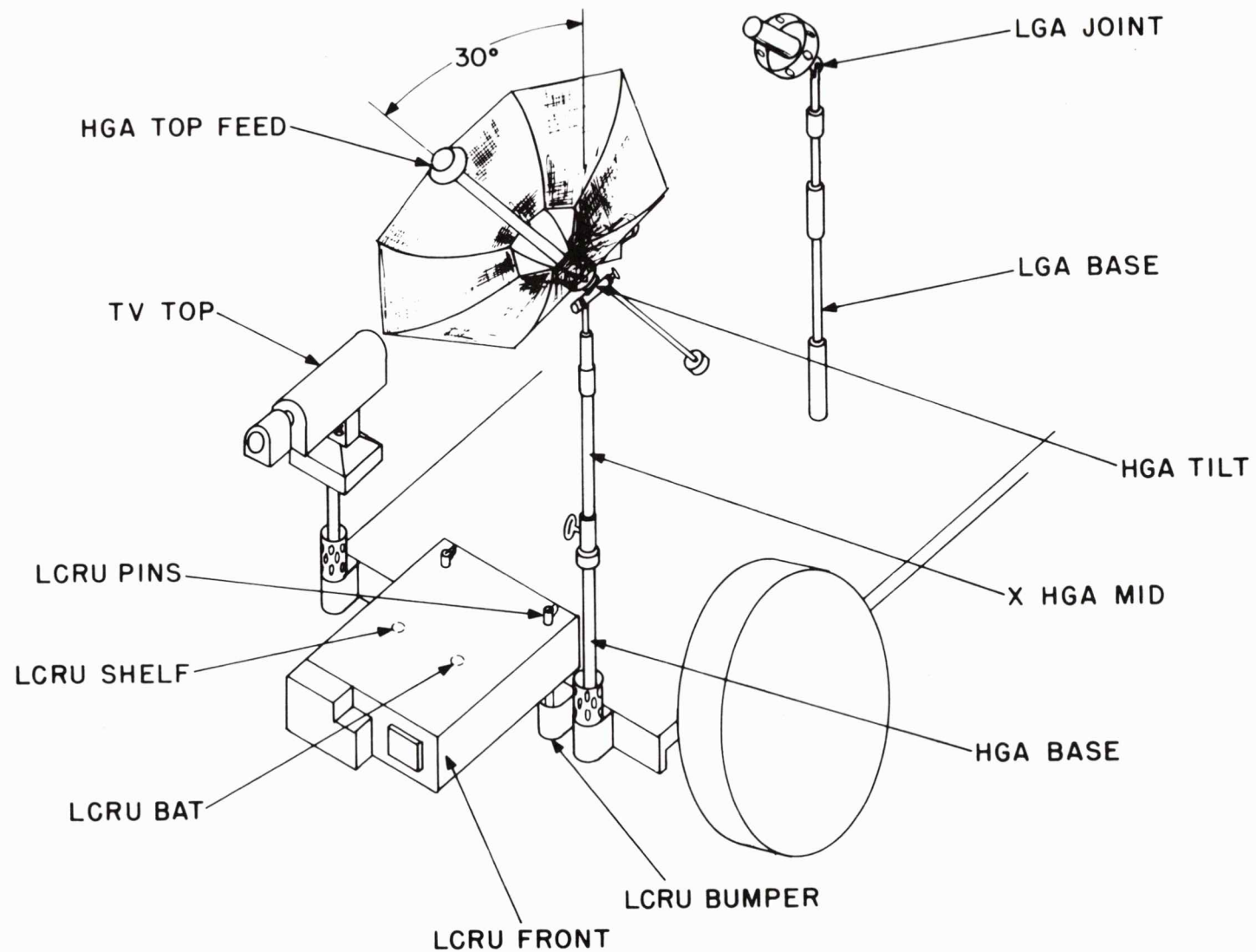
RCA

**LRV VIBRATION TEST
9-10-70
BOEING KENT, WASHINGTON**



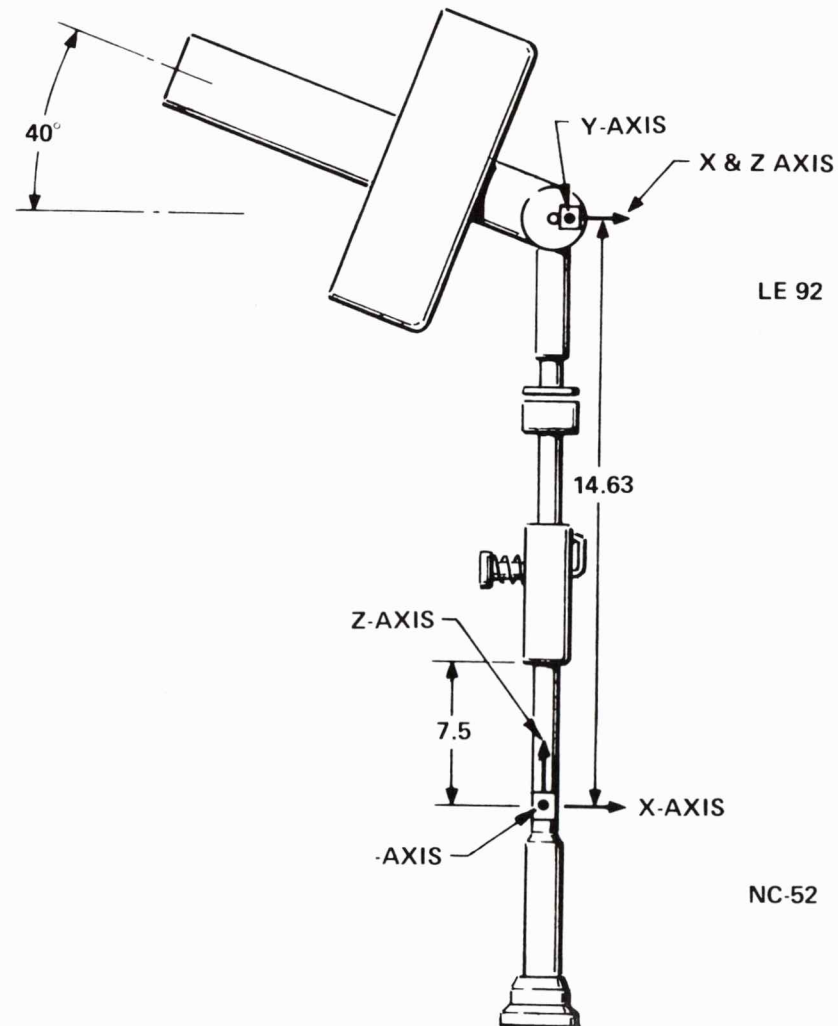


SEATTLE VIBRATION MODAL ANALYSIS PRELIMINARY RESULTS



RCA

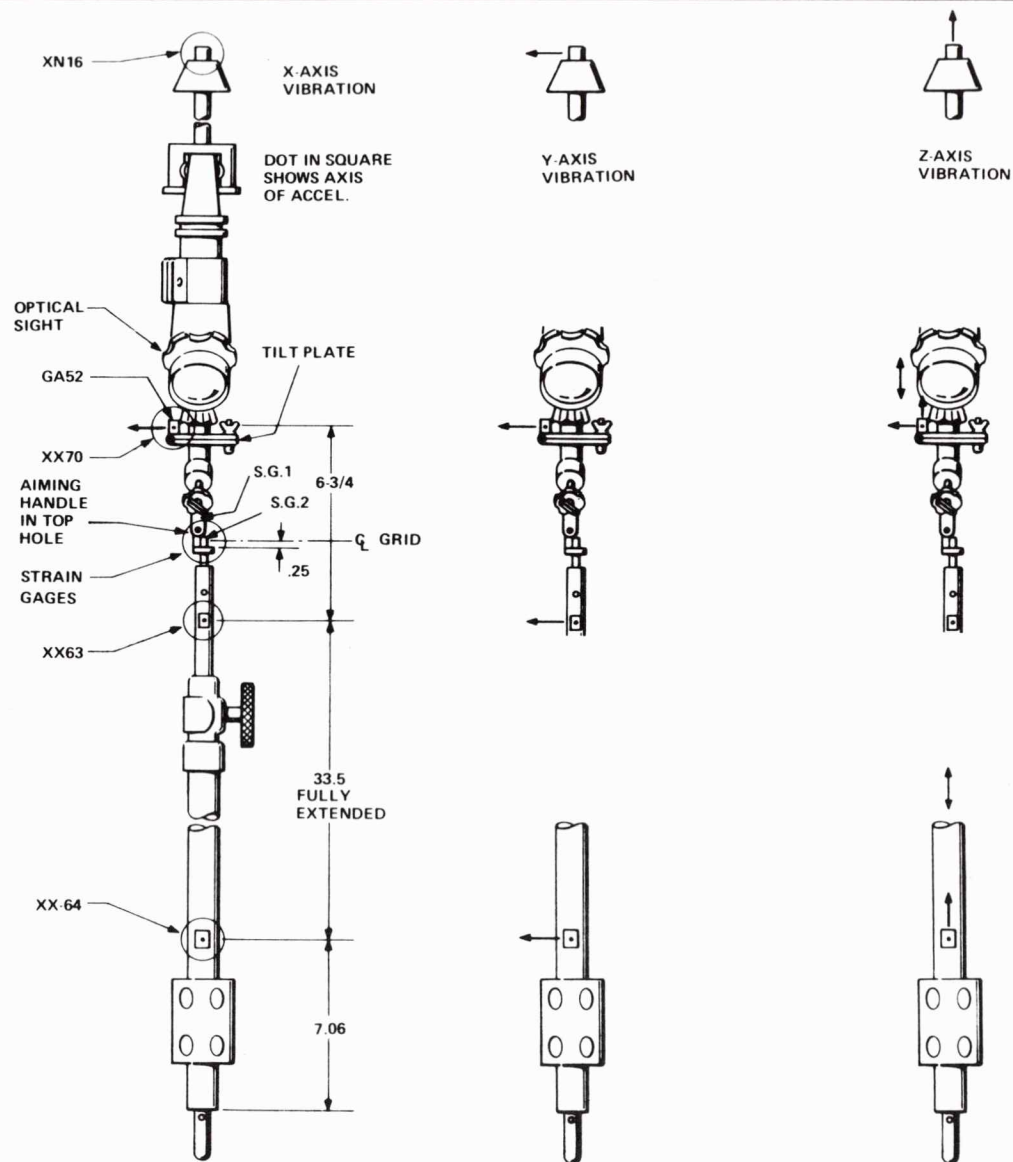
READ IN SHAKE PLANE NOTED ONLY





INSTRUMENTATION LOCATION

LRV/LCRU VIBRATION TEST 9-11-70



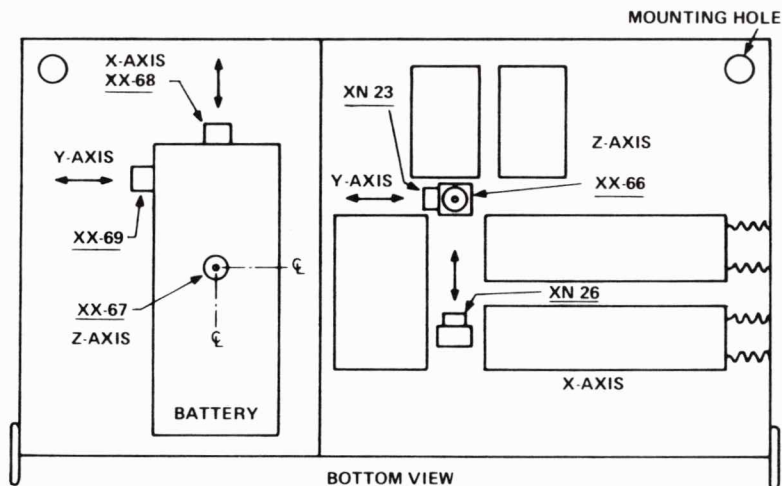


LCRU - ACCELEROMETER LOCATIONS

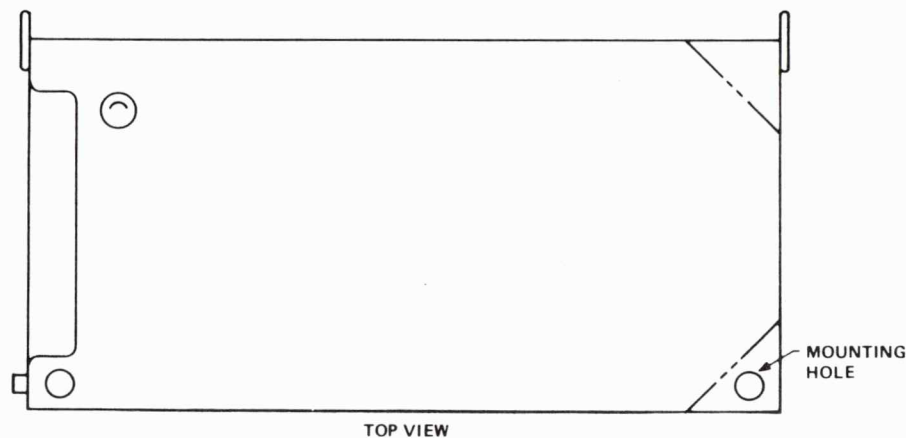
LRV VIBRATION TEST 9-4-70

ENDEVCO ACCELEROMETERS
XX -- = MODEL 2221D
XN -- = MODEL 2222B

READ IN SHAKE PLANE
NOTED ONLY

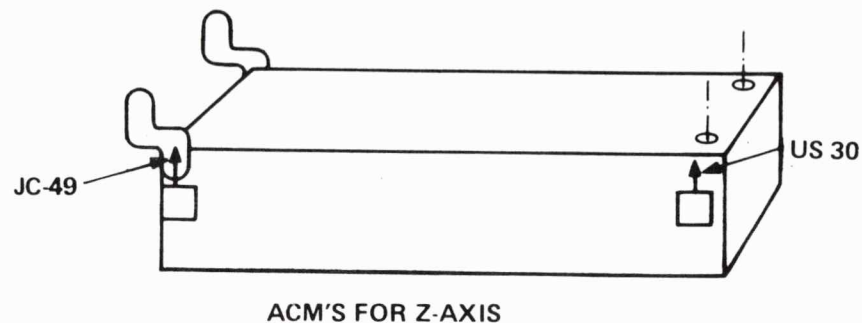
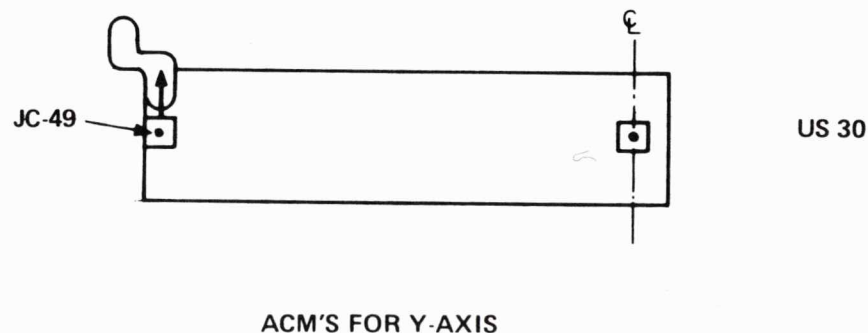
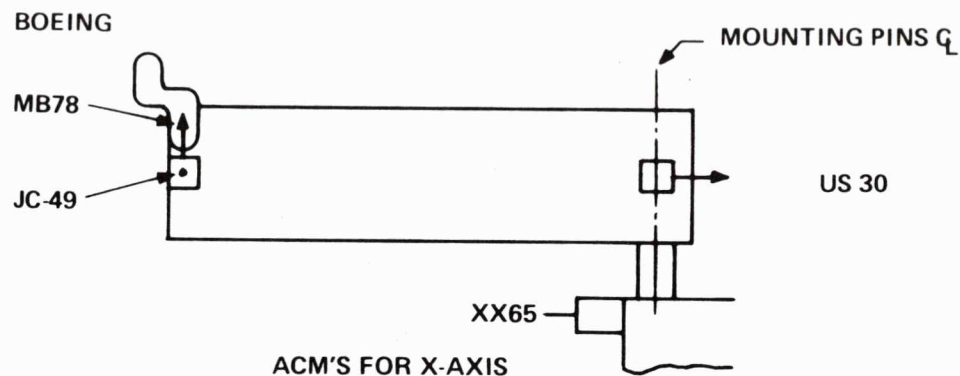


ARROWS INDICATE SENSING DIRECTION FOR INTERNALLY MOUNTED ACC.





LCRU ACCELEROMETER LOCATIONS LRV VIBRATION TEST 9-4-70





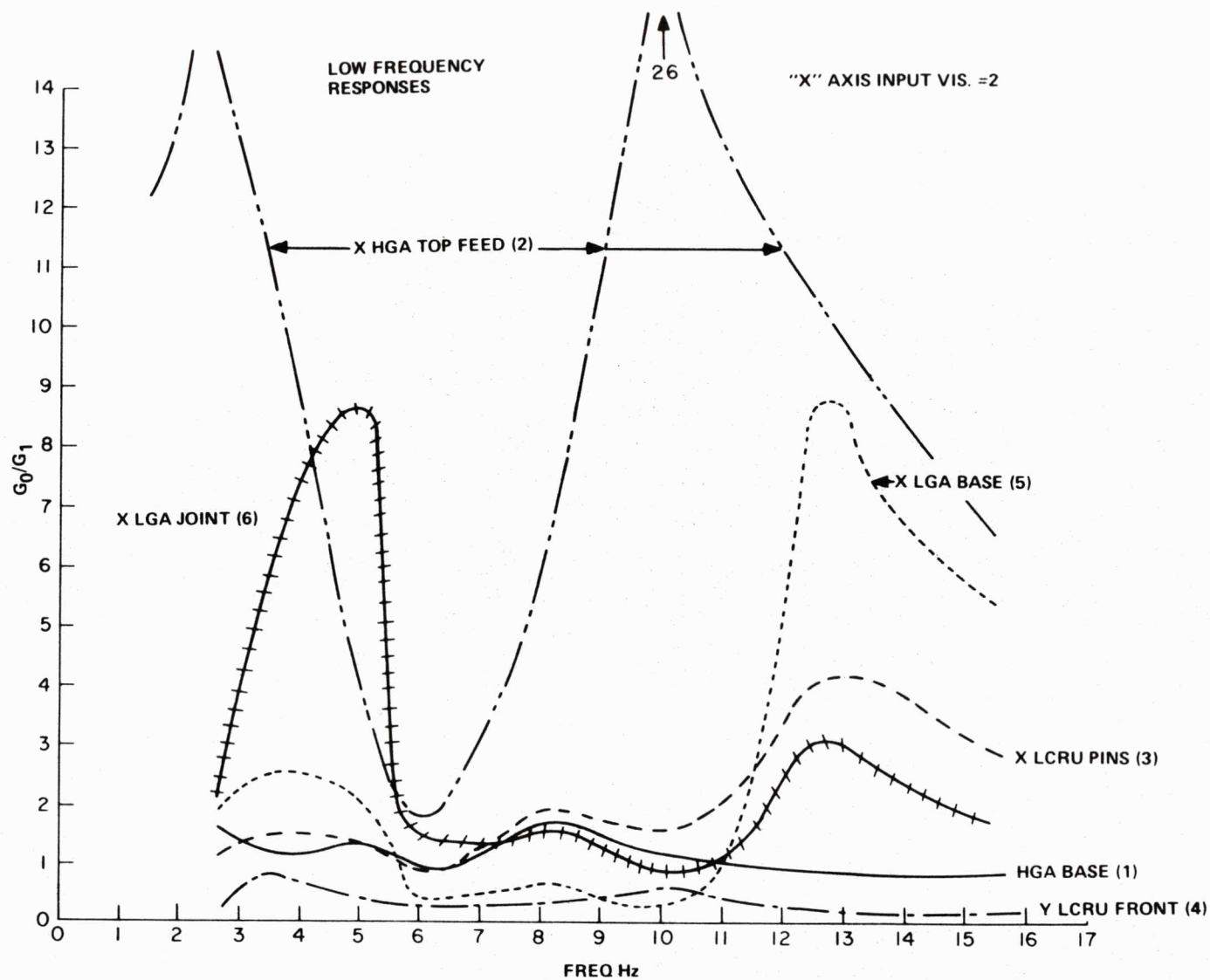
LCRU ACCELEROMETER IDENTIFICATION

LRV VIBRATION TEST 9-4-70

	X	Y	Z
LCRU BOX	XY 68 XN 26 JC 49 US 30 (MB 78) BOEING	XX 69 XN 23 JC 49 US 30 -	XX 67 XX 66 JC 49 US 30 -
HI GAIN ANT.	XN 16, XX 70 GA 52 XX 63 XX 64	XN 16, XY 70 GA 52 XX 63 XX 64	XN 16, XX 70 GA 52 XX 63 XX 64
LO GAIN ANT.	LE 92 NC 52	LE 92 NC 52	LE 92 NC 52
LCRU MOUNTING BRACKET ON VEHICLE	XX 65	XX 65	XX 65

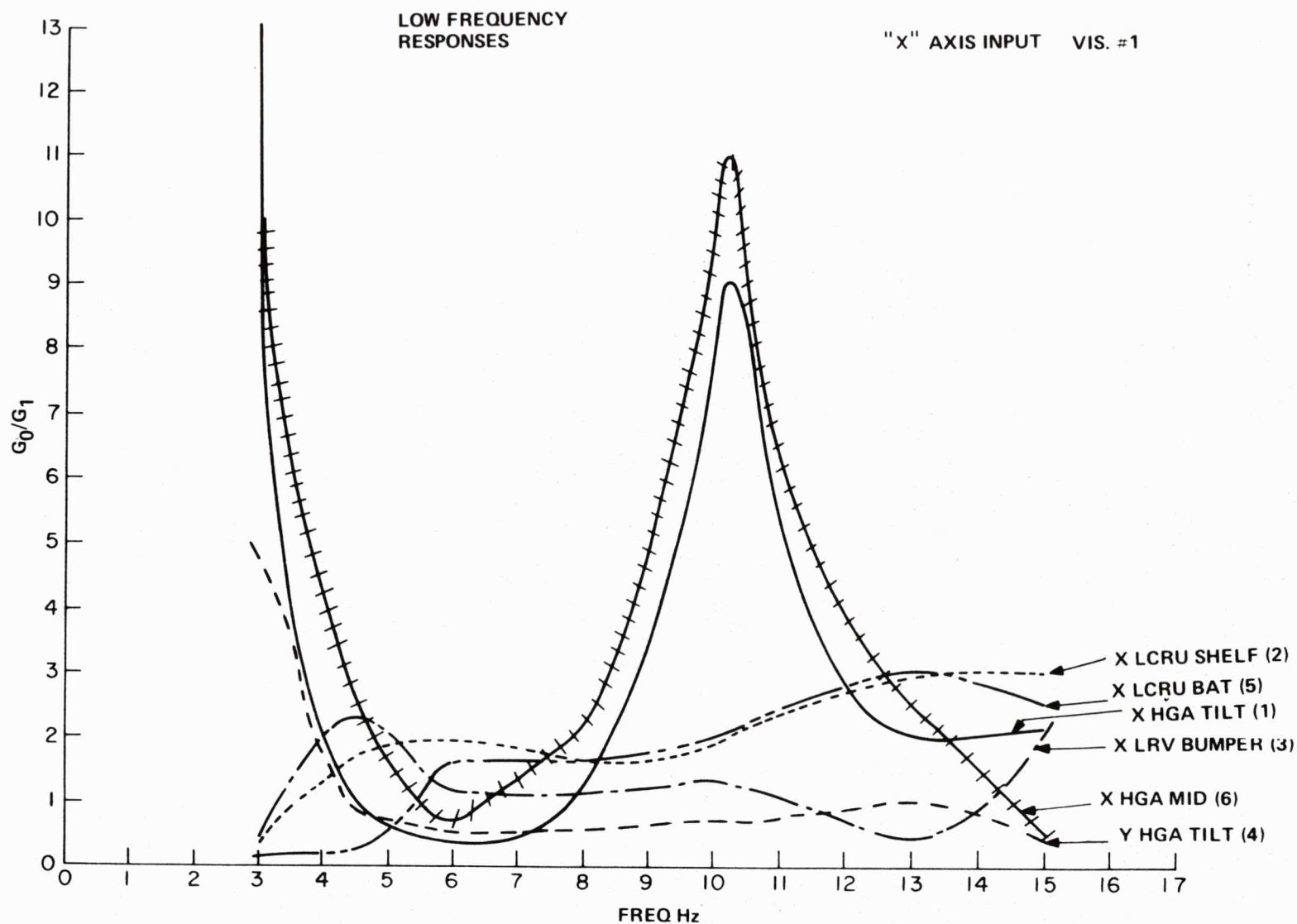


SEATTLE VIBRATION MODAL ANALYSIS PRELIMINARY RESULTS



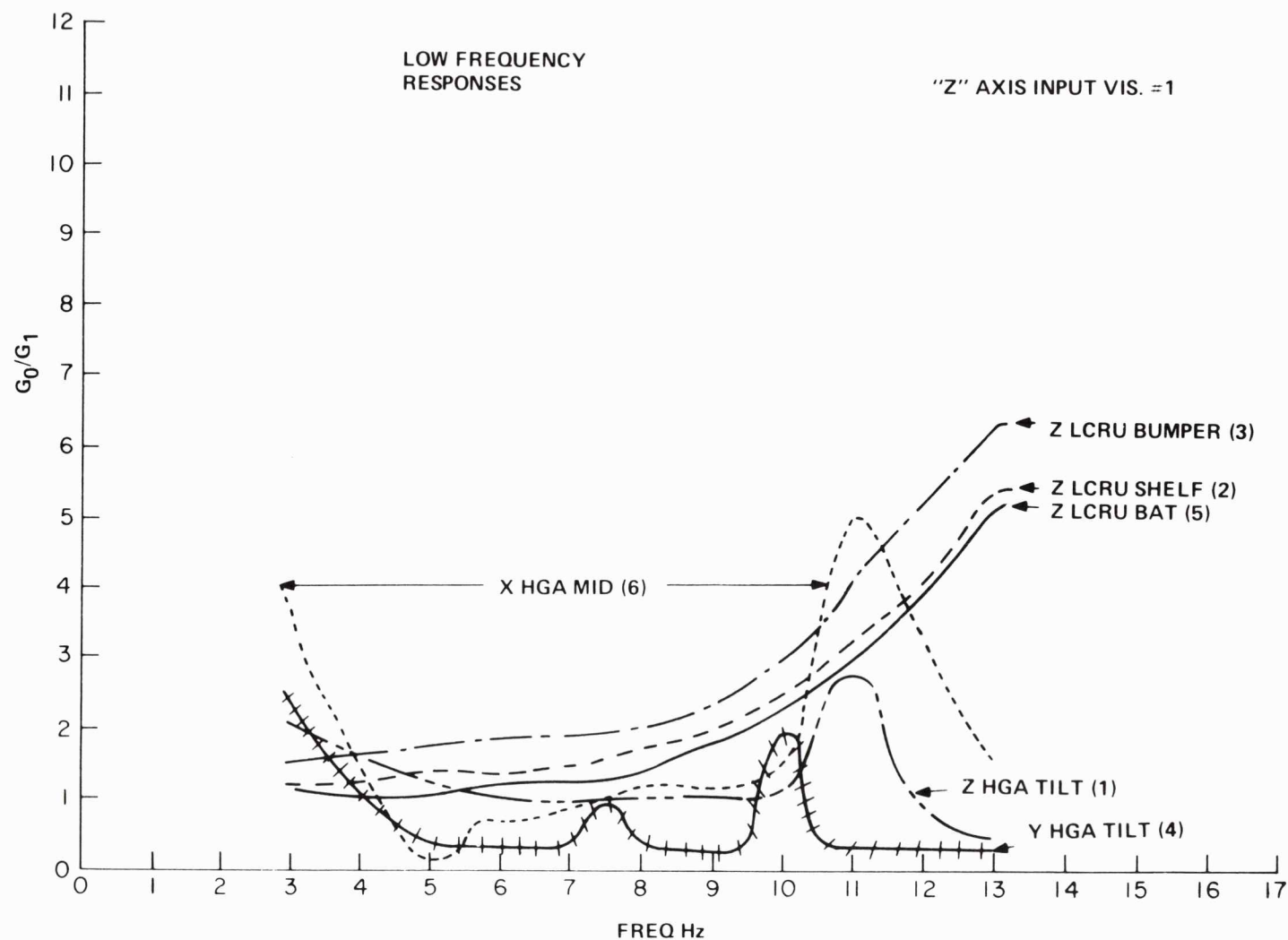


SEATTLE VIBRATION MODAL ANALYSIS PRELIMINARY RESULTS



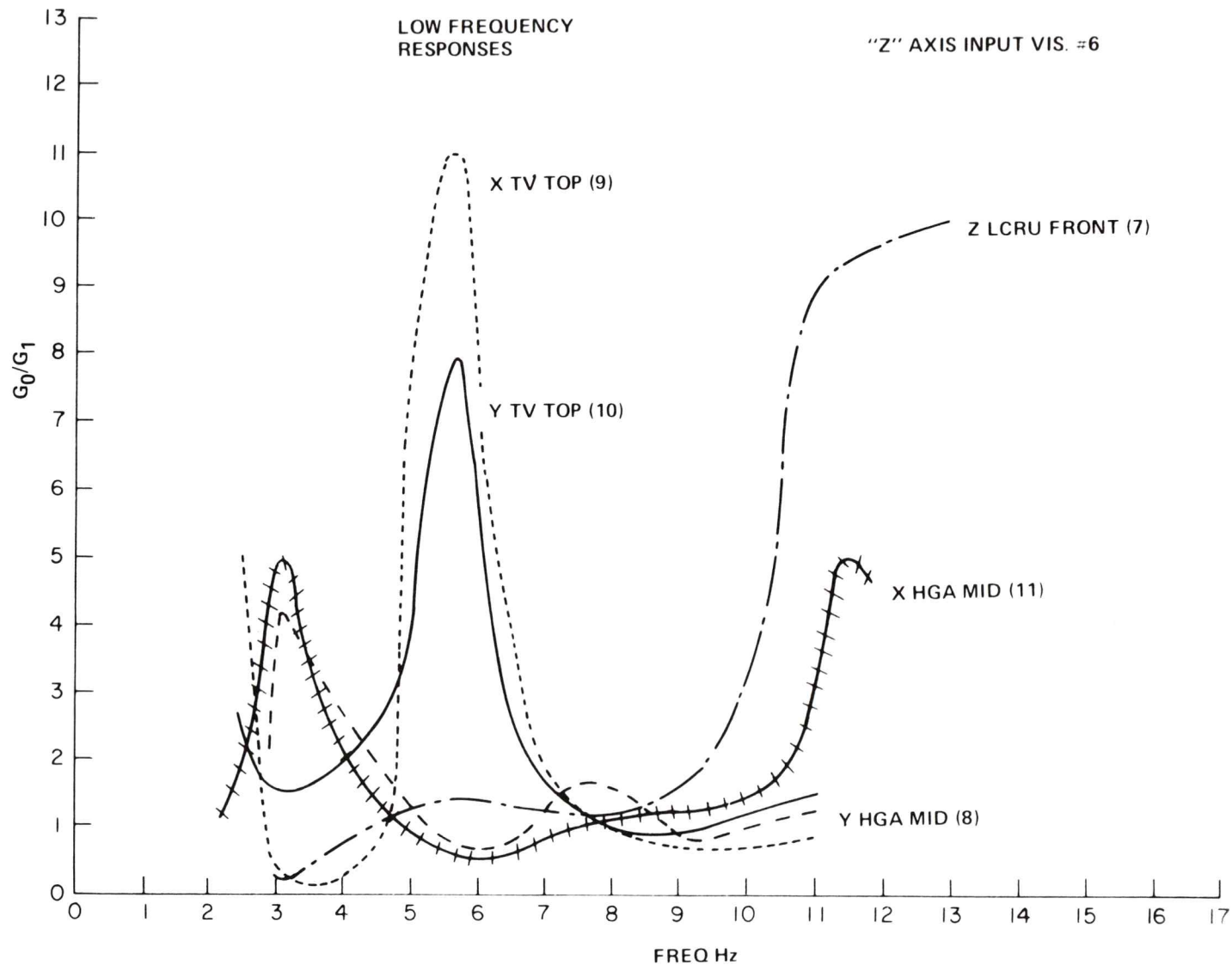


SEATTLE VIBRATION MODAL ANALYSIS PRELIMINARY RESULTS





SEATTLE VIBRATION MODAL ANALYSIS PRELIMINARY RESULTS





LRV INTERFACE

INTERFACE CONTROL DRAWING VIBRATION
EQUIPMENT AT LCRU, HIGH GAIN ANTENNA, AND
TELEVISION CAMERA INTER. (PAR 3.2.7.1 IRN#8)

8-153

<u>DIRECTION</u>	<u>EQUIVALENT SINUSOIDAL DWELL</u>
VERTICAL	0.2 TO 0.6 Hz @ 35.0 IN. D.A. 0.6 TO 3.0 Hz @ 0.64 g- pK 3.0 TO 10.0 Hz @ 0.32 g- pK
FORE/AFT AND LATERAL	0.2 TO 0.6 Hz @ 13.0 IN. D.A. 0.6 TO 3.0 Hz @ 0.24 g- pK 3.0 TO 10.0 Hz @ 0.12 g- pK



SEATTLE VIBRATION MODAL ANALYSIS PRELIMINARY RESULTS

TRANSMISSIBILITY VALUES FOR UNDAMPED SUSPENSION SYSTEM HAVING
NATURAL FREQUENCY OF .7 Hz.

<u>FREQ.</u>	<u>TRANSMISSIBILITY</u>
1	.9
3	.05
5	.02
7	.01
9	.004
11	.003
13	.002
15	.0008



SEATTLE VIBRATION MODAL ANALYSIS PRELIMINARY RESULTS

RESPONES IN 20-100 Hz SWEEP "X" VIS # 1

FREQUENCY Hz →	G_0/G_1					
	48	61	64	70	79	90
LOCATION						
(1) X HGA TILT		1.6		.9		.6
(2) X LCRU SHELF		2.2		1.9	3.8	1.7
(3) X LRV BUMPER		1.0		1.1		1.4
(4) Y HGA TILT		.8		.5		.4
(5) X LCRU BAT		3.8		2.6		2.9
(6) X HGA MID	3.3	1.2	2.2	.9		.3



SEATTLE VIBRATION MODAL ANALYSIS PRELIMINARY RESULTS

RESPONES IN 20-100 Hz SWEEP "X" VIS #2

FREQUENCY Hz →	G_0/G_1													
	23	29	33	41	47	60	64	65	68	76	79	87	92	100
<u>LOCATION</u>														
(1) X HGA BASE	4.3	.4		1.4	3.9	1.2	2.1					1.5		.6
(2) X HGA TOP FEED	1.5	3.5	9.0	1.6	4.7	3.1	4.6				.3	2.2		.3
(3) X LCRU PINS	.8	1.9		.6	.8	2.2	1.7			3.0		4.9		1.8
(4) Y LCRU FRONT	.5	.3		1.2	.7	1.8	.8					1.7		.4
(5) X LGA BASE	1.1	13.2		9.6	1.3	8.5	5.2	1.6	6.6	4.5		1.7	2.6	.5
(6) X LGA JOINT	.8	6.1		8.8	.1	.1	3.8	1.0	4.7			1.2		.5



SEATTLE VIBRATION MODAL ANALYSIS PRELIMINARY RESULTS

FREQUENCY Hz	G_0/G_1				
	26	43	50	70	90
<u>LOCATION</u>					
Z HGA TILT (1)	1.6			1	9.5
Z LCRU SHELF (2)	1			.4	3.2
Z LCRU BUMPER (3)	1.7			1.3	9.5
Y HGA TILT (4)	1.6			3.1	4.3
Z LCRU BAT (5)	1			.6	3
X HGA MID (6)	4			.6	1.5
Z LCRU FRONT (7)				1.3	2
Y HGA MID (8)		8.6	2		3.4
X TV TOP (9)		1.2			
Y TV TOP (10)		1.6			
X HGA MID (11)		1	3.7		1.4

LCRU MOUNTING SYSTEM

DESIGN STUDY

DYNAMIC RESPONSE

TO

SINUSOIDAL VIBRATION

PRELIMINARY

COMPUTATIONS

DEFENSE ELECTRONIC PRODUCTS
MOORESTOWN, NEW JERSEY

S.O. No. _____ PAGE 1

ENGR DKL _____ CHKD _____

DATE _____ REV. _____

SUBJECT: LCRU ELECTRONICS CASE.

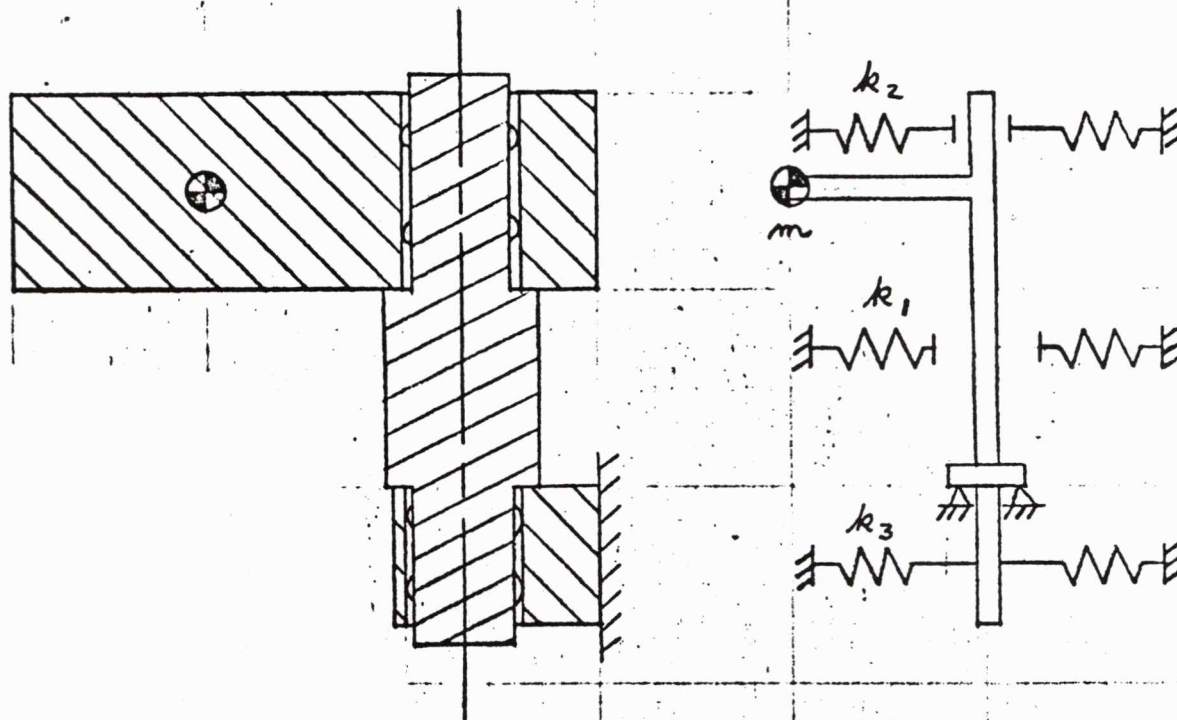
ITEM: VIBRATION CHARACTERISTICS OF MOUNTS.

THIS ANALYSIS OBTAINS AN APPROXIMATE INDICATION OF THE RESPONSE OF THE LCRU ELECTRONICS CASE TO A SINUSOIDAL FORCING. ATTENTION IS GIVEN ONLY TO THE VIBRATION CHARACTERISTICS OF THE CASE MOUNTING POSTS; THE CASE MAY REALISTICALLY BE CONSIDERED A RIGID MASS, AND THE VEHICLE MOUNTING TUBES, WHILE NOT STRICTLY RIGID, ARE CONSIDERED SO IN THIS FIRST ANALYSIS.

THE MOUNTING POSTS ARE CONSIDERED AS A BI-LINEAR SPRING SYSTEM CONNECTING THE CASE MASS TO THE VEHICLE. AS THE CASE OSCILLATES WITH RESPECT TO THE VEHICLE, THE INDIVIDUAL SPRINGS ARE ABRUPTLY COUPLED INTO THE MOUNTING SYSTEM, RESULTING IN A NON-LINEAR SPRING RATE. PRINCIPLE DEFLECTION OF THE CASE IS ROTATIONALLY ABOUT THE VEHICLE; THIS LEADS TO A ONE-DIMENSIONAL STUDY. MINOR TRANSLATIONAL DEFLECTION IS TO BE NEGLECTED FOR SIMPLIFICATION.

SUBJECT: LCRU ELECTRONICS CASE

ITEM:



COMPUTATIONS

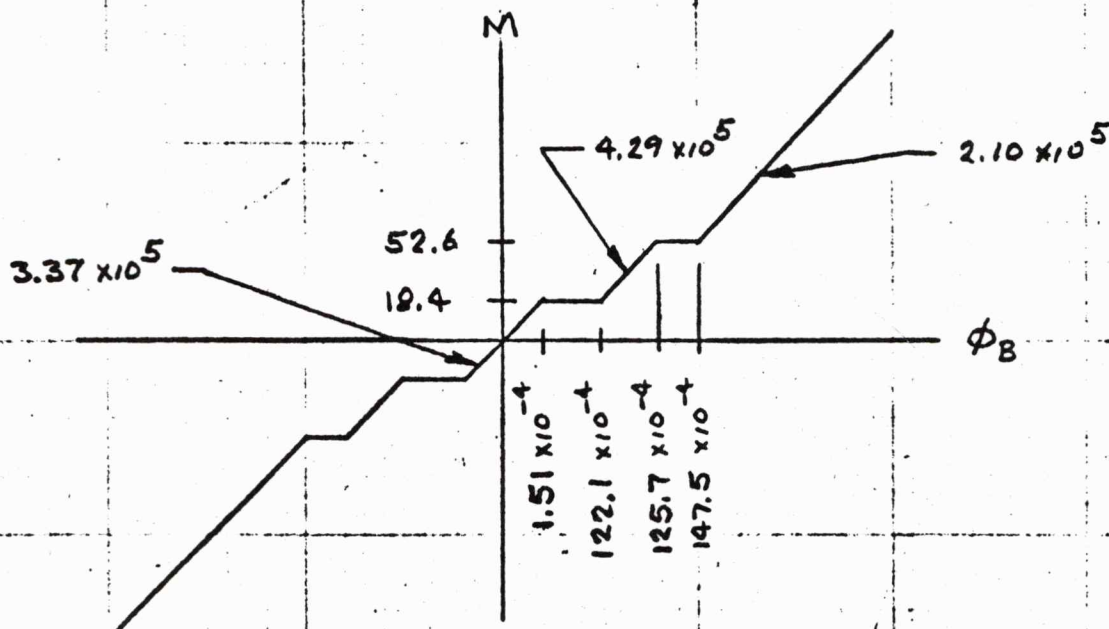
DEFENSE ELECTRONIC PRODUCTS
MOORESTOWN, NEW JERSEY

S.O. No. _____ PAGE 3
ENGR DKL _____ CHKD _____
DATE _____ REV. _____

SUBJECT: LCRV ELECTRONICS CASE

ITEM: _____

THE BI-LINEAR SPRING CONSTANT FOR THE MOUNTING SYSTEM IS SHOWN IN THE SKETCH BELOW. WITHOUT THE STATIC BENDING MOMENT ON THE POST DUE TO LUNAR GRAVITY, THE SYSTEM WOULD BE SYMMETRIC ABOUT THE CENTRAL REST POSITION AS SHOWN BY FIGURE A. APPLICATION OF A BENDING MOMENT CAUSES BENDING OF THE POST AND CASE DEFLECTION UNTIL THE ^{LOWER} POST SPRING PRELOAD IS EQUALIZED, AT WHICH TIME THE POST COCKS IN THE BORE WITH NO INCREASE IN MOMENT. AFTER CONTACT WITH THE BORE WALLS, FURTHER POST AND MASS DEFLECTION REQUIRES INCREASED MOMENT. THE COCKING IS REPEATED AT THE EQUILIZATION OF UPPER POST SPRING PRELOAD.



COMPUTATIONS

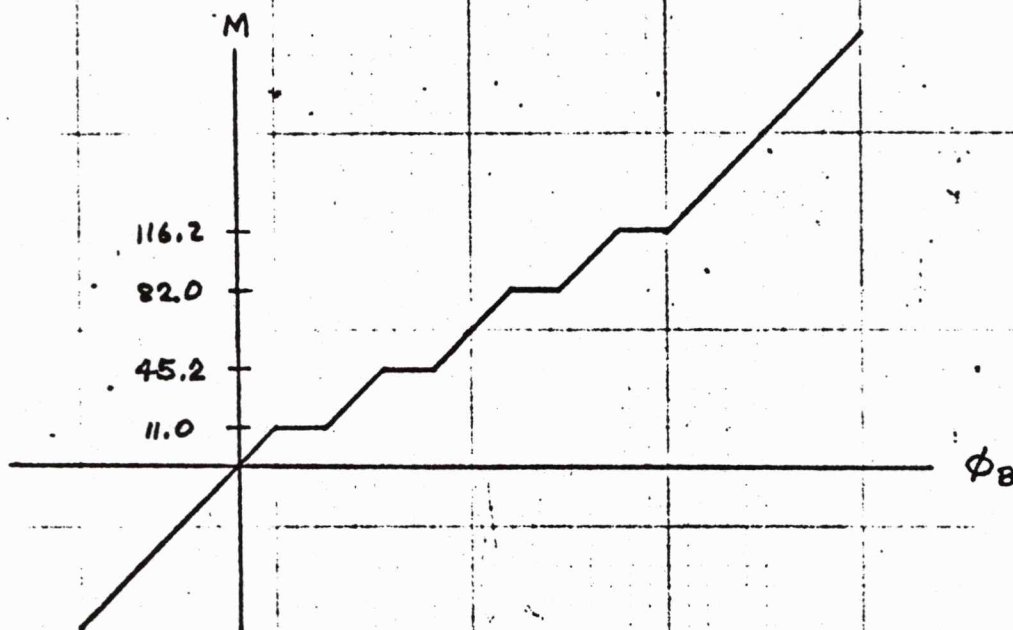
DEFENSE ELECTRONIC PRODUCTS
MOORESTOWN, NEW JERSEY

S.O. No. _____ PAGE 4
ENGR DKL CHKD _____
DATE _____ REV. _____

SUBJECT: LCRV ELECTRONICS CASE

ITEM: _____

WHEN LUNAR GRAVITY IS APPLIED TO THE SYSTEM
A NEW REST POSITION SHIFTS THE DEFLECTION
CURVE TO A NON-SYMMETRIC CONDITION,



WHILE DETERMINATION OF ACTUAL CHARACTERISTICS
AND MAGNITUDES IS ESSENTIALLY IMPOSSIBLE WITHOUT
IMPRACTICALLY TIME CONSUMING ANALYSIS, THIS
STUDY WILL OBTAIN ^{THE NATURE OF} GENERAL RESPONSE AND CHANGES
TO BE EXPECTED WITH MODIFICATIONS IN DESIGN.

COMPUTATIONS

DEFENSE ELECTRONIC PRODUCTS
MOORESTOWN, NEW JERSEY

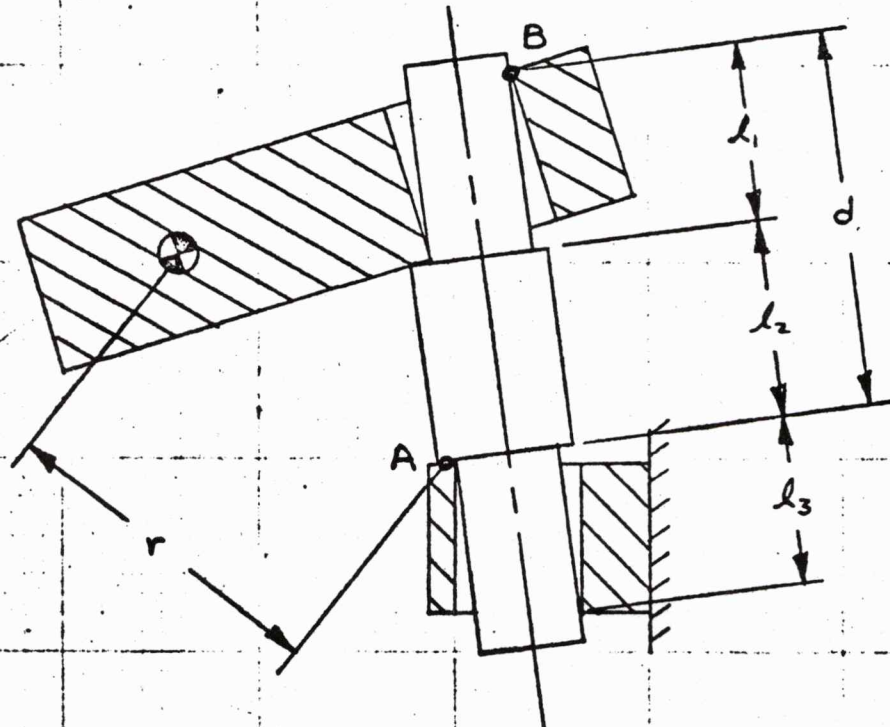
S.O. No. PAGE 5 (KI)
ENGR DKL CHKD
DATE REV.

SUBJECT: LCRU ELECTRONICS CASE

ITEM:

EVALUATION OF SPRING CONSTANT k_1

WHEN THE CASE HAS ROTATIONALLY DEFLECTED TO THE EXTENT THAT THE MOUNTING POST CONTACTS THE WALLS OF THE CASE AND MOUNTING TUBE BORES, AS CONFIGURED IN THE SKETCH BELOW, FURTHER DEFLECTION BENDS THE POST. THE POST ACTS AS SPRING 1 OF THE MASS-SPRING SYSTEM AND HAS A LINEAR SPRING CONSTANT k_1 . THE MOUNTING POST IS A BEAM, AND FROM BEAM DEFLECTION RELATIONS THE SPRING CONSTANT IS OBTAINED.



DEFLECTION OF THE MASS ABOUT 'A' IS PROPORTIONAL TO THE DEFLECTION OF POINT 'B'.

COMPUTATIONS

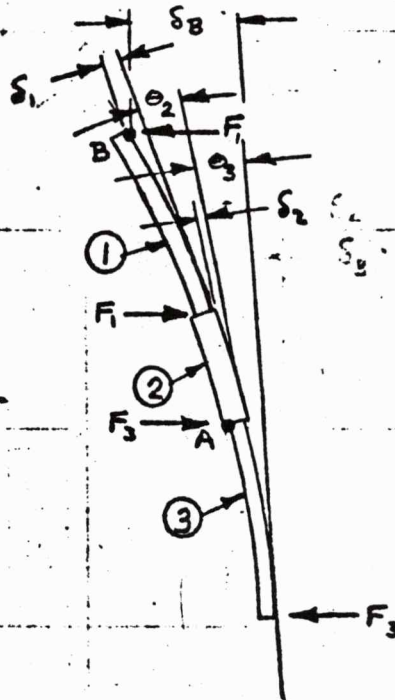
DEFENSE ELECTRONIC PRODUCTS
MOORESTOWN, NEW JERSEY

S.O. No. PAGE 6 (K2)
ENGR DKL CHKD
DATE REV.

SUBJECT: LCRV ELECTRONICS CASE

ITEM:

DEFLECTION OF THE POST AT POINT 'B' IS
DETERMINED FOR A PIVOT AT POINT 'A' WHEN
A UNIT MOMENT IS APPLIED BY THE CASE.



$$\begin{aligned}\delta_B &= \delta_1 + \theta_2 l_1 + \delta_2 + \frac{l_1 + l_2}{l_3} \delta_3 \\ &= \left[\frac{M l_1^2}{3 E_1 I_1} + \frac{M}{G_1 A_1} f \right] + \frac{M l_2}{E_2 I_2} l_1 + \left[\frac{M l_3^2}{3 E_3 I_3} + \frac{M}{G_3 A_3} f \right] + \\ &\quad \frac{l_1 + l_2}{l_3} \left[\frac{M l_3^2}{3 E_3 I_3} + \frac{M}{G_3 A_3} f \right]\end{aligned}$$

WHERE $M = F_1 l_1$

AND f IS THE SHEAR DEFLECTION
FORM FACTOR.

THE ROTATIONAL DEFLECTION OF POINT 'B' ABOUT
POINT 'A' IS

$$\phi_B = \delta_B / d$$

THE SPRING CONSTANT, WITH REFERENCE TO 'B' IS

$$k_1 = \frac{F_1 d}{\phi_B} = \left(\frac{F_1}{\delta_B} \right) d^2$$

COMPUTATIONS

DEFENSE ELECTRONIC PRODUCTS
MOORESTOWN, NEW JERSEY

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ENGR DKL CHKD _____
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SUBJECT: LCRV ELECTRONICS CASE

ITEM: _____

PARAMETER VALUES ARE LISTED BELOW:

SECTION	L (in.)	E (psi)	G (psi)	I (in ⁴)	A (in ²)
1	5.00	9.9×10^6	3.8×10^6	4.31×10^{-2}	.637
2*	1.88	~	~	~	~
3	2.50	9.9×10^6	3.8×10^6	4.31×10^{-2}	.637

* PROPERTIES OF A COMPOSITE OF GLASS-EPOXY LAMINATE AND ALUMINUM ALLOY.

$$E_2 I_2 = (EI)_{GEL} + (EI)_{AA} = 1.013 \times 10^6 \text{ lb-in}^2$$

$$G_2 A_2 = (GA)_{GEL} + (GA)_{AA} = 3.22 \times 10^6 \text{ lb}$$

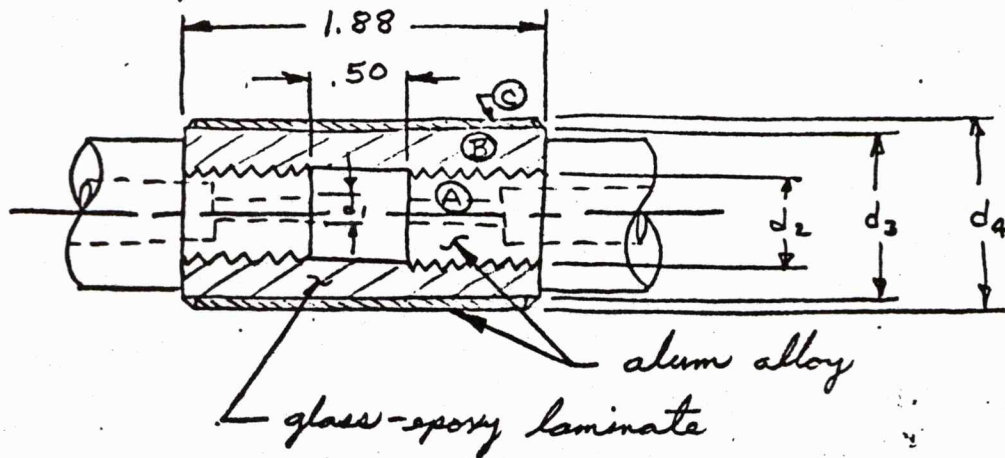
$$d = L_1 + L_2 = 6.88$$

$$f = 10/9$$

$$\begin{aligned} S_2/F_1 = & \frac{125.}{3(9.9 \times 10^6) 4.31 \times 10^{-2}} + \frac{5(10/9)}{3.8 \times 10^6 (.637)} + \frac{25. (1.88)}{1.01 \times 10^6} + \\ & \frac{5.00 (3.54)}{3 (1.01 \times 10^6)} + \frac{5.00 (10/9)}{3.22 \times 10^6} + \\ & \left(\frac{6.88}{2.50} \right) \frac{5.00 (6.25)}{3 (9.9 \times 10^6) 4.31 \times 10^{-2}} + \left(\frac{6.88}{2.50} \right) \frac{5.00 (10/9)}{3.8 \times 10^6 (.637)} \\ = & 2.26 \times 10^{-4} \text{ in/lb} \end{aligned}$$

$$k_1 = \frac{6.88^2}{2.26 \times 10^{-4}} = 2.10 \times 10^5 \text{ lb-in per post}$$

Composite post center section:



For practical purposes, consider the internal threaded ends of the upper and lower post sections as continuous through the center section, and that local deformation of threads has no effect.

$$d_1 = .25 \text{ * inch.} \quad E_{AA} = 9.9 \times 10^6 \text{ psi}$$

$$d_2 = .75 \quad E_{GEL} = 2.4 \times 10^6$$

$$d_3 = 1.25 \quad G_{AA} = 3.8 \times 10^6$$

$$d_4 = 1.38 \quad G_{GEL} = .92 \times 10^6$$

$$I = \frac{\pi}{64} (d_o^4 - d_i^4)$$

$$I_A = 1.53 \times 10^{-2} \text{ in}^4$$

$$I_B = 1.20 \times 10^{-1}$$

$$I_C = 5.79 \times 10^{-2}$$

$$A = \frac{\pi}{4} (d_o^2 - d_i^2)$$

$$A_A = .393 \text{ in}^2$$

$$A_B = .786$$

$$A_C = .267$$

$$\begin{aligned} EI &= 9.9 \times 10^6 (1.53 + 5.79) \times 10^{-2} + 2.4 \times 10^6 (1.20 \times 10^{-1}) \\ &= 7.25 \times 10^5 + 2.88 \times 10^5 = 10.13 \times 10^5 \text{ lb-in}^2 \end{aligned}$$

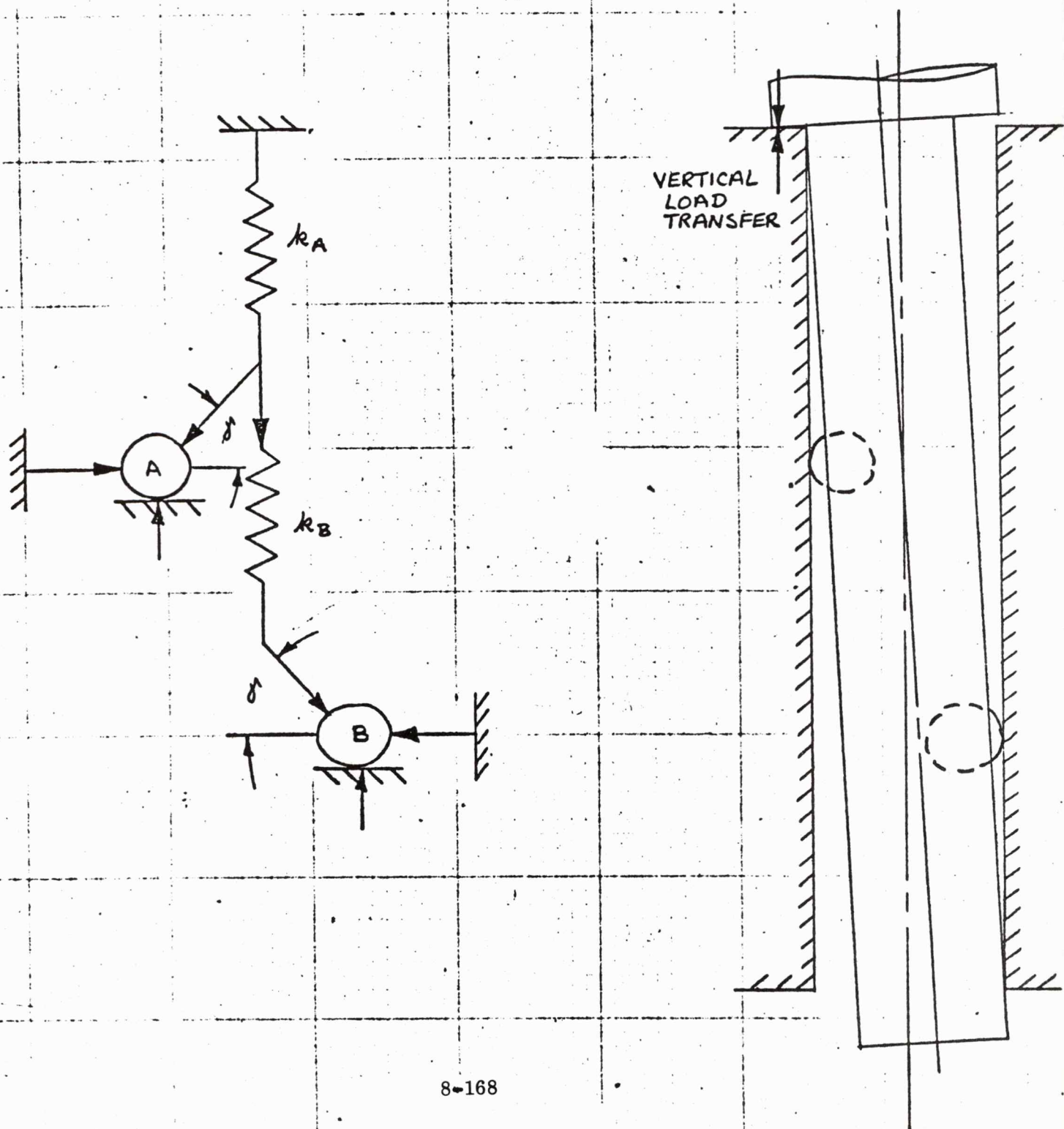
$$\begin{aligned} GA &= 3.8 \times 10^6 (.393 + .267) + .92 \times 10^6 (.786) \\ &= 2.51 \times 10^6 + .74 \times 10^6 = 3.22 \times 10^6 \text{ lb} \end{aligned}$$

SUBJECT: LCRU ELECTRONICS CASE

ITEM: _____

EVALUATION OF SPRING CONSTANT k_2 AND k_3

THE UPPER AND LOWER POSTS ARE CONFIGURED
AS SHOWN IN THE SCHEMATIC DIAGRAMS BELOW.



DEFENSE ELECTRONIC PRODUCTS
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S.O. No. _____ PAGE 11 (K5)
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SUBJECT: LCRU ELECTRONICS CASE

ITEM: _____

SPRINGS 'A' AND 'B' PRESS THE ROLLERS OUTWARD FROM THE POST AND INTO CONTACT WITH THE BORE WALL. ALL ROLLERS AROUND THE POST PERIPHERY CARRY AN EQUAL PRELOAD AND CENTER THE POST WITHIN THE BORE. UPON APPLICATION OF A BENDING MOMENT, PRELOAD IS TRANSFERRED TO THE EQUIVALENT OF TWO ROLLERS, AS SHOWN IN THE DIAGRAM. THERE IS CONSIDERED TO BE NO DEFLECTION NECESSARY TO TRANSFER THE PRELOAD. AN INCREASE IN THE BENDING MOMENT AFTER PRELOAD TRANSFER RESULTS IN COCKING OF THE POST IN THE BORE WITH DEPRESSION OF THE ROLLERS, AND BENDING OF POST, TO THE POINT AT WHICH THE POST CONTACTS THE BORE WALLS. IT IS THIS MOMENT-DEFLECTION RELATIONSHIP WHICH CONSTITUTES THE SPRINGS 2' AND 3 OF THE CASE MOUNTING SYSTEM.

ALL VERTICAL LOADING IS CONSIDERED TO BE CARRIED AT THE END OF THE POST'S CENTER SECTION, AS SHOWN ON THE PRECEDING PAGE. THE VERTICAL LOAD BEARING SURFACES ARE TAKEN AS FREE TO SLIDE, BUT AS A SOURCE OF VIBRATION DAMPING. ALSO.

DEFENSE ELECTRONIC PRODUCTS
MOORESTOWN, NEW JERSEY

S.O. No. _____ PAGE 12 (K6)

ENGR DKL _____ CHKD _____

DATE _____ REV. _____

SUBJECT: LCRU ELECTRONICS CASE

ITEM: _____

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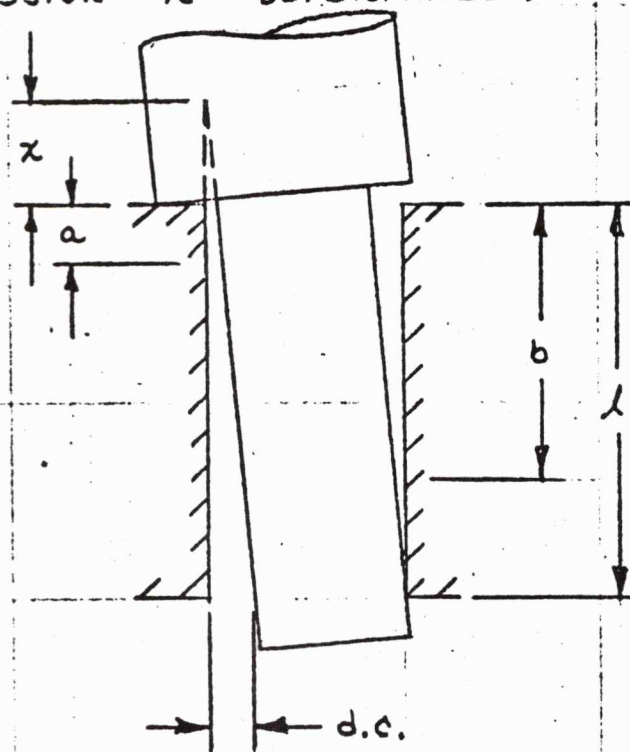
DEFENSE ELECTRONIC PRODUCTS
MOORESTOWN, NEW JERSEY

S.O. No. _____ PAGE 13 (K7)
ENGR DKL CHKD _____
DATE _____ REV. _____

SUBJECT: LCRU ELECTRONICS CASE

ITEM: _____

BASED ON THE ASSUMPTION THAT ROLLER DEPRESSION IS SMALL AND, SO, ROLLER FORCES REMAIN ESSENTIALLY EQUAL TO THE IDENTICAL PRELOAD FORCES, THE DEPRESSION IS DETERMINED:



ROLLER DEFLECTION AT THE MOMENT THE POST CONTACTS THE BORE WALL IS

$$R.D. = \frac{(l+x) - (a+x)}{(l+x)} d.c. - \frac{d.c.}{2} = \frac{b+x}{l+x} d.c. - \frac{d.c.}{2}$$

$$x = l - (a+b)$$

PARAMETER VALUES ARE LISTED:

POST	a (in)	b (in)	l (in)
LOWER	.77	1.63	2.50
UPPER	1.03	3.49	5.00

$$d.c. = 1.000^{+.005} - .975^{-.005} = .030 \text{ (MEAN)}$$

DEFENSE ELECTRONIC PRODUCTS
MOORESTOWN, NEW JERSEY

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SUBJECT: LCRV ELECTRONICS CASE

ITEM: _____

LOWER POST

$$x = .11$$

$$R.D. = 5.00 \times 10^{-3} \text{ in.}$$

UPPER POST

$$x = .48$$

$$R.D. = 9.75 \times 10^{-3} \text{ in}$$

POST SPRING COMPRESSION IS

$$C = R.D. / \tan \delta \quad (\delta = 25^\circ)$$

LOWER POST

$$C = 10.7 \times 10^{-3} \text{ in}$$

UPPER POST

$$C = 20.9 \times 10^{-3} \text{ in}$$

THE CHANGE IN THE FORCE ON SPRING 'A', WHEN SPRING 'B' IS CONSIDERED "CONSTANT FORCE", IS ONLY 2% FOR THE UPPER POST AND 1% FOR THE LOWER. BECAUSE THE CHANGE IS SO SMALL, THE POST SPRINGS HAVE NEGLIGIBLE EFFECT ON THE SYSTEM SPRING RATE. THEREFORE k_2 AND k_3 ARE TAKEN TO BE ZERO.

SUBJECT: LCRU ELECTRONICS CASE

ITEM: _____

EVALUATION OF ROLLER PRELOAD

REFERING TO THE SKETCH ON PAGE K4, THE REACTION FORCES AT THE ROLLER 'A' / BORE INTERFACE AND THE ROLLER 'B' / BORE INTERFACE ARE

$$R_A = (F_{kA} - F_{kB}) / \tan \gamma$$

$$R_B = F_{kB} / \tan \gamma$$

$$F_{kA} = 2 F_{kB}, \text{ SO}$$

$$R_A = R_B = F_{kB} / \tan \gamma$$

THE BENDING MOMENT NECESSARY FOR THESE REACTION FORCES AT 'A' AND 'B' IS

$$M = R (b-a) \quad (\text{REFER TO SKETCH ON PAGE K7})$$

PARAMETER VALUES ARE LISTED:

POST	$F_{kB} (lb)$	$(b-a) (in.)$	$\gamma (deg)$
LOWER	10	.86	25
UPPER	10	2.46	25

$$M_{\text{LOWER}} = 18.4 \text{ lb in}$$

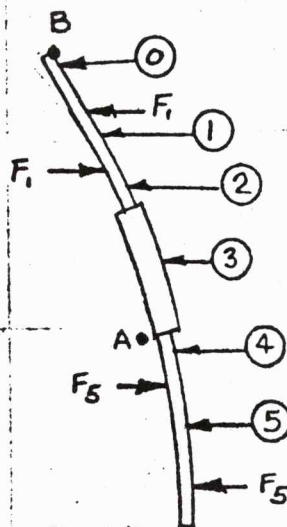
$$M_{\text{UPPER}} = 52.6 \text{ lb in}$$

SUBJECT: LCRU ELECTRONICS CASE

ITEM: _____

DETERMINATION OF POST DEFLECTION AT PRELOAD EQUILIZATION

BENDING DEFLECTION OF POINT 'B' WITH RESPECT TO 'A'
IS GIVEN BY BEAM BENDING RELATIONS.



FOR THE SMALLEST MOMENT VALUE, REQUIRED AT THE LOWER POST,

$$\delta_B = \theta_1 l_0 + \delta_1 + \theta_2 l_{0,1} + \delta_2 + \theta_3 l_{0,1,2} + \delta_3 + \theta_4 l_{0,1,2,3} +$$

$$\delta_4 + \theta_5 / 2 l_{0,1,2,3,4}$$

$$= \frac{M l_1}{E_1 I_1} l_0 + \left[\frac{M l_1^2}{3 E_1 I_1} + \frac{M}{G_1 A_1} f \right] + \frac{M l_2}{E_2 I_2} (l_0 + l_1) +$$

$$\left[\frac{M l_2^2}{3 E_2 I_2} + \frac{M}{G_2 A_2} f \right] + \frac{M l_3}{E_3 I_3} (l_0 + l_1 + l_2) +$$

$$\left[\frac{M l_3^2}{3 E_3 I_3} + \frac{M}{G_3 A_3} f \right] + \frac{M l_4}{E_4 I_4} (l_0 + l_1 + l_2 + l_3) +$$

$$\left[\frac{M l_4^2}{3 E_4 I_4} + \frac{M}{G_4 A_4} f \right] + \frac{M l_5}{2 E_5 I_5} (l_0 + l_1 + l_2 + l_3 + l_4)$$

$$M = F_1 l_1$$

$$k_5 = \left(\frac{F_1}{\delta_B} \right) d^2 = \left(\frac{M}{\delta_B} \right) \frac{d^2}{l_1}$$

DEFENSE ELECTRONIC PRODUCTS
MOORESTOWN, NEW JERSEY

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SUBJECT: LCRV ELECTRONICS CASE

ITEM: _____

FOR THE LARGER MOMENT, WITH THE LOWER POST
COCKED IN ITS BORE,

$$\delta_B = \theta_1 l_0 + \delta_1 + \theta_2 l_{0,1} + \delta_2 + \theta_3 l_{0,1,2} + \delta_3 +$$

$$\frac{l_{0,1,2,3}}{l_{4,5}} \delta_{4,5}$$

$$= \frac{M l_1}{E_1 I_1} l_0 + \dots + \left[\frac{M l_3^2}{3 E_3 I_3} + \frac{M}{G_3 A_3} t \right] +$$

$$\frac{l_0 + l_1 + l_2 + l_3}{l_4 + l_5} \left[\frac{M (l_4 + l_5)^2}{3 E_{4,5} I_{4,5}} + \frac{M}{G_{4,5} A_{4,5}} t \right]$$

$$M = F_1 l_1$$

$$k_4 = \left(\frac{F_1}{\delta_B} \right) d^2 = \left(\frac{M}{\delta_B} \right) \frac{d^2}{l_1}$$

PRELOAD EQUILIZATION DEFLECTION (LOWER POST)

SECTION	$l(\text{in})$	$EI (\text{lt-in}^2)$	$GA (\text{lt})$
0	1.51	$\sim$	$\sim$
1	2.47	$.427 \times 10^6$	2.42×10^6
2	1.03	$.427 \times 10^6$	2.42×10^6
3	1.88	1.013×10^6	3.22×10^6
4	.77	$.427 \times 10^6$	2.42×10^6
5	.86	$.427 \times 10^6$	2.42×10^6

$$M = 18.4 \text{ lt-in} \quad d = 6.88 \text{ in}$$

$$\begin{aligned} \frac{\delta_B}{M} = & \frac{2.47(1.51)}{.427 \times 10^6} + \frac{2.47^2}{3(.427 \times 10^6)} + \frac{10/9}{2.42 \times 10^6} + \\ & \frac{1.03(3.98)}{.427 \times 10^6} + \frac{1.03^2}{3(.427 \times 10^6)} + \frac{10/9}{2.42 \times 10^6} + \\ & \frac{1.88(5.01)}{1.01 \times 10^6} + \frac{1.88^2}{3(1.01 \times 10^6)} + \frac{10/9}{3.22 \times 10^6} + \\ & \frac{.77(6.89)}{.427 \times 10^6} + \frac{.77^2}{3(.427 \times 10^6)} + \frac{10/9}{2.42 \times 10^6} + \\ & \frac{.86(7.66)}{2(.427 \times 10^6)} \end{aligned}$$

$$= .5687 \times 10^{-4}$$

$$\delta_B = 18.4 (.568 \times 10^{-4}) = 10.4 \times 10^{-4} \text{ in}$$

$$k_5 = \frac{1}{.568 \times 10^{-4}} \cdot \frac{6.88^2}{2.47} = 3.37 \times 10^5 \text{ lt-in per post}$$

PRELOAD EQUILIZATION DEFLECTION (UPPER POST)

$$M = 52.6 \text{ lb in}$$

$$\frac{\delta_B}{M} = 35.82 \times 10^{-6} + \frac{6.89}{1.63} \left[\frac{1.63^2}{3(1.427 \times 10^6)} + \frac{10/9}{2.42 \times 10^6} \right]$$

$$= .466 \times 10^{-4} \text{ in}$$

$$\delta_B = 52.6 (.466 \times 10^{-4}) = 24.5 \times 10^{-4} \text{ in}$$

$$k_4 = \frac{1}{.466 \times 10^{-4}} \left(\frac{6.88^2}{2.47} \right) = 4.29 \times 10^5 \text{ lb in per post}$$

DEFENSE ELECTRONIC PRODUCTS
MOORESTOWN, NEW JERSEY

S.O. No. _____ PAGE 20 (K12)
ENGR DKL _____ CHKD _____
DATE _____ REV. _____

SUBJECT: LCRV ELECTRONICS CASE

ITEM: _____

DETERMINATION OF COCKING DEFLECTION

ROTATION OF POINT 'B' ABOUT POINT 'A' WITH
COCKING OF THE UPPER AND LOWER POST IN
THEIR BORES IS

LOWER POST

$$\delta_B = \frac{l_1 + l_2}{l_3} \text{ d.c.}$$
$$= \frac{6.88}{2.50} (.030) = .083 \text{ in}$$

UPPER POST

COCKING RESULTS IN NO NORMAL DEFLECTION
WITH RESPECT TO THE POST.

THE ANALYSIS IS TO BE CONTINUED .
UTILIZING THE BASIC RELATIONSHIPS
AND SPRING CONSTANTS OBTAINED HERE.

ONE BASIC MODIFICATION TO THE
POST CONFIGURATION IS TO REPLACE THE
LOWER SPRING/ROLLER POST ASSEMBLY
WITH A BOLTED CLAMPING TO THE
VEHICLE MOUNTING TUBE.

RESULTS OF THE CONTINUED ANALYSIS
WILL INCLUDE THE FREQUENCY AT AND
MAGNITUDE OF WORST VIBRATION RESPONSE
FOR CHOSEN VALUES OF INPUT VIBRATION
LEVEL AND DAMPING. BENDING MOMENTS
IMPRESSED IN THE POST AT WORST
VIBRATION RESPONSE WILL LEAD TO
DETERMINATION OF POST STRESS. A
CORRELATION OF VIBRATION RESPONSE AND
POST STRESS TO POST CONFIGURATION
WILL BE USEFUL FOR POSSIBLE WEIGHT
REDUCTION .

COMPUTATIONS

DEFENSE ELECTRONIC PRODUCTS
MOORENTOWN, NEW JERSEY

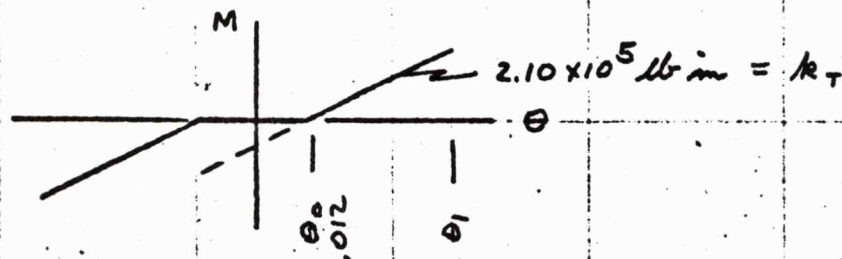
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SUBJECT: LCRU ELECTRONICS CASE

ITEM:

OSCILLATION PERIOD, FREE VIBRATION (GROSS APPROXIMATION)

USING THE POST BENDING SPRING RATE k ,
WITH FREE COCKING OF THE POST WITHIN THE
BORES AND NO DAMPING, THE OSCILLATION
PERIOD IS DETERMINED:



$$\theta = \theta_0 + (\theta_1 - \theta_0) \cos pt$$

$$p^2 = \frac{k_T}{I_m}$$

$$\dot{\theta} = -(\theta_1 - \theta_0) p \sin pt$$

$$(I_m = 11.85 \text{ lb-in-sec}^2)$$

$$\ddot{\theta} = -(\theta_1 - \theta_0) p^2 \cos pt$$

$$\text{CHOOSE } \ddot{s} = r \ddot{\theta} = 5g \text{ PEAK} \quad (r \approx 9.00 \text{ in})$$

$$\ddot{\theta} = -214 / \text{sec}^2 \quad \text{AT } t = 0$$

$$\theta_1 = \theta_0 + \frac{\ddot{\theta}}{p^2} = .012 + \frac{214}{2.10 \times 10^5} 11.85 = .024$$

$$\theta_0 = \theta_0 + (\theta_1 - \theta_0) \cos pt_1$$

$$pt_1 = \pi/2$$

$$t_1 = \frac{\pi}{2p} = \frac{\pi}{2} \sqrt{\frac{I_m}{k_T}} = 11.8 \times 10^{-3} \text{ sec.}$$

$$\dot{\theta}_0 = -(\theta_1 - \theta_0) p \sin pt_1$$

$$\dot{\theta}_0 = .012 (p) = 1.60 \text{ rad/sec}$$

THE TIME FOR HALF THE COCKING IS

$$t_2 = \dot{\theta}_0 / \ddot{\theta}_0 = 7.50 \times 10^{-3} \text{ sec}$$

THE PERIOD OF OSCILLATION IS

$$T = 4(t_1 + t_2) = 77.2 \times 10^{-3} \text{ sec/cycle}$$

$$f = 1/T = 12.9 \text{ Hz}$$

THIS RESULT INDICATES THE GENERAL MAGNITUDE OF 'NATURAL' FREQUENCY TO BE EXPECTED OF MORE " DETAILED ANALYSIS.

LCRU CASE
PRESSURIZATION STRESS ANALYSIS

JUNE 30, 1970

RCA CORP.
CONTRACT NO. NAS9-10660

PRELIMINARY ANALYSIS

RIB AND WEB DIMENSION DETERMINATION FOR LCRU CASE

The two pressure conditions are:

on earth 14.7 external* 7.5 internal

on moon 0 external 7.5 internal

safety factor applied to limit load is $1.5 \sqrt{F_{ty}}$ (tensile yield stress) from MIL-HDBK-5A. For 6061-T6 is 35,000 psi* (heat treated and aged)* Transverse grain loading, basis is 99% of values fall above with 95% confidence. For 6061-T4 heat treated only $F_{ty} = 16,000$ psi. We will use $F_{ty} = 35,000$ psi.

Determine temperature effect - from Fig. 3.2.6.2.1(a) of MIL-HDBK-5A for 200 °F worst case we have 92% of room temperature F_{ty} for the modulus E @ 200 °F we have 98%

$$E = 9.9 \times 10^6 \text{ psi at room temp}$$

$$E = 9.9 \times 10^6 (.98) = 9.7 \times 10^6 \text{ psi}$$

$$F_{ty} = 35,000 (.95) (1/1.5) = 22,200 \text{ psi.}$$

Stress and deflection formulas are from Formulas for Stress and Strain by R. J. Roark

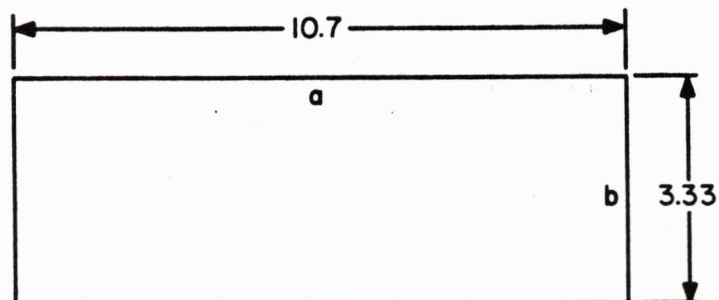
Determine the web thickness required for the following conditions

$$F_{ty} = 22,200 \text{ psi}$$

$$E = 9.7 \times 10^6 \text{ psi}$$

*Experienced during purge and fill.

I For the side of the case



$$a/b = 10.7/3.33 = 3.22$$

$$B = .50, \alpha = .0284$$

$$S = B \frac{wb^2}{t^2}$$

$$t^2 = \frac{B wb^2}{S} = \frac{(.5) (14.7) (3.22)^2}{22.2 \times 10^3}$$

$$t^2 = \frac{(.5) (14.7) (10.4)}{(22.2 \times 10^3)} = \frac{76.5}{22.2 \times 10^3} = 3.44 \times 10^{-3}$$

$$t^2 = 34.4 \times 10^{-4}$$

$$t = 5.87 \times 10^{-2} = .0587 \text{ in.}$$

this is approximately 1/16" thickness the deflection for 14.7 psia is as follows

$$y = \alpha \frac{wb^4}{Et^3} = \frac{(.0284) (14.7) (3.22)^4}{(9.7 \times 10^6) (.239 \times 10^{-3})}$$

$$y = \frac{(.417) (108)}{(2.32 \times 10^3)} = 19.4 \times 10^{-3}$$

$$y = .019 \text{ in}$$

For the 7.5 psia pressure condition we have the following.

$$S = B \frac{wb^2}{t^2} = \frac{(1) (7.5)}{(.062)^2} = 11,300 \text{ psi}$$

$$y = \alpha \frac{wb^4}{Et^3} = \frac{(.0284) (7.5) (3.22)^4}{(9.7 \times 10^6) (.239 \times 10^{-3})} = .0097 \text{ in.}$$

II Determine the pressure cover web size and structural requirements

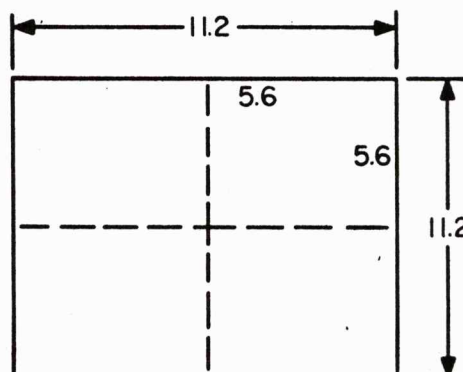
Assumed Conditions

$$S_{\max} = 22.2 \times 10^3 \text{ psi}$$

$$E = 9.7 \times 10^6 \text{ psi}$$

web thickness, $t = .0625 \text{ in.}$ loading 14.7 psia delta in both directions.

Cover is square.



The panel must be divided in quarters at least.

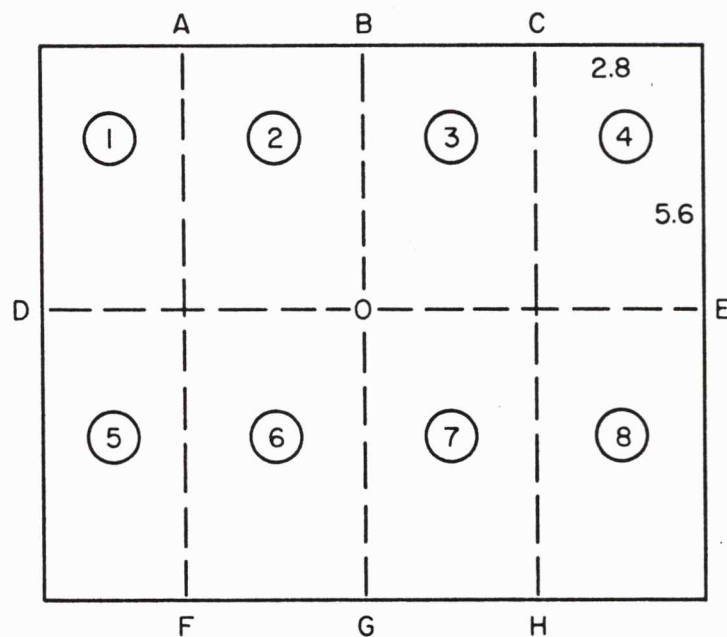
$$a/b = 1, B = .3078, \alpha = .0138$$

$$S = B \frac{wb^2}{t^2} = \frac{(.3078) (14.7) (5.6)^2}{(.062)^2}$$

$$S = \frac{(4.5) (31)}{(38.5 \times 10^{-4})} = \frac{139.5}{38.5 \times 10^{-4}} = 3.62 \times 10^4$$

$$S = 36,200 \text{ psi this is too large}$$

Let us divide the cover into eight webs



$$a = 5.6 \quad b = 2.8 \quad \frac{a}{b} = \frac{5.6}{2.8} = 2$$

$$B = .4974, \alpha = .0277$$

$$S = B \frac{wb^2}{t^2} = \frac{(.4974) (14.7) (2.8)^2}{(38.5 \times 10^{-4})}$$

$$S = \frac{(7.123) (7.8)}{(38.5 \times 10^{-4})} = \frac{55.5}{38.5 \times 10^{-4}} = 1.44 \times 10^{+4}$$

$$S = 14,400 \text{ psi}$$

the deflection will be

$$y = \alpha \frac{wb^4}{Et^3} = \frac{(.0277) (14.7) (61)}{(9.7 \times 10^6) (.239 \times 10^{-3})}$$

$$y = \frac{24.8}{2.32 \times 10^3} = 10.7 \times 10^{-3} = .0107 \text{ in}$$

III Determine the beam structure required to support the webs. The total load on any web is

$$W = (2.8) (5.6) (14.7) = 230 \text{ lb.}$$

the edge loading in shear is

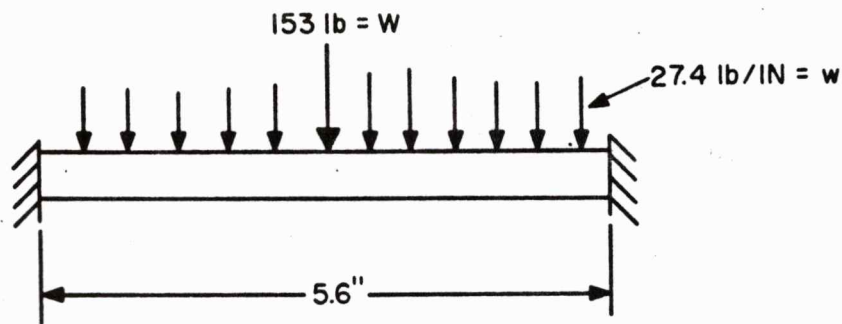
$$\frac{230}{5.6 + 11.2} = \frac{230}{16.8} = 13.7 \text{ lb/in.}$$

we will assume a center support point.

The beam from 0 to E will have a distributed load and a concentrated load.

The distributed load is $(13.7) (2) = 27.4 \text{ lb/in}$

The concentrated load is $\frac{11.2 (27.4)}{2} = 153. \text{ lb}$



so the m will be

$$m = \frac{1}{8} (153) (5.6) + \frac{1}{12} (27.4) (5.6)^2$$

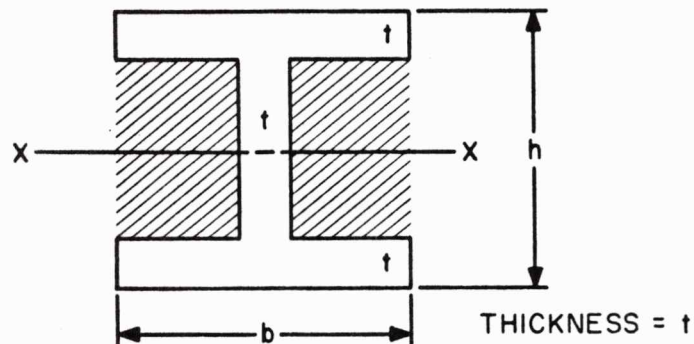
$$m = 107 + 71.6 = 178.6 \text{ in/lb}$$

$$\frac{I}{C} = \frac{178.6}{22.2 \times 10^3} = 8 \times 10^{-3}$$

$$\frac{I}{C} = .008 \text{ in}^3 \text{ for the primary beam}$$

$$I = (8 \times 10^{-3}) \left(\frac{.562}{2} \right) = 2.24 \times 10^{-3}$$

let us use .0625 thick sections for the I beam.



about the x-x axis

$$I = \frac{1}{12} b h^3 - 2 \frac{1}{12} \frac{b-t}{2} (h-2t)^3$$

$$\text{Let } I = (.008) \left(\frac{.562}{2} \right) = 2.24 \times 10^{-3} \text{ in}^4$$

$$h = (.562)$$

$$t = (.062)$$

solve for b

$$(2.24 \times 10^{-3}) = \frac{b(.562)^3}{12} - \frac{(b-.062)}{12} [.562 - .125]^3$$

$$(2.24 \times 10^{-3}) = (.0148)b - (b-.062) (.00694)$$

$$(2.24 \times 10^{-3}) = .0148 b - .00694 b + .43 \times 10^{-3}$$

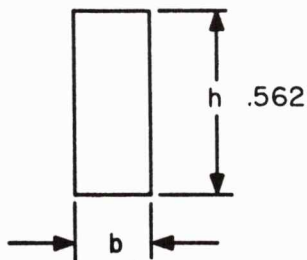
$$2.24 \times 10^{-3} = .00786b + .43 \times 10^{-3}$$

$$1.81 \times 10^{-3} = 7.86 \times 10^{-3}$$

$$b = \frac{1.81 \times 10^{-3}}{7.86 \times 10^{-3}} = .23 \text{ in}$$

use a .25 in wide flange

IV Determine rib thickness if no flanges were used (this would simplify the machining)



$$I = \frac{1}{12} b h^3$$

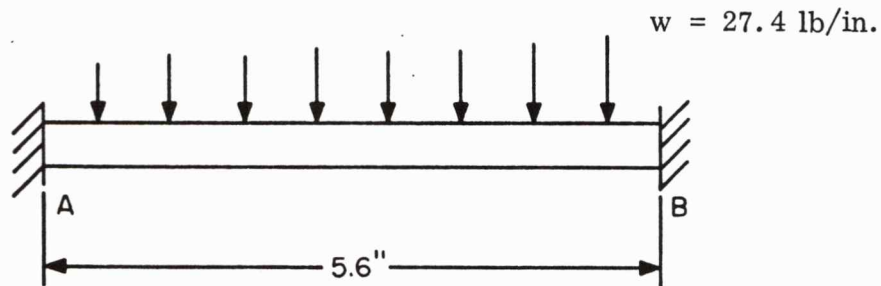
$$C = \frac{.562}{2} = .281$$

$$\frac{b (.177)}{12 (.281)} = 22.6 \times 10^{-3}$$

$$b = \frac{(22.6 \times 10^{-3}) (12) (.281)}{.177} = \frac{76 \times 10^{-3}}{.177} = 430 \times 10^{-3}$$

b = .430 in it is better to use the I beam

V Determine the flange width for the secondary beams from 0 to B and so forth.



max m at points A & B

$$m = \frac{1}{12} W l = \frac{1}{12} (27.4) (5.6) (5.6)$$

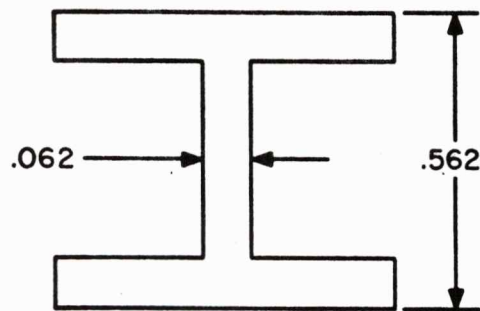
$$m = 71.5 \text{ in lb.}$$

$$S = \frac{m}{I/C} = (22.2 \times 10^3) = \frac{71.5}{I/C}$$

$$\frac{I}{C} = \frac{71.5}{22.2 \times 10^{-3}} = 3.22 \times 10^{-3}$$

$$\frac{I}{C} = .00322 \text{ in}^3$$

Let us use .0625 thick sections for the I beam



about the x-x axis

$$I = (3.22 \times 10^{-3}) \left(\frac{.562}{2} \right) = .905 \times 10^{-3}$$

$$.905 \times 10^{-3} = .00786b + .43 \times 10^{-3}$$

$$.475 \times 10^{-3} = 7.86 \times 10^{-3} b$$

$$b = \frac{.475 \times 10^{-3}}{7.86 \times 10^{-3}} = .0605$$

Conclusion the flange is not required on the secondary ribs.

VI Determine reaction loads of cover

The total load on the cover is

$$(14.7) (11.2) (11.2) = 1840 \text{ lb}$$

Now determine the reaction loads at the end of the beams. For the beam 0-E

$$\frac{153 + 27.4 (5.6)}{2} = 153 \text{ lb at reaction}$$

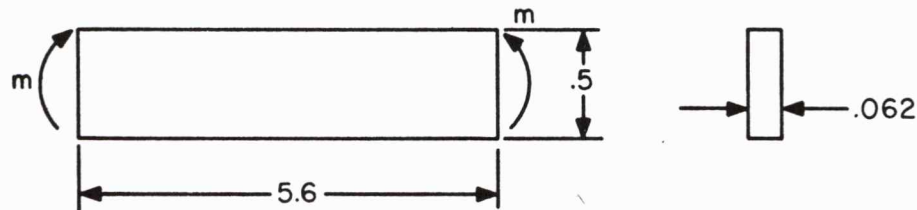
For the Beam 0-B

$$\frac{153}{2} = 76.5 \text{ lb at reaction}$$

So total load on center screw will be $153 + 153 + 76.5 + 76.5 = 459$ lb.

This requires a number 6 screw. A #6-32 CRS screw is good for 540 lb. min.

VII Check for buckling



Critical bending moment m^1

$$m^1 = \frac{2 \pi b^3 d \sqrt{EG (1 - 0.63 \frac{b}{d})}}{6l}$$

$$b = .062, d = .5, l = 5.6$$

$$E = 9.7 \times 10^6 \quad G = 3.75 \times 10^6$$

$$m^1 = \frac{(6.28) (2.38 \times 10^{-4}) (.5) \sqrt{(9.7) (3.75) \times 10^{12} (1 - 0.63 (.125))}}{33.6}$$

$$m^1 = \frac{(7.5 \times 10^{-4}) \sqrt{(36.4 \times 10^{12}) (.921)}}{33.6}$$

$$m^1 = \frac{(7.5 \times 10^{-4}) (5.8 \times 10^6)}{33.6} = \frac{43.5 \times 10^2}{33.6} = 1.3 \times 10^2$$

$$m^1 = 130 \text{ in lb}$$

The max m for the secondary beams is 71.5 in lb so we do not need a flange

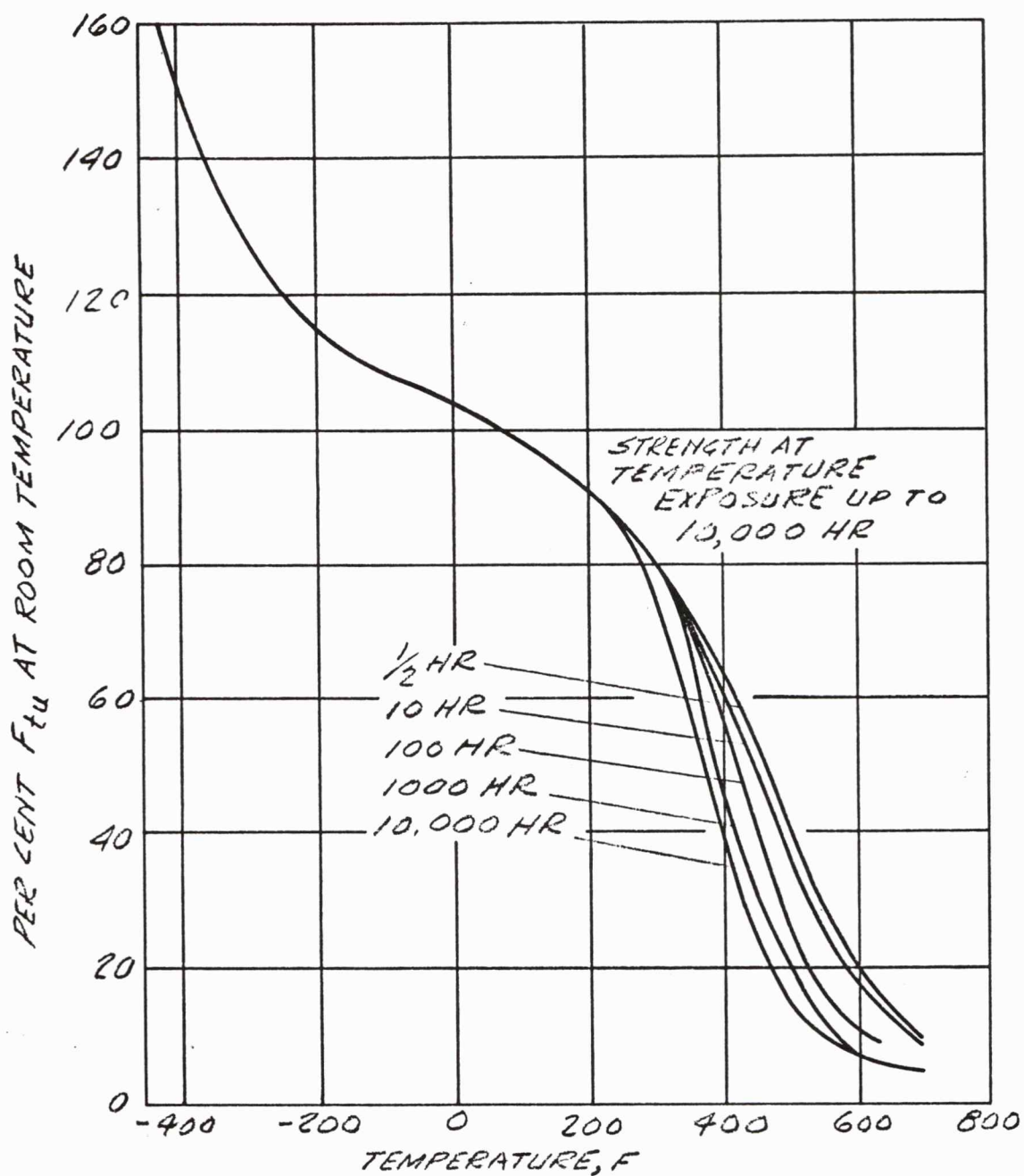


Figure 3.2.6.2.1(a). Effect of temperature on the ultimate tensile strength (F_{tu}) of 6061-T6 aluminum alloy (all products).

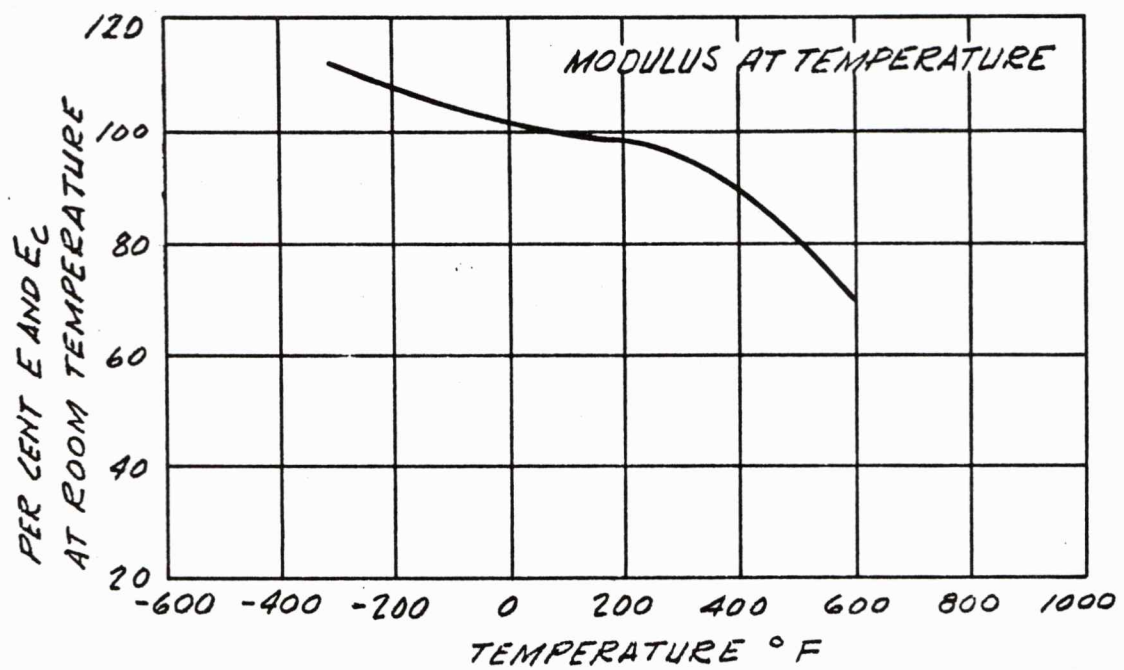


Figure 3.2.6.2.4. Effect of temperature on the tensile and compressive moduli (E and E_c) of 6061, aluminum alloy

24 August 1970

LRV/LCRU MOUNTING INTERFACE

TOLERANCE ANALYSIS

LRV/LCRU MOUNTING INTERFACE TOLERANCE ANALYSIS

1

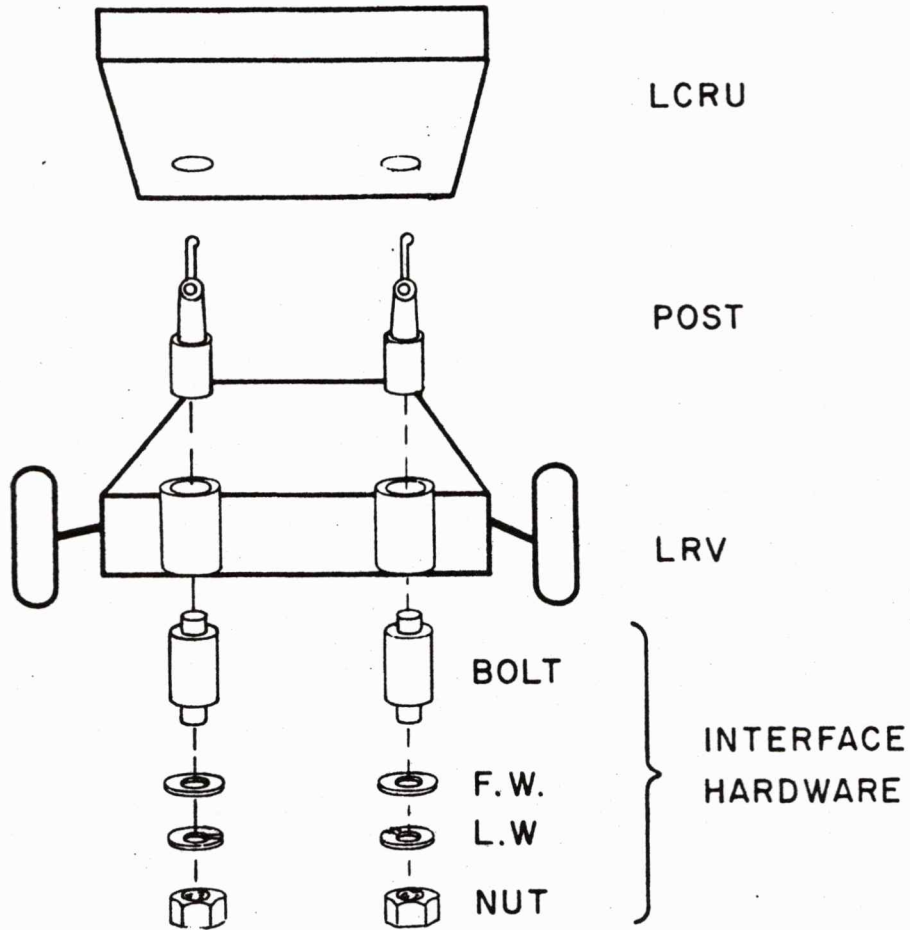


Figure 1. LRV/LCRU Mechanical Interface

2

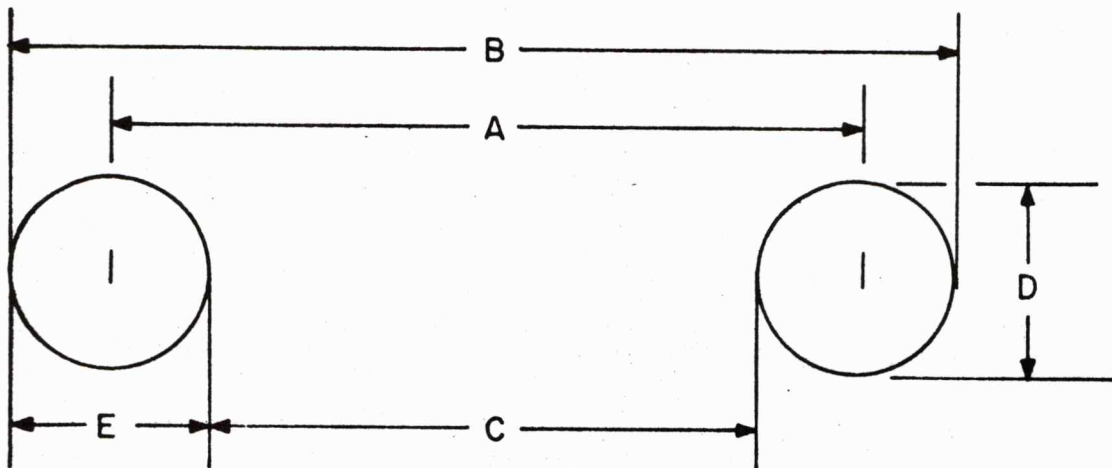


Figure 2. Dimension References

TABLE 1. PRESENT INTERFACE DIMENSIONS

	<u>A</u>	<u>D</u> + .005 1.000 - .000 DIA
LRV Tubes	19.700 ± .010	
LCRU Holes	19.700 ± .010	+ .005 1.000 - .000 DIA
Bolt	-	+ .000 0.998 - .002 DIA

TABLE 2. TOLERANCE VARIABLES

FOR LCRU MINIMUM HOLE, 1.000 DIA
& 19.700 ± .010 CENTERLINE

	<u>Minimum</u>	<u>Nominal</u>	<u>Maximum</u>
A	19.690	19.700	19.710
B	20.690	20.700	20.710
C	18.690	18.700	18.710

TABLE 3

FOR LRV MAXIMUM TUBE, 1.005 DIA
& 19.700 ± .010 CENTERLINE

	<u>Minimum</u>	<u>Nominal</u>	<u>Maximum</u>
A	19.690	19.700	19.710
B	20.695	20.705	20.715
C	18.685	18.695	18.705

4 c Cont.

$$\begin{aligned} \text{Post} &= \frac{19.719 + .010}{19.681 - .010} = \frac{19.729 \text{ Max}}{19.671 \text{ Min}} \\ &\quad .058 \text{ Tot} \\ &\quad \text{or } \pm .029 \end{aligned}$$

5

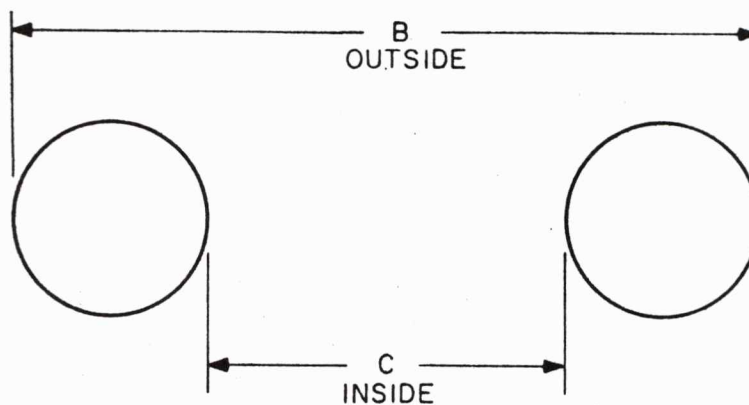


Figure 4.

For Post DIA Max = .975

$$\begin{aligned} B (\text{Post}) &= \text{Post} + .975 \\ &= 19.729 + .975 = 20.704 \text{ Max} \end{aligned}$$

$$\begin{aligned} C (\text{Post}) &= \text{Post} - .975 \\ &= 19.691 - .975 = 18.696 \text{ Min} \end{aligned}$$

6

Potential Interference

Outside: $B (\text{Post}) - B (\text{LRV Tube})$

Max: $20.704 - 20.695 = .009 \text{ Interference}$

Inside: $C (\text{LRV Tube}) - C (\text{Post})$

Max: $18.705 - 18.696 = .009 \text{ Interference}$

NOTE B&C (LRV Tube) From Table 3

7

Temperature Effect (Assumed)

Add $\pm .015$ Allowance For $\Delta T = 50^\circ F$

Between LRV & LCRU at Time of
Assembly or Disassembly in Lunar
Environment

$$.009 + .015 = \pm .024 \text{ Potential Interference}$$

8

Recommendations

- a. Dimension LCRU Holes & LRV Tubes in Accordance with the A, B, C, D System of Figure 2.
- b. Establish Fixed Orientation For Mounting Posts & Reduce Lateral Dimension While Maintaining Fore-Aft Dimension as Permitted by Weight Vs Stress Analysis.
- c. Consider Slight Elongation of LCRU Holes in the Lateral Direction



EXAMPLE : POST



EXAMPLE : LCRV HOLE

4 c

FOR BOLT IN LRV TUBE

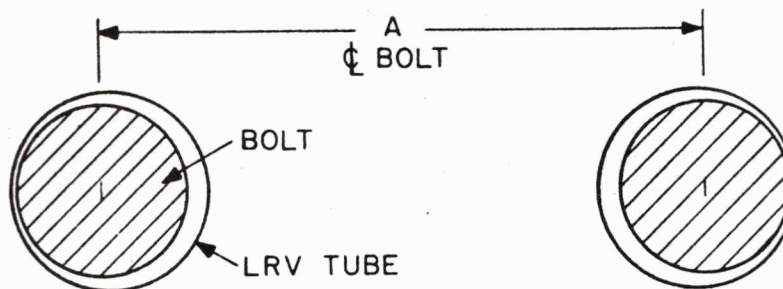


Figure 3.

LRV TUBE = 1.005 DIA

$$\text{Bolt} = .998 \text{ DIA} + .000 \text{ Max} - .002 \text{ Min} = .996 \text{ Min}$$

$$A \text{ (Bolt) Max} = B \text{ (Tube)} - .996$$

$$A \text{ (Bolt) Min} = C \text{ (Tube)} + .996$$

	Min	Nom	Max
4 d For A (LRV Tube) =	19.690	19.700	19.710

(See Table 3 For LRV Tube B&C)

A (Bolt) =	19.699	19.709	19.719	Max
	19.681	19.691	19.691	Min

$$\phi \text{ Bolt} = 19.719 \text{ Max}$$

$$19.681 \text{ Min}$$

$$.038 \text{ Tot, or } \pm .019$$

4 e Assumed: Let Eccentricity (TIR) Post Assembly
= .010

$$\text{Then } \phi \text{ Post Assy} = \phi \text{ Bolt} \pm .010$$

LCRU LEAK RATE ANALYSIS

REVISED AUGUST 19, 1970

Prepared By:

R. E. Holston

LCRU Mechanical Design

RCA Corporation

LCRU CASE LEAK RATE ANALYSIS

1.0 SCOPE

The purpose of this analysis is to analytically predict the leak rate characteristic and the moisture content of the LCRU pressure case 8370854-501 after exposure to the specification environment of the LCRU subsystem RCA Dwg. No. 8370855.

2.0 APPLICABLE DOCUMENTS

LCRU Specification	SE-C-0043A
Case Assembly	8370873-501
Cover	8670921-1
Sealing Tube	8659204-501
Connector Receptable	
Specification Sealing	
Specification, Gasket	8555261

3.0 DETAIL ANALYSIS

3.1 PHYSICAL CHARACTERISTICS OF CASE AND COMPONENTS

The characteristics of the case, cover and connectors are as follows:

Case Volume

$$\begin{aligned} 11.6 \times 11.7 \times 3.7 &= 504 \text{ cu. in.} \\ 504 \times 16.4 &= 8260 \text{ C.C.} \end{aligned}$$

Assume 50% of volume is components.

Gas Volume

$$\begin{aligned} (504) (0.5) &= 252 \text{ cu. in.} \\ (8260) (0.5) &= 4130 \text{ C.C.} \end{aligned}$$

Gasket material B-591-8 45 in. long from Parker Handbook, leak rate is

@ 77°F 2.7 to 8.0 ATM CC/IN/YR He
@ 176°F 8.7 to 26.0 ATM CC/IN/YR He

Connectors - Two leak sources

- (a) Glass Seal
- (b) Rubber "O" ring

Glass Seal Leak Rates

Selectro Conn.	(1)	1×10^{-8}	ATM CC/SEC He
Triplexer Conn.	(1)	1×10^{-9}	ATM CC/SEC He
Diplexer Conn.	(2)	1×10^{-9}	ATM CC/SEC He
Multipin Conn.	(1)	3×10^{-9}	ATM CC/SEC He
Total		1.6×10^{-8}	ATM CC/SEC He

O-Ring Leak Rates

<u>Connector</u>	<u>O-Ring Length, Inches</u>		
Selectro Conn.	(3.14)	(0.25)	= 0.785
Triplexer Conn.	(3.14)	(0.50)	= 1.570
Diplexer Conn.	(2)	(3.14) (0.50)	= 3.140
Multipin Conn.	(3.14)	(1.5)	= 4.700
Sub Total			10.195
<u>Pressure Cover</u>			
Screw O-Ring	(3.14)	(0.5)	= 1.570
Fill Tube O-Ring	(3.14)	(0.5)	= 1.570
Total			13.335

The O-ring leak rates according to Parker Seal Co. are approximately 3 times that of the molded in place "Gask-o-seal" used in the pressure cover.

$$3 (13.335) = 40.0 \text{ equivalent inches of gasket.}$$

So the total gasket length is $45.0 + 40.0 = 85.0$ inches of gasket.

The glass seal leakage is

$$(1.6 \times 10^{-8}) (3.16 \times 10^7) = 0.506 \text{ ATM CC/YR He}$$

The gasket and O-ring leak rate is

$$15 \text{ ATM CC/IN/YR He}$$

$$15 (85.0) = 1280 \text{ ATM CC/YR He}$$

The 15 ATM CC/IN/YR He leak rate is the average value for the B591-8 butyl compound at 80°C from the Parker Seal Handbook (see Appendix).

Total leak rate for the case
 gasket and o-rings
 Glass seals
 total

1280.000 ATM CC/YR He
 .506 ATM CC/YR He
 1280.506 ATM CC/YR He

3.2 PRESSURE DROP DETERMINATION

Gas content 100% nitrogen internal pressure 7.5 psia case temperature on moon 140°F max.

Convert the leak rate to the equivalent leak rate for nitrogen:

$$Q_2 = Q_1 \frac{\lambda_1}{\lambda_2}$$

where Q = Leak rate

λ = Molecular diffusion rate coefficient

(see chart in Appendix from Parker Seal Co.)

$$Q_2 = 1280 \frac{4.5}{7.2} = 800 \text{ ATM CC/YR N}_2 @ 140^\circ\text{F}$$

The pressure after a period of time in the case can be calculated as

$$P = P_o e^{-L \frac{T}{V}}$$

Assume the leak rate is constant to simplify the calculations. (It actually decreases) convert the leak rate to CC/MONTH

$$800 \text{ ATM CC/YR N}_2 @ 140^\circ\text{F} @ 1 \text{ ATM } \Delta P$$

For 1 month

$$P = (7.5) e^{\frac{-800/12 (1)}{4130}}$$

$$P = (7.5)/e^{.0161} = \frac{7.5}{1.0162} = 7.4 \text{ psia}$$

For 12 months

$$P = (7.5) e^{\frac{-800}{4130}} = (7.5) e$$

$$P = (7.5)/1.214 = 6.18 \text{ psia}$$

For 50 months

$$P = (7.5) e^{\frac{-800/12 (50)}{4130}}$$

$$P = (7.5) e^{-.81} = 3.34$$

For 100 months

$$P = (7.5) e^{\frac{-800/12 (100)}{4130}}$$

$$P = \frac{7.5}{5.05} = 1.49 \text{ psia}$$

This data is shown in graph form in Figure 1. The graph shows that the critical pressure for corona of approximately 1.0 psia will not be reached until after 150 months of exposure to the vacuum of space.

Analysis of Screw Loading on Pressure Cover

Screws: # 6-32 stainless steel flat head

Minimum tension for screw: = 540 lb.

Breaking torque = 14.0 in. lb.

40% safety factor is recommended.

$$\frac{540}{1.4} = 385 \text{ lb.}$$

$$\frac{14.0}{1.4} = 10 \text{ in. lb.}$$

Clamping force should be 30-150 lb per in. of seal. Screws are on 1.0 inch centers so we have one screw per inch of seal. The #6 screw will easily carry the load of 150 lb.

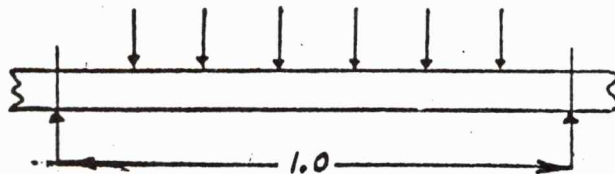
The torque required will be approximately:

$$T = \frac{KDW}{12} = \frac{(.30) (.138) (150)}{12} = 0.52 \text{ ft. lb.}$$

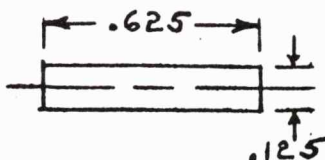
$$T = 6.25 \text{ in. lb. per screw}$$

Determine the deflection of the cover flange between the screws.

$$w = 150 \text{ lb/in.}$$



$$\text{Max } y = -\frac{1}{384} \frac{WL^3}{EI}$$



$$I = \frac{1}{12} \times .625 (.125)^3 = \frac{.625 (1.95 \times 10^{-3})}{12} = 1.02 \times 10^{-4} \text{ in}^4$$

$$y = \frac{150}{(384) (10 \times 10^6) (1.02 \times 10^{-4})} = \frac{.39}{10.2 \times 10^4}$$

$$y = -3.82 \times 10^{-4} = .00038 \text{ in.}$$

No problem with deflection.

3.3 Relative Humidity Determination

The following analysis predicts the moisture content in the LCRU pressurized compartment after exposure to the total environment.

Condition 1: 140°F 100% R. H. 1 month (transportation)

Condition 2: 80°F 50% R. H. 36 months (storage)

Condition 3: 80°F 80% R. H. 1 month (launch, etc.)

3.3.1 Weight of water vapor at the start of storage. Assume at the end of bake cycle that the entire volume is filled with water vapor 100 microns pressure @ 140°F. The weight of water present will then be:

$$PV = WRT$$

$$R = \frac{1545}{18} = 85.8 \text{ FT-lb/lb} - ^\circ\text{R}$$

$$V = \frac{252}{1728} = .146 \text{ cu FT}$$

$$P = 100 \text{ microns} = .1 \text{ mm Hg}$$

$$P = \frac{.1}{760} (14.7) = .00193 \text{ PSI}$$

$$T = 460 + 140 = 600^\circ\text{R}$$

$$W = \frac{(.279) (.146)}{(85.8) (600)} = .79 \times 10^{-6} \text{ lb. of Water}$$

3.3.2 The unit is filled with 100% nitrogen at 7.5 psia at 70°F. Calculate lbs. of gas in container.

$$PV = WRT$$

$$R = \frac{1545}{28.0} = 55.0 \text{ ft-lb/lb}^\circ\text{R}$$

$$V = .146 \text{ cu. ft.}$$

$$P = 7.5 (144) = 1080 \text{ lb/ft}^2$$

$$T = 460 + 70 = 530^\circ\text{R}$$

$$W = \frac{(1080) (.146)}{(55) (530)} = 5.42 \times 10^{-3} \text{ lb. of gas}$$

The water content of the gas is assumed to be 10.5 ppm.

$$(10.5 \times 10^{-6}) (5.42 \times 10^{-3}) = 57.0 \times 10^{-9} \text{ lb H}_2\text{O}$$

3.3.3 So the total initial water in the unit will be:

$57.0 \times 10^{-9} \text{ lb}$	from fill gas
$790.0 \times 10^{-9} \text{ lb}$	from initial purge
$847.0 \times 10^{-9} \text{ lb}$	total H ₂ O

The initial relative humidity in the case at 70°F will be as follows:

Partial pressure of H_2O at 70°F

$$P_o = \frac{W_o RT}{V} = \frac{(.847 \times 10^{-6}) (85.8) (530)}{(.146) (144)}$$

$$P_o = 1.83 \times 10^{-3} \text{ psia}$$

Saturation pressure @ 70°F = .3628 psia

$$\text{R.H.} = \frac{1.83 \times 10^{-3}}{.3628} (100) = 0.505\% \text{ R.H.}$$

3.3.4 Water vapor leakage for Condition 1. 140°F 100% R.H., 1 month

Partial pressure H_2O in air @ 140°F

$$100\% \text{ R.H.} = (1.0) (2.887) = 2.887 \text{ psia}$$

The partial pressure of the H_2O in the case at 140°F is:

$$P_o = \frac{W_o RT}{V} = \frac{(.847 \times 10^{-6}) (85.5) (600)}{(.142) (144)}$$

$$P_o = 2.13 \times 10^{-3} \text{ psia}$$

The diffusion ΔP @ 140°F therefore is:

$$2.887 - .00213 = 2.885 \text{ psia}$$

The diffusion leak rate for H_2O @ 140°F is 266 ATM CC/YR H_2O

So the leak rate of H_2O into the case for Condition 1 will be:

$$\frac{2.885 \times 266}{14.7} = 52.1 \text{ ATM CC/YR } H_2O$$

In one month

$$\frac{52.1}{12} = 4.34 \text{ ATM CC } H_2O$$

$$\frac{52.1}{(3600)(24)(365)} = \frac{52.1}{(3.6 \times 10^3)(24)(3.65 \times 10^2)} = \frac{2.17}{13.2 \times 10^5}$$

$$= .165 \times 10^{-5} \text{ ATM CC/SEC.}$$

$$(.165 \times 10^{-5})(9.66 \times 10^4) = 1.6 \times 10^{-1} \text{ micron cu ft/HR}$$

$$= .16 \text{ micron cu ft/HR}$$

$$(30)(24)(.16) = 11.5 \text{ micron cu. ft.}$$

$$(11.5)(1.32 \times 10^{-6}) = 15.2 \times 10^{-6} \text{ ATM cu. ft.}$$

$$\text{The weight of water: } \frac{(14.7)(144)(15.2 \times 10^{-6})}{(85.8)(600)} = .626 \times 10^{-6} \text{ lb. water.}$$

3.3.5 Water vapor leakage for Condition 2. 80°F 50% R.H. 36 months

$$\text{Partial pressure H}_2\text{O in air @ 80°F 50\% R.H.} = (.5)(.5066) = .253 \text{ psia}$$

The weight of water in the case at the start of storage is:

$$.626 \times 10^{-6} + .847 \times 10^{-6} = 1.473 \times 10^{-6} \text{ lb.}$$

The partial pressure of the H₂O in the case is now:

$$P_o = \frac{W_o RT}{V} = \frac{(1.473 \times 10^{-6})(85.8)(540)}{(.146)(144)}$$

$$P_o = 3.24 \times 10^{-3} \text{ psia}$$

The partial pressure of the H₂O outside the case @ 80°F = .253 psia.

Diffusion ΔP @ 80°F is then:

$$.253 - .003 = .25 \text{ psia}$$

The leak rate for H₂O @ 140°F is 266 ATM CC/YR H₂O.

Corrected to 80°F

$$\frac{.75}{1.6} (266) = 125 \text{ ATM CC/YR H}_2\text{O}$$

So the leak rate of H₂O into the case for Condition 2 will be:

$$\frac{.25}{14.7} (125) = 2.12 \text{ ATM CC/YR H}_2\text{O}$$

$$\frac{2.12}{3.16 \times 10^7} = .67 \times 10^{-7} \text{ ATM CC/SEC.}$$

$$(.67 \times 10^{-7}) (9.66 \times 10^4) = 6.47 \times 10^{-3} \text{ Micron cu. ft. /HR}$$

$$(6.47 \times 10^{-3}) (24) (365) (3) = 17 \times 10^1 \text{ Micron cu. ft.}$$

$$= 170 \text{ Micron cu. ft.}$$

$$(170) (1.32 \times 10^{-6}) = 224 \times 10^{-6} \text{ ATM cu. ft.}$$

The weight of water increase will be:

$$= \frac{(14.7) (144) (224 \times 10^{-6})}{(85.8) (540)} = 10.3 \times 10^{-6} \text{ lb. H}_2\text{O}$$

3.3.6 Water vapor leakage for Condition 3:

80°F 80% R.H. 1 month

Partial pressure H_2O in air @ 80°F 80% R.H.

$$(.8) (.5066) = .405 \text{ psia}$$

The weight of water vapor at start of Condition 3 is:

$$1.473 \times 10^{-6} + 10.3 \times 10^{-6} = 11.8 \times 10^{-6} \text{ lb.}$$

The partial pressure of the H_2O in the case is now:

$$P_o = \frac{W_o RT}{V} = \frac{(11.8 \times 10^{-6}) (85.8) (540)}{(.146) (144)}$$

$$P_o = 26.0 \times 10^{-3} \text{ psia}$$

The partial pressure of the H_2O outside the case @ 80°F = .253 psia

Diffusion ΔP @ 80°F is then:

$$.253 - .0026 = .250 \text{ psia}$$

Leak rate corrected to 80°F is 125 ATM CC/YR H₂O.

So the leak rate into the case for Condition 3 will be:

$$\frac{.25}{14.7}(125) = 2.12 \text{ ATM CC/YR H}_2\text{O}$$

$$\frac{.25}{3.16 \times 10^7} = .67 \times 10^{-7} \text{ ATM CC/SEC.}$$

$$(.67 \times 10^{-7})(9.66 \times 10^4) = 6.47 \times 10^{-3} \text{ micron cu. ft./HR}$$

$$(6.47 \times 10^{-3})(24)(30) = 4.65 \text{ micron cu. ft.}$$

$$(4.65)(1.32 \times 10^{-6}) = 6.15 \times 10^{-6} \text{ ATM cu. ft.}$$

The weight of water increase will be:

$$= \frac{(14.7)(144)(6.15 \times 10^{-6})}{(85.8)(540)} = .282 \times 10^{-6} \text{ lb H}_2\text{O}$$

3.3.7 The total water vapor in the case and relative humidity.

$$\text{Initial} = .847 \times 10^{-6} \text{ lb.}$$

$$\text{Condition 1} = .626 \times 10^{-6} \text{ lb.}$$

$$\text{Condition 2} = 10.300 \times 10^{-6} \text{ lb.}$$

$$\text{Condition 3} = .282 \times 10^{-6} \text{ lb.}$$

$$\text{Total} = 12.055 \times 10^{-6} \text{ lb.}$$

The final partial pressure inside the case at 50°F:

$$P_o = \frac{W_o RT}{V} = \frac{(12.05 \times 10^{-6})(85.8)(510)}{(.146)(144)} = .025 \text{ psia}$$

Saturation pressure @ 50°F = .1780 psia

$$\text{R.H. @ 50°F} = \frac{.025}{.1780}(100) = 14\%$$

3.3.8 Determine the dew point temperature. Try 4°F.

$$P_o = \frac{(12.05 \times 10^{-6}) (85.8) (464)}{(.146) (144)} = .0228 \text{ psia}$$

Saturation pressure at 4°F = .0227

$$\text{R.H.} = \frac{.0228}{.0227} (100) = 100\%$$

Dew Point = 4°F.

LCRU LEAK RATE ANALYSIS

APPENDIX A

K&E SEMI-LOGARITHMIC 358-70
KEUFFEL & ESSER CO. MADE IN U.S.A.
3 CYCLES X 60 DIVISIONS

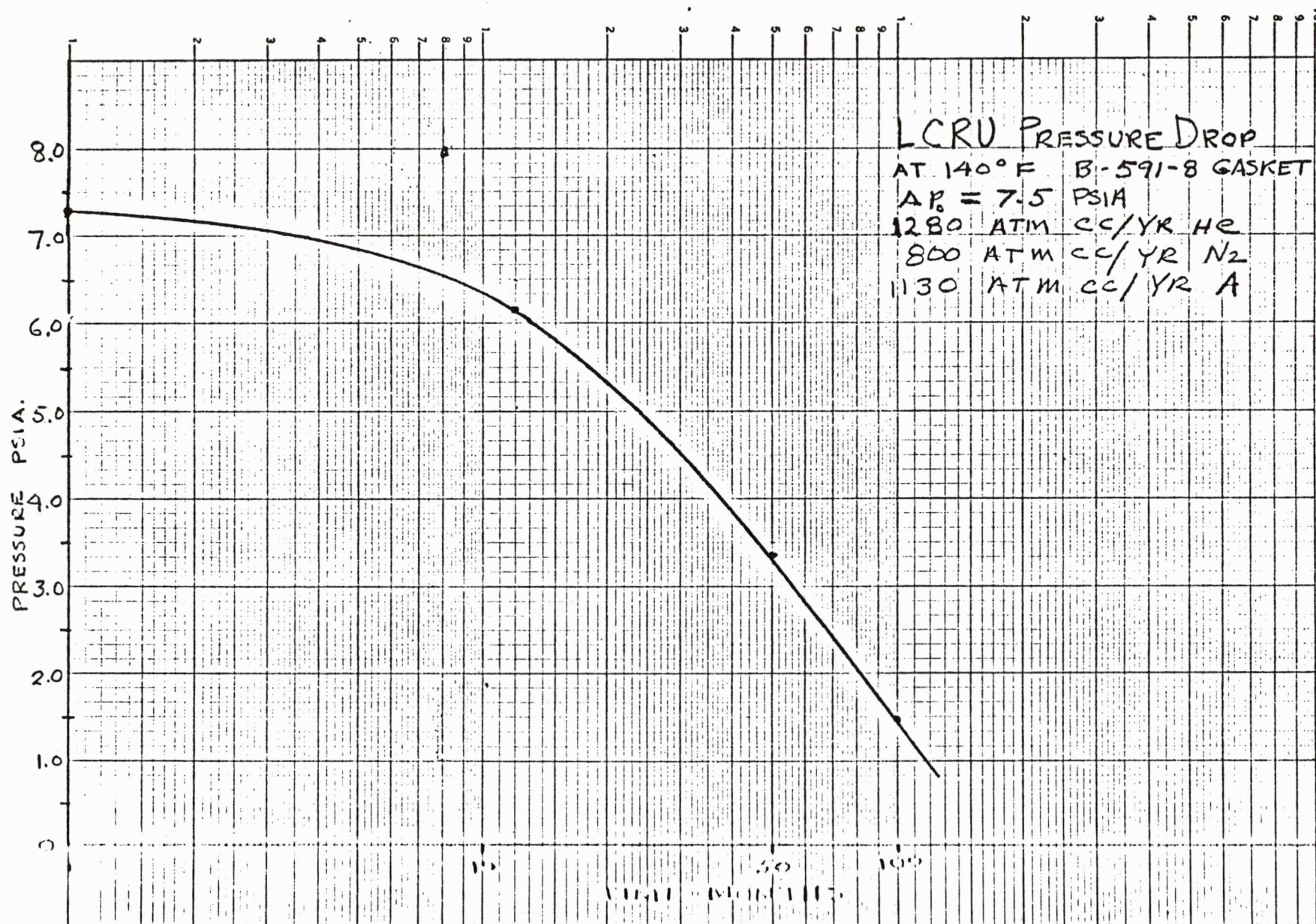


FIGURE 1

TABLE II-1

GASK-O-SEAL VACUUM LEAK RATE
at one atmosphere differential pressure***

Compound (Base Elastomer)	Stabilized Leak Rate Range (ATM cc/in/yr* He) **		
	Temperature		
	25°C (77°F)	80°C (176°F)	150°C (302°F)
77-545 (Fluorocarbon)	2.0 to 6.0	4.5 to 14.0	6.1 to 19.0
B318-7 (Butyl)	1.8 to 5.5	8.0 to 24.0	
B591-8 (Butyl)	2.7 to 8.0	8.7 to 26.0	
B612-7 (Butyl)	1.0 to 3.0	3.0 to 9.0	
E515-8 (EP)	6.3 to 19.0	33.4 to 100.0	103.5 to 310.0
S383-7 (Silicone)	49.3 to 150.0	125.6 to 380.0	269.2 to 810.0

*Atmospheric cubic centimeters of Helium per linear inch of seal per year.

**Test results of 460-xxx-16 series Gask-O-Seal (302/304 Cres. Retainers).

***Tested with Helium at one atmosphere pressure inside the seal, and an average absolute pressure of 3.5×10^{-7} torr, outside seal.

The helium low limit leak rates noted in table II-1 were measured under controlled laboratory conditions using ideal geometric flange design and seal style.

Recent studies of actual applications indicate that allowances must be made for the limit of accuracy of leak detection apparatus and normal variations which affect the seal such as bolt spacing, flange separation and surface finish, etc.

Therefore, in most applications it is recommended that the high limit leak rate, as noted in table II-1 (three times the low limit) be used as the predicted stabilized leak rate for actual service conditions. These values may be exceeded if the mating surface is too rough, if flanges separate, or if the components are not sufficiently clean.

The estimated leak rates of other gases can be found in relation to helium from 72°F to 165°F using the equation on page 2-6 and the curves of Figure II-2. Also, the change in estimated leak rate of gas due to temperature can be determined by this means.

One word of caution is in order. When applying the leak rate data of Table II-1 to a specific seal design, multiply the linear inches of seal line by the diffusion rate. A two sided seal has twice the seal length of a single seal. Also, for higher temperatures, greater pressure differentials, or compounds other than shown, the rates will change. In these cases, tolerable leak rates of gases should be specified.

TABLE II-2
WEIGHT LOSS UNDER VACUUM AS A FUNCTION OF TEMPERATURE

Compound (Base Elastomer)	Temperature °F	Weight Loss %	Pressure torr
B318-7 (1) (Butyl)	77	3.3	6×10^{-8}
	120	5.1	2×10^{-8}
	165	6.8	3×10^{-8}
77-545 (2) (Fluorocarbon)	77	2.1	0.18×10^{-8}
(1) (Fluorocarbon)	77	0	1.2×10^{-8}
	120	0.7	4×10^{-8}
	165	1.3	5×10^{-8}
E515-8 (3) (EP)	75	0.4	4×10^{-8}

Separate sets of samples were tested at each temperature:

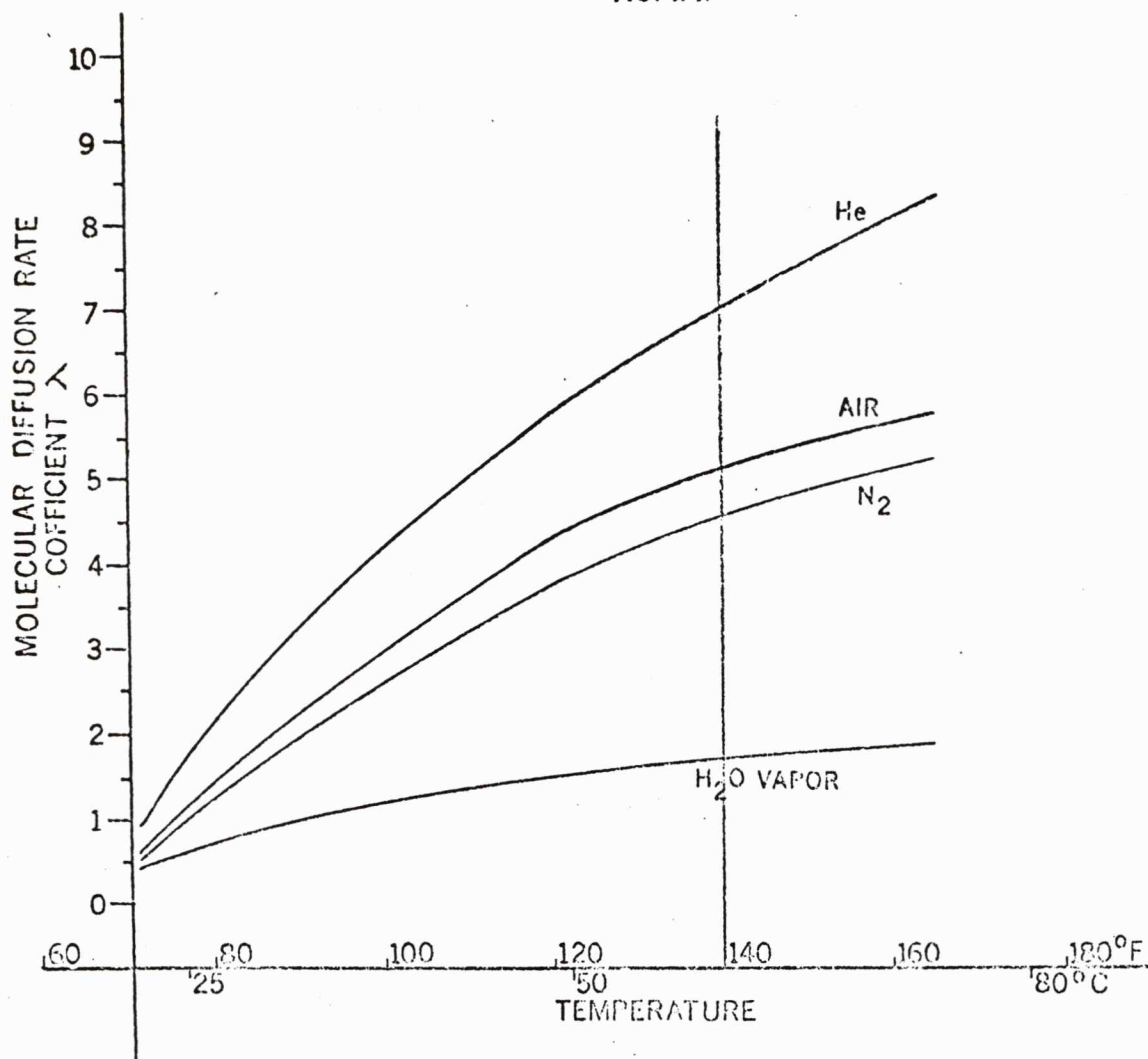
(1) Duration of test, 8 days.

(2) Duration of test, 84 hours.

(3) Duration of test, 24 days.

VACUUM LEAK RATE COEFFICIENT OF VARIOUS GASES
AS A FUNCTION OF TEMPERATURE AT ONE ATMOSPHERE DIFFERENTIAL PRESSURE

FIG. II-2



Equation: $Q_2 = Q_1 \frac{\lambda_2}{\lambda_1}$

Where Q = Leak rate
 λ = Diffusion rate coefficient
 Q_1 = Known leak rate of test gas at a known temperature
 Q_2 = Leak rate is to be calculated for any temperature between 72°F and 165°F

DESIGNING FOR VACUUM

For moderate temperature use and vacuum levels from slightly below atmospheric pressure to vacuums approaching 1×10^{-3} torr, special precautions in the Gask-O-Seal design are seldom necessary. If a standard catalog item seal will fit the application, it may be ordered "off the shelf" unless it is extremely important to reduce the leakage to the lowest possible rate. Usually, the very slight Gask-O-Seal leakage experienced on these moderate vacuum applications is not objectionable.

In the "high vacuum" range, from 1×10^{-3} torr, to levels close to 1×10^{-6} torr, special manufacturing techniques must be employed to assure an acceptably low leak rate. Be sure therefore, that Parker Seal is notified of the vacuum level for applications in this range. There will be an extra charge for this special handling and additional delivery time should be allowed.

LEAK DETECTION HINTS

1. **MAKE** certain that your leak detector is peaked on helium before attempting to leak check an object. (See your O&M Manual for instructions.)
2. **NEVER** use the leak detector to evacuate an external system. Rough out the space between the system and the leak detector with an external roughing pump before opening the throttle valve.
3. **REMEMBER** to always recalibrate your leak detector if you change the position of the pumping speed control valve.
4. **ALWAYS** remember to shield a helium pressurized object from drafts and breezes when probing.
5. If you are operating "around the clock" and the leak detector is not in an air conditioned room, it is advisable to calibrate the instrument at least 3 times a day, applying the temperature correction listed on the label of the standard leak each time.
6. When fabricating an external leak test system, make sure that all external lines are as short as possible, and are of as

large a diameter as possible. Remember that small long lines increase pump down time, limit the degree of vacuum obtainable, and increase response and clean up time.

7. **ALWAYS** tighten flanges evenly! Uneven tightening of a flange will distort the gasket or O ring thereby encouraging leakage.
8. When pressure leak testing a large object such as pipe line and tank fittings, a sheet of plicofilm or vinyl tape loosely around the fitting will provide a retaining medium for the helium during the test.
9. **ALWAYS TREAT YOUR MAGNET CAREFULLY.** If the magnet is damaged, its field strength may be changed thereby altering the sensitivity of your leak detector.
10. After reassembly and re-adjustment following a maintenance tear-down and cleaning, use your leak detector to leak check itself for leaks.
11. **FOR LONG, TROUBLE-FREE instrument life, SET UP and FOLLOW a regular program of MAINTENANCE AND SERVICE;** a maintenance log will pay for itself many times over.

TABLE OF LEAK RATE CONVERSION FACTORS

TO CONVERT	TO	MULTIPLY COLUMN 1 BY
atm cc/sec	micron liters/sec micron cu ft/hr Torr liters/sec	7.60×10^2 9.66×10^4 7.60×10^{-1}
micron liters/sec	atm cc/sec micron cu ft/hr Torr liters/sec	1.32×10^{-3} 1.27×10^2 1.00×10^{-3}
Torr liters/sec	atm cc/sec micron liters/sec micron cu ft/hr	1.32 1.00×10^3 1.27×10^5
micron cu ft/hr	atm cc/sec micron liters/sec Torr liters/sec	1.04×10^{-5} 7.87×10^{-3} 7.87×10^{-6}

Example: Given: 0.1 micron cu ft/hr.
Find: number of Atm cc/sec
Solution: $0.1 \times 1.04 \times 10^{-5} = 1.04 \times 10^{-6}$ Atm cc/sec

USEFUL FACTORS IN LEAK DETECTION WORK

1 atmosphere = 14.7 psia = 760 mm H_g = 7.6×10^5 microns
 1 micron = 1×10^{-6} meters of mercury = 1×10^{-3} mm H_g
 1 Torr = 1/760 of a standard atmosphere
 1 milli Torr = 1×10^{-3} Torr
 1 micro Torr = 1×10^{-6} Torr
 1 cu ft = 28.320cc = 28.32 liters = 7.48 gallons
 1 cu in = 16.4 cc
 1 liter = 61.0 cu in = 0.0353 cu ft = 1.0567 U. S. quart
 Seconds in 1 year = 31,563,000 = 3.16×10^7
 Percentage of helium in air = 0.0004%
 Partial pressure of helium in air at STP = 0.00304 mm H_g = 3.04 microns