THERMAL SUBSYSTEM

FINAL ENGINEERING REPORT

For

OGO-F, EP-5 (Experiment F-22 and Experiment F-24)

(9 November 1967 - 15 June 1969)

Contract No. NAS 5-11095

Prepared For

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

GODDARD SPACE FLIGHT CENTER

Greenbelt, Maryland

Prepared By

TIME-ZERO corporation
3530 Torrance Boulevard, Torrance, California 90503

(Formerly Marshall Laboratories)

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GODDARD SPACE FLIGHT CENTER

Contracting Officer: M. Stephens

Technical Officer: Dr. E.P. Mercanti

Prepared By

TIME-ZERO CORPORATION

(Formerly Marshall Laboratorie.,

Project Manager: Eric Azari/Sam Pollack

ENGINEERING REPORT

OGO-F THERMAL SUBSYSTEM FOR THE EP-5 (Experiment Package)

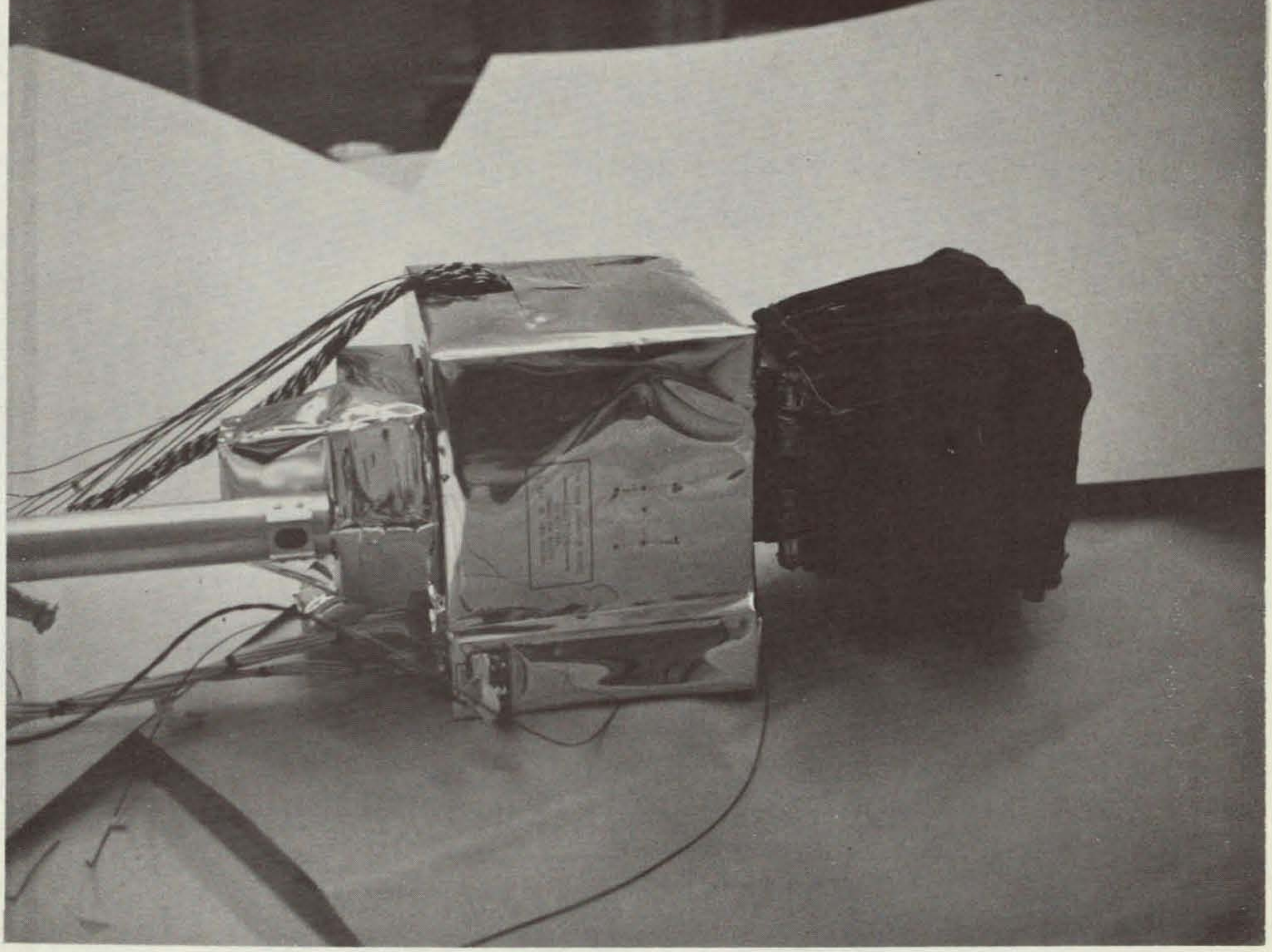
CONTRACT NO. NAS 5-11095

Prepared By: Sam Pollack 9/17/69
Sam Pollack
Program Mechanical Engineer

Approved By: Eric Azari
Eric Azari
Program Manager

Approved By: Robert Kobayashi
Robert Kobayashi
Director of Engineering

Approved By: George Mohler
George Mohler
Program Director



Experiment Package Five (EP-5)
Boom Mounted
OGO-F Thermal Blanket and
Proportional Heater Control System

Photo A

ACKNOWLEDGEMENT

The authors wish to express their gratitude to all Goddard Space Flight Center and Time-Zero Corporation (formerly Marshall Laboratories) personnel who contributed maximum effort in developing the OGO-F Thermal Subsystem for the EP-5 and in the preparation of this document.

ABSTRACT

This contract, awarded to Time-Zero Corporation (formerly Marshall Laboratories) by Goddard Space Flight Center, is for purposes of designing, developing, fabricating, testing, and integrating a thermal subsystem necessary to maintain a controlled environment for Experiment Package-Five (EP-5) on the OGO-F Spacecraft. The thermal capabilities of two (2) experiments, F-22 (Dr. Smith's Search Coil Magnetometer) and F-24 (Dr. Helliwell's VLF Polarization and Wave Normal Direction Antenna System) were involved in this project.

Time-Zero Corporation provided two complete thermal subsystems, (1) prototype and (1) flight unit. In addition, Time-Zero Corporation provided three (3) spare thermal blankets and one (1) spare proportional heater.

Detail thermal analysis and extensive thermal testing was performed by Time-Zero to insure thermal subsystem design capability.

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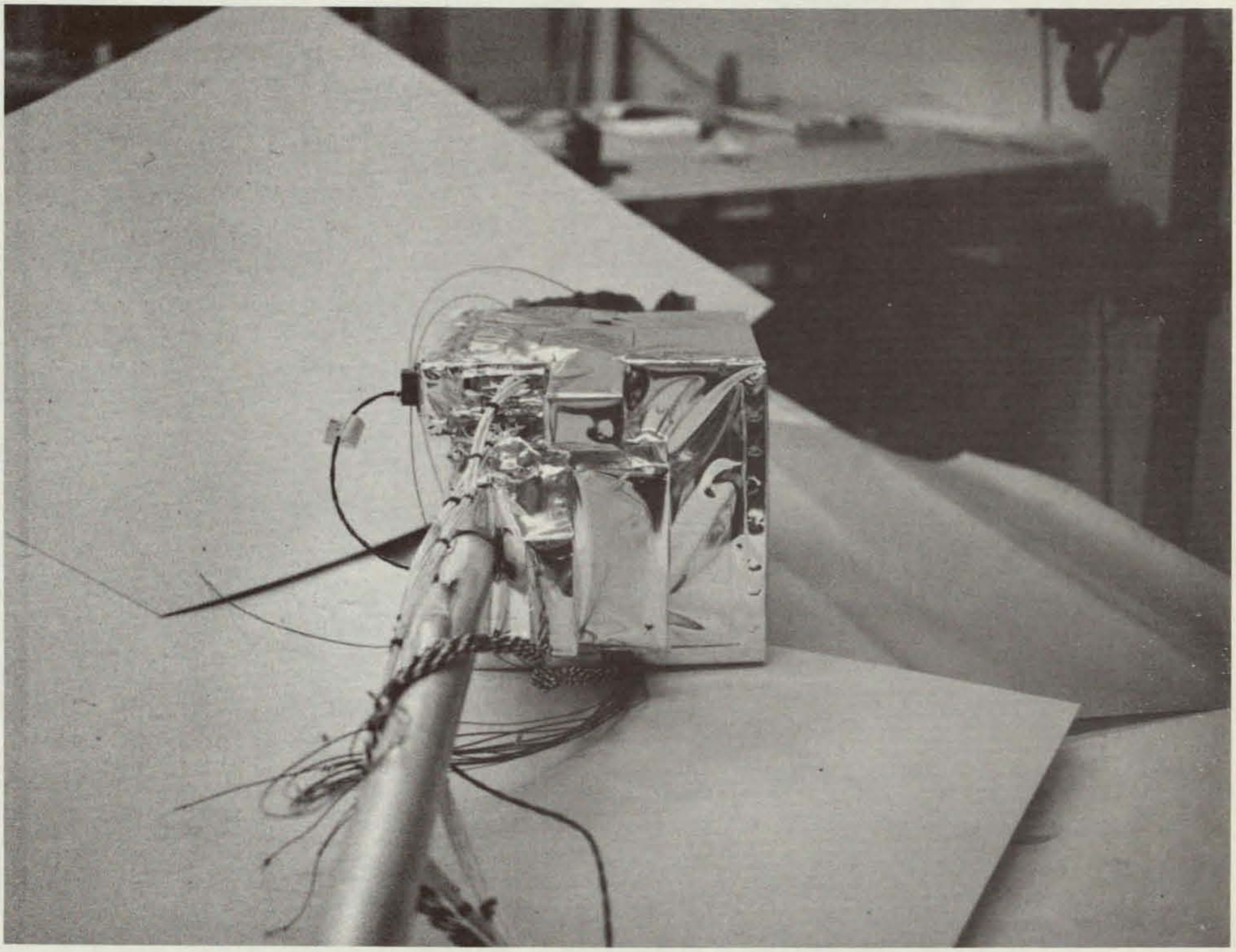
LIST OF PHOTOGRAPHS

1.0 INTRODUCTION

This final project report covers the history of the EP-5 appendage of the OGO-F Spacecraft as performed by Time-Zero (formerly Marshall Laboratories), under a GSFC/NASA contract number NAS 5-11095.

The objective of this experiment was to maintain a controlled thermal environment on Experiments F-22, (Dr. Smith's Search Coil Magnetometer) and F-24, (Dr. Helliwell's VLF Polarization and Wave Normal Direction Antenna System) which comprises the Experiment Package Five, (See Photo A and Photo B).

This report describes the thermal design and the environmental tests it was subjected to. This report also discloses the thermal analysis performed in support of the design concepts used in the development of the EP-5 system.



Experiment Package Five (EP-5)
Boom Mounted
OGO-F Thermal Blanket and
Proportional Heater Control System

Photo B

2.0 EP-5 SYSTEM CONFIGURATION

The EP-5 System contains portions of two experiments, F-22 and F-24 both within a thermal equilibrium blanket and mounted to the +Y end of the EP-5 Boom.

2.1 Experiment Package-Five (EP-5)

The EP-5 System as shown in Figure 2-1, and Figure 2-2 is partially contained within a 11.0" x 9.5" x 9.0" parallelepiped thermal envelope. The F-24 antenna extends beyond the thermal envelope. The thermal envelope, which makes up the electronics compartment, consists of multi-layer aluminized mylar sheets and pure silk mesh arranged in a sandwich type construction with the mylar side facing outward. Within the environmental controlled electronics compartment are the Search Coil Magnetometer coils and preamplifiers for the F-22 Search Coil Magnetometer Experiment, developed by Dr. E. J. Smith of JPL and Professor Holzer of UCLA, and the Preamplifier for the F-24 VLF Antenna Experiment developed by Dr. Helliwell and Dr. R. Smith of Stanford University. Because of the sensitivity of the experiments within the EP-5 to magnetic fields and RF noise, Time-Zero Corporation developed and used a non-magnet proportional heater as an active temperature control device within the EP-5 Package.

The wiring diagram for the thermal subsystem mock-up is shown in the Appendix, drawing 805800. The interface envelope drawing and final assembly drawings 805100 and 805200 respectively, are also shown in the Appendix.

FIGURE 2-1 EP-5 DESIGN CONFIGURATION

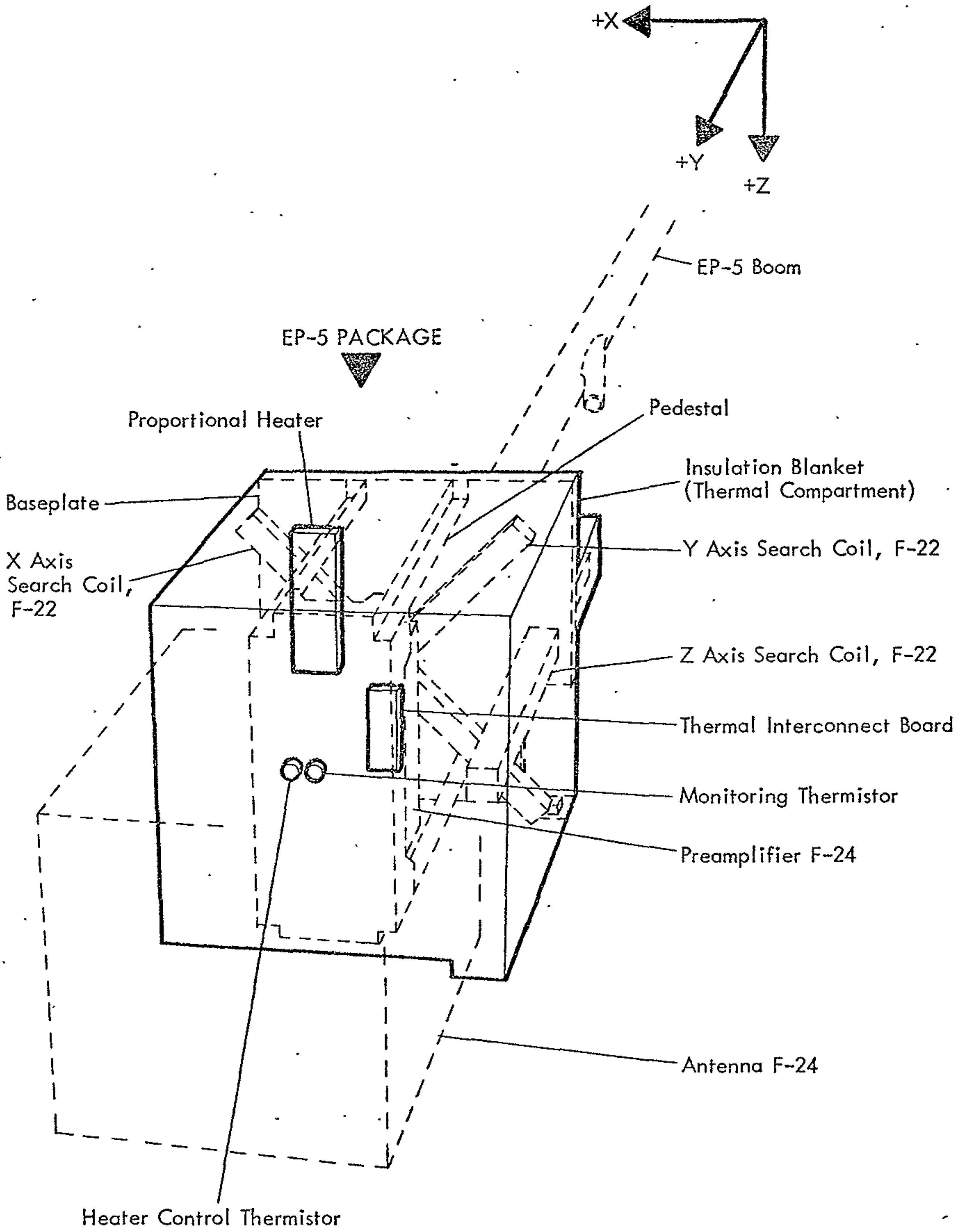
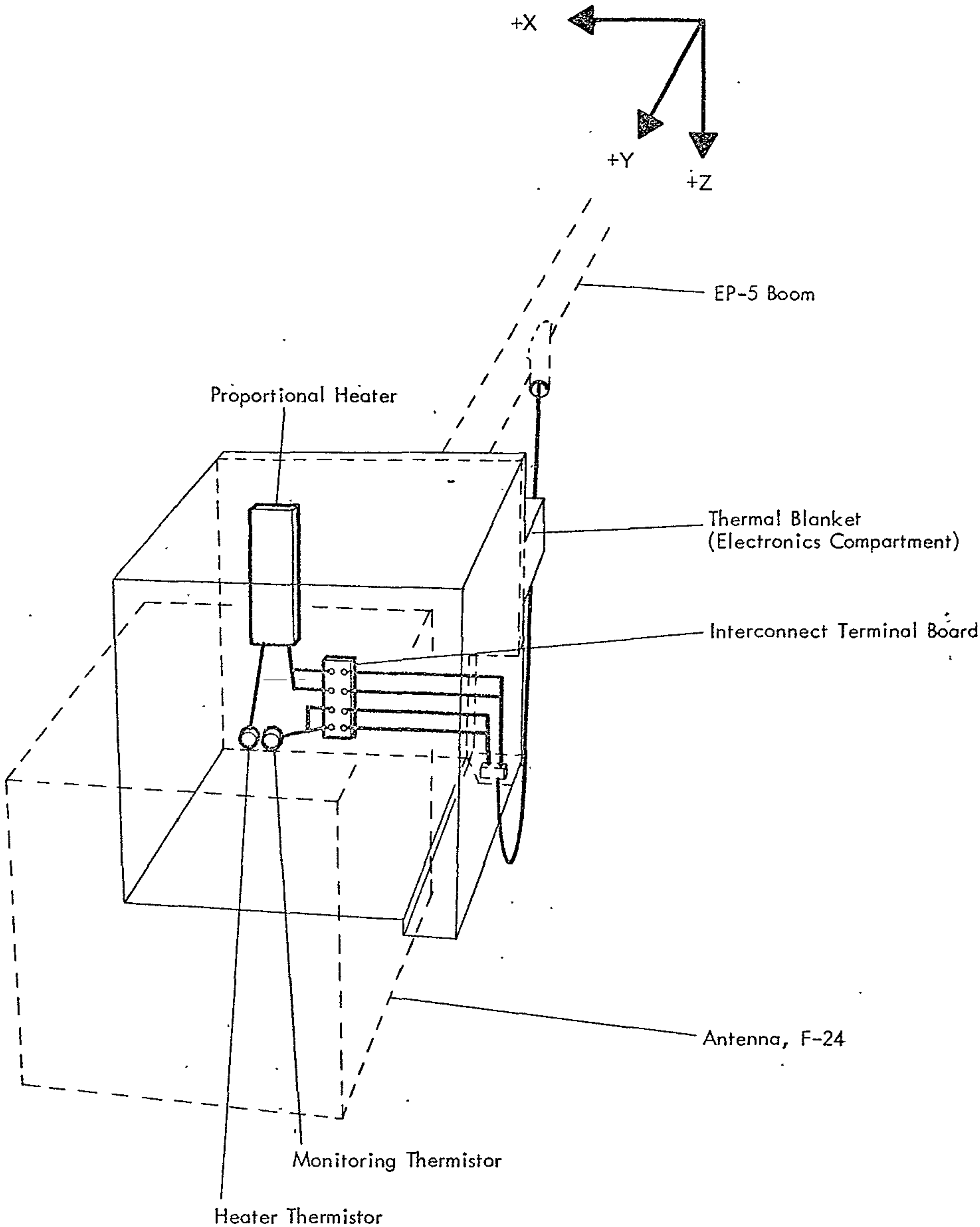


FIGURE 2-2 EP-5 THERMAL SUB-SYSTEM/OGO-F



3.0 EP-5 PROGRAM HISTORY

The EP-5 program began at Time-Zero (formerly Marshall Laboratories) in November 1967 with GSFC/NASA Contract Number NAS 5-11095 and continued through to the OGO-F Spacecraft Launch. During this period, Marshall Laboratories efforts on the EP-5, OGO-F Program were as follows.

3.1 Organization and Management

Program organization and management were established directly after Marshall Laboratories received the go-ahead from NASA/GSFC on Contract NAS 5-11095. A master project schedule was drafted outlining the tasks to be performed and key program personnel were assigned.

The key personnel active on this EP-5 thermal subsystem program are listed below:

<u>Program Manager</u>

Eric Azari

D. L. Chingurg

<u>Project Engineer</u>

S. Pollack (Program Manager EP-5)

J. Kohan

D. Petrics

Program reports and financial management reports were distributed in accordance with the contract requirements.

3.2 Quality Assurance

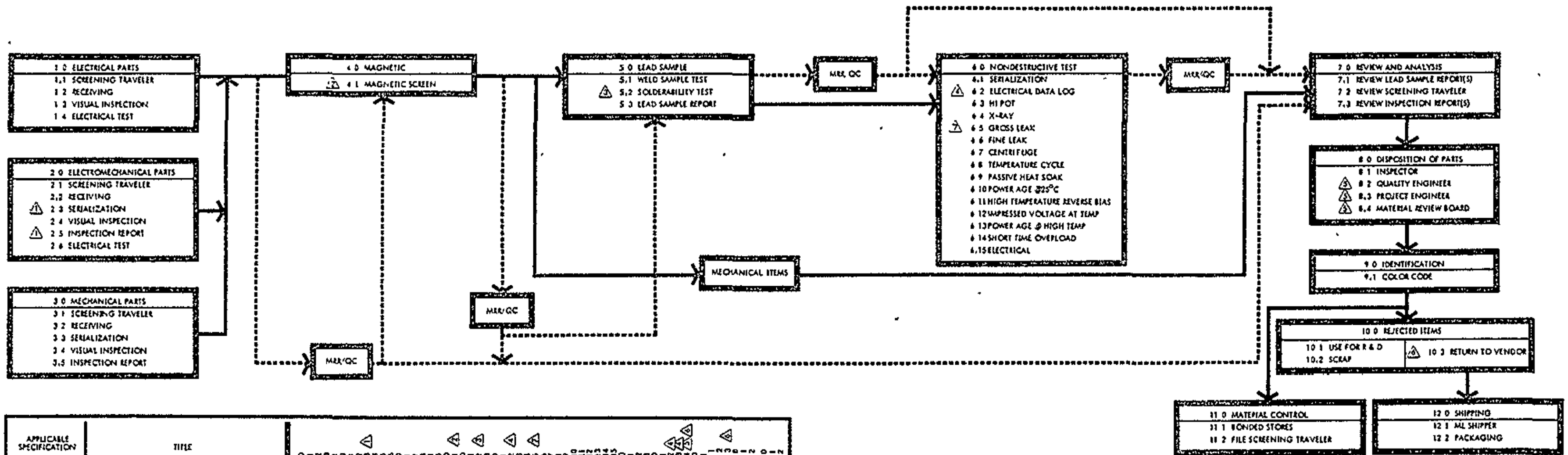
Marshall Laboratories Quality Assurance Program for this project was controlled by ML/TN7500.007, "Quality Control and Inspection Manual" in accordance with NASA Quality Publications NPC 200-3 and NPC 200-4. The inspection flow chart was submitted to NASA/GSFC and maintained through the life of the project (see Figures 3-1, 3-2 and 3-3).

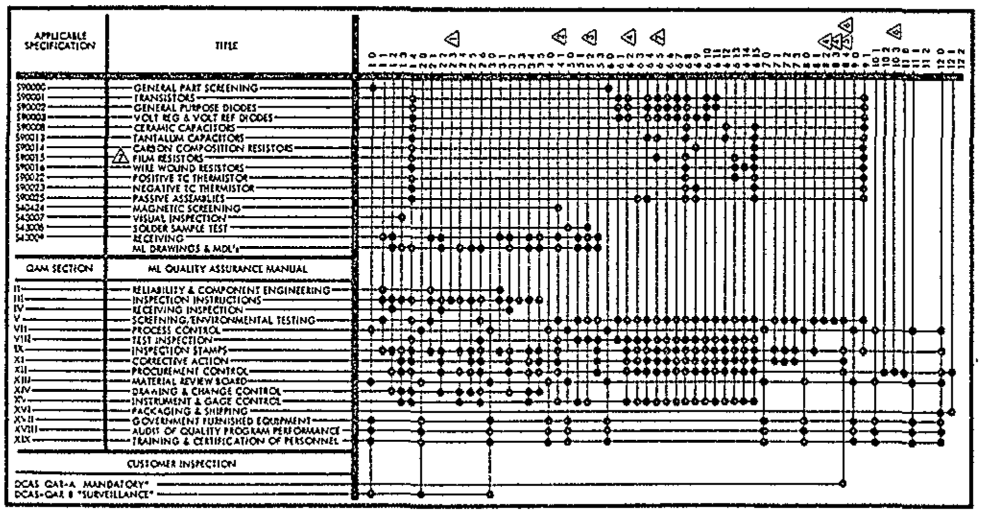
3.3 EP-5 Thermal Subsystem Design

Preliminary design of the EP-5 System began 9 November 1967 and continued through 10 January 1968 when Marshall Laboratories submitted perliminary drawings to Goddard Space Flight Center for approval. In accordance with the contract, Article 1, paragraph 1.3.1, Preliminary Interface and Design Drawings (805100 and 805200 Appendix herein) were submitted to Mr. M. Stephens, Code 246, NASA, 10 January 1968 for approval, see letter in GSFC correspondence Appendix.

3.3.1 Thermal Design Concept

The original thermal design concept of individual experiment heaters and thermal blankets were reported as inadequate and inefficient. The required thermal environment cannot





NOTES

1. DETERMINED BY TYPE OF ITEM BEING SCREENED
2. PRECISION RESISTORS ONLY
3. SOLDERABILITY TEST PERFORMED ONLY ON CONTRACTS UTILIZING THIS TYPE OF FABRICATION
4. SEMICONDUCTOR DEVICES ONLY
5. REQUIRED FOR NONCONFORMING ARTICLES
6. REVIEWED BY PURCHASING PRIOR TO SHIPMENT
7. DETERMINED BY COMPONENT CONSTRUCTION/APPLICABLE SPECIFICATION

---- INDICATES MATERIAL REVIEW REPORT (MRR)

LIST OF MATERIALS

CONTRACT NO. NAS 5-11096

MARSHALL LABORATORIES
TORRANCE, CALIFORNIA

TITLE: LEVEL 300 SCREENING INSPECTION PLAN
THERMAL SUB-SYSTEM EP 5 OGO-F

SIZE D | CODE IDENT NO. 13126 | DWG NO. 805000

SCALE NONE | RELEASED | SHEET 1 OF 1

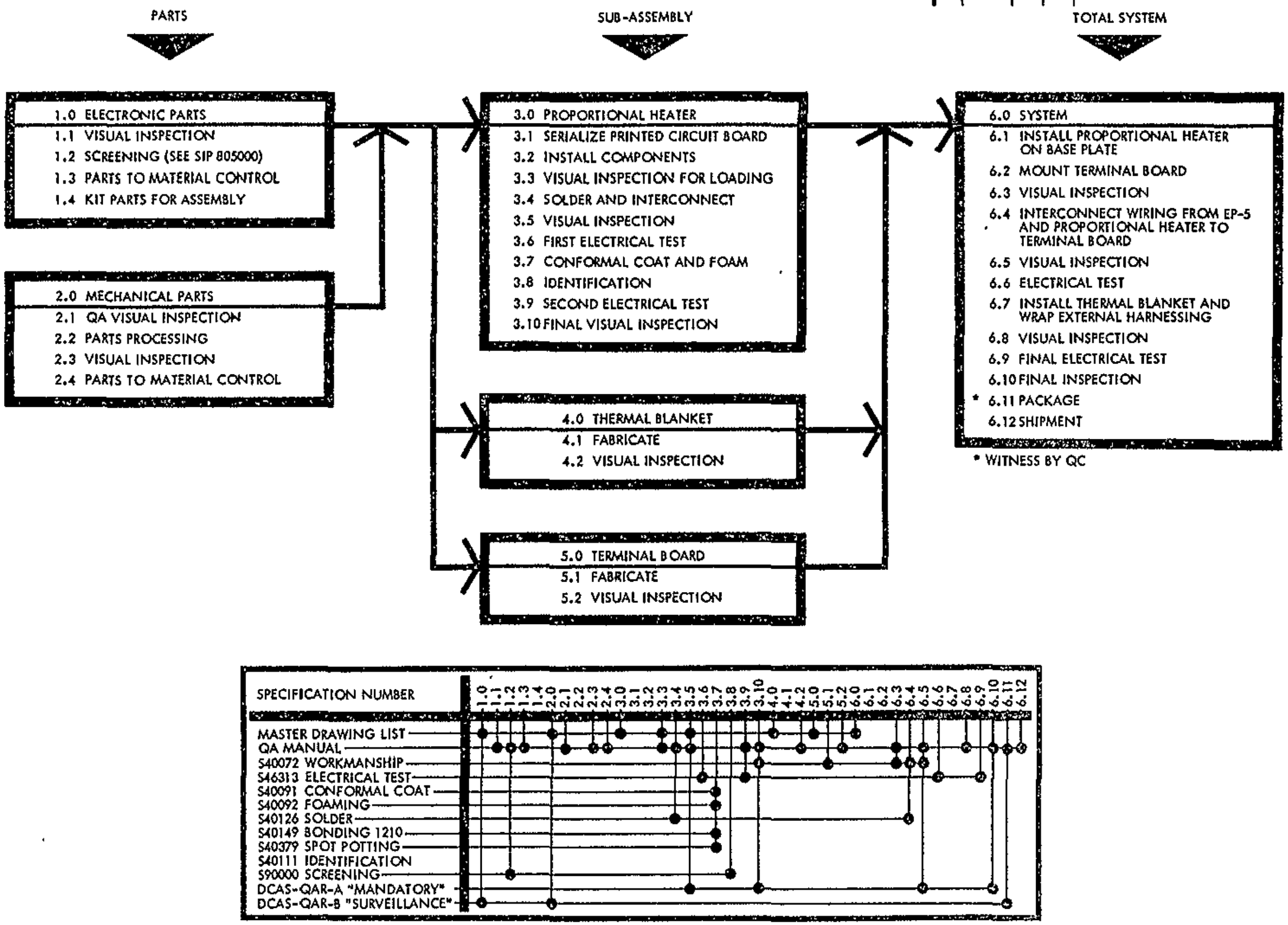
JAN 1 6 1968

PARTS DISPOSITION
1. USE
2. REWORK
3. CANNOT BE REWORKED
4. RECORD
5. ______

805001

REVISIONS

DISP	EFF	ZONE	REV	DESCRIPTION	BY	CK	DATE	APPROVAL



						PART NO	SPECIFICATION	NOMENCLATURE OR DESCRIPTION	ELEC REF DES	CODE IDENT	ZONE	ITEM NO.

QTY REQD PER NOTED ASSY
CONFIGURATION
LAYOUT NO.
DIST CODE 8-05 A

LIST OF MATERIALS

DASH NO.	MODEL NO.	NEXT ASSEMBLY	MODEL NO.	FINAL ASSEMBLY	MODEL NO.

APPLICATION

INTERPRET THIS DRAWING PER STANDARDS IN MIL-D-70327
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS: .X ±.1, .XX ±.03, .XXX ±.010, .XXXX ±.0050
ANGLES: ± 0° 30'
√ SURFACE ROUGHNESS

HOLE DIA.	TOLERANCE
.0135 THRU .125	+ .004 — .001
.126 THRU .250	+ .005 — .001
.251 THRU .500	+ .006 — .001
.501 THRU .750	+ .008 — .001
.751 THRU 1.000	+ .010 — .001
1.000 THRU 2.000	+ .012 — .001
2.001 AND OVER	LINEAR

CONTRACT NO.

		DATE
DRAWN	C. Fortmuller	12/15/67
CHECK		
MECH ENG	[signature]	1/15/68
ELEC ENG	[signature]	1/15/68
PROJ MGR	[signature]	1.15.68
APPR	[signature]	1-12-68
DESIGN ACTIVITY APPD	[signature]	1-12-68
CUSTOMER		

ML

MARSHALL LABORATORIES
TORRANCE, CALIFORNIA

TITLE
FABRICATION & INSPECTION PLAN
THERMAL SUB-SYSTEM EP-5 OGO-F

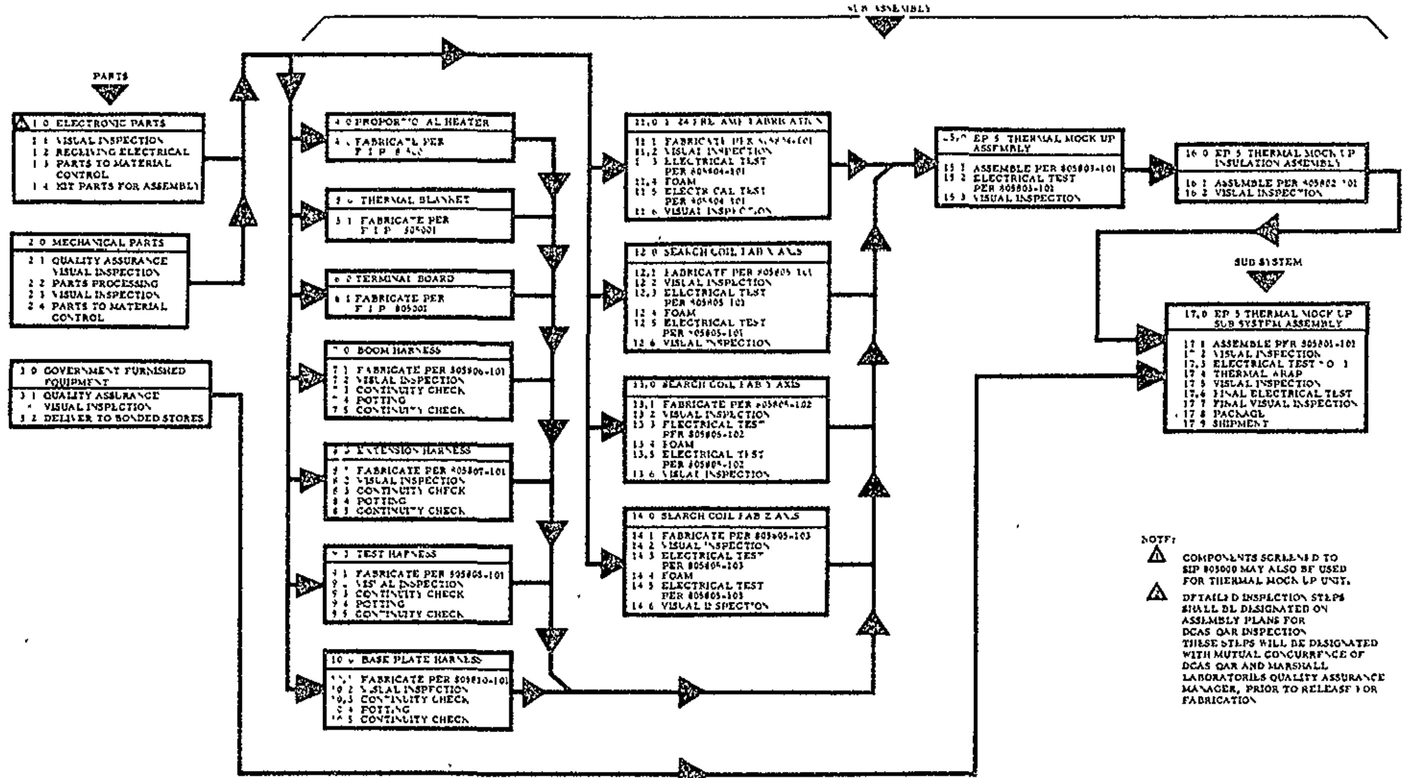
SIZE	CODE IDENT NO	DWG NO.	REV
C	13126	805001	

SCALE | RELEASE JAN 18 1968 | SHEET 1 OF 1

ML FORM 192

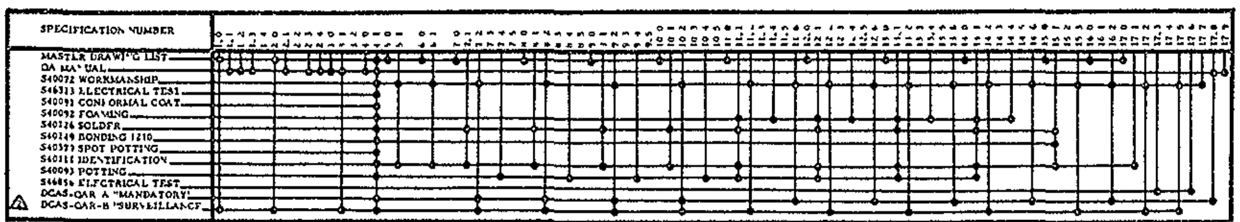
B B A A 2 1

Figure 3-2



NOTE:

1. COMPONENTS SCREENED TO SIP 805000 MAY ALSO BE USED FOR THERMAL MOCK UP UNIT.
2. DETAILED INSPECTION STEPS SHALL BE DESIGNATED ON ASSEMBLY PLANS FOR DCAS QAR INSPECTION. THESE STEPS WILL BE DESIGNATED WITH MUTUAL CONCURRENCE OF DCAS QAR AND MARSHALL LABORATORIES QUALITY ASSURANCE MANAGER, PRIOR TO RELEASE FOR FABRICATION.



NOTES: UNLESS OTHERWISE SPECIFIED

QTY REQD PER NOTED ASSY		PART NO	SPECIFICATION	NOMENCLATURE OR DESCRIPTION	ELEC REF DES / CODE IDENT / ZONE / ITEM NO.
LIST OF MATERIALS					

MARSHALL LABORATORIES
TORRANCE, CALIFORNIA

TITLE: FABRICATION & INSPECTION PLAN
EP 5 THERMAL MOCK UP

INTERPRET THIS DRAWING PER STANDARDS IN MIL-D-1000
DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS .X ± .1 .XX ± .03 .XXX ± .010 .XXXX ± .0050 ANGLES ± 0° 30'

SIZE D | CODE IDENT NO. 13126 | DWG NO. 805002

RELEASED | SHEET | OF

REVISIONS

PARTS DISPOSITION: 1 USE 2 REWORK 3 CANNOT BE REWORKED 4 RECORD

APPLICATION: DASH NO. | MODEL NO. | NEXT ASSEMBLY | MODEL NO. | FINAL ASSEMBLY | MODEL NO.

be maintained due to a large thermal gradient across the F-22 Search Coil Probe resulting in an out of range condition. The reason for the large thermal gradient was due primarily to the positioning of the proportional heater within the search coil probe with respect to the clamping configuration.

The F-24 preamplifier was originally to be heated by an internal 3 watt proportional heater. A preliminary analysis indicates this would not be sufficient to maintain a minimum 50°C. environment within the preamp during eclipse conditions.

Additional studies indicated that the individual thermal blanket concept would be an inefficient approach to thermal control in this instance, due to the increased cost of fabrication, and the difficulties involved in installation and removal.

3.3.2 Thermal Design Concept Modification

Marshall Laboratories recommended that one large thermal blanket be used to enclose the experiments F-22 and F-24 in a controlled environment package. The thermal blanket was constructed similarly to the OGO-E blanket with the exception of using a silk mesh layer between the layers of aluminized mylar for structural rigidity. The heat source is a 10 watt propostional heater bonded to the EP-5 base plate. Control monitoring is a thermistor sensing unit, mounted on the EP-5 base plate. The heater power is provided from existing spacecraft power to a terminal board also mounted on the EP-5 base plate. The preliminary drawings submitted for comments were:

805100	Envelope Drawing EP-5, OGO-F
805200	Assembly Drawing EP-5, OGO-F

3.4 Thermal Analysis

The thermal analysis was prepared and submitted to NASA/GSFC in accordance with the requirements of Contract NAS-5-11095. The thermal analysis verified the necessity of an active thermal control device in the EP-5 assembly. A non-magnetic proportional heater was used as this active temperature control device. The EP-5 proportional heater developed by Marshall Laboratories is bonded to the base plate and provides heat to the experiments by conduction and radiation from the base plate. Figure 2-2 illustrates the EP-5 temperature control system. The electronic compartment has an acceptable temperature range of -20°C to +50°C and a minimum internal dissipation of .22 watts when the internal temperature is 12°C. Between the temperature range of 6°C and 12°C the dissipation may vary from 1.575 watts to .22 watts depending on the position of the spacecraft relative to the sun.

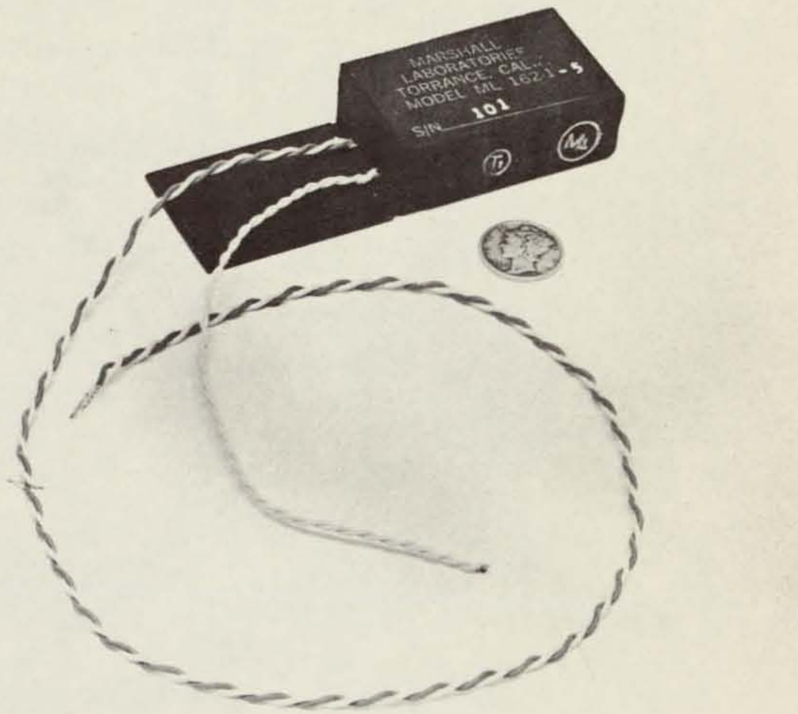
The final thermal analysis for Experiment package five is included as a part of this report and included in the Appendix.

3.5 Proportional Heater Control - ML-306 Series

The thermal proportional heater control was developed by Time-Zero Corporation (formerly Marshall Labs) for purposes of providing a temperature control device for electronic units without the introduction of interfacing magnetic fields. The control circuit consists of a thermistor bridge, amplifier and heater. Feedback is used to minimize ac current through the heater. Flexibility is allowed by the circuit design to adjust gain (Watts/°C), and operating temperatures. The following illustrations, Figure 3-4 through Figure 3-11 show the typical mechanical and electronic parameters associated with the proportional heater control configuration. A complete electrical

MODEL ML162-1

Proportional Heater, Non-Magnetic



DESCRIPTION . . .

The ML 162-1 heater has application on spacecraft and missile payloads where temperature control of electronic units, without the introduction of interfering magnetic fields, is required.

Features include:

- Wattage proportional to ΔT
- Small size
- Low weight
- Remote temperature sense.

The control circuit consists of a thermistor bridge, amplifier and heater. Feedback is used to minimize a-c current through the heater. Flexibility is allowed by the circuit design to adjust gain (watts/°C) and operating temperature.

TIME-ZERO corporation

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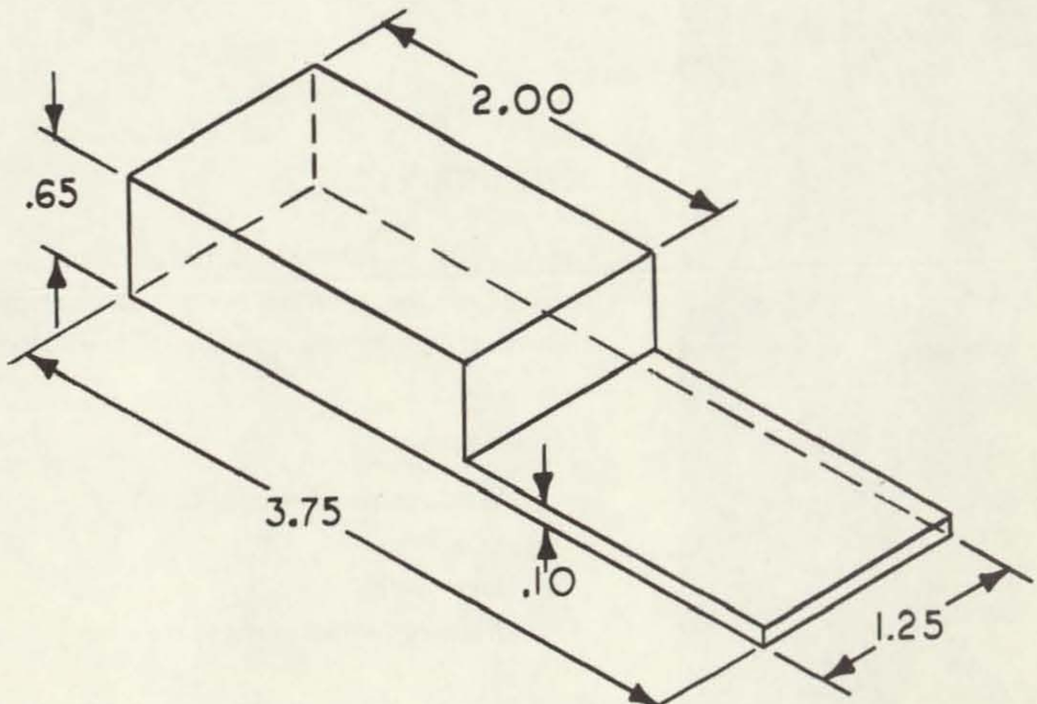
SPECIFICATIONS . . .

Voltage:	+28.5 volts nominal 23.5-33.5 range
Power:	1-15 watts possible; 10 watts nominal
Gain:	Adjustable within the limits of 20°C/watt to 3°C/watt
Operate Temperature:	Can be set within the limits of -20°C to $+70$°C
D-C Magnetic Field:	$<75\gamma$ at 1″
A-C Magnetic Field:	$<1 \times 10^{-4}\gamma$ at 1″ F=1 Kc/s
Weight:	56 gms
Size:	See Figure 1.



10-62

FIGURE

TIME-ZERO *corporation*

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ML 306

PROPORTIONAL HEATER

TYPICAL

BILL OF MATERIALS (Reference Only)

Part No.	Qty.	Description	Ref. Des.	Applicable Spec.
52343	1	P.C. Board		ML
52344	1	Housing		ML
PT4-13004-8	1	Heater Strip		TRW PT4-13004
26000	1	Thermistor	RTI	ML
CSR13F333KP	1	Capacitor	C1	MIL C 39003/1
CSR13G225KP	2	Capacitor	C2, C3	MIL C 39003/1
CK05CW102K	1	Capacitor	C4	MIL C 11015
1N753A	1	Diode	CR1	Motorola
1N965B	1	Diode	CR2	Motorola
1N645A	2	Diode	CR3, CR4	GE or TI
RC07GFXXXJ	6	Resistors	R1, R3, R5, R7, R8, R11	MIL R11
RN55CXXXXF	3	Resistors	R2, R4, R6	MIL R 10509E
RWP-19	2	Resistors	R9, R10	MIL R 23379
2N2484	2	Transistor	Q1, Q2	Texas Instrument
2N2907A	1	Transistor	Q3	Texas Instrument
2N2222A	1	Transistor	Q4	Motorola
2N1486	2	Transistor	Q5, Q6	RCA

Figure 3-5

MIL 306

PROPORTIONAL HEATER

TYPICAL

POWER STRESS LEVEL OF ELECTRONIC COMPONENTS (Ref. Only)

Ref. Des.	Part No.	% Stress
Heater Strip	PT4-13004-8	63
RT1	52347	5
C1	CSR13G333KP	16 *
C2	CSR13G225KP	30 *
C3	CSR13G225KP	30 *
C4	CRO5CW102K	6 *
R1	RCO7GFXXXJ	< 1
R2	RN55CXXXXF	3
R3	RC07GFXXXJ	15
R4	RN55CXXXXF	< 1
R5	RC07GFXXXJ	< 1
R6	RNJ5CXXXXF	2
R7	RC07GFXXXJ	< 1
R8	RC07GFXXXJ	3
R9	RWP-19-XXX	11
R10	RWP-19-XXX	13
R11	RC07GFXXXJ	20
CR1	1N753A	21
CR2	1N965B	9
CR3	1N645A	5
CR4	1N645A	< 1
Q1, Q2	2N2484	< 1
Q3	2N2907A	2
Q4	2N3107	3
Q5	2N1486	1.5
Q6	2N1486	12

* Voltage stress is given in place of power stress.

FIGURE 3-6

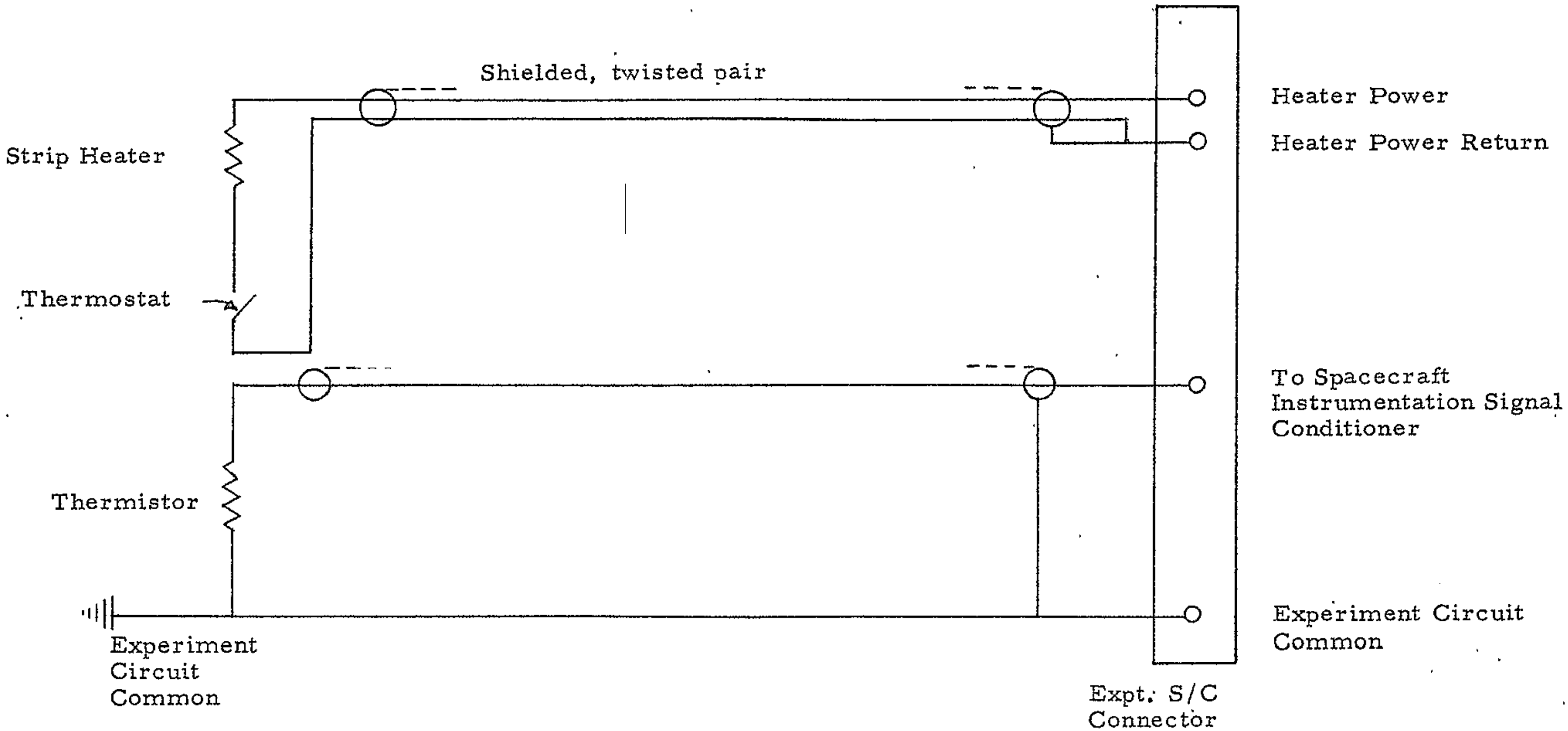


Figure 3-7

TYPICAL
PROPORTIONAL HEATER CIRCUIT
WIRING DIAGRAM

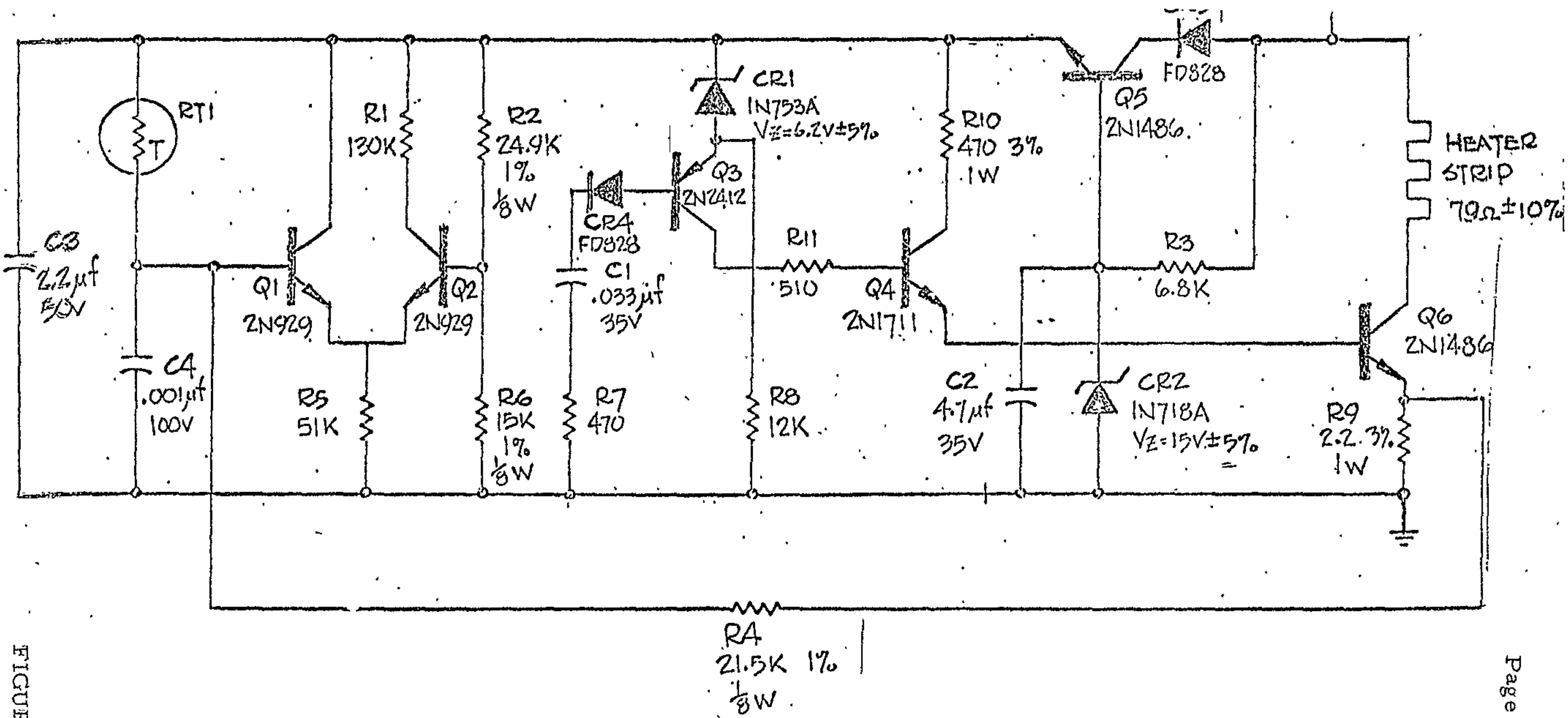
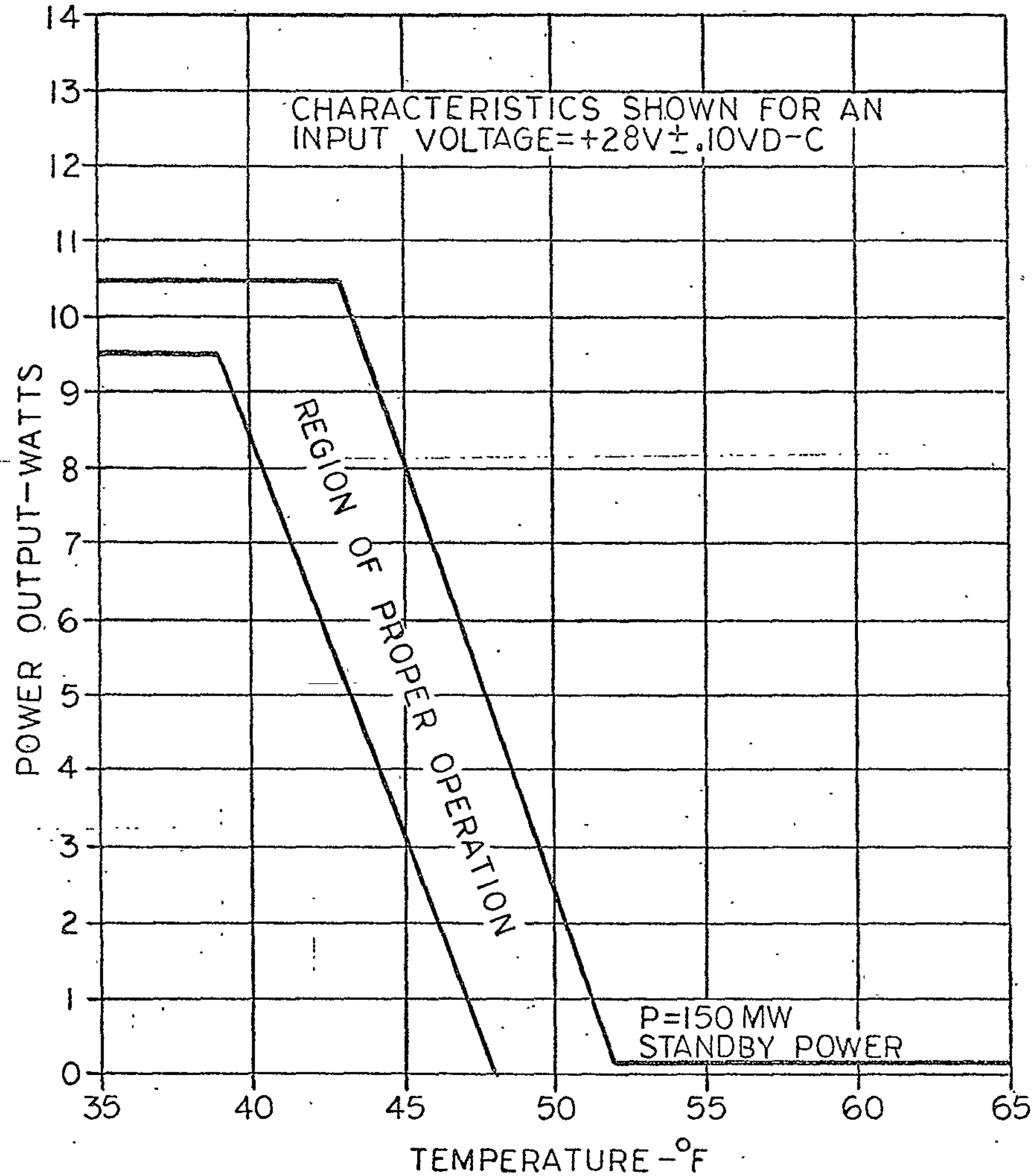


FIGURE 3-8

TYPICAL

Proportional Heater ML 306

Circuit Schematic (Ref. Only)



PROPORTIONAL HEATER
INPUT-OUTPUT CHARACTERISTICS
(TYPICAL)

FIGURE 3-9

MAGNETIC LIMITATIONS: FOR EP-5 OGO-F (Ref. Only)

1 Weber = 10^8 Maxwells

1 Gauss = 1.0 Maxwells/Square CM = 10^4 Maxwells/Square meter

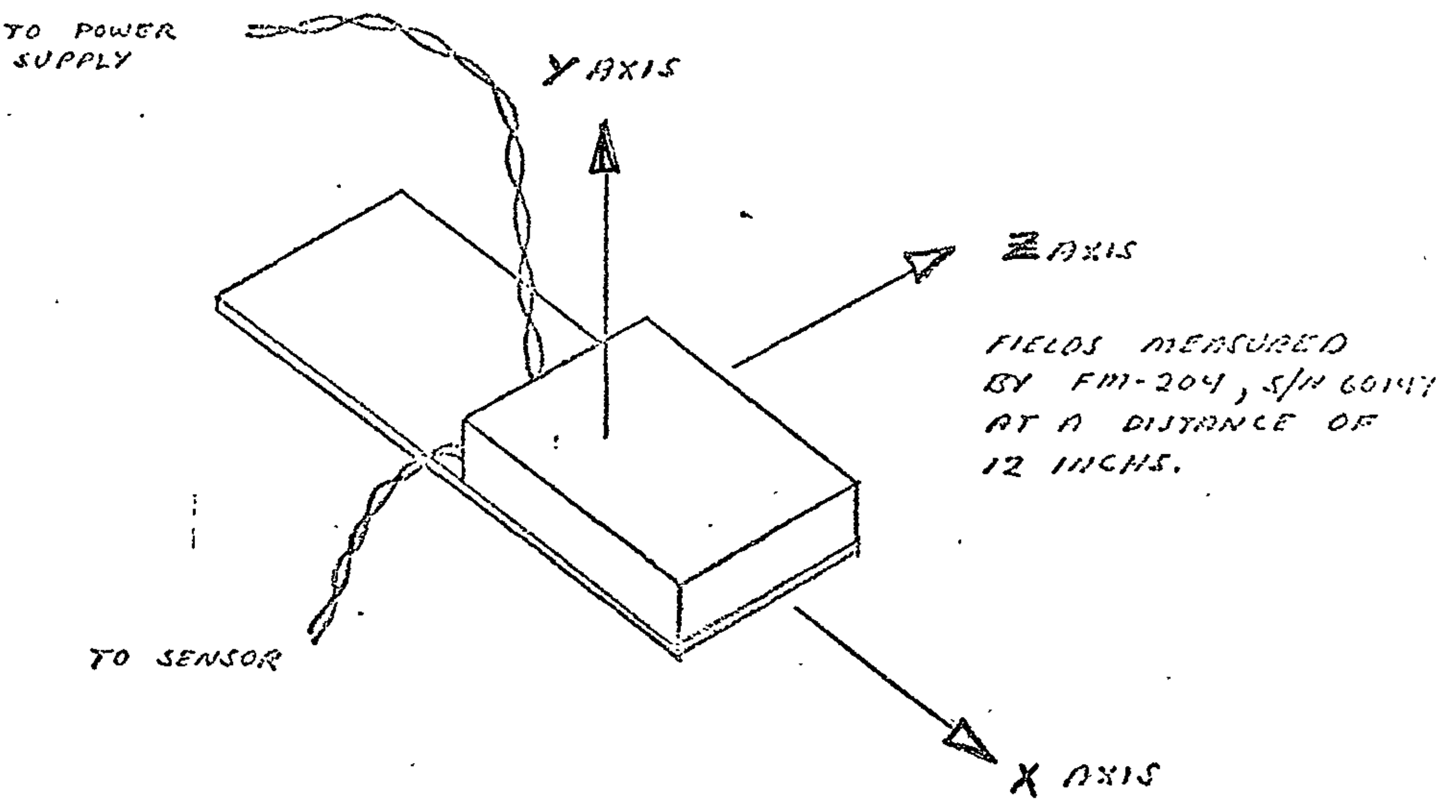
1 Gamma = 10^{-5} Gauss $\therefore$ 1 Weber/Square Meter 10^9 Gamma

VLF EXP LIMITS

Band 1	200 cps	1.2×10^{-13}	Weber = 1.2×10^{-4} Gamma
Any 50 cps band	1.6 k cps	1.5×10^{-14}	Weber = 1.5×10^{-5} Gamma
Band 2	1.6 k cps	2.7×10^{-14}	Weber = 2.7×10^{-5} Gamma
Any 160 cps band	12.5 k cps	3.5×10^{-15}	Weber = 3.5×10^{-6} Gamma
Band 3	12.5 k cps	5.9×10^{-15}	Weber = 5.9×10^{-6} Gamma
Any 500 cps band	100 k cps	7.6×10^{-16}	Weber = 7.6×10^{-7} Gamma

FIGURE 3-10

NON - MAGNETIC HEATER - Typical Gamma Readings



S/N	X AXIS	Y AXIS	Z AXIS	I_T
1	+1γ	+3γ	+1.5γ	0
1	0γ	0γ	0γ	Δ1.5ma
1	+.5γ	+1γ	+1γ	Δ340ma
2	+.5γ	+1γ	0γ	0
2	0γ	0γ	0γ	Δ1.5ma
2	0γ	0γ	0γ	Δ335ma

FIGURE 3-11

analysis of the proportional heaters was conducted and is submitted as part of the appendix (for information purposes only). The proportional heater controls were fabricated in accordance with the assembly drawing 52168. The reference schematic drawing is 52238. All tests conducted on these proportional heaters were tested thoroughly and found to meet the basic requirements satisfactorily.

3.6 Thermal Blanket

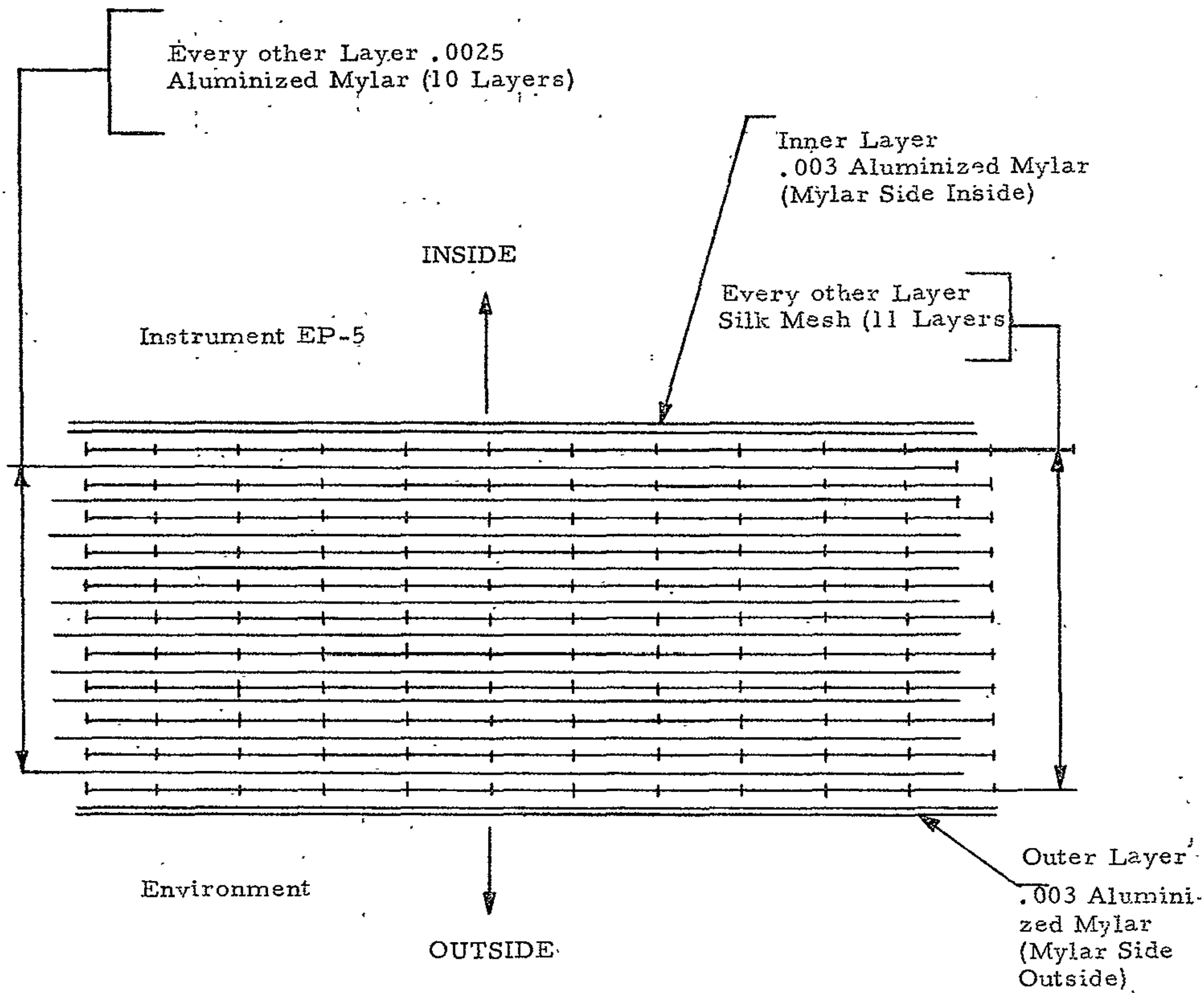
A thermal blanket was designed and fabricated by Time-Zero Corporation (formerly Marshall Laboratories) for purposes of maintaining the required temperature range of the EP-5 experiment package. The basic geometry of this thermal blanket is shown in Figure 2-1 and 2-2. The construction is shown in Figure 3-12 and the detail flat pattern, materials, and assembly shown in drawing 805202 (Appendix). The thermal blanket was assembled in a clean room area which meets the class 10,000 cleanliness requirements of the Federal Standard 209A. This assembly was formed on a special form block T805205 (Appendix) and critical seams ultra sonically welded.

Aluminized tape was applied to all welded areas after visual inspections were made.

Two sets of thermal blankets were provided; one for the prototype system and one for the flight system on shippers M/L 68-0723, S.O. 7564. Three thermal blanket spares were also sent at this time.

3.7 Control Thermistor

The control thermistor, a component of the proportional heater control (P/N 52168) is physically bonded to the EP-5 base plate



Ref. Dwg. 805202 for details.

Figure 3-12

as shown on drawing 805200 (Appendix). The heater control thermistor is also illustrated in Figures 2-1 and 2-2; this however is not to be construed as its exact location (shown for reference purposes only).

The thermistor assembly (P/N 20032 Appendix) is the non-magnetic type and conforms to specification ML S46066 (reference G. E. drawing 9RT1H116). Epibond 1210 is used to bond thermistor to EP-5 base plate. Leads to thermistor are twisted to further insure against electromagnetic interference problems. The temperature characteristics of this G. E. thermistor is shown in Figure 3-13.

3.8 Heater Strip

The heater strip consists of a double glass covered 32 gage (Evanohm) wire embedded in a laminated silicone substrate. This element is looped, folded back and twisted together with a minimum of four and a maximum of eight twists per inch. There are no welds or solder joints within the element, and the only termination allowed is at the exposed element approximately one inch from the heater body.

To further minimize any magnetic interference, the heater leads are twisted at the rate of 12 to 15 turns per inch. A typical heater strip configuration is shown in Figure 3-14. The actual heater strip used with the proportional control is shown in the Appendix, Drawing 20037. The relative location of this heater strip is shown in the proportional control drawing 52168.

3.9 EP-5 Stub Boom

A stub boom P/N 107957-900 was delivered during the month of June, 1968 to TRW Systems in support of the solar-vac tests conducted on the prototype and flight EP-5 assemblies. See Appendix

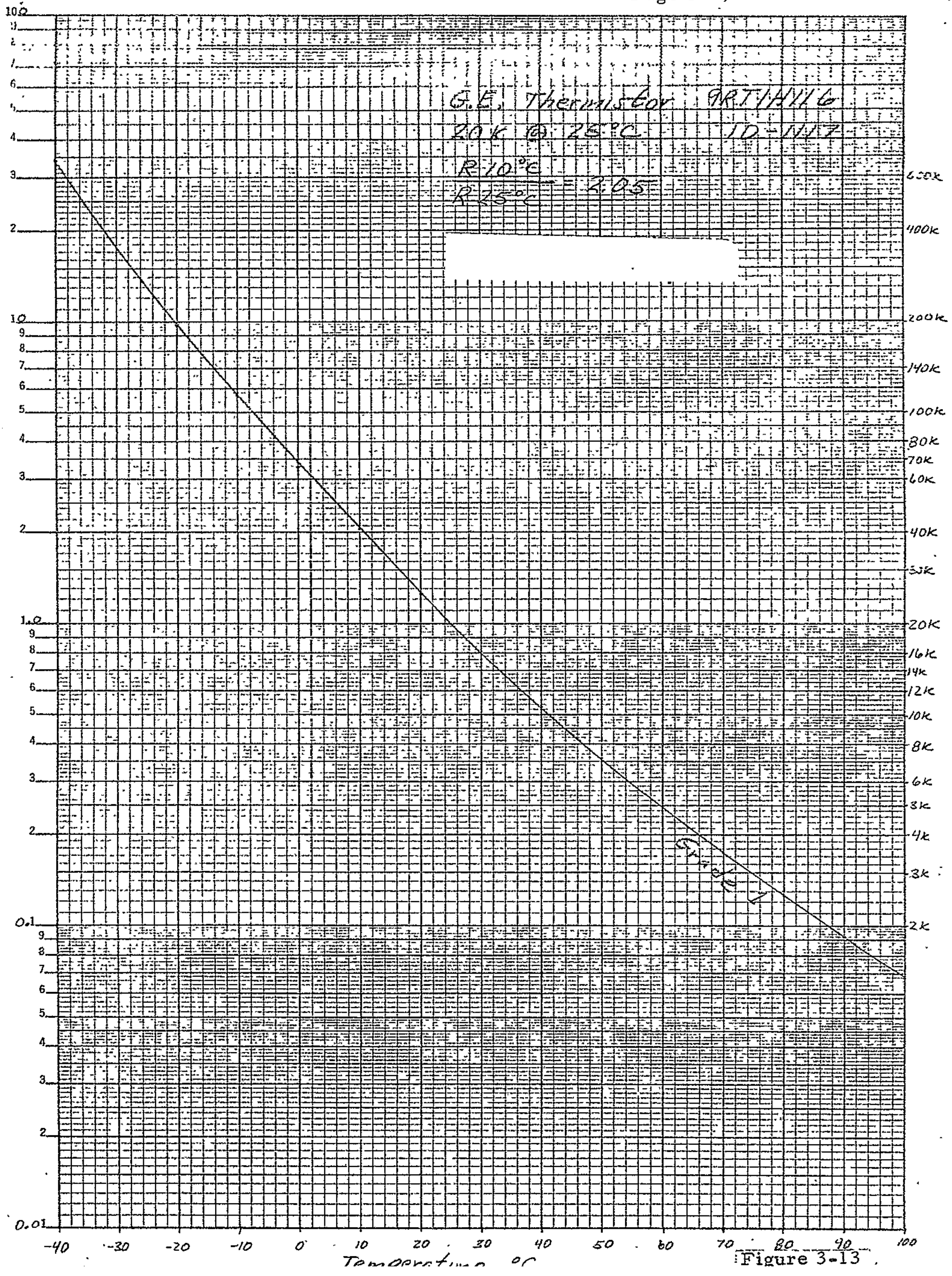
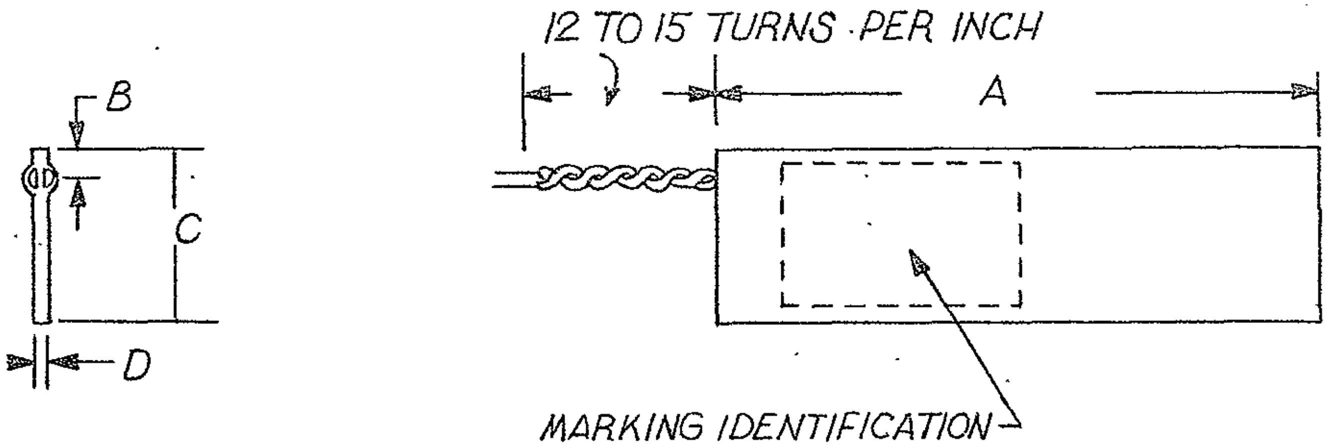

G.E. Thermistor 9RT1H116
20K @ 25°C
1D-N17
$\frac{R\,10°C}{R\,25°C} = 2.05$
Grade 1
600K
400K
200K
140K
100K
80K
70K
60K
40K
20K
16K
14K
12K
10K
8K
6K
4K
3K
2K
10
1.0
0.1
0.01
-40
-30
-20
-10
0
10
20
30
40
50
60
70
80
90
100
Temperature °C

Figure 3-13



DIMENSIONS

CODE	DIMENSIONS
A	3.50 ± 0.10
B	0.183 ± 0.061
C	1.00 ± 0.03
D	0.050 MAX

HEATER, STRIP, FLEXIBLE (TYPICAL)
FIGURE 3-14

for letter of transmittal and Figure 3-15 for the EP-5 thermal mock-up (boom mounted) subassembly.

3.10 EP-5 Container

The EP-5 thermal mock-up container is approximately 16" x 16" x 6'0" fabricated with birch, paneled over pine and douglas fir plywood. This container is fabricated per drawing 805809 (Appendix) and designed to handle the EP-5 subsystem mock-up shown in Figure 3-15. Special cradle provisions, clamping brackets, and fasteners are provided to securely hold the thermal subsystem in place. This container is presently held in Bonded Stores at Time-Zero Corporation/Marshall Laboratories.

3.11 Base Plate Pedestal

The base plate pedestal essentially supports the F22 Search Coil Magnetometer and the F24 Antenna Assembly (for details of the base plate, see GSFC drawing No. GE-1250099 and GE-1250121 and for a basic outline of the base plate pedestal, see Figure 2-1. The integration of the base plate pedestal harness and thermal subsystem including the proportional heater were shipped in accordance with Article VII of this contract (NAS 5-11095). The temperature sensing thermistor and proportional heater are both bonded to this base plate in accordance with assembly drawing 805200 (Appendix). The thermal blanket is formed or configured about the base plate pedestal is shown in Drawing 805202 Sheet 2 (Appendix).

3.12 Test Harness

A test harness was developed and fabricated for the EP-5 thermal mockup per Drawing 805808 (Appendix) and illustrated in Figure 3-16. This cable or harness is in the form of a "Y" configuration with an overall length of 360 inches. One leg of the "Y" is

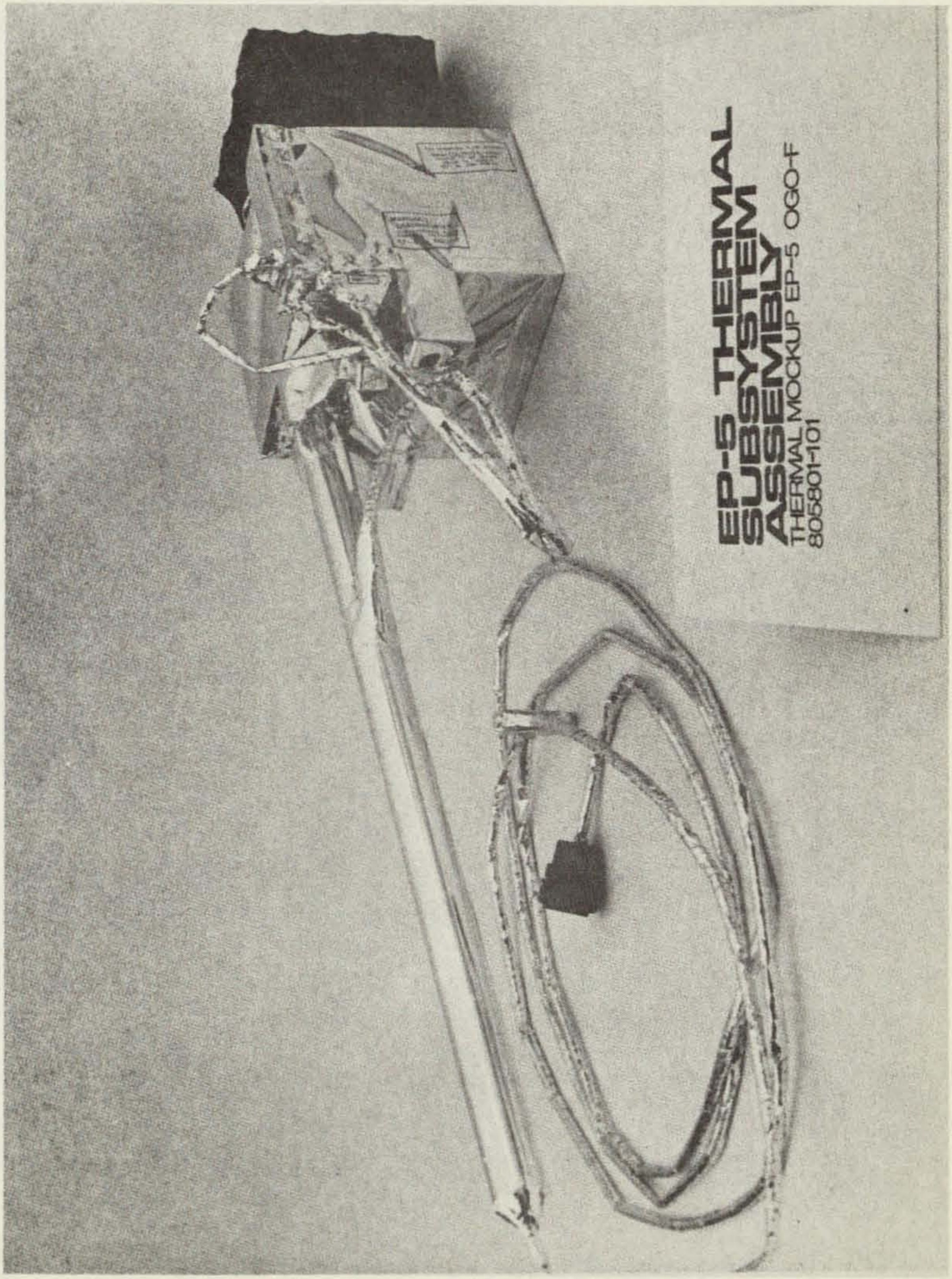
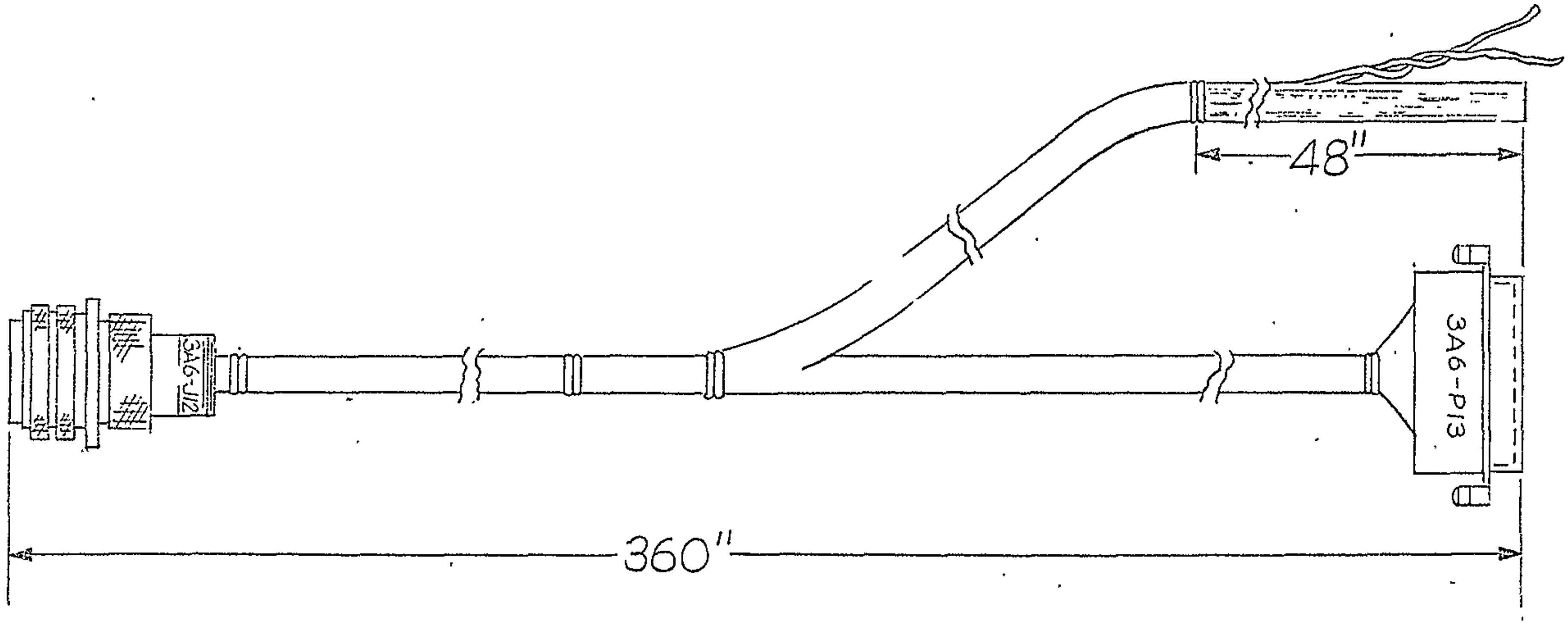

EP-5 THERMAL
SUBSYSTEM
ASSEMBLY
THERMAL MOCKUP EP-5 OGO-F
805801-101

FIGURE 3-15



TEST HARNESS
THERMAL MOCK-UP
EP-5 OGO-F
(REF. DWG. 805808)

FIG. 3-16

is a pigtailed section 48 inches long with the adjacent "Y" leg terminating at a 25 pin cannon connector. The remaining cable end in an amphenol connector (21 pins).

3.13 Thermal Mock-Up Assembly (Weighted)

The thermal mock-up assembly, approximately 9" x 9" x 16" contains the base plate, pedestal assembly for the Search Coil Experiment F-22, the antenna for F-24 Experiment, proportional heaters, and the associated supporting hardware and harness (reference Drawing 905803 in the Appendix). See Photograph A, Photograph B and Figure 3-15. This assembly is essentially the weighted configuration of the thermal system exclusive of the thermal blanket subsystem. This subsystem is discussed in the following section.

3.14 Thermal Mock-Up Subsystem (Blanket Assembly)

The thermal mock-up subsystem is constructed of aluminized mylar as shown in Drawing 805801 (Appendix). This blanket essentially envelopes the complete EP-5 Package (as discussed in Paragraph 3.13) and the associated harness and boom section. The thermal blanket is fastened in critical areas by the method of "crinkling" sections of 3 MIL aluminized mylar accordingly and tying with dacron thread. Aluminized tape is also used to secure ends. Ultrasonic welded sections are required in areas shown on Drawing 805801 for purpose of obtaining additional strength integrity. See Figures 3-17 and 3-18 for typical harness and boom thermal blanket wrap around.

These blankets are assembled in an area which meets the class 10,000 cleanliness requirements of Federal Standard 209A clean white cotton or mylar gloves are used to handle this subsystem materials and components.

EP-5 THERMAL MOCK-UP SUBSYSTEM

HARNESS & BOOM BLANKET

(REF DWG 805801)

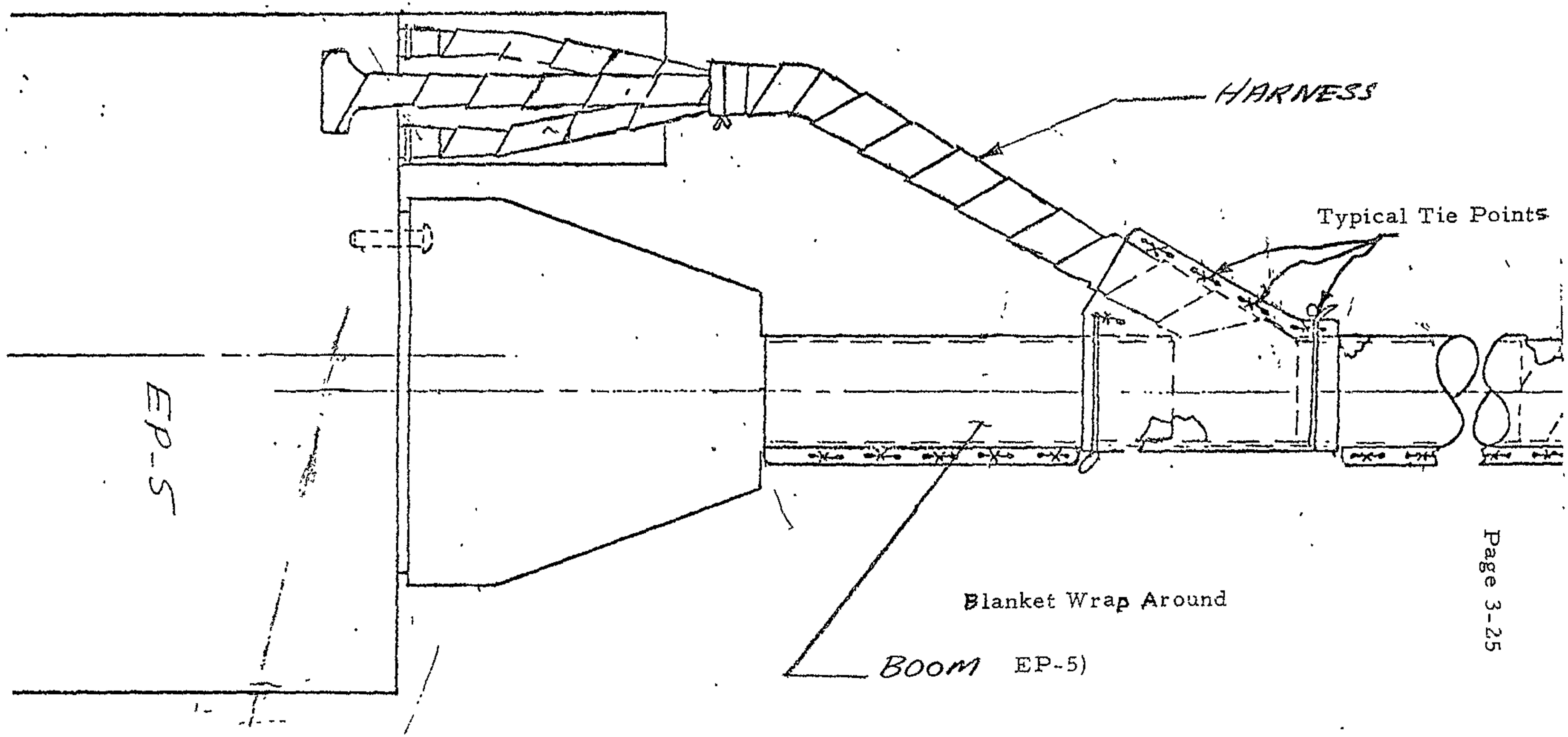
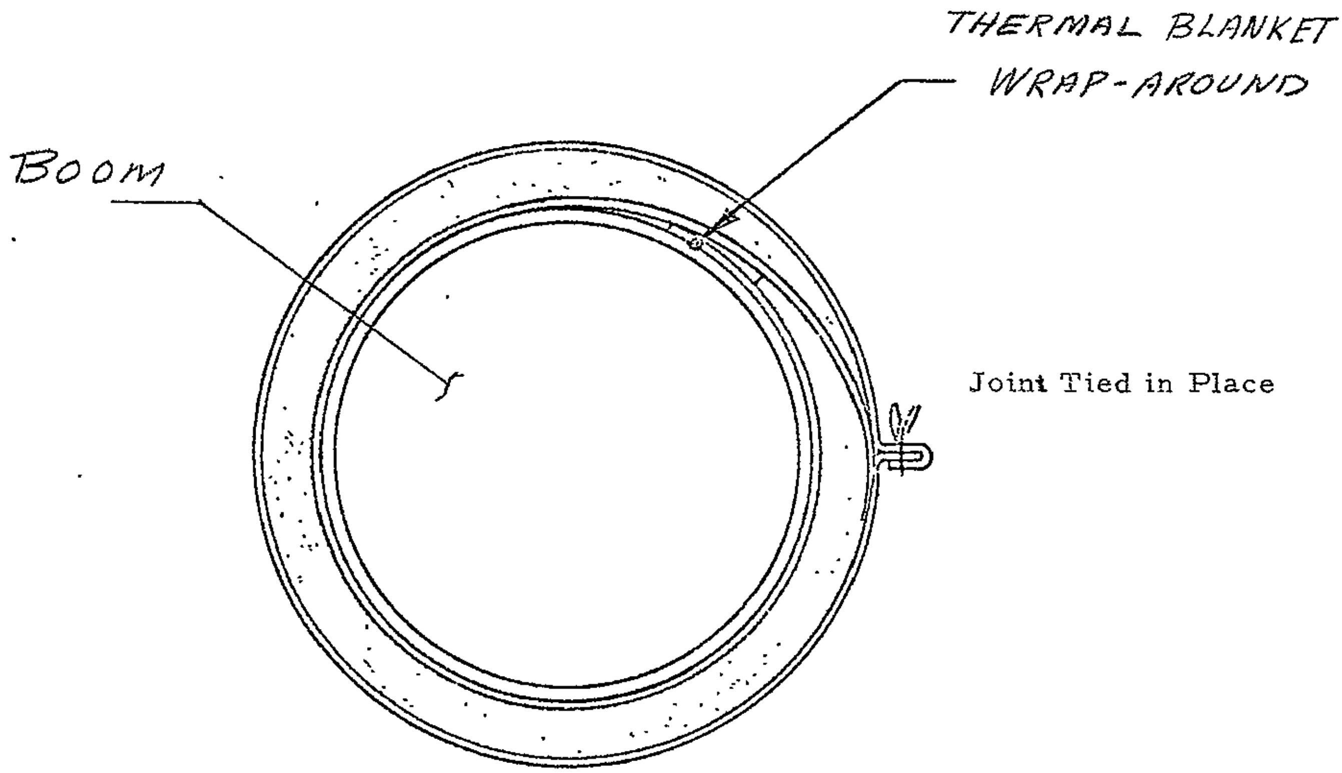


FIGURE 3-17



TYPICAL CROSS SECTION OF BOOM
SCALE: NONE

(OGO-F BOOM)

FIGURE 3-18

The EP-5 Thermal Mock-Up Subsystem was completed and shipped to GSFC for the solar vacuum design verification tests (reference monthly progress report of April, 1968, Paragraph 2.3).

3.15 Solar Vacuum Design Verification

A solar vacuum design verification test, in accordance with Paragraph 1.3.5 of NAS 5-11095, was satisfactorily performed at TRW Systems, Redondo Beach, California, during the week of 19 August 1968. See Appendix for abridged copy of test report and design verification test specification S46865.

Official copies of this test report were submitted to GSFC, Mr. M. Stephens, (See Appendix for letter of transmittal).

All thermal and mechanical design objectives were satisfactorily concluded.

3.16 Mutual Environmental Interference Test

For purposes of establishing mutual electromagnetic interference compatibility between the Experiments F-22 Triaxial Search Coil Magnetometer, and the Experiment F-24 VLF Antenna, a Time-Zero Corporation (Marshall Laboratories Specification S46868 was generated and submitted to GSFC. Copies of this specification and transmittal letter are part of the appendix. Based on a contract modification, the mutual interference test between the F-22 and F-24 experiments was to be conducted by NASA/GSFC (See reference letter of 24 May 1968, No. 68-0584 to GSFC from Marshall Laboratories (See attached Appendix). This letter was generated on the basis of a 20 May 1968 telegram between J. E. Painter, K. Meese, M. Stephens of GSFC and D. White and D. Petrics of Marshall Laboratories.

3.17 Prototype EP-5

In accordance with Article I, Paragraph 1.3.10, the EP-5 Thermal package (i.e. blanket and proportional heater system) was delivered to the NASA/GSFC project office at TRW on 10 June 1968. Coupled with this shipment, one flight blanket and three spares were also delivered; see letter of transmittal 68-0723 in Appendix.

3.18 Flight Unit EP-5

A complete flight unit system was submitted to TRW Systems 24 May 1968 in accordance with Article I, Paragraph 1.3.11 of this contract (NAS 5-11095). The EP-5 OGO-F Thermal System consisted of a base plate, pedestal and harness assembly (S/N 4) with an EP-5 proportional heater installed (S/N 3); see appendix for letter of transmittal.

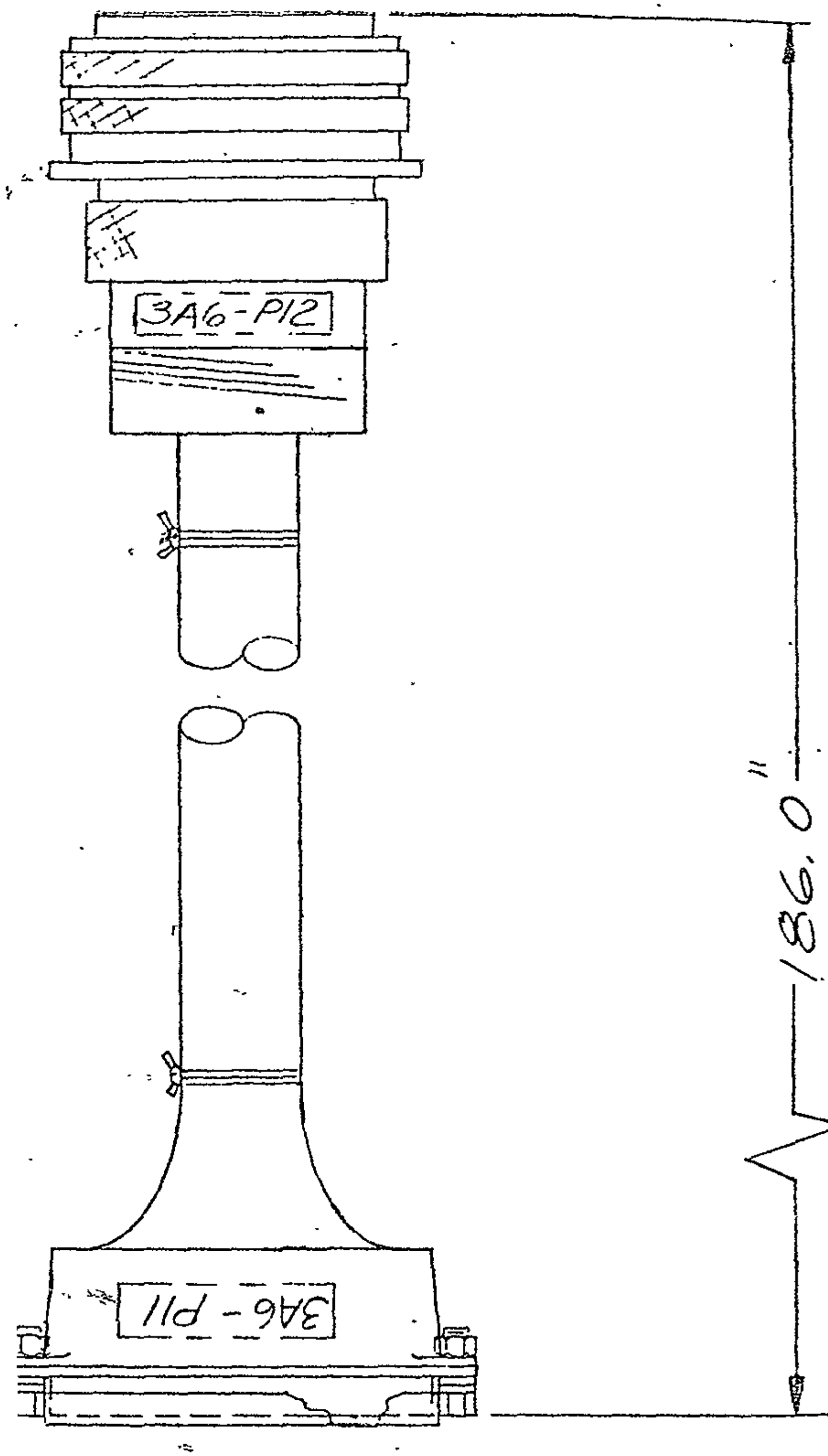
3.19 Extension Cables

An extension cable for the EP-5 Thermal Mock-Up was designed and fabricated in accordance with Drawing 805807 per M/L production work order No. 1417 dated February 1968 (see Figure 3-19 for cable illustration and drawing 805807 in Appendix for details in wiring and fabrication).

3.20 Field Service

Field service was performed by Time-Zero Corporation (Marshall Laboratories) personnel in accordance with the contract requirements of Article I, Paragraph 1.4 of NAS 5-11095. This item calls for field service to be performed as necessary at TRW Systems, GSFC, the associated experimenters facilities, and the Western Test

BOOM EXTENSION HARNESS
THERMAL MOCK-UP EP-5 OGO-F
(REF 805807)



Range. All field service performed to date on the EP-5 Therma
Subsystem was believed to be complete and satisfactory.

4.0 CONCLUSIONS

The basic contract requirements as delineated below were satisfactorily performed in providing an overall thermal system control for the F-22 Jet Propulsion Laboratory Magnetometer Experiment and the F-24 Stanford University Antenna Experiment.

a) Coordination of the thermal requirements of the experimenters.

b) Designed and supplied the necessary thermal enclosures and heating and control devices.

c) Performed tests to verify the thermal design.

d) Provided interface specifications and interface drawings.

e) Integrated thermal control subsystems on the experiments (EP-5).

f) Delivered integrated thermal control subsystems and spares to the spacecraft contractor.

APPENDIX

THERMAL SUBSYSTEM EP-5 OGO-F APPENDIX

Item	Description	Transmittal Letter/ Ref. Document
1	Mutual Environmental Interference Test	S46868
2	Thermal Vacuum Design Verification	69-0102
3	Master Drawing Lists	
4	Thermal Analysis for EP-5/OGO-F	68-0110
5	Worst Case Analysis (Proportional Heater)	
6	GSFC Correspondence	
7	Typical Proportional Heater Inspection Report	
8	Solar-Vac Design Verification Specification	S46865
9	EP-5 Thermal System Drawings	

ITEM 1

MUTUAL ENVIRONMENTAL INTERFERENCE TEST

S 46868

PARTS DISPOSITION			SPEC NO.	REV
1. USE 2. REWORK	3. CANNOT BE REWORKED 4. RECORD	5.	S 46868	

REVISIONS

DISP	EFF	REV	DESCRIPTION	BY	CK	DATE	APPROVAL

SHEET INDEX	REV								
	SHEET								
SHEET INDEX	REV								
	SHEET	1	2	3	4	5	6	7	8

CONTRACT NO. NAS 5-11095		
PREP D. Petrics	8 May 68	
CK		
ENGR		
APPD	17 May 68	
APPD		
QC APPD	17 May 68	
DESIGN APPD	2	
CUSTOMER		

M L — **MARSHALL LABORATORIES**, TORRANCE, CALIFORNIA

TITLE: Mutual Environmental Interference Test Specification for EP-5 Integration, OGO-F

SIZE	CODE IDENT NO:	SPECIFICATION NO.	REV
A	13126	S 46868	

RELEASED	SHEET
MAY 24 1968	1 OF 8

ML FORM 202

1.0 SCOPE

1.1 This procedure covers the mutual electromagnetic interference test requirements among experiment F-22, Triaxial Search Coil Magnetometer, and F-24, VLF Antenna.

2.0 APPLICABLE DOCUMENTS

2.1 The following documents of the latest issue and revision letter in effect form a part of this specification to the extent specified herein.

Drawings, Marshall Laboratories

Drawing Number	Revision	Title
ML805200-101	A	Experiment Assembly OGO-F, EP-5
ML805900-101, 102, 103	N/C	Cable, Interference Test
ML52238	C	Schematic Proportional Heater
TRW Systems		
X232133	A	Interconnection Diagram Experiment F-24
X232131	A	Interconnection Diagram Experiment F-22
Lockheed		
R76270	N/C	Tri-Loop Antenna Assembly
GSFC		
GE1250106	N/C	Appendage Interface Drawing EP-5, OGO-F
GJ1250070	N/C	EP-5 Dimensional Control & Design Layout OGO-F
GJ1250122	N/C	Assembly, EP-5, OGO-
GJ1250208	N/C	Wiring Installation EP-5, OGO-F

Specifications

OGO

Contract NAS 5-11095

GSFC, "Specification for the Orbiting Geophysical Observatories S-49/50" (Latest Revision).

TRW

STL Observatory Environmental Test Specifications D13353 and D13354 (Latest Revisions).

STL Experiment Interface Specification D13356 (Latest Revision).

General

Performance Specifications for each experiment of the OGO form a part of this document and will be used as a standard to judge the performance of the applicable experiment.

Letter from JPL to ML dated 3-25-68, subject Interference Tests.

Letter from ML to SU, dated 5-8-68, subject Interference Tests.

3.0 REQUIREMENTS

3.1 Test Equipment

3.1.1 Standard The following test equipment (or equivalent) may be used.

3.1.1.1 Oscilloscope - Tektronix Model 545A.

3.1.1.2 Plug-In- Unit - Tektronix Type CA.
Tektronix Type L

3.1.1.3 D.C. Power Supplies

3.1.1.4 Precision D.C. Voltmeters

3.1.1.5 Precision A.C. Voltmeters

3.1.1.6 Sinewave Generator

3.1.1.7 A.C. Power Supplies

3.1.2 Non-Standard. The following test equipment is not available commerciall

3.1.2.1 OGO, F-24 Ground Support Equipment

3.1.2.2 OGO, F-24 Main Experiment Package

3.1.2.3 OGO, F-22 GSE Bench Test Equipment

3.1.2.4 OGO, F-22 Main Experiment Package

3.1.2.5 OGO, EP-5 Interference test cables

3.2 Expected Actual Interference Environment

The Electronic and Mechanical Assemblies shall perform satisfactorily under the conditions expected to exist during time of operation in orbit and be able to withstand, with no out-of-tolerance degradation, all environmental interference conditions expected to be encountered.

3.3 Simulation of Environment

Laboratory Environmental Interference Tests for Electronic and Mechanical Assemblies are intended to simulate conditions which are somewhat more severe than field conditions in order to provide better assurance of locating design deficiencies; however, the conditions are not intended to be severe enough to exceed design safety margins or excite unrealistic modes of failure. Should such modes occur, pertinent requirements will be waived in accordance with applicable procedures. The required Environmental Interference Test procedures are outlined in paragraph 3.11.

3.4 Test Facilities

3.4.1 Apparatus and Conditions

The apparatus used in conducting tests shall be capable of producing and maintaining the test conditions required, with the assembly under test installed on or in the apparatus and non operating. Changes in apparatus conditions from the nominal conditions specified by the appropriate test procedure shall not exceed the assembly specification requirements or the requirements of Paragraph 3.6.1 of this specification, whichever limits.

3.4.2 Volume

The volume of the test facilities shall be such that the bulk of the equipment under test shall not interfere with the geneation or maintenance of the test conditions.

3.4.3 Standard Conditions for Test Area

Conditions for conducting assembly functional tests shall be as indicated below:

a) Temperature: $25 \pm 3^{\circ}C$ ($77^{\circ} \pm 5^{\circ}F$)

b) Relative Humidity: 55 percent or less

c) Barometric Pressure: Room ambient (Correct to 29.92 inches Hg is fo specified in the applicable equipment specification).

3.5 Measurements

All measurements shall be made with instruments whose accuracy conforms to acceptable standards and which are appropriate for the parameters measured and the environmental conditions concerned. The accuracy of the measurement equipment shall be verified by the supplier.

3.5.1 Tolerances

The maximum allowable tolerances for test conditions shall be specified by the applicable test section in the Mutual Environmental Interference Test Specifications.

3.6 Performance Record

Prior to conducting any of the tests specified herein, the assembly shall be subjected to a comprehensive functional test under standard conditions and a record made of all data necessary to determine compliance with the applicable assembly specification. These data shall provide the basis for checking satisfactory performance of the equipment during or after environmental interference tests. A chronological log of performance data shall be available at one central location throughout the test program and shall be maintained by each experimenter to indicate accumulated running times suitable for reliability review. Three (3) copies of the recorded test data will be furnished to Marshall Laboratories upon completion of testing by each participating experimenter.

3.7 Installation Check

Following installation in the test apparatus and prior to test, the assembly shall be inspected by each participating experimenter to sufficiently insure that no malfunction or damage was caused due to faulty installation procedure or handling.

3.8 Criteria for Failure

Degradation or change in performance of any assembly which exceeds limits established by its specification and applicable test procedure during any test period shall be considered as a failure. Testing shall be discontinued until the malfunction (including design defects) is corrected. If the corrective action consists of simple repair, such as replacement with identical parts, the complete test procedure under which failure occurred shall be repeated in its entirety without equipment failure before proceeding to the next test. If corrective action, such as redesign, is required, the test procedure under which failure occurred shall be repeated as indicated above for repair action. In addition, if such redesign affects the results of previously completed tests, such tests shall be repeated.

3.9 Failure Reporting

Upon occurrence of a failure(s), as outlined in Paragraph 4.7 an immediate verbal report shall be made to Marshall Laboratories EP-5 integration Project Manager or his designated representative followed by a confirmation in writing to Marshall Laboratories within 48 hours,

3.10 Test Instructions

3.10.1 The mutual environmental interference tests will be performed in a magnetically shielded room at JPL. The test setup will be as shown in Figure 1. The F-24 Antenna shall be in a deployed state. The EP-5 assembly shall be placed in a Helmholz coil pair inside a magnetically shielded room.

The main body packages, GSE instrument, A.C. - D.C. power supplies, voltmeters and other miscellaneous test equipment will be located outside the shielded room.

3.10.2 This portion of mutual environmental interference tests will be performed with no excitation field applied to EP-5.

a) Observe and record F-24 outputs with F-22 off.
b) Observe and record F-24 outputs with F-22 turned on.
c) Observe and record F-24 outputs with F-22 in various gain states and IFC modes.
d) Observe and record F-24 outputs with heater on, off, and varying temperature range.
e) Observe and record F-24 outputs with F-22 turned off.
f) Observe and record F-22 outputs with F-24 off.
g) Observe and record F-22 outputs with F-24 turned on.

h) Observe and record F-22 outputs with F-24 in operation with various data sampling rate.

i) Observe and record F-22 outputs with F-24 operating in IFC mode.

j) Observe and record F-22 outputs with EP-5 heater on and off.

k) Observe and record F-22 outputs with F-24 turned off.

3.10.3 This portion of mutual environmental interference tests will be performed with VLF electric fields applied to F-24.

a) Observe and record F-22 outputs with F-24 off.

b) Observe and record F-22 outputs with F-24 turned on.

c) Observe and record F-22 outputs with F-24 in operation with various data sampling rate.

d) Observe and record F-22 outputs with F-24 operating in IFC mode.

e) Observe and record F-22 outputs with EP-5 heater on and off.

f) Observe and record F-22 outputs with F-24 turned off.

3.10.4 This portion of mutual environmental interference tests will be performed with low frequency magnetic excitation field (< 100 Hz) applied to F-22.

a) Observe and record F-24 outputs with F-22 off.

b) Observe and record F-24 outputs with F-22 turned on.

c) Observe and record F-24 ouputs with F-22 in various gain states and IFC modes.

d) Observe and record F-24 outputs with F-22 turned off.

4.0 QUALITY ASSURANCE PROVISIONS

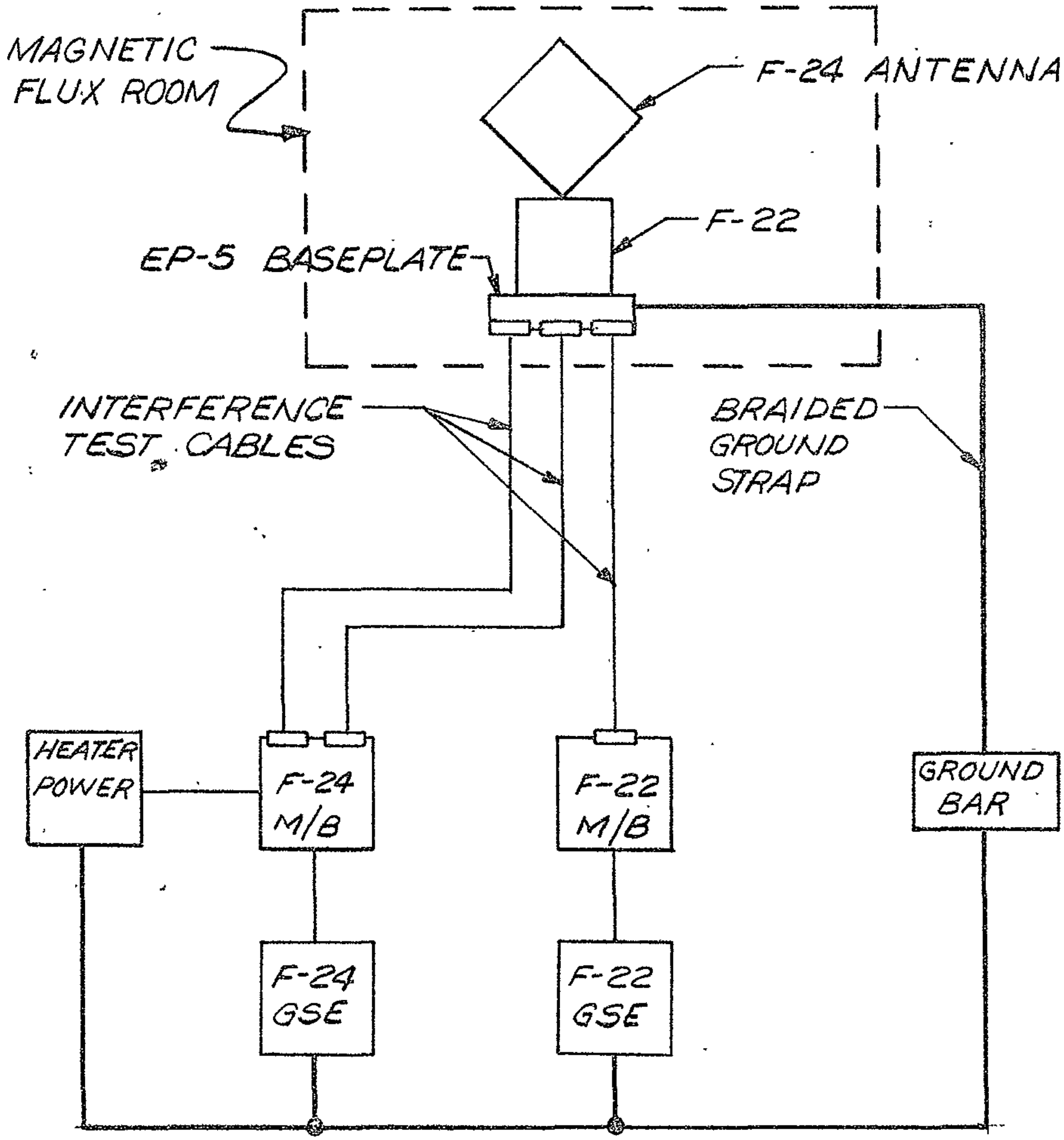
The requirements section of this specification form the Quality Assurance Provisions.

5.0 PREPARATION FOR DELIVERY

"Not Applicable to this Specification"

6.0 NOTES

"Not Applicable to this Specification"



MUTUAL INTERFERENCE
TEST SET-UP
EP-5 (OGO-F)

FIG. 1

MARSHALL LABORATORIES TORRANCE CALIFORNIA	TITLE Mutual Environmental Interference Test Specification for EP-5 Integration, OGO-F	SPECIFICATION NO. S 46868	REV
ODE ENT NO 13126		SHEET 8 OF 8	

ITEM 2

THERMAL VACUUM DESIGN VERIFICATION TEST REPORT

EXPERIMENT PACKAGE FIVE - OGO-F

(18 March 1969, 69-0102)

THERMAL VACUUM DESIGN VERIFICATION
TEST REPORT
For
EXPERIMENT PACKAGE 5 OGO-F

Contract No. NAS 5-11095

Prepared By: J. Kohan
J. Kohan
Project Engineer

Approved By: E. Azari
E. Azari
Program Manager

MARSHALL LABORATORIES
3530 Torrance Boulevard
Torrance, California

Table of Contents

Figures

1.0 INTRODUCTION

The purpose of this report is to present the results of the solar-vac design verification tests of the Experiment Package Five (EP-5) for the OGO-F Spacecraft. The tests were performed at TRW Systems during the period of 19 August 1968 through August 21, 1968.

The EP-5 assembly contains portions of two experiments, F-22 and F-24. Both are within a thermal equilibrium blanket and mounted to the +Y end of the EP-5 boom.

This report covers a review of the tests performed on the following two "worst case" orbit conditions.

1. The EP-5 is in total eclipse, shadowed by spacecraft and heater power is reduced to 27 volts.

2. The EP-5 is receiving normal insolation (1.0 sun) on its -Y and -Z surfaces (45° incline) and heater power is increased to 32.5 volts.

2.0 EXPERIMENT PACKAGE FIVE CONFIGURATION

The EP-5 as shown in Figure 1, is partially contained within an 11.5" x 9.5" x 9.0" parallel piped thermal envelope. The F-24 antenna extends beyond the thermal envelope and this is not maintained within the thermally controlled environment. The thermal envelope which makes up the electronics compartment, consists of multilayer aluminized mylar sheets and pure silk mesh arranged in a sandwich type construction with the mylar side facing out.

Within the environmental controlled electronics compartment are the prototype search coil magnetometer coils and preamplifiers for the F-22 Search Coil Magnetometer Equipment, developed by Dr. E. Smith of JPL and Professor Holzer of UCLA, and the prototype preamplifier for the F-24 VLF Antenna Experiment developed by Dr. Helliwell and Dr. R. Smith of Stanford University. Because of the sensitivity of the experiments within the EP-5 to magnetic fields and RF noise, a non-magnetic proportional heater is used as an active temperature control device. The EP-5 proportional heater developed by Marshall Laboratories, is bonded to the baseplate and provides heat to the experiments by conduction and radiation from the baseplate. Figure 2 illustrates the EP-5 temperature control

Figure 1 EP-5 DESIGN CONFIGURATION

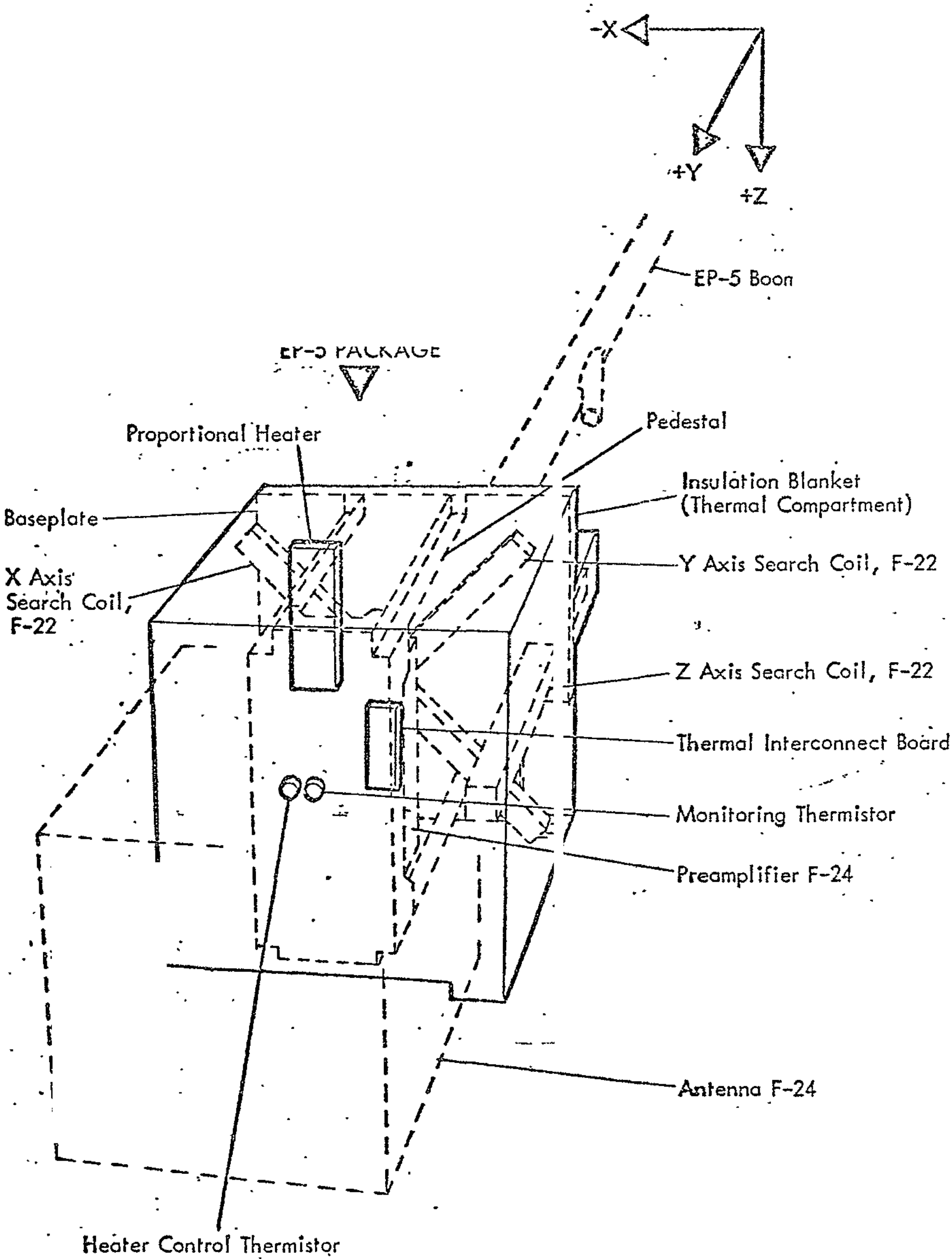
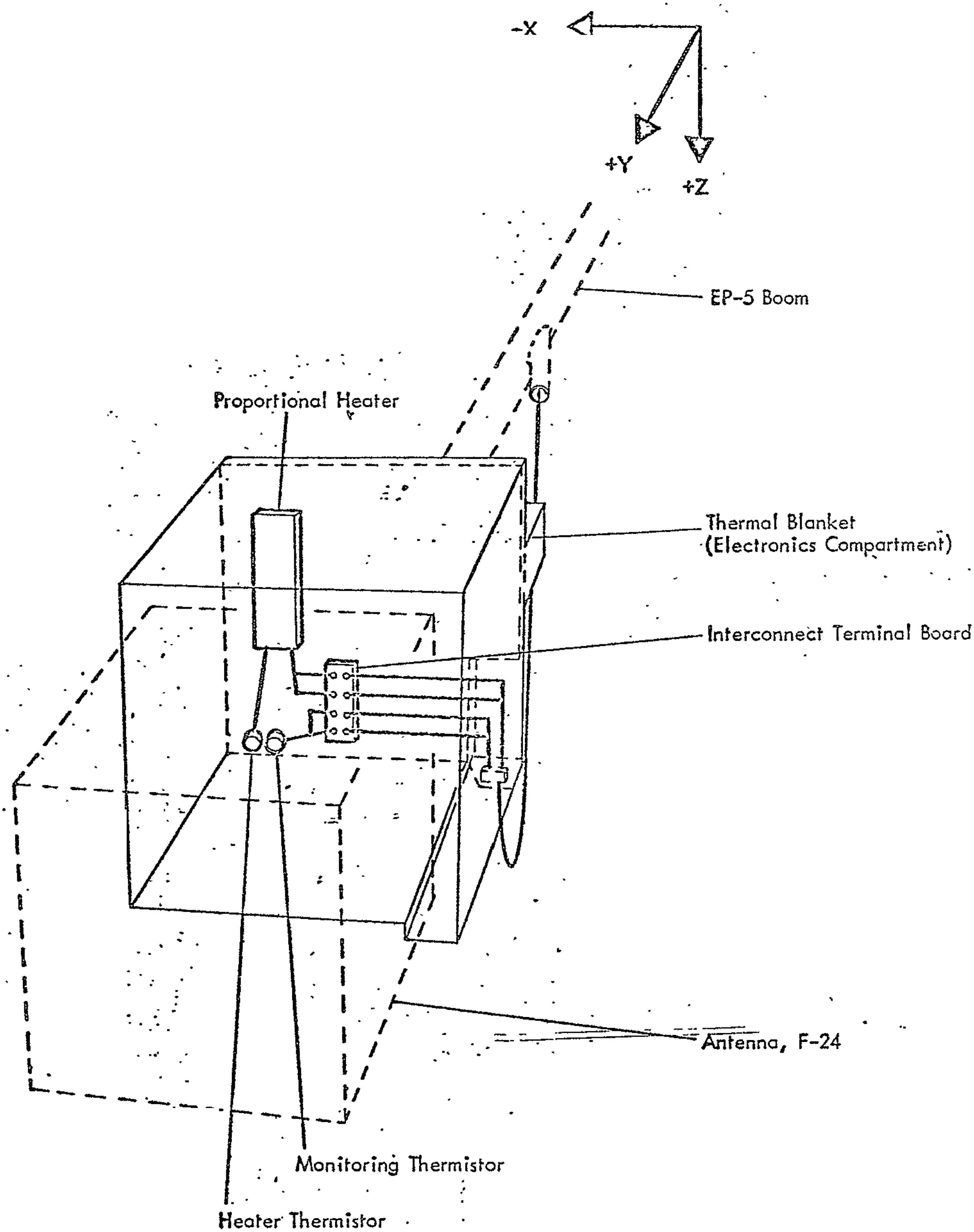


Figure 2 EP-5 THERMAL SUB-SYSTEM, GO-F



system. The electronics compartment has an acceptable temperature range of -20°C to +50°C and a minimum internal dissipation of .22 watts when the internal temperature is 12°C. Between the temperature range of 6°C and 12°C the dissipation may vary from 1.575 watts to .22 watts depending on the position of the spacecraft relative to the sun.

The heat dissipations for the EP-5 experimenters components were as follows:

1.	F-22 Search Coil	0.240 Watts
2.	F-24 Preamplifier	0.0988 Watts

To sense the temperature within the EP-5 package during solar-vac testing 9 YS1 44018 thermisters and 10 thermocouples were installed at various selected positions as indicated below:

TM1 & TC12	F-22 X-Axis Search Coil
TM2 & TC13	F-22 X-Axis Search Coil
TM3 & TC14	F-22 Y-Axis Search Coil
TM4 & TC15	F-22 Y-Axis Search Coil
TM5 & TC16	F-22 Z-Axis Search Coil
TM6 & TC17	F-22 Z-Axis Search Coil
TM7 & TC18	EP-5 Base Plate, New Heater Control Thermisto:
TM8 & TC19	F-24 Preamplifier
TM9 & TC9	F-24 Preamplifier
TC1	EP-5 Base Plate opposite end from Heater Control Thermister
TC2	Relay Module
TC3	P1 Squib
TC4	P2 Squib
TC5, TC6 & TC7	Boom
TC8	Cable
TC10 & TC11	F-24 Ejection Mechanism

The experiment monitoring thermistors and thermocouples TC1, TC2, TC9, TM1 through TM9 and TC12 through TC19 were positioned inside the experiment. Two thermistors and/or thermocouples within each experiment positioned at maximum separation to record the thermal gradient of each experiment components.

All thermistor and thermocouple leads were brought out of the EP-5 assembly along side the EP-5 Boom and thermally wrapped and insulated by TRW.

3.0 TEST EQUIPMENT

	Equipment	S/N	Date Calibration Due
1.	Leed & Northrop Speedomax W Temperature Recorder	01-183312	2/10/69
2.	OGO-F Simulator	NAS 5-3900	10/5/68
3.	Leeds & Northrop Speedomax G Temperature Recorder	01-113469	1/20/69
4.	TRW Thermistor Thero-meter Selector Box	CL33571	1/13/69
5.	Hewlett Packard DC Vacuum Tube Voltmeter	SN15766	11/25/68
6.	Hewlett Packard 344DA Digital Voltmeter	01-177995	10/14/68
7.	Weston Instruments Power Supply	01-123986	5/5/69
8.	Lambda Power Supply	SW1426	8/25/69
9.	(4) SVE Ohmeter	3259	10/21/68
10.	(4) Weston Ammeter	8R0523	12/20/68

11. Thermistor test selector box with individual readout capability from a digital voltmeter in degree "C".

4.0 PRE-TEST MODIFICATIONS

There were no pre-test modifications to the EP-5 assembly for this test.

5.0 PRE-TEST CHECKOUT

The EP-5 Thermal Boom Assembly was suspended in the 7 x 12 solar chamber as shown in Figure 3 and a pre-test checkout was performed as follows and the results were satisfactory:

1. Resistance check of test thermistors and heaters.
2. Calibrated thermistor test selector box and readout EP-5 thermistors at room temperature on digital voltmeter.
3. Radiometer board calibration of solar simulator.
4. Functional checkout of experiment.
5. Sealed chamber door and evacuated chamber to 1×10^{-5} torr minimum.
6. Flooded shroud with LN_2; shroud temperature: $-185^\circ C$.

6.0 PHASE I SOLAR-VAC TEST EP-5 ECLIPSE CONDITION

The first phase of the solar-vac qualification test was to simulate an eclipse or shadowed condition. Power was on to all experiments. The proportional heater power was set at 27.0 volts. Reading of the sensing thermistors, heater voltage, heater current were recorded. Experiments were monitored throughout the entire test and data was recorded.

Temperature curves of the experiment stabilization are shown on Figures 4 through 8 for the eclipse condition.

The EP-5 proportional heater performed satisfactorily for the eclipse portion of the solar-vac test. Maximum recorded current drain for the EP-5 proportional heater was 235 milliamps. The EP-5 stabilized with the proportional heater at 235 milliamps. This would indicate a heat loss for the EP-5 assembly during eclipse of 6.32 watts. The temperature stabilized within the EP-5 assembly between $11.7^\circ C$ and $-8.62^\circ C$.

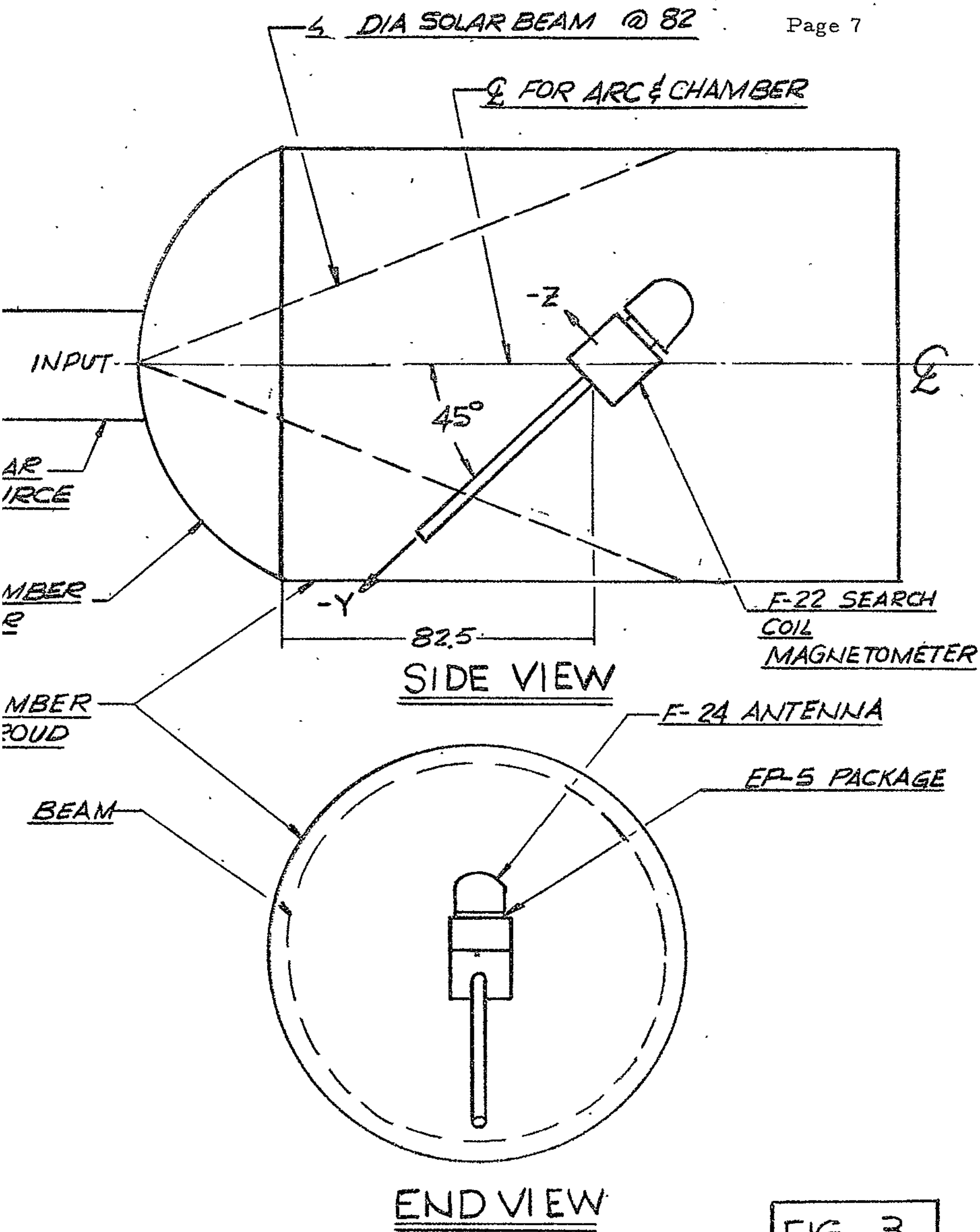


FIG. 3

EP-5, POSITIONING WITHIN 7×12 SOLAR-VAC CHAMBER

7.0 PHASE II SOLAR-VAC TEST EP-5, SOLAR CONDITION

The second phase of the solar-vac qualification tests was to simulate solar conditions. During this phase of the test the -Y and -Z surface was subjected to insulation at 1.042 sun intensity. Power was on to all experiments. The proportional heater power was set at 32.5 watts. Readings of the sensing thermistors, heater voltage, heater current were recorded. The EP-5 experiments underwent a functional checkout prior to and after the solar-vac tests and during stabilization period.

Temperature curves of the experiment stabilization are shown on Figures 9 through 13 for the solar condition.

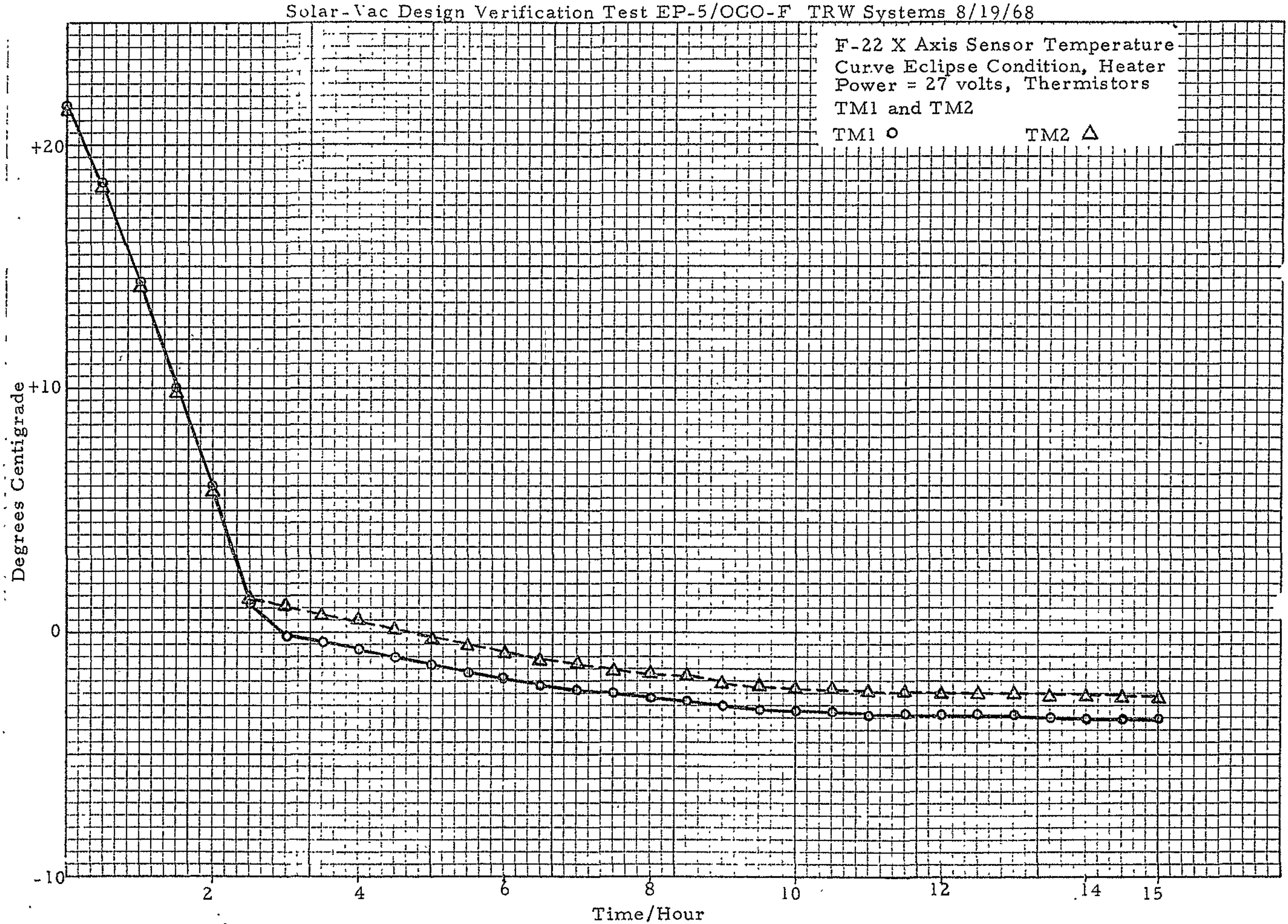
The EP-5 proportional heater performed satisfactorily for the solar portion of the solar-vac test. Maximum recorded current drain for the EP-5 proportional heater was 183 milliamps. The EP-5 stabilized with the proportional heater at 77 milliamps. This would indicate a heat loss of 2.5 watts for the EP-5 assembly during the solar condition. The temperature stabilized within the EP-5 assembly between 5.38°C and 12.18°C.

8.0 SOLAR CALIBRATION

The chamber solar simulator was calibrated under ambient conditions using a radiometer target board to obtain a 19 inch 1.043 suns constant pattern, and the maximum allowable deviations from 1.0 sun are ±10%. In the pre-test calibration the average solar intensity was 1.043 sun (+4.3% deviation). During the sun turn-on period the solar constant was maintained during the test within ±10% of the 1.0 sun value. The post-test calibration indicated a solar intensity of 1.013 (+1.3% deviation). The spacing of the radiometers on target board is shown in Appendix "B"

9.0 CONCLUSIONS

The results indicate that the thermal design will maintain the EP-5 assembly within the operating band of -20°C and +50°C during environment extremes. At no time during either phase of the solar-vac test did the temperature in the experiments approach the design limits. It is therefore concluded that the thermal design for the EP-5 assembly is proven adequate for its intended use.


Solar-Vac Design Verification Test EP-5/OGO-F TRW Systems 8/19/68
F-22 X Axis Sensor Temperature Curve Eclipse Condition, Heater Power = 27 volts, Thermistors TM1 and TM2
TM1 o
TM2 △
Degrees Centigrade
+20
+10
0
-10
2
4
6
8
10
12
14
15
Time/Hour

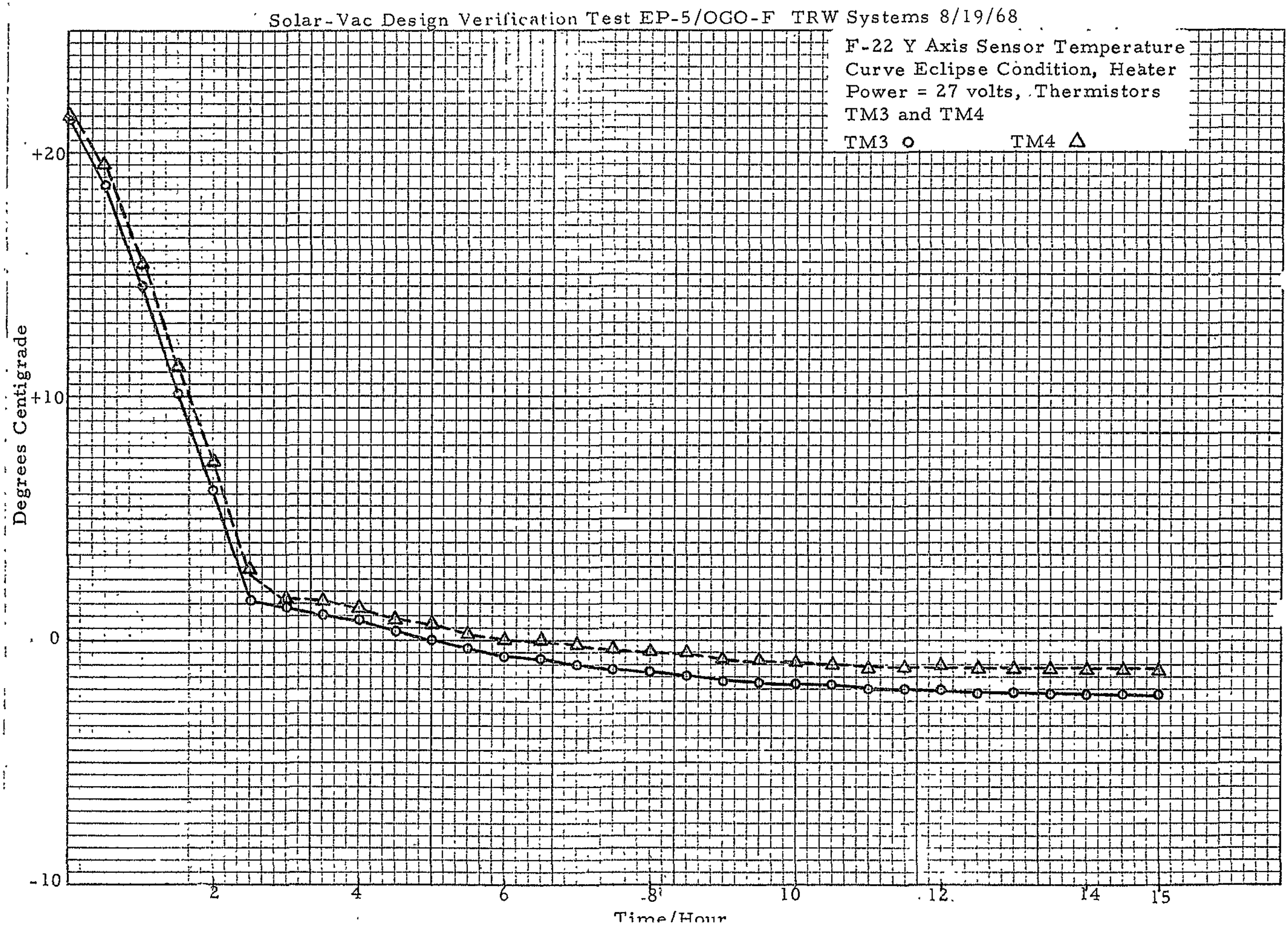
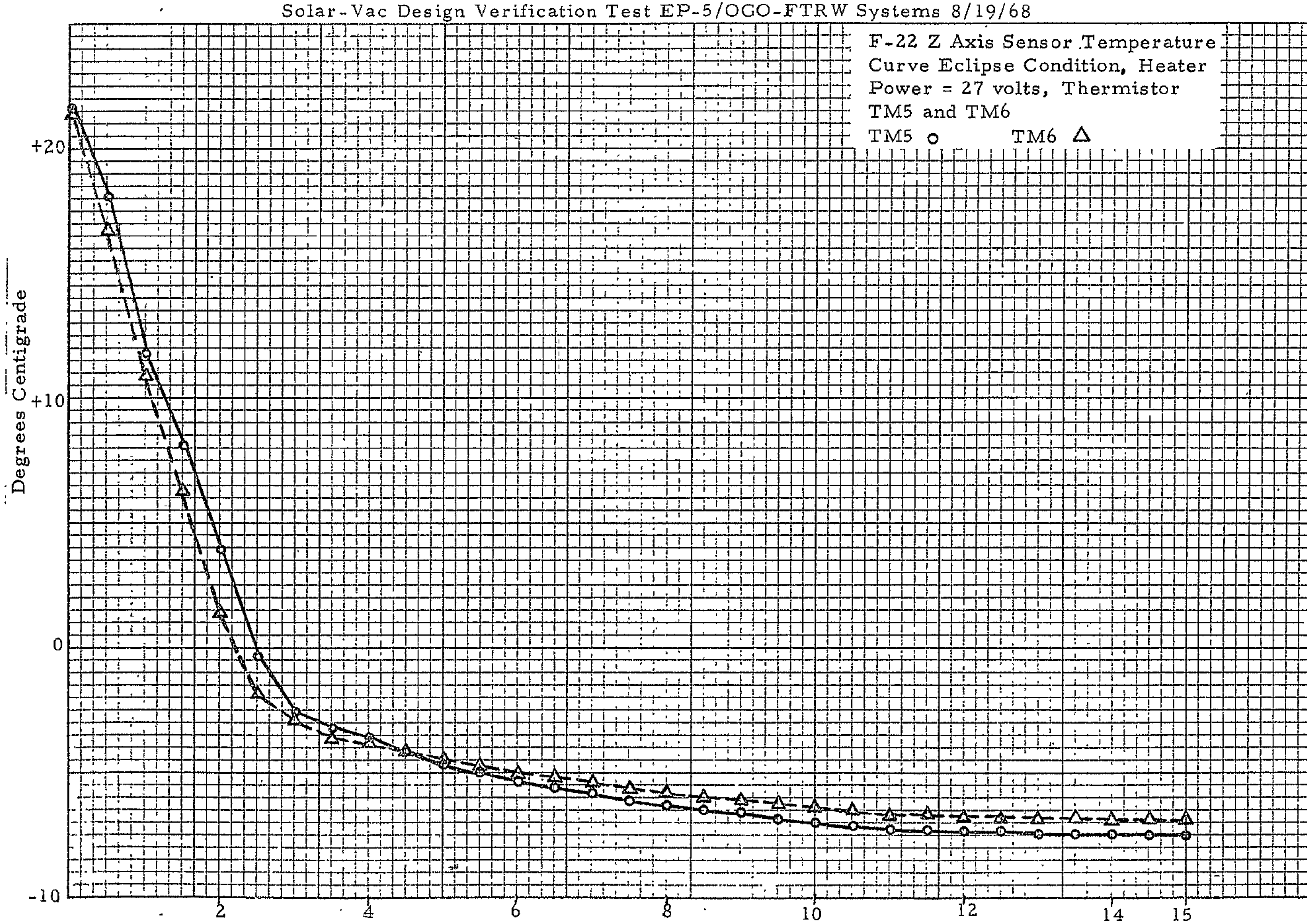

Solar-Vac Design Verification Test EP-5/OGO-F TRW Systems 8/19/68
F-22 Y Axis Sensor Temperature Curve Eclipse Condition, Heater Power = 27 volts, Thermistors TM3 and TM4
TM3 o
TM4 Δ
Degrees Centigrade
+20
+10
0
-10
2
4
6
8
10
12
14
15
Time/Hour

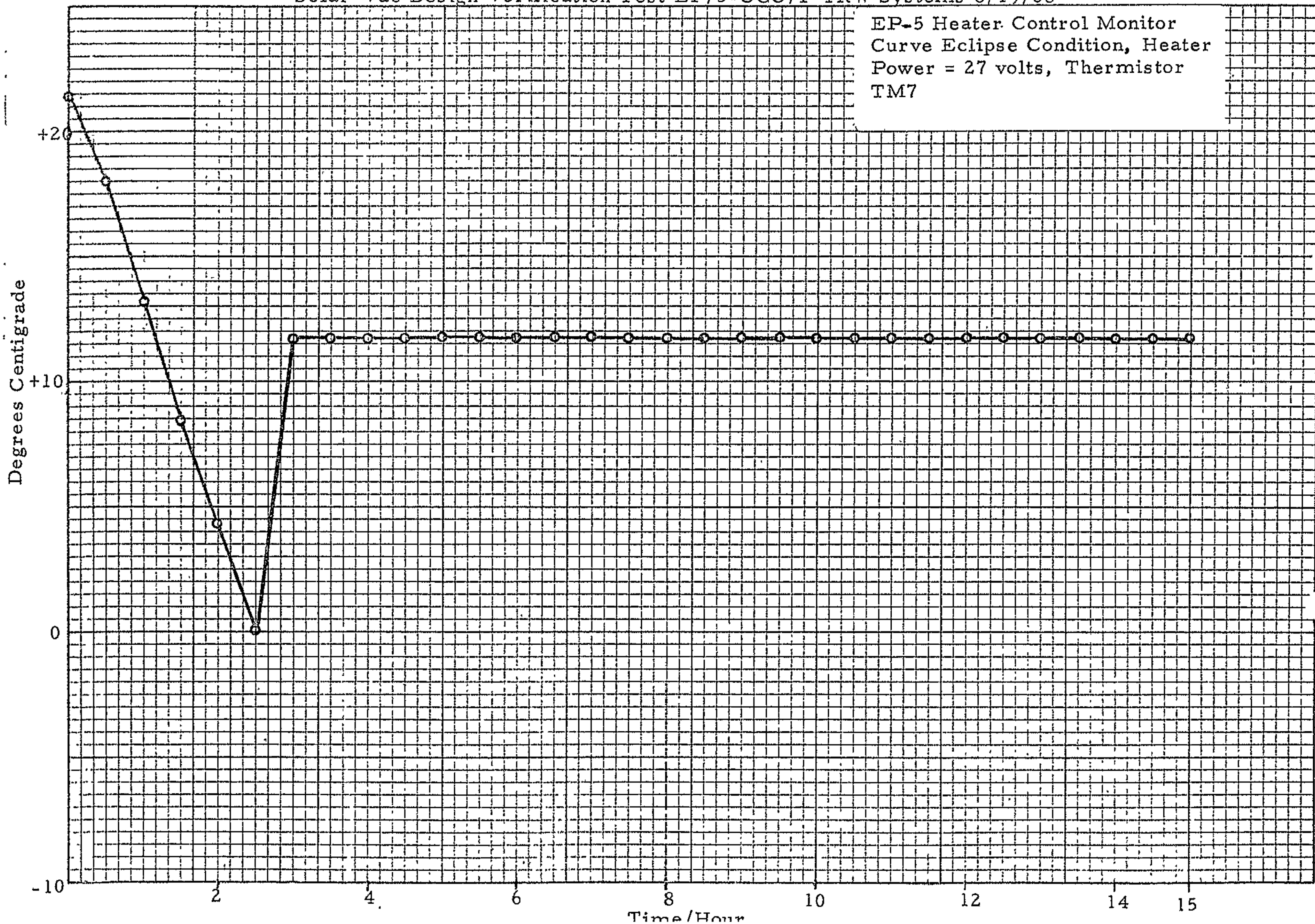
Figure 5



Solar-Vac Design Verification Test EP-5/OGO-FTRW Systems 8/19/68
F-22 Z Axis Sensor Temperature Curve Eclipse Condition, Heater Power = 27 volts, Thermistor TM5 and TM6
TM5 o
TM6 △
Degrees Centigrade
+20
+10
0
-10
2
4
6
8
10
12
14
15

Figure 6

Solar-Vac Design Verification Test EP/5-OGO/F TRW Systems 8/19/68



Solar-Vac Design Verification Test EP-5/OGO-F TRW Systems 8/19/68

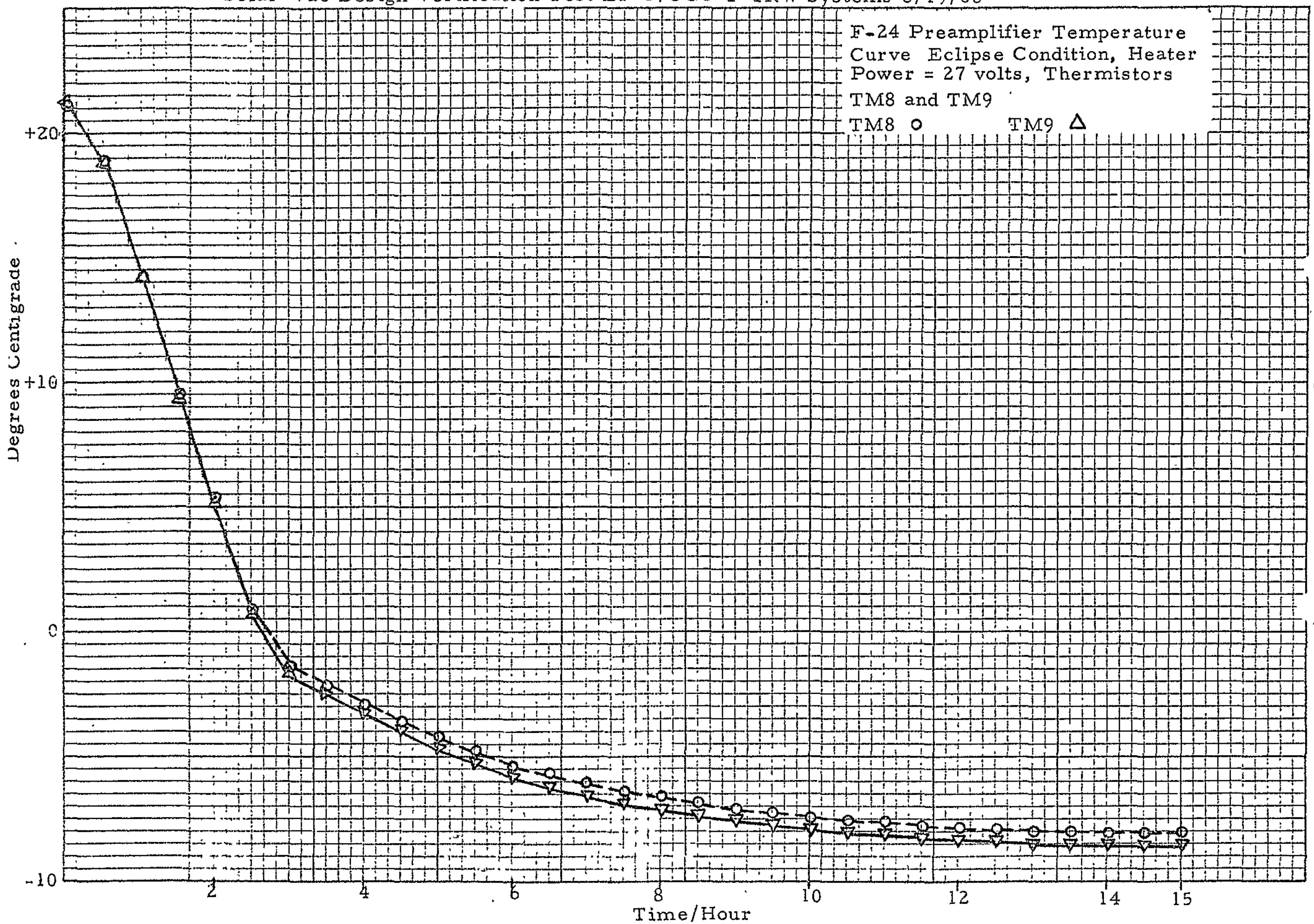


Figure 8

KE 10 X 10 TO THE INCH 46 0703
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.

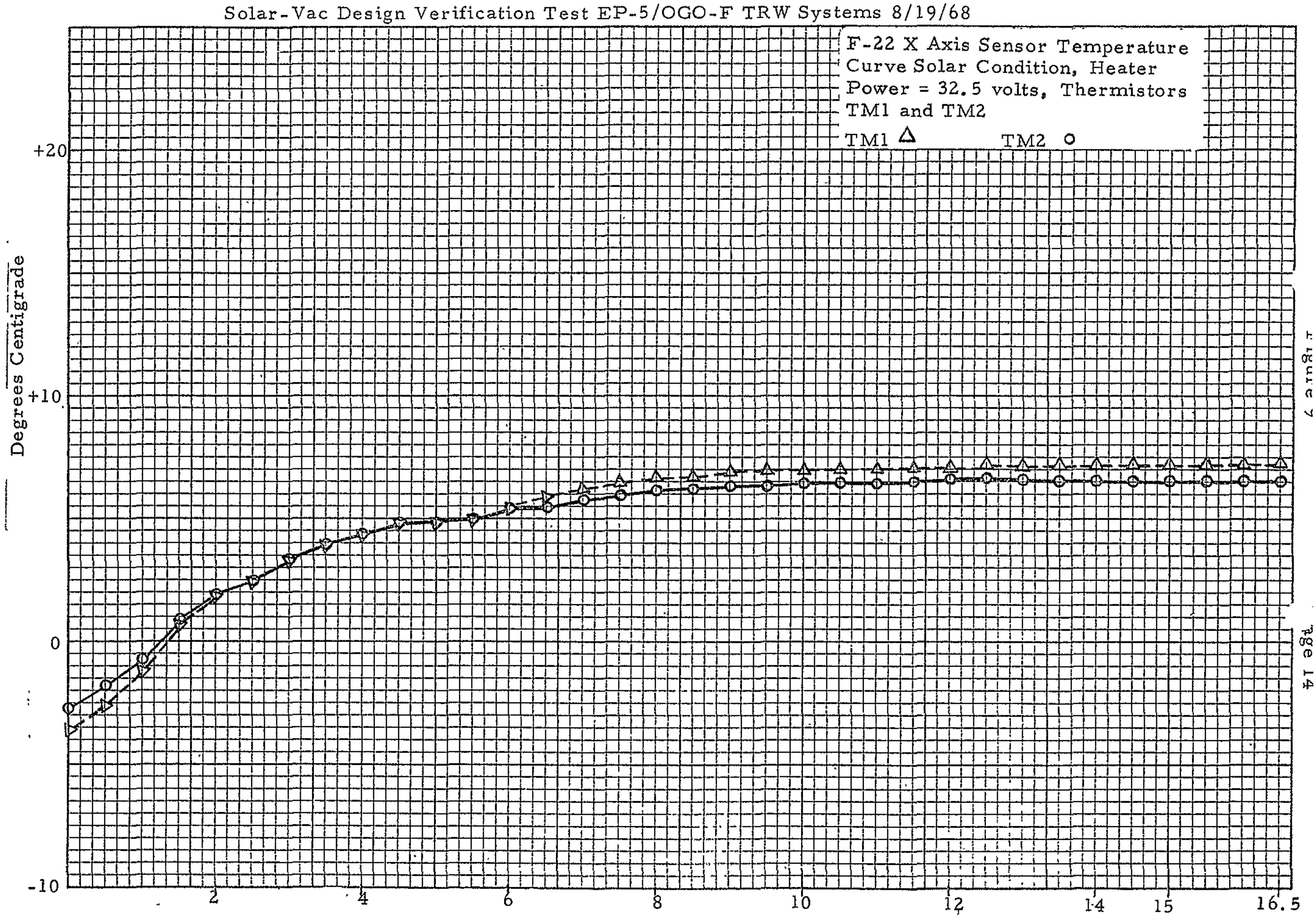


Figure 7

Solar-Vac Design Verification Test EP-5/OGO-F TRW Systems 8/19/68

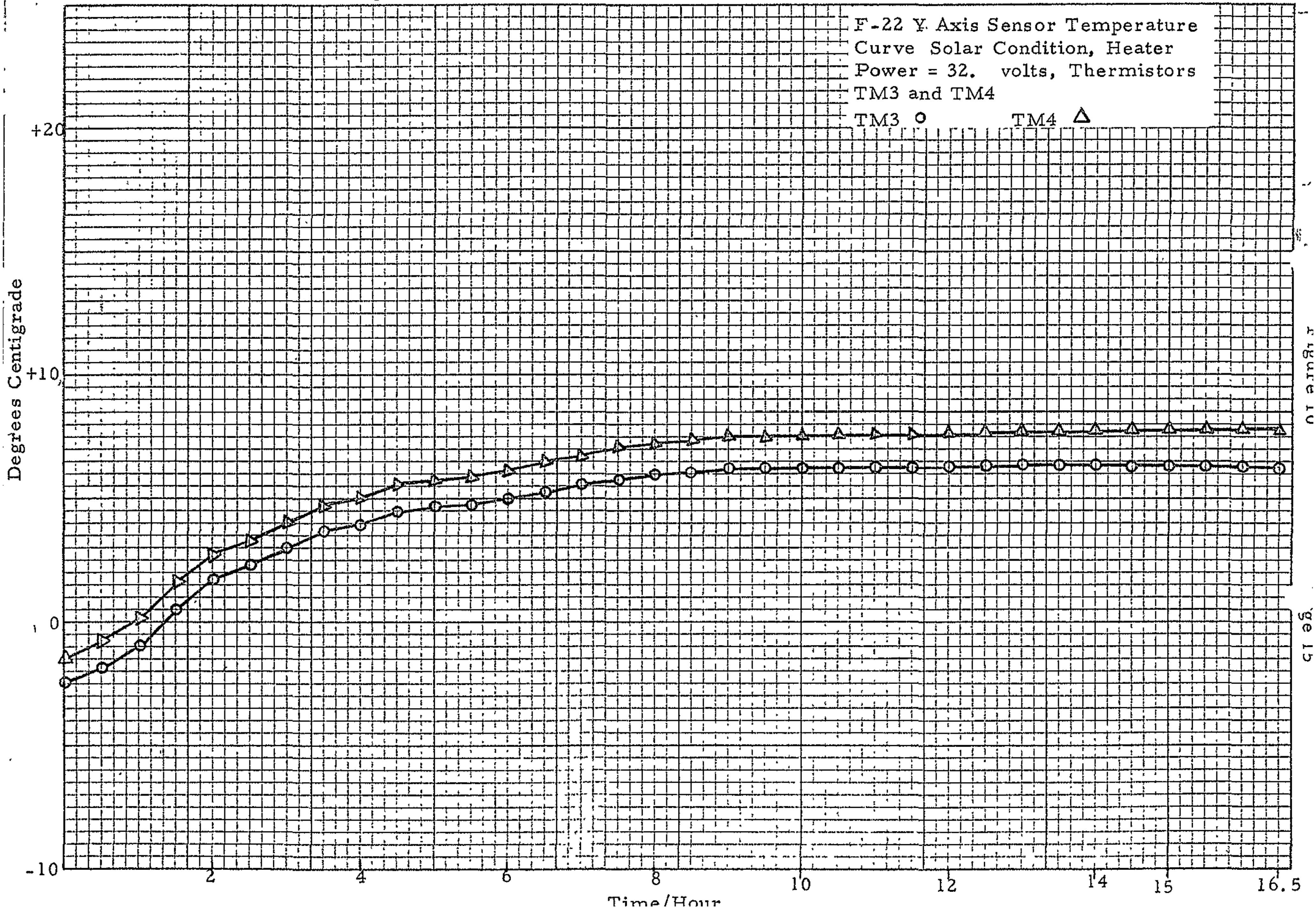
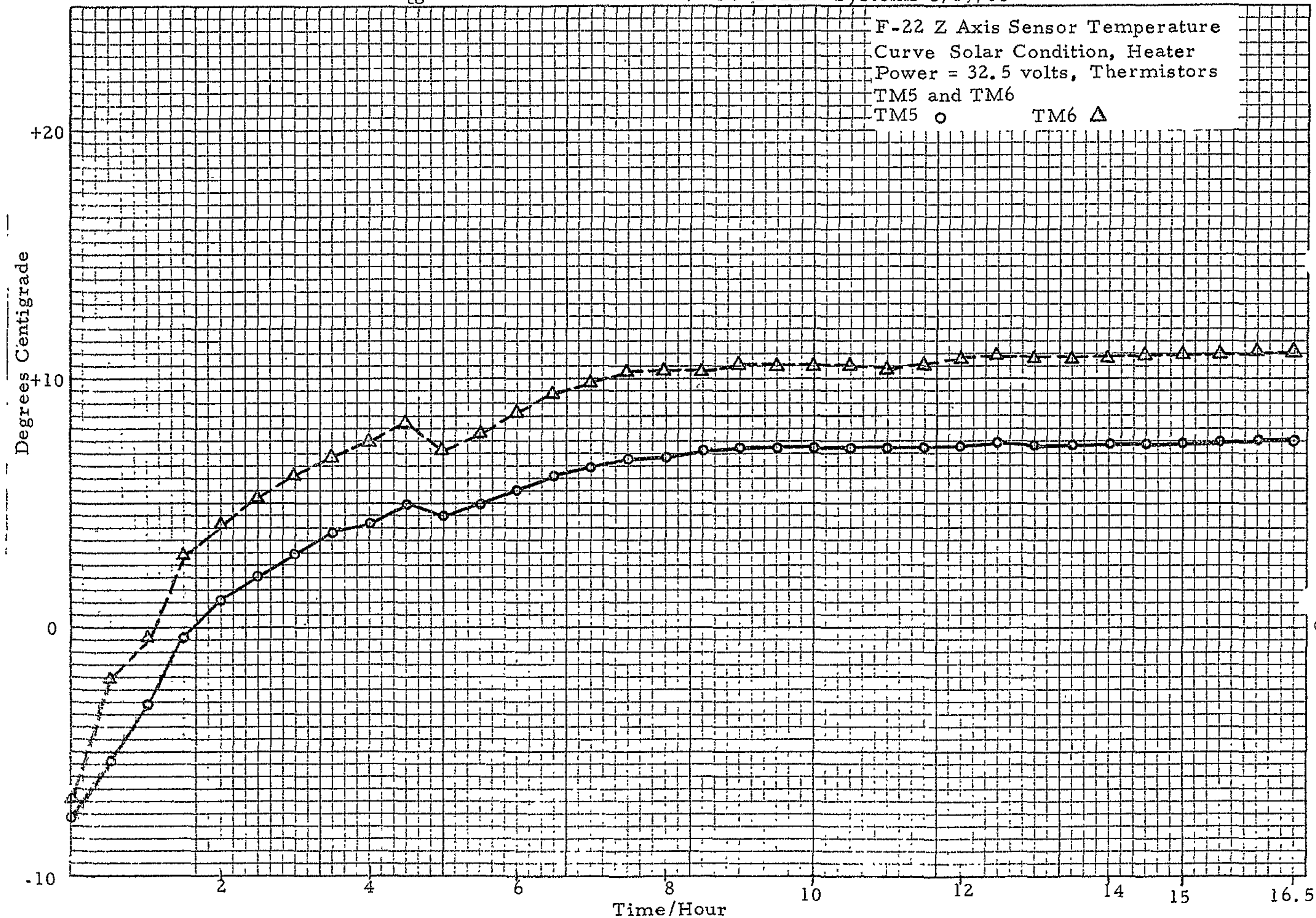
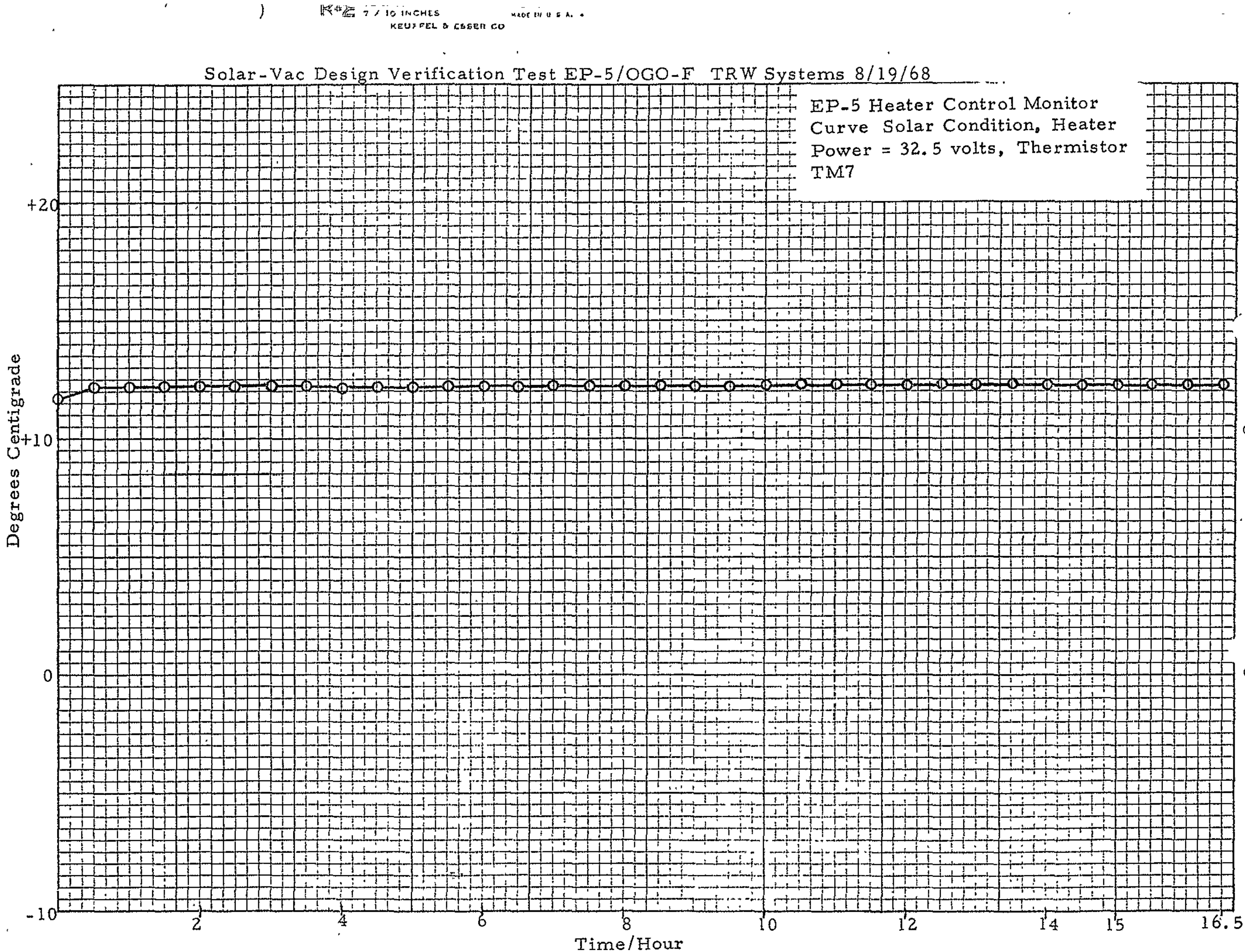


Figure 10

Page 15

Solar-Vac Design Verification Test EP-5/OGO-F TRW Systems 8/19/68

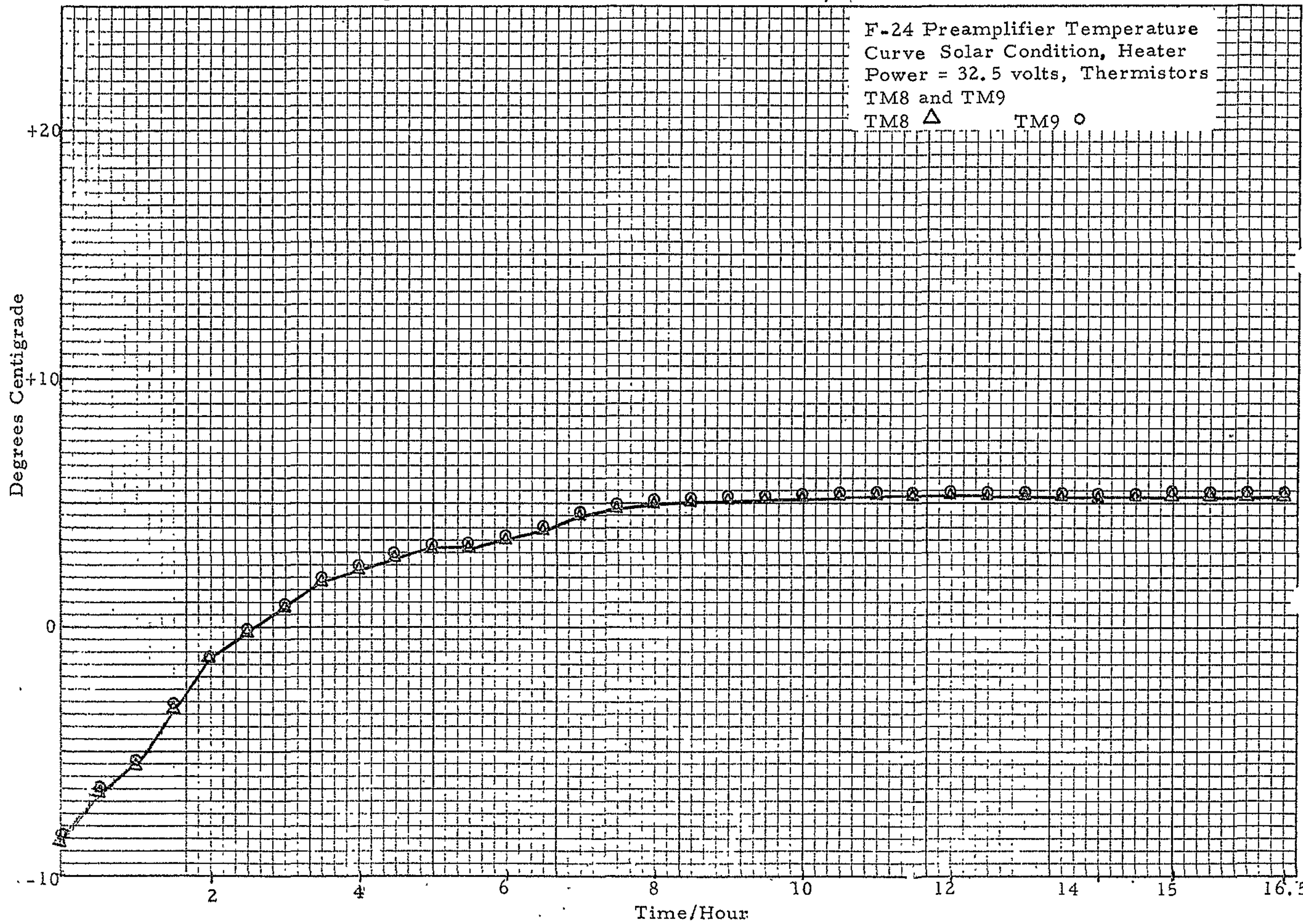




K+E 7 X 10 INCHES
KEUFFEL & ESSER CO.
MADE IN U.S.A.
Solar-Vac Design Verification Test EP-5/OGO-F TRW Systems 8/19/68
EP-5 Heater Control Monitor
Curve Solar Condition, Heater
Power = 32.5 volts, Thermistor
TM7
+20
+10
0
-10
Degrees Centigrade
2
4
6
8
10
12
14
15
16.5
Time/Hour

Figure 12

Solar-Vac Design Verification Test EP-5/OGO-F TRW Systems 8/19/68



ITEM 3

MASTER DRAWING AND PARTS LISTS

PL 805200	PL 805805
PL 805202	PL 805806
PL 805203	PL 805807
PL 805205	PL 805808
PL 805801	PL 805809
PL 805802	PL 805810
PL 805803	PL 805811
PL 805804	PL 805900

APPLICATION	
ASSY	FINAL ASSY

PARTS DISPOSITION
1. USE 3. CANNOT BE REWORKED
2. REWORK 4. RECORD 5. ......

DWG. NO. PL805200 REV A

REVISIONS

DISP	EFF	REV	DESCRIPTION	BY	CK	DATE	APPD
4	1&UP	A	DELETED ITEMS 5, 7 THRU 13, & 25	RB	[illegible]	[illegible]	[illegible]

1. ITEM 2 IS GFE FROM GSFC

NOTES: (UNLESS OTHERWISE SPECIFIED)

SHEET INDEX	REV	A	A
	SHEET	1	2

ERPRET THIS DRAWING PER STANDARDS IN MIL-D-70327
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .1
X ± .03
XX ± .010
ANGLES ± 0° 30′
.XXXX ± .0050

SURFACE ROUGHNESS

HOLE DIA.	TOLERANCE
.135 THRU .125	+ .004 − .001
.126 THRU .250	+ .005 − .001
.251 THRU .500	+ .006 − .001
.501 THRU .750	+ .008 − .001
.751 THRU 1.000	+ .010 − .001
1.000 THRU 2.000	+ .012 − .001
2.001 AND OVER	LINEAR

CONTRACT NO. NAS5-11095
DRAWN Beazley 29Dec67
CHECK [illegible] 1-9-67
MECH ENGR [illegible] 1/9/68
ELECT ENGR
PROJ MGR [illegible] 1/9/68
APPD
DESIGN ACTIVITY APPD [illegible]
CUSTOMER

ML

MARSHALL LABORATORIES
TORRANCE, CALIFORNIA

TITLE PARTS LIST
FINAL ASSEMBLY
EP-5 OGO-F

SIZE	CODE IDENT NO.	DWG NO.	REV
A	13126	PL805200	A

SCALE NONE RELEASED JAN 10 1968 SHEET 1 OF 2

QTY REQD		-101	PART NO.	SPECIFICATION	DESCRIPTION	ELEC REF DES	CODE IDENT	ZONE	ITEM NO.
			805200-101		ASSY - FINAL				1
		1	GJ1250122	GSFC	- EP-5 OGOF				2
		1	805202-101		- THERMAL BLANKET				3
		1	52169-102		ASSY - PROPORTIONAL HEATER	RT1			4
			DELETED						5
		1	805202-2		TOP THERMAL BLANKET				6
			DELETED			RT2			7
									8
									9
									10
									11
									12
			DELETED						13
		A/R	1/4 MIL X 2.0 X A/R		ALUMINIZED MYLAR				14
		A/R	2 MIL X 0.5 X A/R		TAPE ALUMINIZED MYLAR				15
		A/R	3 MIL X 1.0 X A/R		ALUMINIZED MYLAR				16
		A/R			THREAD, DACRON				17
		REF		S42001	THERMAL INSTALLATION ASSY SPEC FOR				18
		REF		S40111	IDENTIFICATION SPEC				19
		REF		S46850	TEST SPEC FOR				20
		REF	AP805200-101		ASSEMBLY PLAN				21
		REF		S40126	SOLDERING PROCESS SPEC				22
		A/R		MIL-A-8525 TYPE I	ADHESIVE, EPIBOND 8525A BORDEN CHEMICAL				23
		REF	805100		ENVELOPE DWG				24
			DELETED						25
		REF	805205		BLOCK FORM				26
		A/R		S40379	SPOT POTTING SPEC (RTV 891)				27
		A/R	STYLE 20B	GUDEBROD B205	LACING TAPE-NYLON				28
		A/R		S40149	BONDING SPEC (ECCOBOND 1210)				29
		REF		S40072	MANUFACTURING SPEC				30

TITLE	SIZE	CODE IDENT NO.	LM NO.	REV
PARTS LIST FINAL ASSEMBLY EP-5 OGO F	A	13126	PL805200	A
LIST OF MATERIALS	SCALE NONE	RELEASED		SHEET 2 OF

APPLICATION	
XT ASSY	FINAL ASSY
5200-101	805200-101

PARTS DISPOSITION
1. USE 3. CANNOT BE REWORKED
2. REWORK 4. RECORD 5. ....

DWG. NO. PL805202 REV

REVISIONS

DISP	EFF	REV	DESCRIPTION	BY	CK	DATE	APPD

1. DECAL DWG 805208-1 TO BE USED ON 805202-101, & -102 ASSY

NOTES: UNLESS OTHERWISE SPECIFIED

SHEET INDEX	REV				
	SHEET	1	2		

INTERPRET THIS DRAWING PER STANDARDS IN MIL-D-70327
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS: .X ± .1, .XX ± .03, .XXX ± .010, .XXXX ± .0050
ANGLES ± 0° 30'
√ SURFACE ROUGHNESS

HOLE DIA.	TOLERANCE
.0135 THRU .125	+ .004 − .001
.125 THRU .250	+ .005 − .001
.251 THRU .500	+ .006 − .001
.501 THRU .750	+ .008 − .001
.751 THRU 1.000	+ .010 − .001
1.000 THRU 2.000	+ .012 − .001
2.001 AND OVER	LINEAR

CONTRACT NO. NAS 5-11095
DRAWN Beasley 12 FEB 68
CHECK 15 FEB 68
MECH ENGR
ELECT ENGR
PROJ MGR E. Ferris
APPD
DESIGN ACTIVITY APPD 2-19-68
CUSTOMER

M L — MARSHALL LABORATORIES
TORRANCE, CALIFORNIA

TITLE PARTS LIST - DETAIL ASSEMBLY, THERMAL BLANKET EP-5 (OGO-F)

SIZE	CODE IDENT NO.	DWG NO.	REV
A	13126	PL805202	

SCALE NONE | RELEASED FEB 19 1968 | SHEET 1 OF 2

QTY REQD -1	-102	-101	PART NO.	SPECIFICATION	DESCRIPTION	ELEC REF DES	CODE IDENT	ZONE	ITEM NO.
		1	805202-1		ASSY-THERMAL BLKT				1
	1		805202-2		ASSY-THERMAL BLKT				2
REF			805202-3		TEMPLATE PATTERN				3
			805202-4		TEMPLATE PATTERN				4
A/R			.003 MIL THK	S43015	ALUMINIZED MYLAR				5
A/R			.00025 MIL THK	S43015	ALUMINIZED MYLAR				6
A/R			1300-108	4 STAR MILLS	PURE SILK MESH				7
									8
A/R			.50 WIDE		ALUMINIZED MYLAR TAPE				9
									10
		2	805207-1		DECAL-CAUTION				11
		1	805204-1		DECAL-NAMEPLATE				12
	REF	1	805208-1 $\boxed{1}$		DECAL-DESIGNATORS				13
									14
		REF	T805205		FORM BLOCK ASSY				15
REF	REF	REF		S43016	ULTRASONIC WELD SPEC				16
REF	REF	REF		S40111	IDENTIFICATION SPEC				17
REF	REF	REF		FED-STD 209A	FEDERAL STANDARD				18
		REF	805100		ENVELOPE DWG				19
									20
									21
									22
									23
									24
									25
									26
									27
									28
									29
									30

E: PARTS LIST ETAIL ASSEMBLY HERMAL BLANKET P-5 OGO-F LIST OF MATERIALS	SIZE A	CODE IDENT NO. 13126	LM NO. PL805202	REV
	SCALE NONE	RELEASED	SHEET 2 OF	

APPLICATION	
NEXT ASSY	FINAL ASSY

PARTS DISPOSITION
1. USE 3. CANNOT BE REWORKED
2. REWORK 4. RECORD 5.

P/L NO. PL805203 REV

REVISIONS

DISP	EFF	REV	DESCRIPTION	BY	CK	DATE	APPD

SHEET	REV		
INDEX	SHEET	1	2

INTERPRET THIS DRAWING PER STANDARDS IN MIL-D-70327
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS .X ± .1, .XX ± .03, .XXX ± .010, .XXXX ± .0050
ANGLES ± 0° 30'
SURFACE ROUGHNESS

HOLE DIA.	TOLERANCE
.035 THRU .125	+ .004 – .001
.126 THRU .250	+ .005 – .001
.251 THRU .500	+ .006 – .001
.501 THRU .750	+ .008 – .001
.751 THRU 1.000	+ .010 – .001
1.000 THRU 2.000	+ .012 – .001
2.001 AND OVER	LINEAR

CONTRACT NO. NAS 5-11095,
DRAWN Beasley 22JAN68
CHECK 1/24/68
MECH ENGR 1/24/68
ELECT ENGR
PROJ MGR 1/25/68
APPD
DESIGN ACTIVITY APPD 1-29-68
CUSTOMER

M L — MARSHALL LABORATORIES, TORRANCE, CALIFORNIA

TITLE PARTS LIST— BOARD, INSULATED TERMINAL EP-5 (OGO-F)

SIZE	CODE IDENT NO.	P/L NO.	REV
A	13126	PL805203	

SCALE NONE | RELEASED JAN 30 1968 | SHEET 1 OF 2

QTY REQD			PART NO.	SPECIFICATION	DESCRIPTION	ELEC REF DES	CODE IDENT	ZONE	ITEM NO.
	-1	-10							
		1	805203-1		ASSY INSULATED TERMINAL BD				1
	1		805203-2	MIL-P-18177 TYPE GEE	BOARD-SHEET (.031 THK) LAMINATE EPOXY-GLASS				2
		1	805203-3	MIL-P-18177 TYPE GEE	INSULATOR-SHEET (.062 THK) LAMINATE EPOXY-GLASS				3
									4
	8		3650-1	LYN-TRON	TERMINALS				5
									6
		A/R		S40149	GENERAL PURPOSE BONDING SPEC (EPIBOND 1210)				7
		REF		S40072	FABRICATION SPEC				8
		REF		S40111	IDENTIFICATION SPEC				9
									10
									11
									12
									13
									14
									15
									16
									17
									18
									19
									20
									21
									22
									23
									24
									25
									26
									27
									28
									29
									30

LE: PARTS LIST— BOARD, INSULATED TERMINAL EP-5 (060-F)	SIZE A	CODE IDENT NO. 13126	P/L NO. PL805203	REV
	SCALE NONE	RELEASED		SHEET 2 OF

APPLICATION	
NEXT ASSY	FINAL ASSY
805202-101	805202-101

PARTS DISPOSITION
1. USE 3. CANNOT BE REWORKED
2. REWORK 4. RECORD 5. ....

DWG. NO. PLT805205 REV

REVISIONS

DISP	EFF	REV	DESCRIPTION	BY	CK	DATE	APPD

SHEET INDEX	REV		
	SHEET	1	2

INTERPRET THIS DRAWING PER STANDARDS IN MIL-D-70327
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS: .X ± .1, .XX ± .03, .XXX ± .010, .XXXX ± .0050
ANGLES ± 0° 30′
√ SURFACE ROUGHNESS

HOLE DIA	TOLERANCE
.0135 THRU .125	+ .004 − .001
.126 THRU .250	+ .005 − .001
.251 THRU .500	+ .006 − .001
.501 THRU .750	+ .008 − .001
.751 THRU 1.000	+ .010 − .001
1.001 THRU 2.000	+ .012 − .001
2.001 AND OVER	LINEAR

CONTRACT NO. NAS 5-11095
DRAWN C. Golden 6 Feb 69
CHECK 7 Feb 69
MECH ENGR 2/8/69
ELECT ENGR
PROJ MGR 2/8/69
APPD
DESIGN ACTIVITY APPD 2-7-69
CUSTOMER

M L — MARSHALL LABORATORIES, TORRANCE, CALIFORNIA

TITLE PARTS LIST- FORM BLOCK ASSEMBLY, THERMAL BLANKET, EP-5 OGO-F

SIZE	CODE IDENT NO.	DWG NO.	REV
A	13126	PLT805205	

SCALE — RELEASED SEP 9 1969 SHEET 1 OF 2

FORM 34A

QTY REQD		-101	PART NO.	SPECIFICATION	DESCRIPTION	ELEC REF DES	CODE IDENT	ZONE	ITEM NO.
		1	T805205-1		FORM BLOCK				1
		1	T805205-2		SUPPORT				2
		1	T805205-3		BASE				3
		1	T805205-4		FLANGE				4
									5
									6
		REF.		S40111	IDENTIFICATION SPEC.				7
									8
									9
									10
									11
									12
									13
									14
									15
									16
									17
									18
									19
									20
									21
									22
									23
									24
									25
									26
									27
									28
									29
									30

TITLE: PARTS LIST-
FORM BLOCK ASSY,
THERMAL BLANKET,
EP-5 OGO-F

LIST OF MATERIALS

SIZE	CODE IDENT NO.	LM NO.	REV
A	13126	PLT805205	

SCALE | RELEASED | SHEET 2 OF

FORM 9B

APPLICATION	
ASSY	FINAL ASSY
UAL	—

PARTS DISPOSITION
1. USE 3. CANNOT BE REWORKED
2. REWORK 4. RECORD 5. ....

DWG. NO. MDL805801 REV

REVISIONS

DISP	EFF	REV	DESCRIPTION	BY	CK	DATE	APPD

SHEET	REV		
INDEX	SHEET	1	2

INTERPRET THIS DRAWING PER STANDARDS IN MIL-D-70327
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS .X ± .1, .XX ± .03, .XXX ± .010, .XXXX ± .0050
ANGLES ± 0° 30'
SURFACE ROUGHNESS

HOLE DIA.	TOLERANCE
.135 THRU .125	+ .004 − .001
.126 THRU .250	+ .005 − .001
.251 THRU .500	+ .006 − .001
.501 THRU .750	+ .008 − .001
.751 THRU 1.000	+ .010 − .001
1.000 THRU 2.000	+ .012 − .001
2.001 AND OVER	LINEAR

CONTRACT NO. NAS5-11095
DRAWN Beasley 2May68
CHECK [signature] 5-3-68
MECH ENGR
ELECT ENGR
PROJ MGR [signature] 5-6-68
APPD
DESIGN ACTIVITY APPD [signature]
CUSTOMER

MARSHALL LABORATORIES
TORRANCE, CALIFORNIA

TITLE MASTER DRAWING LIST SUB-SYSTEM THERMAL MOCKUP EP-5 (OGO-F)

SIZE	CODE IDENT NO.	DWG NO.	REV
A	13126	MDL 805801	

SCALE NONE RELEASED MAY 6 1968 SHEET 1 OF 2

1	2	3	4	5	6	7	8	9	QTY	DRAWING NUMBER	REV LTR	DRAWING TITLE	DWG SIZE
X									REF	805801		ASSY - SUB SYSTEM	
	X								1	PL805801-101		PARTS LIST - SUB SYSTEM	
	X								REF	805802		ASSY - INSULATION	
		X							1	PL805802-101		PARTS LIST - INSULATION	
		X							REF	805202		THERMAL BLANKET DETAIL ASSY	
			X						1	PL805202-101		PARTS LIST - THERMAL BLKT	
			X						1	PL805202-102		PARTS LIST - THERMAL BLKT - TOP	
		X							REF	805803		THERMAL MOCK-UP	
			X						1	PL805803-101		PARTS LIST - THERMAL MOCKUP	
			X						1	52168-102		PROPORTIONAL HEATER	
			X						REF	805810		BASE PLATE HARNESS	
				X					1	PL805810-101		PARTS LIST	
			X						4	805811-101		TERMINAL BOARD - ASSY	
			X						1	805203-101		TERMINAL BOARD ASSY	
			X						REF	805805		SEARCH COIL ASSEMBLE	
				X					1	PL805805-101		PARTS LIST - SEARCH COIL - X AXIS	
				X					1	PL805805-102		PARTS LIST - SEARCH COIL - Y AXIS	
				X					1	PL805805-103		PARTS LIST - SEARCH COIL - Z AXIS	
				X					3	SP30148-105		HOUSING & COVER	
				X					9	805811-101		TERMINAL BOARD ASSY	
				X					1	SP30307-1		STAMP (X-AXIS)	
				X					1	-2		(Y-AXIS)	
				X					1	-3		(Z-AXIS)	
				X					1	-37		(6A22-2-J1)	
				X					1	-38		(6A22-3-J1)	
				X					1	SP30307-39		STAMP (6A22-4-J1)	
				X					1	SP30148-11		COVER (FIXTURE)	
				X					1	T50747-104		FIXTURE, FOAMING	
			X						REF	805804		PREAMPLIFIER ASSY	
				X					1	PL805804-101		PARTS LIST PREAMP ASSY	
				X					3	805811-101		TERMINAL BOARD	
	X								1	805806-101		BOOM HARNESS	
	X								1	805807-101		EXTENSION HARNESS	
		X	X						REF	S43015		ALUMINIZED MYLAR SPEC	
	X	X	X	X	X				REF	805800		WIRING DIAGRAM	
		X	X						REF	S43016		ULTRASONIC WELD	
	X	X	X	X					REF	S40111		IDENTIFICATION SPEC	
		X	X						REF	FED-STD-209A		FEDERAL STANDARD	
			X	X					REF	S40091		CONFORMAL COATING SPEC.	
			X	X					REF	S40126		SOLDERING SPEC	
			X	X					REF	S4[illegible]149		BONDING SPEC	
	X	X	X	X					REF	S40172		MANUFACTURING SPEC	
			X	X					REF	[illegible]40379		SPOT POTTING SPEC	
	X								REF	[illegible]46865		TEST SPEC FOR	

L NO. N/A

MASTER DRAWING LIST
[illegible]B-SYSTEM
[illegible]ERMAL MOCKUP
[illegible]-5 (OGO-F)

SIZE	CODE IDENT NO.	DWG NO.	REV
A	13126	MDL 805801	

SCALE NONE | RELEASED | SHEET 2 OF

APPLICATION	
NEXT ASSY	FINAL ASSY
FINAL	

PARTS DISPOSITION
1. USE 3. CANNOT BE REWORKED
2. REWORK 4. RECORD 5. ....

DWG. NO. PL805801 REV

REVISIONS

DISP	EFF	REV	DESCRIPTION	BY	CK	DATE	APPD

SHEET	REV		
INDEX	SHEET	1	2

INTERPRET THIS DRAWING PER STANDARDS IN MIL-D-70327
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS: .X ± .1; .XX ± .03; .XXX ± .010; .XXXX ± .0050
ANGLES: ± 0° 30′
√ SURFACE ROUGHNESS

HOLE DIA	TOLERANCE
.0135 THRU .125	+ .004 − .001
.126 THRU .250	+ .005 − .001
.251 THRU .500	+ .006 − .001
.501 THRU .750	+ .008 − .001
.751 THRU 1.000	+ .010 − .001
1.000 THRU 2.000	+ .012 − .001
2.001 AND OVER	LINEAR

CONTRACT NO.	NAS 5-11095	
DRAWN	B. Easley	28 FEB 68
CHECK	[signature]	3/18/68
MECH ENGR	[signature]	3/18/68
ELECT ENGR		
PROJ MGR	[signature]	3/18/68
APPD		
DESIGN ACTIVITY APPD	[signature]	3/18/68
CUSTOMER		

M L — MARSHALL LABORATORIES, TORRANCE, CALIFORNIA

TITLE: PARTS LIST - ASSEMBLY SUB-SYSTEM, THERMAL MOCK UP, EP-5 (OGO-F)

SIZE	CODE IDENT NO.	DWG NO.	REV
A	13126	PL805801	

SCALE NONE | RELEASED [illegible] | SHEET 1 OF 2

QTY REQD		-101	PART NO.	SPECIFICATION	DESCRIPTION	ELEC REF DES	CODE IDENT	ZONE	ITEM NO.
		REF	805801-101		ASSY-SUB SYSTEM				1
									2
		1	805802-101		ASSY-INSULATION				3
		1	805806-101		ASSY- BOOM HARNESS				4
		1	805807-101		ASSY- EXTENSION HARNESS				5
									6
		4	MS35215-60		SCREW, PAN HD, #10-32 X 1 1/16				7
									8
		A/R	1/4 MIL X 2.0 X A/R		ALUMINIZED MYLAR				9
		A/R	2 MIL X 0.5 X A/R	TYPE 805	TAPE, ALUMINIZED MYLAR ADHESIVE				10
		A/R	3 MIL X 1.0 X A/R	S43015	ALUMINIZED MYLAR				11
		A/R	3 MIL X A/R X A/R	S43015	ALUMINIZED MYLAR				12
		A/R	1/4 MIL X A/R X A/R	S43015	ALUMINIZED MYLAR				13
									14
		REF		S40111	IDENTIFICATION SPEC				15
		REF		S46865	TEST SPEC FOR				16
		REF	805800		WIRING DIAGRAM				17
		REF		S43016	ULTRASONIC WELD SPEC				18
		REF		FED-STD 209A	FEDERAL STANDARD				19
									20
									21
									22
									23
									24
									25
									26
									27
									28
									29
									30

E: ASSY - SUB SYSTEM THERMAL MOCKUP EP-5 (OGO-F)	SIZE A	CODE IDENT NO. 13126	LM NO. PL805801	REV
LIST OF MATERIALS	SCALE NONE	RELEASED	SHEET 2 OF	

APPLICATION	
NEXT ASSY	FINAL ASSY
805801-101	805801-101

PARTS DISPOSITION
1. USE 3. CANNOT BE REWORKED
2. REWORK 4. RECORD 5. ....

DWG. NO. PL805802

REV

REVISIONS

DISP	EFF	REV	DESCRIPTION	BY	CK	DATE	APPD

SHEET	REV																												
INDEX	SHEET	1	2																										

INTERPRET THIS DRAWING PER STANDARDS IN MIL-D-70327
DIMENSIONS ARE IN INCHES
TOLERANCES ON

DECIMALS	ANGLES
.X ± .1	± 0° 30′
.XX ± .03	
.XXX ± .010	.XXXX ± .0050

√ SURFACE ROUGHNESS

HOLE DIA.	TOLERANCE
.0135 THRU .125	+ .004 − .001
.126 THRU .250	+ .005 − .001
.251 THRU .500	+ .006 − .001
.501 THRU .750	+ .008 − .001
.751 THRU 1.000	+ .010 − .001
1.001 THRU 2.000	+ .012 − .001
2.001 AND OVER	LINEAR

CONTRACT NO	NAS5-11095	
DRAWN	Bensley	23 FEB 68
CHECK		
MECH ENGR		3/13/68
ELECT ENGR		
PROJ MGR		3/15/68
APPD		
DESIGN ACTIVITY APPD		
CUSTOMER		

M L

MARSHALL LABORATORIES
TORRANCE, CALIFORNIA

TITLE PARTS LIST — INSULATION, THERMAL MOCK-UP EP-5 (OGO-F)

SIZE	CODE IDENT NO.	DWG NO.	REV
A	13126	PL805802	

SCALE None | RELEASED [illegible] | SHEET 1 OF 2

QTY REQD		-101	PART NO.	SPECIFICATION	DESCRIPTION	ELEC REF DES	CODE IDENT	ZONE	ITEM NO.
		REF	805802-101		ASSY INSULATION THERMAL MOCKUP				1
									2
		1	805803-101		ASSY- THERMAL MOCKUP				3
		1	805202-101		THERMAL BLANKET				4
		1	805202-102		THERMAL BLANKET COVER				5
		A/R	1/4 MIL X 2.0 X A/R		ALUMINIZED MYLAR				6
		A/R	2 MIL X 0.5 X A/R		TAPE ALUMINIZED MYLAR				7
		A/R	3 MIL X 1.0 X A/R		ALUMINIZED MYLAR				8
		A/R			THREAD, DACRON				9
									10
		REF		FED-STD-209A	FEDERAL SPECIFICATION				11
		REF		S40111	IDENTIFICATION SPEC				12
		REF	AP 805802-101		ASSEMBLY PLAN				13
		REF	805100		ENVELOPE DWG				14
		A/R		S40149	GENERAL PURPOSE BONDING SPEC				15
									16
									17
									18
									19
									20
									21
									22
									23
									24
									25
									26
									27
									28
									29
									30

TITLE: PARTS LIST - THERMAL MOCKUP INSULATION	SIZE	CODE IDENT NO.	LM NO.	REV
	A	13126	PL 805802	

EP-5 LIST OF MATERIALS (OGO-F) | SCALE NONE | RELEASED | SHEET 2 OF

APPLICATION	
ASSY	FINAL ASSY
302-101	805801-101

PARTS DISPOSITION
1. USE 3. CANNOT BE REWORKED
2. REWORK 4. RECORD 5. ....

DWG. NO. PL805803

REV

REVISIONS

DISP	EFF	REV	DESCRIPTION	BY	CK	DATE	APPD

EET	REV				
DEX	SHEET	1	2	3	

PRET THIS DRAWING PER NDARDS IN MIL-D-70327
ENSIONS ARE IN INCHES
TOLERANCES ON
IMALS ± .1 ± .03 ± .010
ANGLES ± 0° 30'
.XXXX ± .0050
SURFACE ROUGHNESS

OLE DIA.	TOLERANCE
THRU .125	+ .004 − .001
THRU .250	+ .005 − .001
THRU .500	+ .006 − .001
THRU .750	+ .008 − .001
THRU 1.000	+ .010 − .001
THRU 2.000	+ .012 − .001
AND OVER	LINEAR

CONTRACT NO.	NAS 5-11095	
DRAWN	Bensley	28 FEB 68
CHECK	CHY	14 Mar 68
MECH ENGR		14 Mar 68
ELECT ENGR		
PROJ MGR		14 Mar
APPD		
DESIGN ACTIVITY APPD		3-15-68
CUSTOMER		

M L — MARSHALL LABORATORIES
TORRANCE, CALIFORNIA

TITLE PARTS LIST - ASSY; THERMAL MOCKUP; EP-5 (OGO-F)

SIZE	CODE IDENT NO.	DWG NO.	REV
A	13126	PL805803	

SCALE NONE RELEASED MAR 15 1968 SHEET 1 OF 2

QTY REQD			PART NO.	SPECIFICATION	DESCRIPTION	ELEC REF DES	CODE IDENT	ZONE	ITEM NO.
		-101							
		REF	805803-101		ASSY-THERMAL MOCK-UP				1
									2
		1	GE1250099	GSFC	BASEPLATE				3
		1	GD1250121	GSFC	PEDESTAL ASSY				4
		1	GD1250104	GSFC	BRACKET, CONNECTOR				5
		1	GD1250105	GSFC	BRACKET, SEARCH COIL SUPPORT				6
		2	GC1250109	GSFC	Z-SEARCH COIL CLAMP				7
		2	GC1250107	GSFC	Y-SEARCH COIL CLAMP				8
		2	GC1250108	GSFC	X-SEARCH COIL CLAMP				9
									10
		1	805805-101		ASSY-SEARCH COIL SENSOR	X-AXIS			11
		1	805805-102		ASSY-SEARCH COIL SENSOR	Y-AXIS			12
		1	805805-103		ASSY-SEARCH COIL SENSOR	Z-AXIS			13
		1	805804-101		ASSY-PRE-AMPLIFIER				14
		1	R76270	LOCKHEED	ASSY-ANTENNA				15
		4	805811-101		ASSY-TERMINAL BD	TB2-TB5			16
		1	805203-101		ASSY-TERMINAL BD	TB1			17
									18
		1	805810-101		BASE PLATE HARNESS				19
									20
		4	#44018	YSI	THERMISTORS	RT7-RT10			21
		1	52168-102		PROPORTIONAL HEATER				22
									23
		1	GJ1250208	GSFC	EXPERIMENT HARNESS				24
		REF	805800		WIRING DIAGRAM				25
		REF		S40091	SPEC CONFORMAL COATING				26
		4	GC1250111	GSFC	PEDESTAL ISOLATOR				27
		REF		S40126	SPEC, SOLDERING				28
		REF	AP805803-101		ASSEMBLY PLAN				29
									30

E: PARTS LIST SSEMBLY THERMAL MOCK-UP EP-5(O.O-F)	SIZE A	CODE IDENT NO. 13126	LM NO. PL805803	REV
LIST OF MATERIALS	SCALE NONE	RELEASED	SHEET 2 OF	

TY REQD -101	PART NO.	SPECIFICATION	DESCRIPTION	ELEC REF DES	CODE IDENT	ZONE	ITEM NO.
4	MS35215-55	GSFC	PAN HD BOLT, #10-32 X.526LG				31
4	MS35215-53		, #10-32 X.338LG				32
2	MS35214-40		, #8-32 X .401LG				33
8	MS35214-32		, #6-32 X 1.214LG				34
4	MS35214-28		X.588LG				35
4	MS35214-31		X .901 LG				36
3	MS35214-24		PAN HD BOLT, #6-32 X.338LG				37
29	MS15795-605		WASHER, №6				38
2	MS15795-607		WASHER №8				39
8	MS15795-608		WASHER №10				40
2	AN507C632-R5		FLAT HD BOLT 100° #6-32X.338				41
4	MS35218-27		SCREW PAN HD #6-32 X .50				42
4	MS20364D632		NUT, #6-32				43
4	NAS1131C32	GSFC	PAN HD SCREW, #6-32 X2.276				44
							45
3	TYPE 4T 3/8" WIDE 5/16-4T	GSFC	CLAMP (WECKESSER CO. INC)				46
3	TYPE 4T, 3/8" WIDE 1/16-4T		(WECKESSER CO. INC)				47
2	TYPE 4T 3/8" WIDE 3/16-4T		(WECKESSER CO. INC.)				48
2	GC1250195	GSFC	CLAMP MOD.				49
A/R	AWG 26	MIL-W-16878D	WIRE, HK-UP (TYPE E BROWN)				50
A/R	STYLE 20B	GUDEBROD BROS	LACING TAPE-NYLON				51
A/R		AMS3654	TUBING (AWG 26)				52
A/R		MIL-A-8625 TYPE I	ADHESIVE, EPIPHEN 825A BORDEN CHEMICAL				53
A/R	AWG 26	MIL-W-16878D	WIRE, HK-UP (TYPE-E' RED)				54
REF		S40111	IDENTIFICATION SPEC				55
REF		S40379	SPOT POTTING SPEC (RTV891)				56
REF		S40072	MANUFACTURING SPEC				57
A/R	AWG 26	MIL-W-16878D	WIRE, HK-UP (TYPE-E WHITE)				58
A/R	(EPIBOND 1210)	S4-0149	BONDING SPEC				59
							60

E: PARTS LIST SSEMBLY – THERMAL CKUP EP-5 (060-F)	SIZE A	CODE IDENT NO. 13126	LM NO. PL805803	REV
LIST OF MATERIALS	SCALE	RELEASED	SHEET 2 OF	

APPLICATION	
T ASSY	FINAL ASSY
303101	805833-101

PARTS DISPOSITION
1. USE 3. CANNOT BE REWORKED
2. REWORK 4. RECORD 5. ....

DWG. NO. PL805804

REV

REVISIONS

DISP	EFF	REV	DESCRIPTION	BY	CK	DATE	APPD

1 ITEMS TO BE FURNISHED BY STANFORD RESEARCH INST.

NOTES: (UNLESS OTHERWISE SPECIFIED)

SHEET INDEX	REV		
	SHEET	1	2

INTERPRET THIS DRAWING PER STANDARDS IN MIL-D-70327
DIMENSIONS ARE IN INCHES
TOLERANCES ON

DECIMALS	ANGLES
.X ± .1	± 0° 30'
.XX ± .03	
.XXX ± .010	.XXXX ± .0050

√ SURFACE ROUGHNESS

HOLE DIA.	TOLERANCE
.0135 THRU .125	+ .004 − .001
.126 THRU .250	+ .005 − .001
.251 THRU .500	+ .006 − .001
.501 THRU .750	+ .008 − .001
.751 THRU 1.000	+ .010 − .001
1.000 THRU 2.000	+ .012 − .001
2.001 AND OVER	LINEAR

CONTRACT NO	NAS 5-11095	
DRAWN	Bensley	20FEB68
CHECK	[illegible]	21Feb68
MECH ENGR	JB	23FEB68
ELECT ENGR		
PROJ MGR	[illegible] by RK	
APPD	[illegible]	2/23/68
DESIGN ACTIVITY APPD	[illegible]	
CUSTOMER		

ML

MARSHALL LABORATORIES
TORRANCE, CALIFORNIA

TITLE PARTS LIST
PRE-AMPLIFIER ASSEMBLY
THERMAL MOCK-UP
EP-5 (F24) (050-F)

SIZE	CODE IDENT NO.	DWG NO.	REV
A	13126	PL805804	

SCALE NONE | RELEASED FEB 26 1968 | SHEET 1 OF 2

FORM 34A

X-050-A

QTY REQD		-101	PART NO.	SPECIFICATION	DESCRIPTION	ELEC REF DES	CODE IDENT	ZONE	ITEM NO.
		REF	805804-101		PRE-AMP ASSY				1
									2
	1	1	C-6045-4-5	STANFORD RES. INST.	COVER-PRE-AMP CANISTER				3
	1	1	C-6045-4-6	STANFORD RES. INST.	CANISTER PRE-AMP				4
		REF		S46863	TEST SPEC FOR				5
	1	1	DBM-25P	CANNON	CONNECTOR (MALE)	6A24-2-J1			6
		4	D20418-2	CANNON	SCREW LOCK (FE-MALE)				7
	1	1	DEM-9S	CANNON	CONNECTOR (FE-MALE)	6A24-2-J2			8
		A/R	AWG 26	MIL-W-16878D	WIRE, HOOK-UP (TYPE 'E')	BRN			9
		A/R	AWG 26	MIL-W-16878D	WIRE, HOOK-UP (TYPE 'E')	WHT			10
		A/R	AWG 26	MIL-W-16878D	WIRE, HOOK-UP (TYPE 'E')	RED			11
		3	805811-101		TERMINAL BOARD	TB1, TB2 TB3			12
		A/R	STYLE 20B	GUDEBROD BROS	LACING TAPE NYLON (BLACK)				13
		1	RC05GF513J	MIL-R-11	RESISTOR (51K ± 5%)	R1			14
		2	No 44018	YSI	THERMISTOR	RT11 RT12			15
		A/R		AMS3654	SLEEVING				16
		REF		S40379	SPOT POTTING SPEC				17
		REF		S40091	CONFORMAL COAT. SPEC				18
		REF		S40111	IDENTIFICATION SPEC				19
		REF		S40149	BONDING SPEC (EPIBOND 1210)				20
		REF		S40126	SOLDERING SPEC				21
		REF		S40118	PROTECTIVE FINISH SPEC				22
		REF		S40092	FOAMING SPEC				23
		REF		S40072	FABRICATION SPEC				24
		REF	805800		WIRING DIAGRAM				25
	1	4		STANFORD RES. INST	SCREW, SLOTTED #8-32 RD HD, X 2 1/2 LG				26
	1	4		STANFORD RES. INST	NUT, HEX #8-32				27
	1	4		STANFORD RES. INST.	SPACER #8 X 1.92 LG				28
	1	2		STANFORD RES. INST.	SCREW SLOTTED #4-40 PAN HD X 1/4 LG				29
		1			STAMP (THERMAL MOCKUP)				30

TITLE	SIZE	CODE IDENT NO.	LM NO.	REV
LE: PARTS LIST — PRE-AMPLIFIER ASSY THERMAL MOCK-UP o-5 (OGO-F)	A	13126	PL805804	
LIST OF MATERIALS	SCALE NONE	RELEASED	SHEET 2 OF	

APPLICATION	
T ASSY	FINAL ASSY
03-101	805803-101

PARTS DISPOSITION
1. USE 3. CANNOT BE REWORKED
2. REWORK 4. RECORD 5. ....

DWG. NO. PL805805 REV

REVISIONS

DISP	EFF	REV	DESCRIPTION	BY	CK	DATE	APPD

SHEET	REV						
INDEX	SHEET	1	2	3			

ERPRET THIS DRAWING PER
TANDARDS IN MIL-D-70327
IMENSIONS ARE IN INCHES
TOLERANCES ON
ECIMALS ± .1 / X ± .03 / XX ± .010
ANGLES ± 0° 30'
.XXXX ± .0050
√ SURFACE ROUGHNESS

HOLE DIA.	TOLERANCE
135 THRU .125	+ .004 − .001
26 THRU .250	+ .005 − .001
51 THRU .500	+ .006 − .001
01 THRU .750	+ .008 − .001
51 THRU 1.000	+ .010 − .001
00 THRU 2.000	+ .012 − .001
01 AND OVER	LINEAR

CONTRACT NO.	NAS 5-11095	
DRAWN	R. Golden	15Feb69
CHECK	[illegible]	21Feb69
MECH ENGR	JB	23FEB 69
ELECT ENGR		
PROJ MGR	[illegible]	RK
APPD	[illegible]	2/2?/69
DESIGN ACTIVITY APPD	[illegible]	
CUSTOMER		

M L — MARSHALL LABORATORIES
TORRANCE, CALIFORNIA

TITLE PARTS LIST — SEARCH COIL SENSOR ASSY, THERMAL MOCKUP EP-5 OGO-F (F-22)

SIZE	CODE IDENT NO.	DWG NO.	REV
A	13126	PL805805	

SCALE RELEASED FEB 2 6 1969 SHEET 1 OF 3

QTY REQD			PART NO.	SPECIFICATION	DESCRIPTION	ELEC REF DES	CODE IDENT	ZONE	ITEM NO.
-103	-102	-101							
1	1	1	SP30148-105		HOUSING & COVER				1
									2
									3
1	1	1	DAM-15P	CANNON	CONNECTOR	6A22-2-J1 6A22-3-J1 6A22-4-J1			4
2	2	2	D20418-2	CANNON	SCREW LOCK (FEMALE)				5
									6
3	3	3	805811-101		TERMINAL BOARD ASSY	TB1, TB3	TB2,		7
3	3	3	RC07GF152J	MIL-R-11/3	RESISTOR (1.5K±5%)	R1, R3	R2,		8
2	2	2	Nº 44018	YSI	THERMISTOR	RT1 THRU	RT6		9
									10
									11
									12
REF	REF	REF		S46864	TEST SPEC				13
		1	SP30307-1		STAMP (X-AXIS)				14
	1		SP30307-2		STAMP (Y-AXIS)				15
1			SP30307-3		STAMP (Z-AXIS)				16
									17
		1	SP30307-37		STAMP (6A22-2-J1)				18
	1		SP30307-38		STAMP (6A22-3-J1)				19
1			SP30307-39		STAMP (6A22-4-J1)				20
									21
REF	REF	REF	805800		WIRING DIAGRAM				22
A/R	A/R	A/R	STYLE 20B	GUEDEBROD BROS.	LACING TAPE NYLON (BLK)				23
A/R	A/R	A/R		AMS3654	SLEEVING				24
									25
1	1	1			STAMP (THERMAL MOCK UP)				26
									27
									28
A/R	A/R	A/R	AWG 26	MIL-W-16878D	WIRE, HOOK-UP (TYPE-E BRN)				29
A/R	A/R	A/R	AWG 26	MIL-W-16878D	WIRE, HOOK-UP (TYPE-E RED)				30

TITLE	SIZE	CODE IDENT NO.	LM NO.	REV
PARTS LIST - TECH COIL SENSOR ASSY - THERMAL MOCKUP TP-5 CGO-F	A	13126	PL805805	

LIST OF MATERIALS

SCALE | RELEASED | SHEET 2 OF

QTY REQD			PART NO.	SPECIFICATION	DESCRIPTION	ELEC REF DES	CODE IDENT	ZONE	ITEM NO.
102	103	101							
NR	NR	NR	AWG 26	MIL-W-16878D	WIRE, HOOK-UP (TYPE "E" WHITE)				31
									32
REF	REF	REF	T50742-104		FIXTURE, FOAMING				33
REF	REF	REF	SP30149-11		COVER (FIXTURE)				34
									35
REF	REF	REF		S40149	BONDING SPEC. (EPIBOND 1210)				36
REF	REF	REF		S40126	SOLDERING SPEC.				37
REF	REF	REF		S40118	PROTECTIVE FINISH SPEC.				38
REF	REF	REF		S40111	IDENTIFICATION SPEC.				39
REF	REF	REF		S40379	SPOT POTTING SPEC.				40
REF	REF	REF		S40092	FOAMING SPEC.				41
									42
REF	REF	REF		S40072	FABRICATION SPEC.				43
REF	REF	REF		S40091	CONFORMAL COATING SPEC				44
REF	REF	REF		S40318	BONDING SPEC. (U-1156)				45
									46
									47
									48
									49
									50
									51
									52
									53
									54
									55
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									58
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									60

TITLE	SIZE	CODE IDENT NO.	LM NO.	REV
PARTS LISTS - SEARCH COIL SENSOR ASSY, THERMAL MOCKUP EP-5 OGO-F	A	13126	PL805805	

LIST OF MATERIALS

SCALE | RELEASED | SHEET 2 OF

APPLICATION	
(T ASSY	FINAL ASSY
801-101	805801-101

PARTS DISPOSITION
1. USE 3. CANNOT BE REWORKED
2. REWORK 4. RECORD 5. ....

DWG. NO. PL805806 REV

REVISIONS

DISP	EFF	REV	DESCRIPTION	BY	CK	DATE	APPD

SHEET INDEX	REV		
	SHEET	1	2

ERPRET THIS DRAWING PER STANDARDS IN MIL-D-70327
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .1, .X ± .03, .XX ± .010, .XXXX ± .0050
ANGLES ± 0° 30′
SURFACE ROUGHNESS

HOLE DIA.	TOLERANCE
.035 THRU .125	+ .004 − .001
.126 THRU .250	+ .005 − .001
.251 THRU .500	+ .006 − .001
.501 THRU .750	+ .008 − .001
.751 THRU 1.000	+ .010 − .001
1.001 THRU 2.000	+ .012 − .001
2.001 AND OVER	LINEAR

CONTRACT NO. NAS 5-11095
DRAWN R. Golden 5 Feb 68
CHECK [illegible] 5 Feb 68
MECH ENGR [illegible] 2/5/68
ELECT ENGR
PROJ MGR [illegible] 2/5/68
APPD
DESIGN ACTIVITY APPD [illegible]
CUSTOMER

ML
MARSHALL LABORATORIES
TORRANCE, CALIFORNIA

TITLE PARTS LIST — BOOM HARNESS, THERMAL MOCKUP, EP-5 OGO-E

SIZE A | CODE IDENT NO. 13126 | DWG NO. PL805806 | REV

SCALE — | RELEASED FEB 5 1968 | SHEET 1 OF 2

QTY REQD	-101	PART NO.	SPECIFICATION	DESCRIPTION	ELEC REF DES	CODE IDENT	ZONE	ITEM NO.
	1	DD53570	CANNON	DUST CAP (FEMALE)				1
	1	DCM-37S	CANNON	CONNECTOR	3A10-P1			2
	1	DAM-15S			3A10-P2			3
	1	DEM-25P			3A10-P3			4
	1	DDM-50S		CONNECTOR	3A6-J11			5
	1	DA53564		DUST CAP (FEMALE)				6
	1	DC50907-1		POTTING SHELL				7
	1	DA50905-1						8
	1	DB50906-1						9
	1	DD50908-1		POTTING SHELL				10
	1	DB53567		DUST CAP (MALE)				11
	1	DC53568		DUST CAP (FEMALE)				12
	4	D20419		SCREW LOCK (MALE)				13
	2	D20419-18						14
	2	D20420	CANNON	SCREW LOCK (MALE)				15
								16
	A/R	AWG 26	MIL-W -16878D	WIRE, HOOK-UP (TYPE E, WHITE)				17
	A/R	AWG 26	MIL-W -16878D	WIRE, HOOK-UP (TYPE E, RED)				18
	A/R	AWG 26	MIL-W -16878D	WIRE, HOOK-UP (TYPE E, BROWN)				19
								20
	A/R	STYLE 20B	GUDEBROD BROS.	LACING TAPE (NYLON)				21
	A/R	CRN TYPE 2 (CLEAR)	RAYCLAD	TUBING-THERMOFIT				22
								23
	REF.		S40111	IDENTIFICATION SPEC				24
	REF.		S40126	SOLDERING SPEC.				25
	REF.		S40092	CONNECTOR SEALING SPEC.				26
								27
								28
	REF.	805800		WIRING DIAGRAM				29
	1	107957-900	TRW	BOOM-MODIFIED (GFE)				30

TITLE: PARTS LIST - BOOM HARNESS THERMAL MOCKUP, EP-5 OGO-F

LIST OF MATERIALS

SIZE	CODE IDENT NO.	LM NO.	REV
A	13126	PL805806	

SCALE — RELEASED SHEET 2 OF

APPLICATION	
ASSY	FINAL ASSY
03-101	805801-101

PARTS DISPOSITION
1. USE 3. CANNOT BE REWORKED
2. REWORK 4. RECORD 5. ....

DWG. NO. PL805807 REV

REVISIONS

DISP	EFF	REV	DESCRIPTION	BY	CK	DATE	APPD

SHEET	REV		
INDEX	SHEET	1	2

INTERPRET THIS DRAWING PER STANDARDS IN MIL-D-70327
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS: .X ± .1; .XX ± .03; .XXX ± .010; .XXXX ± .0050
ANGLES ± 0° 30'
√ SURFACE ROUGHNESS

HOLE DIA.	TOLERANCE
.0135 THRU .125	+ .004 − .001
.126 THRU .250	+ .005 − .001
.251 THRU .500	+ .006 − .001
.501 THRU .750	+ .008 − .001
.751 THRU 1.000	+ .010 − .001
1.000 THRU 2.000	+ .012 − .001
2.001 AND OVER	LINEAR

CONTRACT NO.	NAS5-11095	
DRAWN	Beasley	30 Jan 68
CHECK	[illegible]	2 Feb 68
MECH ENGR	[illegible]	2/2/68
ELECT ENGR		
PROJ MGR	[illegible]	2/2/68
APPD		
DESIGN ACTIVITY APPD	[illegible]	2-2-68
CUSTOMER		

ML

MARSHALL LABORATORIES
TORRANCE, CALIFORNIA

TITLE PARTS LIST — BOOM EXTENSION HARNESS — THERMAL MOCK-UP EP-5 (OGO-F)

SIZE	CODE IDENT NO	DWG NO.	REV
A	13126	PL805807	

SCALE NONE RELEASED SHEET 1 OF 2

QTY REQD		-101	PART NO.	SPECIFICATION	DESCRIPTION	ELEC REF DES	CODE IDENT	ZONE	ITEM NO.
			805807-101		HARNESS-ASSY				1
		1	DDM-50P	CANNON	CONNECTOR	3A6-P11			2
		1	MS3106A28-21P(C)	AMPHENOL	CONNECTOR	3A6-P12			3
		1	DD50908-1	CANNON	POTTING SHELL				4
		1	DD53571	CANNON	DUST CAP				5
		2	D20418-2	CANNON	SCREW LOCK ASSY (FEMALE)				6
		A/R	STYLE 20B	GUEDE BROD BROS	LACING TAPE NYLON				7
									8
		REF		S40093	CONNECTOR POTTING SPEC				9
		REF		S40126	SOLDER SPEC				10
		REF		S40111	IDENTIFICATION SPEC				11
									12
		A/R	26 AWG	MIL-W-16878D	WIRE, HOOK-UP, TYPE 'E' (RED)				13
		A/R	26 AWG	MIL-W-16878D	WIRE, HOOK-UP, TYPE 'E' (WHITE)				14
		A/R	26 AWG	MIL-W-16878D	WIRE, HOOK-UP, TYPE 'E' (BROWN)				15
									16
		REF	805800		WIRING DIAGRAM				17
									18
									19
									20
									21
									22
									23
									24
									25
									26
									27
									28
									29
									30

TITLE	SIZE	CODE IDENT NO.	LM NO.	REV
LE: PARTS LIST- OOM EXTENSION HARNESS HERMAL MOCK-UP P-5 (OGO-F)	A	13126	PL805807	
	SCALE NONE	RELEASED		SHEET 2 OF

APPLICATION	
ASSY	FINAL ASSY
...01-101	805801-101

PARTS DISPOSITION
1. USE 2. REWORK 3. CANNOT BE REWORKED 4. RECORD 5. ....

DWG. NO. PL805808 REV

REVISIONS

DISP	EFF	REV	DESCRIPTION	BY	CK	DATE	APPD

SHEET INDEX			
REV			
SHEET	1	2	

...RPRET THIS DRAWING PER ...ANDARDS IN MIL-D-70327
...MENSIONS ARE IN INCHES
TOLERANCES ON
...CIMALS ± .1; ± .03; ...X ± .010 — ANGLES ± 0° 30'; .XXXX ± .0050
SURFACE ROUGHNESS

HOLE DIA.	TOLERANCE
...35 THRU .125	+ .004 − .001
...6 THRU .250	+ .005 − .001
...1 THRU .500	+ .006 − .001
...1 THRU .750	+ .008 − .001
...1 THRU 1.000	+ .010 − .001
...0 THRU 2.000	+ .012 − .001
...1 AND OVER	LINEAR

CONTRACT NO.	NAS 5-11095	
DRAWN	P. Gotchm	FEB 68
CHECK	[illegible]	5 FEB 68
MECH ENGR	[illegible]	2/5/68
ELECT ENGR		
PROJ MGR	[illegible]	2/5/68
APPD		
DESIGN ACTIVITY APPD	[illegible]	
CUSTOMER		

M L — MARSHALL LABORATORIES
TORRANCE, CALIFORNIA

TITLE: PARTS LIST — TEST HARNESS, THERMAL MOCKUP, EP-5 OGO-F

SIZE	CODE IDENT NO.	DWG NO.	REV
A	13126	PL805808	

SCALE — RELEASED FEB 5 1968 — SHEET 1 OF 2

TY REQD	-101	PART NO.	SPECIFICATION	DESCRIPTION	ELEC REF DES	CODE IDENT	ZONE	ITEM NO.
								1
	1	DBM-25P	CANNON	CONNECTOR	3AG-P13			2
								3
	1	MS3106A28-21S(C)	AMPHENOL	CONNECTOR	3AG-J12			4
								5
	2	D20419	CANNON	SCREW LOCK (MALE)				6
	1	DB50906-1	CANNON	POTTING SHELL				7
	1	DB53567	CANNON	DUST CAP				8
								9
								10
	A/R	AWG 26	MIL-W-16878D	WIRE, HOOK-UP (TYPE E WHITE)				11
	A/R	AWG 26	MIL-W-16878D	WIRE, HOOK-UP (TYPE E RED)				12
	A/R	AWG 26	MIL-W-16878D	WIRE, HOOK-UP (TYPE E BROWN)				13
								14
	A/R	STYLE 208	GUDEBROD BROS.	LACING TAPE (NYLON)				15
								16
								17
	REF		S40093	CONNECTOR SEALING SPEC.				18
	REF		S40111	IDENTIFICATION SPEC.				19
	REF		S40126	SOLDERING SPEC.				20
								21
								22
	REF	805800		WIRING DIAGRAM				23
								24
								25
								26
								27
								28
								29
								30

: PARTS LIST —
EST HARNESS,
HERMAL MOCKUP,
-5 OGO-F

LIST OF MATERIALS

SIZE	CODE IDENT NO.	LM NO.	REV
A	13126	PL805808	

SCALE. | RELEASED | SHEET 2 OF

APPLICATION	
ASSY	FINAL ASSY

PARTS DISPOSITION
1. USE 3. CANNOT BE REWORKED
2. REWORK 4. RECORD 5. ....

DWG. NO. PL805809 REV

REVISIONS

DISP	EFF	REV	DESCRIPTION	BY	CK	DATE	APPD

SHEET	REV			
INDEX	SHEET	1	2	

INTERPRET THIS DRAWING PER STANDARDS IN MIL-D-70327
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .1, .X ± .03, .XX ± .010, .XXXX ± .0050
ANGLES ± 0° 30'
SURFACE ROUGHNESS

HOLE DIA.	TOLERANCE
.135 THRU .125	+ .004 – .001
.126 THRU .250	+ .005 – .001
.251 THRU .500	+ .006 – .001
.501 THRU .750	+ .008 – .001
.751 THRU 1.000	+ .010 – .001
1.001 THRU 2.000	+ .012 – .001
2.001 AND OVER	LINEAR

CONTRACT NO. NAS 5-11095
DRAWN E. Gordon 13Feb68
CHECK [illegible] 26Feb68
MECH ENGR [illegible] 3/7/68
ELECT ENGR
PROJ MGR [illegible] 3/7/68
APPD
DESIGN ACTIVITY APPD [illegible]
CUSTOMER

M L — MARSHALL LABORATORIES
TORRANCE, CALIFORNIA

TITLE PARTS LIST-
SHIPPING CONTAINER, THERMAL SUB SYSTEM MOCK
EP-5 OGO-F

SIZE A | CODE IDENT NO. 13126 | DWG NO. PL805809 | REV

SCALE — | RELEASED MAR 8 1968 | SHEET 1 OF 2

TY REQD		PART NO.	SPECIFICATION	DESCRIPTION	ELEC REF DES	CODE IDENT	ZONE	ITEM NO.
	-101							
	1	805809-1		FRAMEWORK				1
	1	805809-2		TOP				2
	1	805809-3		BOTTOM				3
	1	805809-4		SIDE, LEFT				4
	1	805809-5		SIDE, RIGHT				5
	1	805809-6		END, FRONT				6
	1	805809-7		END, REAR				7
	1	805809-8		SUPPORT, FRONT				8
	1	805809-9		SUPPORT, CENTER				9
	1	805809-10		SUPPORT, REAR				10
	3	805809-11		CLAMP				11
	1	805809-12		PANEL, RIGHT				12
	1	805809-13		PANEL, LEFT				13
	A/R	805809-14	METHOD OPTIONAL	COMPLETE OUTSIDE PANELING				14
								15
	2	#1205-1B-4	STANLEY	HANDLE, CHEST				16
								17
	1	.187 DIA.	COM'L	PIN, DOWEL (CRES 1.0 LONG)				18
								19
	6	1/4-20	COM'L	WASHER, FLAT (CAD.R STL.)				20
	6	1/4-20	COM'L	WING NUT (CAD R STL.)				21
	6	1/4-20	COM'L	STUD, WOOD (3½ LONG)				22
	A/R	1/8 THK.	COM'L	RUBBER, NEOPRENE SHT. (MEDIUM HARD)				23
								24
	3	#289-F 2½x2½	STANLEY	HINGE, BUTT				25
	3	#156425ZP	CORBIN	CATCH, DRAW-PULL				26
								27
								28
								29
								30

PARTS LIST - ...PPING CONTAINER, ...NAL SUBSYSTEM ...UP EF-5 OGO-F... LIST OF MATERIALS	SIZE A	CODE IDENT NO. 13126	LM NO. PL805809	REV
	SCALE	RELEASED	SHEET 2 OF	

APPLICATION	
ASSY	FINAL ASSY
03-101	805801-101

PARTS DISPOSITION
1. USE 3. CANNOT BE REWORKED
2. REWORK 4. RECORD 5. ....

DWG. NO. PL805810 REV

REVISIONS

DISP	EFF	REV	DESCRIPTION	BY	CK	DATE	APPD

SHEET REV	REV																										
INDEX	SHEET	1	2																								

INTERPRET THIS DRAWING PER STANDARDS IN MIL-D-70327
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .1, ± .03, ± .010 | ANGLES ± 0° 30' | .XXXX ± .0050
SURFACE ROUGHNESS

HOLE DIA.	TOLERANCE
THRU .125	+ .004 – .001
THRU .250	+ .005 – .001
THRU .500	+ .006 – .001
THRU .750	+ .008 – .001
THRU 1.000	+ .010 – .001
THRU 2.000	+ .012 – .001
AND OVER	LINEAR

CONTRACT NO.	NAS 5-11095	
DRAWN	P Golden	31Jan68
CHECK	[illegible]	5Feb68
MECH ENGR	[illegible]	2/5/68
ELECT ENGR		
PROJ MGR	[illegible]	2/5/68
APPD		
DESIGN ACTIVITY APPD	[illegible]	2-5-68
CUSTOMER		

M L — MARSHALL LABORATORIES
TORRANCE, CALIFORNIA

TITLE PARTS LIST— BASEPLATE HARNESS, THERMAL MOCKUP, EP-5 OGO-F

SIZE	CODE IDENT NO.	DWG NO.	REV
A	13126	PL805810	

SCALE | RELEASED [illegible] | SHEET 1 OF 2

QTY REQD		PART NO.	SPECIFICATION	DESCRIPTION	ELEC REF DES	CODE IDENT	ZONE	ITEM NO.
	-101							
								1
	1	DAM-15P	CANNON	CONNECTOR	3A10-J2			2
								3
	1	DA50905-1	CANNON	POTTING SHELL				4
	1	DA53565	CANNON	DUST CAP				5
	2	D20418-2	CANNON	SCREW LOCK (FE-MALE)				6
								7
	A/R	AWG 26	MIL-W-16878D	WIRE, HOOK-UP (TYPE E WHITE)				8
	A/R	AWG 26	MIL-W-16878D	WIRE, HOOK-UP (TYPE E RED)				9
	A/R	AWG 26	MIL-W-16878D	WIRE, HOOK-UP (TYPE E BROWN)				10
								11
								12
	A/R	STYLE 20B	GUDEBROD BROS	LACING TAPE (NYLON)				13
	REF	805800		WIRING DIAGRAM				14
								15
								16
								17
	REF.		S40093	CONNECTOR SEALING SPEC.				18
	REF.		S40111	IDENTIFICATION SPEC.				19
	REF.		S40126	SOLDERING SPEC.				20
								21
								22
								23
								24
								25
								26
								27
								28
								29
								30

TITLE	SIZE	CODE IDENT NO.	LM NO.	REV
E: PARTS LIST - [illegible]SEPLATE HARNESS, [illegible]ERMAL MOCKUP, P-5 OGO-F	A	13126	PL805810	

LIST OF MATERIALS

SCALE | RELEASED | SHEET 2 OF

APPLICATION	
ASSY	FINAL ASSY

PARTS DISPOSITION
1. USE 3. CANNOT BE REWORKED
2. REWORK 4. RECORD 5. ....

P/L NO. PL805811 REV

REVISIONS

DISP	EFF	REV	DESCRIPTION	BY	CK	DATE	APPD

SHEET	REV																										
INDEX	SHEET	1	2																								

INTERPRET THIS DRAWING PER STANDARDS IN MIL-D-70327
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .1, ± .03, ± .010, .XXXX ± .0050
ANGLES ± 0° 30'
SURFACE ROUGHNESS

HOLE DIA.	TOLERANCE
.035 THRU .125	+ .004 − .001
.126 THRU .250	+ .005 − .001
.251 THRU .500	+ .006 − .001
.501 THRU .750	+ .008 − .001
.751 THRU 1.000	+ .010 − .001
1.001 THRU 2.000	+ .012 − .001
2.001 AND OVER	LINEAR

CONTRACT NO.	NAS 5-11095	
DRAWN	Beasley	22 JAN 68
CHECK		1/29/68
MECH ENGR		1/29/68
ELECT ENGR		
PROJ MGR		1/29/68
APPD		
DESIGN ACTIVITY APPD		
CUSTOMER		

M L — MARSHALL LABORATORIES, TORRANCE, CALIFORNIA

TITLE: PARTS LIST - BOARD INSULATED TERMINAL EP-5 (OGO-F)

SIZE	CODE IDENT NO.	P/L NO.	REV
A	13126	PL805811	

SCALE NONE | RELEASED JAN 30 1968 | SHEET 1 OF 2

QTY REQD			PART NO.	SPECIFICATION	DESCRIPTION	ELEC REF DES	CODE IDENT	ZONE	ITEM NO.
		-101							
			805811-101		ASSY- INSULATED TERMINAL BD.				1
		1	805811-1	MIL-P-18177 TYPE GEE	BOARD-SHEET (.031 THK) LAMINATE, EPOXY-GLASS				2
		1	805811-2		INSULATOR-(.010 MYLAR)				3
									4
		4	3650-1	LYN-TRON	TERMINALS				5
									6
		A/R		S40149	GENERAL PURPOSE BONDING SPEC (EPIBOND 1210)				7
		REF		S40072	FABRICATION SPEC				8
		REF		S40111	IDENTIFICATION SPEC				9
									10
									11
									12
									13
									14
									15
									16
									17
									18
									19
									20
									21
									22
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									26
									27
									28
									29
									30

TITLE	SIZE	CODE IDENT NO.	P/L NO.	REV
PARTS LIST BOARD, INSULATED TERMINAL COMPONENT [illegible]	A	13126	PL805811	

APPLICATION	
NEXT ASSY	FINAL ASSY
FINAL	FINAL

PARTS DISPOSITION
1. USE 3. CANNOT BE REWORKED
2. REWORK 4. RECORD 5. ....

DWG. NO. PL805900 REV

REVISIONS

DISP	EFF	REV	DESCRIPTION	BY	CK	DATE	APPD

SHEET INDEX	REV				
	SHEET	1	2		1

INTERPRET THIS DRAWING PER STANDARDS IN MIL-D-70327
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .1 ± .03 .XXX ± .010 .XXXX ± .0050
ANGLES ± 0° 30′
SURFACE ROUGHNESS

HOLE DIA.	TOLERANCE
.035 THRU .125	+ .004 − .001
.126 THRU .250	+ .005 − .001
.251 THRU .500	+ .006 − .001
.501 THRU .750	+ .008 − .001
.751 THRU 1.000	+ .010 − .001
1.001 THRU 2.000	+ .012 − .001
2.001 AND OVER	LINEAR

CONTRACT NO. NAS5-11095
DRAWN Benson 11APR68
CHECK [illegible] 16 April 68
MECH ENGR
ELECT ENGR
PROJ MGR E. Piaia
APPD
DESIGN ACTIVITY APPD [illegible] 4-17-68
CUSTOMER

MARSHALL LABORATORIES
TORRANCE, CALIFORNIA

TITLE PARTS LIST-ASSEMBLY-INTERFERENCE TEST CABLE EP-5 (OGO-F-22, F-24)

SIZE A CODE IDENT NO. 13126 DWG NO. PL805900 REV

SCALE NONE RELEASED APR 1 7 1968 SHEET 1 OF 2

QTY REQD -103	QTY REQD -102	QTY REQD -101	PART NO.	SPECIFICATION	DESCRIPTION	ELEC REF DES	CODE IDENT	ZONE	ITEM NO.
		REF	805900-101		HARNESS ASSY				1
	REF		805900-102		HARNESS ASSY				2
REF			805900-103		HARNESS ASSY				3
									4
	1		DCM-37S-NM	CANNON	CONNECTOR	3A10-P1			5
		1	DBM-25S-NM			3A10-P3			6
	1	1	DBM-25P-NM			3A10-J3X	6A24-1-P3		7
1			DAM-15S-NM			3A10-P2			8
1			DAM-15P-NM		CONNECTOR	3A6-P11			9
	1		DC50907-1		POTTING SHELL (37 PIN)				10
	1	2	DB50906-1		POTTING SHELL (25 PIN)				11
2			DA50905-1		POTTING SHELL (15 PIN)				12
	1		DC-59-20		DUST CAP (37S)				13
		1	DB-59-20		(25S)				14
	1	1	DB-60-20		(25P)				15
1			DA-59-20		(15S)				16
1			DA-60-20		DUST CAP (15P)				17
4	2	2	D20419-12		SCREW, LOCK ASSY (MALE)				18
	2	2	D20419-22	CANNON	SCREW, LOCK ASSY (MALE)				19
		A/R	22 AWG	MIL-W-16878D TYPE 22 BN	WIRE, FOUR COND. (TWISTED SHIELDED)				20
	A/R				THREE COND.				21
A/R	A/R	A/R			TWO COND. (TWISTED SHIELDED)				22
A/R					SINGLE COND. (SHIELDED)				23
A/R	A/R	A/R	22 AWG	MIL-W-16878D TYPE 22 BN	WIRE, HOOK-UP				24
A/R	A/R	A/R	PRC 1520		MOLDING MATERIAL				25
A/R	A/R	A/R	NEOPRENE (1/16" WALL)	MIL-S-6855B TYPE 2 GRADE 60	HARNESS JACKET				26
									27
REF	REF	REF		S40111	IDENTIFICATION SPEC				28
A/R	A/R	A/R		AMS3654	SLEEVING				29
REF	REF	REF		S40126	SOLDER SPEC				30

E: PARTS LIST ASSEMBLY- CABLE TERFERENCE TEST P-5 (OSO-F22, F24)	SIZE A	CODE IDENT NO. 13126	LM NO. PL805900	REV
LIST OF MATERIALS	SCALE NONE	RELEASED		SHEET 2 OF

ITEM 4

THERMAL ANALYSIS EP-5/OGO-F

(5 February 1968)
68-0110

THERMAL ANALYSIS

For

EXPERIMENT PACKAGE FIVE

OGO-F

CONTRACT NO. NAS 5-11095

Prepared By: D. E. Petrics
Project Engineer

Approved By: Eric Azari
Eric Azari
Program Manager

MARSHALL LABORATORIES
3530 Torrance Boulevard
Torrance, California

For

GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland

CONTENTS

FIGURES

1.0. INTRODUCTION

The purpose of this report is to present the results of the thermal analysis of the Experiment Package Five (EP-5) for the OGO-F Spacecraft. The EP-5 package contains portions of two experiments, F-22 and F-24 both within a thermal equilibrium blanket and mounted to the +Y end of the EP-5 boom.

This report contains the heat transfer equations and results of two "worst case" orbit conditions. These conditions are as follows:

I. The EP-5 is receiving normal insolation on its +X axis.

II. The EP-5 is shadowed by the spacecraft.

2.0 EXPERIMENT PACKAGE FIVE CONFIGURATION

The EP-5, as shown in Figure 1, is partially contained within a 11.0" x 9.5" x 9.0" parallel piped thermal envelope. The F-24 antenna extends beyond the thermal envelope and thus is not maintained within the thermally controlled environment. The thermal envelope, which makes up the electronics compartment, consists of multilayer aluminized mylar sheets and pure silk mesh arranged in a sandwich type construction with the mylar side facing out.

Within the environmental controlled electronics compartment are the search coil magnetometer coils and preamplifiers for the F-22 Search Coil Magnetometer Experiment, developed by Dr. E. Smith of JPL and Professor Holzer of UCLA, and the preamplifier for the F-24 VLF Antenna Experiment developed by Dr. Helliwell and Dr. R. Smith of Standford University. Because of the sensitivity of the experiments within the EP-5 to magnetic fields and RF noise, a non-magnetic proportional heater is used as an active temperature control device. The EP-5 proportional heater developed by Marshall Laboratories, is bonded to the baseplate and provides heat to the experiments by conduction and radiation from the baseplate. Figure 2 illustrates the EP-5 temperature control system. The electronics compartment has an acceptable temperature range of -20°C to +50°C and a minimum internal dissipation of .22 watts when the internal temperature is 12°C. Between the temperature range of 6°C and 12°C the dissipation may vary from 1.575 watts to .22 watts depending on the position of the spacecraft relative to the sun.

3.0 ORBITAL CONDITIONS

The orbit conditions used for this analysis of the OGO-F EP-5 container are for an eccentric earth orbit with an apogee of 1300 kilometers and a perigee of 400 kilometers at 82° prograde. During the one year life of the OGO-F vehicle, the EP-5 will be subjected to a wide

Figure 1 EP-5 DESIGN CONFIGURATION

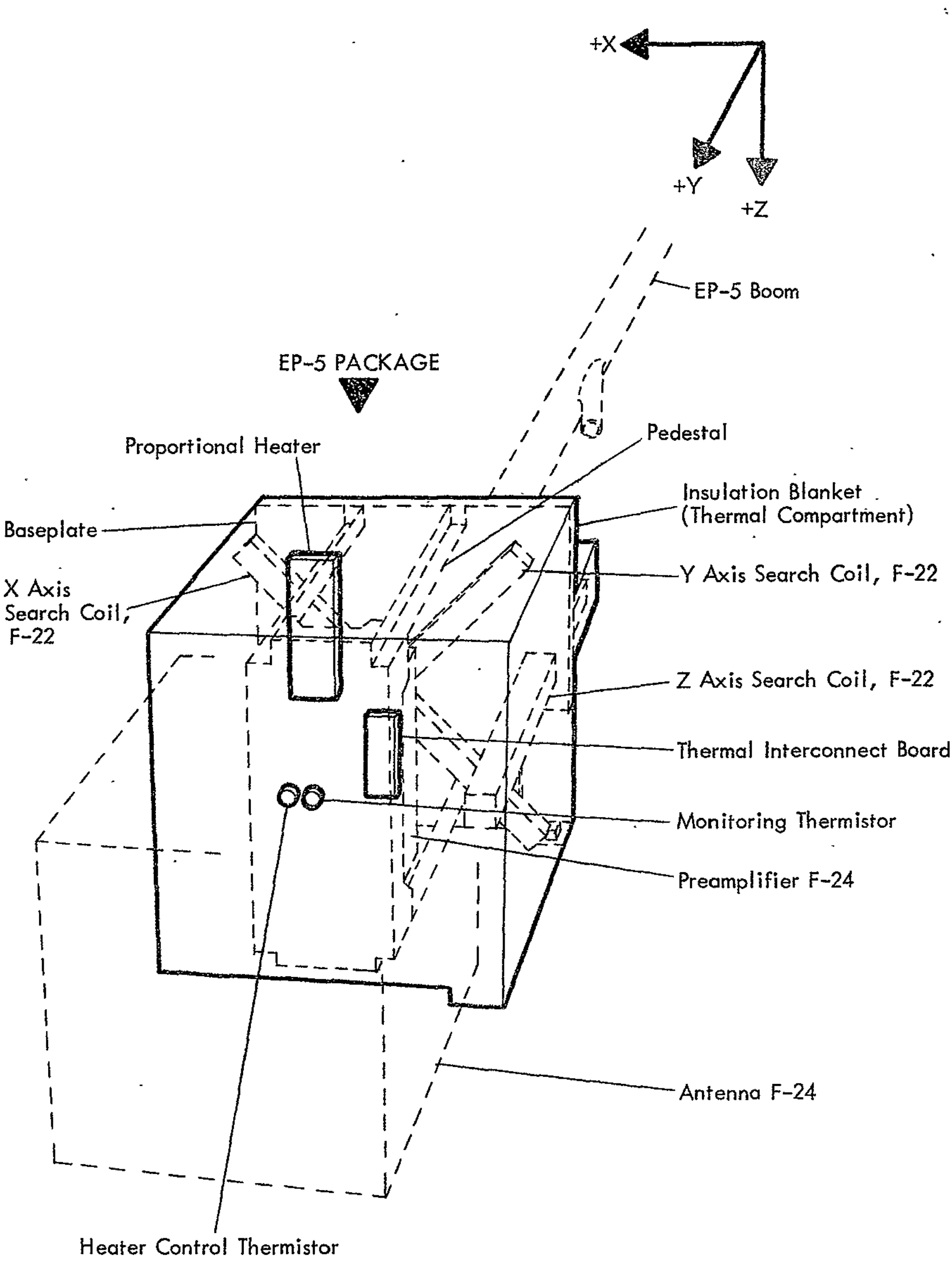
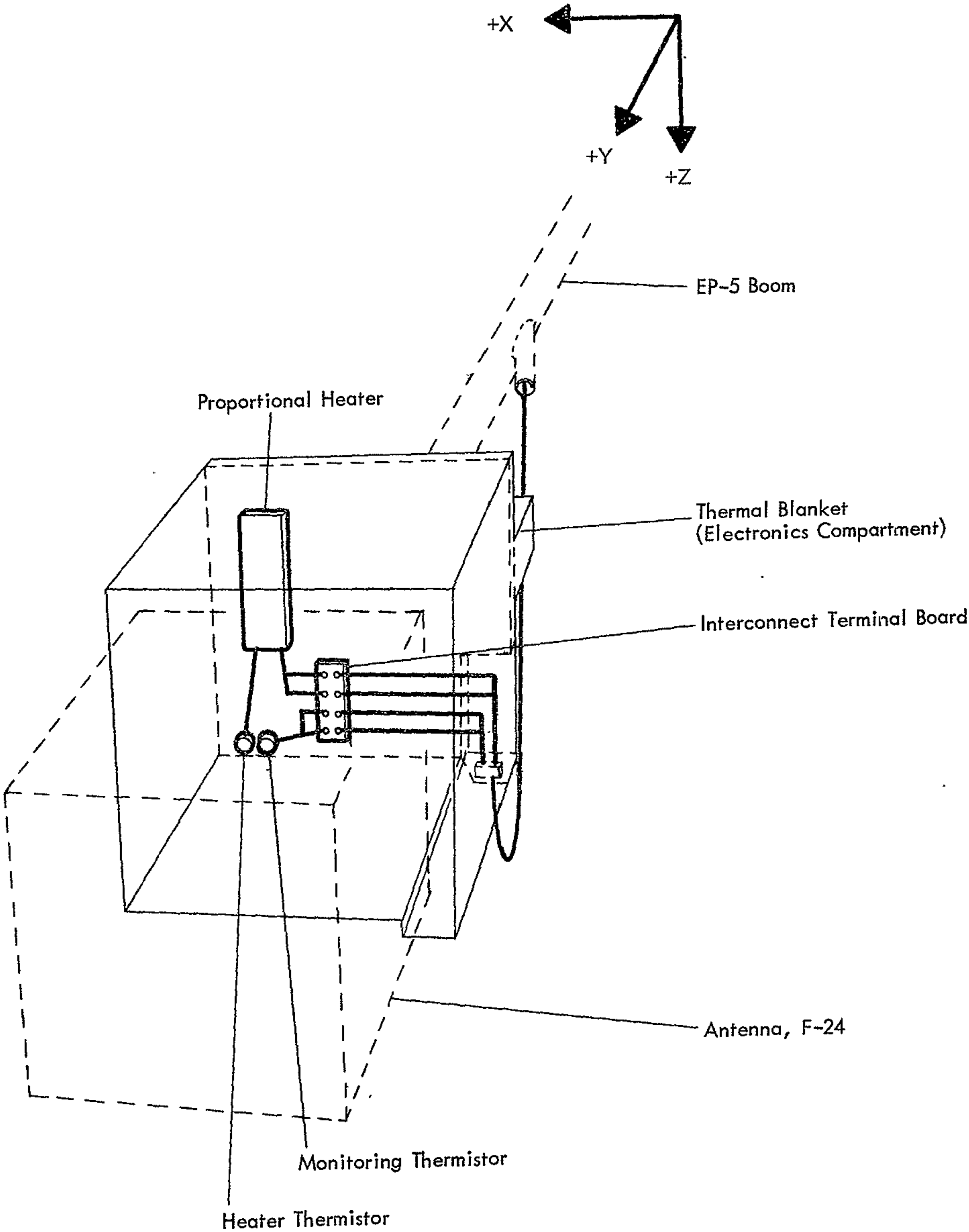


Figure 2 EP-5 THERMAL SUB-SYSTEM/OGO-F



range of thermal conditions. These conditions vary from an equilibrium eclipse, caused by spacecraft shadowing, to the case of normally incident solar irradiation on the +X surface. In all of these cases heat inputs from earth albedo and infrared radiation are negligible.

4.0 INTERNAL DISSIPATIONS

The following are estimated power dissipations within the EP-5 for various conditions of internal temperatures.

1. The three (3) F-22 Search Coil probes dissipate a total of .15 watts above $12^{\circ}C$ and 1.5 watts below $6^{\circ}C$.

2. The F-24 preamplifier dissipates a constant 15 milliwatts.

3. The EP-5 proportional heater dissipates 60 milliwatts above $12^{\circ}C$ and 10 watts at 28 VDC below $6^{\circ}C$.

5.0 LIST OF SYMBOLS

q_L	=	total compartment heat loss, BTU/hr.
q_B	=	heat loss through the wire bundle and/or boom, $^{\circ}F$/BTU/hr.
T_i	=	internal temperature of the EP-5, degrees Rankine
k/l	=	conductance of insulation per unit area, BTU/hr-ft^2-$^{\circ}R$
A_1	=	area of insulation on the solar irradiated surface, ft^2
T_1	=	temperature of the outer surface of insulation on A_1, degrees Rankine
A_2	=	area of insulation $\pm$ X, $\pm$ Y, and $\pm$ Z EP-5 surfaces which radiate to space, ft^2
T_2	=	temperature of the outer surface of insulation on A_2, degrees Rankine
ϵ	=	infrared emissivity of the outer surface of insulation
σ	=	Stefan - Boltzman constant (0.173×10^{-8} BTU/hr - ft^2 - $^{\circ}R^4$)

$_s$ = solar absorptivity of the outer surface of insulation

H_s = solar constant at earth's radius (442 ± 16 BTU/hr - ft^2).

The property values used for the following analysis are listed below

* $k/l = 0.010 \begin{smallmatrix} +.005 \\ -.000 \end{smallmatrix}$ BTU/hr - ft^2 - ^oR, * = 0.75 ± .04 and

* $\alpha_s = 0.24 \begin{smallmatrix} +.09 \\ -.04 \end{smallmatrix}$

* Data furnished by TRW Systems.

6.0 CONDITION I ANALYSIS

The assumed conditions where the EP-5 compartment is receiving normal solar irradiation on its +X surface. This analysis is based on the following assumptions:

1. The EP-5 compartment is in thermal equilibrium when the orbital position causes normal solar irradiation of the +X surfaces.

2. The inner surfaces of the insulation and the electronics form one isothermal system.

3. The heat flow along the boom and wire bundle is out of the respective package and is assumed to be 3.0 BTU/hr.

Based on the above assumptions the following equations describe the heat flow through the EP-5 compartment walls for this orbital condition.

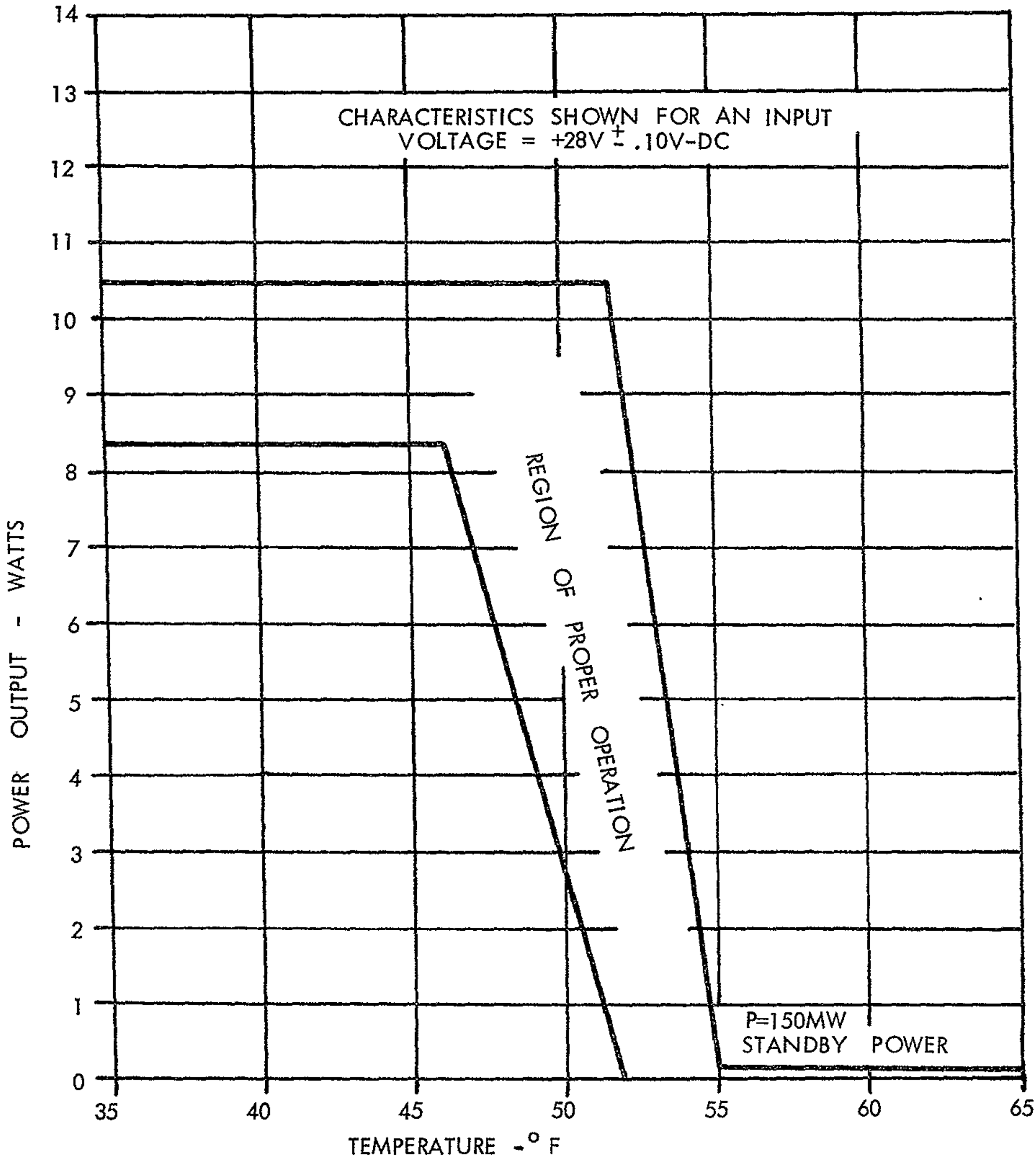
1. $q_L = q_B + (k/l)\,A_1\,(T_i - T_1) + (k/l)\,A_2\,(T_i - T_2)$

2. $(k/l)\,A_1\,(T_i - T_1) = \epsilon\sigma A_1\,T^4 - \alpha_s \cdot A_1\,H_s$

3. $(k/l)\,A_2\,(T_i - T_2) = \epsilon\sigma A_2\,T^4$

6.1 Nominal Values

Using nominal values for the listed properties and a value of $T_i = 45^oF$ which is the mid-point of the proportional heater cycle, the solutions of the above equations yield the following values for the EP-5 electronics compartment. A typical curve of the proportional heater cycle is shown in Figure 3.



PROPORTIONAL HEATER

INPUT— OUTPUT CHARACTERISTICS ML-306-3

Figure 3

$T_1 = 535^{\circ}R\ (75^{\circ}F),\ T_2 = 220^{\circ}R\ (-240^{\circ}F)$

and $q_L = 10.02$ BTU/hr = 2.94 watts

6.2 Adverse Tolerances

When adverse tolerances are applied to the above property values, solution of the above equations yields the following for the EP-5 compartment.

$T_1 = 593^{\circ}R\ (133^{\circ}F)$

$T_2 = 234^{\circ}R\ (-226^{\circ}F)$ and

$q_L = 9.48$ BTU/hr = 2.78 watts

6.3 Summary

For the case where nominal values are used for the solution of the above equations, the maximum heater power required to maintain the compartment temperature. (T_i) at $45^{\circ}F$ is 2.72 watts. When adverse tolerance is applied to the shield property values, the maximum heater power requirement is reduced to 2.56 watts. Both of these conclusions are less than the internal dissipations of .22 watts. Since heater power is required for all of the above conditions, the equilibrium compartment temperatures will fall between $+4^{\circ}C$ and $+12^{\circ}C$, thus no radiating area will be required for the EP-5 package electronics compartment.

7.0 CONDITION II ANALYSIS

The assumed condition where the EP-5 compartment is totally shadowed by the spacecraft in eclipse.

1. The EP-5 compartment is in thermal equilibrium when its orbital position causes the spacecraft to shadow the compartment from the sun.

2. The inner surfaces of the insulation and the electronics form one isothermal system.

3. The EP-5 compartment temperature is $45^{\circ}F$, the mid-point of the proportional heater cycle.

4. The heat flow along the boom and wire bundle is out of the EP-5 electronics compartment and is estimated to be 8.0 ± 1 BTU/hr.

The temperature of [illegible]

Based on the above assumptions the following equations describe the heat losses from the EP-5 electronic compartment for this condition.

1. $q_L = q_B + (k/l)\ A_2\ (T_i - T_2)$

2. $(k/l)\ A_2\ (T_i - T_2) = \epsilon \sigma A_2 T_2^{\,4}$

7.1 Nominal Values

Using nominal values for the listed properties and a value of $T_i = 45^{\circ}F$, which is mid-point of the proportional heater cycle, the solutions of the above equations yield the following values for the EP-5 electronics compartment:

$T_2 = 217^{\circ}R$ or $-243^{\circ}F$

$q_L = 16.75$ BTU/hr = 3.9 watts

7.2 Adverse Tolerances

When adverse tolerances are applied to the above property values, solution of the above equations yields the following for the EP-5 compartment:

$T_2 = 234^{\circ}R$ or $-226^{\circ}F$

$q_L = 18.8$ BTU/hr = 5.5 watts

7.3 Summary

For the case where nominal values are used for the solution of the above equations, the maximum heater power required to maintain the compartment temperatures (T_i) at $45^{\circ}F$ is 2.3 watts with the F-22 proportional heater functioning full on and 3.8 watts with the F-22 proportional heater off. When adverse tolerances are applied to the shield property values and the F-22 proportional heater is not functioning the maximum heater power will be 5.4 watts. Both of these conclusions are less than the internal dissipations of 1.6 watts.

8.0 CONCLUSIONS

Based on this analysis the EP-5 flight configuration will meet or surpass all the thermal environmental requirements which might be met during the OGO-F orbit. During the life of the vehicle, the temperature within the EP-5 electronics compartment can be expected to range between $+4^{\circ}C$ and $+12^{\circ}C$:

The average spacecraft heater power required for EP-5 during an orbit will vary over the range from 2.72 watts to 5.4 watts depending on its orbital position to the sun.

Therefore, the nominally ten (10) watt heater strip within the EP-5 proportional heater will be ample to support the desired thermal environment within the EP-5 electronic compartment plus provide quick recovery when required by orbital condition change.

9.0 REFERENCES

1. Thermal Analysis of Standard Boom-Mounted Experiment Packages, OGO Program, Contract No. NAS 5-899; TRW IOC 9723.1-127, dated 14 September 1962.

2. Kreith, Frank. Radiation Heat Transfer. Scranton, Penn.: International Textbook Company, 1962

ITEM 5

WORST CASE ANALYSIS

ELECTRICAL ANALYSIS

of

PROPORTIONAL HEATER

MODEL ML 306-1

&

MODEL ML 306-3

Prepared By

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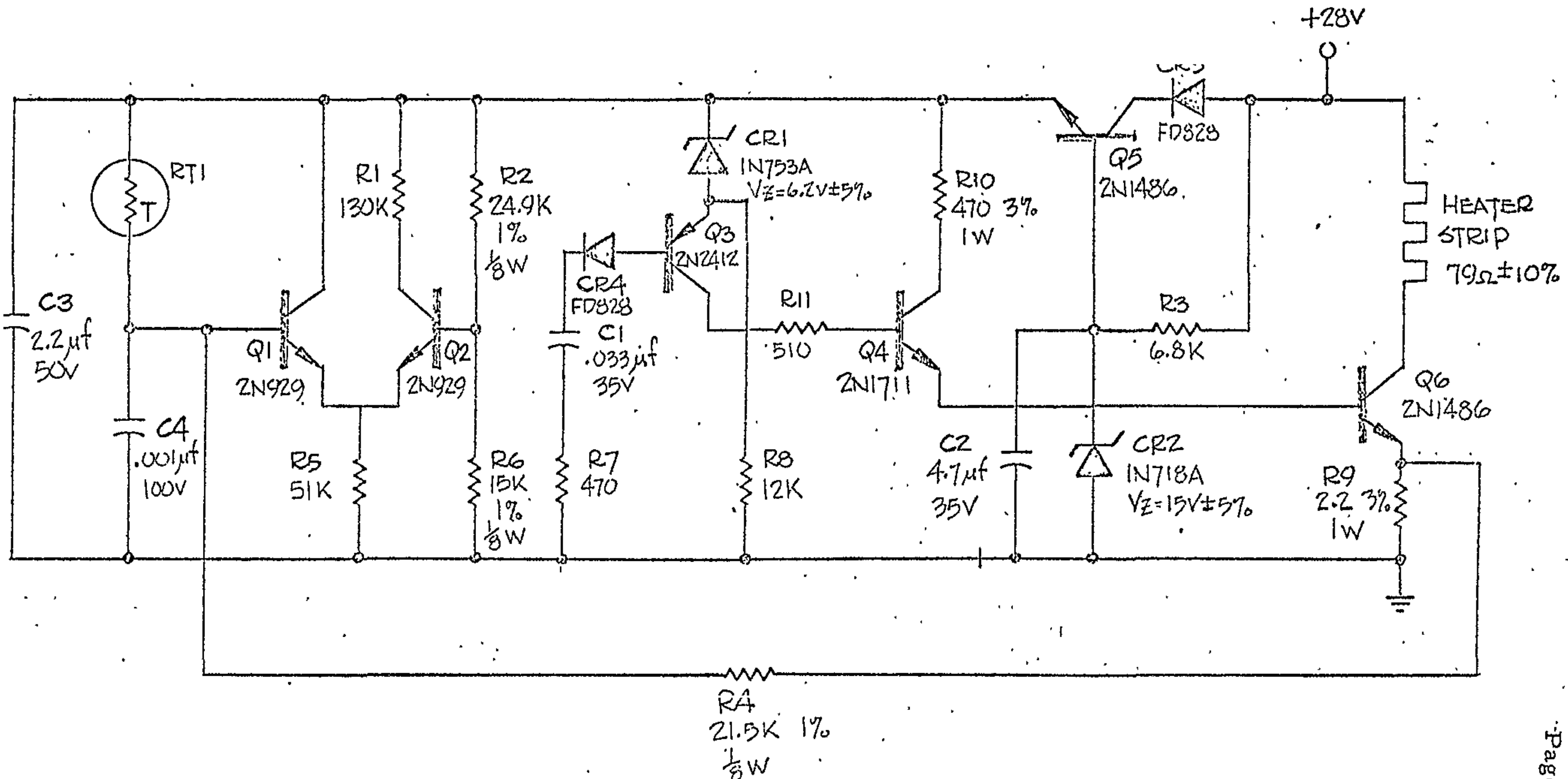
MARSHALL LABORATORIES
3530 Torrance Boulevard
Torrance, California

January 1968

CONTENTS



Proportional Heater ML 306-1

Circuit Schematic

Figure 1

I. Component Stress

The extent to which each component is stressed is calculated under the worst case conditions for each parameter rating of each component. The calculations are done separately because of the fact that all parameters of a component are not stressed at the worst case level for a single operating condition. A component stress summary table is included at the end of this section.

At $T = +10^{\circ}C$, $R_T = 35K\Omega$

At $T = -18^{\circ}C$, $R_T \doteq 70K\Omega$

At $T = +54^{\circ}C$, $R_T = 10K\Omega$

$V^+ = 14.3V$ = Regulated amplifier voltage

$\underline{Q_1}$ - 2N929

Worst Case: $T = -18^{\circ}C$, V_{BE}, V_{CB}, V_{CE}

$T = +54^{\circ}C$, I_c, P_d

Maximum Ratings:

$V_{BE} = 5V$ $\quad I_{cmax.} = 30$ ma

$V_{CB} = 50V$ $\quad P_{dmax.} = 240$mw @ $T = 54^{\circ}C$

$V_{CE} = 45V$

$$V_B = \frac{R_4 V^+}{R_T + R_4} = \frac{(21.5)(14.3)}{70 + 21.5} = 3.37V$$

$$V_E = V_{BQ_2} - V_{BESatQ_2} = \frac{R_6 V^+}{R_2 + R_6} - .55V = \frac{(15)(14.3)}{15 + 24.9} = 5.37 - .55 = 4.82V$$

$V_C = 14.3V$

$\underline{\underline{V_{BE}}} = 4.82 - 3.37 = 1.45V$ OK $\qquad \underline{\underline{V_{CB}}} = 14.3 - 3.37 = 10.93V$ OK

$\underline{\underline{V_{CE}}} = 14.3 - 4.82 = 9.48V$ OK

$$\underline{\underline{I_C}} = \frac{V_B - V_{BE(ON)}}{R_5} = \frac{\frac{R_4 V^+}{R_4 + R_T} - .55}{(51)} = \frac{\frac{(21.5)(14.3)}{21.5 + 10} - .55}{51} = 180\mu a \quad \text{OK}$$

$\underline{\underline{P_d}}$ negligible

Q_2 - 2N929

Worst Case: $T = -18^{\circ}C$, I_c, P_d

$T = +54^{\circ}C$, V_{BE}, V_{CB}, V_{CE}

Maximum Ratings

$V_{BE} = 5V \qquad I_{cmax.} = 30$ ma

$V_{CB} = 50V \qquad P_{dmax.} = 300mw$ @ $T = -18^{\circ}C$

$V_{CE} = 45V$

$$V_B = \frac{R_6 V^+}{R_2 + R_6} = 5.37V$$

$$V_E = V_{BQ_1} - V_{BE(ON)} = \frac{(21.5)(14.3)}{21.5 + 10} - .55 = 9.2V$$

$V_C = 14.3$ V

$\underline{\underline{V_{BE}}} = 9.2 - 5.37 = 3.83$ V [Stressed only during turn on] OK

$\underline{\underline{V_{CB}}} = 14.3 - 5.37 = 8.93$ V OK

$\underline{\underline{V_{CE}}} = 14.3 - 9.2V = 5.1V$ OK

$$\underline{\underline{I_C}} = \frac{V_B - V_{BE(ON)}}{R_5} = \frac{5.37 - .55}{51} = 95\mu a \quad \text{OK}$$

$\underline{\underline{P_d}}$ = negligible

Q_3 - 2N2412

Worst Case: $T = +10^{\circ}C$ (Switching), P_d

$T = -18^{\circ}C$, I_c

$T = +54^{\circ}C$, V_{BE}, V_{CB}, V_{CE}

Maximum Ratings

$V_{BE} = 5V$ $\quad I_{cmax.} = 200$ ma

$V_{CB} = 50V$ $\quad P_{dmax.} = 360$ mv @ $T = -18^{o}C$

$V_{CE} = 40V$

$V_B = 14.3V - V_{rCR_4} = 11.2$

$V_E = V^+ - V_{ZCR_1} = 14.5 - 6.2 \doteq 8.1V$

$V_C = 0^+$

$\underline{\underline{V_{BE}}} = 14.3 - 11.2 = 3.1V$ OK

$\underline{\underline{V_{CE}}} \doteq 8.1V$ OK

$\underline{\underline{V_{CB}}} = 14.3V$ OK

$$I_C = \frac{V^+ - V_{ZCR1} - V_{CE(Sat)\ Q3}}{R_{11} + \text{Rin } Q_4}$$

Rin $Q_4 = (R_9)\ (\beta + 1)\ Q_6 \times (\beta + 1)\ Q_4 = (2.2)\ (21)\ (26) = 1.2K\Omega$

$$\underline{\underline{I_C}} = \frac{14.3 - 6.2 - .2}{.51 + 1.2K} = \frac{7.9V}{1.7K} = 4.6 \text{ ma} \quad \text{OK}$$

$\underline{\underline{P_d}} = (4.05V)(2.3ma) = 9.3$ $\overline{\text{mw}}$ OK
at $10^{o}C$

$\underline{Q_4 - 2N1711}$

Worst Case: $T = +10^{o}C$ (Switching), P_d
$T = -18^{o}C$, I_c
$T = +54^{o}C$, V_{BE}, V_{CB}, V_{CE}

Maximum Ratings:

$V_{BE} = 7V$ $\quad I_{Cmax.} = 600$ ma

$V_{CB} = 75V$ $\quad P_{dmax.} = 500$ mw @ $T = 10^{o}C$

$V_{CE} = 50V$

$V_B = 0^+$

$V_C = 14.3$ V

$V_E = 0^+$

$\underline{\underline{V_{CE}}} = 14.3$ OK

$\underline{\underline{V_{CB}}} = 14.3$ OK

$\underline{\underline{V_{BE}}} = V_{BE(on)} =$OK

$$\underline{\underline{I_C}} = \frac{V^+ - V_{eQ6} + V_{BE(On)Q6} - V_{CE(sat)Q4}}{R_{10}}$$

$$= \frac{14.3 - .6 - .7 - .2}{470} = \frac{13.2}{470} = 28 \text{ ma} \quad \text{OK}$$

$\underline{\underline{P_{dmax.}}} = (6.6V)(14ma) = 92.5$ mw [Safety factor of 5]

$\underline{Q_5}$ - 2N1486

Worst Case: $E^+ = 42V$, V_{CE}, V_{CB}

$T = -18^\circ C$, I_{cmax}, P_{dmax}

V_{BE} always safe ($= V_{BE(on)}$)

Maximum Ratings:

$V_{BE} = 6V$ $\qquad I_{C\ max} = 4A$ @ $10^\circ C$

$V_{CE} = 60V$ $\qquad P_{dmax} = 20$ watts @ $10^\circ C$

$V_{CB} = 80V$

$V_C = E^+ - V_{fCR3} = 42 - .7V = 41.3V$

$V_B = V_{ZCR2} = 15V$

$V_E = V_{ZCR2} - V_{BE(sat)} = 15V - .7V = 14.3V$

$\underline{\underline{V_{CE}}} = 41.3V = 14.3V = 27.0V$ OK

$\underline{\underline{V_{CB}}} = 41.3 - 15V = 26.3V$ OK

$\underline{\underline{I_C}} = I_{Cmax}\ Q_4 + I_{Cmax}\ Q_3 = 28$ ma + 4.6 ma = 32.6 ma [Only during turn on]

$\underline{\underline{P_d}} = I_{Cmax} V_{CE} = (32.6ma)(27v) = .89W$ OK [Only during turn on]

$\underline{Q_6 \text{ - 2N1486}}$

Worst Case: $T = +54^{\circ}C$, V_{CE}, V_{CE}

$T = -18^{\circ}C$, $E^{+} = 42V$, $I_{Cmax.}$

$T = +10^{\circ}C$ (Switching), $P_{d\,max.}$

V_{BE}(Not Stressed)

$$\underline{\underline{I_{Cmax.}}} = \frac{E^{+} - V_{CE(sat)Q6}}{R\ \text{Heater} + R_9} = \frac{42 - .4}{70.6 + 2.0} = \frac{41.6}{72.6} = 575\ \text{ma} \quad \text{OK}$$

$\underline{\underline{P_{dmax.}}} = (14V)(290ma) = 4.1$ watts [Safety factor of 5]

$V_C = 42V$

$V_B = +0$

$V_E = 0$

$\underline{\underline{V_{CE}}} = 42V$ [Safety factor of .6]

$\underline{\underline{V_{CB}}} = 42V$ OK

R_1 - 130K, 5%, 1/4 watt

Worst Case: $T = -18^{o}C$

$$I_{R_1} = I_{CQ_2 \text{ (worst case)}} = 95\mu a$$

$$P_d = (I_{R_1})^2 R_1 = (95 \times 10^{-6})^2 (130 \times 10^3) = (.009 \times 10^{-6})(130 \times 10^3)$$

$$= .117 \text{ mw}$$

R_2 - 24.9K, 1%, 1/8 watt

Worst Case: None

$$I_{R_2} = \frac{V^+}{R_2 + R_6} = \frac{14.3}{24.9K + 15K} = 360\mu a$$

$$P_d = I_{R_2}{}^2 (R_2) = (.36 \times 10^{-3})^2 (24.9 \times 10^3) = 3.24 \text{ mw}$$

R_3 - 6.8K, 5%, 1/4 watt

Worst Case: $E^+ = 42V$

$$I_{R_3} = \frac{E^+ - V_{ZCR2}}{R_3} = \frac{42 - 15}{6.8K} = 3.95 \text{ ma}$$

$$P_d = (I_{R_3})^2 (R_3) = (16 \times 10^{-6})(6.8 \times 10^3) = 110 \text{ mw}$$

for nominal (+28V) input voltage

$$I_{R_3} = \frac{28 - 15}{6.8K} = 1.9 \text{ ma}$$

$$P_d = (1.9 \times 10^{-3})^2 (6.8 \times 10^3) = 27 \text{ mw} \cong 1/10\ P_d \text{ max.}$$ OK

R_4 - 21.5K, 1%, 1/8 watt

Worst Case: $T = +54^{o}C$

$$I_{R_4} = \frac{V^+}{R_T + R_4} = \frac{14.3}{10K + 21.5K} = .45 \text{ ma}$$

$$P_d = (.45 \times 10^{-3})^2 (21.5 \times 10^3) = 4.35 \text{ mw}$$

R_5 - 51K, 5%, 1/4 watt

Worst Case: $T = +54^{\circ}C$

$$I_{R_5} = \frac{\frac{R_4 \; V^+}{R_T + R_4} - V_{BE(ON)Q_1}}{R_5} = \frac{\frac{(21.5K)(14.3)}{10K + 21.5K} - .55V}{51K} = \frac{9.28V}{51K} = .18 \text{ ma}$$

$$P_d = (.18 \times 10^{-3})^2 (51 \times 10^3) = 1.7 \text{ mw}$$

R_6 - 15K, 1%, 1/8 watt

Worst Case: None

$$I_{R_6} = I_{R_2} = 360 \mu a$$

$$P_d = (360 \times 10^{-6})^2 \; (15 \times 10^3) = 2 \text{ mw}$$

R_7 - 470Ω, 5%, 1/4 watt

Worst Case: Power Turn-On

$$I_{R_7} = \frac{V^+ - V_{ZCR1} - V_{fCR4} - V_{BE(ON)Q3}}{R_7} = \frac{6.7V}{470} = 14.3 \text{ ma (Transient)}$$

$P_d = (14.3 \times 10^{-3})^2 (470) = 96$ mw (Transient) OK

R_8 -12K, 5%, 1/4 watt

Worst Case: $T = +54^{\circ}C$

$$I_{R_8} = \frac{V^+ - V_{ZCR_1}}{R_8} = \frac{14.3 - 6.2}{12K} = .75 \text{ ma}$$

$$P_d = (8.1V)(.75 \times 10^{-3}) = 6 \text{ mw}$$

R_9 - 2.2Ω, 3%, 1.25 watt @ $55^{\circ}C$, 2W @ $25^{\circ}C$

Worst Case: $T = -18^{\circ}C$, $E^+ = 42V$

$I_{R_9} = I_{CQ_6 \text{ (worst case)}} = 575$ ma [Only during turn on @ low temperature]

$P_d = (.575)^2\ (2.2) = 715$ mw $\longrightarrow$ (S. F. of 3 @ 10°C)

For nominal (+28V) input voltage :

$$I_{R_9} = \frac{V^+ - V_{CE(sat)Q6}}{R\ \text{Heater} + R_9} = \frac{28 - .4}{78.6 + 2.2} = 340 \text{ ma}$$

$P_d = (.34)^2(2.2) = (.12)(22) = 260$ mw = 13% of P_d max. [Only during turn-on]

<u>R_{10} - 470Ω, 5%,</u> 1.25 watt @ 55°C 2W @ 25°C

Worst Case: T = -18°C

$I_{R_{10}} = I_{CQ_{4(\text{worst case})}} = 28$ ma

$P_d = (28 \times 10^{-3})^2(470) = 370$ mw = 19% of P_d max. @ 10°C

<u>R_{11} - 510Ω, 5%, 1/4 watt</u>

$I_{R_{11}} = I_{CQ_{3(\text{worst case})}} = 4.6$ ma

$P_d = (4.6 \times 10^{-3})^2(510) = 10.8$ mw

<u>CR_1 - 1N753A, $V_z = 6.2V \pm 5\%$, I_r max. = 60 ma</u>

Worst Case: T = -18°C

$I_rCR_1 = I_{CQ_{3(\text{worst case})}} + I_{R_{8\,(\text{worst case})}} = 4.6 \text{ ma} + .75 \text{ ma} = 5.4\text{ma}$

$$P_d \leq 10\% \text{ of allowable } P_d$$

<u>CR_2 - 1N718A, $V_z = 15V \pm 5\%$, I_r max. = 21 ma</u>

Worst Case: T = +54°C, $E^+ = +42$, I_r max

$E^+ = -28V$ (Reversed Supply Voltage), I_f max.

$I_{rCR_2} = I_{R_{3(\text{worst case})}} = 3.9$ ma

$I_{fCR2} = \dfrac{-28V - V_{fCR_2}}{R_3} = \dfrac{27.3}{6.8K} = 4\ ma$; $P_{d\,max.} < 20\%$ of allowable P_d

<u>CR_3 - FD828, $V_f = .7V$, $I_{f\,max.} = 115$ ma</u>

Worst Case: $T = -18^{\circ}C$

$I_f CR_3 = I_{CQ_{5(\text{worst case})}} = 32.6$ ma ; $P_{d\,max.} < 20\%$ of allowable P_d

<u>CR_4 - FD828, $V_f = .7V$, $I_{f\,max.} = 115$ ma</u>

Worst Case: $T = -18^{\circ}C$

$I_f CR_4 = I_{CQ_{2(\text{worst case})}} = 95\mu a$

<u>C_1 - .033μf, 35 wvdc</u>

$V_{C_1} = V^+ = 14.3$ V

<u>C_2 - 4.7μf, 35 wvdc</u>

$V_{C_2} = V_{Z\,CR_2} = 15V$

<u>C_3 -2.2μf, 50WVDC</u>

$V_{CE} = V^+ = 14.3V$

<u>C_4 -1000pf, 100WVDC</u>

$V_{C4} < V^+ = 14V$

FIGURE 2
COMPONENT STRESS SUMMARY
ML 306-1

Transistors	V_{BE}	V_{CE}	V_{CB}	I_{Cmax}	P_d	I_{fmax}	I_{rmax}	WV max
Q1	29%	21%	20%	5%	5%			
Q2	77%*	18%	11%	5%	5%			
Q3	62%	20%	29%	5%	5%			
Q4	5%	29%	19%	5%	19%			
Q5	5%	44%	33%	5%	5%			
Q6	5%	70%	53%	14%	20%			
Diodes								
CR1					10%		9%	
CR2					20%	5%	18%	
CR3					20%	29%		
CR4					5%	5%		
Resistors								
R1					5%			
R2					5%			
R3					44%			
R4					5%			
R5					5%			
R6					5%			
R7					37% *			
R8					5%			
R9					57% *			
R10					19%			
R11					5%			
Capacitors								
C1								40%
C2								43%
C3								28%
C4								40%

* Transient Condition

D. C. Operation

Worst Case Voltage Gain

Stage #1 - Differential Amplifier

Q_1, Q_2 (2N929) Specifications:

1) $h_{FE} = 70$ at $T = -20^{\circ}C$, $Ic = 50\ \mu a$
   with safety factor of two, use h_{FE} min = 35

2) $V_{BE(On)} = .55V \pm 80$ mv @ $-8^{\circ}C$, $Ic = 50\ \mu a$

3) Assume max. offset $\left(V_{BE1} - V_{BE2}\right) = 80$ mv.

Below Threshold* (Q3 ON)

$$\frac{V^{+} - V_{CQ2}}{V_{B2} - V_{B1}} = Av_1 = \frac{Rin\ (Q3)}{2\left(\frac{Rs}{\beta} + r_e\ Q_1\right)}$$

$$Av_1 = \frac{1.7K}{2\left(\frac{9.35}{35} + .520\right)} = 1.1$$

Where Rin (Q3) = Rin of Q3

$$= (\beta + 1)\ Q_3\ X\ (R_{CR_1} + r_e\ Q_3)$$

$$= (26)\ (40 + 26) = 1.7K\Omega$$

$$R_s = \frac{R_6 R_2}{R_6 + R_2} = 9.35\ K\Omega$$

$$r_e Q_1 = \frac{26}{Ie} = \frac{26}{.05} = 520\Omega$$

Above Threshold* (Q3 OFF)

$$\frac{V^{+} - V_{CQ2}}{V_{B2} - V_{B1}} = Av_1 = \frac{R_1}{2\left(\frac{Rs}{\beta} + r_e Q_1\right)}$$

$$Av_1 = \frac{130K}{1.4K} = 93$$

* "Threshold" is defined as the point where transistor Q_3 changes from cut-off to conduction. As the temperature moves below the threshold, transistor Q_6 begins to conduct and power is dissipated in the heater strip.

Stage #2 - PNP Inverter

Q_3 - 2N2412 Specifications:

1) $h_{FE} = 50$ at $T = -20^\circ C$, $Ic = 1$ ma

∴ with safety factor of two, use h_{FE} min = 25

2) $V_{BE\ Sat} = .7V \pm .1V$ @ $Ic = 1$ ma, $T = 0^\circ C$

$$Av_2 = \frac{R_L}{R_e} \quad \text{where } R_e = R_{CR_1} + r_e Q_3 = 40 + \frac{26}{1\text{ ma}} = 66\,\Omega$$

$$R_L = R_9\,(\beta + 1)\,Q_6 \times (\beta + 1)\,Q_4 + R_{11}$$

$$= (2.2)\,(21)\,(31) + 510 = 1.9K\Omega$$

$$Av_2 = \frac{1.9K}{66} = 31$$

Stage #3 - Emitter Follower

Q_4 - 2N1711 Specifications:

1) $h_{FE} = 60$ at $T = -20^\circ C$, $Ic = 1$ ma

with safety factor of two, use h_{FE} min = 30

$$Av_3 = \frac{Rin}{Rin + R_{11}} \quad \text{where } Rin = R_9\,(\beta + 1)\,Q_6 \times (\beta + 1)\,Q_4$$

$$= (22)\,(21)\,(31) = 1.4K\Omega$$

$$= \frac{1.4K}{1.4 + .51} = .74$$

Stage #4 - NPN Inverter

Q_6 - 2N1486 Specifications:

1) $h_{FE} = 40$ at $T = -20^\circ C$, $Ic = 500$ ma

with safety factor of two, use h_{FE} min = 20

$$Av_4 = \frac{R\ Heater}{R_o} = \frac{78.4}{2.2} = 36$$

Total Open Loop Voltage Gain (Worst Case)

Below Threshold $\quad A_T = (Av_1)\ (Av_2)\ (Av_3)\ (Av_4)$

(Q_3 ON) $\quad = (1.1)\ (31)\ (.74)\ (36) = 910$

Best Case Voltage Gain

Use h_{FE} = 10 X(worst case)

Stage # 1

Below Threshold

(Q_3 ON)

$$Av_1 = \frac{\text{Rin } Q3 \parallel R_1}{2\left(\frac{Rs}{\beta} + r_e Q_1\right)}$$

where $\text{Rin } Q3 = (\beta + 1)\ Q_3 \text{ X } (R_{CR_1} + r_e\ Q_3)$

$$= (251)\ 40 + \frac{26}{.01} = 650K\Omega$$

$$\text{Rin } Q3 \parallel R_1 = \frac{(650)\ (130)}{650 + 130} = 110K\Omega$$

$$Av_1 = \frac{110K}{2\left(\frac{9.35K}{250} + .65\right)} = 85$$

$Rs = 9.35K$

$$\left.\begin{aligned} r_e Q_1 &= \frac{26}{.0} = 870\,\Omega \\ r_e Q_2 &= \frac{26}{.06} = 430\,\Omega \end{aligned}\right\} AV \sim 650\Omega$$

Above Threshold

(Q_3 OFF)

$$Av_1 = \frac{R_1}{1.3K} = \frac{130K}{1.3K} = 100$$

Full Power Output - Low Extreme

1) $$V_o = \left[\left(V_{BQ_{2\,(Hi)}} - V_{BQ_1} \right) - \left(V_{BQ_2} - V_{BQ_1} \right)_{\text{Threshold}} \right] A_{o\ Hi}$$

2) $$V_o = \frac{(28V)\ (R_9)}{R\ \text{Heater}} = \frac{(28)\ (2.2)}{78.6} = .78V$$

where $V_o = V_{eQ_6}$ $\quad V_{BQ_{2(Hi)}} = \dfrac{(1.02) R_6 V^+}{.98 R_2 + 1.02 R_6} =$

$$\frac{(15.3)(14.3)}{24.4 + 15.3} = 5.52$$

$A_{o(Hi)}$ = open loop voltage at emitter of

$$Q_6 = \frac{A_{T(Hi)}\ R_9}{R\ \text{Heater}}$$

$$= \frac{(156,000)(2.2)}{78.6} = 4340$$

$$V_o = \left(V_{BQ_{2\,(Hi)}} - V_{BQ_1} \right) A_{o(Hi)} - (.048)\ (A_{o(Hi)}) = .78V$$

$$(4340)\ \ (5.52)\ \ - (4340) V_{BQ_1}\ - 407 = .78$$

$$V_{BQ_1} = \frac{23,810}{4340} = 5.48V$$

$$V_{BQ_1} = V_o + \frac{V^+ - V_o\ R_4}{R_T + R_4} = .78 + \frac{(14.3 - .78)\ (21.5)}{R_T + 21.5} = 5.48V$$

$$R_T = \frac{(8.82)\ (21.5)}{4.7} \approx 40K\Omega$$

This is the smallest value of thermistor (R_T) resistance for which the heater power output will just reach its maximum.

Full Power Output - High Extreme

1) $$V_o = \left[\left(V_{BQ_2} - V_{BQ_1}\right) - \left(V_{BQ_2} - V_{BQ_1}\right)_{\text{Threshold}}\right] A_o\,(Lo)$$

2) $$V_o = \frac{(28v)\,R_9}{R\ \text{Heater}} = .78v \quad \text{where} \quad V_o = V_{eQ_6}$$

$$V_{BQ_{2(Lo)}} = \frac{.98\,R_6\,V^+}{1.02\,R_2 + .98\,R_6} = \frac{(14.7)(14.3)}{25.5 + 14.7} = 5.25V$$

$A_o\,(Lo)$ = open loop voltage at emitter of

$$Q_6 = \frac{A_{T(Lo)}\,R_9}{R\ \text{Heater}}$$

$$= \frac{(910)\,(2.2)}{78.6} = 25.5$$

1) $$V_o = \left(V_{BQ_{2\,(Lo)}} - V_{BQ_1}\right) A_{o(Lo)} - 0.1\,A_{o(Lo)} = .78V$$

$$(5.25)(25.5) - V_{BQ_1}(25.5) - 2.55 = .78\,v$$

$$V_{BQ_1} = \frac{130.67}{25.5} = 5.12V$$

$$V_{BQ_1} = V_o + \frac{(V^+ - V_o)\,R_9}{R_T\ R_4} = .78 + \frac{(14.3 - .78)\,(21.5)}{R_T + 21.5} = 5.12V$$

$$R_T = \frac{(9.18)\,(21.5)}{4.34} \approx 46K$$

This is the largest value of thermistor (R_T) resistance for which the heater power output will just reach its maximum.

Worst Case Operating Range - $\left(R_T\right) V_s \left(P_o\right) (E^+ = 28V)$

Low Threshold = 36.5K - .66K = 35.8K Ω

High Threshold = 36.5K + .66K = 37.2KΩ

Full power output point - low extreme = 40KΩ

Full power output point - high extreme = 46KΩ

For:

R_T = 35.8K, T = +13.0°C = 55.4°F
R_T = 37.2K, T = +12°C = 53.6°F
R_T = 40.0 K, T = +11°C = 51.8°F
R_T = 46.0 K, T = +7°C = 44.6°F

Maximum Power Output

$$P_o = \left(I_{CQ_6}\right)^2 \text{ R Heater}$$

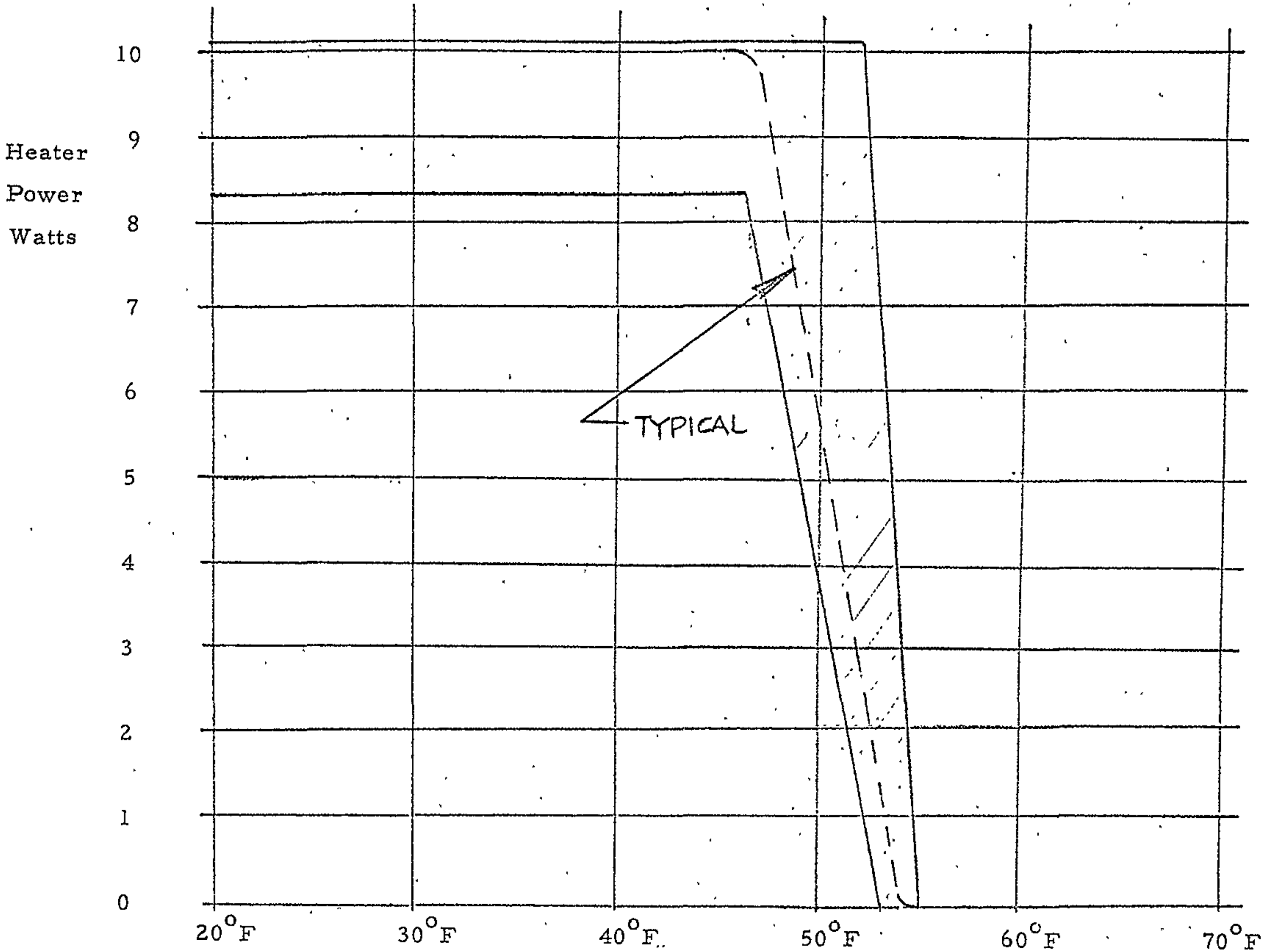
$$I_{CQ_6} = \frac{E^+ - V_{CEQ_{6sat}}}{\text{R Heater} + R_9} = \frac{28 - .4}{78.6 + 2.2}$$

$$P_o = (.342)^2 \ (78.6\Omega)$$

$$I_{CQ_6} = \frac{27.6}{80.8} = 342 \text{ ma}$$

P_o = 9.2 watts (nominal)

Worst case range ± 10% of nominal = 8.3 to 10.12 watts



PROPORTIONAL HEATER
INPUT - OUTPUT CHARACTERISTICS
FIGURE 3

Comparison Between Degrees Centigrade and Degrees Fahrenheit

Deg. C.	Deg. F.	Deg. C.	Deg. F.	Deg. C.	Deg. F.	Deg. C.	Deg. F.	Deg. C.	Deg. F.	Deg. C.	Deg. F.
−40	−40.0	8	46.4	56	132.8	104	219.2	152	305.6	200	392.0
−39	−38.2	9	48.2	57	134.6	105	221.0	153	307.4	201	393.8
−38	−36.4	10	50.0	58	136.4	106	222.8	154	309.2	202	395.6
−37	−34.6	11	51.8	59	138.2	107	224.6	155	311.0	203	397.4
−36	−32.8	12	53.6	60	140.0	108	226.4	156	312.8	204	399.2
−35	−31.0	13	55.4	61	141.8	109	228.2	157	314.6	205	401.0
−34	−29.2	14	57.2	62	143.6	110	230.0	158	316.4	206	402.8
−33	−27.4	15	59.0	63	145.4	111	231.8	159	318.2	207	404.6
−32	−25.6	16	60.8	64	147.2	112	233.6	160	320.0	208	406.4
−31	−23.8	17	62.6	65	149.0	113	235.4	161	321.8	209	408.2
−30	−22.0	18	64.4	66	150.8	114	237.2	162	323.6	210	410.0
−29	−20.2	19	66.2	67	152.6	115	239.0	163	325.4	211	411.8
−28	−18.4	20	68.0	68	154.4	116	240.8	164	327.2	212	413.6
−27	−16.6	21	69.8	69	156.2	117	242.6	165	329.0	213	415.4
−26	−14.8	22	71.6	70	158.0	118	244.4	166	330.8	214	417.2
−25	−13.0	23	73.4	71	159.8	119	246.2	167	332.6	215	419.0
−24	−11.2	24	75.2	72	161.6	120	248.0	168	334.4	216	420.8
−23	− 9.4	25	77.0	73	163.4	121	249.8	169	336.2	217	422.6
−22	− 7.6	26	78.8	74	165.2	122	251.6	170	338.0	218	424.4
−21	− 5.8	27	80.6	75	167.0	123	253.4	171	339.8	219	426.2
−20	− 4.0	28	82.4	76	168.8	124	255.2	172	341.6	220	428.0
−19	− 2.2	29	84.2	77	170.6	125	257.0	173	343.4	221	429.8
−18	− 0.4	30	86.0	78	172.4	126	258.8	174	345.2	222	431.6
−17	+ 1.4	31	87.8	79	174.2	127	260.6	175	347.0	223	433.4
−16	3.2	32	89.6	80	176.0	128	262.4	176	348.8	224	435.2
−15	5.0	33	91.4	81	177.8	129	264.2	177	350.6	225	437.0
−14	6.8	34	93.2	82	179.6	130	266.0	178	352.4	226	438.8
−13	8.6	35	95.0	83	181.4	131	267.8	179	354.2	227	440.6
−12	10.4	36	96.8	84	183.2	132	269.6	180	356.0	228	442.4
−11	12.2	37	98.6	85	185.0	133	271.4	181	357.8	229	444.2
−10	14.0	38	100.4	86	186.8	134	273.2	182	359.6	230	446.0
− 9	15.8	39	102.2	87	188.6	135	275.0	183	361.4	231	447.8
− 8	17.6	40	104.0	88	190.4	136	276.8	184	363.2	232	449.6
− 7	19.4	41	105.8	89	192.2	137	278.6	185	365.0	233	451.4
− 6	21.2	42	107.6	90	194.0	138	280.4	186	366.8	234	453.2
− 5	23.0	43	109.4	91	195.8	139	282.2	187	368.6	235	455.0
− 4	24.8	44	111.2	92	197.6	140	284.0	188	370.4	236	456.8
− 3	26.6	45	113.0	93	199.4	141	285.8	189	372.2	237	458.6
− 2	28.4	46	114.8	94	201.2	142	287.6	190	374.0	238	460.4
− 1	30.2	47	116.6	95	203.0	143	289.4	191	375.8	239	462.2
0	32.0	48	118.4	96	204.8	144	291.2	192	377.6	240	464.0
+ 1	33.8	49	120.2	97	206.6	145	293.0	193	379.4	241	465.8
2	35.6	50	122.0	98	208.4	146	294.8	194	381.2	242	467.6
3	37.4	51	123.8	99	210.2	147	296.6	195	383.0	243	469.4
4	39.2	52	125.6	100	212.0	148	298.4	196	384.8	244	471.2
5	41.0	53	127.4	101	213.8	149	300.2	197	386.6	246	474.8
6	42.8	54	129.2	102	215.6	150	302.0	198	388.4	248	478.4
7	44.6	55	131.0	103	217.4	151	303.8	199	390.2	250	482.0

FIGURE 4 Centigrade to Fahrenheit Conversion Chart

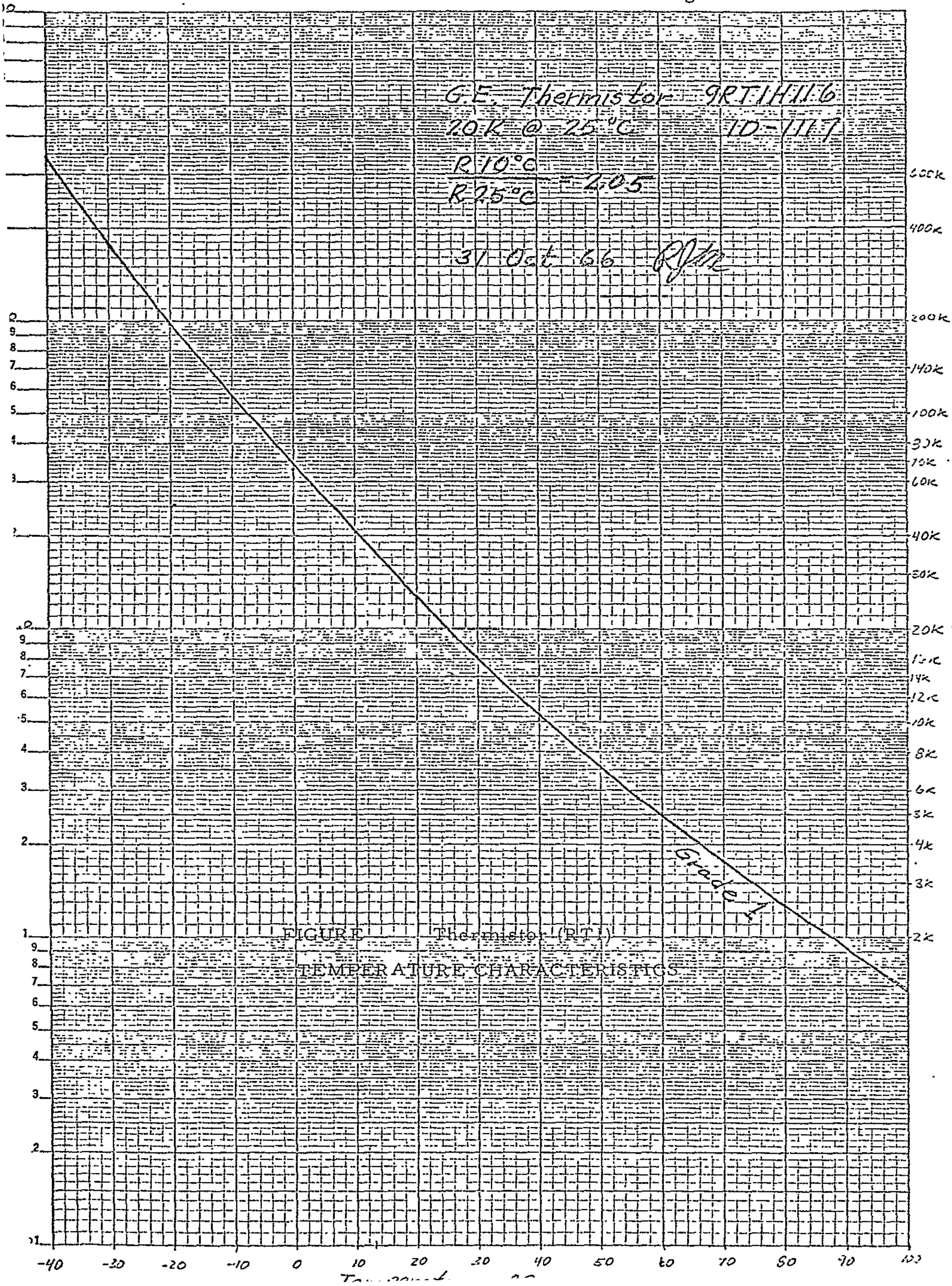


FIGURE Thermistor (RT1)

TEMPERATURE CHARACTERISTICS

Current required for full power output.

Base drive, Q_6 current requirements - using h_{FE} safety factor of 2.0

Worst Case - $E^+ = 32V$ = Input Voltage

$R_{Heater} = 70\Omega$

$R_9 = 2\Omega$

$V_{CE(sat)\,Q_6} = .2V$

$\min Q_6 = 20$

$$I_C = \frac{V^+ - V_{CE(sat)}}{R\,Heater + R_9} = \frac{32 - .2}{70 + 2} = 440 \text{ ma}$$

Required base drive for Q_6 saturation $= \frac{I_C}{\beta} = \frac{440\text{ma}}{20} = 22$ ma

---

$$I_{bQ_3} = I_{CQ_2} - I_{R_1}$$

$$I_{CQ_2} = \frac{V_{CQ2}}{R_5} = \frac{V_{BQ2} - V_{BE(sat)Q2}}{R_5} = \frac{\frac{R_6\,V^+}{R_6 + R_2} - .63}{56K} = \frac{\frac{(14.7)(14.3)}{(14.7)+(25.4)} - .63}{56} = 82\mu a$$

$$I_{bQ_3} = 82\mu a - \frac{V^+ - V_{Clamp}}{R_1} = 82\mu a - \frac{7.60}{117K} = 82 - 65\mu a = 17\mu a$$

$$I_{bQ_4} = I_{CQ_3} = \beta_{Q_3} I_{BQ_3}$$

$$I_{bQ_4} = (25)(17) = 425\ \mu a$$

$$I_{bQ_6} = (\beta + 1)_{Q_4} (I_{bQ_4}) = (31)(425\mu a) = 13.2 \text{ ma}$$

I_{bQ_6} (Worst Case) = 13.2 ma

I_{bQ_6} (required for full output) = 22 ma $\therefore$ Q6 will not saturate under worst case conditions

Current required for full power output.

Base drive, Q_6 current requirements - using h_{FE} safety factor = 1.5

Worst Case: $-E^+ = 32V$

$R_{Heater} = 70\Omega$

$R_9 = 2\Omega$

$V_{CE(sat)Q_6} = .2V$

$\beta min.\ Q_6 = \frac{40}{27} = 27$

$\beta min.\ Q_4 = \frac{60}{1.5} = 40$

$\beta min.\ Q_3 = \frac{50}{1.5} = 33\ 1/3$

$$I_C = \frac{V^+ - V_{CE(sat)\ Q6}}{R_{Heater} + R_9} = \frac{32 - .2}{70 + 2} = 440\ ma$$

Required base drive for Q_6 saturation $= \frac{I_C}{\beta Q_6} = \frac{440\ ma}{33.3} = 13.2\ ma$

Current required (S. F. = 1.5)

$$I_{bQ_3} = I_{CQ_2} - I_{R_1}$$

$$I_{CQ_2} = \frac{V_{CQ2}}{R_5} = \frac{V_{BQ2} - V_{BE(sat)\ Q2}}{R_5} = \frac{\frac{R_6 V^+}{R_6 + R_2} - .63}{56K} = 82\mu a$$

$$I_{bQ_3} = 82\mu a - \frac{V^+ - V_{Clamp}}{R_1} = 17\mu a$$

$$I_{bQ_4} = I_{CQ_3} = \beta\ Q_3\ I_{bQ_3}$$

$$I_{bQ_4} = (33.3)(17) = 566\mu a$$

$$I_{bQ_6} = (\beta + 1)\ Q_4\ (I_{eQ_4}) = (41)\ (566\mu a) = 23ma$$

$$I_{bQ_6\ (worst\ case)} = 23\ ma$$

I_{bQ_6} (required for full output) = 13.2 ma $\therefore$ Q_6 will produce full power output under worst case conditions.

Stage #2

$$A_{V2} = \frac{R_L}{R_e} \qquad \text{where} \qquad R_e = R_{CR_1} + r_e\, Q_3 = 40 + \frac{26}{.01} = 2.6K\Omega$$

$$R_L = \left[R_9 \, (\beta + 1)\, Q_6 \, (\beta + 1)\, Q_4 + R_{11}\right.$$

$$= \left[(2.2)\,(201)(301) + 510\right.$$

$$R_L \cong 133K$$

$$A_{V2} = \frac{133K}{2.6K} = 51$$

Stage #3

$$Av_3 = \frac{Rin}{Rin + R_{11}} \qquad \text{where} \qquad Rin = \left[R9\, (\beta + 1) + r_b Q_6\right] \times (\beta+1)\, Q_4$$

$$= 133K\Omega$$

$$Av_3 = \frac{133\,K\Omega}{133K\Omega + 510} \approx 1$$

Stage #4

$$Av_4 = \frac{R\ Heater}{R_9} = \frac{78.6}{2.2} = 36$$

Total Open Loop Voltage Gain (Highest Case)

Below Threshold $\quad A_T = (85)(51)(1)(36) = 156,000$

Voltage Regulation (Worst Case)

When the input voltage (E^+) is at minimum value (=23v), resistor R3 must supply enough current to bias zener CR2 below the knee of its V-I characteristic and to drive transistor Q5 under its maximum load condition.

$$\text{or} \quad I_{R3\,min} \quad 2\,I_{ZTCR2} + \frac{I_{eQ5(max)}}{(\ \ +1)\ \text{min Q5}}$$

$$\text{for} \quad E^+ = 23V,\ I_{eQ5(max)} \quad I_{eQ4\,max} = \frac{V^+}{R2+R6} + \frac{V^+ - V_{ZCR1}}{R8}$$

$$I_{eQ4\,max} = \frac{\dfrac{E^+ - V_{CE(sat)Q6}}{R\ Heater(Lo) + R_{9(Lo)}}}{(\ \ +1)\ Q6\ min.} = \frac{\dfrac{23 - .2}{70.8 + 2.0}}{21} = \frac{.313}{21} \quad 15\ \text{ma}$$

$$\frac{V^+}{R2 + R6} = \frac{14.3}{40K} = .36\ \text{ma}$$

$$\frac{V^+ - V_{ZCR1}}{R8} = \frac{8.1}{12K} = .75\ \text{ma}$$

$$I_{eQ5(max)} = 15\ \text{ma} + .36 + .75 \quad 16\ \text{ma}$$

I_{ZTCR2} (from Mf's specs) = .25 ma

$$I_{R3min} \quad .5\ \text{ma} + \frac{16\ \text{ma}}{21} = 1.27\ \text{ma}$$

$$I_{R3} = \frac{E^+_{(Lo)} - V_{ZCR2(Hi)}}{R_{3(Hi)}} = \frac{23 - 15.8}{7.1K} = \frac{7.2}{7.1K} \quad 1\ \text{ma}$$

R_3 provides insufficient current for proper voltage regulation. R_3 should be changed to a lower value in subsequent units.

III. AC Stability Analysis

Worst Case Conditions:

1. Voltage gains of each transistor stage are at highest levels.

2. Minimum gain bandwidth (f_T) figures are used for all transistors.

3. Miller enhancement of collector output capacitance (C_{ob}) in stages where voltage gain is present is assumed constant with frequency (thus neglecting effect of gain roll-off).

4. Nominal component values are used.

Using the above conditions, on A. C. equivalent circuit for the open loop is derived. The loop is broken at the emitter of transistor Q_6 producing a unity feedback configuration.

The transfer function for this circuit is derived from the equivalent circuit and the frequency response is plotted in figures and . At the point where the loop gain A drops to Odb, the phase shift is 180°. Under the worst case conditions specified above, this is an acceptable figure for phase margin. In subsequent configurations, component changes will be made to produce satisfactory phase-gain margin.

Stage Q_2

$$2N929 = \beta\text{max.} = 350$$

$$C_{ob} = 8\text{ pf}$$

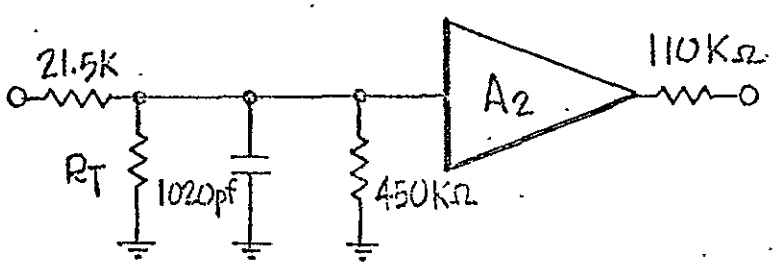
$$C_{ib} = 12\text{ pf}$$

$$R_o \cong r_c \| R_1 = 1M\Omega \| 130K = 110K\,\Omega$$

$$R_{in} = 2\beta(.65) = (2)(350)(.65) = 450K$$

$$f_T \text{ @ } I_c = 10\mu a = 4.2mc$$

$$T_\beta = \frac{A_1}{f_T} = \frac{\frac{R_L}{2r_e}}{4.2mc} = \frac{\frac{110K}{2.6K}}{4.2mc} = \frac{85}{4.2mc} \cong 20 \times 10^{-6} = \frac{1}{50KC}$$



$$A_2 = \frac{85}{1 + \frac{S}{2\pi 50\times10^3}} = \frac{85}{1 + \frac{S}{314 \times 10^3}}$$

Stage Q_3 2N2412

$r_b = 400\Omega$ $C_{ob} = 12$ pf

$C_{ib} = 8$ pf

$$R_{in}Q_3 = r_b + r_e(\beta+1) = .400 + (2.6)(250) \approx 650K\Omega$$

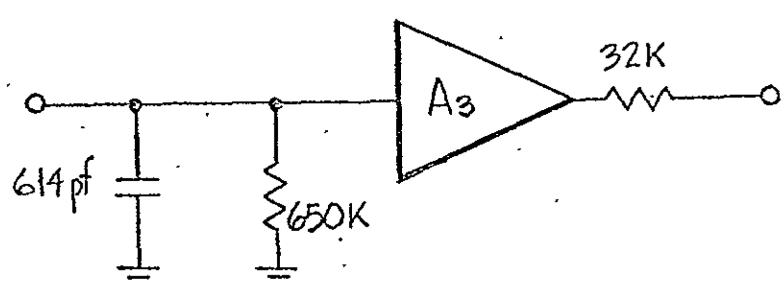
$$R_0Q_3 = r_c(1-\alpha) + r_e + \frac{r_e(r_c - r_e)}{R_g + r_e + r_b} = \frac{10^6}{\beta} + 2.6K + \frac{2.6K(997K)}{100K + 2.6K}$$

$$R_0Q_3 = 4K + 2.6K + 25.4K = 32K$$

$$(A+1)(C_{ob}) + C_{ib} = (51)(12) + 8 = 614pf$$

$f_T =$ mc @ $I_c = 10$ ma

$$T_\beta = \frac{A_{V3}}{f_T} = \frac{\frac{133K}{2.6K}}{125\,mc} = \frac{51}{125\,mc} \approx \frac{1}{2.5mc}$$



$$A_3 = \frac{51}{1 + \frac{S}{15.7\times10^6}}$$

Stage Q_4 2N1711

$C_{ob} = 25$ $\beta max = 300$

$C_{ib} = 80$

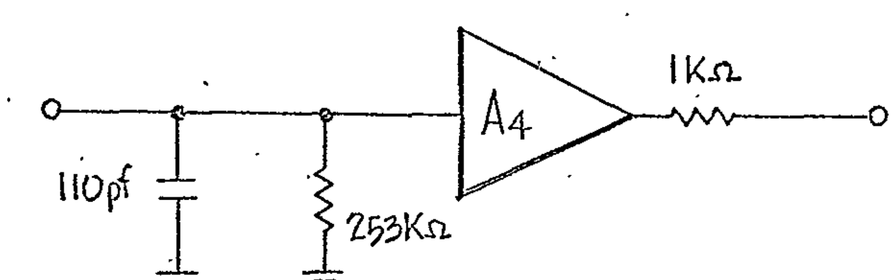
$$R_0 = r_e + \frac{r_b + r_g}{\beta + 1} = \frac{26}{10ma} + \frac{400 + 32K}{301} = 2.6\Omega + 1080$$

$R_o = 1.08K\Omega \approx 1K$

$R_{in}Q_4 = r_b + (R_L + r_e)(\beta+1) = 400 + (840 + 0)(301) = 253K\Omega$

$f_T = 300mc$ @ $I_c = 1$ ma

$$f_c = \frac{f_T}{A_4} = \frac{300mc}{1} = 300mc \text{ (Neglect } \beta \text{ roll-off)}$$



<u>Stage Q_6 2N486</u>

$C_{ob} = 46$ pf $\beta max. = 200$

$C_{ib} = 150$ pf

$f_T = 10mc$ @ $I_c = 500ma$

$$\tau_\beta = \frac{A}{f_T} = 2\pi \frac{1}{10mc} = \frac{1}{62.8 \times 10^6}$$

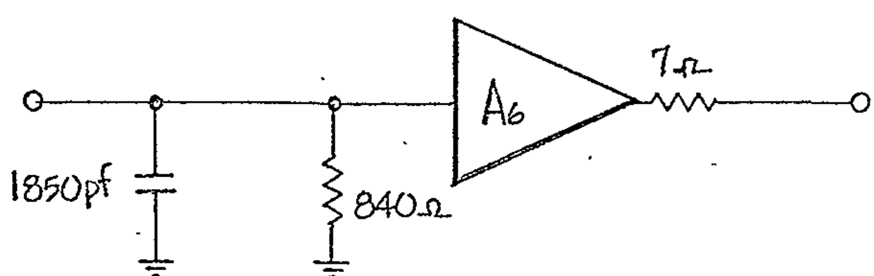
$$A_{V_6} = \frac{1}{1 + S\, T_\beta} = \frac{1}{1 + S\, T} = \frac{1}{1 + \frac{S}{62.8 \times 10^6}}$$

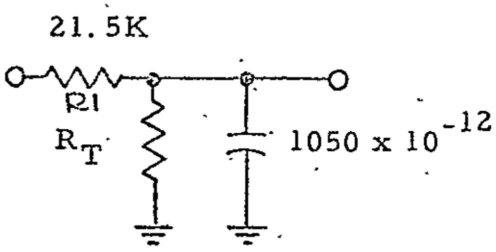
$(A+1)(C_{ob}) = (37)(46pf) = 1700$ pf

$R_{in} = r_b + (\beta+1)(r_e + R_L) = 400\Omega + (201)(2.2)$

$R_{in} = 840\Omega$

$$R_o = r_e + \frac{r_b + R_g}{\beta + 1} = 0 + \frac{400 + 1K}{201} = \frac{1.4K}{201} = 7\Omega$$

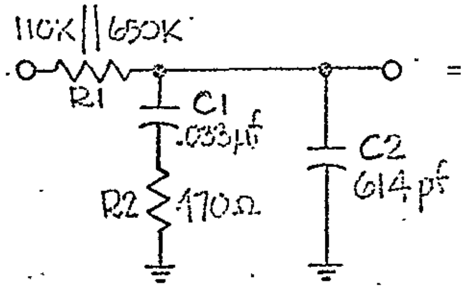


$G_1 =$ 

$$= \frac{\frac{R_T}{C_s}}{R_1R_T + \frac{R_1}{C_s} + \frac{R_T}{C_s}} = \frac{R_T}{R_1R_TC_s + (R_1+R_T)}$$

(Let $R_T = 36K$)

$$G_1 = \frac{\frac{R_T}{R_1 + R_T}}{1 + S\left(\frac{R_1R_TC}{R_1 + R_T}\right)} = \frac{\frac{R_T}{21.5 \times 10^3 R_T}}{1 + S\left[\frac{R_T(22.6 \times 10^{-6})}{21.5 \times 10^3 + R_T}\right]} = \frac{.625}{1 + \frac{S}{7.4 \times 10^4}}$$

$G_2 =$ 

$$= \frac{1 + SR_2C_1}{SR_1C_1 + SR_1C_2 + S^2R_1R_2C_1C_2 + 1 + SR_2C_1}$$

$$G_2 = \frac{1 + SR_2C_1}{R_1R_2C_1C_2\left[S^2 + S\,\frac{R_1C_1 + R_1C_2 + R_2C_1}{R_1R_2C_1C_2} + \frac{1}{R_1R_2C_1C_2}\right]}$$

$$G_2 = \frac{1 + S\,(470)(.033 \times 10^{-6})}{(466 \times 10^{-12})(S + .32 \times 10^3)(S + 3.3 \times 10^6} = \frac{\left(1 + \frac{S_1}{64 \times 10^3}\right)\left(.85\right)}{\left(1 + \frac{S}{320}\right)\left(1 + \frac{S}{3.3 \times 10^6}\right)}$$

Worst Case Threshold

$$V_{BQ_2} - V_{BQ_1}\ \text{Threshold} = \frac{V^+ \pm 10\% - V_{ZCR_1} \pm 10\% + V_{BESat\,Q3} \pm 30\% + V_{fCR4} \pm 30\%}{Av_1 \begin{pmatrix}\text{Worst case}\\ \text{above threshold}\end{pmatrix}}$$

$$= 14.3 \pm 1.43v - (6.2 \pm .62 + .6 \pm .2 + .6 \pm .2)$$

$$V_{BQ_2} - V_{BQ_1}\ \text{Threshold} = \frac{(14.3 - 7.4) \pm 2.5V}{93} = 74 \pm 26 \text{ mv}$$

$$V_{BQ_1}\ \text{Threshold} = V_{BQ_2} - V_{BQ_1}\ \text{Threshold} + V_{BQ_2} = \frac{R_6 V^+}{R_6 + R_2} = 5.374 - .074 \pm .026$$

$$= 5.3V \pm 26 \text{ mv}$$

$$V_{BQ_1}\ \text{Threshold} = \frac{R_4 V^+}{R_t + R_4} = \frac{(21.5)(14.3)}{R_t + 21.5} = 5.3, \quad R_t = 36.5K$$

$$\frac{(21.5)(14.3)}{36.5 + \Delta R_T + 2.15} = 5.3 \pm .026, \quad \Delta R_T = 380\Omega$$

At threshold, $R_T = \left(36.5 \pm .38K\right)$ for perfectly matched Q_1, Q_2.

Effect of V_{BE} offset in Q_1 & Q_2

Assume worst case temperature coefficient for V_{BE} (Q_1 & Q_2) = 1.0 mv/$^\circ$C

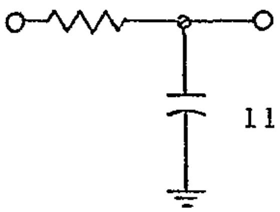
Over the range of operation, 0°C to 20°C, maximum $\Delta V_{BE(T)}$

for Q_1 and Q_2 = 20°C X 1mv/$^\circ$C = 20 mv

$$V_{BQ_2} - V_{BQ_1}\ \text{Threshold} = 5.3V \pm 26 \text{ mv} \pm 20 \text{ mv} = 5.3V \pm 46 \text{ mv}$$

At threshold, $R_T = \left(36.5 \pm .66K\right)$ (Worst Case)

$$32 \,||\, 253K = 28K$$

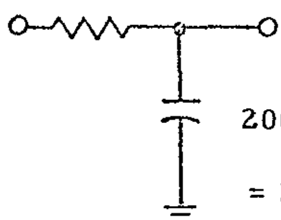
G_3 = 

110×10^{-12}

$$= \frac{1}{1 + \dfrac{S}{\dfrac{1}{(28 \times 10^3)(.11 \times 10^{-9})}}}$$

$$= \frac{.92}{1 + \dfrac{S}{325 \times 10^3}}$$

$$1K \,||\, 840 = 455\Omega$$

G_4 = 

2000×10^{-12}

$= 2 \times 10^{-9}$

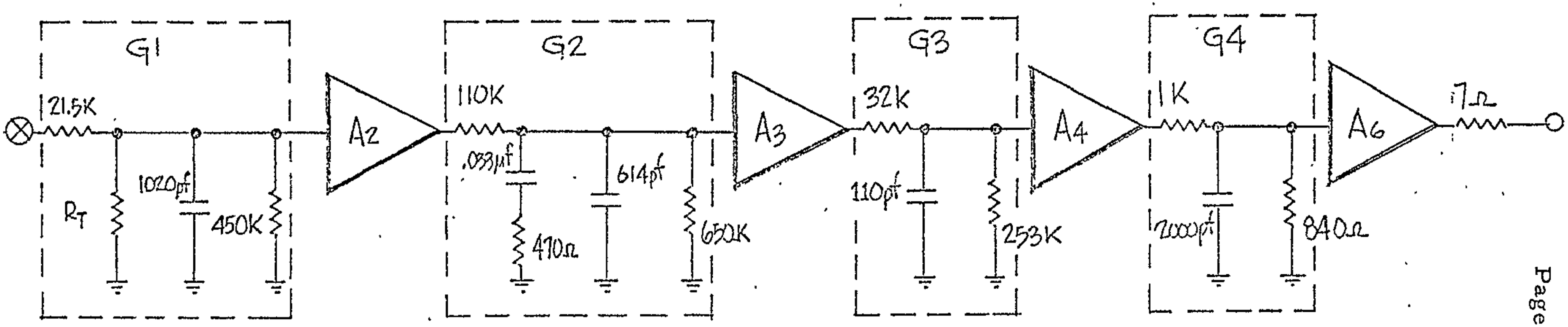
$$= \frac{1}{1 + \dfrac{S}{\dfrac{1}{(455)(2 \times 10^{-9})}}}$$

$$= \frac{.46}{1 + \dfrac{S}{1.1 \times 10^6}}$$

$$G_{Total} = \underset{G_1}{\frac{.625}{1+\frac{S}{7.4\times10^4}}} \times \underset{A_2}{\frac{21}{1+\frac{S}{3.14\times10^5}}} \times \underset{G_2}{\frac{1+\frac{S}{6.4\times10^4}}{\left(1+\frac{S}{320}\right)\left(1+\frac{S}{6.8\times10^6}\right)}} \times \underset{A_3}{\frac{45}{1+\frac{S}{3.2\times10^7}}} \times \underset{G_3}{\frac{1}{1+\frac{S}{3.2\times10^5}}} \times \underset{A_4}{1} \times \underset{G_4}{\frac{1}{1+\frac{S}{1.1\times10^6}}} \times \underset{A_6}{\frac{1}{1+\frac{S}{6.3\times1(}}}$$

$$G_{Total} = (.625)(21)(45) = 600 \approx 56\text{db}$$

FIGURE 6



Proportional Heater AC Equivalent Circuit (Open Loop)

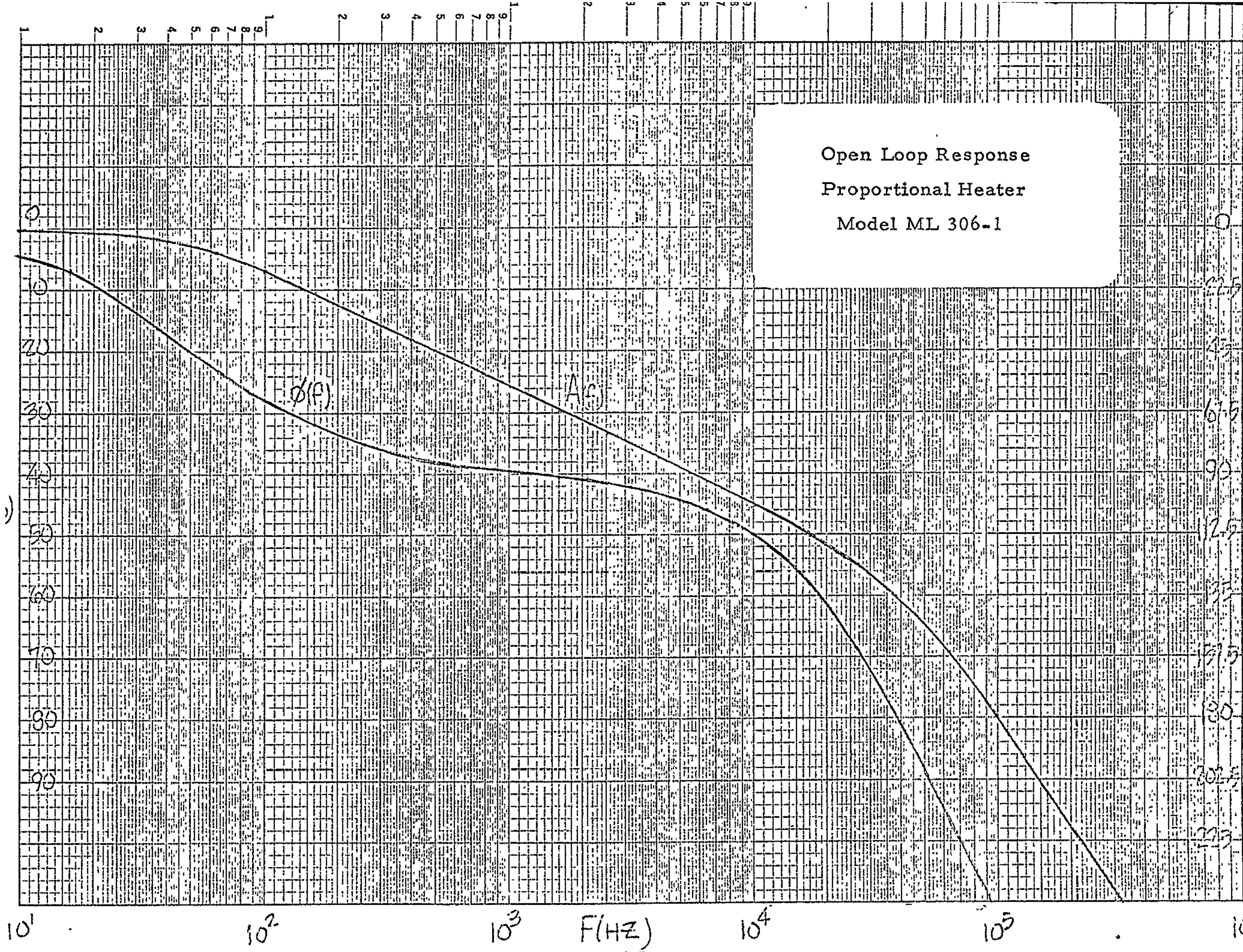

Open Loop Response
Proportional Heater
Model ML 306-1
ϕ(f)
A(f)
ϕ
0
10
20
30
40
50
60
70
80
90
22.5
45
67.5
90
112.5
180
F(HZ)
10^1
10^2
10^3
10^4
10^5
10^6

FIGURE 7

FIGURE 8

BODE 14:34 LAI WED 1/31/68

F[HZ]	AMPLITUDE [DB]	ANGLE [DEGRE
.1	-6.77109 E-5	.112541
.158489	-9.25064 E-5	.178365
.251189	-1.56403 E-4	.282685
.398107	-3.15666 E-4	.448021
.630957	-7.15256 E-4	.710045
1	-1.72043 E-3	1.12526
1.58489	-4.24293 E-3	1.78308
2.51189	-1.05734 E-2	2.82461
3.98107	-2.64349 E-2	4.47126
6.30967	-.066081	7.06499
10.	-.163893	11.1133
15.8489	-.40043	17.2944
25.1189	-.9433	26.2707
39.8107	-2.06652	38.0537
63.0957	-4.03225	51.1752
100.	-6.85263	63.1744
158.489	-10.2764	72.4731
251.189	-14.0236	79.0155
398.107	-17.9182	83.4807
630.957	-21.8742	86.6175
1000.	-25.853	89.0473
1584.89	-29.8361	91.2883
2511.89	-33.8097	93.8536
3981.07	-37.7581	97.4086
6309.57	-41.6743	103.034
10000.	-45.6242	112.485
15848.9	-49.849	127.931
25118.9	-54.5054	151.045
39810.7	-61.1158	182.11
63095.7	-69.3832	218.937
100000.	-79.8239	257.683
158489.	-92.2821	295.67
251189.	-106.562	331.509
398107.	-122.498	365.437
630957.	-139.924	396.042
1.00000 E 6	-158.593	423.256
1.58489 E 6	-178.195	447.897
2.51189 E 6	-198.592	472.167
3.98107 E 6	-219.962	498.161
6.30957 E 6	-242.693	526.014
1.00000 E 7	-267.043	553.375

Computed Response

Proportional Heater

Model MI. 306-1

DELETED

The following component changes are recommended for improved performance.

A. Change Q_1, Q_2 to 2N2484 (were 2N929)

Advantage: Increased h_{FE} min 2N2484 = 80
2N929 = 70

B. Change Q_3 to 2N2907A (was 2N2412)

Advantage: Increased h_{FE} min 2N2907A = 70
2N2412 = 50

C Change R_1 from 130K, 5% to 270K

Advantages: a) Increased voltage gain (X2) of differential amplifier resulting in reduced threshold variation.

b) Increased base current (X3) for Q_3 resulting in improved base drive for Q_6.

D. Change R_5 from 51K% to 51.1K 1%

Advantage: Reduced uncertainity in collector current Q_1, Q_2.

E. Change C1 from .033 μf to .33 μf, C4 from .001 μf to .01 μf.

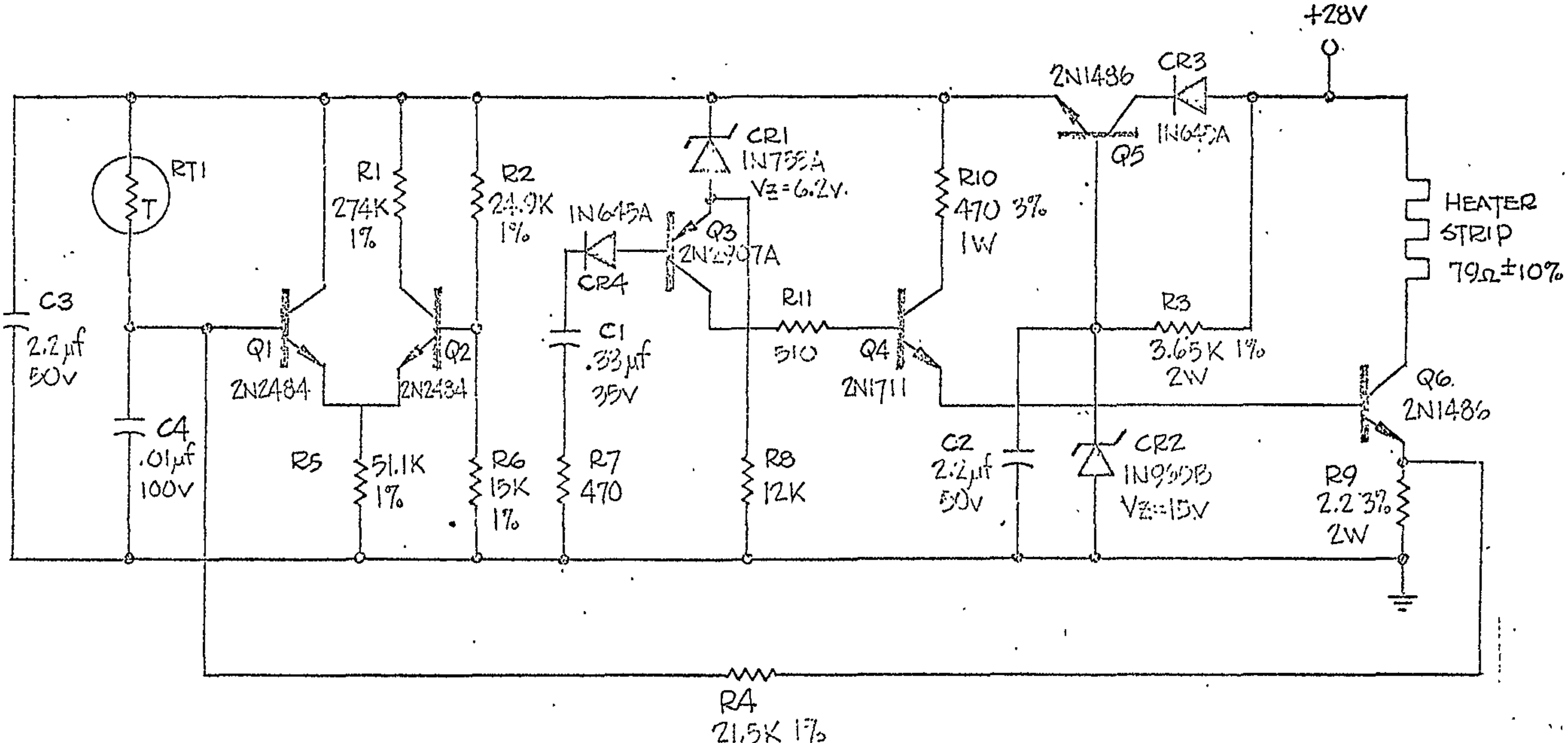
Advantage: Improved A. C. Stability. The pole and zero produced by C1 is moved one decade lower in frequency. Moving the pole produced by C4 down on decade will cause it to be cancelled by the zero. The open loop gain will then roll-off at 20 db/decade an be below 0 db before the higher frequency poles begin to have an effect.

F. Change R3 from 6.8 IK, 1/4 w, 5% to 3.6K, 3w, 1%

Advantage: Improved voltage regulation under worst case conditions. Present value provides insufficient current under low voltage (+23V) input.

It is recommended that the following components be exchanged for components which are more commonly used at Marshall Laboratories:

CR2:	Change to 1N965B (Was 1N718A)
CR3, 4:	Change to 1N645A (Was FD828)
C2:	Change to CSR13G225KP (Was 150D475X9035B2)
C3:	Change to CSR13G225KP (Was 150D225X0050B2)
R2:	Change to RN55C2492F (Was CG1/824.9K -1%)
R3:	Change to RWP-19-3.65K -1% (Was RC07GF683J)
R4:	Change to RN55C2152F (Was RC07GF1/4 21.5K-1%)
R6:	Change to RN55C-502F (Was CG 1/8 15K-1%)
R9:	Change to RWP-19-2.2Ω -1% (Was G-1-2.2 3%)
R10:	Change to RWP-19-470Ω -1% (Was GB4715)



Proportional Heater ML306-3

Circuit Schematic

Figure 9

V. D.C. Operation (ML306-3)

Worst Case Voltage Gain

Stage #1 - Differential Amplifier

Q_1, Q_2 2N2484 Specifications:

1) $h_{FE} = 80$ at $T = -20^{\circ}C$, $Ic = 50\ \mu a$

with safety factor of two, use h_{FE} min = 40

2) $V_{BE\,(On)} = .55\ V \pm 80\ mv$ @ $10^{\circ}C$, $Ic = 50\ \mu a$

3) Assume max. offset $V_{BE1} - V_{BE2} = 80\ mv$

Below Threshold

(Q_3 On)

$$\frac{V^{+} - V_{CQ2}}{V_{B2} - V_{B1}} = A_{V1} = \frac{R_{in}(Q_3)}{2\left(\frac{Rs}{\beta} + r_e Q_1\right)}$$

$$A_{V1} = \frac{2.4K}{2\left(\frac{9.35}{40} + .520\right)} = 1.6$$

Where $R_{in}(Q_3) = R_{in}$ of Q_3

$= (\beta + 1)\ Q_3 \times (R_{CR_1} + r_e Q_3)$

$= (36)\ (40 + 26) = 2.4K\,\Omega$

$$R_s = \frac{R_6 R_2}{R_6 + R_2} = 9.35K\,\Omega$$

$$r_e Q_1 = \frac{26}{Ie} = \frac{26}{.05} = 520\Omega$$

Above Threshold

(Q_3 Off)

$$\frac{V^{+} - V_{CQ2}}{V_{B2} - V_{B1}} = A_{V1} = \frac{R_1}{2\left(\frac{R_s}{\beta} + r_e Q_1\right)}$$

$$A_{V1} = \frac{274K}{1.4K} = 195$$

Stage #2 - PNP Inverter (ML306-3)

Q_3 2N2907A Specifications:

1) $h_{FE} = 70$ at $T = -20^\circ C$, $Ic = 1$ ma
with safety factor of two, use h_{FE} min = 35

2) $V_{BE\ Sat} = .7V \pm .1V$ @ $Ic = 1$ ma, $T = 0^\circ C$

$$A_{V2} = \frac{R_L}{R_e} \quad \text{where } R_e = R_{CR_1} + r_eQ_3 = 40 + \frac{26}{1\text{ ma}} = 66\,\Omega$$

$$R_L = R_9\ (\beta + 1)\ Q_6 \times (\beta + 1)\ Q_4 + R_{11}$$

$$= (2.2)(21)(31) + 510 = 1.9K\Omega$$

$$A_{V2} = \frac{1.9K}{66} = 31$$

Stage #3 - Emitter Follower

Q_4 -.2N1711 Specifications:

1) $h_{FE} = 60$ at $T = -20^\circ C$, $Ic = 1$ ma

with safety factor of two, use h_{FE} min = 30

$$A_{V3} = \frac{R_L\ (\beta+1)}{R_9 + r_b + (R_L + r_e)(\beta+1)} = \frac{(31)(21)(2.2)}{500 + (31)(21)(2.2)} = .74$$

Stage #4 - NPN Inverter

Q_6 - 2N1486 Specifications:

1) $h_{FE} = 40$ at $T = -20^\circ C$, $Ic = 500$ ma

with safety factor of two, use h_{FE} min = 20

$$A_{V4} = \frac{R\ \text{Heater}}{R_9} = \frac{78.4}{2.2} = 36$$

Total Open Loop Voltage Gain (Worst Case)

Below Threshold $A_{T(Lo)} = (A_{V1})(A_{V2})(A_{V3})(A_{V4})$

(Q_3 On) $= (1.6)(31)(.74)(36) = 1320$

$A_{O(Lo)}$ = Gain at Q_6 Emitter $= (1.6)(31)(.74) = 37$

Best Case Voltage Gain

Use $h_{FE} = 10 \times$ (worst case)

Stage #1

Below Threshold*

(Q_3 On)

$$A_{V1} = \frac{R_{in}\,Q_3 \| R_1}{2\left(\frac{R_s}{\beta} + r_e Q_1\right)}$$

where $R_{in}\,Q_3 = (\beta + 1)\,Q_3 \times (R_{CR_1} + r_e\,Q_3)$

$$= (351)\left(40 + \frac{26}{.01}\right) = 910K\,\Omega$$

$$R_{in}\,Q_3 \| R_1 = \frac{(910)(274)}{(910) + 274} = 210K\,\Omega$$

$$A_{V1} = \frac{210K}{2\left(\frac{9.35K}{350} + .65\right)} = 160$$

$R_s = 9.35K$

$$\left.\begin{array}{l} r_e Q_1 = \dfrac{26}{.04} = 870\Omega \\ r_e Q_2 = \dfrac{26}{.06} = 430\Omega \end{array}\right\} AV \sim 650\,\Omega$$

*"Threshold is defined as the point where transistor Q_3 changes from cut-off to conduction. As the the temperature moves below the threshold, transistor Q_6 begins to conduct and power is dissipated in the heater strip

Above Threshold*

(Q_3 Off)

$$A_{V1} = \frac{R_1}{1.3K} = \frac{274K}{1.3K} = 210$$

Stage #2

$$A_{V2} = \frac{R_L}{R_e} \qquad \text{where } R_e = R_{CR_1} + r_e Q_3 = 40 + \frac{26}{.01} = 2.6K$$

$$R_L = R_9 (\beta + 1) Q_6 \times (\beta + 1) Q_4 + R_{11}$$

$$= (2.2)(301)(201) + 510\,\Omega$$

$$R_L = 133K$$

$$A_{V2} = \frac{133K}{2.6K} \simeq 51$$

Stage #3

$$A_{V3} = \frac{R_{in}}{R_{in} + R_{11}} \qquad \text{where } R_{in} = R_9 (\beta + 1) Q_6 \times (\beta + 1) Q_4$$

$$= 133K\Omega$$

$$A_{V3} = \frac{133K\Omega}{133K + 510} \simeq 1$$

Stage #4

$$A_{V4} = \frac{R\ \text{Heater}}{R_9} = \frac{78.6}{2.2} = 36$$

Total Open Loop Voltage Gain (highest case)

Below Threshold $\qquad A_{T(Hi)} = (160)(51)(1)(36) = 290,000$

$A_{O(Hi)}$ = Gain at emitter of Q_6

$= (160)(51)(1) = 8,100 \simeq 78\text{db}$

$$V_{BQ_2} - V_{BQ_1\ \text{Threshold}} = \frac{V^+ \pm 10\% - V_{ZCR_1} \pm 10\% + V_{BE(sat)Q_3} \pm 30\% + V_{fCR_4} \pm 30\%}{A_{V1} \begin{pmatrix}\text{Worst case} \\ \text{above threshold}\end{pmatrix}}$$

$$= 14.3 \pm 1.43V - (6.2 \pm .62 + .6 \pm .2 + .6 \pm .2)$$

$$V_{BQ_2} - V_{BQ_1\ \text{Threshold}} = \frac{(14.3-7.4) \pm 2.5V}{195} = 35 \pm 13 \text{ mv}$$

$$V_{BQ_1\ \text{Threshold}} = -\left(V_{BQ_2} - V_{BQ_1}\right)_{\text{Threshold}} + V_{BQ_2} = 5.374 - .035 \pm .013$$

$$= 5.34V \pm 13 \text{ mv}$$

$$V_{BQ_1\ \text{Threshold}} = \frac{R_4 V^+}{R_t + R_4} = \frac{(21.5)(14.3)}{R_t + 21.5} = 5.34, \quad R_t = 36.5K$$

$$\frac{(21.5)(14.3)}{36.5 + \Delta R_T + 2.15} = 5.34 \pm .013, \quad \Delta R_T = 380\,\Omega$$

At threshold, $R_T = \left(36.5 \pm .38K\right)$ for perfectly matched Q_1, Q_2

Effect of V_{BE} offset in Q_1 & Q_2

Assume worst case temperature coefficient for V_{BE} (Q_1 & Q_2) = 1.0 mv/°C

Over the range of operation, 0°C to 20°C, maximum $\Delta V_{BE(T)}$

for Q_1 and Q_2 = 20°C x 1 mv/°C = 20 mv

$$V_{BQ_2} - V_{BQ_1\ \text{Threshold}} = 5.34V \pm 13 \text{ mv} \pm 20 \text{ mv} = 5.34 \pm 33 \text{ mv}$$

At threshold, $R_T = \left(36.5 \pm .66K\right)$ (Worst Case)

Full Power Output - Low Extreme

1) $$V_o = \left[\left(V_{BQ_{2(Hi)}} - V_{BQ_1}\right) - \left(V_{BQ_2} - V_{BQ_1}\right)_{Threshold}\right] A_{o\,Hi}$$

2) $$V_o = \frac{(28V)\,(R_9)}{R\ Heater} = \frac{(28)(2.2)}{78.6} = .78V$$

where $V_o = V_{eQ_6}$; $$V_{BQ_{2(Hi)}} = \frac{(1.02)R_6\,V^+}{.98R_2 + 1.02\,R_6} =$$

$$\frac{(15.3)(14.3)}{24.4 + 15.3} = 5.52$$

$A_{o(Hi)}$ = Open loop voltage at emitter of

$$Q_6 = \frac{A_{T(Hi)}\,R_9}{R\ heater}$$

$$= \frac{(290,000)(2.2)}{78.6} = 8100$$

$$V_o = \left(V_{BQ_{2(Hi)}} - V_{BQ_1}\right) A_{o(Hi)} - (.022)(A_{o(Hi)}) = .78V$$

$$(8100)(5.52) - (8100)V_{BQ_1} - 178 = .78$$

$$V_{BQ_1} = \frac{44,600}{8100} = 5.50V$$

$$V_{BQ_1} = V_o + \frac{V^+ - V_o\ R_4}{R_T + R_4} = .78 + \frac{(14.3-.78)(21.5)}{R_T + 21.5} = 5.50V$$

$$R_T = \frac{(8.82)(21.5)}{4.7} \approx 40K\,\Omega$$

This is the smallest value of thermistor (R_T) resistance for which the heater power output will just reach its maximum.

Full Power Output - High Extreme

1) $$V_o = \left[\left(V_{BQ_2} - V_{BQ_1}\right) - V_{BQ_2} - V_{BQ_1} \text{ Threshold}\right] A_{o(lo)}$$

2) $$V_o = \frac{(28V)\, R_9}{R \text{ Heater}} = .78V \quad \text{where } V_o = V_{eQ_6}$$

$$V_{BQ2(Lo)} = \frac{.98 R_6 V^+}{1.02\, R_2 + .98 R_6} = \frac{(14.7)(14.3)}{25.5 + 14.7} = 5.25V$$

$A_{o(Lo)}$ = Open loop voltage at emitter of

$$Q_6 = \frac{A_{T(Lo)} R_9}{R \text{ Heater}}$$

$$= \frac{(1320)(2.2)}{78.6} = 37$$

1) $$V_o = \left(V_{BQ_{2(Lo)}} - V_{BQ_1}\right) A_{o(Lo)} - 0.48\, A_{o(Lo)} = .78V$$

$$(5.25)(37.0) - V_{BQ_1}(37) - 1.80 = .78V$$

$$V_{BQ_1} = \frac{193.1}{37} = 5.21V$$

$$V_{BQ_1} = V_o + \frac{\left(V^+ - V_o\right) R_9}{R_T\, R_4} = .78 + \frac{(14.3 - .78)(21.5)}{R_T + 21.5} = 5.21V$$

$$R_T = \frac{(9.18)(21.5)}{4.34} \approx 46K$$

This is the largest value of thermistor (R_T) resistance for which the heater power output will just reach its maximum.

<u>Worst Case Operating Range</u> - $\left(R_T\right) V_s \left(P_o\right) (E^+ = 28V)$

Low Threshold = 36.5K - .66K = 35.8K Ω

High Threshold = 36.5K + .66K = 37.2K Ω

Full Power Output Point - Low Extreme = 40K Ω

Full Power Output Point - High Extreme = 46K Ω

FOR: $R_T = 35.8K$, $T = +13.0°C = 55.4°F$

$R_T = 37.2K$, $T = +12°C = 53.6°F$

$R_T = 40.0K$, $T = +11°C = 51.8°F$

$R_T = 46.0K$, $T = +7°C = 44.6°F$

<u>Maximum Power Output</u>

$$P_o = \left(I_{CQ_6}\right)^2 \text{ R Heater}$$

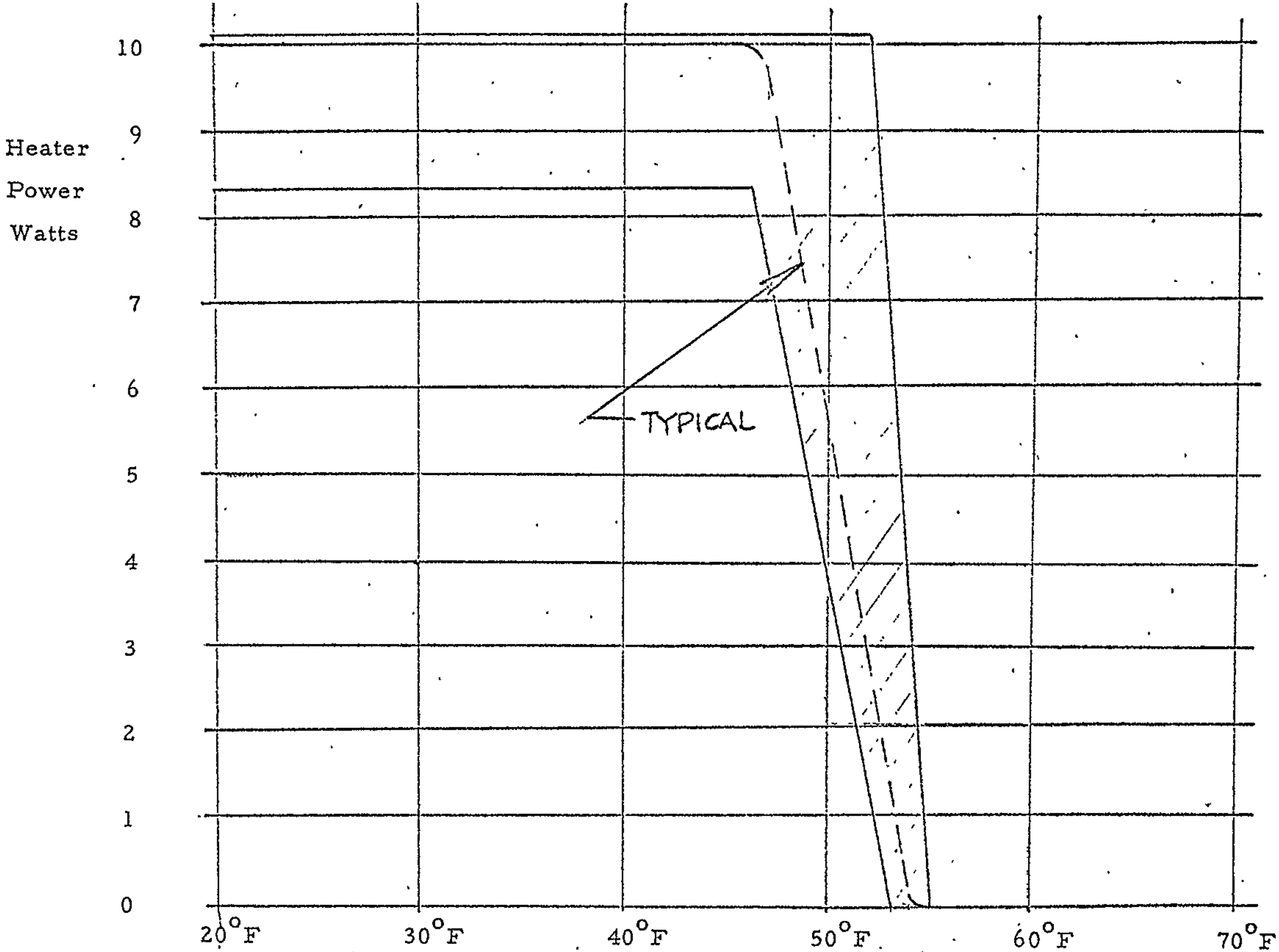
$$I_{CQ_6} = \frac{E^+ - V_{CEQ_6\,sat}}{\text{R Heater} + R_9} = \frac{28 - .4}{78.6 + 2.2}$$

$$P_o = (.342)^2 (78.6)$$

$$I_{CQ_6} = \frac{27.6}{80.8} = 342 \text{ ma}$$

P_o = 9.2 watts (nominal)

Worst case range ± 10% of nominal = 8.3 to 10.12 watts



PROPORTIONAL HEATER
INPUT - OUTPUT CHARACTERISTICS
Model ML 306-3
Figure 10

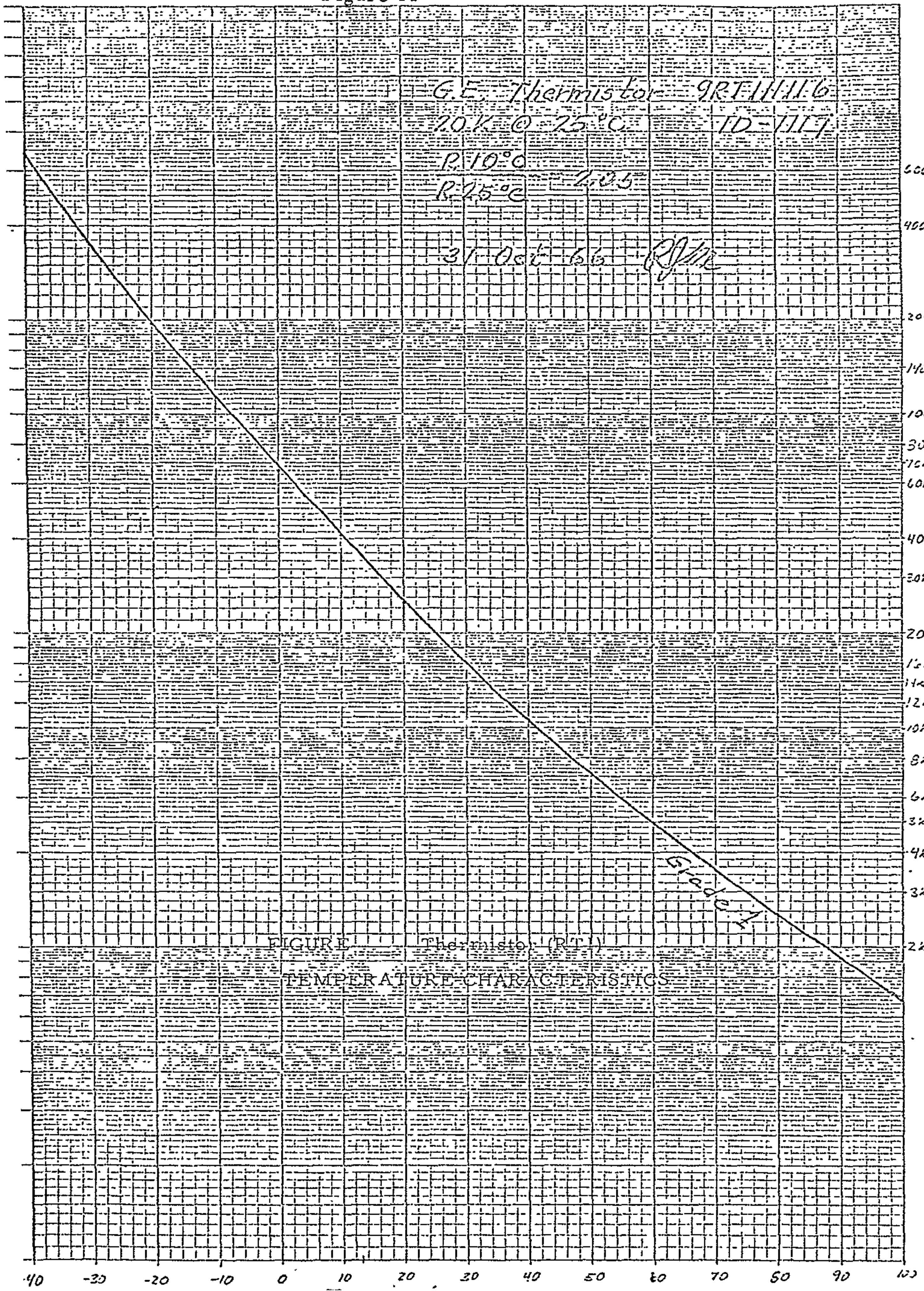


FIGURE Thermistor (RT1)

TEMPERATURE CHARACTERISTICS

Comparison Between Degrees Centigrade and Degrees Fahrenheit

Deg. C.	Deg. F.	Deg. C.	Deg. F.	Deg. C.	Deg. F.	Deg. C.	Deg. F.	Deg. C.	Deg. F.	Deg. C.	Deg. F.
−40	−40.0	8	46.4	56	132.8	104	219.2	152	305.6	200	392.0
−39	−38.2	9	48.2	57	134.6	105	221.0	153	307.4	201	393.8
−38	−36.4	10	50.0	58	136.4	106	222.8	154	309.2	202	395.6
−37	−34.6	11	51.8	59	138.2	107	224.6	155	311.0	203	397.4
−36	−32.8	12	53.6	60	140.0	108	226.4	156	312.8	204	399.2
−35	−31.0	13	55.4	61	141.8	109	228.2	157	314.6	205	401.0
−34	−29.2	14	57.2	62	143.6	110	230.0	158	316.4	206	402.8
−33	−27.4	15	59.0	63	145.4	111	231.8	159	318.2	207	404.6
−32	−25.6	16	60.8	64	147.2	112	233.6	160	320.0	208	406.4
−31	−23.8	17	62.6	65	149.0	113	235.4	161	321.8	209	408.2
−30	−22.0	18	64.4	66	150.8	114	237.2	162	323.6	210	410.0
−29	−20.2	19	66.2	67	152.6	115	239.0	163	325.4	211	411.8
−28	−18.4	20	68.0	68	154.4	116	240.8	164	327.2	212	413.6
−27	−16.6	21	69.8	69	156.2	117	242.6	165	329.0	213	415.4
−26	−14.8	22	71.6	70	158.0	118	244.4	166	330.8	214	417.2
−25	−13.0	23	73.4	71	159.8	119	246.2	167	332.6	215	419.0
−24	−11.2	24	75.2	72	161.6	120	248.0	168	334.4	216	420.8
−23	− 9.4	25	77.0	73	163.4	121	249.8	169	336.2	217	422.6
−22	− 7.6	26	78.8	74	165.2	122	251.6	170	338.0	218	424.4
−21	− 5.8	27	80.6	75	167.0	123	253.4	171	339.8	219	426.2
−20	− 4.0	28	82.4	76	168.8	124	255.2	172	341.6	220	428.0
−19	− 2.2	29	84.2	77	170.6	125	257.0	173	343.4	221	429.8
−18	− 0.4	30	86.0	78	172.4	126	258.8	174	345.2	222	431.6
−17	+ 1.4	31	87.8	79	174.2	127	260.6	175	347.0	223	433.4
−16	3.2	32	89.6	80	176.0	128	262.4	176	348.8	224	435.2
−15	5.0	33	91.4	81	177.8	129	264.2	177	350.6	225	437.0
−14	6.8	34	93.2	82	179.6	130	266.0	178	352.4	226	438.8
−13	8.6	35	95.0	83	181.4	131	267.8	179	354.2	227	440.6
−12	10.4	36	96.8	84	183.2	132	269.6	180	356.0	228	442.4
−11	12.2	37	98.6	85	185.0	133	271.4	181	357.8	229	444.2
−10	14.0	38	100.4	86	186.8	134	273.2	182	359.6	230	446.0
− 9	15.8	39	102.2	87	188.6	135	275.0	183	361.4	231	447.8
− 8	17.6	40	104.0	88	190.4	136	276.8	184	363.2	232	449.6
− 7	19.4	41	105.8	89	192.2	137	278.6	185	365.0	233	451.4
− 6	21.2	42	107.6	90	194.0	138	280.4	186	366.3	234	453.2
− 5	23.0	43	109.4	91	195.8	139	282.2	187	368.6	235	455.0
− 4	24.8	44	111.2	92	197.6	140	284.0	188	370.4	236	456.8
− 3	26.6	45	113.0	93	199.4	141	285.8	189	372.2	237	458.6
− 2	28.4	46	114.8	94	201.2	142	287.6	190	374.0	238	460.4
− 1	30.2	47	116.6	95	203.0	143	289.4	191	375.8	239	462.2
0	32.0	48	118.4	96	204.8	144	291.2	192	377.6	240	464.0
+ 1	33.8	49	120.2	97	206.6	145	293.0	193	379.4	241	465.8
2	35.6	50	122.0	98	208.4	146	294.8	194	381.2	242	467.6
3	37.4	51	123.8	99	210.2	147	296.6	195	383.0	243	469.4
4	39.2	52	125.6	100	212.0	148	298.4	196	384.8	244	471.2
5	41.0	53	127.4	101	213.8	149	300.2	197	386.6	246	474.8
6	42.8	54	129.2	102	215.6	150	302.0	198	388.4	248	478.4
7	44.6	55	131.0	103	217.4	151	303.8	199	390.2	250	482.0

FIGURE 12 Centigrade to Fahrenheit Conversion Chart

Current Required for Full Power Output

Base drive, Q_6 current requirements - using h_{FE} safety factor of 2.0

Worst Case - $E^+ = 32V$ = Input Voltage

$R_{Heater} = 70\Omega$

$R_9 = 2\Omega$

$V_{CE(sat)\,Q_6} = .2V$

$\beta \min Q_6 = 20$

$$I_C = \frac{V^+ - V_{CE(sat)}}{R_{Heater} + R_9} = \frac{32 - .2}{70 + 2} = 440 \text{ ma}$$

Required base drive for Q_6 saturation $= \dfrac{I_C}{\beta} = \dfrac{440\text{ma}}{20} = 22$ ma

---

$$I_{bQ_3} = I_{CQ_2} - I_{R_1}$$

$$I_{CQ_2} = \frac{V_{CQ2}}{R_5} = \frac{V_{BQ2} - V_{BE(sat)Q2}}{R_5} = \frac{\dfrac{R_6 V^+}{R_6 + R_2} - .63}{56K} = \frac{\dfrac{(14.7)(14.3)}{(14.7) + (25.4)} - .63}{56} = 82\mu a$$

$$I_{bQ_3} = 82\mu a - \frac{V^+ - V_{Clamp}}{R_1} = 82\mu a - \frac{7.60}{268K} = 82 - 28\mu a = 54\mu a$$

$$I_{bQ_4} = I_{CQ_3} = \beta Q_3 I_{BQ_3}$$

$$I_{bQ_4} = (35)(54) = 1.9 \text{ ma}$$

$$I_{bQ_6} = (\beta + 1)\, Q_4 (I_{bQ_4}) = (31)(1.9\text{ma}) = 59.0 \text{ ma}$$

$$I_{bQ_6}(\text{Worst Case}) = 59.0 \text{ ma}$$

I_{bQ_6} (required for full output) = 22 ma $\therefore$ Q_6 will produce full power output under worst case condition

Voltage Regulation (Worst Case)

When the input voltage (E^+) is at minimum value (=23 V), resistor R3 must supply enough current to bias zener CR2 below the knee of its V-I characteristic and to drive transistor Q5 under its maximum load condition.

$$\text{or} \quad I_{R3\,min.} \geq Z\, I_{ZTCR2} + \frac{I_{eQ5}\,(max)}{(\beta+1)\ \min Q5}$$

$$\text{for } E^+ \doteq 23V, \quad I_{eQ5(max)} \backsimeq I_{eQ4(max)} = \frac{V^+}{R_2+R_6} + \frac{V^+ - V_{ZCR1}}{R_8}$$

$$I_{eQ4\,max} = \frac{E^+ - V_{CE(sat)\,Q6}}{\dfrac{R_{Heater(Lo)} + R_{9(Lo)}}{(\beta+1)\ Q6\ min.}} = \frac{23 - .2}{\dfrac{70.8 + 2.0}{21}} = \frac{.313}{21} \backsimeq 15ma$$

$$\frac{V^+}{R_2 + R_6} = \frac{14.3}{40K} = .36\ ma$$

$$\frac{V^+ - V_{ZCR1}}{R_8} = \frac{8.1}{12K} = .75\ ma$$

$$I_{eQ5(max)} = 15\ ma + .36 + .75 = 16\ ma$$

$$I_{ZTCR2}(\text{from Mf's specs}) = .25\ ma$$

$$\therefore I_{R3\,min} \geq .5\,ma + \frac{16ma}{21} = 1.27\ ma$$

$$I_{R_3} = \frac{E^+_{(Lo)} - V_{ZCR2(Hi)}}{R_{3(Hi)}} = \frac{23 - 15.8}{3.6K} = 2.0\ ma > 1.27\ ma$$

$\therefore$ R_3 provides sufficient current for proper regulation.

AC Stability Analysis

Worst Case Conditions:

1. Voltage gains of each transistor stage are at highest levels.

2. Minimum gain bandwidth (f_T) figures are used for all transistors.

3. Miller enhancement of collector output capacitance (C_{ob}) in stages where voltage gain is present is assumed constant with frequency (thus neglecting effect of gain roll-off).

4. Nominal component values are used.

Using the above conditions, on A. C. equivalent circuit for the open loop is derived. The loop is broken at the emitter of transistor Q_6 producing a unity feedback configuration. The open loop gain is down to -6db at 30 KHz. At this frequency, the phase margin is $> 45^{\circ}$ which is a satisfactory figure for conservative design.

Stage Q_2

2N2484 β max. = 400

$C_{ob} = 6$ pf

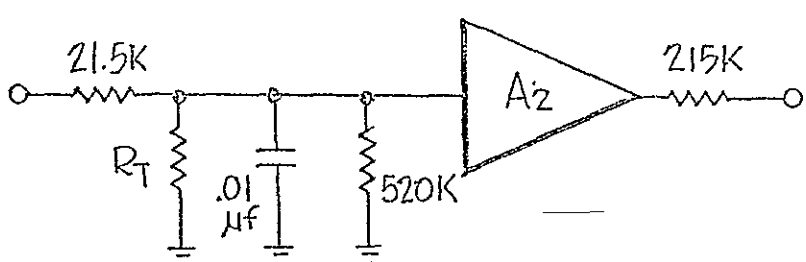
$C_{ib} = 6$ pf

$R_o \backsimeq r_c || R_1 = 1M\Omega || 274K = 215K\,\Omega$

$R_{in} = 2\beta\,(.65) = (2)(400)(.65) = 520K$

$f_T \left(@\ I_c = 10\mu a\right) = 40$ mc

$$T_\beta = \frac{A_1}{f_T} = \frac{160}{40\text{mc}} = \frac{1}{250\text{KC}}$$



$$A_2 = \frac{160}{1 + \frac{S}{2\pi 250 \times 10^3}} = \frac{160}{1 + \frac{S}{1.57 \times 10^6}}$$

Stage Q_3 2N2907A

$r_b' = 400\,\Omega$

$C_{ob} = 6$ pf

$C_{ib}' = 20$ pf

$\beta_{max.} = 350$

$$R_{in}\,Q_3 = r_b + r_e\,(\beta+1) = .400 + (2.6)(350) \simeq 910K\,\Omega$$

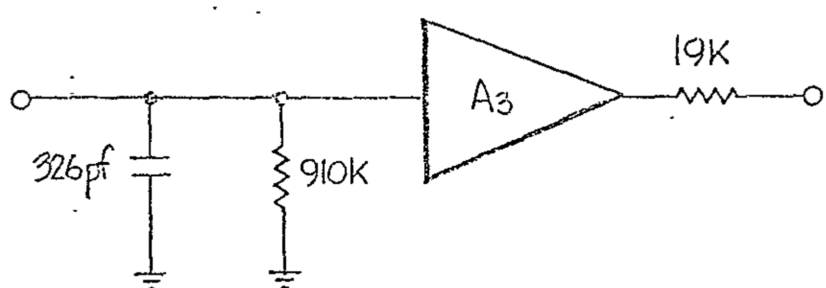
$$R_o Q_3 = r_c\,(1-\alpha) + r_e + \frac{r_e\,(r_c - r_e)}{R_g + r_e + r_b} = \frac{10^6}{\beta} + 2.6K + \frac{2.6K\,(997K)}{215K + 2.6K}$$

$$R_o Q_3 = 4K + 2.6K + 12K = 19K$$

$$(A+1)\,(C_{ob}) + C_{ib} = (51)(6) + 20 = 326 \text{ pf}$$

$$f_T = 200\text{mc} @ I_c = 10 \text{ ma}$$

$$T_\beta = \frac{A_{V3}}{f_T} = \frac{51}{200\text{mc}} = \frac{1}{4\text{mc}}$$



$$A_3 = \frac{51}{1 + \dfrac{S}{25 \times 10^6}}$$

Stage Q_4 2N1711

$C_{ob} = 25$

$C_{ib} = 80$

$\beta_{max.} = 300$

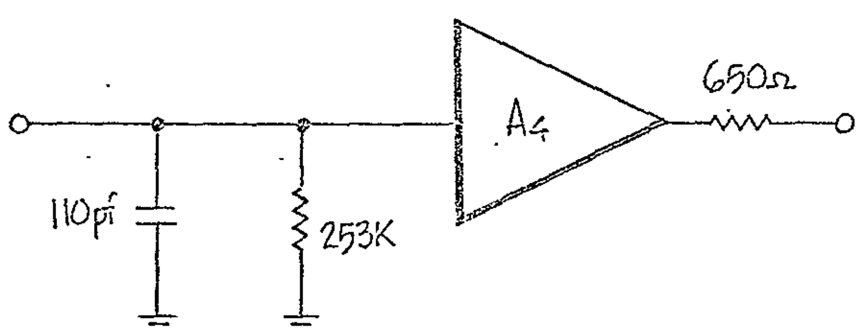
$$R_o = r_e + \frac{r_b + r_g}{\beta + 1} = \frac{26}{10ma} + \frac{400 + 19K}{301} = 2.6\Omega + 645$$

$$R_o = 649 \cong 650\Omega$$

$$R_{in}\,Q_4 = r_b + (R_L + r_e)(\beta+1) = 400 + (840 + 0)(301) = 253K\Omega$$

$$f_T = 300mc\left(@\ I_c = 1\ ma\right)$$

$$f_c = \frac{f_T}{A_4} = \frac{300mc}{1} = 300mc \text{ (Neglect } \beta \text{ roll-off)}$$



Stage Q_6 2N1486

$C_{ob} = 46$ pf

$C_{in} = 150$ pf

$\beta_{max.} = 200$

$f_T = 10\text{mc} \; @ \; I_c = 500\text{ma}$

$$\tau_\beta = \frac{A}{f_T} = \frac{1}{(2\pi)\, 10\text{mc}} = \frac{1}{62.8 \times 10^6}$$

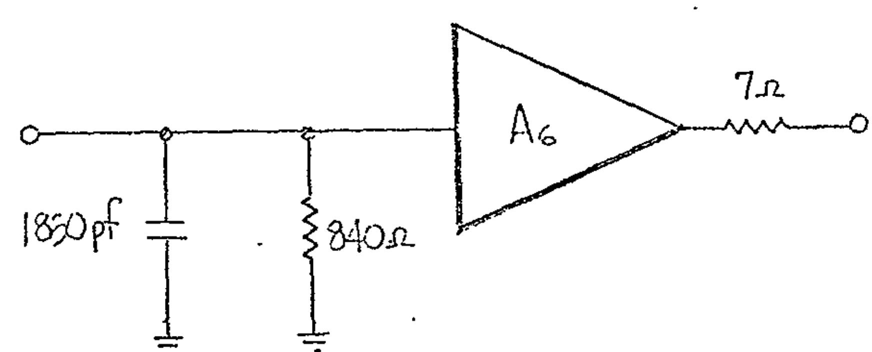
$$A_{V_6} = \frac{1}{1 + S\,T_\beta} = \frac{1}{1 + \dfrac{S}{62.8 \times 10^6}}$$

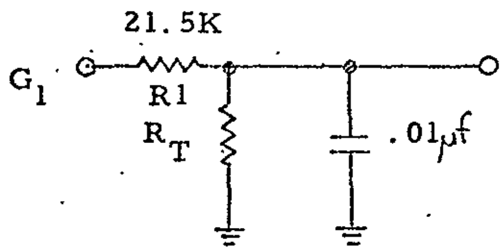
$(A+1)(C_{ob}) = (37)(46 \text{ pf}) = 1700$ pf

$R_{in} = r_b + (\beta+1)(r_e + R_L) = 400\Omega + (201)(2.2)$

$R_{in} = 840\,\Omega$

$$R_o = r_e + \frac{r_b + R_g}{\beta + 1} = 0 + \frac{400 + 1K}{201} = \frac{1.4K}{201} = 7\,\Omega$$



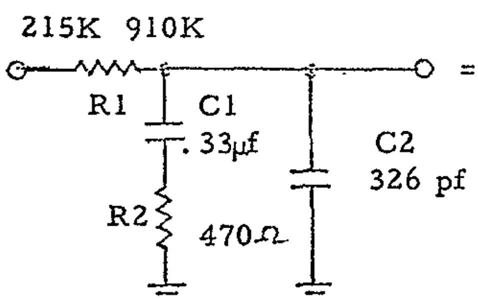


$$= \frac{\frac{R_T}{C_s}}{\frac{R_1R_T+R_1}{C_s}+\frac{R_T}{C_s}} = \frac{R_T}{R_1R_TC_s+(R_1+R_T)}$$

(Let $R_T = 36K$)

$$G_1 = \frac{\frac{R_T}{R_1+R_T}}{1+S\left(\frac{R_1R_TC}{R_1+R_T}\right)} = \frac{\frac{R_T}{21.5 \times 10^3\ R_T}}{1+S\left[\frac{R_T\ (2.15 \times 10^{-4})}{21.5 \times 10^3+R_T}\right]} = \frac{.625}{1+\frac{S}{7.4 \times 10^3}}$$

$G_2 =$



$$= \frac{1+SR_2C_1}{SR_1C_1+SR_1C_2+S^2R_1R_2C_1C_2+1+SR_2C_1}$$

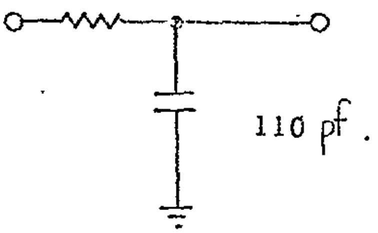
$R1 = 175K$

$$G_2 = \frac{1+SR_2C_1}{R_1R_2C_1C_2\left[S^2+S\left(\frac{R_1C_1+R_1\ C_2+R_2\ C_1}{R_1R_2C_1C_2}\right)+\frac{1}{R_1R_2C_1C_2}\right]}$$

$$G_2 = \frac{\left(1+\frac{S}{6.4 \times 10^3}\right)}{\left(1+\frac{S}{1.8 \times 10^1}\right)\left(1+\frac{S}{6.6 \times 10^6}\right)}$$

$19 \parallel 253K = 18K$

$G_3 =$

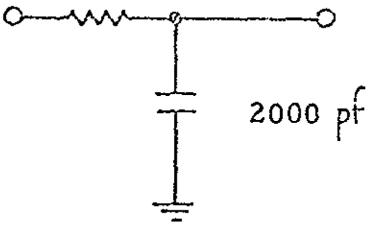


$$\frac{1}{1 + \dfrac{S}{\dfrac{1}{(18 \times 10^3)(.11 \times 10^{-9})}}}$$

$$\frac{1}{1 + \dfrac{S}{5 \times 10^5}}$$

$650 \parallel 840 = 360\Omega$

$G_4 =$

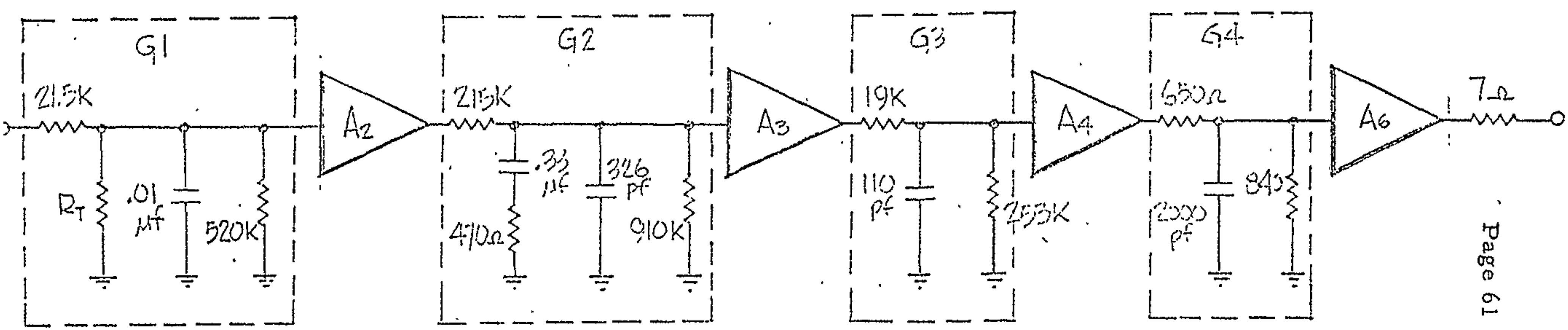


$$\frac{1}{1 + \dfrac{S}{(366)(2 \times 10^{-9})}}$$

$$= \frac{1}{1 + \dfrac{S}{1.4 \times 10^6}}$$

$$\text{Total} = \overset{G_1}{\frac{.625}{1+\frac{S}{7.4 \times 10^3}}} \times \overset{A_2}{\frac{160}{1+\frac{S}{1.57 \times 10^6}}} \times \overset{G_2}{\frac{1+\frac{S}{6.4 \times 10^3}}{\left(1+\frac{S}{1.8 \times 10^1}\right)\left(1+\frac{S}{6.6 \times 10^6}\right)}} \times \overset{A_3}{\frac{.51}{1+\frac{S}{2.5 \times 10^7}}} \times \overset{G_3}{\frac{1}{1+\frac{S}{5 \times 10^5}}} \times \overset{A_4}{1} \times \overset{G_4}{\frac{1}{1+\frac{S}{1.4 \times 10^6}}} \times \overset{A_6}{\frac{1}{1+\frac{S}{6.3 \times 1}}}$$

$$\text{Total} = (.625)(160)(51) = 5050 = 74 \text{ db}$$



Proportional Heater AC Equivalent Circuit (Open Loop)

Figure 13

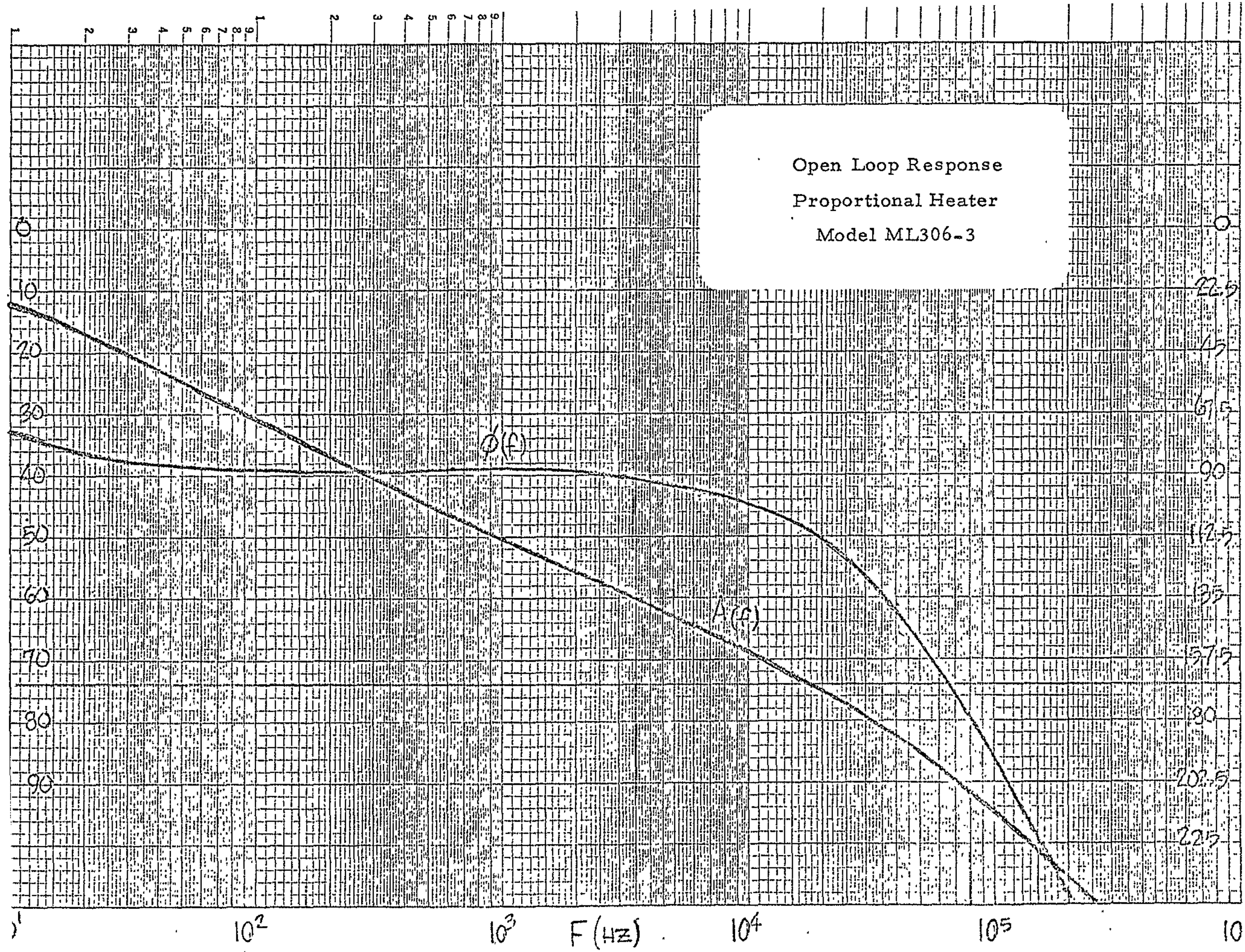

Open Loop Response
Proportional Heater
Model ML306-3
0
10
20
30
40
50
60
70
80
90
0
22.5
45
67.5
90
112.5
135
157.5
180
202.5
225
φ(f)
A(f)
10^2
10^3
F (Hz)
10^4
10^5
10^6

Figure 14

MYERS 8:38 LA1 FRI 2/02/68

F[HZ]	AMPLITUDE [DB]	ANGLE [DEGR
.01	1.33514 E-5	.199937
1.58489 E-2	-6.67572 E-5	.316874
2.51189 E-2	-2.67029 E-4	.502214
3.98107 E-2	-7.72476 E-4	.7[illegible]591
6.30957 E-2	-2.03991 E-3	1.26131
.1	-5.22232 E-3	1.99856
.158489	-1.32055 E-2	3.16556
.251189	-3.31945 E-2	5.00937
.398107	-8.30021 E-2	7.90896
.630957	-.205652	12.4169
1	-.499271	19.236
1.58489	-1.15959	28.9427
2.51189	-2.47673	41.2288
3.98107	-4.6703	54.2359
6.30957	-7.67207	65.5401
10.	-11.2005	73.9508
15.8489	-14.9975	79.6538
25.1189	-18.9136	83.3347
39.8107	-22.8789	85.6327
63.0957	-26.8629	87.003
100.	-30.8512	87.7331
158.489	-34.8336	87.9874
251.189	-38.7955	87.8548
398.107	-42.711	87.4264
630.957	-46.5439	86.9516
1000.	-50.2856	86.9783
1584.89	-54.0071	88.0385
2511.89	-57.8043	90.1043
3981.07	-61.6995	92.9277
6309.57	-65.6677	96.6441
10000.	-69.6962	101.853
15848.9	-73.8124	109.562
25118.9	-78.1132	121.197
39810.7	-82.8202	138.498
63095.7	-88.3361	162.952
100000.	-95.1965	194.826
158489.	-103.91	232.857
251189.	-114.853	274.456
398107.	-128.097	316.066
630957.	-143.343	355.345
1.00000 E 6	-160.28	392.244
1.58489 E 6	-178.771	427.322
2.51189 E 6	-198.743	461.066
3.98107 E 6	-220.214	493.947
6.30957 E 6	-243.28	525.478
1.00000 E 7	-267.935	554.064

Computer Response
Proportional Heater
Model ML306-3

IME: 13 SECS.

BYE

*** OFF AT 8:42 LA1 FRI 2/02/68.

Summary - ML 306-3

A. D. C. Operation - Satisfactory: The unit will perform properly under all conditions of temperature and component variation. The unit may be guaranteed to operate within the range shown in Figure

B. A. C. Stability - Satisfactory: Open loop gain is down to -18db when the phase shelf reads 180°.

ITEM 6

GSFC CORRESPONDENCE REFERENCE (Partial)

MARSHALL LABORATORIES
A subsidiary of Marshall Industries

3530 Torrance Boulevard, Torrance, California 90503 : Telephone (213) 371-3501

10 January 1968
68-1044

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland

Attention: Mr. M. Stephens, Code 246
Contract Negotiator

Subject: Preliminary Interface Drawings EP-5, OGO-F

Reference: Contract NAS 5-11095

Gentlemen:

In accordance with contract ARTICLE I paragraph 1. 3. 1 submitted for your approval are the attached preliminary interface drawings of the Thermal Subsystem for EP-5, OGO-F. Contracting Officer approval of these drawings pursuant to paragraph 1. 3. 1 is requested prior to January 26, 1968 to preclude any schedule slip.

Very truly yours,

MARSHALL LABORATORIES
ORIGINAL SIGNED BY:
J. DAVID WHITE
J. David White
Assistant to the General Manager

JDW:ggo

Enclosures: (1) 805100 N/C
(1) 805200 N/C

cc: Mr. R. Treadwell - Fairchild Hiller Corp. (3) encl.
Mr. E. Painter - GSFC - (3) enclosures
Mr. K. Bradford - TRW - (3) enclosures
Dr. E. Smith - JPL - (3) enclosures
Dr. R. Smith - Stanford University - (3) enclosures
Dr. Helliwell - Stanford University - (3) enclosures

bcc: D. Petrics wo/encl.
R. Kobayashi wo/encl.
G. Mohler wo/encl./File 8-05

MARSHALL LABORATORIES
A subsidiary of Marshall Industries

3530 Torrance Boulevard, Torrance, California 90503 : Telephone (213) 371-3501

5 February 1968
68-0110

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland

Attention: Mr. M. Stephens, Code 246
Contract Negotiator

Subject: Thermal Analysis, EP-5/OGO-F

Reference: Contract NAS 5-11095

Gentlemen:

In accordance with Article VII of the reference contract, we are herein transmitting three (3) copies of the Thermal Analysis for EP-5/OGO-F.

Should you have any questions regarding the enclosed report, please do not hesitate to contact us.

Very truly yours,

MARSHALL LABORATORIES

J. David White
Assistant to the General Manager

JDW:sw

Enclosure: Thermal Analysis EP-5/OGO-F

cc. Dr. E Mercanti, GSFC w/encl. (2)

bc E. Azari w/encl.
F. Petric w/encl.
R. Kobayashi w/encl.
G. Mohler/8-05 w/encl.

MARSHALL LABORATORIES
A subsidiary of Marshall Industries

3530 Torrance Boulevard, Torrance, California 90503 : Telephone (213) 371-3501

24 May 1968
68-0584

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland

Attention: Dr. E. P. Mercanti

Subject: Contract Requirement Modifications
Shift of Responsibility

Reference: (a) Contract NAS 5-11095

(b) Telecon between J. E. Painter, K. Meese, M. Stephens all of GSFC and D. White, D. Petrics of ML on 20 May 1968

Gentlemen:

This letter is intended to verify the shift of responsibility as a result of the subject contract requirement modifications to the reference (a) contract as requested by GSFC in the reference (b) telephone conversation. The shift of responsibility will be as follows:

1. Marshall Laboratories will not coordinate or monitor the mutual interference tests on EP-5 between experiments F-22 and F-24. This responsibility will be assumed by NASA/GSFC.

2. Marshall Laboratories will not install or remove the thermal blankets on the EP-5 assembly. This responsibility will be assumed by NASA/GSFC.

3. Marshall Laboratories will not deliver completed components, assemblies, etc. for this program, to TRW Systems OGO Program Office. Delivery will be made to the NASA/GSFC OGO Program Office at TRW Systems, attention Mr. A. Clarke.

Should there be any questions regarding the above information, please do not hesitate to contact me.

Very truly yours,

MARSHALL LABORATORIES

Eric Azari
Program Manager

EA:sw

cc: K. Z. Bradford
A. Clarke
A. Frandsen
R. Helliwell
K. Meese
J. Painter
E. Smith
R. Smith
M. Stephens

bc R. Kobayashi
D. Petrics
Mohler/White/8-050

MARSHALL LABORATORIES
A subsidiary of Marshall Industries

3530 Torrance Boulevard, Torrance, California 90503 : Telephone (213) 371-3501

24 May 1968
68-0557

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland

Attention: Dr. E. P. Mercanti

Subject: Transmittal of Interference Test Cables

Reference: (a) Contract NAS 5-11095

(b) Telecon E. Painter, K. Meese, M. Stephens all of GSFC and D. Petrics, D. White of ML on 20 May 1968

Gentlemen:

Pursuant to the reference (b) telephone conversation the enclosed packing slip No. 7531 indicates our delivery of the subject interference test cables.

Should there be any questions regarding the above information please do not hesitate to contact me.

Very truly yours,

MARSHALL LABORATORIES

Eric Azari
Program Manager

EA:sw

Enclosure

cc: K. Z. Bradford
J.E. Painter
M. Stephens

bc: R. Kobayashi
D. Petrics
Mohler/White/8-050

SHIPPING ORDER

PACKING SLIP

RSHALL LABORATORIES

a Subsidiary of Marshall Industries

№ 7531

530 TORRANCE BOULEVARD, TORRANCE, CALIFORNIA

Date May 20, 1968

SHIP TO TRW Systems
One Space Park
Redondo Beach, California
~~NASA/GSFC OGO Project Office~~

Attention: Mr. Art Clarke

Customer Order No. 8-050

Our Order No.

No. of Pkgs. One

Via Hand Carry

QUANTITY	DESCRIPTION
1 ea	805900-101 IntFr. Test Cable
1 ea	805900-102 Intfr. Test Cable
1 ea	805900-103 Intfr. Test Cable
	(Test Procedure and Cable Drawings to be delivered 21 MAY 68)

IMPORTANT

CLAIMS FOR SHORTAGE, REJECTION OR BREAKAGE MUST BE MADE WITHIN 10 DAYS FROM RECEIPT OF GOODS. NO MATERIAL RETURNED TO US WITHOUT OUR WRITTEN CONSENT.

RECEIVED BY:

Date 20 May 68

Name [signature]

Company NASA/GSFC

)01(2-62)

SHIPPING

MARSHALL LABORATORIES A subsidiary of Marshall Industries

3530 Torrance Boulevard, Torrance, California 90503 ; Telephone (213) 371-3501

27 May 1968
68-0539

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland

Attention: Mr. M. Stephens
Contract Negotiator

Subject: Delivery, F/U -1 EP-5, OGO-F

Reference: Contract NAS 5-11095

Gentlemen:

In accordance with Article VII of the reference contract this letter advises you of our delivery of the Flight Unit One EP-5, OGO-F as indicated on the enclosed shipping documents.

Delivery was made on 24 May 1968 to the NASA/GSFC OGO Project Office at TRW Systems.

Should you have any questions regarding the above information, please do not hesitate to contact us.

Very truly yours,

MARSHALL LABORATORIES

J. David White
Assistant to the General Manager

JDW:sw

Enclosures

cc: Dr. E. P. Mercanti
J.E. Painter

bc: E. Azari
R. Kobayashi
D. Petrics ✓
Mohler/8-050

SHIPPING ORDER

PACKING SLIP

№ 7541

[MA]RSHALL LABORATORIES
a Subsidiary of Marshall Industries

3530 TORRANCE BOULEVARD, TORRANCE, CALIFORNIA

Date: May 24, 1968

[S]HIP TO: TRW Systems
One Space Park
Redondo Beach, California
~~NASA/GSFC OGO Project Office~~

[A]ttention: Art Glarke

Customer Order No.: 8-050

Our Order No.:

No. of Pkgs.: One

Via: Hand Carry

QUANTITY	DESCRIPTION
1 ea	EP-5, OGO-F Base Plate Pedestal and Harness Assembly S/N 4 (F/U-1) With EP-5 Proportional Heater - Installed S/N -3 (F/U-1)

IMPORTANT

CLAIMS FOR SHORTAGE, REJECTION OR BREAKAGE MUST BE MADE WITHIN 10 DAYS FROM RECEIPT OF GOODS. NO MATERIAL RETURNED TO US WITHOUT OUR WRITTEN CONSENT.

RECEIVED BY: Date: 24 May 68

Name: A. Clarke

Company: NASA/GSFC

1-001(2-62)

SHIPPING

REQUISITION AND INVOICE/SHIPPING DOCUMENT

NO. 1 SHEETS 24May1968

1. FROM
Marshall Laboratories, Torrance, California

2. TO
TRW Systems
One Space Park
Redondo Beach, California

3. SHIP TO • MARK FOR
NASA/GFC OGO Project Office

Attention: Mr. Art Clarke

7. DATE MATERIEL REQUIRED

8. PRIORITY
DO-A2

9. AUTHORITY OR PURPOSE
Contract Delivery

10. SIGNATURE

11a. VOUCHER NUMBER AND DATE
5/24/68

12. DATE SHIPPED
24 May 1968

b. VOUCHER NUMBER AND DATE
109568-5

13. MODE OF SHIPMENT
Hand Carry

14. BILL OF LADING NUMBER

15. AIR MOVEMENT DESIGNATOR OR PORT REFERENCE NUMBER

4. ACCOUNTING AND FUNDING DATA

CONTRACT NAS 5-11095

ITEM NO. a	FEDERAL STOCK NUMBER, DESCRIPTION, AND CODING OF MATERIEL AND/OR SERVICES b	UNIT OF ISSUE c	QUANTITY REQUESTED d	SUPPLY ACTION e	TYPE CONTAINER f	CONTAINER NOS. g	UNIT PRICE h	TOTAL COST i
1	EP 5 OGO-F Base Plate, Pedestal and Harness Assembly. SN4, (F/U-1) with EP-5 proportional heater installed SN 3 (F/U-1)							
	Return Receipt Requested — Assembly Value						$	20,000

Rcd 24 May 68
A. Blanks

NOT REPRODUCIBLE

16. TRANSPORTATION VIA MATS OR MSTS CHARGEABLE TO

17. SPECIAL HANDLING

18. RECAPITULATION OF SHIPMENT	TOTAL CONTAINERS	TYPE CONTAINER	DESCRIPTION	TOTAL WEIGHT	TOTAL CUBE
ISSUED BY D. Petrics	1	Metal Container			
CHECKED BY					
PACKED BY					
	1	← TOTAL →			

19. RECEIPT	DATE	BY	
CONTAINERS RECEIVED EXCEPT AS NOTED			SHEET TOTAL
QUANTITIES RECEIVED EXCEPT AS NOTED			GRAND TOTAL
POSTED			20. RECEIVER'S VOUCHER NO.

DD FORM 1 MAR 60 1149 REPLACES EDITION OF 1 MAR ... WHICH MAY BE USED

MARSHALL LABORATORIES
A subsidiary of Marshall Industries

3530 Torrance Boulevard, Torrance, California 90503 : Telephone (213) 371-3501

27 May 1968
63-0594

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland

Attention. Mr. M. Stephens
Contract Negotiator

Subject: Test Procedure, Mutual Interference Test,
EP-5, OGO-F

Reference. Contract NAS 5-11095

Gentlemen:

In accordance with Article VII of the reference contract, we are herein transmitting the Mutual Interference Test Procedure, EP-5/OGO-F No. 46868.

Should you have any questions regarding the enclosed specification, please do not hesitate to contact us.

Very truly yours,

MARSHALL LABORATORIES

J. David White
Assistant to the General Manager

JDW:sw

Enclosure

cc: E. P. Mercanti
E. Smith
A. Frandsen
R. Smith
R. Helliwell
A. Clarke

bc: E. Azari
D. Petrics
Mohler/White/8-050

MARSHALL
LABORATORIES A subsidiary of Marshall Industries

3530 Torrance Boulevard, Torrance, California 90503 : Telephone (213) 371-3501

5 June 1968
68-0696

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland

Attention: Dr. E. P. Mercanti

Subject: Transmittal of EP-5 Stub Boom

Reference: Contract No. NAS 5-11095

Gentlemen:

This letter is intended to inform you of the transmittal of the EP-5 Stub Boom, No. 107957-900, from Marshall Laboratories to TRW Systems as indicated on the enclosed shipping documents. The EP-5 Stub Boom was delivered to TRW Systems in support of the forthcoming solar-vac tests on the prototype and flight EP-5 assemblies.

Should there be any questions regarding the above information, please do not hesitate to contact me.

Very truly yours,

MARSHALL LABORATORIES

Eric Azari
Program Manager

EA:sw

cc: J. E Painter
M. Stephens
K. Z. Bradford

bc R. Kobayashi
D. Petrics
Mohl~~er~~/White/8-050

SHIPPING ORDER

PACKING SLIP

Nº 7556

ARSHALL LABORATORIES
a Subsidiary of Marshall Industries

3530 TORRANCE BOULEVARD, TORRANCE, CALIFORNIA

Date June 4, 1968

Customer Order No. 8-050

Our Order No.

No. of Pkgs. One

Via Hand Carry

SHIP TO TRW Systems
One Space Park
Redondo Beach, California
~~OGO Program Office S/1869~~

Attention: Mr. Fritz Odegaard

QUANTITY	DESCRIPTION
1 ea	EP-5 Stub Boom No. 107957-900 For Solar-Vac Tests

IMPORTANT

CLAIMS FOR SHORTAGE, REJECTION OR BREAKAGE MUST BE MADE WITHIN 10 DAYS FROM RECEIPT OF GOODS. NO MATERIAL RETURNED TO US WITHOUT OUR WRITTEN CONSENT.

RECEIVED BY: Date 6/4/68

Name F. A. Odegaard

Company TRW

01(2-62)

SHIPPING

SHIPPING ORDER

PACKING SLIP

№ 7564

:SHALL LABORATORIES
a Subsidiary of Marshall Industries

:30 TORRANCE BOULEVARD, TORRANCE, CALIFORNIA

Date June 10, 1968

Customer Order No. 8-050

Our Order No.

No. of Pkgs. One

Via Hand Carry

P TO TRW Systems
One Space Park
NASA/GSFC, OGO Project Office
~~Redondo Beach, California~~

:ention: Mr. Art Clarke

QUANTITY	DESCRIPTION
5 ea	805202-101,102 Thermal Blanket Assy. Serial No's 3,4,5,6, and 7 This completes the thermal blankets required under Contract NAS5-11095

IMPORTANT

:LAIMS FOR SHORTAGE, REJECTION OR :REAKAGE MUST BE MADE WITHIN 10 DAYS :ROM RECEIPT OF GOODS. NO MATERIAL :TURNED TO US WITHOUT OUR WRITTEN :ONSENT.

RECEIVED BY:

Date 10 Jun 68

Name A. Clarke

Company NASA / GSFC

1(2-62)

SHIPPING

MARSHALL LABORATORIES
A subsidiary of Marshall Industries

3530 Torrance Boulevard, Torrance, California 90503 : Telephone (213) 371-3501

11 June 1968
68-0723

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland

Attention. Mr. M. Stephens

Subject: Delivery, Thermal Blankets EP-5, OGO-F

Reference: Contract NAS 5-11095

Gentlemen:

In accordance with Article VII of the reference contract this letter advises you of our delivery of five (5) thermal blankets consisting of (1) prototype, (1) flight and (3) spares for the EP-5, OGO-F Spacecraft.

Delivery was made on 10 June 1968 to the NASA/GSFC OGO Project Office at TRW Systems as indicated on the enclosed shipping document.

This delivery completes the contract requirements of deliverable thermal components with the exception of one (1) spare proportional heater which will remain in the project inventory at Marshall Laboratories until such time as it may be required to be installed on an EP-5 assembly by Marshall Laboratories personnel.

Should you have any questions regarding the above information, please do not hesitate to contact us.

Very truly yours,

MARSHALL LABORATORIES

J. David White
Assistant to the General Manager

JDW:AW

cc: Dr. E.P. Mercanti
Mr. J.E. Painter

bc E. Azari, R. Kobayashi, D. Petrics V Contract File 8-060

MARSHALL LABORATORIES
A subsidiary of Marshall Industries

3530 Torrance Boulevard, Torrance, California 90503 : Telephone (213) 371-3501

18 March 1969
69-0102

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland

Attention. Mr. M. Stephen
Contract Negotiator

Subject: Test Data and Results of the Space Simulation Tests performed on the EP-5, OGO-F Test Mock-up.

Reference: Contract NAS 5-11095
Article I
Paragraph 1.3.5 Space Simulation Tests

Gentlemen:

In accordance with the requirements of the reference contract, Article I, Paragraph 1.3.5, we are herein transmitting the test data and results of the space simulation test performed on the EP-5 OGO-F Test Mock-up Experiment Package No. 5.

Should you have any questions regarding the enclosed "Simulator Test Report", please do not hesitate to contact us.

Very truly yours,

MARSHALL LABORATORIES

Leo C. Young
Controller

LCY:sw

Enclosure

ITEM 7

TYPICAL PROPORTIONAL HEATER INSPECTION REPORT

INSPECTION REPORT

Scope: This report describes the physical condition of the electronic equipment specified below at the time that the equipment leaves Marshall Laboratories.

Equipment: Name of Equipment: Non Magnetic Heater

Serial Number: 7,8,9,10, 12 No. of Units: 5

Job Number: ______ Contract: ______

Inspection: Requested by: ______ Date: ______

Point in Sequence: Final Inspection

Inspection Performed by: ______ Date: ______

Findings: (If discrepancy, place X in right hand column)

	Comments	Discrep.	OK
A. Housing & Mechanical Parts:			
1. Connectors seated properly	N/A		
2. R-F filters seated properly	N/A		
3. Covers mate properly			X
4. Holes match where required			X
5. Hardware securely mounted			X
6. Nuts, bolts properly tightened			X
7. Nylon hardware where required	N/A		
8. Paint removed under ground lugs			X
9. Locknuts/lockwashers where required			X
10. Boards chipped, broken, split			X
11. Housing surface smooth			X
12. Plating flaking or bubbly			X
13. Plating tarnished			X
14. Plating scratched to sub-metal			X
15.			
16.			
17.			
18.			
19.			
20.			

	Comments	Discrep.	OK
B. Connectors:			
1. Proper length threaded studs	N/A		
2. Secure mounting			
3. Surface tarnish			
4. Hi Rel connector			
5. Potting material on back			
6. Potting material around pins			
7. Pins floating, where required			
8. Pins straight			
9. Dielectric discoloration.			
10. Wires properly dressed, soldered			
11. Shrinkable sleeving employed			
12. Shrinkable sleeving split	N/A		
13.			
14.			
15.			
16.			

	Comments	Discrep.	OK
C. Cabling and Hard Wiring:			
1. Cables properly grouped			✓
2. Cables properly spot epoxied			✓
3. Cables properly laced			✓
4. Non-shrinkable lacing cord			✓
5. Shielded wires properly terminated			✓
6. Wire insulation properly stripped			✓
7. Cold-flow possibilities			✓
8. Wires stripped proper distance from termination			✓
9. Proper protrusion thru fork terminals	N/A		
10. Proper protrusion thru p/c eyelet			✓
11. Wrap around terminals	N/A		
12. Wire strands broken			✓
13. Cable spans protected against fatigue			✓
14.			
15.			
16.			

	Comments	Discrep.	OK
D. Component Mounting			
1. Proper lead length, body to terminal	N/A		
2. Proper lead bend radius			✓
3. Leads protrude thru terminals proper distance	N/A		
4. Max. no. of leads per fork term	N/A		
5. Transistor cases insulated from leads and p/c lines			✓
6. Metallic cased components insulated from leads and p/c lines			✓
7. Heavy components tied to board			✓
8. Lacing cord non-shrinkable			✓
9. Nylon mounting hdw. where required			✓
10. Support provided for components stood off boards			✓
11. Lead seals broken			✓
12. Tantalum welds broken			✓
13. Component leads sleeved where required			✓
14. Sleeving cold flow condition possibility			✓
15. Shrinkable sleeving split			✓
16. Any components movable?			✓
17.			
18.			
19.			
20.			
E. Coatings			
1. Conformal coat even	N/A		
2. Fillets around components	N/A		
3. Bubbles in conformal coat	N/A		
4. Conformal coat on connectors	N/A		
5. Thermal paint inside as required			✓
6. Thermal paint outside as required			✓
7. Epoxy spot-ties as required			✓
8. Coats, epoxy, etc. peeling or loose			✓
9.			
10.			

	Comments	Discrep.	OK
F. Electrical Connections			
1. Cold solder joints			✓
2. Contaminated solder joints			✓
3. Excess solder			✓
4. Insufficient solder			✓
5. Rosin joints			✓
6. Dirty solder joints			✓
7. Solder properly wicked			✓
8. Holes in solder joint surface			✓
9. Weld joint deformation proper	N/A		
10. Weld joint splatter (whiskers)	N/A		
11. Weld joint blow holes	N/A		
12. Other improper welds	N/A		
13. Scribe marks or other deformations			✓
14.			
15.			
16.			
17.			
18.			
G. Cleanliness			
1. Solder splash on board, housing, coat			✓
2. Dirt or debris on board, housing, coat			✓
3. Rosin cleaned from board			✓
4. Paint on improper surfaces, coat			✓
5. Grease or finger marks on plating			✓
6. Dirt or debris in connectors	N/A		
7.			
8.			
H. Labelling			
1. Connectors labelled in ink	N/A		
2. Modules labelled in ink			✓
3. Unit labelled, model, S/N			✓
4. Decals used	N/A		
5. Labelling protected	N/A		
6.			

Deficiency Disposition:

Item	Disposition
1.	All five assemblies vary upwards in width from 1.256". S/B 1.12 ± .12
2.	All five assemblies have some illegibility of letters or numbers of identification markings
3.	All five assemblies have spots along bottom edges that are bare of paint. Also some other areas have finish removed.
	ITEM #1 spec change in process that will accept Dims.
	Items 2 & 3 Rwk if Possible.
	Rework of items 2 + 3 performed + inspected

Inspector:______________________ Date:______________________

Engineer:______________________ Date:______________________

Approval to Ship:______________________ Date:______________________

Inspection verified by:______________________ Agency:______________ Date:________

Inspection verified by:______________________ Agency:______________ Date:________

ITEM 8

SOLAR VACUUM DESIGN VERIFICATION

SPECIFICATION S46865

PARTS DISPOSITION		SPEC NO.	REV
1. USE 2. REWORK	3. CANNOT BE REWORKED 4. RECORD 5.	S 46865	

REVISIONS

ISP	EFF	REV	DESCRIPTION	BY	CK	DATE	APPROVAL

SHEET INDEX	REV														
	SHEET	1	2	3	4	5	6	7	8	9	10	11	12	13	14
SHEET INDEX	REV														
	SHEET														

CONTRACT NO. NAS 5-11095	
PREP D. Petrics	3/13/68
CK	3/13/68
ENGR	3/13/68
APPD	3/13/68
APPD	
QC APPD J. Squires	3/13/68
DESIGN APPD RSL 3-13-68	
CUSTOMER	

M L — MARSHALL LABORATORIES
TORRANCE, CALIFORNIA

TITLE

Solar-Vac Design Verification
Test Procedure
EP-5 OGO-F

SIZE	CODE IDENT NO.	SPECIFICATION NO.	REV
A	13126	S 46865	

RELEASED MAR 15 1968 | SHEET 1 OF

ML FORM 202

TABLE OF CONTENTS

FIGURES

1.0 SCOPE

1.1 Introduction

This specification defines the solar-vac design verification test procedures for the EP-5 appendage of the OGO-F Spacecraft. The EP-5 appendage package contains portions of two experiments, F-22 and F-24 both within a thermal equilibrium blanket and mounted to the +Y end of the EP-5 boom.

The EP-5, as shown in Figure 1, is partially contained within a 11.0" x 9.5" x 9.0" parallel piped thermal envelope. The F-24 antenna extends beyond the thermal envelope and thus is not maintained within the thermally controlled environment. The thermal envelope, which makes up the electronics compartment, consists of multilayer aluminized mylar sheets and pure silk mesh arranged in a sandwich type construction with the mylar side facing out.

Within the environmental controlled electronics compartment are the search coil magnetometer coils and preamplifiers for the F-22 Search Coil Magnetometer Experiment, developed by Dr. E. Smith of JPL and Porfessor Holzer of UCLA, and the preamplifier for the F-24 VLF Antenna Experiment developed by Dr. Helliwell and Dr. R. Smith of Stanford University. Because of the sensitivity of the experiments within the EP-5 to magnetic fields and RF noise, a non-magnetic proportional heater is used as an active temperature control device. The EP-5 proportional heater developed by Marshall Laboratories, is bonded to the baseplate and provides heat to the experiments by conduction and radiation from the baseplate. Figure 2 illustrates the EP-5 temperature control system. The electronics compartment has an acceptable temperature range of $-20^{\circ}C$ to $+50^{\circ}C$ and a minimum internal dissipation of .22 watts when the internal temperature is $12^{\circ}C$. Between the temperature range of $6^{\circ}C$ and $12^{\circ}C$ the dissipation may vary from 1.575 watts to .22 watts depending on the position of the spacecraft relative to the sun.

1.2 Test Requirements

The test procedures established herein are in accordance with Goddard Space Flight Center T&E Specification No. S-4-101 Revision A entitled "Specification Environmental Design Qualification Test OGO Experiments".

1.3 Responsibility

The responsibility and authority for decisions relative to the requirements of this specification rests with Marshall Laboratories subject to approval by NASA/GSFC.

2.0 APPLICABLE DOCUMENTS

2.1 Specifications

Goddard Space Flight Center

2.1.1 S-4-101 — Specification Environmental Design Qualification Test OGO Experiment.

2.2 Drawings

Marshall Laboratories

2.2.1 805800 — Wiring Diagram Subsystem Thermal Mockup EP-5

2.2.2 805801 — Subsystem Assembly Thermal Mockup EP-5

2.2.3 805802 — Insulation Assembly Thermal Mockup EP-5

2.2.4 805803 — Assembly, Thermal Mockup EP-5

3.0 ENVIRONMENTAL REQUIREMENTS

3.1 Simulation of Environment

Laboratory design verification tests for electronic and mechanical assemblies are intended to simulate environmental conditions which are more severe than field conditions in order to provide better assurance of locating design deficiencies. However, the conditions are not intended to be severe enough to exceed design safety margins or to excite unrealistic modes of failure. Should such modes occur, pertinent requirements will be waived in accordance with the applicable procedures.

4.0 TEST EQUIPMENT

4.1 Standard Equipment

a) 7' x 8' Vacuum Chamber and supporting equipment.

b) Digital Voltmeter - Cubic Corporation V-71

c) Power Supply (4) - Hewlett Packard Model HP721A

d) Milliammeter (3) - T ·iplett Model 630NA

4.2 Special Equipment

a) Thermometer — Marshall Laboratories Model No. ML-332

5.0 TEST FACILITIES

The design verification solar-vac testing of the EP-5 Thermal Mockup is to be conducted at Goddard Space Flight Center, Greenbelt, Maryland.

5.1 Apparatus and Conditions

The apparatus used in conducting the solar-vac design verification tests shall be capable of producing and maintaining the test conditions required within this specification.

6.0 INSTALLATION CHECK

Following installation into the test apparatus and prior to pump down a comprehensive inspection and electrical check of the EP-5 instrument shall be performed by Marshall Laboratories and GSFC to insure that no malfunction or damage was caused due to faulty installation procedure or handling.

7.0 CRITERIA FOR FAILURE

With the concurrence of the Marshall Laboratories authorized representative, degradation or change in performance of the EP-5 which exceeds limits established by its specification and applicalbe test procedure during any test period shall be considered as a failure. Testing shall be discontinued until the malfunction (including design defects) is corrected. If the corrective action consists of simple repair, such as replacement with identical parts, the complete test procedure under which failure occurred shall be repeated in its entirety without equipment failure before proceeding to the next test. If corrective action such as redesign, is required, the test procedure under which failure occurred shall be repeated as indicated above after repair action. In addition, if such redesign affects the results of previously completed tests, such tests shall be repeated.

8.0 EVALUATION

The acceptable compartment temperatures for the EP-5 are from -20°C to +50°C. To monitor the compartment and experiment temperatures during testing, twelve (12) YSI type 44018 thermistors have been installed throughout the package as follows.

RT-1	F-22 X-Axis Sensor
RT-2	F-22 X-Axis Sensor
RT-3	F-22 Y-Axis Sensor
RT-4	F-22 Y-Axis Sensor
RT-5	F-22 Z-Axis Sensor
RT-6	F-22 Z-Axis Sensor
RT-7	EP-5 Base Plate, near Heater Control Thermistor
RT-8	EP-5 Search Coil Bracket
* RT-9	Base of F-24 Antenna near squibbs. External of Thermal blanket.
* RT-10	Inside of Thermal Blanket.
RT-11	F-24 Preamplifier
RT-12	F-24 Preamplifier

* RT-9 and RT-10 are thermistors installed for academic information only and are not to be used as criteria for failure.

8.1 Performance Recording

Performance data recording shall be taken every hour and consist of the following:

a) date
b) time
c) chamber pressure
d) thermistor temperatures
e) heater voltage
f) experiment voltages
g) heater current
h) experiment currents
i) shroud temperatures
j) thermometer voltage

8.2 Stabilization

Stabilization shall be considered achieved when all the monitoring thermistors listed in paragraph 8.0 do not vary more than 1°C during a three (3) hour period. This requirement excludes thermistors RT-9 and RT-10.

8.3 Test Duration

Tests shall be continued for a period of twenty-four (24) hours after achieving stabilization, in both solar and eclipse environments.

9.0 TEST PROCEDURES

This test will be conducted in two phases covering worst case conditions.

Phase I will be the worst case hot condition where EP-5 is receiving direct solar radiation on its +X surface. Phase II will be the worst case cold condition where the EP-5 is in total eclipse.

9.1 Pre-Test Requirements

9.1.1 The EP-5 Assembly shall be suspended by insulated wire and waxed cord, in a 7' x 8' solar-vac chamber capable of achieving and maintaining 1×10^{-5} mm Hg or less. The test item orientation is shown on Figure 3.

9.1.2 Perform two pre-test and post-test solar scans with arc set for 1.0 sun at 51 1/2 inches from the door flange. Beam diameter shall be 40 inches minimum. The chamber solar simulator shall be calibrated under ambient conditions using a radiometer target board and shall not vary more than 10% over the pattern.

9.1.3 Connect test equipment as shown in Figure 4 and perform pre-test checkout (ref. par. 6.0).

Installation Check List

Item	Responsibility
1. Test configuration correct including boom and thermal blankets	GSFC/ML
2. Experiment package suspended in correct position (including orientation as well as distance from the solar simulator)	GSFC
3. Minimum conductive heat transfer between the test item and the chamber shroud.	GSFC
4. Monitoring radiometer suspended.	GSFC
5. All cables wrapped and suspended away from the chamber shroud and out of the solar simulator beam as much as possible.	GSFC
6. Warm chamber ports covered	GSFC
7. Chamber checked for cleanliness	GSFC
8. Pictures of test setup taken	GSFC

9. Operational test of all thermistors, thermocouples, heaters, and experiment mockups. GSFC/ML

9.1.4 Rough out chamber to 1×10^{-5} torr or better.

9.1.5 Flood shrouds with LN_2.

9.2 <u>Test Phase I Solar Condition</u>

9.2.1 Turn arc ON at 1.0 sun after chamber walls are at -100°C or less.

9.2.2 Turn experiments, heater power, and test equipment power ON.

a) F-22 Search Coil, 28V @ 18 ma

b) F-24 Preamp, 28V @ .55 ma

c) EP-5 proportional heater 33V

d) Test equipment 14.2V

9.2.3 Establish stabilization per paragraph 8.2, recording readings per paragraph 8.1.

9.2.4 Continue test after stabilization for 24 hours in accordance with paragraph 8.3.

9.3 <u>Test Phase II, Eclipse Condition</u>

9.3.1 Shutdown arc source.

9.3.2 Adjust proportional heater power to 23V

9.3.3 Establish stabilization per paragraph 8.2, recording readings per paragraph 8.1.

9.3.4 Continue test after stabilization for 24 hours in accordance with paragraph 8.3.

9.4 Post Test Requirements

9.4.1 Turn off all power supplies.

9.4.2 Secure chamber. Use arc to warm shrouds.

9.4.3 Perform ambient checkout. Same as paragraph 9.1.3 item 9.

9.4.4 Perform post test solar scans. Same as paragraph 9.1.2.

Figure 1 EP-5 DESIGN CONFIGURATION

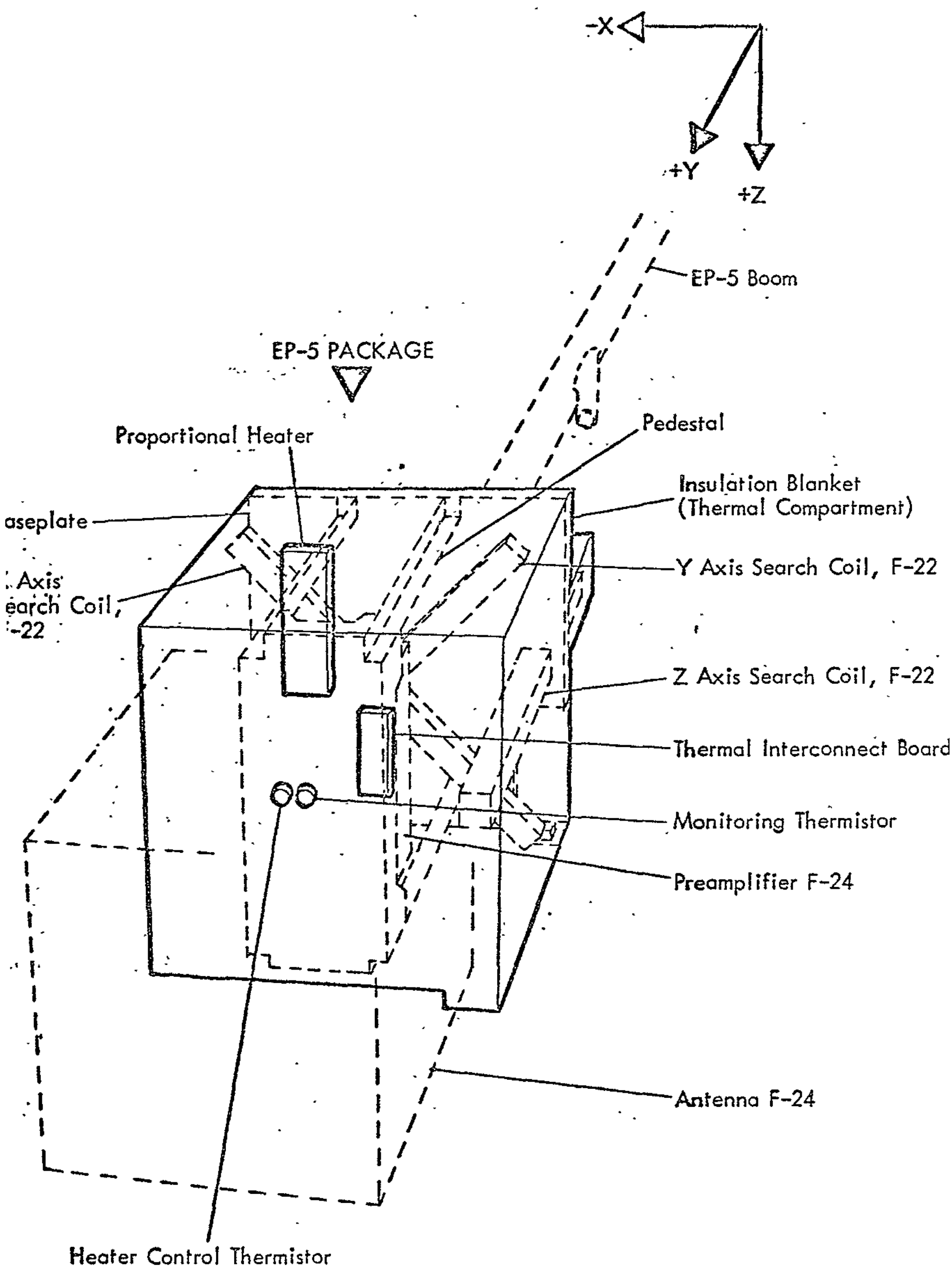
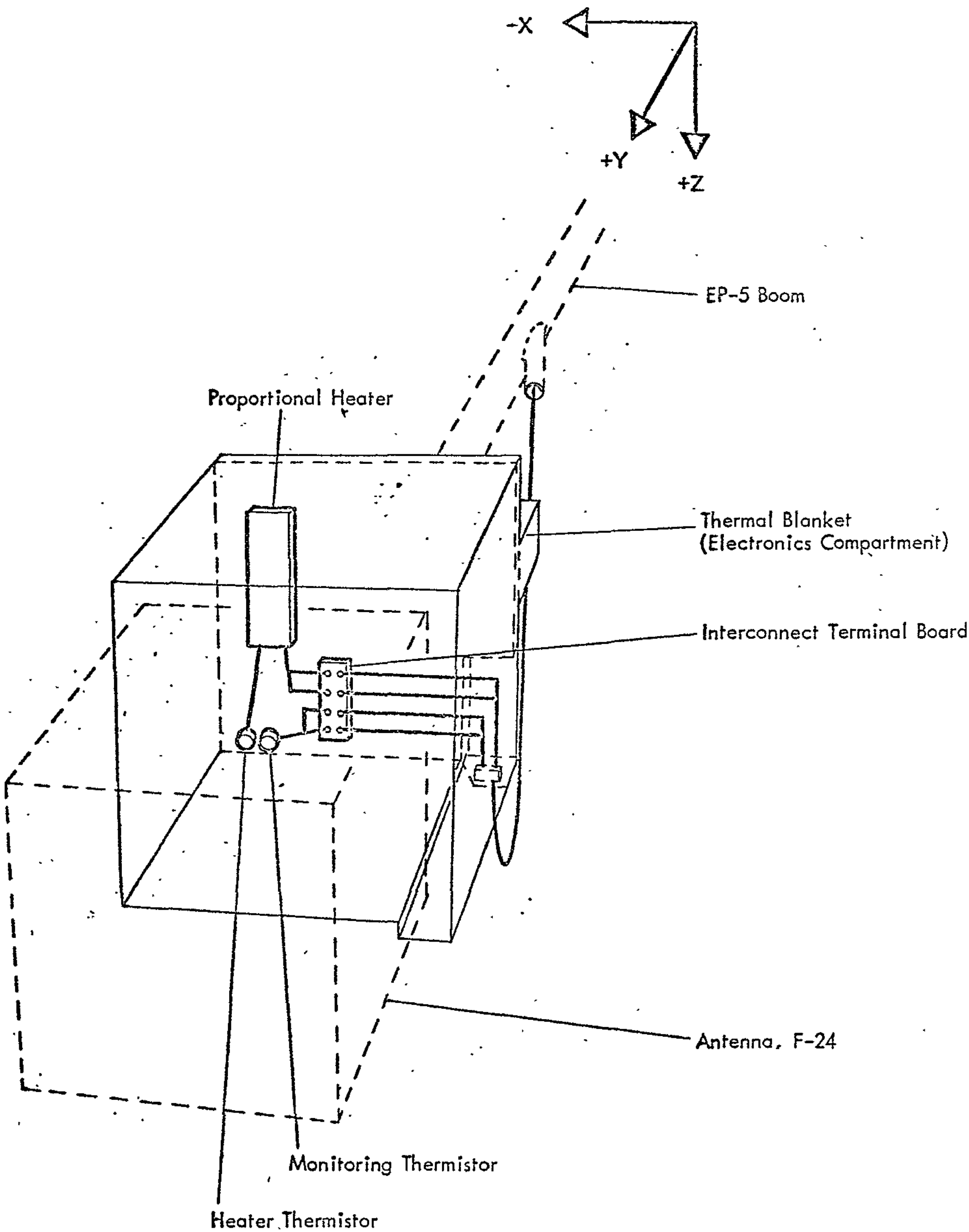


Figure 2 EP-5 THERMAL SUB-SYSTEM/OGO-F



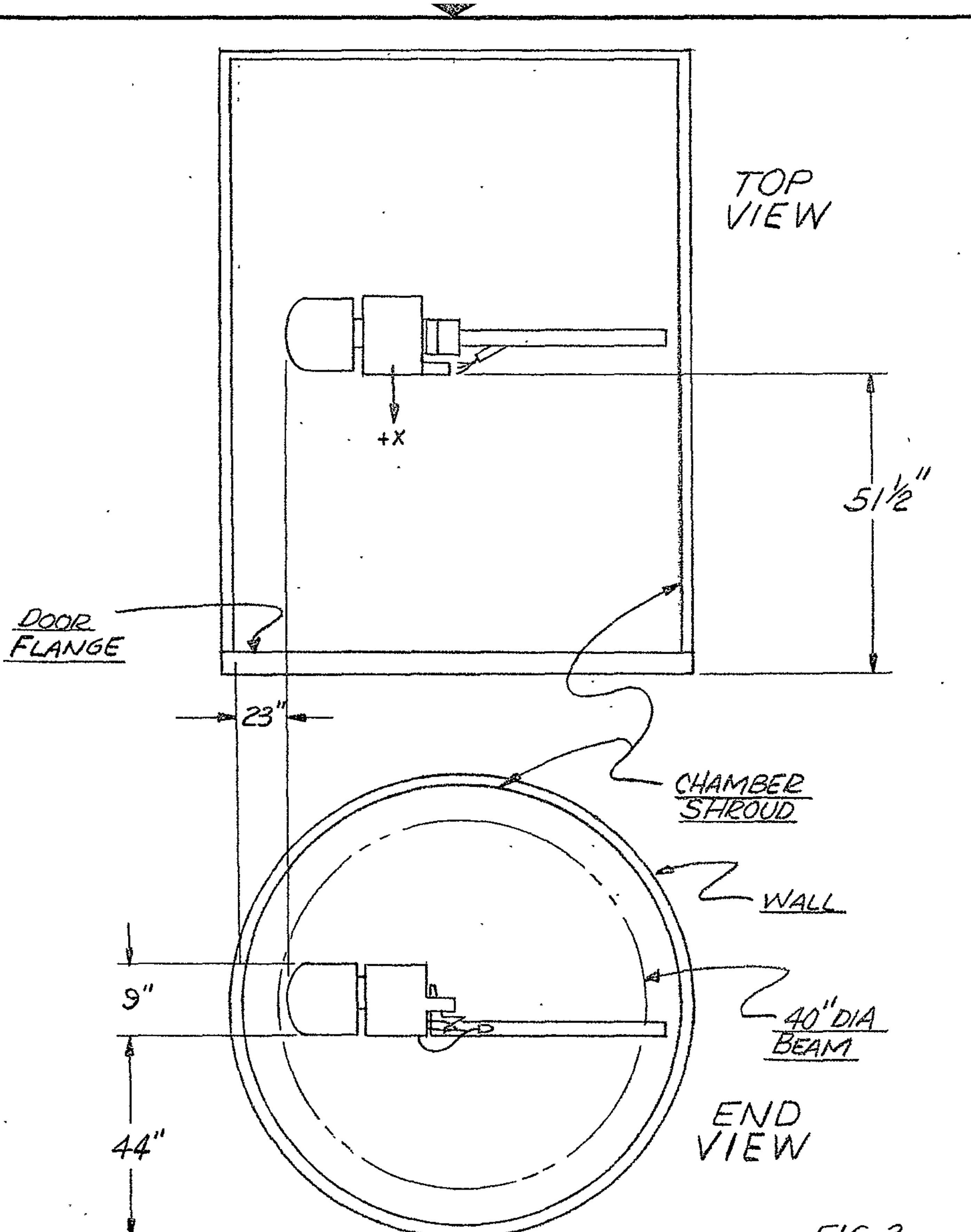
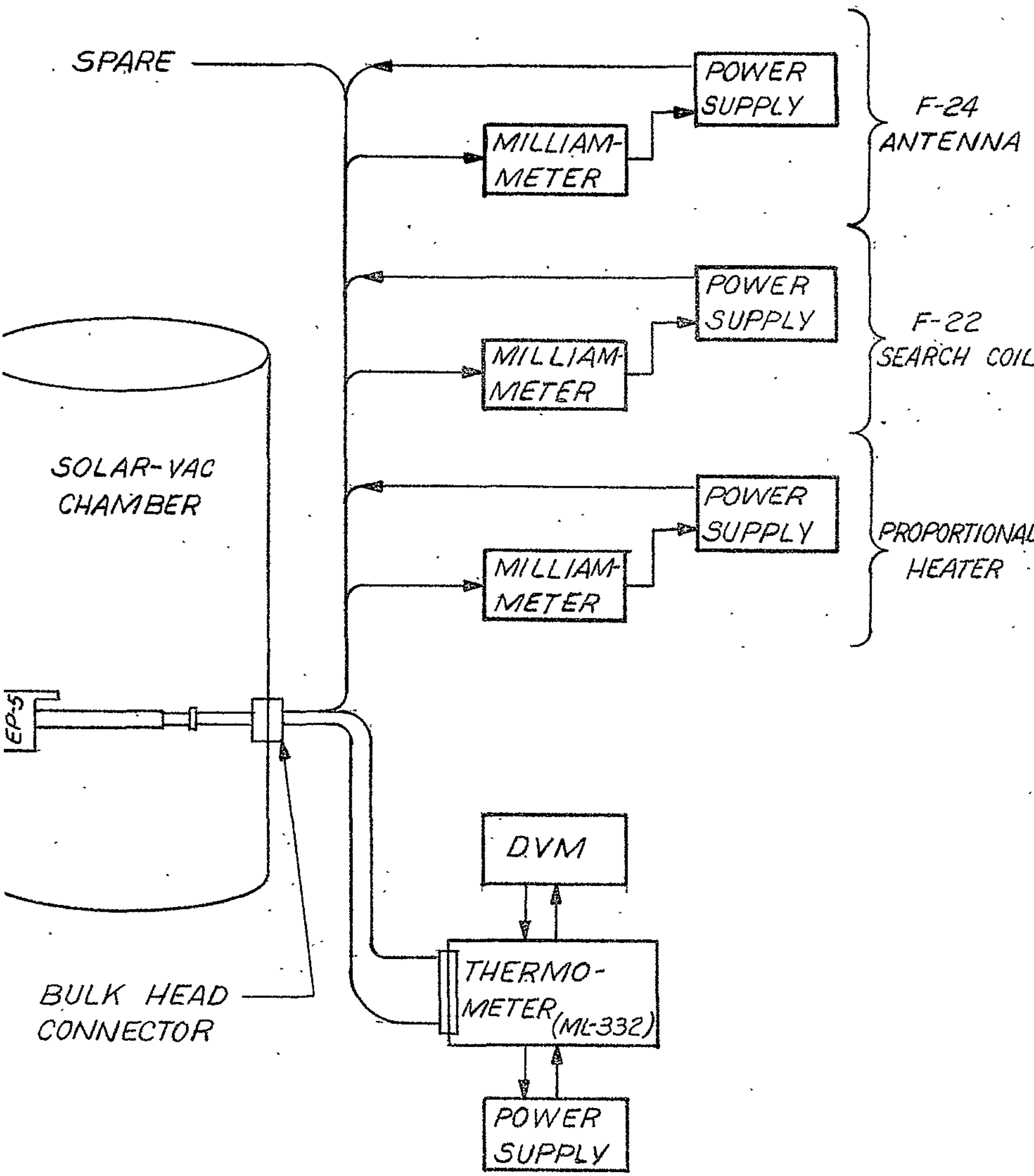


FIG. 3

CHAMBER INSTALLATION - OGO-F, EP-5 - THERMAL SUBSYSTEM

M L **MARSHALL LABORATORIES** TORRANCE CALIFORNIA	TITLE Solar-Vac Design Verification Test Procedure EP-5, OGO-F	SPECIFICATION NO. S 46865	REV
CODE IDENT NO **13126**		SHEET 11 OF	

FORM 201



EP-5 SOLAR-VAC TEST DIAGRAM FIG. 4

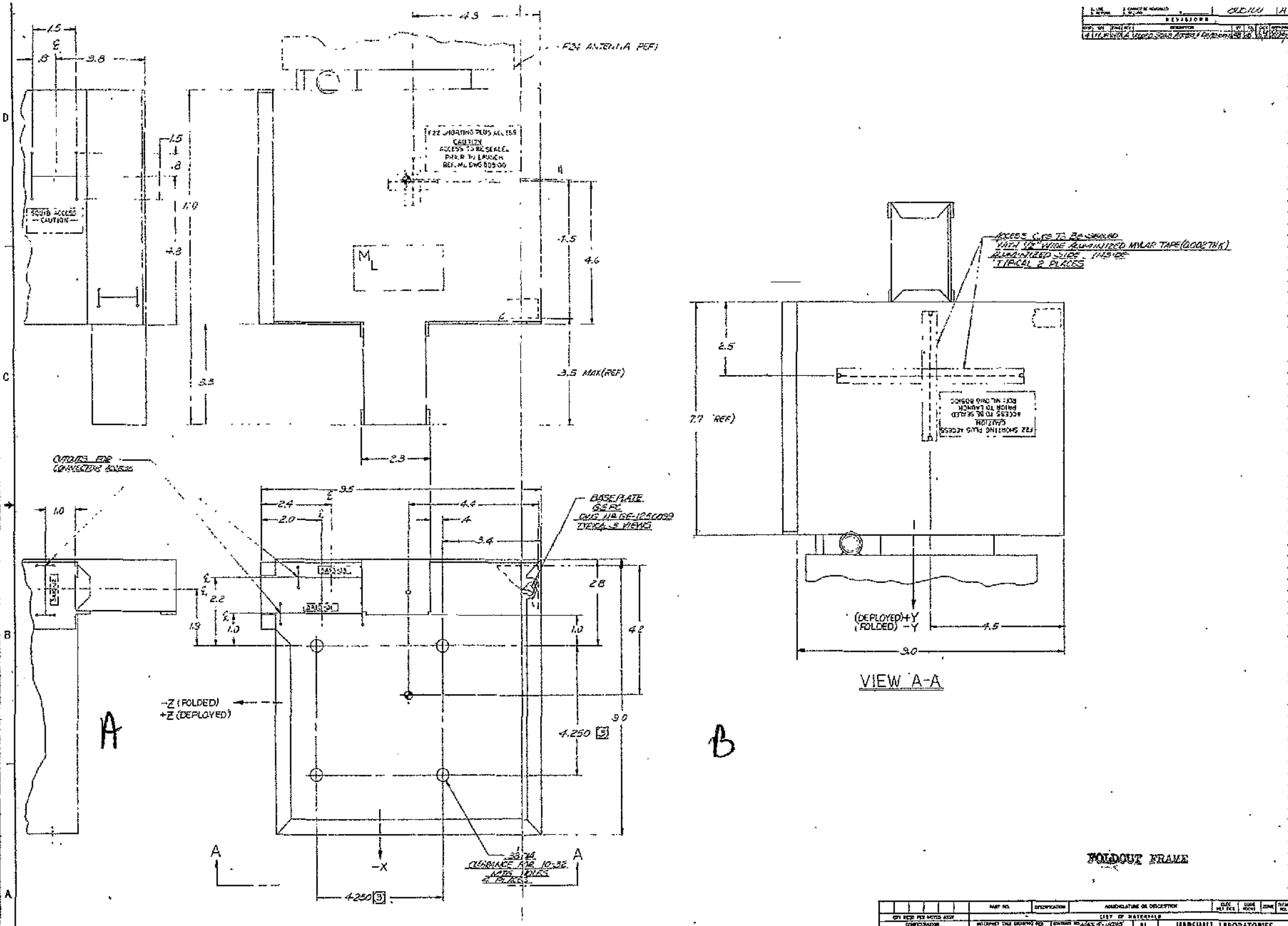
MARSHALL LABORATORIES TORRANCE CALIFORNIA	TITLE Solar-Vac Design Verification Test Procedure Ep-5, OGO-F	SPECIFICATION NO. S 46865	REV
NO 13126		SHEET 12 OF	

ITEM 9

EP-5 THERMAL SYSTEM DRAWINGS

EP-5 THERMAL SYSTEM DRAWINGS

Drawing Number	Description
805100	EP-5 Envelope
805200	EP-5 Final Assembly
805202	Thermal Blanket Assembly
805205	Thermal Blanket Form Block
805800	Wiring Diagram EP-5 Thermal Mock-Up
805801	Subsystem Assembly EP-5 Thermal Mock-Up
805803	Assembly EP-5 Thermal Mock-Up
805804	Preamplifier Assembly EP-5 Thermal Mock-Up
805805	Search Coil Sensor Assembly EP-5 Thermal Mock-Up
805806	Boom Harness EP-5 Thermal Mock-Up
805807	Boom Extension Harness EP-5 Thermal Mock-Up
805808	Test Harness EP-5 Thermal Mock-Up
805809	Container Assembly EP-5 Thermal Mock-Up
805810	Base Plate Harness EP-5 Thermal Mock-Up
805811	Assembly Board Insulated EP-5 Thermal Mock-Up
805900	Assembly Cable Interference Test EP-5 Thermal Mock-Up
20032	Thermistor Assembly
20037	Strip Heater
52168	Proportional Heater Assembly
52238	Schematic Proportional Heater



FOLDOUT FRAME

FOLDOUT FRAME

3. DIMENSIONS SHOWN ARE BASIC INTERFACE DIMENSIONS FROM GSFC DWG Nº 5E1250?? APPENDAGE INTERFACE DWG EP5 OGO-F

2. APPROXIMATE WEIGHT EQUALS 6.8 LBS

1. ⌖ INDICATES APPROXIMATE CENTER-OF-GRAVITY.

NOTES: UNLESS OTHERWISE SPECIFIED

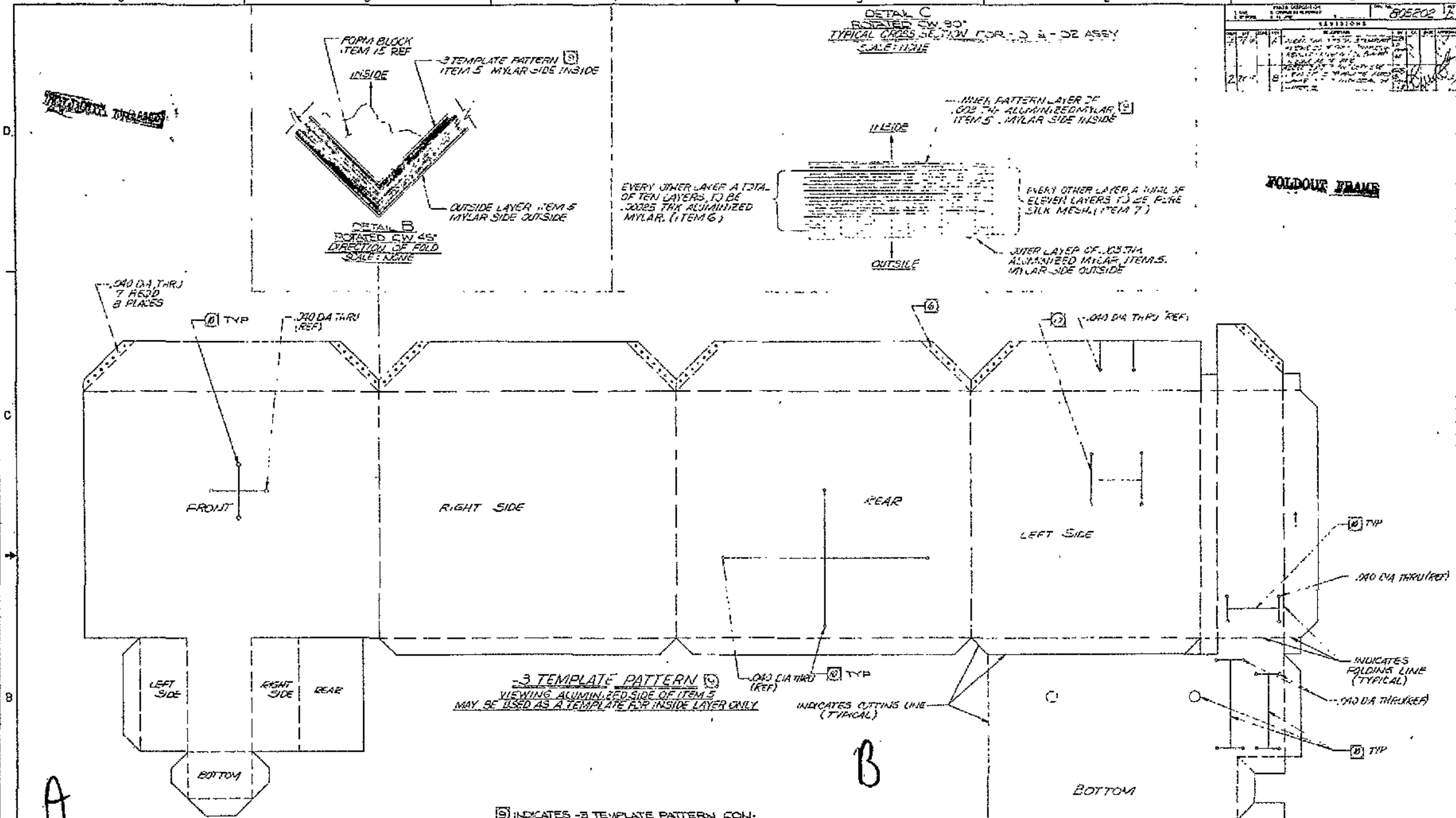
CONTRACT NO NAS 5-11095

MARSHALL LABORATORIES
TORRANCE, CALIFORNIA

TITLE: ENVELOPE — EXPERIMENT PACKAGE Nº 5, OGO-F

SIZE E | CODE IDENT NO 13126 | DWG NO 805100 | REV A

SCALE FULL | SHEET 1 OF 1



12 FOR ENVELOPE DWG SEE ML DWG 805100.
11 CUT DECAL DWG 805208, INTO FIVE SEPARATE DECALS AND APPLY TO SURFACES APPROX AS SHOWN, (ITEM 13).
10 AFTER COMPLETION OF -1 ASSY, CUTOUTS AND HOLES ARE TO BE MADE BY CENTERING PORTIONS OF -3 PATTERN TO INDICATED OUTSIDE SURFACES. DIMENSIONS ARE FOR REF ONLY. DO NOT MAKE CUTOUTS AND HOLES AT -3 FABRICATION.

9 INDICATES -3 TEMPLATE PATTERN CONFIGURATION, INSIDE LAYER ONLY.
8 AFTER VISUAL INSPECTION OF WELDS APPLY ALUMINIZED TAPE ITEM 9 ON ALL WELDS & ON EVERY SEAM, APPROX AS SHOWN
7 BAG AND STRING IDENTIFY PER MIL SPEC S40111, CLASS IV TYPE III.
6 STRING IDENTI... PER MIL SPEC S40111 CLASS IV, TYPE ... APPROX AS SHOWN.
5 INDICATES ULTRASONIC WELDING AT APPROX INTERVALS AS SHOWN, USING MIL SPEC S43016.
4 ALL DIMENSIONS ARE DETERMINED BY USING THE FORM BLOCK, DWG 805205, USE FORM BLOCK FOR ALL WRAPPINGS AND TAPING OF ASSY.
3. ASSEMBLY TA... SHALL BE PROVIDED WITH SURFACES DES... TO PREVENT DAMAGE TO ALUMINIZED SURFACES BY ABRASION.
2. CLEAN, WHITE, COTTON OR NYLON GLOVES SHALL BE USED FOR HANDLING THERMAL INSULATING MATERIAL.
1. THERMAL INSULA... ASSEMBLY OF EP-5 PACKAGE SHALL BE PERFORMED IN AN AREA WHICH MEETS THE CLASS 100,000 ... REQUIREMENTS OF FEDERAL STANDARD 209A.

NOTES: UNLESS OTHERWISE SPECIFIED

SEE SEPARATE PARTS LIST ML DWG PL-805202.

LIST OF MATERIALS

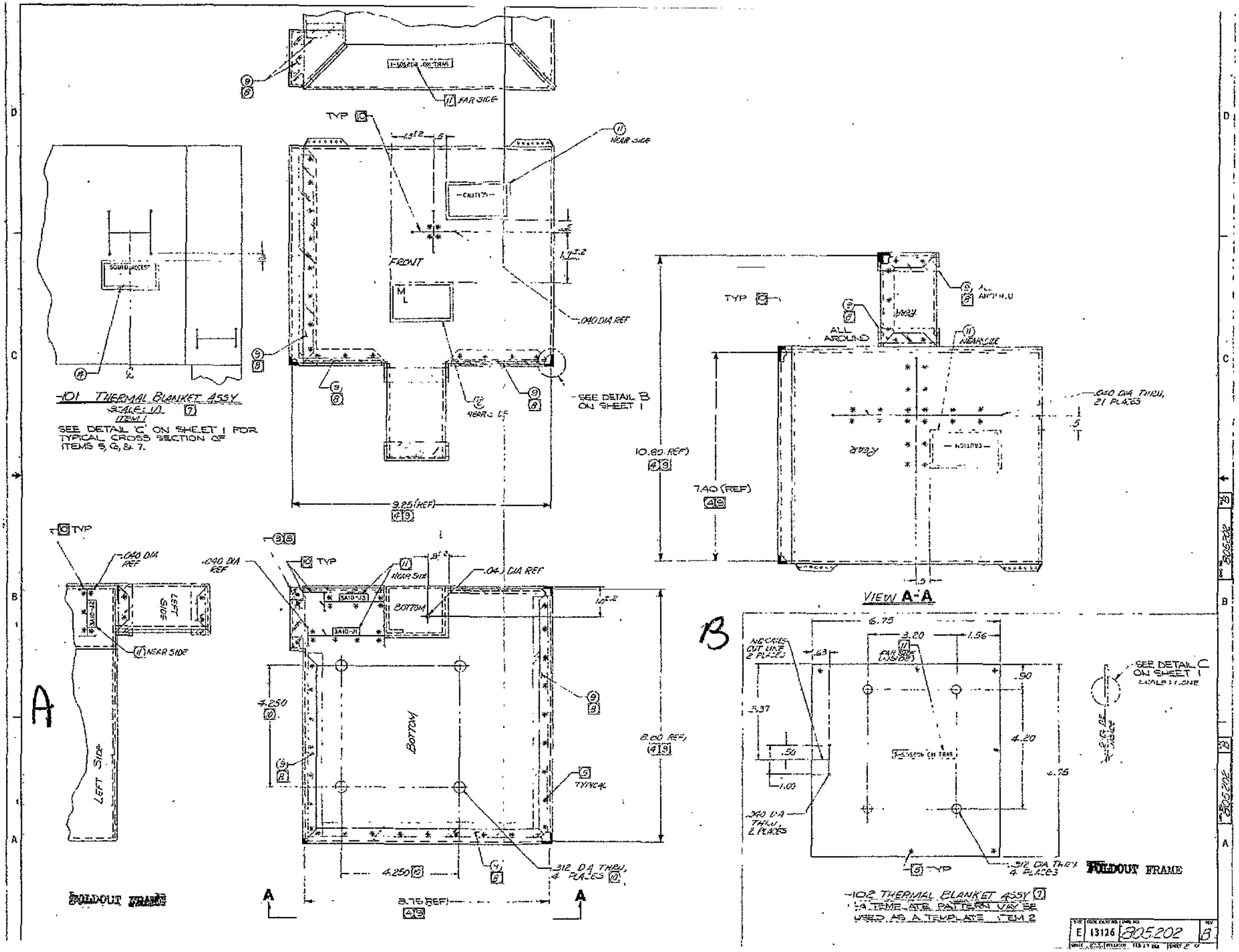
CONTRACT NO. NAS 5-11093

MARSHALL LABORATORIES
TORRANCE, CALIFORNIA

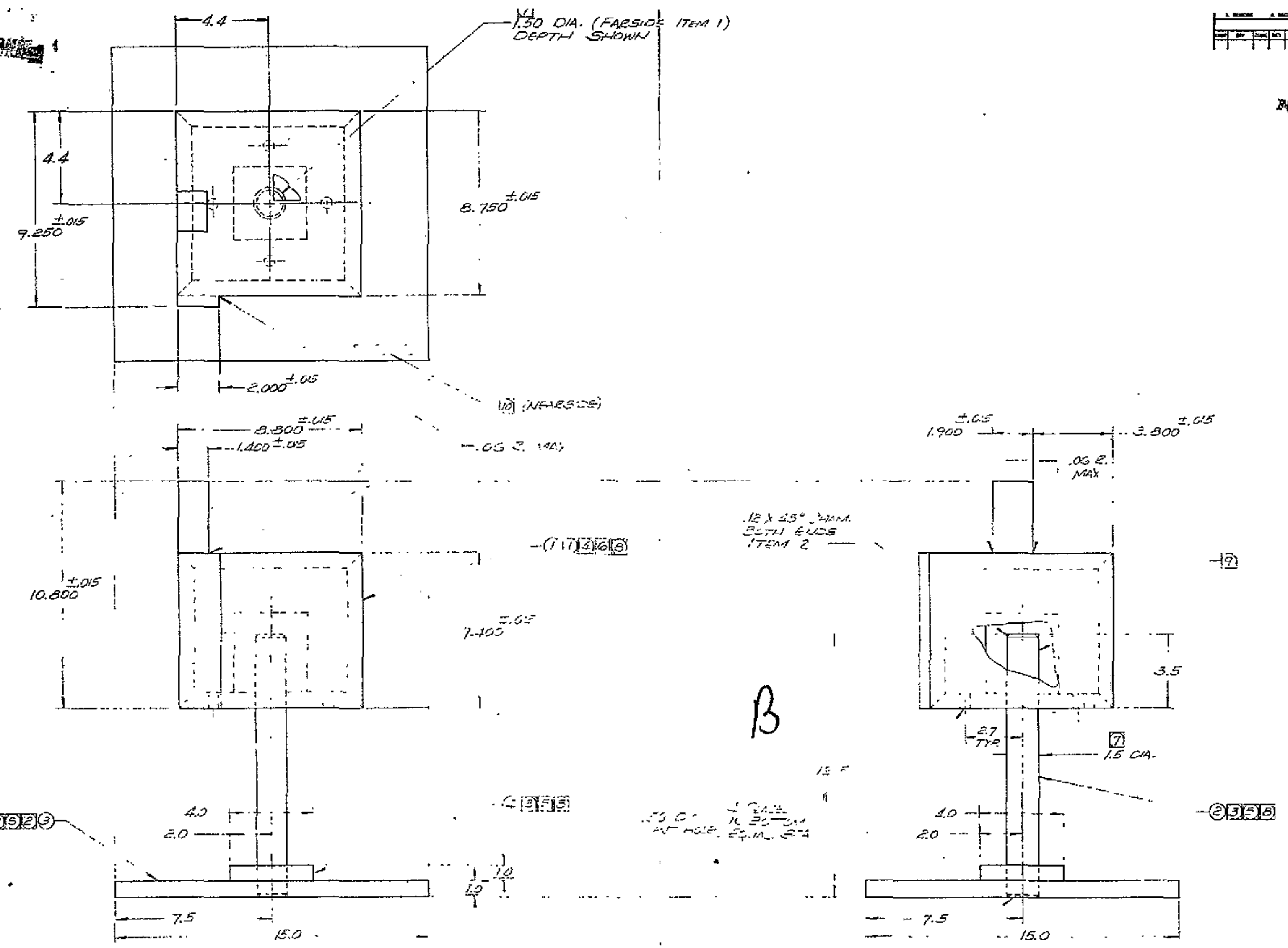
TITLE DETAIL ASSEMBLY — THERMAL BLANKET EP-5 (OGO-F)

SIZE E | CODE IDENT NO. 13126 | DWG NO. 805202 | REV B

SHEET 1 OF 2



-101 THERMAL BLANKET ASSY
SCALE: 1/1
ITEM 1
SEE DETAIL 'C' ON SHEET 1 FOR TYPICAL CROSS SECTION OF ITEMS 5, 6, & 7.
FRONT
CAUTION
NEAR SIDE
FAR SIDE
.040 DIA REF
SEE DETAIL B ON SHEET 1
9.25 (REF)
TYP
BOTTOM
LEFT SIDE
.040 DIA REF
.04 DIA REF
4.250
8.00 REF
8.75 (REF)
.312 DIA THRU, 4 PLACES
TYPICAL
A
VIEW A-A
Rear
10.80 REF
7.40 (REF)
ALL AROUND
.040 DIA THRU, 21 PLACES
B
6.75
3.20
1.56
.90
4.20
5.37
.50
1.00
.040 DIA THRU, 2 PLACES
.312 DIA THRU, 4 PLACES
SEE DETAIL C ON SHEET 1
-102 THERMAL BLANKET ASSY
-14 TEMPLATE PATTERN MAY BE USED AS A TEMPLATE ITEM 2
FOLDOUT FRAME
E 13126 805202 B



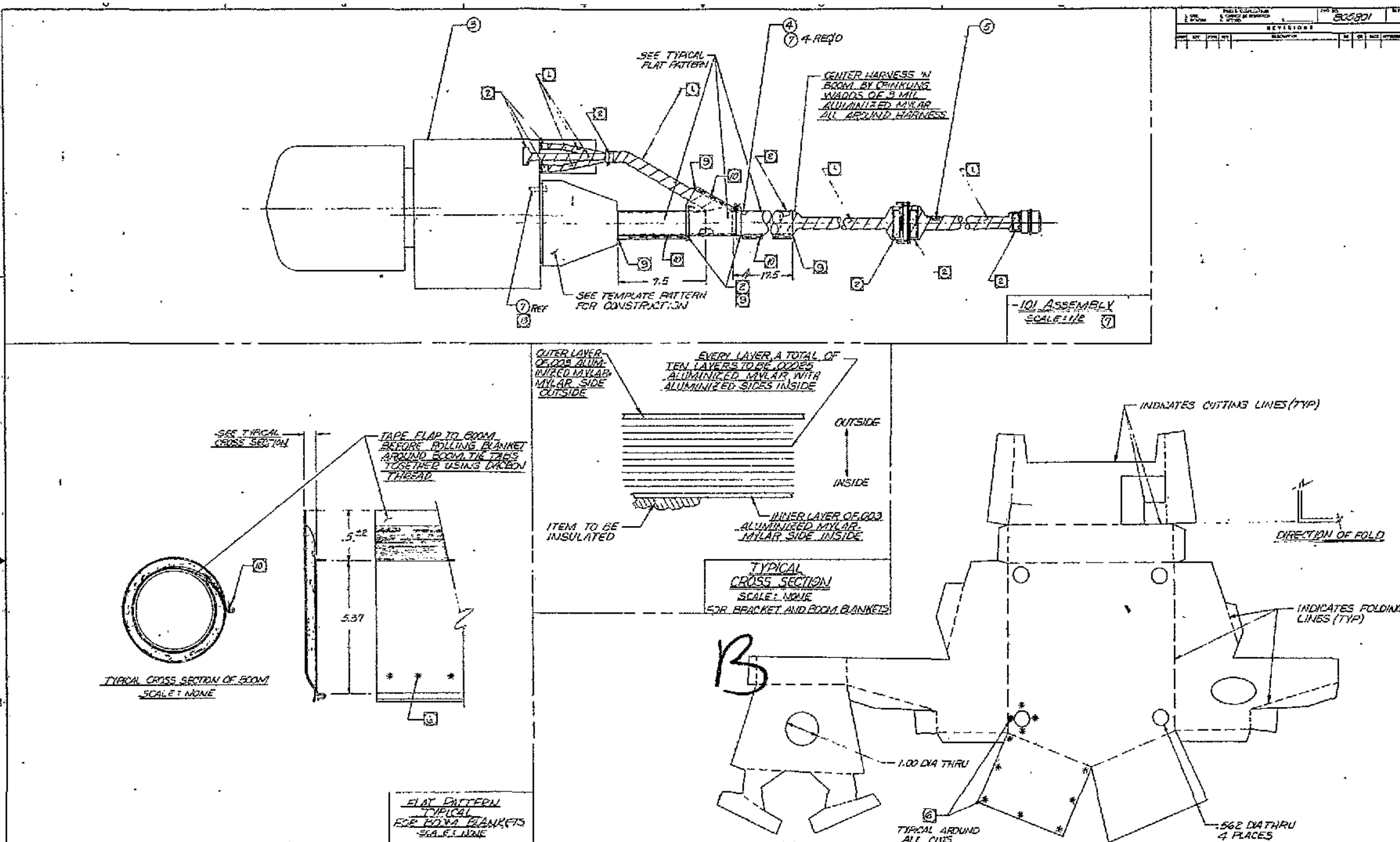
11 — SEE SEPARATE PARTS LIST ML DWG PLT805205

11 ITEM 2 TO BE FLUSH TO ITEM 3 AS SHOWN.
10 IDENTIFY PER ML SPEC. S40111, CLASS I, TYPE III.
9 CONTACT AREAS BETWEEN ITEMS 1 & 2 TO BE TREATED WITH SILICON SPRAY TO REDUCE FRICTION.
8 FINISH: ORANGE SHELLAC (BEST COM'L GRADE) INSIDE & OUTSIDE PER BEST COM'L. PRACTICE.
7 NOTED DIAMETERS TO MATCH FOR CLOSE SLIP-FIT, TO ALLOW ROTATION OF ITEM 1.
6 ALL SHARP EDGES TO HAVE .031 RADIU[S]
5 ITEMS 2,3 & 4 TO BE ORIENTED AS SH[O]WN & BONDED TOGETHER PER BEST COM'L PRACTICE.
4 TO BE MULTI-PIECE CONSTRUCTIO[N] MAT'L. PER NOTE 1) ALL REQD. BONDING PER BEST C[O]M'L. PRACTICE.
3 MATERIAL: COM'L GRADE FAS OAK DOWEL OR EQUIV.
2 MATERIAL: COM'L. GRADE AB DOUGLA[S] FIR PLYWOOD OR EQUIV.
1 MATERIAL: WOOD, MAHOGANY, CLOSE GR[AIN] 3/4 THK. LAMINATE (KILN DRIED) OR EQ[UIV.]

NOTES: UNLESS OTHERWISE SPECIFIED.

CONTRACT NO.	NAS 5-11095
DRAWN	R. Golden
TITLE	FORM BLOCK ASSEMBLY — THERMAL BLANKET, EP-5 OGO-F
SIZE	F
CODE IDENT NO.	13126
DWG NO.	T805205
SCALE	1/2
SHEET	1 OF 1

MARSHALL LABORATORIES
TORRANCE, CALIFORNIA



13. TORQUE SCREWS TO 25.9 LB/IN

12. FOR WIRING DIAGRAM REFER TO ML DWG 805800

11. TEST PER MIL SPEC S46865.

10. TIE ENDS OF BLANKET TOGETHER BY USING DACRON THREAD. AFTER FLAPS ARE TIED, FOLD FLAPS DOWN AND SECURE WITH TAPE.

9. COMBINE VARIOUS TYPES OF WRAPPINGS BY USING ALUMINIZED TAPE (AS REQ'D)

8. AFTER CUTTING AND WELDING OF TEMPLATE, FOLD OVER BRACKET AND SECURE ALL FLAPS WITH .50 ALUMINIZED TAPE (AS REQ'D). WRAP NIPPLE WITH TIP CROSS-SECTION AND TAPE TO BRACKET.

7. BAG AND TAG IDENTIFY PER MIL SPEC S40111, CLASS II, TYPE III.

6. INDICATES ULTRASONIC WELDING AT APPROX. INTERVALS AS SHOWN, PER MIL SPEC S43016. WELD AT FLAT PATTERN LEVEL. DO NOT WELD AFTER FOLDING.

5. ASSEMBLY TABLES SHALL BE PROVIDED WITH SURFACES DESIGNED TO PREVENT DAMAGE TO ALUMINIZED SURFACES BY ABRASION.

4. CLEAN, WHITE, COTTON OR NYLON GLOVES SHALL BE USED FOR HANDLING THE THERMAL INSULATING MATERIAL.

3. THERMAL INSULATION ASSEMBLY OF EP-5 PACKAGE SHALL BE PERFORMED IN AN AREA WHICH MEETS THE CLASS 100,000 CLEANLINESS REQUIREMENTS OF FEDERAL STANDARD 209A.

2. TIE WITH DACRON THREAD TO RETAIN INSULATION AROUND PLUG, THEN SEAL WITH ALUMINIZED TAPE TO PREVENT UNRAVELING.

1. WRAP 2.0" WIDE STRIPS OF 1/4 MIL ALUMINIZED MYLAR AROUND CABLE, WITH MYLAR SIDE INSIDE, TO EQUAL 5 LAYERS (WRAP EACH LAYER INDIVIDUALLY & DON'T PULL TAUT) & TAPE. COVER WITH .003 ALUMINIZED MYLAR STRIPS 1.0 WIDE OVERLAPPING EACH FOR ABOUT 0.5 WITH MYLAR SIDE OUTSIDE. TAPE ALL EDGES WITH .50 ALUMINIZED MYLAR TAPE.

NOTES: UNLESS OTHERWISE SPECIFIED

FOLDOUT FRAME

SEE SEPARATE PARTS LIST, DWG Nº PL 805801

LIST OF MATERIALS

FINAL

APPLICATION

MARSHALL LABORATORIES
TORRANCE, CALIFORNIA

ASSEMBLY-SUB. SYSTEM
THERMAL MOCKUP
EP-5 (OGO-F)

E | 13126 | 805801

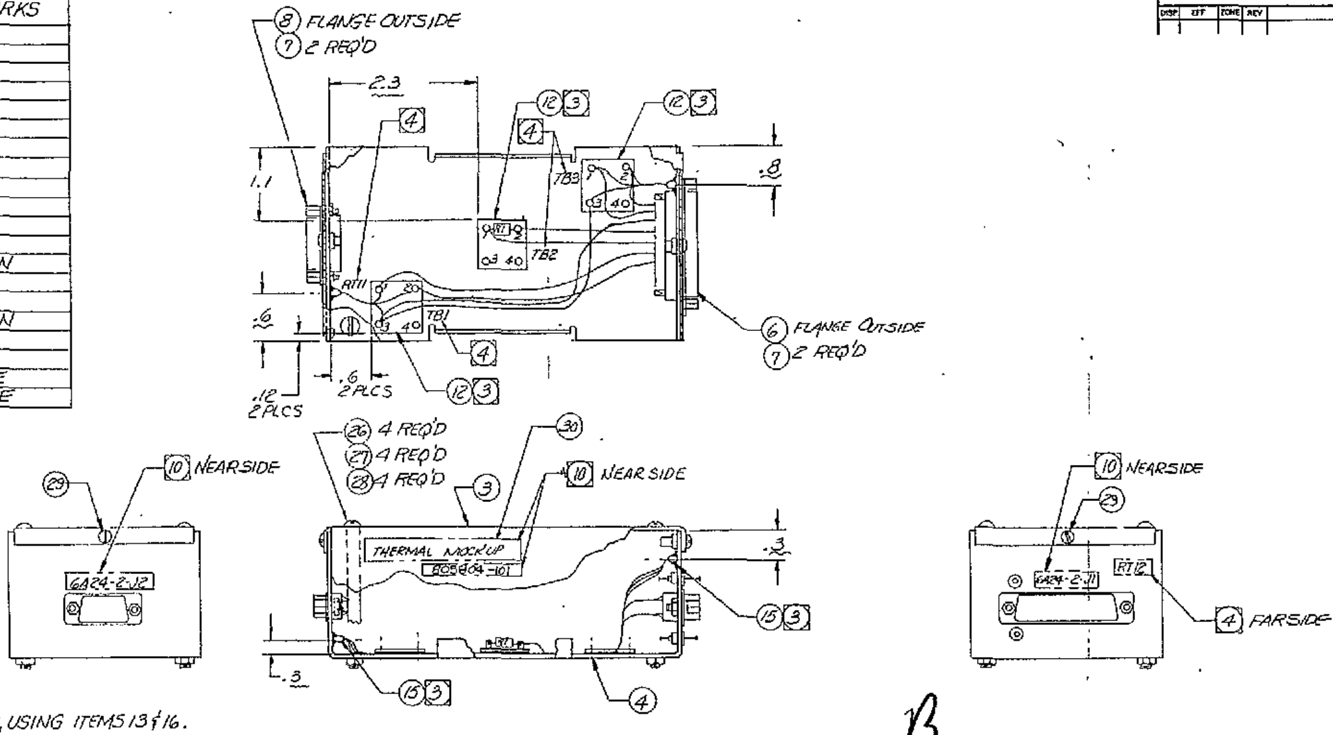
SHEET 1 OF 1

FOLDOUT FRAME

805801

WIRING LIST

FROM	TO	FUNCTION	GAGE	REMARKS
RT11-BARE	TB1-3	GRD		
RT11-BRN	TB1-2	RT11		
RT11-RED	TB1-1	RT11		
RT12-BARE	TB3-3	GRD		
RT12-BRN	TB3-2	RT12		
RT12-RED	TB3-1	RT12		
TB1-3	TB3-3	GRD	ITEM 10	WHITE
TB1-3	6A24-2-J1-14	GRD	ITEM 10	WHITE
TB1-2	-18	RT11	ITEM 9	BROWN
TB1-1	-22	RT11	ITEM 11	RED
TB3-2	-24	RT12	ITEM 9	BROWN
TB3-1	-16	RT12	ITEM 11	RED
TB2-2	-15	PRE-AMP RET	ITEM 10	WHITE
TB2-1	6A24-2-J1-25	PRE-AMP	ITEM 10	WHITE



12. SPOT TIE AND SLEEVE A/R, USING ITEMS 13 & 16.
11. SPOT POT (AS REQ'D) PER M/L SPEC S40379, CLASS II, TYPE I.
10. MARKINGS: RUBBER STAMP (WHITE) APPROX. AS SHOWN, PER M/L SPEC. S40111, CLASS II, TYPE III.
9. APPLY PROTECTIVE FINISH TO ALL EXTERNAL SURFACES (EXCLUDING 6A24-2-J1 & 6A24-2-J2) PER M/L SPEC. S40118, CLASS I, TYPE IV, PRIMED (FLAT BLACK)
8. AFTER ASSY & TEST, FOAM CAVITY PER M/L SPEC S40092, CLASS I, TYPE I, CURE I, @ 170°F.
7. TEST PER M/L SPEC S46863
6. CONFORMAL COAT TERMINAL BOARD ASSY PER M/L SPEC S40091, CL I, TYPE I, CURE @ 170°F
5. SOLDER PER M/L SPEC S40126
4. MARKINGS: CHARACTERS APPROX. AS SHOWN, PER M/L SPEC S40111, CLASS III, TYPE III.
3. BOND AS SHOWN PER M/L SPEC S40149, TYPE II.
2. FABRICATE PER M/L SPEC S40072.
1. FOR WIRING DIAGRAM REFER TO M/L DWG 805800.

NOTES: UNLESS OTHERWISE SPECIFIED

SEE SEPARATE PARTS LIST DWG PL805804

DASH NO.	MODEL NO.	NEXT ASSEMBLY	MODEL NO.	FINAL ASSEMBLY	MODEL NO.
-101		805802-101		805803-101	

APPLICATION

LIST OF MATERIALS

MARSHALL LABORATORIES
TORRANCE, CALIFORNIA

CONTRACT NO. NAS5-11055

TITLE: PRE-AMPLIFIER ASSY— THERMAL MOCK-UP EP-5 (F-24) (OGO-F)

SIZE D | CODE IDENT NO. 13126 | DWG NO. 805804

SCALE 1/1 | RELEASED FEB 26 1968 | SHEET 1 OF 1

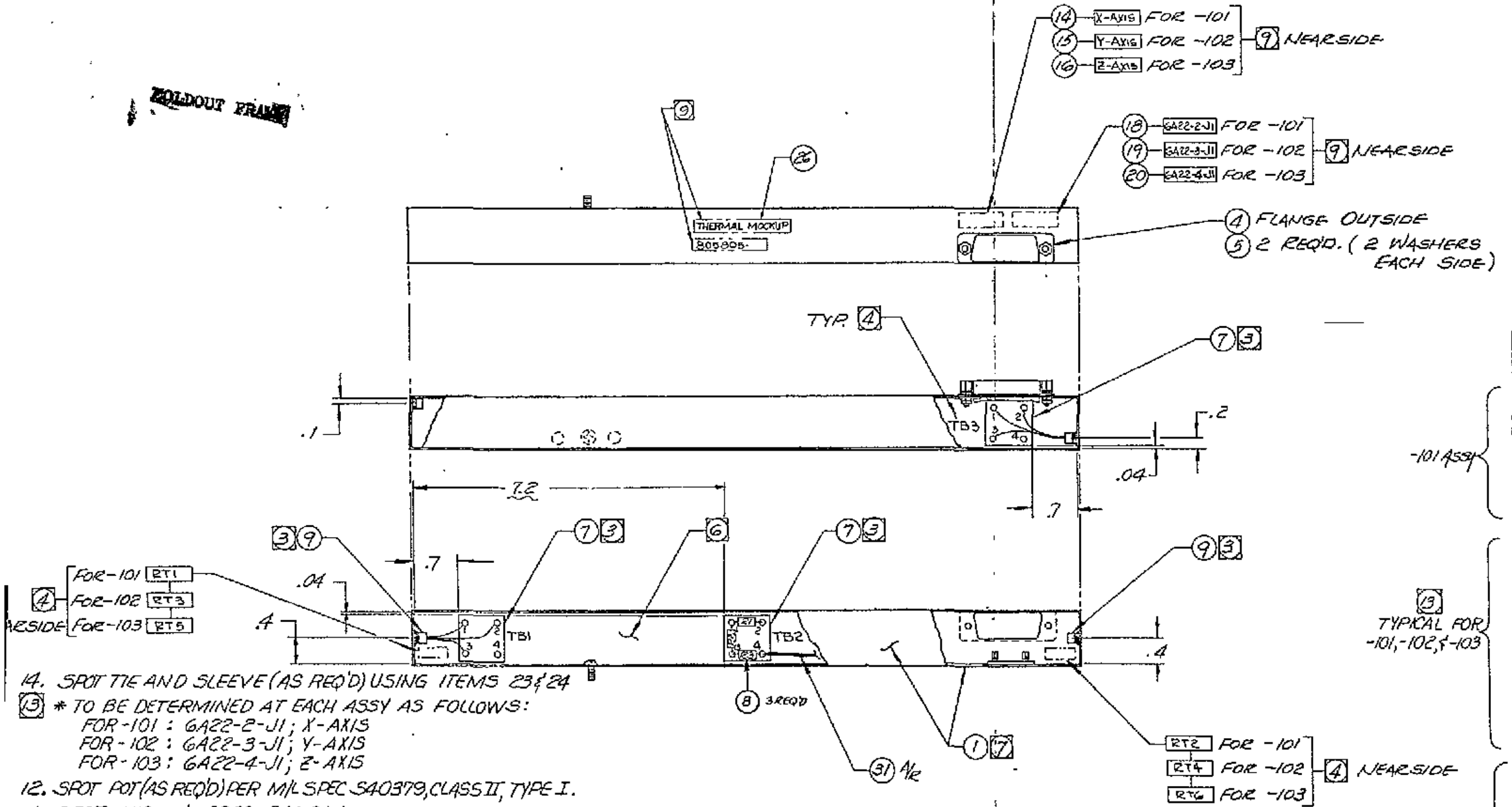
DWG NO 805804

PARTS DISPOSITION		
1. USE	3. CANNOT BE REWORKED	
2. REWORK	4. RECORD	

REVISIONS

DISP	EFF	ZONE	REV	DESCRIPTION	BY	CK	DATE	APPROVAL

FOLDOUT FRAME



FOLDOUT FRAME

	WIRE NO.	FROM	TO	FUNCTION	GAGE	REMARKS
				WIRING LIST		
-101 ASSY	1	RT1-BARE	TB1-1	GRD		BARE
	2	RT1-BRN	TB1-2	X-AXIS RT1		BRN
	3	RT1-RED	TB1-3	X-AXIS RT1		RED
	4					
	5	RT2-BARE	TB3-1	GRD		BARE
	6	RT2-BRN	TB3-2	X-AXIS RT2		BRN
	7	RT2-RED	TB3-3	X-AXIS RT2		RED
	8					
[13] TYPICAL FOR -101, -102, & -103	9	TB1-1	TB3-1	GRD	ITEM 31	WHT
	10	TB1-2	6A22-*-J1-1	*AXIS	ITEM 29	BRN
	11	TB1-3	6A22-*-J1-9	*AXIS	ITEM 30	RED
	12					
	13	TB2-2	6A22-*-J1-3	*AXIS S/C PWR	ITEM 31	WHT
	14	TB2-4	6A22-*-J1-11	*AXIS S/C RET.	ITEM 31	WHT
	15					
	16					
	17	TB3-1	6A22-*-J1-12	GRD	ITEM 31	WHT
	18	TB3-2	6A22-*-J1-5	*AXIS	ITEM 29	BRN
	19	TB3-3	6A22-*-J1-4	*AXIS	ITEM 30	RED
	20					
-102 ASSY	21	RT3-BARE	TB1-1	GRD		BARE
	22	RT3-BRN	TB1-2	Y-AXIS RT3		BRN
	23	RT3-RED	TB1-3	Y-AXIS RT3		RED
	24	RT4-BARE	TB3-1	GRD		BARE
	25	RT4-BRN	TB3-2	Y-AXIS RT4		BRN
	26	RT4-RED	TB3-3	Y-AXIS RT4		RED
	27					
-103 ASSY	28	RT5-BARE	TB1-1	GRD		BARE
	29	RT5-BRN	TB1-2	Z-AXIS RT5		BRN
	30	RT5-RED	TB1-3	Z-AXIS RT5		RED
	31	RT6-BARE	TB3-1	GRD		BARE
	32	RT6-BRN	TB3-2	Z-AXIS RT6		BRN
	33	RT6-RED	TB3-3	Z-AXIS RT6		RED

B

14. SPOT TIE AND SLEEVE (AS REQ'D) USING ITEMS 23 & 24
[13] * TO BE DETERMINED AT EACH ASSY AS FOLLOWS:
FOR -101 : 6A22-2-J1 ; X-AXIS
FOR -102 : 6A22-3-J1 ; Y-AXIS
FOR -103 : 6A22-4-J1 ; Z-AXIS
12. SPOT POT (AS REQ'D) PER M/L SPEC S40379, CLASS II, TYPE I.
11. TEST PER M/L SPEC S46864.
10. CONFORMAL COAT TERMINAL BOARD ASSY'S PER M/L SPEC S40091, CLASS I, TYPE I, 170°F CURE.
[9] MARKINGS: RUBBER STAMP (WHITE) APPROX AS SHOWN, PER ML SPEC. S40111, CLASS II, AS REQ'D PER ASSEMBLY.
8. APPLY PROTECTIVE FINISH TO ALL EXTERNAL SURFACES (EXCLUDING 6A22-2-J1, 6A22-3-J1 & 6A22-4-J1) PER M/L SPEC S40118, CLASS I, TYPE IV, PRIMED (FLAT BLACK).
[7] BOND COVER OF ITEM 1 IN PLACE, AS SHOWN (AS REQ'D) PER ML SPEC. S40318 (J-1156), CLASS II, TYPE I.
[6] AFTER ASSEMBLY & TEST, FOAM-IN-PLACE CAVITY PER ML SPEC. S40092, CLASS I, TYPE I, CURE I, 170°F FOR 1 HR, USING ITEMS 33 & 34.
5. SOLDER IN PLACE PER ML SPEC. S 40126.
[4] MARKINGS: BLACK CHARACTERS, APPROX. AS SHOWN, PER ML SPEC. S40111, CLASS III, TYPE III.
[3] BOND AS SHOWN PER ML SPEC. S40149, TYPE II. (ACCEL. CURE).
2. FABRICATE PER ML SPEC. S40072.
1. FOR WIRING DIAGRAM REFER TO ML DWG. 805800.

NOTES: UNLESS OTHERWISE SPECIFIED.

A

SEE SEPARATE PARTS LIST ML DWG PL805805

QTY REQD PER NOTED ASSY	PART NO.	SPECIFICATION	NOMENCLATURE OR DESCRIPTION	ELEC REF DES	CODE IDENT	ZONE	ITEM NO
CONFIGURATION			LIST OF MATERIALS				

-101	805803-101	805805-101	
DASH NO.	MODEL NO.	NEXT ASSEMBLY	MODEL NO.	FINAL ASSEMBLY	MODEL NO.

APPLICATION

LAYOUT NO.
DIST CODE B-CD 4

INTERPRET THIS DRAWING PER STANDARDS IN MIL D-1000
DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS X ± .1, .XX ± .03, .XXX ± .010, .XXXX ± .0050; ANGLES ± 0° 30'
√ SURFACE ROUGHNESS

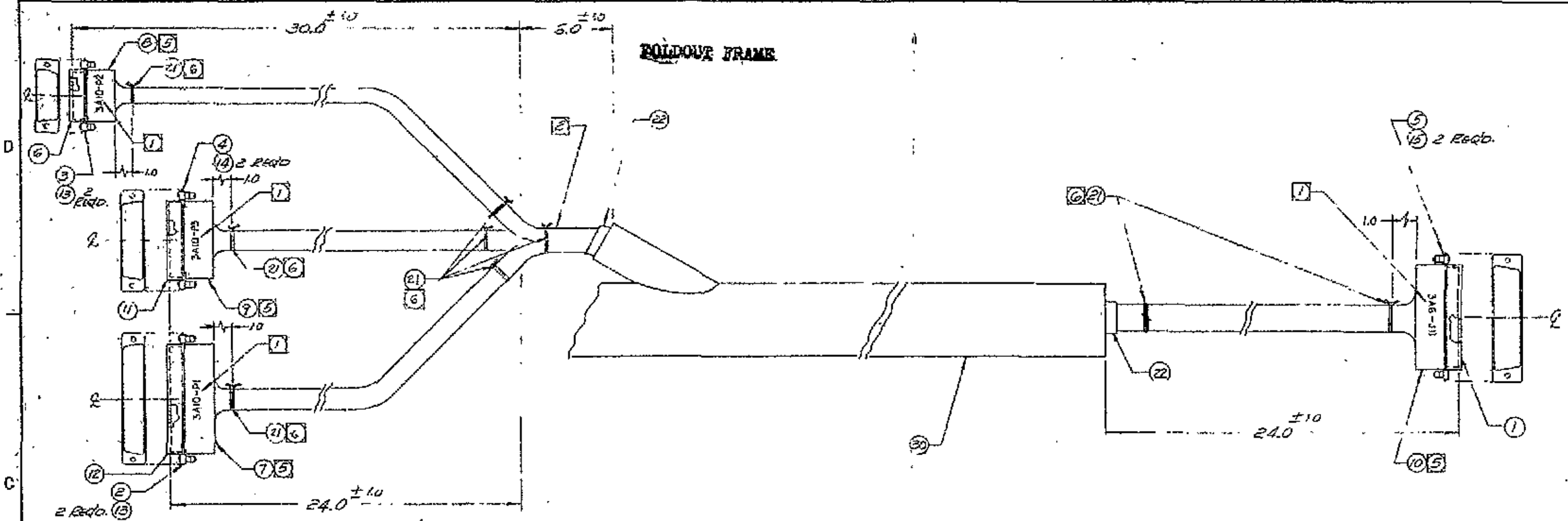
CONTRACT NO. NAS 5-11095
DRAWN C. Goteley 5 Feb 68
CHECK 21 Feb 68
ELEC ENG
PROJ. ENGR
APPD
DESIGN ACTIVITY APPD 2-23-68
CUSTOMER

MARSHALL LABORATORIES
TORRANCE, CALIFORNIA

TITLE SEARCH COIL SENSOR ASSY - THERMAL MOCKUP, EP-5 (F-22) OGO-F

SIZE D CODE IDENT NO 13126 DWG NO. 805805 REV

SCALE 1/1 RELEASED FEB 26 1968 SHEET 1 OF 1



PARTS DISPOSITION	DWG NO.	REV
1. USE 2. REWORK 3. CANNOT BE REWORKED 4. SCRAP	805806	

REVISIONS

REV	LTR	ZONE	DESCRIPTION	BY	CK	DATE	APPROVAL

WIRING LIST

WIRE NO	FROM	TO	FUNCTION	GAGE	REMARKS
1	3A6-J11-1	3A10-P3-1	X-AXIS RT1	26	BROWN
2	-2	-14	X-AXIS RT1		RED
3	-3	-2	[illegible]		WHITE
4	-4	-15	[illegible]		WHITE
5	-5	-16	X-AXIS RT2		BROWN
6	-6	-3	X-AXIS RT2		RED
7	-7	-4	GRD		WHITE
8	-8	-5	Y-AXIS RT3		BROWN
9	-9	-18	Y-AXIS RT3		RED
10	-10	-20	Y-AXIS RT4		BROWN
11	-11	-7	Y-AXIS RT4		RED
12	-12	-9	Z-AXIS RT5		BROWN
13	-13	-22	Z-AXIS RT5		RED
14	-14	-24	Z-AXIS RT6		BROWN
15	-15	3A10-P3-11	Z-AXIS RT6	26	RED
16	-16	N/C			
17	-17	3A10-P2-1	+28V HATER PWR	26	WHITE
18	-18	-2	+28V HATER RET		WHITE
19	-19	-3	GRD		WHITE
20	-20	-4	RT7		BROWN
21	-21	3A10-P2-5	RT7	26	RED
22	-22	N/C			
23	-23	3A10-P2-7	RT8	26	BROWN
24	-24	-8	RT8		RED
25	-25	-10	RT9		BROWN
26	-26	-11	RT9		RED
27	-27	-12	PWR SUP		SPARE
28	-28	-13	RT10		BROWN
29	-29	3A10-P2-14	RT10	26	RED
30	-30	N/C			
31	-31	3A10-P1-20	GRD	26	WHITE
32	-32	-25	RT11		BROWN
33	-33	-31	RT11		RED
34	-34	-36	PRE-AMP PWR		WHITE
35	-35	-22	PRE-AMP RET		WHITE
36	-36	-33	RT12		BROWN
37	-37	3A10-P1-24	RT12	26	RED
38	-38	N/C			
39	-39				
40	-40				
41	-41				
42	-42				
43	-43				
44	-44				
45	-45				
46	-46				
47	-47				
48	-48				
49	-49				
50	-50	N/C			
51	-7	3A6-J11-19	GRD	26	JUMPER WHITE
52	3A6-J11-19	3A6-J11-31	GRD		
53	3A10-P3-2	3A10-P3-6	SEARCH COIL PWR		
54	-15	-19	SEARCH COIL RET		
55	-4	-8	GRD		
56	-6	-10	SEARCH COIL RET		
57	-19	-23	SEARCH COIL RET		
58	3A10-P3-8	3A10-P3-12	GRD	26	JUMPER WHITE
59					
60					
61					
62					

B

7. FOR WIRING DIAGRAM REFER TO ML DWG 805800.
6. TIE HARNESS AT APPROX. 3.0 IN. INTERVALS USING ITEM 21.
5. CONNECTORS TO BE SEALED PER ML SPEC. S40093, CLASS III, TYPE I.
4. MAKE VISUAL INSPECTION PRIOR TO SEALING CONNECTORS.
3. SOLDER PER ML SPEC. S40126.
2. IDENTIFY HARNESS ASSEMBLY PER ML SPEC. S40111, CLASS IV, TYPE III.
1. IDENTIFY CONNECTORS PER ML SPEC. S40111, CLASS I, TYPE III.

NOTES: UNLESS OTHERWISE SPECIFIED.

SEE SEPARATE PARTS LIST ML DWG PL805806

LIST OF MATERIALS

QTY REQD PER NOTED ASSY	PART NO.	SPECIFICATION	NOMENCLATURE OR DESCRIPTION	ELEC REF DES	CODE IDENT	ZONE	ITEM NO.

DASH NO.	MODEL NO.	NEXT ASSEMBLY	MODEL NO.	FINAL ASSEMBLY	MODEL NO.
-21	—	805800-21	—	FINAL	—

APPLICATION

INTERPRET THIS DRAWING PER STANDARDS IN MIL-D-70327
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS .X ±.1 .XX ±.03 .XXX ±.010 ANGLES ±0° 30'
✓ SURFACE ROUGHNESS

CONTRACT NO. NAS 5-11095

MARSHALL LABORATORIES
TORRANCE, CALIFORNIA

TITLE BOOM HARNESS— THERMAL MOCKUP, EP-5 OGO-F

SIZE	CODE IDENT NO.	DWG NO.	REV
F	13126	805806	

SCALE 1/1 RELEASED FEB 5 1968 SHEET 1 OF 1

DWG NO. 805806

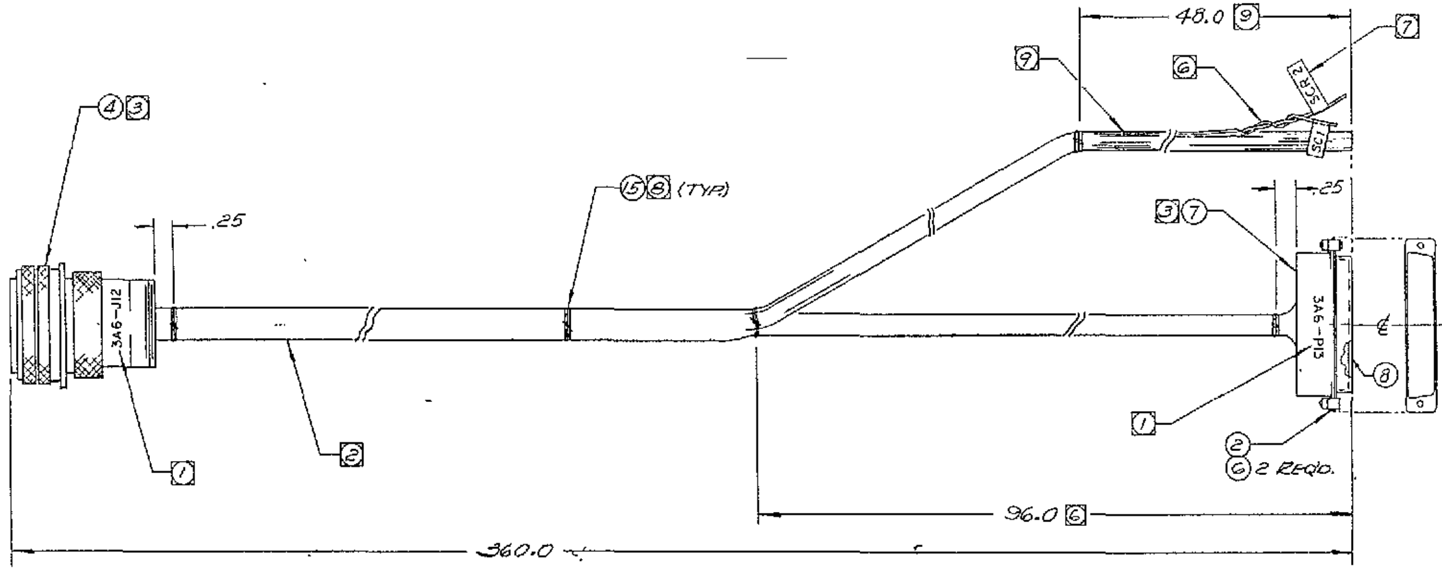
DWG NO. 805806

WIRING LIST

FROM	TO	FUNCTION	GAGE	REMARKS	
3A6-J12-A	3A6-P13-14	X-AXIS RT1	26	BROWN	
-B	3A6-P13-1	X-AXIS RT1		RED	
-C	PIGTAIL	X,Y & Z AXIS SEARCH COIL		SC1 WHITE	6 7
-D	PIGTAIL	X,Y & Z AXIS SEARCH COIL RTN		SCR2 WHITE	6 7
-E	3A6-P13-15	X-AXIS RT2		BROWN	
-F	-2	X-AXIS RT2		RED	
-G	-13	GRD		WHITE	
-H	-16	Y-AXIS RT3		BROWN	
-J	-3	Y-AXIS RT3		RED	
-K	-17	Y-AXIS RT4		BROWN	
-L	-4	Y-AXIS RT4		RED	
-M	-18	Z-AXIS RT5		BROWN	
-N	-5	Z-AXIS RT5		RED	
-P	-19	Z-AXIS RT6		BROWN	
-R	3A6-P13-6	Z-AXIS RT6	26	RED	
-U	N/C				
-V	N/C				
-S	PIGTAIL	+28 V. PWR.	26	PH1 WHITE	6 7
-T	PIGTAIL	+28V RTN.		PHR2 WHITE	6 7
-g	PIGTAIL	SPARE		S WHITE	6 7
-a	3A6-P13-20	RT7		BROWN	
-b	-7	RT7		RED	
-c	-21	RT8		BROWN	
-d	-8	RT8		RED	
-e	-22	RT9		BROWN	
-f	-9	RT9		RED	
-h	-23	RT10		BROWN	
-j	-10	RT10		RED	
-k	-24	RT11		BROWN	
-m	3A6-P13-11	RT11		RED	
-n	PIGTAIL	PRE-AMP		PA1 WHITE	6 7
-p	PIGTAIL	PRE-AMP RTN		PAR2 WHITE	6 7
-r	3A6-P13-25	RT12		BROWN	
-s	3A6-P13-12	RT12	26	RED	
-W	N/C				
-X	N/C				
3A6-J12-Z	N/C				

A

FOLDOUT FRAME



B

FOLDOUT FRAME

NOTED 48.0 IN SEGMENT OF PIGTAILED CABLE NOT TO BE SPOT-TIED PER NOTE 8.

SPOT-TIE HARNESS AT APPROX. 3.0 IN. INTERVALS USING ITEM 15.

INDIVIDUAL CONDUCTORS IN NOTED CABLE SEGMENT TO BE IDENTIFIED BY CORRESPONDING INFORMATION FROM REMARKS COLUMN IN WIRING LIST PER ML SPEC. S40111, CLASS X, TYPE III.

NOTED WIRES TO BE ROUTED INTO 96.0 IN PIGTAILED CABLE SEGMENT & SHALL BE COMBINED BY TWISTING PER REMARKS COLUMN IN WIRING LIST.

FOR WIRING DIAGRAM REFER TO ML DWG. 805800.

SOLDER PER ML SPEC. S40126.

CONNECTORS TO BE SEALED PER ML SPEC. S40095, CLASS III, TYPE I, AFTER VISUAL INSPECTION.

IDENTIFY HARNESS ASSEMBLY PER ML SPEC. S40111, CLASS IV, TYPE III.

IDENTIFY CONNECTORS PER ML SPEC. S40111, CLASS I, TYPE III.

NOTES: UNLESS OTHERWISE SPECIFIED.

SEE SEPARATE PARTS LIST ML DWG. PL805808

PARTS DISPOSITION	DWG NO	REV
1. USE 2. REWORK 3. CANNOT BE REWORKED 4. RECORD 5.	805808	

REVISIONS

DISP	EFF	ZONE	REV	DESCRIPTION	BY	CK	DATE	APPROVAL

QTY REQD PER NOTED ASSY	PART NO	SPECIFICATION	NOMENCLATURE OR DESCRIPTION	ELEC REF DES	CODE IDENT	ZONE	ITEM NO
			LIST OF MATERIALS				

CONFIGURATION

LAYOUT NO.

DIST CODE B-050 A

DASH NO.	MODEL NO.	NEXT ASSEMBLY	MODEL NO.	FINAL ASSEMBLY	MODEL NO.
101	—	805801-101	—	FINAL	—

APPLICATION

INTERPRET THIS DRAWING PER STANDARDS IN MIL-D-1000

DIMENSIONS ARE IN INCHES

TOLERANCES ON DECIMALS X ± .1, XX ± .03, XXX ± .010, XXXX ± .0050; ANGLES ± 0° 30'

✓ SURFACE ROUGHNESS

HOLE DIA. / TOLERANCE: .015 THRU .125 + .004 —.001; .126 THRU .250 + .005 —.001; .251 THRU .500 + .006 —.001; .501 THRU .750 + .008 —.001; .751 THRU 1.000 + .010 —.001; 1.001 THRU 2.000 + .012 —.001; 2.001 AND OVER LINEAR

CONTRACT NO. NAS 5-11095

DRAWN R. Golden — DATE 1 Feb 68

CHECK — 5 Feb 68

MECH ENG — 5 Feb 68

ELEC ENG

PROJ ENGR — 2/5/68

APPR

DESIGN ACTIVITY APPD — 2-5-68

CUSTOMER

MARSHALL LABORATORIES
TORRANCE, CALIFORNIA

TITLE: TEST HARNESS — THERMAL MOCKUP, EP-5 OGO-F

SIZE	CODE IDENT NO.	DWG NO	REV
D	13126	805808	

SCALE NONE RELEASED FEB 5 1969 SHEET 1 OF 1

PARTS DISPOSITION	DWG NO.	REV
1. USE 2. REWORK 3. CANNOT BE REWORKED 4. RECORD 5.	805807	

REVISIONS

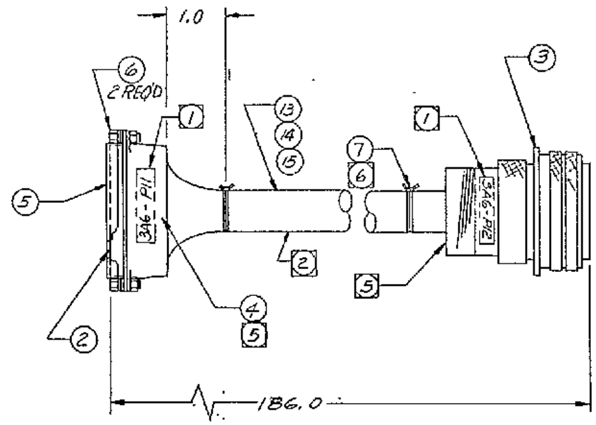
DISP	EFF	ZONE	REV	DESCRIPTION	BY	CK	DATE	APPROVAL

WIRING LIST

FROM	TO	FUNCTION	GAGE	REMARKS
3A6-P11-1	3A6-P12-A	X-AXIS RT1	26	BROWN
-2	-B	X-AXIS RT1		RED
-3	-C	X,Y&Z-AXIS SEARCH COIL		WHITE
-4	-D	X,Y&Z-AXIS S.C. RET		WHITE
-5	-E	X-AXIS RT2		BROWN
-6	-F	X-AXIS RT2		RED
-7	-G	RT1 THRU RT12 GRD		WHITE
-8	-H	Y-AXIS RT3		BROWN
-9	-J	Y-AXIS RT3		RED
-10	-K	Y-AXIS RT4		BROWN
-11	-L	Y-AXIS RT4		RED
-12	-M	Z-AXIS RT5		BROWN
-13	-N	Z-AXIS RT5		RED
-14	-P	Z-AXIS RT6		BROWN
-15	3A6-P12-R	Z-AXIS RT6		RED
-16	N/C			
-17	3A6-P12-S	+28V PROPORTIONAL HEATER PWR		WHITE
-18	3A6-P12-T	+28V PROPORTIONAL HEATER RET		WHITE
-19	N/C			
-20	3A6-P12-a	RT7		BROWN
-21	3A6-P12-b	RT7		RED
-22	N/C			
-23	3A6-P12-c	RT8		BROWN
-24	-d	RT8		RED
-25	-e	RT9		BROWN
-26	-f	RT9		RED
-27	-g	SPARE		WHITE
-28	-h	RT10		BROWN
-29	3A6-P12-j	RT10		RED
-30	N/C			
-31	N/C			
-32	3A6-P12-k	RT11		BROWN
-33	-m	RT11		RED
-34	-n	PRE-AMPLIFIER		WHITE
3A6-P11-35	3A6-P12-p	PRE-AMPLIFIER RET	26	WHITE

WIRING LIST (CONT)

WIRE NO	FROM	TO	FUNCTION	GAGE	REMARKS
36	3A6-P11-36	3A6-P12-r	RT12	26	BROWN
37	-37	3A6-P12-s	RT12	26	RED
38	-38	N/C			
39	-39				
40	-40				
41	-41				
42	-42				
43	-43				
44	-44				
45	-45				
46	-46				
47	-47				
48	-48				
49	-49				
50	3A6-P11-50	N/C			



A

B

BORDOUT FRAME

BORDOUT FRAME

7. FOR WIRING DIAGRAM SEE DWG 805800.

6 TIE HARNESS AT APPROX 3.0 IN. INTERVALS USING ITEM 7.

5 CONNECTORS TO BE SEALED PER M/L SPEC S40093, CLASS III, TYPE I.

4. MAKE VISUAL INSPECTION PRIOR TO SEALING CONNECTORS.

3. SOLDER PER M/L SPEC S40126.

2 IDENTIFY HARNESS ASSY PER M/L SPEC S40111 CL IV, TYPE III.

1 IDENTIFY CONNECTORS PER M/L SPEC S40111 CL I, TYPE III.

NOTES: UNLESS OTHERWISE SPECIFIED

SEE SEPARATE PARTS LIST M/L DWG PL805807

PART NO	SPECIFICATION	NOMENCLATURE OR DESCRIPTION	ELEC REF DES	CODE IDENT	ZONE	ITEM NO

LIST OF MATERIALS

QTY REQD PER NOTED ASSY

CONFIGURATION

LAYOUT NO.

DIST CODE 8-050 A

DASH NO.	MODEL NO.	NEXT ASSEMBLY	MODEL NO.	FINAL ASSEMBLY	MODEL NO.
-101		805803-101		805801-101	

APPLICATION

INTERPRET THIS DRAWING PER STANDARDS IN MIL D-1000

DIMENSIONS ARE IN INCHES

TOLERANCES ON DECIMALS: X ± 1, XX ± .03, XXX ± .010, XXXX ± .0050; ANGLES ± 0° 30'

✓ SURFACE ROUGHNESS

HOLE DIA. TOLERANCE

.0135 THRU .125 + .004 − .001
.126 THRU .250 + .005 − .001
.251 THRU .500 + .006 − .001
.501 THRU .750 + .008 − .001
.751 THRU 1.000 + .010 − .001
1.001 THRU 2.000 + .012 − .001
2.001 AND OVER LINEAR

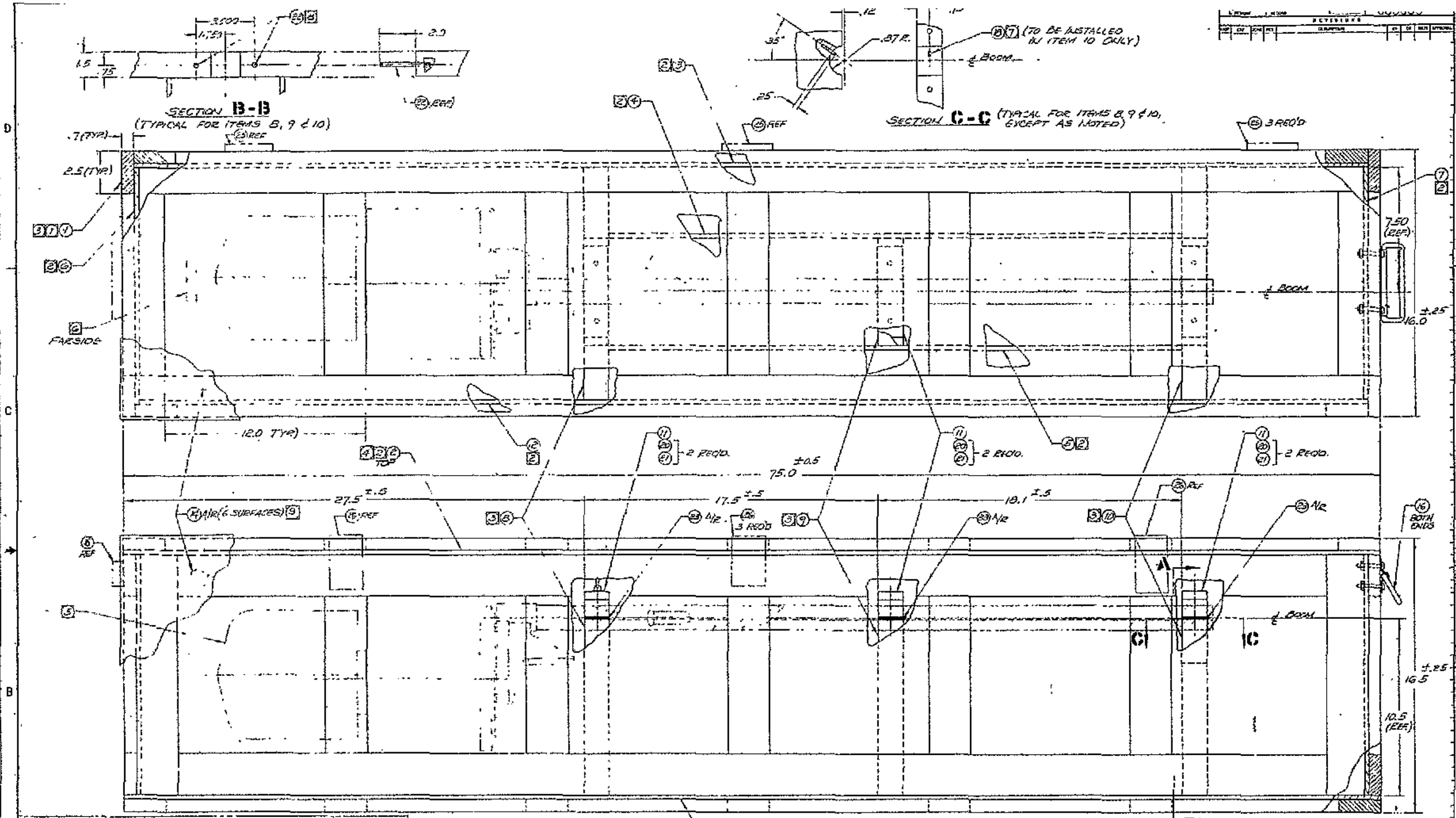
		DATE
CONTRACT NO.	NAS 5-11095	
DRAWN	Beasley	29 JAN 68
CHECK		2/1/68
MECH ENG		2/2/68
ELEC ENG		
PROJ ENGR		2/2/68
APPR		
DESIGN ACTIVITY APPD		2-2-68
CUSTOMER		

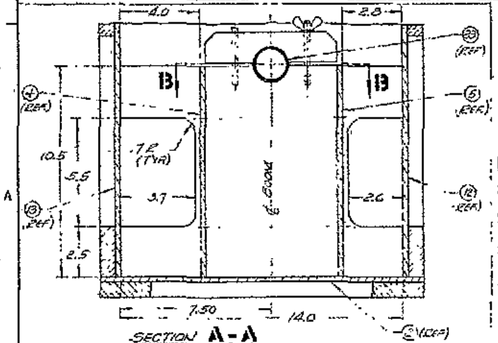
ML MARSHALL LABORATORIES TORRANCE, CALIFORNIA

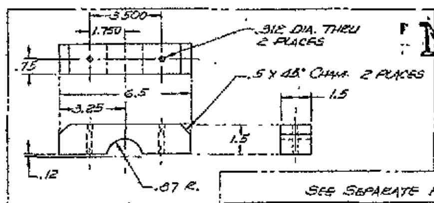
TITLE BOOM EXTENSION HARNESS – THERMAL MOCK-UP, EP-5 (OGO-F)

SIZE	CODE IDENT NO.	DWG NO	REV
D	13126	805807	

SCALE FULL | RELEASED FEB 5 1968 | SHEET 1 OF 1







805809-11 CLAMP DETAIL

9 AFTER CONSTRUCTION, BOND 3/16 PRE-FINISHED BIRCH PANELING ON ALL SURFACES, PER BEST COM'L PRACTICE.

8 INSTALL ITEM 22 INTO ITEMS 8, 9 & 10, AS SHOWN, PER BEST COM'L PRACTICE.

7 PRESS FIT OR BOND ITEM 18 INTO ITEM 10, APPROX AS SHOWN, PER BEST COM'L PRACTICE.

6 IDENTIFY PER ML SPEC. S4011, CLASS IV, TYPE XI.

5 [ ] DENOTES OUTLINE OF THERMAL SUB SYSTEM.

4 OPENING OF TOP SHALL BE LIMITED TO 105° ±10° (METHOD OPTIONAL)

3 MAT'L: COM'L. GRADE FAS PINE, AS REQ'D (OR EQUIV).

2 MAT'L: COM'L. GRADE AB, DOUGLAS FIR PLYWOOD, 1/2 THK (OR EQUIV).

1 ALL CONSTRUCTION TYPICAL FOR TYPE 1 DOMESTIC SHIPPING CONTAINER, PER BEST COM'L. PRACTICE.

NOTES: UNLESS OTHERWISE SPECIFIED.

β FOLDOUT FRAME

SEE SEPARATE PARTS LIST ML DWG PL805809

LIST OF MATERIALS

CONTRACT NO. NAS 5-1095

MARSHALL LABORATORIES
TORRANCE, CALIFORNIA

TITLE: SHIPPING CONTAINER-THERMAL SUB SYSTEM MOCKUP, EP-5 OGO-F

SIZE E | CODE IDENT NO. 13126 | DWG NO. 805809

SCALE 1/2 | SHEET 1 OF 1

805809

FOLDOUT FRAME

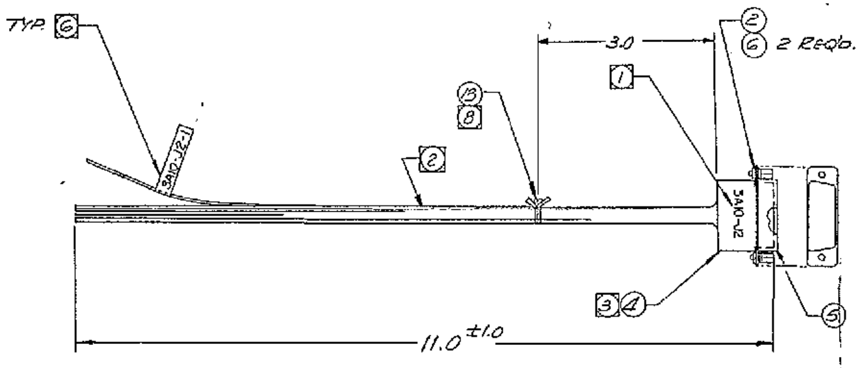
FOLDOUT FRAME

1. USE	3. CANNOT BE REWORKED	5.	PARTS DISPOSITION	805810
2. REWORK	4. RECORD			

REVISIONS

DISP	EFF	ZONE	REV	DESCRIPTION	BY	CK	DATE	APPROV

FOLDOUT FRAME



A

B

WIRING LIST

FROM	TO	FUNCTION	GAGE	REMARKS
3A10-J2-1	PIGTAIL	+28 V HTR. PWR.	26	WHITE
-2		+28 V. HTR. RET.		WHITE
-3		GRD		WHITE
-4		RT7		BROWN
-5	PIGTAIL	RT7	26	RED
-6	N/C			
-7	PIGTAIL	RT8	26	BROWN
-8	PIGTAIL	RT8	26	RED
-9	N/C			
-10	PIGTAIL	RT9	26	BROWN
-11		RT9		RED
-12		PWR. SUP.(SPARE)		
-13		RT10		BROWN
-14	PIGTAIL	RT10	26	RED
3A10-J2-15	N/C			

8. SPOT TIE HARNESS AS SHOWN PER ITEM 13.
7. MAKE VISUAL INSPECTION PRIOR TO SEALING CONNECTORS.
6. INDIVIDUAL CONDUCTORS TO BE IDENTIFIED BY CORRESPONDING CONNECTOR PIN NOS PER ML SPEC. S40111, CLASS X, TYPE III.
5. FOR WIRING DIAGRAM REFER TO ML DWG. 805800.
4. SOLDER PER ML SPEC. S40126.

CONNECTORS TO BE SEALED PER ML SPEC. S40093, CLASS III, TYPE I.
IDENTIFY HARNESS ASSEMBLY PER ML SPEC. S40111, CLASS IV, TYPE III.
IDENTIFY CONNECTORS PER ML SPEC. S40111, CLASS I, TYPE III.
NOTES: UNLESS OTHERWISE SPECIFIED.

SEE SEPARATE PARTS LIST ML DWG. PL805811

	PART NO	SPECIFICATION	NOMENCLATURE OR DESCRIPTION	ELEC REF DES	CODE IDENT	ZONE
QTY REQD PER NOTED ASSY	LIST OF MATERIALS					

DASH NO.	MODEL NO.	NEXT ASSEMBLY	MODEL NO.	FINAL ASSEMBLY	MODEL NO.
-101	—	805803-101	—	805801-101	—

APPLICATION

CONFIGURATION

LAYOUT NO.

DIST CODE 805 A

INTERPRET THIS DRAWING PER STANDARDS IN MIL D-1000

DIMENSIONS ARE IN INCHES

TOLERANCES ON DECIMALS: X ±.1, XX ±.03, XXX ±.010, XXXX ±.0050; ANGLES ±0° 30'

√ SURFACE ROUGHNESS

HOLE DIA. TOLERANCE: .0135 THRU .125 + .004 -.000; .126 THRU .250 + .005 -.001; .251 THRU .500 + .006 -.001; .501 THRU .750 + .008 -.001; .751 THRU 1.000 + .010 -.001; 1.000 THRU 2.000 + .012 -.001; 2.001 AND OVER LINEAR

CONTRACT NO NAS 5-11095

DRAWN R Golden 3/14/68

CHECK 3/14/65

MECH ENG 3/5/68

ELEC ENG

PROJ ENGR 3/5/68

APPR

DESIGN ACTIVITY APPD 2-5-68

CUSTOMER

MARSHALL LABORATORIES
TORRANCE, CALIFORNIA

TITLE BASEPLATE HARNESS - THERMAL MOCKUP, EP-5 OGO-F

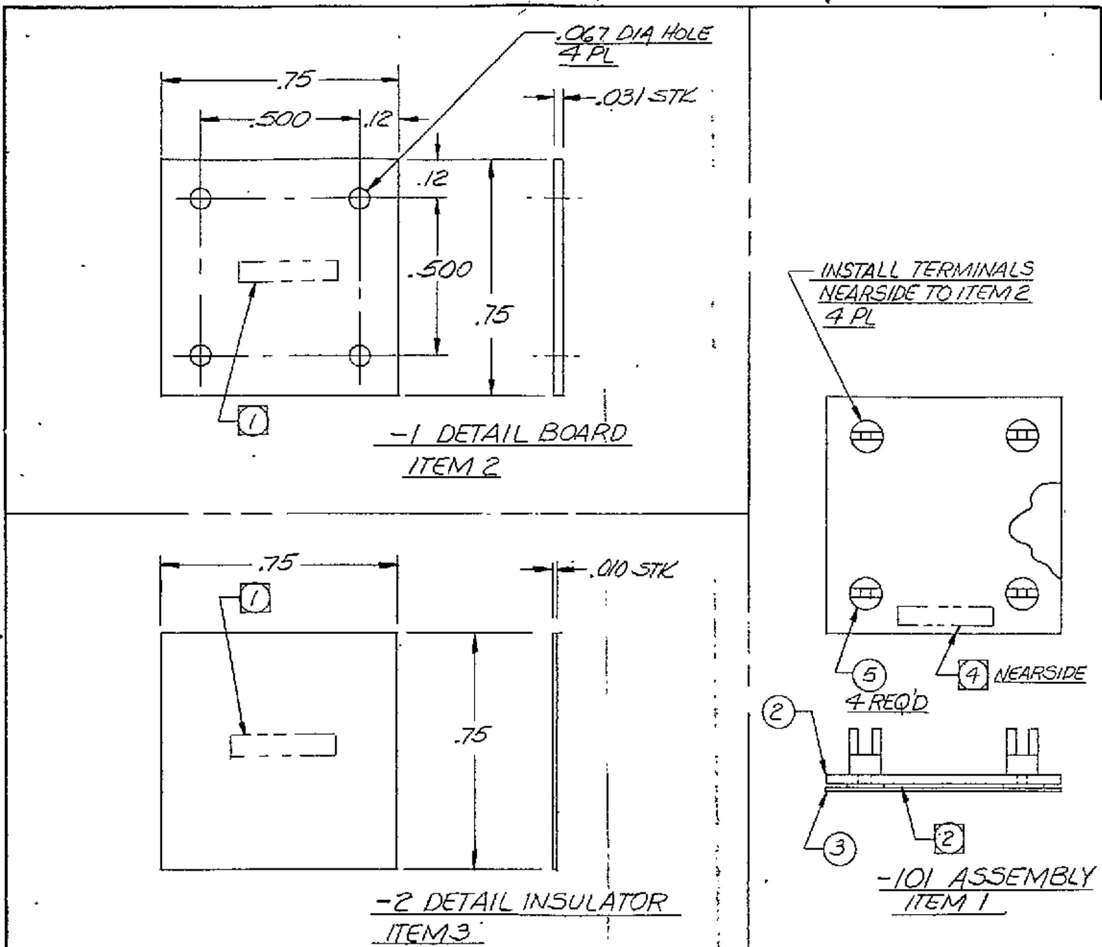
SIZE D | CODE IDENT NO. 13126 | DWG NO. 805810

SCALE 1/1 | RELEASED | SHEET 1 OF 1

PARTS DISPOSITION		DWG NO.	REV
1. USE 2. REWORK	3. CANNOT BE REWORKED 4. RECORD 5.	805811	

REVISIONS

DISP	EFF	ZONE	REV	DESCRIPTION	BY	CK	DATE	APPROVAL



B

A

SEE SEPARATE PARTS LIST M/L DWG PL805811

4 IDENTIFY ASSY PER M/L SPEC S40111, CL I, TYPE III.
3. FABRICATE PER M/L SPEC S40072.
2 AFTER INSTALLATION OF TERMINALS BOND ITEM 2 TO ITEM 3 PER M/L SPEC S40149 (EPIBOND 1210)
1 IDENTIFY PER M/L SPEC S40111, CL I, TYPE I.
NOTES: (UNLESS OTHERWISE SPECIFIED)

PART NO.	SPECIFICATION	NOMENCLATURE OR DESCRIPTION	ELEC REF DES	CODE IDENT	ZONE	ITEM NO.

PARTS LIST

QTY REQD PER NOTED ASSY

CONFIGURATION

LAYOUT NO.

DIST CODE 8-05 A

DASH NO.	MODEL NO.	NEXT ASSEMBLY	MODEL NO.	FINAL ASSEMBLY	MODEL NO.
-101		805804-101		805803-101	
-101		805805-101		805803-101	

APPLICATION

INTERPRET THIS DRAWING PER STANDARDS IN MIL-D-70327

DIMENSIONS ARE IN INCHES

TOLERANCES ON
DECIMALS: X ± .1, XX ± .03, XXX ± .010, XXXX ± .0050
ANGLES: ± 0° 30'

✓ SURFACE ROUGHNESS

HOLE DIA.	TOLERANCE
.0135 THRU .125	+ .004 – .001
.125 THRU .250	+ .005 – .001
.251 THRU .500	+ .006 – .001
.501 THRU .750	+ .008 – .001
.751 THRU 1.000	+ .010 – .001
1.000 THRU 2.000	+ .012 – .001
2.001 AND OVER	LINEAR

CONTRACT NO NAS 5-11095

		DATE
DRAWN	Beasley	22 Jan 68
CHECK	[illegible]	1/26/68
MECH ENG	[illegible]	1/26/68
ELEC ENG		
PROJ MGR	[illegible]	1/29/68
APPR		
DESIGN ACTIVITY APPD	[illegible]	1-29-68
CUSTOMER		

M L MARSHALL LABORATORIES
TORRANCE, CALIFORNIA

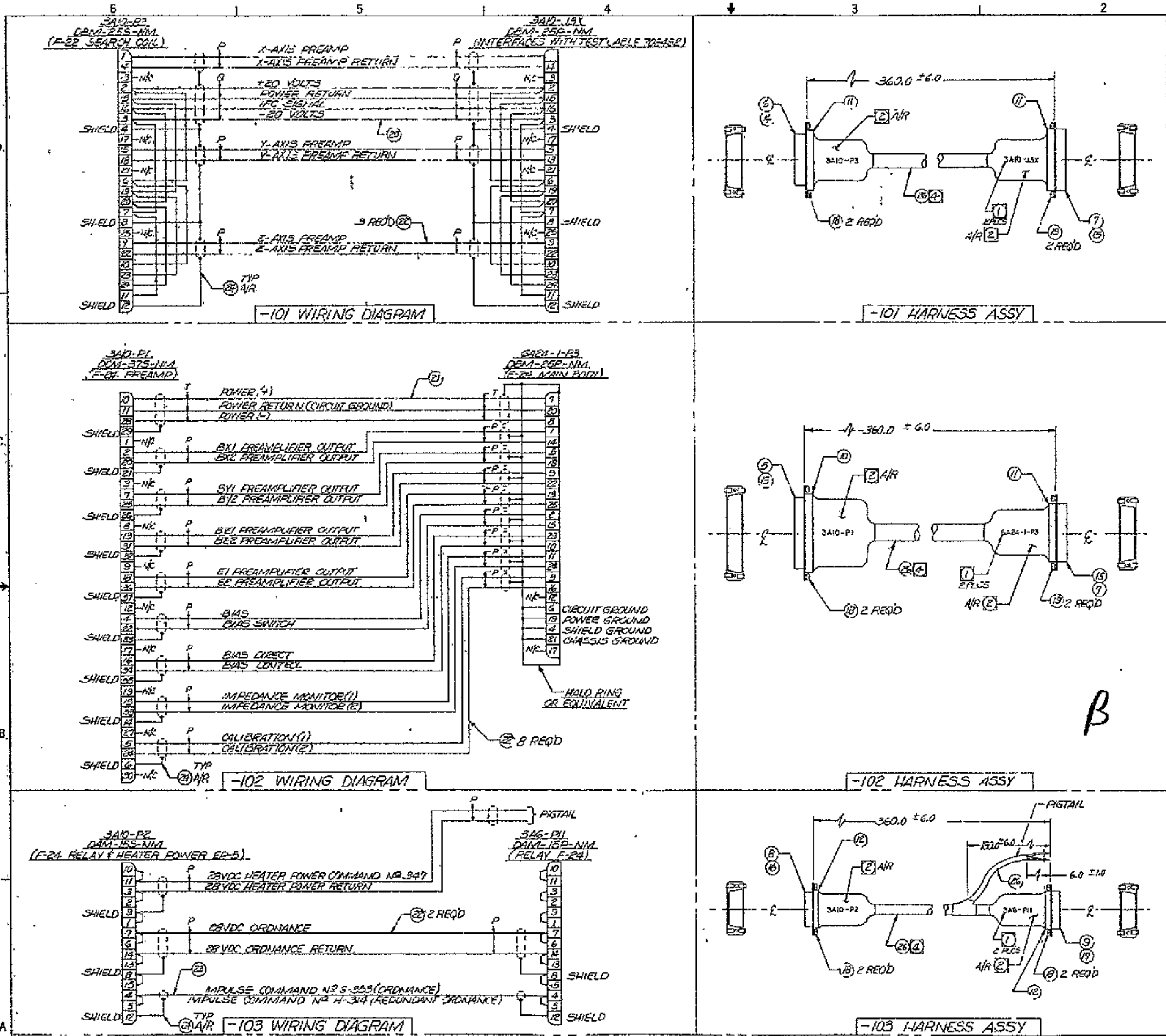
TITLE ASSEMBLY - BOARD, INSULATED TERMINAL EP-5 (060-F)

SIZE	CODE IDENT NO	DWG NO.	REV
C	13126	805811	

SCALE 4/1 RELEASED SHEET 1 OF 1

B

A



A

β

FOLDOUT FRAME

SEE SEPARATE LIST OF MATERIALS NO. PL805900

NOT REPRODUCIBLE
FOLDOUT FRAME

4. IDENTIFY ASSY PER M/L SPEC S40111 CL II, TYPE III.
3. SOLDER PER M/L SPEC S40126 USING SLEEVING (AMS3654) A/R.
2. MOLD CONNECTORS A/R USING PRC 1520 (MOLD CONFIG. OPTIONAL)
1. IDENTIFY CONNECTORS PER M/L SPEC S40111, CL II, TYPE III.

NOTES, UNLESS OTHERWISE SPECIFIED

-103	N/A	FINAL
-102	N/A	FINAL
-101	N/A	FINAL

LIST OF MATERIALS

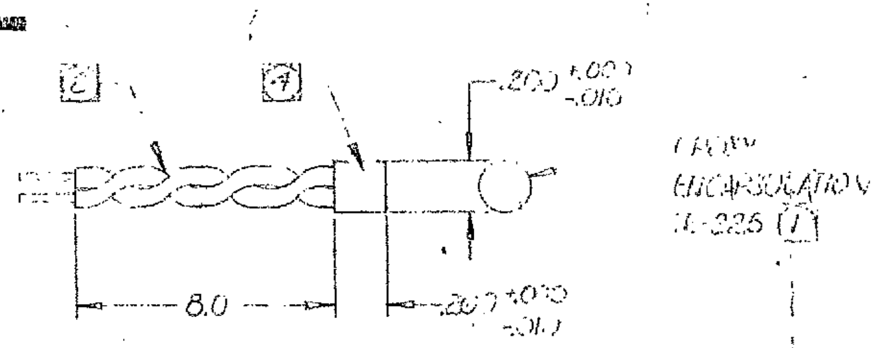
CONTRACT NO. NAS5-11093

MARSHALL LABORATORIES
TORRANCE, CALIFORNIA

ASSEMBLY - CABLE, INTERFERENCE TEST EP-5 (OGO F-22, F-24)

E 13126 805900

FOLDOUT FRAME



DISP	EFF	ZONE	REV	DESCRIPTION	BY	CK	DATE	APPROVAL

REVISIONS

FOLDOUT FRAME

6. PART TO BE NON-MAGNETIC AND MEET ... TO TEST SPEC ML S...
5. RESISTANCE: 10000 Ω ±10% @ 25°C
4. THERMISTOR ID-117
3. $\frac{R_{10°C}}{R_{25°C}} = 2.05 \pm .015$
2. WIRE LEADS ARE #28 AWG. 7-36 STRANDS 6 TURNS PER INCH BELDEN #8501, SILVER COATED COPPER CONDUCTOR TEFLON INSULATED MIL-W-16878-D, TYPE "E".
1. P/O GENERAL ELECTRIC DWG. NO. 9ETIHHG, W/C

NOTES: UNLESS OTHERWISE SPECIFIED

B

[NOT] REPRODUCIBLE

PART NO.	SPECIFICATION	NOMENCLATURE OR DESCRIPTION	ELEC REF DES	CODE IDENT	ZONE	ITEM NO.

LIST OF MATERIALS

QTY REQD PER NOTED ASSY

CONFIGURATION

INTERPRET THIS DRAWING PER STANDARDS IN ...

DIMENSIONS ARE IN INCHES

TOLERANCES ON

DECIMALS | ANGLES

SURFACE ROUGHNESS

APPLICATION

CONTRACT 5-410-30

MARSHALL LABORATORIES

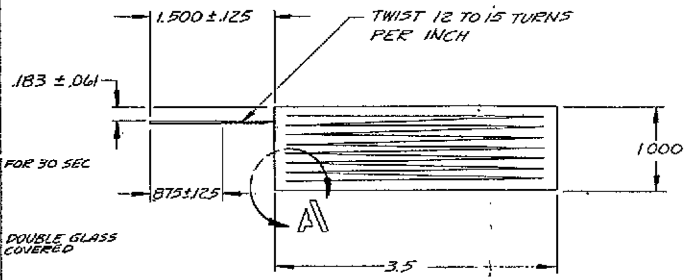
TORRANCE, CALIFORNIA

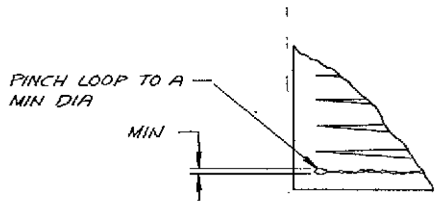
TITLE: THERMISTOR ASSEMBLY

SIZE: B | CODE IDENT NO. 13126 | DWG NO. 20032

SCALE: NONE | RELEASED

ELECTRICAL DATA		
LENGTH	777 FT	
WIRE SIZE	32 GA	
AREA	3.5 IN²	
WATTAGE	10.0 W	
VOLTAGE	28 V	
CURRENT	.35 AMPS	
TOTAL RESISTANCE	78.4	
TOTAL RESISTANCE LIMITS ② ±10% OHMS	86.2	
	70.6	
OHMS/FOOT	10.1	
OHMS/FOOT ② ±8% OHMS	10.9	
	9.28	
W/IN²	2.86	
HIPOT (BOTH)	500 V	FOR 30 SEC
MATERIAL DATA		
HTR SERIES	5340	
	—	
ELEMENT WIRE	TOPHET C Ø.0055	DOUBLE GLASS COVERED
GA	32 GA	
TYPE	2710	
MAT'L LAYERS TOP	1	
" " BOT	1	





DETAIL A
SCALE: 2/1

β

A

3. PART MUST COMPLY TO MARSHALL LABORATORIES TEST SPEC 546068
2. REF TRW PART NO. PT4-13004-10 N/C
1. REF ELECTROFILM PART NO. 101938 N/C
NOTES: UNLESS OTHERWISE SPECIFIED

FOLDOUT FRAME

FOLDOUT FRAME

PARTS DISPOSITION	DWG NO.	REV
1. USE 2. REWORK 3. CANNOT BE REWORKED 4. RECORD 5.	20037	

REVISIONS

DISP	EFF	ZONE	REV	DESCRIPTION	BY	CK	DATE	APPROVAL

QTY REQD PER NOTED ASSY	PART NO.	SPECIFICATION	NOMENCLATURE OR DESCRIPTION	ELEC REF DES	CODE IDENT.	ZONE	ITEM NO.

LIST OF MATERIALS

CONFIGURATION
LAYOUT NO.
DIST CODE 6-4IDA

DASH NO.	MODEL NO	NEXT ASSEMBLY	MODEL NO	FINAL ASSEMBLY	MODEL NO

APPLICATION

INTERPRET THIS DRAWING PER STANDARDS IN MIL-D-70327
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS X ± 1, XX ± 03, XXX ± .010, XXXX ± .0050
ANGLES ± 0° 30'
√ SURFACE ROUGHNESS

HOLE DIA.	TOLERANCE
0135 THRU .125	+ .004 – .001
.126 THRU .250	+ .005 – .001
.251 THRU .500	+ .006 – .001
.501 THRU .750	+ .008 – .001
.751 THRU 1.000	+ .010 – .001
1.000 THRU 2.000	+ .012 – .001
2.001 AND OVER	LINEAR

CONTRACT NO NAS 59248

		DATE
DRAWN	T. TOMPKINS	5 APR 66
CHECK	L.J. SCHOLTEN	11 APR 66
MECH ENG	[signature]	11 APR 66
ELECT ENG		
PROJ MGR		
APPR	[signature]	4-11-66
DESIGN ACTIVITY APPD	[signature]	4-12-66
CUSTOMER		

M L MARSHALL LABORATORIES
TORRANCE, CALIFORNIA

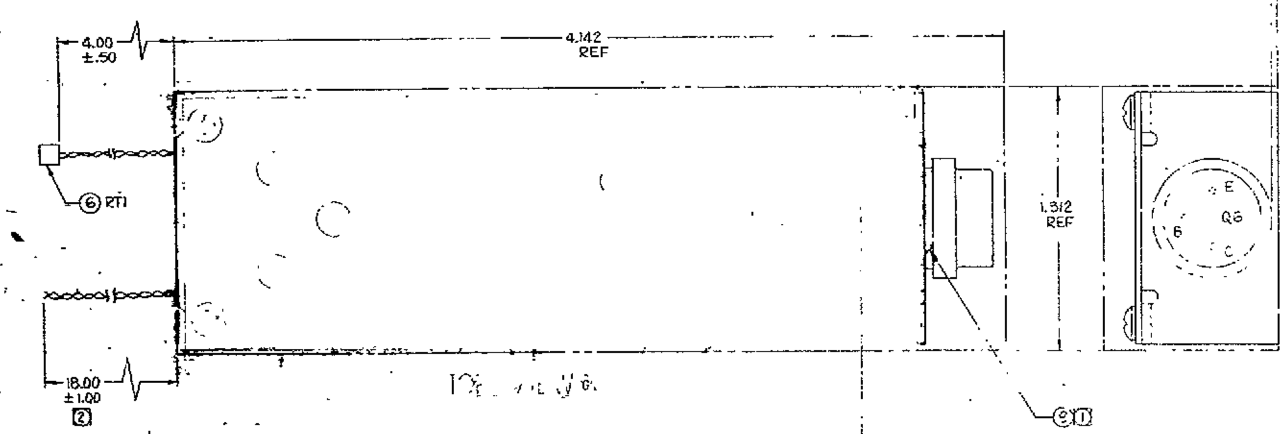
TITLE STRIP HEATER (ELECTROFILM 101938)

SIZE	CODE IDENT NO.	DWG NO.	REV
C	13126	20037	

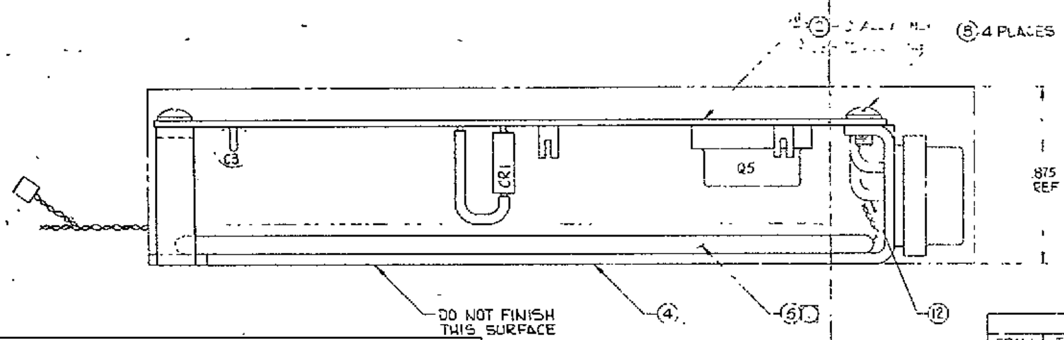
SCALE 1/1 & NOTED | RELEASED APR 12 1966 | SHEET 1 OF 1

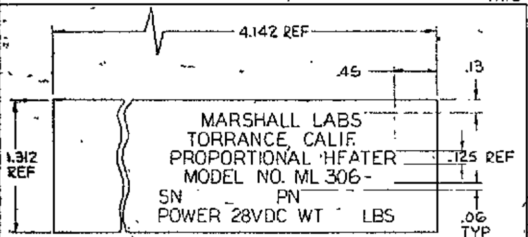
ML FORM 192

FOLDOUT FRAME



NOT REPRODUCIBLE





SCALE 2/1

3

TOP VIEW

WIRE LIST				
FROM	TO	ITEM	SIG	REMARKS
HEATER STRIP	E1	—	Q6-C	
HEATER STRIP	E2	—	+28V	
E2		10	+28V	
E4		11	GRD	
RT1	E3	—	—	
RT1	E5	—	—	

10. FOR FOAMING SEE FIXTURE DWG 52251-101.

9. FOR SCHEMATIC DIAGRAM SEE DWG 52238 FOR -101 AND 305206 FOR -102.

8. TEST [illegible] SPEC S46852.

7. TEST [illegible] S40124.

6. SOLDER PER ML SPEC S40126

5. [illegible] 2 CL III, TYPE II [illegible]

4. FINISH PER ML SPEC S40118, CL I, TYPE IV EXCEPT SURFACE INDICATED

3. MARK PER ML SPEC S40111 CL I, TYPE III, LOCATE APPROX AS SHOWN

2. TWIST ITEM 10 AND 11 [illegible] INCH.

1. BOND ITEM 5 TO ITEM 4 AND ITEM 9 TO ITEM 7 THEN TO ITEM 4 PER ITEM 3

NOTES: UNLESS OTHERWISE SPECIFIED

-102	-101	PART NO.	SPECIFICATION	NOMENCLATURE OR DESCRIPTION		
REF		305206		SCHEMATIC DIAGRAM		
1		52235-102		P.C. BOARD ASSY		
REF			S46852	TEST SPECIFICATION		
1		52168-102		PROPORTIONAL HEATER ASSY.		
A/R	A/R		S40092	FOAMING OF ELECT ASSY		
REF	REF	52251-101		FIXTURE, FOAMING		
		DELETED				
	REF		S40124	TEST SPECIFICATION		
REF	REF		S40126	SOLDERING PROCESS SPEC		
REF	REF		S40111	IDENTIFICATION SPEC		
A/R	A/R		S40118	FINISH SPECIFICATION		
A/R	A/R	826-A	MIL-A-8623 TYPE I	ADHESIVE EPIPHEN (BORDEN CHEMICAL CO)		
A/R	A/R	AMS3654		SLEEVING, INSULATION		
A/R	A/R	44/0411-24-9	RAYCHEM	WIRE, HOOK-UP (WHITE)		
A/R	A/R	44/0411-24-2	RAYCHEM	WIRE, HOOK-UP (RED)		
1	1	52246-1		WASHER, NON-METALIC		
4	4	MS35214-1		SCREW, PAN HD #2-56		
1	1	2N1486	RCA	TRANSISTOR	Q6	
1	1	20032		THERMISTOR ASSY	RT1	
1	1	20037		HEATER STRIP		
1	1	52167-1		HOUSING		
	1	52238		SCHEMATIC		
	1	52235-101		P.C. BOARD ASSY		
	1	52168-101		HOUSING ASSY		

LIST OF MATERIALS

INTERPRET THIS DRAWING PER STANDARDS IN MIL-D-70327

DIMENSIONS ARE IN INCHES

CONTRACT NO. 5-410

E. COOPER

BUCK

PETRICS

MORGAN

R. SANDER

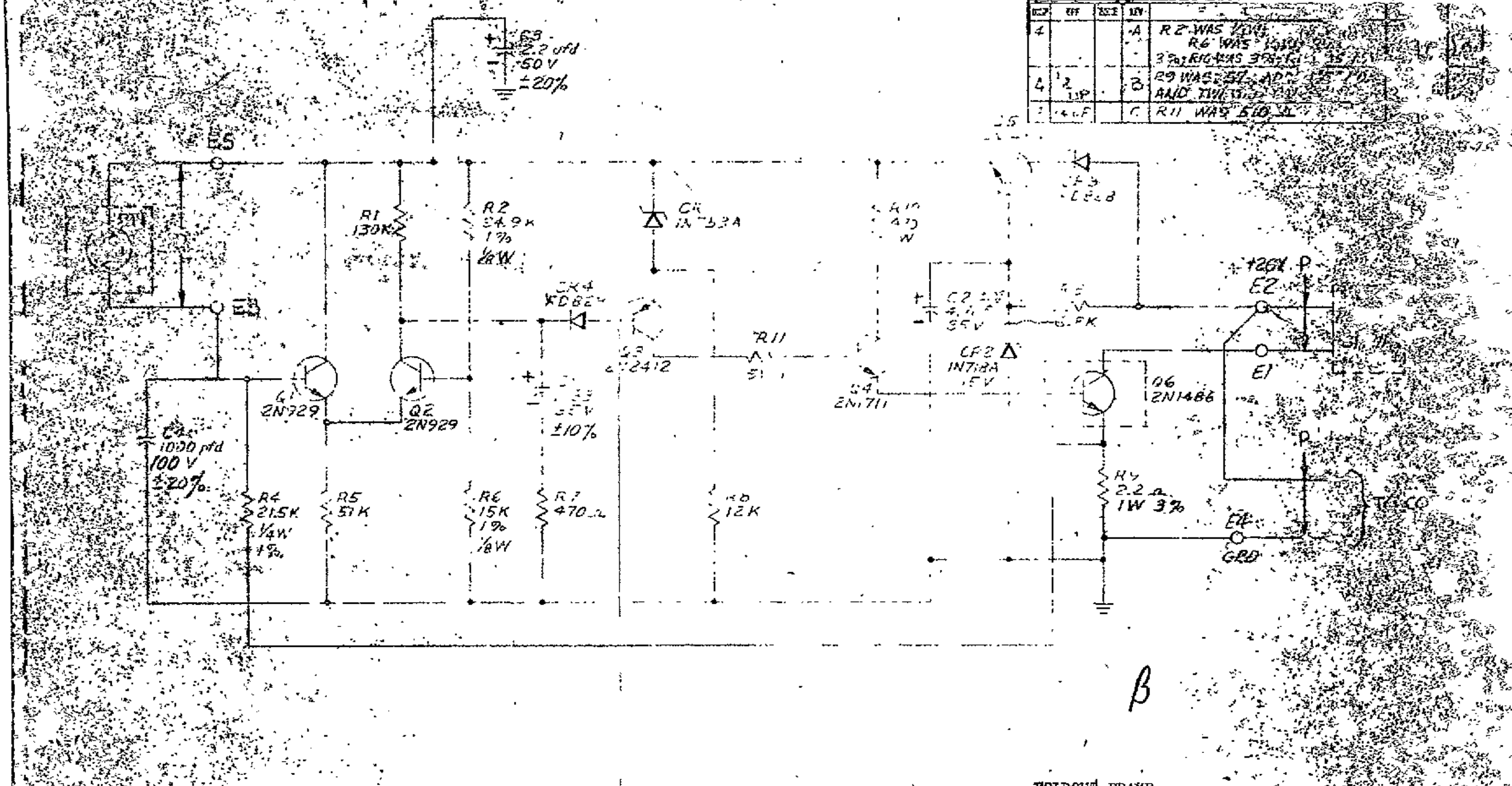
MARSHALL LABORATORIES TORRANCE, CALIFORNIA

PROPORTIONAL HEATER ASSY E18

F 13126 52168

A

NOT REPRODUCIBLE



FOLDOUT FRAME

FOLDOUT FRAME

	52235-1		52740-101	306-1	
NEXT ASSY			FINAL ASSEMBLY		MODEL NO

QTY REQD PER NOTED ASSY

CONFIGURATION

PART NO. | SPECIFICATION | NOMENCLATURE OR DESCRIPTION

LIST OF MATERIALS

INTERPRET THIS DRAWING PER STANDARDS IN MIL D 70327

DIMENSIONS ARE IN INCHES

TOLERANCES ON DECIMALS ANGLES

SURFACE ROUGHNESS

DRAWN 28 JULY 66

TITLE SCHEMATIC PROPORTIONAL

SIZE C CODE IDENT NO. 13176