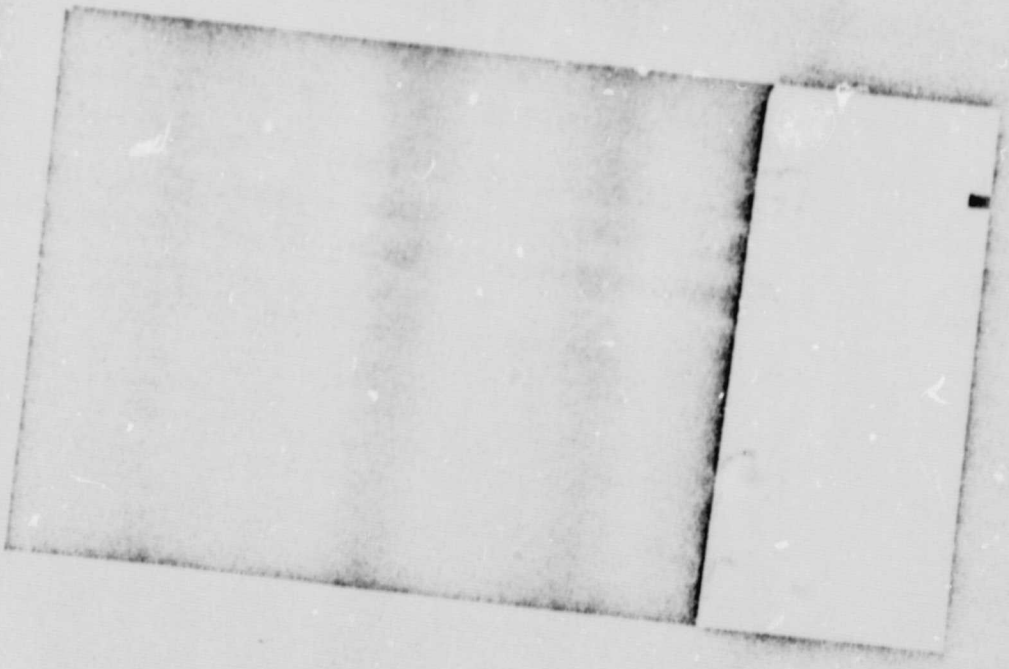

Northrop Corporate Electronics Division NORTHROP

NASA CR 101978

NORT NO. 68-480
August 1969

FINAL REPORT

BIOMEDICAL RECORDING SYSTEMS

Prepared Under
Contract NAS 9-7856

for the

NASA Manned Spacecraft Center
Houston, Texas

T. W. Mann
Northrop Corporation, Electronics Division

25 Aug 1969
Date

NASA MSC Technical Monitor

9-25-69
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FOREWORD

This document has been prepared in fulfillment of the requirements of the Contract Schedule; Article VI - Reports of Work, Paragraph (c) and Exhibit A, Paragraph 2.10.3.2, Final Report of Contract NAS 9-7856, Biomedical Recording Systems.

1.0 SUMMARY

This final report covers hardware definition, development, fabrication and test of the Biomedical Recording System (BRS) which was executed under Contract NAS 9-7856. The Biomedical Recording System is designed for use during portions of pre and post flight medical examinations of flight crew personnel on Apollo missions. To give the BRS flexibility, it is packaged in three suitcases that also serve as shipping containers when closed. Figure 1 shows the system which consists of signal conditioners, visual indicators, magnetic and strip-chart recorders and auxiliary system parts.

Three sets of equipment and spare parts were fabricated by Northrop - Electronics Division for NASA/MSC. The following topics are considered in this report: Design Description, Fabrication and Test, Test Results and Data, Recommendations, Summary of Contractual Communications, and Detailed Appendices showing drawings, procedures, and test plans.

2.0 DESIGN DESCRIPTION

2.1 Functional Elements

This final report covers the hardware definition, development, fabrication and test of the Biomedical Recording System required under Contract NAS 9-7856. The Biomedical Recording System is designed for use during pre and post flight medical examinations of flight crew personnel on Apollo missions. The system consists of three suitcases that serve as their own shipping containers, when closed (Figure 1).

Two of the cases, the Signal Conditioner Case and the Visual Indicator Case, are active cases containing the signal conditioning, interconnection, display and recording equipment while the Accessory Case contains the spare and auxiliary parts for the system. The Signal Conditioner Case contains a power control circuit, a ground protection circuit (to prevent electrical shock), a signal conditioner plug-in card rack, an automatic cuff pump, a patch panel and an eight channel tape recorder/reproducer. The patch panel facilitates selection of any of the Signal Conditioner outputs for visual display or recording.

The Visual Indicator Case contains a time code generator, an oscilloscope with power supply, a cardiotachometer with two digital readouts of heart rate beat by beat and averaged over 5, 15, and 30 seconds, a cardiotachometer calibrator and a 4 channel graphic recorder.

The Accessory Case contains the cables and spare parts required for the complete system. It contains extra signal conditioners, power cables, interconnecting cables, blood pressure cuffs, patch cords, tape recorder reproduce record modules, chart paper, magnetic tape, tiedown cords, an extraction tool, jeweler's screwdriver and tygon tubing for the cuffs.

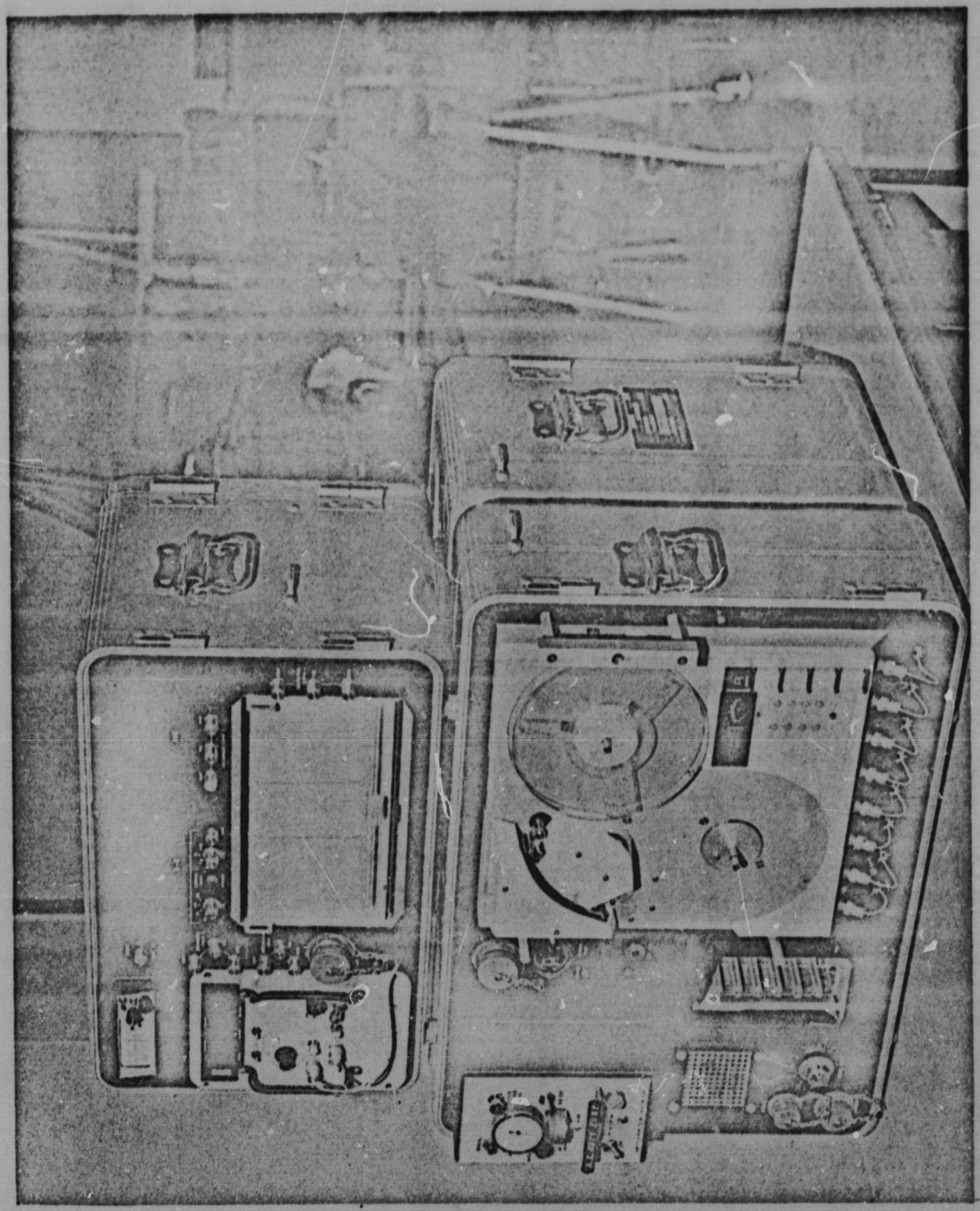


FIGURE 1

2.2 Historical Information

Per revised schedule requirement, System 1 was expedited and delivered earlier than had been expected. It was hand carried to Houston to be subjected to testing including use at sea aboard a carrier during an Apollo flight. Design modifications were under consideration at the time of delivery but not resolved. Later it was decided to return System to Northrop, for Northrop as well as NASA suggested modifications. All modifications described in a letter dated 29 April 1969 from NASA, Manned Spacecraft Center were incorporated. Engineering drawings were then changed to incorporate alterations and modifications in all systems.

After initial fabrication and completion of up to date modifications and alterations, System 2 was selected for environmental and EMI testing. System 2 was also used for testing and finalization of modifications. Paint damage occurred after performance of relative humidity test. The vendor who had painted the cases traced the cause of damage to inadequate priming. Systems 2 and 3 were repainted in-house. System 2 was then resubjected to humidity testing to verify paint suitability.

System 3 was modified to include the above mentioned modifications. The system was repainted after System 2 paint damage occurred. The system was used to investigate a $\pm$ 10 VDC power supply problem. As a result of this investigation, the $\pm$ 10 VDC hybrid circuits in all systems were replaced with units built by another manufacturer.

3.0 FABRICATION

Fabrication and assembly of the hardware elements of the Biomedical Recording System was accomplished in the Electronics Development Laboratory Unit using approved engineering drawings and process procedures (Appendix 7.1, 7.2, and 7.3). All phases of manufacturing and assembly were controlled through planning action and initiation of production orders with quality assurance personnel monitoring each step. Compliance with contract specified workmanship standards was documented and recorded on these production orders which accompany each detail part and subassembly through the shop. Fabrication consisted of performing the described modifications or tasks on the following elements and assembling into the carrying cases.

A) Magnetic Tape Recorder, Lockheed Electronics Model 417, with 8 channel record and reproduce capability. Lockheed Electronics Company made modifications of the power supply, i.e., from battery operation to 117 VAC, before shipment. Northrop removed case and made structural changes to mount the assembly.

B) Graphic Recorder Series M-3 (Mechanics for Electronics, Inc.) After the operational tests on System 1, it was requested that the amplifiers be turned off at the same time as the drive motors to eliminate stylus movements. As a result of the change, the switching of more current created EMI problems which resulted in considerable time lost in securing a cure. Genisco switches resolved the problem.

C) Cuff Pump - E and M Instruments Company, Inc., modifications made by the vendor proved to be inadequate to eliminate EMI. System 1 operational tests disclosed necessity for further modification to eliminate switching transients. A Genisco switch was added to the turn on circuit to bring EMI transients within an acceptable level.

D) Readouts - Fairchild Model 7030 DVM. Cases were removed to cut down bulk and rails were provided for ease of installation. Failures at -22°F per Quality Rejection Report No. 154035, 133254 were resolved after an investigation. Difficulties were found to be random failure of discrete components, well able to withstand -22°F.

E) Patch Panel. Install and wire.

F) Oscilloscope, California Electronics Model 7141. Modifications included removing power cord and hard wiring of 117 VAC, and relocating the vertical positioning control to the front of Visual Indicator Case.

G) Time Code Generator, Systron-Donner Model SD8520. Power cord was removed and hard wired to the 117 VAC source. External B.N.C. connectors supply information and logic to the patch panel.

H) The Cardiotachometer circuit was designed by Northrop. Its function is to translate ECG signal to heart rate - supplying beat by beat and averaged digital readout, as well as an analog output. The circuit is mounted on a printed circuit board located directly behind the readouts. A thermistor was added for temperature drift compensation as requested after operational tests on System No. 1 per letter dated 29 April 1969.

I) The Calibrator Board was designed by Northrop. Its basic function is to provide a constant input signal to the cardiotachometer circuit which is used to calibrate the cardiotachometer, readouts, and graphic recorder. It operates from 60 Hz line voltage, having outputs of 1, 2, and 3 PPS. The 1 PPS is used to actuate the 1 sec. marker.

J) The Power Control Board, designed by Northrop, consists of: 1) the Subject Protection Circuit (Schematic Diagram, Figure 2); the line filter; and 3) the Time Code Generator to cuff pump interface.

After initial testing with System No. 1, the Subject Protection Circuit was modified to withstand larger input current by replacing dual diode CR3. It was also discovered that the relay originally selected to open the circuits would not carry the current which could be expected. This relay was replaced with the present K1 and K3 relays. Test data on the ground protection circuit is listed in Figures 3, 4 and 5.

The Ground Protection circuits operate in the following manner:

Any potential greater than approximately ± 15 MV entering the ground protection circuit on Pin 26 into K1 (2-4) causes circuit activation. A plus or minus voltage is developed on Pin 3 of AR1 across R2 and CR3.

Input sensitivity is adjustable by R5 in the feedback circuit. Complete saturation of AR1 is needed to affect the latching of K1 and K3 through CR4; this is accomplished by K1 contacts 7 and 5 opening.

R6 of AR1 is the internal dc offset. It is used to set the output of AR1 to 0 VDC with the reset switch closed. CR3 is used to protect AR1's input.

R2 is used in the input to develop a voltage drop. It is also to current limit K3 during the protection mode.

After approximately 1 M sec. the contacts on K1 (2-4) open, breaking the man ground (Pin 26). At the same time, K3 is energized through K1 (6-7) and R2 to the power supply ground. Contacts on K3 (2-4) also open breaking continuity between power supply ground and ac power ground. The other contact on K3 is used to supply a ground return from -20 VDC to light the warning indicator lamp.

When the reset button is depressed, AR1's grounded input causes the output to return to 0 VDC, and K1 de-energizes causing K3 to do the same. The man is then grounded, and the warning indicator lamp goes out.

K) Power Supplies - Unitwin Model 164 power supplies were used to obtain the necessary ± 20 VDC. Hybrid voltage regulators were used to step down to ± 10 VDC. Veradyne chip assemblies were selected in original design but, because of manufacturer's design deficiency, were replaced with their new design. Again Veradyne's design proved unsatisfactory. This resulted in considerable time loss. Finally Beckman Helipot Hybrid voltage regulators were tested and used.

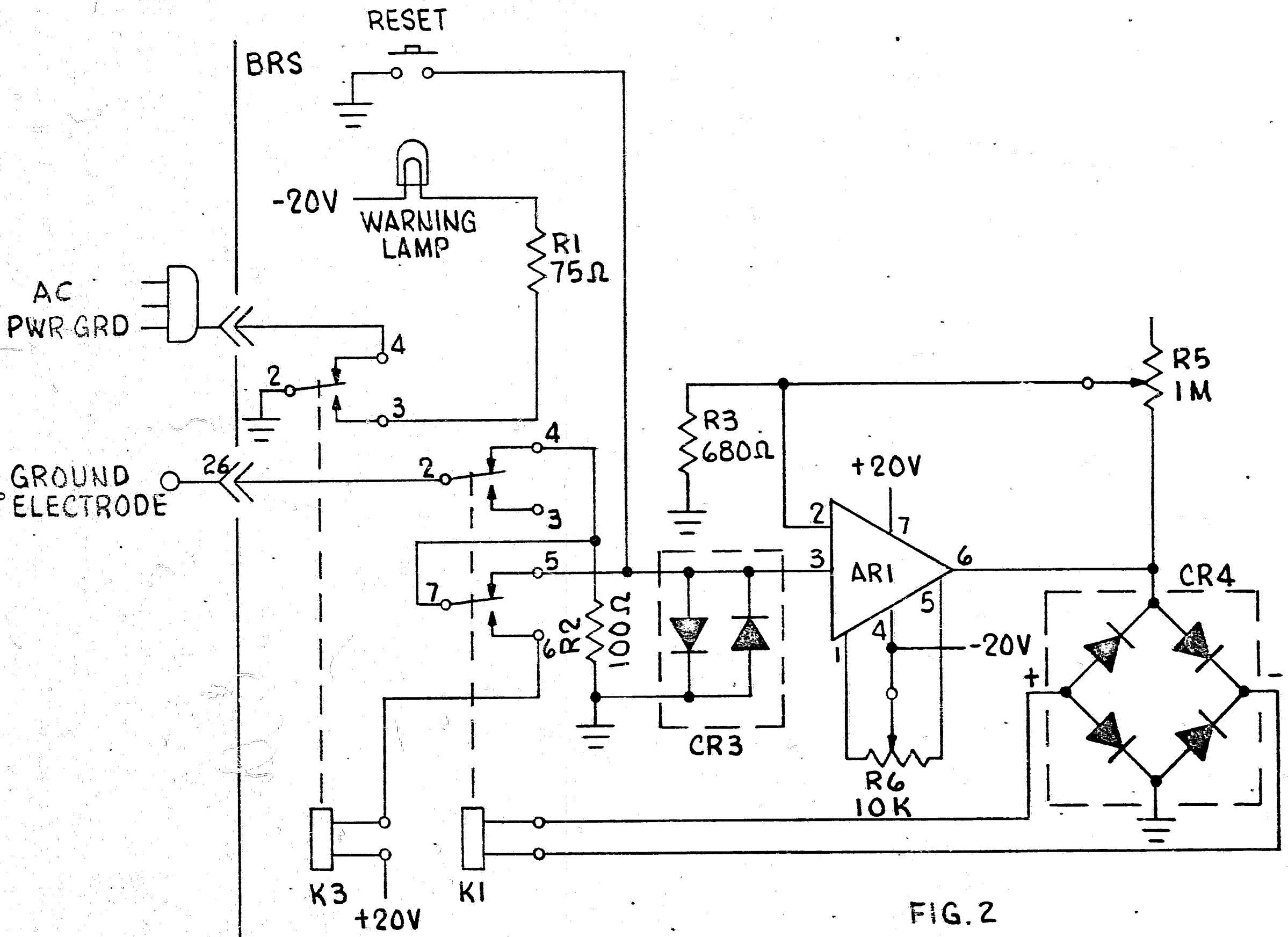
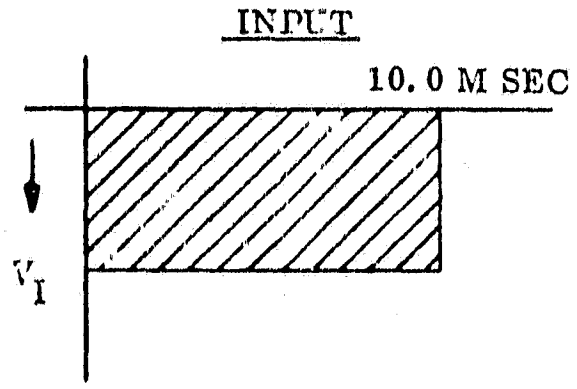


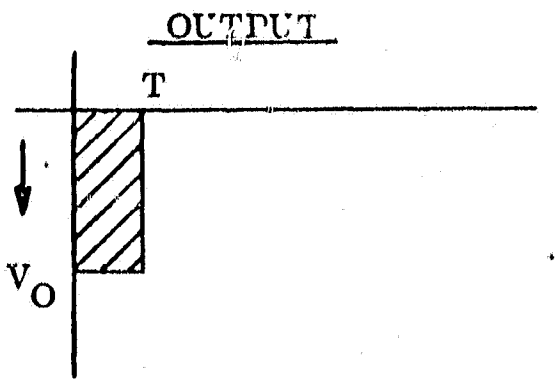
FIG. 2

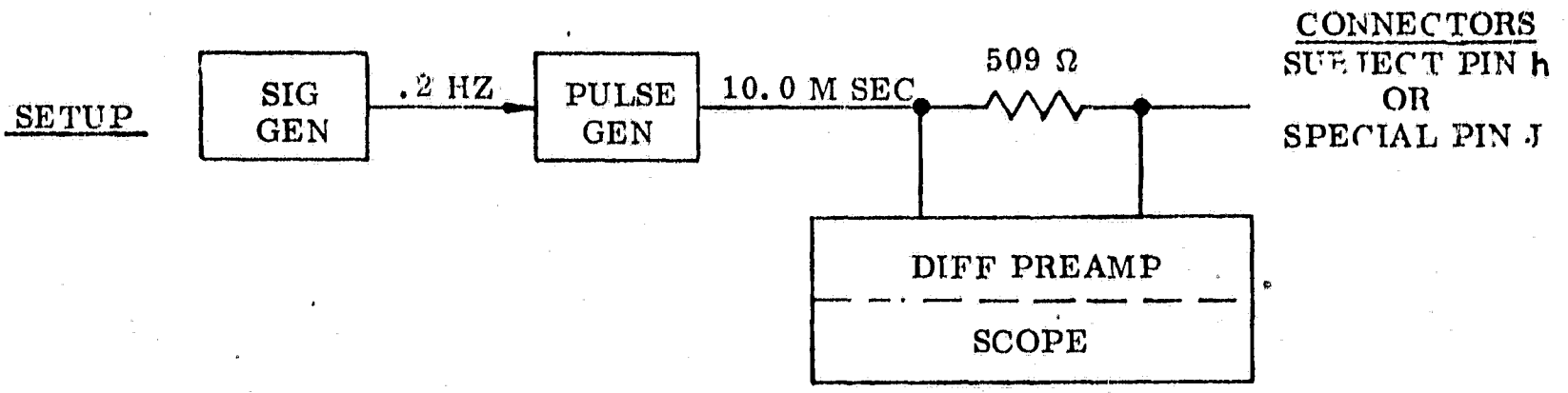
GROUND ELECTRODE PROTECTION CIRCUIT

SYS NO. 2
ALL CIRCUIT
CHANGES PER
PRINTS NOS.
15500078E
15500079D

POWER CONTROL
GROUND PROTECTION CIRCUIT







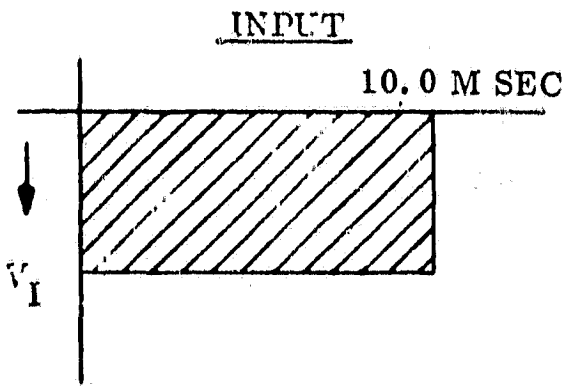
V_I (VOLT IN)	V_O (VOLTS OUT)	T (TIME) M SEC
0.15	0.10	1.70
0.60	0.42	1.04
1.00	0.75	1.04
4.00	2.75	1.04
6.00	4.00	1.08
10.00	6.50	1.08
20.00	10.00	1.10
30.00	12.00	1.12
40.00	13.00	1.14

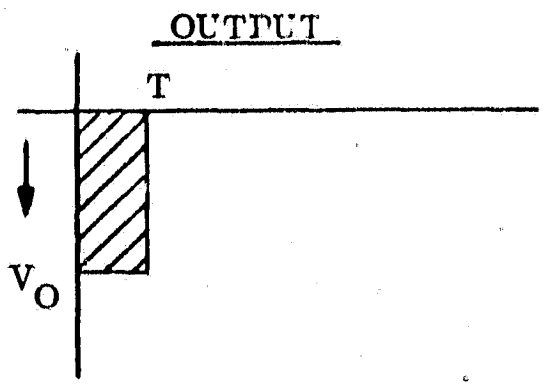
DATE 2 July 1969 BY K. Peterson

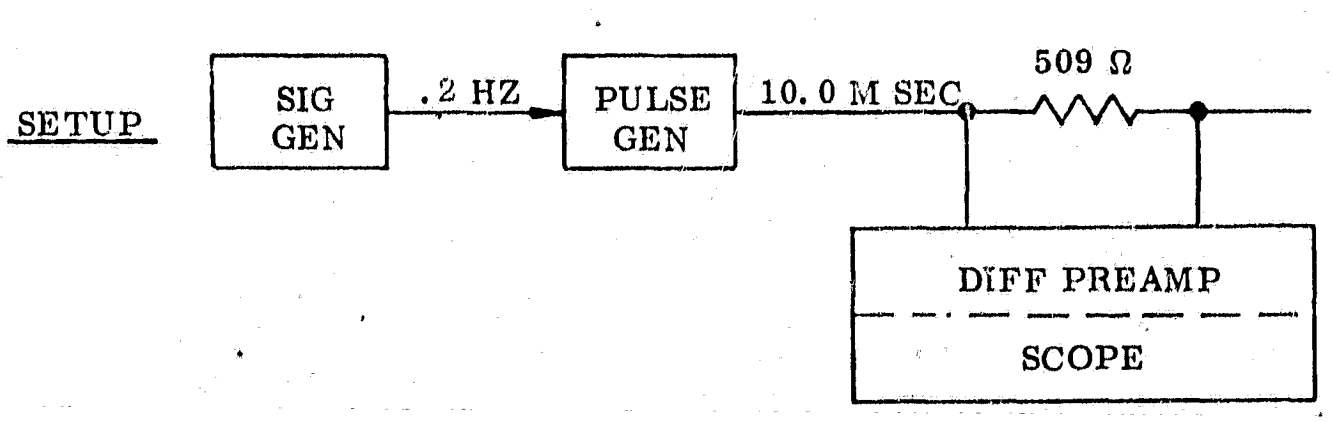
FIGURE 3

SYS NO. 3
ALL CIRCUIT
CHANGES PER
PRINTS NOS.
15500078E
15500079D

POWER CONTROL
GROUND PROTECTION CIRCUIT







CONNECTORS
SUBJECT PIN h
OR
SPECIAL PIN J

V_I (VOLT IN)	V_O (VOLTS OUT)	T (TIME) M SEC
0.15	.115	1.96
0.60	.50	1.95
1.00	.75	1.95
4.00	2.80	1.95
6.00	4.00	1.95
10.00	6.00	1.95
20.00	10.00	1.95
30.00	10.00	1.95
40.00	12.00	1.95

DATE 3 June 1969 BY K. Peterson

FIGURE 4

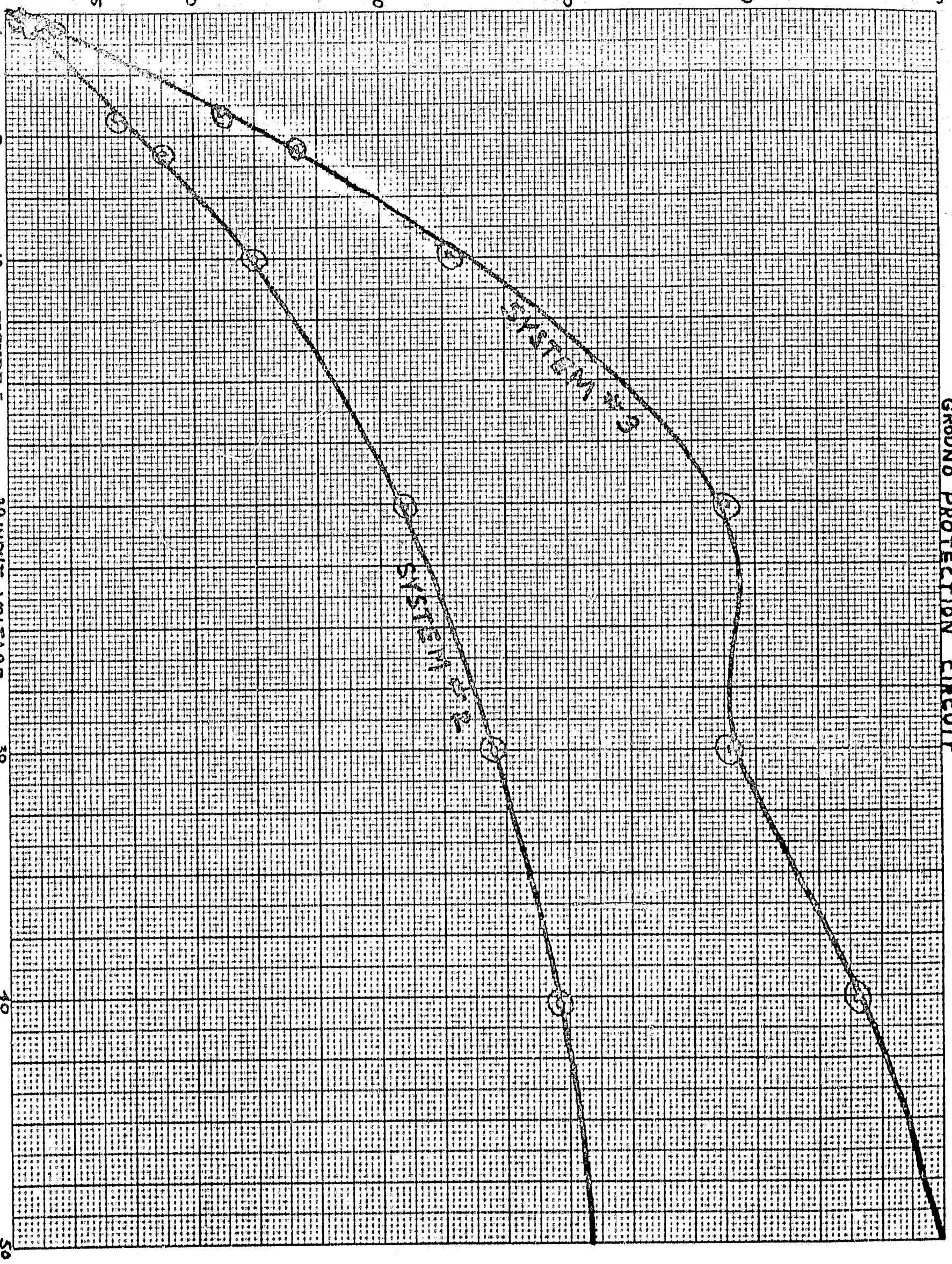


FIGURE 5

NONT 68-480

4.0 TEST RESULTS AND DATA

Functional testing of the assembled systems was performed by engineering personnel using approved test procedures and laboratory test instrumentation to provide data for analysis (Appendix 7.4).

The environmental testing was accomplished using local testing facilities (humidity, temperature, RFI, chambers). Approved test procedures were used in performance of all tests with data accumulated and recorded during each phase. All environmental and acceptance testing on each system was monitored by quality assurance personnel with results documented by test data sheets and production order buy-outs.

4.1 Requirements

The equipment was required to demonstrate its ability to meet the performance requirements as defined in Environmental Test Specification NORT 69-539.

Non-operating condition - Cases were closed, signal conditioner case and visual indicator case. Accessory case (non-electric) was not subjected to environmental test.

Operating condition - System including signal conditioner case, visual indicator case, subject harness, interconnect cable, power cord and signal conditioner, per NORT 69-542, were placed in the chamber. Persons conducting and subjects under test were within the chamber.

4.2 Test History

The tests outlined in NORT 69-539, were performed in Biomedical Recording System Signal Conditioner Case, Part No. 155-00002-301, Serial No. 002. Biomedical Recording System Visual Indicator Case, Part No. 155-00001-301, Serial No. 002.

Paragraph 3.10.3 (Pressure Test)

The Signal Conditioner Case and Visual Indicator were placed in the 64 cu. ft. chamber. The chamber was then reduced in pressure to 2 psi ABS - date was 16 May 1969 - time was 1000 hours.

After 12 hours at 2 psi, the chamber was then started back to sea level pressure. Date was 16 May 1969. - time was 2200 hours.

Sea level was reached at 2300 hours on 16 May 1969. Cases were left in the chamber overnight at sea level pressure.

Biomedical Recording System was removed from chamber and subjected to functional test procedure, NORT 69-542, Paragraph 4.4.1 through 4.4.9. Time was 0930 hours on 17 May 1969. System passed functional test on 17 May 1969 at 1130 hours.

Paragraph 3.10.1 (Relative Humidity)

The Signal Conditioner Case and Visual Indicator Case were placed in 64 cu. ft. chamber and started to 40°F at 0700 hours on 20 May 1969. At 0800 hours, the chamber was started up to 100°F and 95% relative humidity. The chamber reached 100°F and 95% relative humidity on 20 May 1969 at 1000 hours. Started chamber down to ambient temperature and 95% relative humidity at 1100 hours. Reached ambient temperature and humidity and removed units from chamber. Date - 20 May 1969, time - 1530 hours. System was then subjected to functional test NORT 69-542, Paragraph 4.4.1 through 4.4.9, 1700 hours on 20 May 1969. Failed visual inspection of cases. Paint damage due to humidity or temperature or both.

Paragraph 3.10.2 (Operating and Non-Operating at Ambient Temperature

21 May 1969	Specimens, BRS Signal Conditioner Case and Visual Indicator Case were placed in 1000 cu. ft. chamber at 1315 hours.

21 May 1969	1335 hours - Chamber started to +120°F
21 May 1969	1400 hours - Reached +120°F, start 2 hr. soak
21 May 1969	1600 hours - End 2 hr. soak
21 May 1969	1600 hours - Function Test NORT 69-542 - System passed functional test.
21 May 1969	1630 hours - Started up to +160°F
21 May 1969	1700 hours - Reached +160°F, start 36 hr. soak
23 May 1969	0500 hours - End +160°F soak, start to +60°F
23 May 1969	0600 hours - Reached +60°F
23 May 1969	0900 hours - Functional Test NORT 69-542 - System passed functional test.

NORT 69-539, Paragraph 3.10.4 (Operating Humidity)

23 May 1969	1045 hours - Place specimens in 1728 cu. ft. chamber at 29% humidity (only available chamber). (Should be 5% humidity.)
23 May 1969	1115 hours - Functional Test NORT 69-542 - System passed functional test.
23 May 1969	1150 hours - Start to 95% humidity
23 May 1969	1300 hours - Reached 70% humidity only due to large size of chamber and nonavailability of other.
23 May 1969	1330 hours - Functional Test NORT 59-542 - System passed functional test.
23 May 1969	1430 hours - Start down to -22°F
23 May 1969	1600 hours - Reached -22°F, start 8 hr. soak
24 May 1969	0200 hours - End -22°F soak, start to +60°F
24 May 1969	0400 hours - Reached ambient +60°F
24 May 1969	0900 hours - Functional Test NORT 69-542 - Failure of Fairchild digital readout.

NORT 69-539, Paragraph 3.10.2, Retest - 22°F

4 June 1969	1600 hours - Place visual indicator case SN 02 in 64 cu. ft. chamber and start to -22°F.
5 June 1969	0840 hours - Remove case from chamber - end -22°F.
5 June 1969	0930 hours - Functional test NORT 69-542
5 June 1969	0945 hours - Failure, Fairchild readout not reading correctly. Shall be 180 BPM - reads 30 BPM.

NORT 69-539, Paragraph 3.10.2, Retest -22°F

15 June 1969	2030 hours - Place digital readout Model 7030 S/N 000706 in 8 cu. ft. chamber and start to -22°F.
15 June 1969	2045 hours - Reached -22°F, start 10 hr. soak
16 June 1969	0615 hours - Start to ambient 75°F
16 June 1969	1010 hours - Reached ambient temperature - retest OK

4.3 Results

All tests were performed per NORT 69-539, except for Paragraph 3.10.4 wherein the system shall be subjected to 95% and 5% relative humidity at ambient temperature. System was subjected to 70% and 29% relative humidity at ambient temperature. 95% and 5% humidity required could not be reached due to chamber limitations. No other test chambers were available.

Paint damage occurred after performance of NORT 69-539, Paragraph 3.10.1 (Relative Humidity). It was traced to lack of priming of the surfaces by the vendor painting the cases. Systems 2 and 3 were repainted in-house.

Two cardiotachometer readouts (Fairchild Model 7030) failed after NORT 69-539 (-22°F soak). Failure was due to discrete transistors which were within temperature specifications. Cause was assigned to infant mortality.

5.0 RECOMMENDATIONS

5.1 Recommendations for Future Design Changes

A) Cases - More latches could be added to secure cases closed. Also a more positive type latch could be incorporated.

B) Wiring - Power shields are not required. A tight twist should be adequate.

C) Signal Conditioners - The recommended design requirement for the ECG module called out a Bourns potentiometer. The number was 3000-699-203. 699 designated a special order that omitted the potting compound from the feedthrough leads. As a direct result, the module potting compound entered the potentiometer and caused it to freeze up. This potentiometer also was designed for PC board assembly. Because of the shape of the leads, a consistent weld schedule could not be met. Leads were soldered. All signal conditioners could use newer more sophisticated integrated circuits for smaller packaging.

D) Commercial Equipment

1. Graphic recorder could be redesigned to be smaller and lighter. The power supplies and amplifiers could utilize integrated circuits. By the use of smaller potentiometer, the front panel space consumption could be minimized. The pen heat arrangement could be redesigned to minimize heat dissipation and power consumption. A 60% reduction in size and weight could be realized.

2. Time Code Generator - Northrop is presently building a time code generator about the size of a deck of cards. With minor modifications, it would have the same electronic capabilities as that of the presently used generator. Using a newly designed time code reader, the total size would be that of the Fairchild readouts used in the system. In addition, it would permit readout of the time code recorded on magnetic tape.
3. Cuff Pump - The pump could be designed to be smaller and lighter. Also, a pressure bottle could be incorporated.

E) In-house Circuit Designs - New technology could enable these circuits to be miniaturized by at least 50% of their present size and weight.

F) Ground Protection Circuit - Should have a reset over-ride circuit in the event current continues to flow. The circuit should not permit shock to specimen when protection circuit is reset.

6.0 SUMMARY OF CONTRACTUAL COMMUNICATIONS

6.1 Requested vellums for welded modules and schematic for frank lead network. Letter dated 30 July 1968. The brownline reproducible copies of the Apollo signal conditioners were received on 17 August 1968. The full size photo negatives were found to require a large amount of touchup. All schematics and welded module layouts were redrawn.

6.2 Northrop Systems Laboratories' modification of "George C. Marshall Space Flight Center MSFC-STD-271, Amendment 3, 10 January 1967" was forwarded for approval - refer to letter T3915-4248 dated 1 November 1968. Upon approval, the enclosures became the governing documents for the welded electronic modules. Approval was per letter NASA BG721(8), dated 18 November 1968.

6.3 Northrop requested contractual coverage on the accelerated delivery program and on the items referenced in Northrop Letters T3915-4377 dated 18 December 1968 and T3915-4452 dated 24 January 1969. Accelerated work schedule and deviation from NPC-200-4 in letters T3915-4377 dated 18 December 1968 and T3915-4452 dated 24 January 1969 were approved by a TWX from NASA.

6.4 On 27 January 1969, Northrop responded to a NASA request to expedite the construction and test of System 1 for a delivery date of 20 February 1969. To meet the schedule, NASA agreed to a red line drawing system, MRB action on major discrepancies only, and deferred environmental testing to latter system and abbreviated acceptance test specifications. In addition, NASA agreed to overtime, as estimated.

6.5 Request by Northrop telecon for waivers covering RFI tests, digital readout problems, and humidity environmental test was approved by NASA TWX dated 17 June 1969.

6.6 Modifications and corrective actions, per NASA letter dated 29 April 1969, were incorporated. The letter included a reinforced front panel of visual indicator at connector. Modify cardiotachometer to provide stability of triggering and temperature drift. Add covers for connectors. Notch cuff pump cover. Modify blood pressure signal condition input. Replace tape recorder reel retainers. Repair oscilloscope.

7.0 APPENDICES INDEX

7.1 Schematic Diagrams

One (1) copy reproducible and two (2) blueline copies each. Accompany final report submittals.

155-00027C	Schematic Diagram - Cardiotachometer Circuit
155-00058A	Schematic Diagram - B. P. Signal Conditioner
155-00061A	Schematic Diagram - ECG Signal Conditioner
155-00064A	Schematic Diagram - EEG Signal Conditioner
155-00067A	Schematic Diagram - ZPN Signal Conditioner
155-00070A	Schematic Diagram - Body Temperature Signal Conditioner
155-00073A	Schematic Diagram - L. C. Signal Conditioner
155-00075 N/C	Schematic Diagram - VCG Signal Conditioner
155-00079C	Schematic Diagram - Power Control
155-00082C	Schematic Diagram - Signal Conditioner Calibrator
155-00087B	Wiring Diagram, Biomedical Recording System
155-00105 N/C	Schematic Diagram, Cardiotachometer Calibrator
155-00114A	Schematic Diagram, Continuity Tester

7.2 Assembly Drawings

One (1) copy reproducible and two (2) blueline copies each. Accompany Final Report submittal.

155-00001B	Assembly - Visual Indicator Case
155-00002B	Biomedical System Signal Conditioner Case
155-00003A	Case Assembly - Biomedical Recorder Spares
155-00005A	Structure Assembly - Visual Indicator Case
155-00006C	Cardiotachometer Interval Circuit
155-00007A	Cardiotachometer Assembly
155-00008N/C	Fitting Support, Cardiotachometer
155-00009N/C	Track Assembly, Strip Chart
155-00010A	Track Details, Cardiotachometer
155-00011N/C	Track Assembly, Cardiotachometer
155-00012N/C	Track Details, Oscilloscope
155-00013N/C	Support Details, Rear Track
155-00014A	Mount, Rear, Visual Indicator Case
155-00015N/C	Mount Assembly, Forward, Visual Indicator Case
155-00017N/C	Support Track, T.C. Generator
155-00018N/C	Support Track, Rear, Strip Chart Recorder
155-00019N/C	Support Track, Oscilloscope
155-00021N/C	Retainer Assembly, Oscilloscope
155-00024N/C	Mask, Cardiotachometer
155-00029N/C	Markings, Instrument Panel

155-00052A	Housing, Cuff Pump
155-00053 N/C	Cover, Tape Recorder
155-00054 N/C	Printed Circuit Board, Signal Conditioner
155-00055A	Blood Pressure Signal Conditioner
155-00056 N/C	Clamp, Module
155-00057A	Spacer Plate, Module
155-00059A	ECG Signal Conditioner Assembly
155-00060C	ECG Signal Conditioner Module
155-00062A	EEG Signal Conditioner Assembly
155-00063A	EEG Signal Conditioner Module
155-00065A	ZPN Signal Conditioner Assembly
155-00066A	ZPN Signal Conditioner Module
155-00068A	Body Temperature Signal Conditioner Assembly
155-00069A	Body Temperature Signal Conditioner Module
155-00071A	Leg Circ. Signal Conditioner Assembly
155-00072A	Leg Circ. Signal Conditioner Module
155-00074A	VCG Signal Conditioner Assembly
155-00076 N/C	Printed Circuit Board, VCG
155-00078D	Power Control, Biomedical Recorder
155-00083B	Calibrator, Signal Conditioner
155-00084B	Voltage Board, Calibrator
155-00085A	Resistor Board, Calibrator

155-00086A	Case and Cover, Calibrator
155-00088N/C	Tape Recorder, Modified
155-00089B	Cuff Pump, Modified
155-00090B	Subject Harness
155-00091B	Special Harness
155-00092B	Interconnect Cable
155-00096N/C	Bracket, Nutplate L.H.
155-00097N/C	Bracket, Nut Plate R.H.
155-00101N/C	Case Assembly, Welded Spares
155-00104A	Calibrator Board Assembly
155-00106N/C	Bracket, Transistor
155-00107N/C	Bracket, Integrated Circuit
155-00108A1	Board - Calibrator
155-00111N/C	Cuff, Occluding, Modified
155-00112A	Continuity Tester Assembly
155-00113N/C	Spacer Board, Signal Conditioner
155-00115N/C	Bracket, Switch
155-00116N/C	Terminal Board, Tester, Continuity

7.3 In-Process Procedures

Six (6) copies each accompany Final Report submittal.

NORT 68-299	Bonding, Epoxy Polyamide Adhesive EC 1614
NORT 68-300	Conformal Coating, Urethane, PRC 1535
NORT 68-302	Potting of Connectors, RTV-60
NORT 68-304	Painting, Epoxy Pigmented for CAT-A-LAC 436-1-500
NORT 68-494	Modifications to MSFC Specification MSFC-STD-271
MSFC-STD-271	Fabrication of Welded Electronic Modules, Standard
NPC 200-4	Quality Requirements for Hand Soldering of Electrical Connections
MSC-ASPO-S6A	MSC Supplement to NPC 200-4
AMS-2491	Surface Treatment of Polytetra-Fluoroethylene
MIL-C-5541	Chemical Films and Materials for Aluminum and Aluminum Alloys

Nortronics Process Bulletins and Specifications

ST8Y001-1908	Shielded Wire Preparation and Termination
-1909	Installation of Heat-Shrinkable Tubing, Boots and Harnessing Systems
-1911	Use of Sleeving and Tape, General
-1918	Installation of Thomas and Betts TY-Raps
-2178	Terminal and Eyelet Setting
-2706	Application of MIL-P-8585 Zinc Chromate

ST8B002-3151	Bonding with Room Temperature Curing Elastomeric Adhesives
-3174	Application of Thread Sealants
-90701	Hole Pattern, "D" Series Connector
ST9M002-91501	Direct Application Markings and Part Numbers
-91509	Identification of Cables, Cable Assemblies and Harnesses
-92113	Interconnection of Solder Type Stand-Off Terminals Using Solid Copper Wire
ST9Y001-92388	Electrical Connectors, Circular Quick Disconnecting, Wiring and Installation of.
-92401	Installation of Wire Lead Mounted Components to Stand Off Terminals
ST9F005-92700	Standard Finish Codes
-92935	Hand Anodizing of Aluminum Alloys
-98000	General Manufacturing Specification

7.4 Test Procedures and Plans

NORT 69-539	Environmental Test Procedure, Biomedical Recording Systems
NORT 69-540	Radio Frequency Interference Procedure, Biomedical Recording Systems
NORT 69-541	Test Procedures for Biomedical Recording System Signal Conditioners
NORT 69-542	Functional Test Procedure, Biomedical Recording Systems
NORT 69-543	End Item Test Plan Biomedical Recording System

7.5 Reports

NORT 69-608	Report of Qualification Test on Biomedical Recording System - Electromagnetic Interference.