EPS-472

ELECTRON-PROTON SPECTROMETER
SPARES REQUIREMENTS

LEC Document Number EPS-472

Prepared by

Lockheed Electronics Company
Houston Aerospace Division
Houston, Texas
Under Contract NAS 9-11373

For

National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas

September 1971

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INTRODUCTION

INTRODUCTION

The Electron-Proton Spectrometer (EPS) is being developed for the NASA Skylab Program by Lockheed Electronics Company, Houston, Texas under Contract NAS 9-11373.

The EPS is mounted external to the Skylab module complex on the Command Service Module. It is designed to make a 2π omni-directional measurement of electrons and protons which result from solar flares or enhancement of the radiation belts. The EPS data will provide accurate radiation dose information so that uncertain Relative Biological Effectiveness (RBE) factors are eliminated by measuring the external particle spectra. Astronaut Radiation Safety, therefore, can be ensured, as the EPS data can be used to correct or qualify radiation dose measurements recorded by other radiation measuring instrumentation within the Skylab module complex.

The EPS has the capability of measuring an extremely wide dynamic radiation dose rate range, approaching 10^7, to an accuracy generally limited by statistical fluctuations, thereby making it applicable to long missions of low average dose rates. Simultaneously the EPS has the capability to process data from extremely high radiation fields such as might be encountered in the wake of an intense solar flare.

PART II

CONTRACT REQUIREMENTS

1. APPLICABLE DOCUMENTS

1.1 NASA MANNED SPACECRAFT CENTER

"End Item Specification Flight Hardware for Electron/Proton Spectrometer" dated December 15, 1970

Contract Change Authorization No. 1 dated January 11, 1971 "Relocation of the EPS from the MDA to the CSM"

"Apollo Ground Support Equipment General Environmental Criteria and Test Specification" Document # MSC-GSE-1B

1.2 NON-GOVERNMENT DOCUMENTS

"Skylab CSM/Electron-Proton Spectrometer Environmental Requirements, CSM/GFE, NR/MSC" Document # MH04-02120-434

"Skylab CSM/Electron-Proton Spectrometer Electrical Requirements, CSM/GFE, NR/MSC" Document #MH04-02119-234

"Skylab CSM/Electron-Proton Spectrometer Installation, CSM/GFE, NR/MSC" Document # MH04-02118-134

"Skylab CSM/Electron-Proton Spectrometer Ground/BTE Interface Requirements CSM/GFE, NR/MSC" Document # MH04-02121-434

"Electromagnetic Compatibility, Design Criteria, CSM/GFE, NR/MSC" Document #MH04-02057-234

2. MISCELLANEOUS DOCUMENTS

EPS-471

ELECTRON-PROTON SPECTROMETER
ANCILLARY HARDWARE SUPPORT REQUIREMENTS

Prepared by
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ANCILLARY HARDWARE SUPPORT REQUIREMENTS

1. SCOPE

This document defines the support requirements for the Electron-Proton Spectrometer (EPS), flight units, flight back-up unit and Bench Test Equipment (BTE). Much of the same information will be contained in the Ground Handling and Bench Test Equipment Interface Control Document N/R # MH04-02121-434.

2. APPLICABLE DOCUMENTS

Unless specified revision dates are listed, the latest document revision date shall apply.

2.1 NON-GOVERNMENT DOCUMENTS

The following documents provide supporting data to the extent specified herein.

MH04-02118-134	Skylab CSM/Electron-Proton Spectrometer Installation, CSM/GFE, NR/MSC
MH04-02119-234	Skylab CSM/Electron-Proton Spectrometer Electrical Requirements, CSM/GFE, NR/MSC
MH04-02120-434	Skylab CSM/Electron-Proton Spectrometer Environmental Requirements, CSM,GFE, NR/MSC
MH04-02057-234	Electromagnetic Compatibility Design Criteria, CSM/GFE, NR/MSC

2.2 MANNED SPACECRAFT CENTER

MSC-GSE-1B	Apollo Ground Support Equipment General Environmental Criteria and Test Specification.

3. BENCH TEST EQUIPMENT (BTE)

The BTE will be supplied by LEC and will include ground handling procedures, checkout operations, and procedures necessary to maintain the integrity of the equipment and interface prior to launch.

The BTE shall consist of the following:

1. Bench Test Equipment Controller
   a. Honeywell H112 - Minicomputer
   b. Behive Medical Electronic Tape Transporter
   c. BNC Pulser
   d. Lockheed Precision Pulser
   e. Ortec BIN
   f. Voltmeter Rack - Contains 2 N.L.S. Model X4 DVM's.
   g. Power Supplies (Kepco) (2 ea)
2. Hazeltine 2000 CRT Display.
3. Repco 120 Printer.

4. MECHANICAL GROUND SUPPORT EQUIPMENT (GSE)

4.1 SHIPPING CONTAINER

The transportation shipping container will be acceptable for entry into a clean room. Exterior surfaces will be smooth and easily cleanable. Interior padding will not generate particulate contamination. The container described shall not weigh more than 75 pounds including the EPS instrument.

4.2 PROTECTIVE COVER

The EPS will be supplied and installed with a protective cover over the detector shields as described in NR Document MH04-02118-134. The protective cover will be capable of being removed after installation of the EPS on the SM to facilitate checkout operations. Final removal of protective cover must be accomplished prior to installation of the CSM Boost Protective Cover. The EPS protective cover may be removed (or replaced) by removing eight threaded fasteners. The material of the protective cover will not support combustion.

5. GROUND HANDLING

5.1 HANDLING EQUIPMENT

No special handling equipment shall be required to facilitate installation (or removal) of the EPS in the SM. Care shall be exercised during handling of the EPS so that the thermal control surfaces described in NR Document MH04-02120-434 and the detector shields are not damaged.

5.2 MAINTENANCE

Maintenance work on the EPS, except for minor cleaning, should not be performed while the instrument is installed in SM. Cleaning materials must be limited to freon so that the thermal properties of the EPS temperature control are not disturbed.

6. GROUND ENVIRONMENT

The following represents the test or storage environment limits to which the EPS instrument may be exposed during both operating and non-operating conditions at the

Downey and KSC facilities. The instrument will be capable of functioning during and after exposure to any feasible combination of these environments.

a.	Cleanliness	Class 340,000 Test/Stowage Area
b.	Temperature	72 plus or minus 10 F in controlled environments. 15 to 105 F in non-controlled environments.
c.	Humidity	70 percent maximum in controlled environments. Up to 100% including condensation in non-controlled environment.
d.	Pressure	Local ambient to equivalent pressure at 200,000 ft. altitude (10^{-5} TORR) during altitude test.

7. CHECKOUT

7.1 ACCESS

The CSM installation shall permit access to the EPS test points electrical connectors for required test operations.

7.2 OPERATING POWER

Operating power for the EPS during the installed system checkout must be provided from the CSM power bus.

7.3 DATA MONITORING

During checkout operations at Downey and KSC, provisions shall be made to permit real time readout of the EPS data parameters. Primary data display during Downey checkout will be the Telemetry Ground Station (TGS). Real time data display of telemetry measurements at KSC will be through the ACE or the NASA Quick Look Data Station (QLDS) facilities. Recorded data tapes or test results will be provided to NASA/LEC on request. Calibration data for each EPS measurement shall be included in the EPS end item data pack at time of delivery to NR integration facility.

7.4 CHECKOUT OPERATIONS

Checkout operations shall be defined in Table I.

8. EPS INTERFACES

8.1 PHYSICAL INTERFACE

The physical interface of the EPS with the SM, including location, mounting and boost protection requirements shall be as specified in NR Document MH04-02118-134.

8.2 ELECTRICAL INTERFACE

The electrical interface of the EPS with the CSM, including power, control data and connector requirements shall be as specified in NR Document MH04-02119-234.

8.3 ELECTROMAGNETIC COMPATIBILITY (EMC)

The EMC interface of the EPS instrument with the CSM shall be as specified in NR Document MH04-02057-334.

8.4 ENVIRONMENTAL INTERFACE

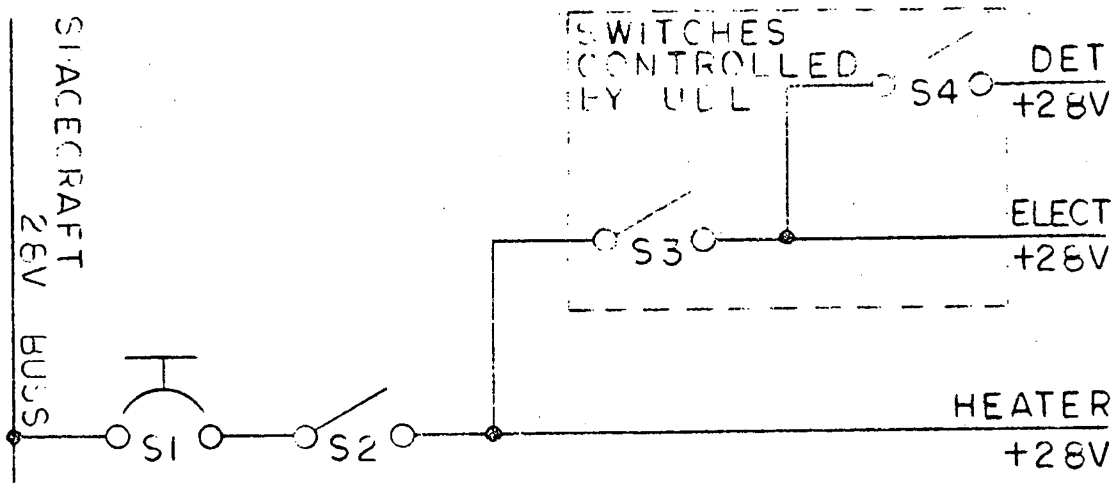
The inflight environmental interface of the EPS with the CSM, including vibration, thermal and contamination sources, shall be as specified in NR Document MH04-02120-434.

TABLE I

	Description	BTE/GSE
Downey		
Installation	EPS temporarily installed in SM.	None
Functional Checkout	Detailed functional checkout of the EPS. Instrument power and timing supplied from CSM and controlled by Up-Data Link (UDL). CSM data system used to monitor EPS parameters.	TGS
Integrated Systems Test	Same as Functional checkout.	TGS
EPS Removal	Remove EPS from SM.	None
MSOB - KSC		
Preinstallation Test	Functional Checkout of EPS in BME area.	Electronics Rack Electronic Display Printer
Installation	EPS installed in SM.	None
Combined Systems Test	Detailed functional checkout of the EPS Instrument power and timing supplied from CSM and controlled by UDL. CSM data system used to monitor EPS parameters.	QLDS
Simulated Altitude Test	Same as Combined Systems Test.	QLDS
Altitude Test	Same as Combined Systems Test.	QLDS
Launch Pad - KSC		
Detailed Functional Checkout and Integrated Test	Detailed functional checkout of the EPS instrument power and timing supplied from CSM and controlled by UDL. CSM data system used to monitor EPS parameters.	QLDS
Simulated Flight	Same as Intergrated Test	QLDS
Countdown Demonstration Test	Same as Intergrated Test	QLDS
Countdown	Same as Intergrated Test	QLDS

9. FLIGHT CREW REQUIREMENTS

Flight crew training is required for familiarization and operation of the two command module mounted switches which place the EPS in the operate mode.



Switches S1 and S2 are flight crew operated switches. Closing both switches puts the EPS in standby mode 1. Switches S3 and S4 are operated by up-data link commands from the ground control console. Closing S3 puts the EPS into standby mode 2. Closing S3 and S4 puts the EPS into operate mode.

10. BASE SUPPORT REQUIREMENTS

The following support requirements will be required at KSC prior to installation of the EPS on the CSM.

10.1 PHYSICAL SPACE

One room having controlled temperature and humidity of at least 100 ft^2 is required.

10.2 SECURITY

The security requirements for the EPS support area should be consistent with KSC procedures and with the requirements of NASA/MSC program requirements.

10.3 SAFETY

The safety requirements and assigned responsibilities for safety implementation shall be consistent with MSC safety program directive No. 1, dated January, 1969 and KSC safety procedures.

10.4 OTHER

No special requirements have been defined for the following:

a. Communications
b. Medical
c. Mail
d. Reproduction and graphics
e. Office machines, furniture, etc.
f. Common supply items

g. Transportation and Vehicle
h. Photographic
i. Shop service
j. Rigging
k. Materials testing chemical analysis, X-ray, etc.
l. Fuels, coolants, gases
m. Ordanance storage and loading.

10.5 UTILITIES

10.5.1 BTE Electrical Power

The electrical power supplied to the BTE shall have the following characteristics.

Voltage:	120 Volts, +3%, -10% Single Phase, 3-wire Line, neutral and ground
Frequency:	60 ± 1 Hz
Harmonic Content:	3% RMS Maximum
Peak Current:	15 Amps, Maximum

10.5.2 Cable Interface

(a) Interconnecting cables between the BTE and the EPS, as shown on Figure 2, shall be supplied by LEC.
(b) Electrical power cables shall interface with the BTE as shown on Figures 1 and 2.

10.6 MECHANICAL INTERFACE

No requirement.

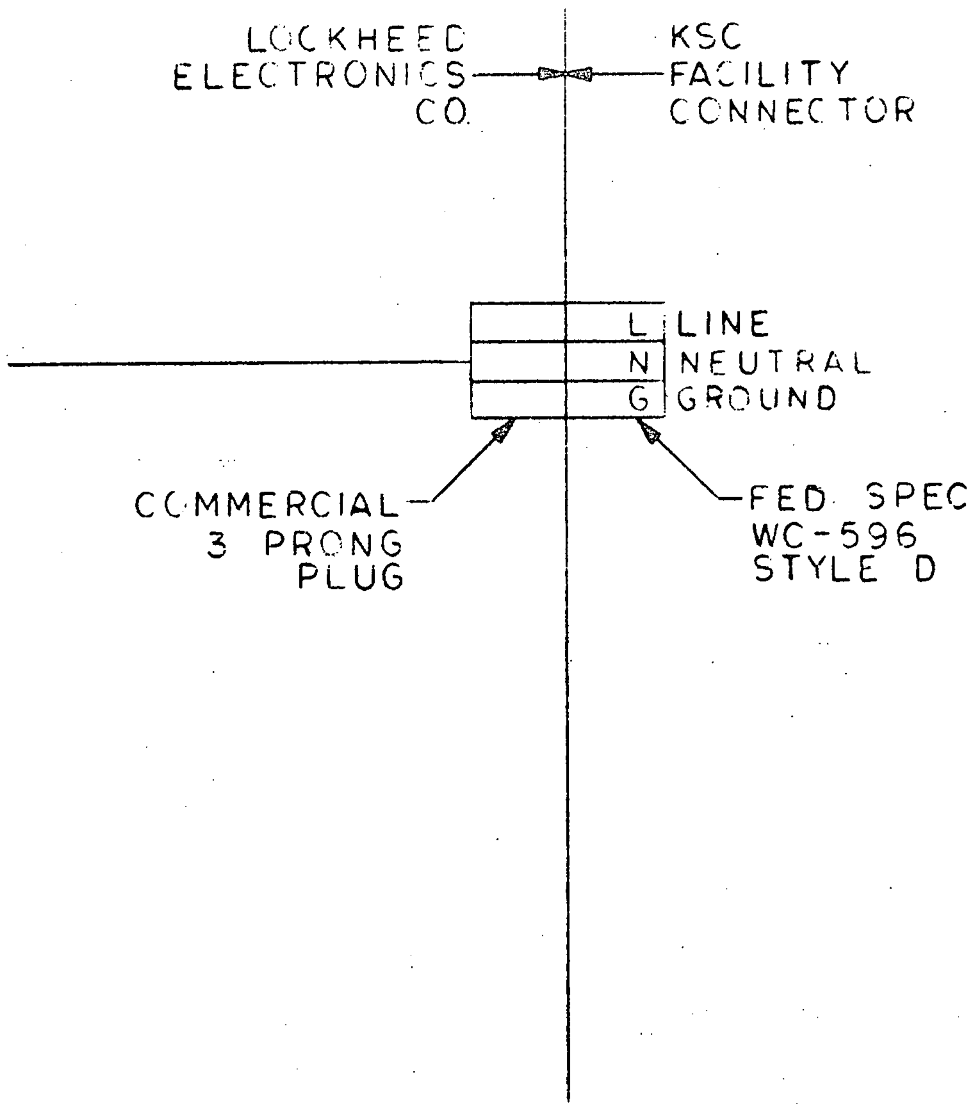
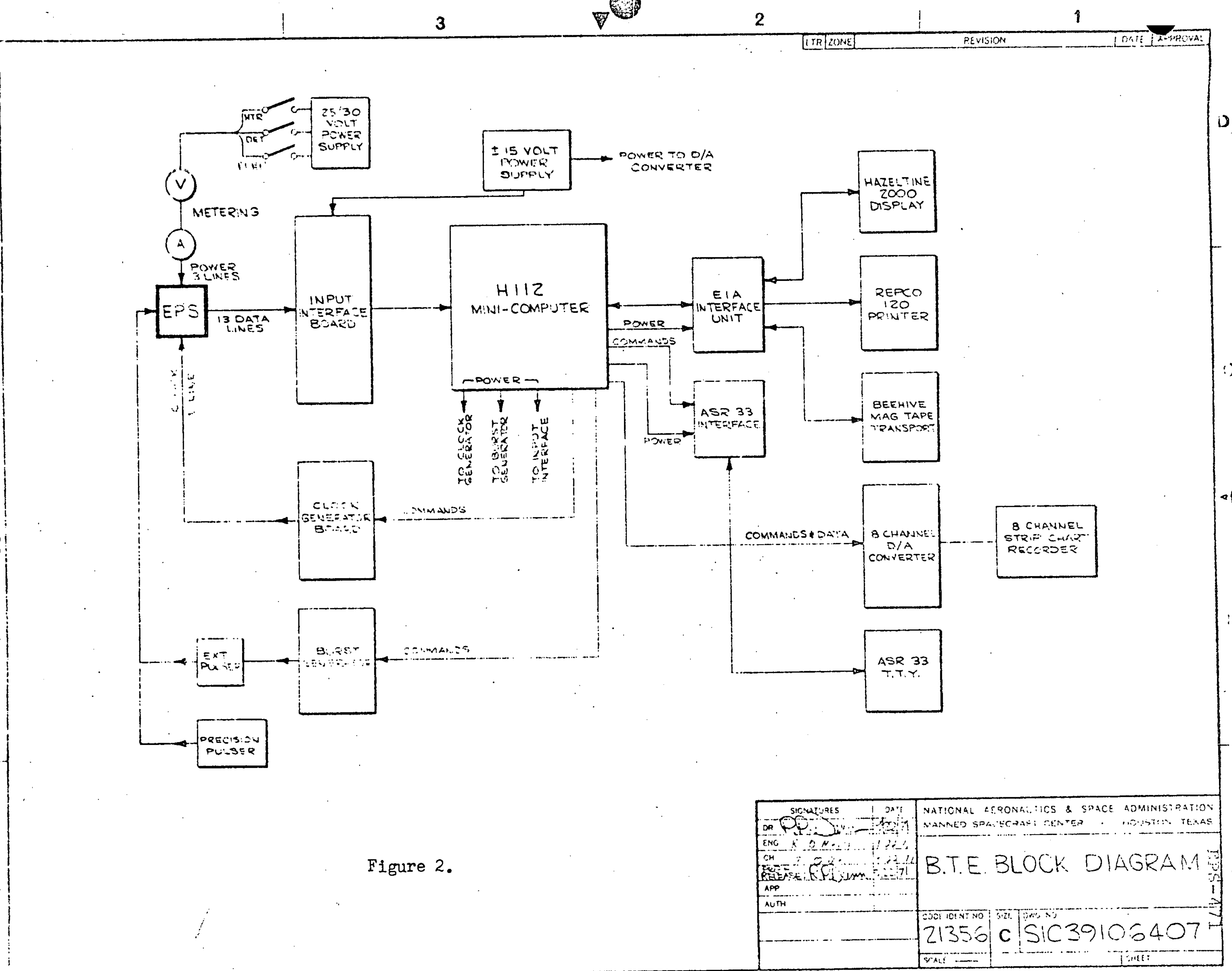


Figure 1 POWER INTERFACE - DME AREA KSC


25/30 VOLT POWER SUPPLY
MTR
DET
± 15 VOLT POWER SUPPLY
POWER TO D/A CONVERTER
METERING
POWER 3 LINES
EPS
13 DATA LINES
INPUT INTERFACE BOARD
H112 MINI-COMPUTER
POWER
TO CLOCK GENERATOR
TO BURST GENERATOR
TO INPUT INTERFACE
EIA INTERFACE UNIT
POWER
COMMANDS
ASR 33 INTERFACE
POWER
HAZELTINE 2000 DISPLAY
REPCO 120 PRINTER
BEEHIVE MAG TAPE TRANSPORT
COMMANDS & DATA
8 CHANNEL D/A CONVERTER
8 CHANNEL STRIP CHART RECORDER
ASR 33 T.T.Y.
COMMANDS
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NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER · HOUSTON, TEXAS
B.T.E. BLOCK DIAGRAM
CODE IDENT NO 21356
SIZE C
DWG NO SIC39106407
SCALE
SHEET
EPS-471

Figure 2.

ELECTRON-PROTON SPECTROMETER
SPARES REQUIREMENTS

LEC Document Number EPS-472

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SPARES REQUIREMENTS

1.0 SCOPE

This document defines the spares requirements of the EPS.

2.0 REQUIREMENTS

The spares furnished with the Flight units, and Flight backup unit are as follows:

a. One Preamplifier Subassembly SEC39107185.

b. One Pulse Amplifier Subassembly SEC39107187.

c. One Discriminator Subassembly SEC39106664.

d. One Low Voltage Power Supply Subassembly SEC39106980.

e. One Detector Bias Supply Subassembly SEC39107184.

f. Detectors Assy.

   <u>Quantity</u>

   8 - 1 mm detectors

   16 - 2 mm detectors

g. Heater Control Subassembly SEC39106664.

h. Temp Mon Subassembly SEC39107189.

i. Input Filter Subassembly SEC39107141.

j. Data Processor Modules.

<u>Quantity</u>

1 - Multiplexer Module - SEC39106988.

1 - A/D Converter Module - SEC39107003.

1 - A/D Logic Module - SEC39107006.

1 - Voltage Monitor Module - SEC39106987.

2 - Counter Memory Module - SEC39106995.

1 - Sequencer Module - SEC39106998.

1 - Compressor Module - SEC39107001.

1 - Word Sync Module - SEC39107009.

PART III
INSTRUMENT DESIGN

1. DESIGN REQUIREMENTS

The Electron-Proton Spectrometer (EPS) (Figure 1) will be placed aboard the Skylab in order to provide data from which electron and proton radiation dose can be determined. The EPS has five sensors, each consisting of a shielded silicon detector, as shown in Figure 2, permitting five differential proton channels, one integral proton channel, and four integral electron channels.

Primary dose from high energy charged particles can be calculated utilizing the range energy relation for energy degradation; that is, a charged particle of kinetic energy E will have an energy E' after penetrating a shield with a thickness t. The relation between E and E' is given by

$$R(E') = R(E) - t$$

where R(E) and R(E') are the ranges in the shield material of a particle with kinetic energies E and E', respectively. The energy deposited in a volume at the center point of a spherical shell of thickness t is the dose at that point and is given by

$$D(t) = 1.6 \times 10^{-8} \int_{0}^{\infty} \frac{dF}{dE} \left(\frac{dE}{dx}\right)_{E'} dE'$$

where $\frac{dF}{dE'}$ is the differential flux at that point, $\left(\frac{dE}{dx}\right)_{E'}$ is the stopping power of a particle with energy E' in the element of volume at the center point of the shield.

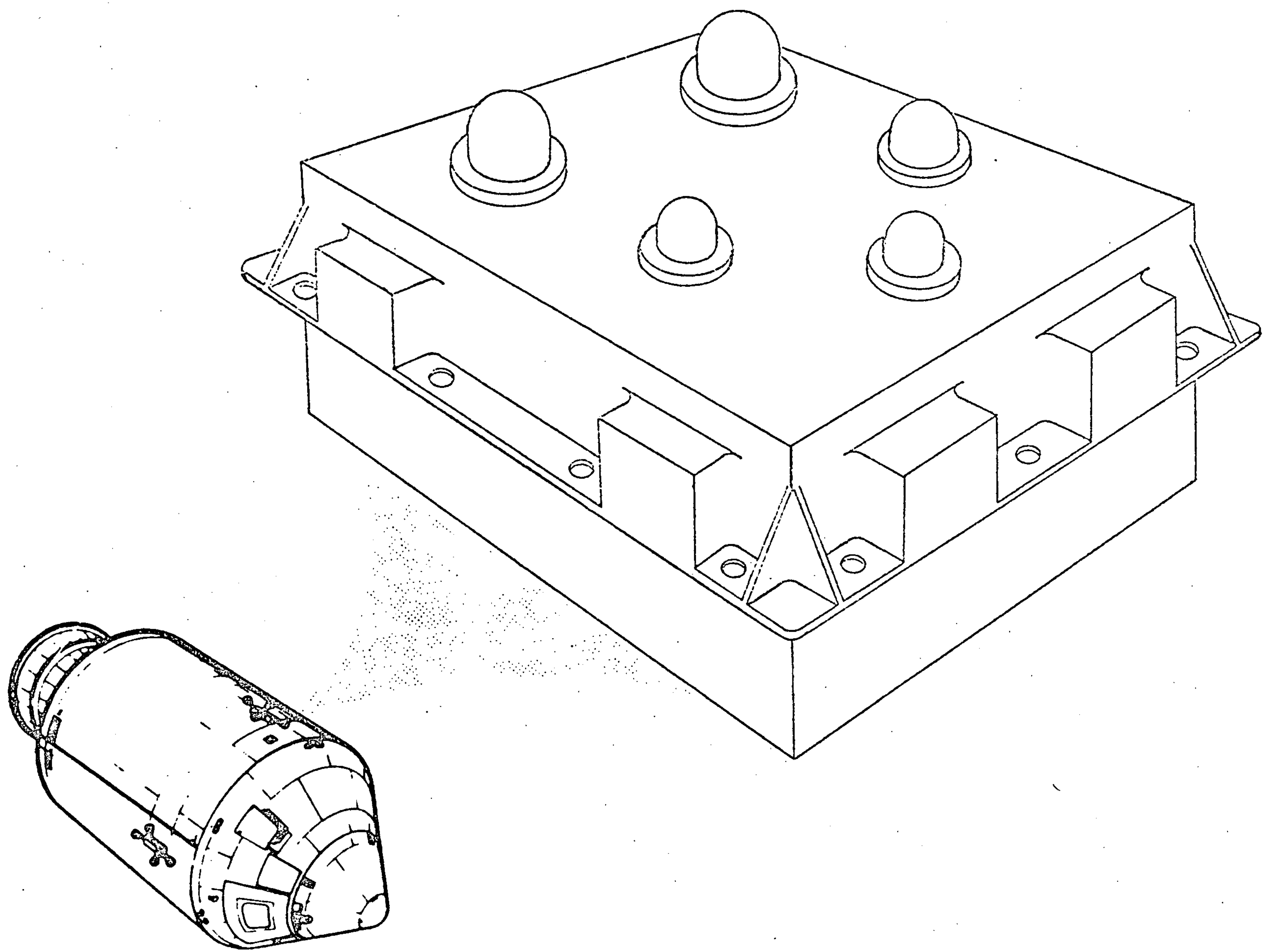


Figure 1. ELECTRON-PROTON SPECTROMETER

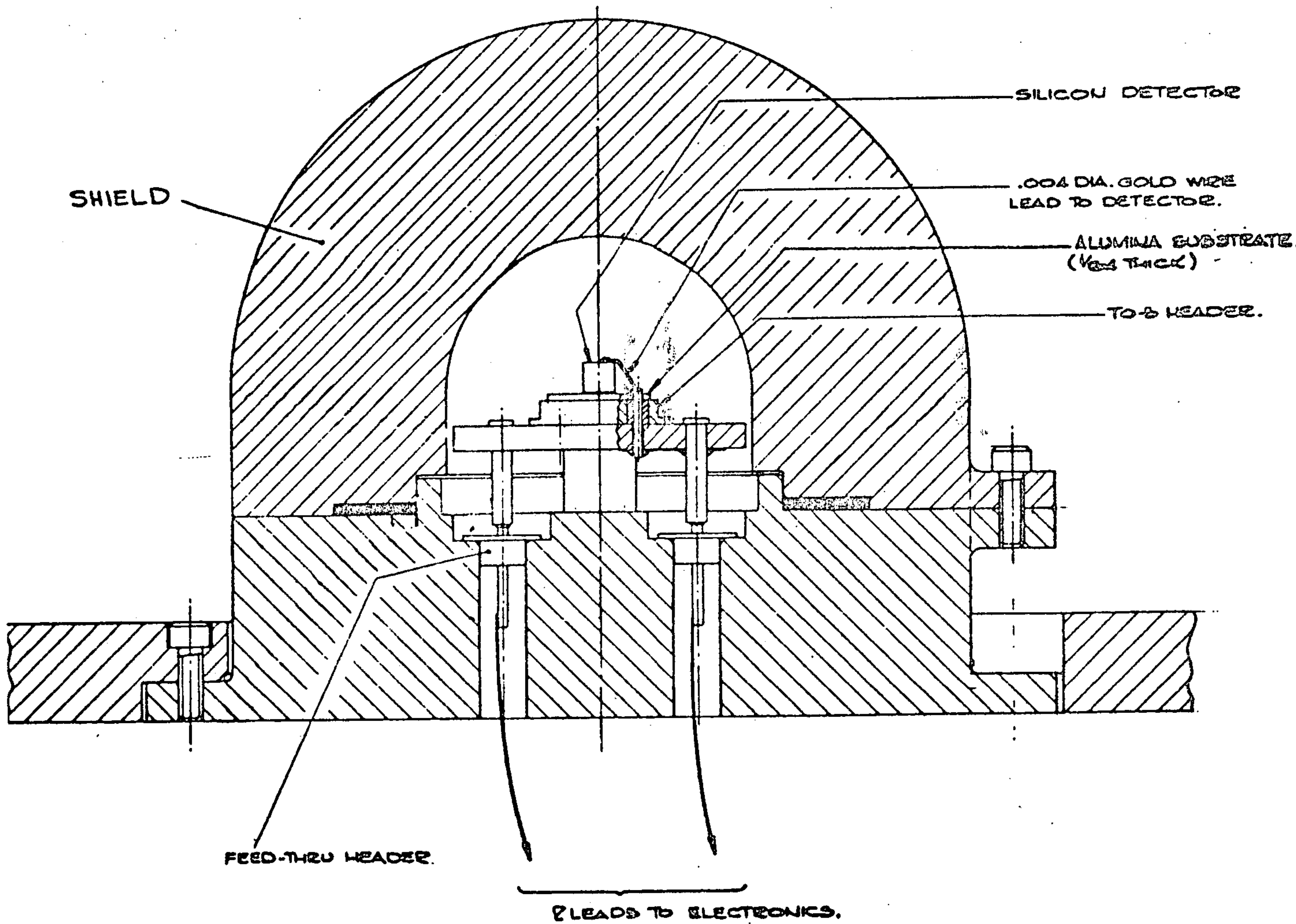


Figure 2. SHIELDED SILICON DETECTOR

All the particles in an energy interval dE about E are degraded to and contained in the energy interval dE' about E', so substituting

$$\frac{dF}{dE} \, dE = \frac{dF}{dE'} \, dE'$$

into the equation for dose gives

$$D(t) = 1.6 \times 10^{-8} \int_{R^{-1}(t)}^{\infty} \frac{dF}{dE} \left(\frac{dE}{dx}\right)_{R^{-1}\left[R\,(E)\,-t\right]} dE$$

where $R^{-1}(t)$ and $R^{-1}[R\,(E)\,-t]$ are inverse ranges corresponding to energies whose ranges are t and R(E) -t, respectively. Hence, it can be seen that determination of the radiation dose inside a shield can be accomplished with knowledge of the shield thickness and the differential spectrum, $\frac{dF}{dE}$, incident on the shield. In the case of the Skylab, the shield thickness comes from the description of the vehicle geometry and the differential spectrum of the incident particulate radiation will be determined by the EPS.

The anticipated differential proton spectrum at an orbit altitude of 235 nautical miles is shown in Figure 3 and can be represented by the sum of two expontials

$$\frac{dF}{dE} = 2.29 \times 10^{6} \, e^{-\frac{E}{4.88}} + 5.33 \times 10^{4} \, e^{-\frac{E}{58.75}}.$$

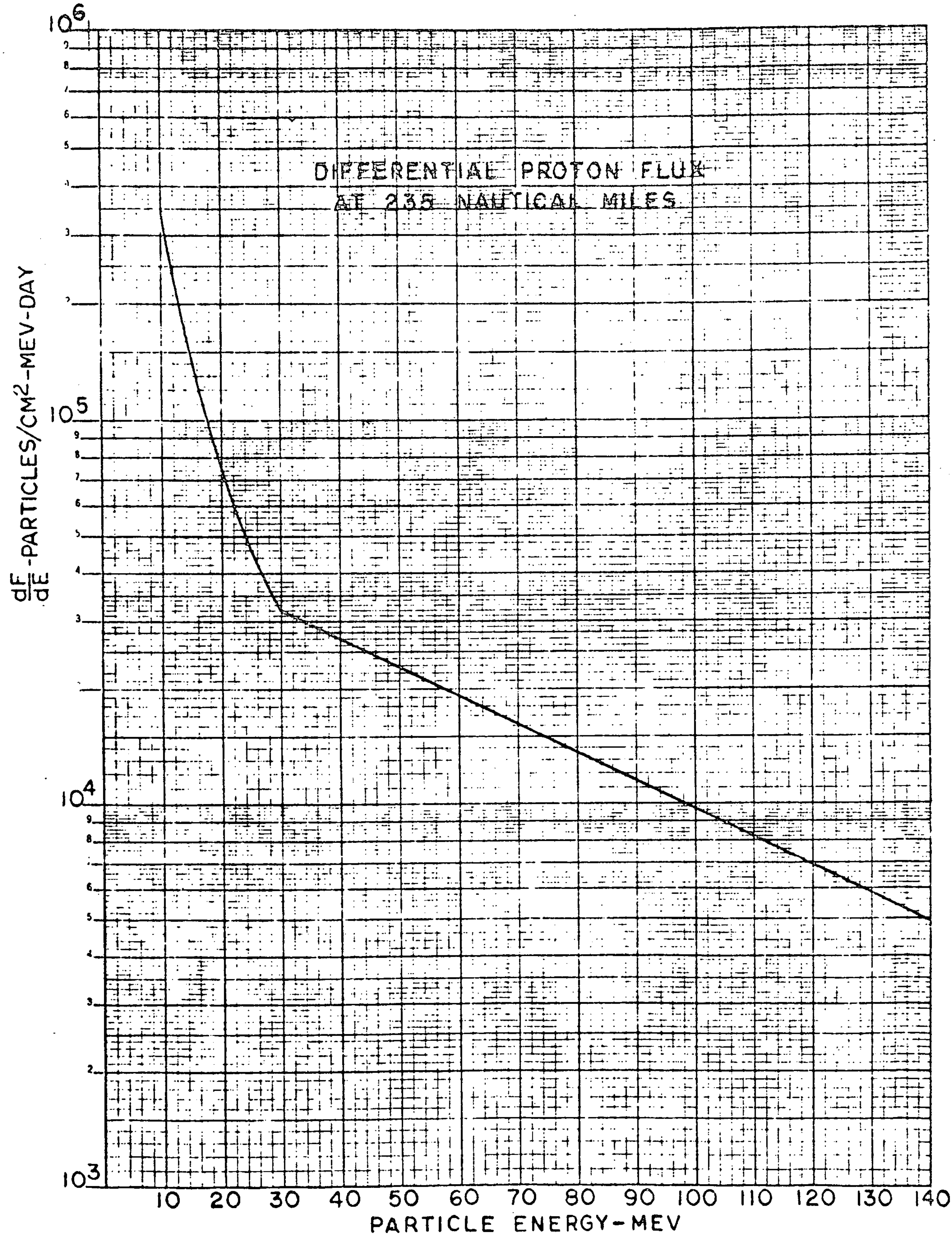


Figure 3. DIFFERENTIAL PROTON FLUX
AT 235 NAUTICAL MILES

The anticipated differential electron spectrum at the orbit altitude of 235 nautical miles is shown in Figure 4. The EPS will be located on the Command-Service Module as shown in Figure 1 so as to permit a view of approximately 2 π steradians.

The sensitive element of the EPS sensor is the silicon detector which consists of a cube of lithium-drifted silicon crystal, as shown in Figure 5. The detector is operated as a reverse-biased diode. The ionization created by the passage of an energetic charged particle through the sensitive volume of the detector is proportional to the energy lost by the particle and when collected and amplified provides a signal which is a measure of the energy deposited in the detector.

The basis for the operation of the EPS can be explained by referring to Figure 6. The curve represents the energy lost by a proton in one millimeter of silicon as a function of proton energy. Since the detectors are assumed to be cubical, the curve would represent the response to protons incident normally to one face. The linear portion of the curve represents the energy deposited by a particle which is stopped in the detector. The nonlinear portion of the curve represents the energy deposited by a particle which penetrates the detector, leaving only a fraction of its total energy. Now since a given energy loss can be achieved by two different proton energies and proton energies between the two give rise to greater energy losses, use of an integral pulse height discriminator will permit detection of those protons whose energies lie between the two limits. As an example, a 5 MeV discriminator will permit detection

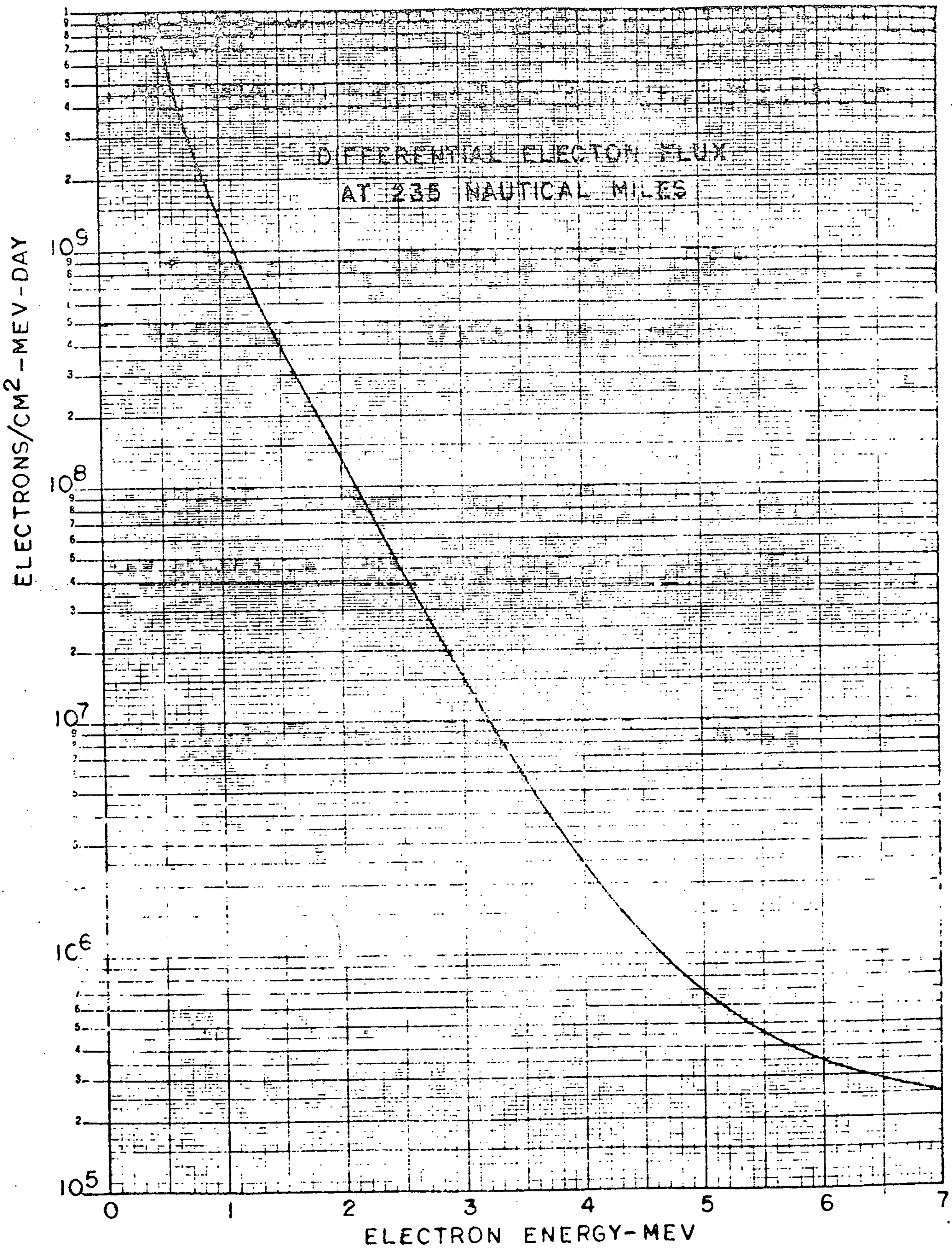


Figure 4. DIFFERENTIAL ELECTRON FLUX
AT 235 NAUTICAL MILES

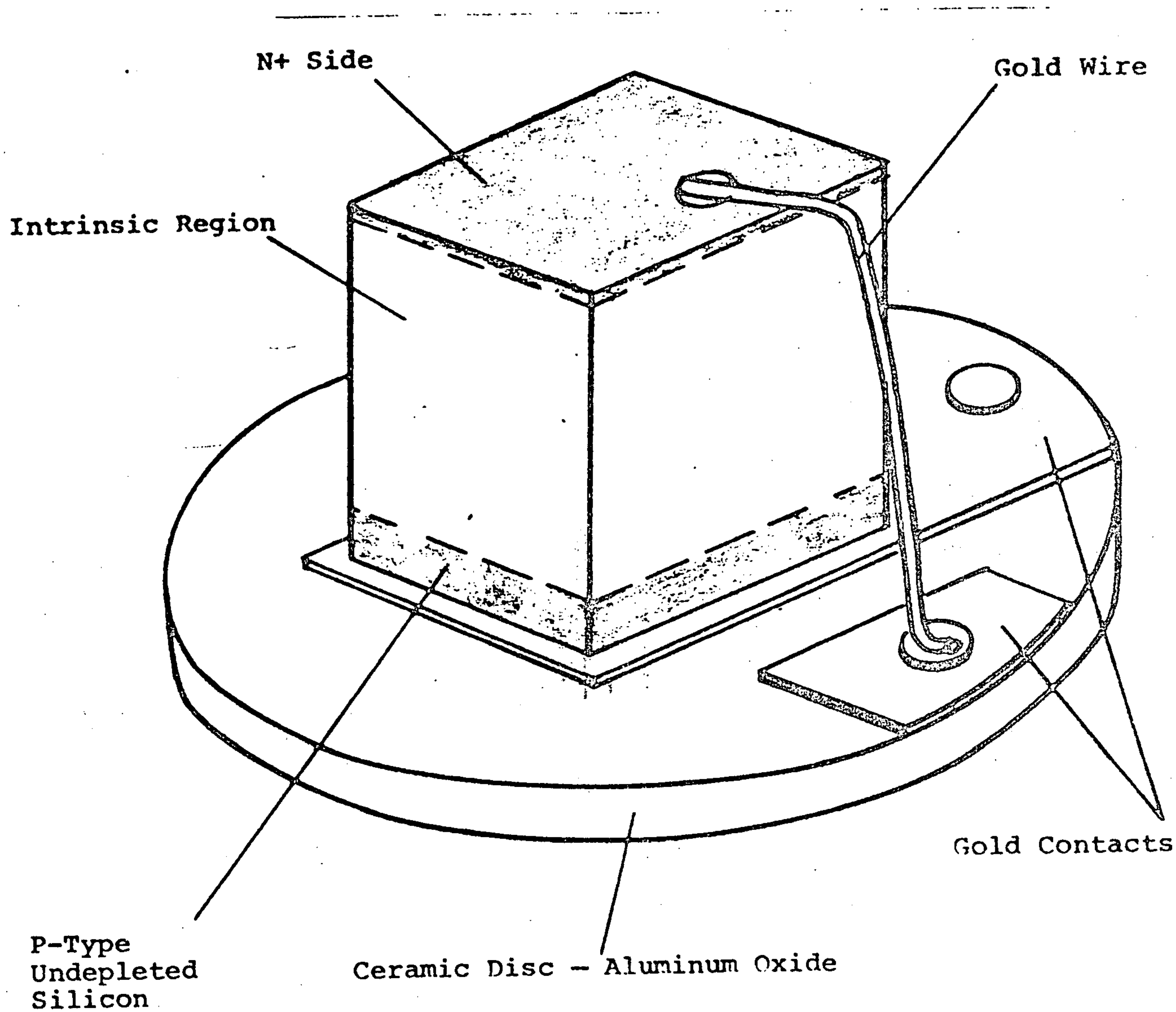


Figure 5. SILICON DETECTOR

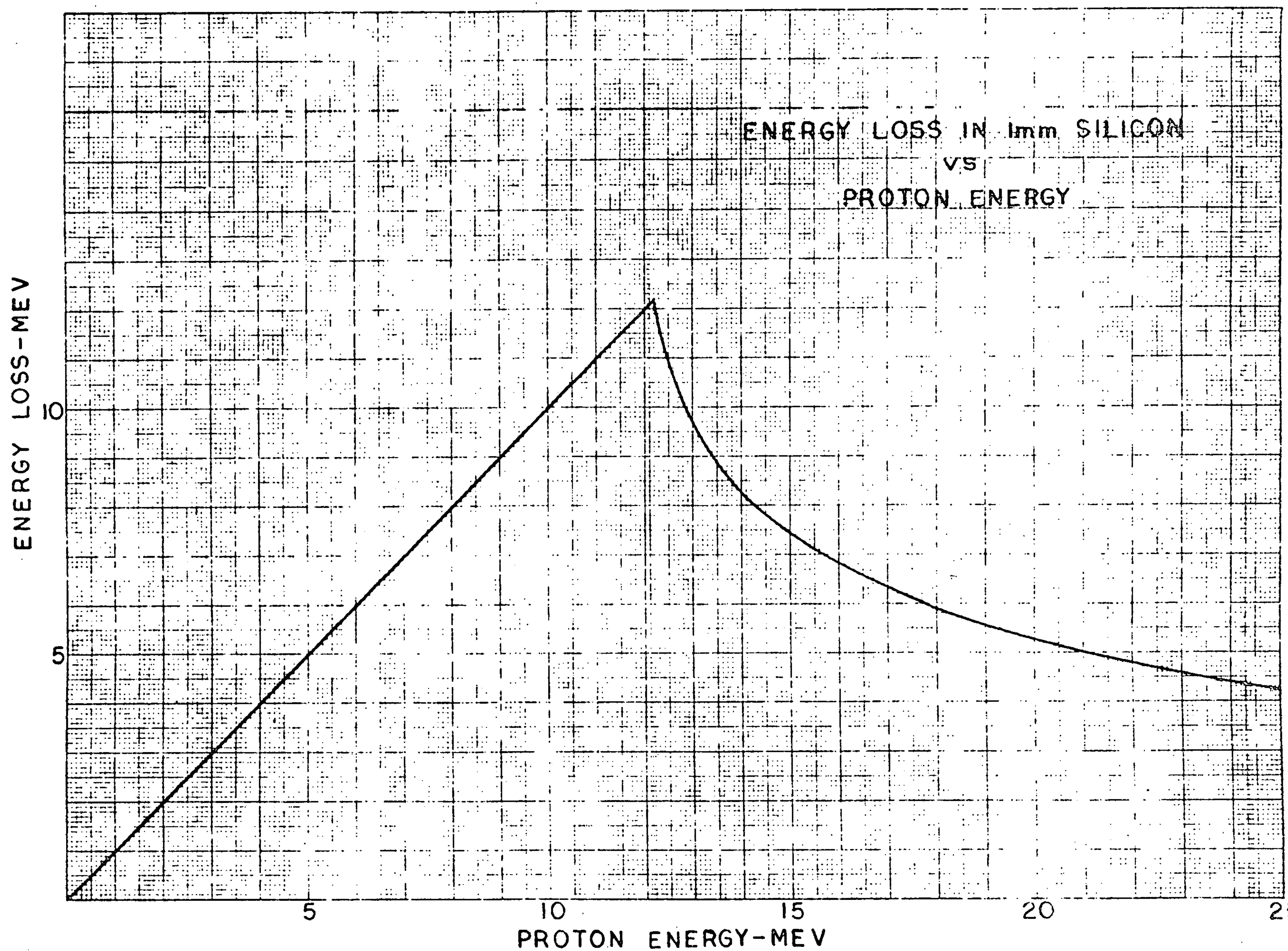


Figure 6. ENERGY LOSS IN 1mm SILICON VS PROTON ENERGY

of protons between 5 MeV and 21 MeV and discrimination against all others. In addition, use of an external shield to degrade the energy of the incident particle allows further control over the location of the energy channel. The energy boundaries of the five EPS detector channels are shown in Table I, along with the required shield thicknesses and discriminator levels.

Detection of electrons in the desired energy range will be accomplished by means of a low level discriminator, 200 - 300 keV, on each of the first four detector channels. By virtue of the low level discrimination the electron measurements will be integral. Separation of the protons and electrons will be accomplished by the fact that no electron can deposit enough energy to be counted in the proton channels. The electron channels must be corrected for the response to protons.

The response of the five differential proton channels to omnidirectional protons has been calculated. The calculation was based on the range energy relation for energy degradation and consisted of determining, as a function of angle, the portion of the detector thick enough to provide a pathlength long enough to absorb enough energy to exceed the discriminator level and integrating over 2 π steradians. The calculated response functions are shown in Figures 7 - 11.

A calibration program is planned to provide data needed to confirm the analytic response functions. Since the response function is strongly dependent upon the dimensions of the detector sensitive volumes, the detector thicknesses will

TABLE I

CHANNEL BOUNDARIES AND ENERGY LEVELS

Detector Channel	Detector Size (mm)	Proton Boundaries (MeV)	Shield Thickness (cm)	Disc. Level (MeV)	Electron Threshold Energy
1	1	10 - 20	.037	5.9	0.45
2	2	20 - 40	.180	6.8	1.22
3	2	30 - 50	.406	6.1	2.38
4	2	40 - 80	.710	3.7	3.90
5	2	80 - 120	.890 BR	3.2	
		> 120		~1.0	

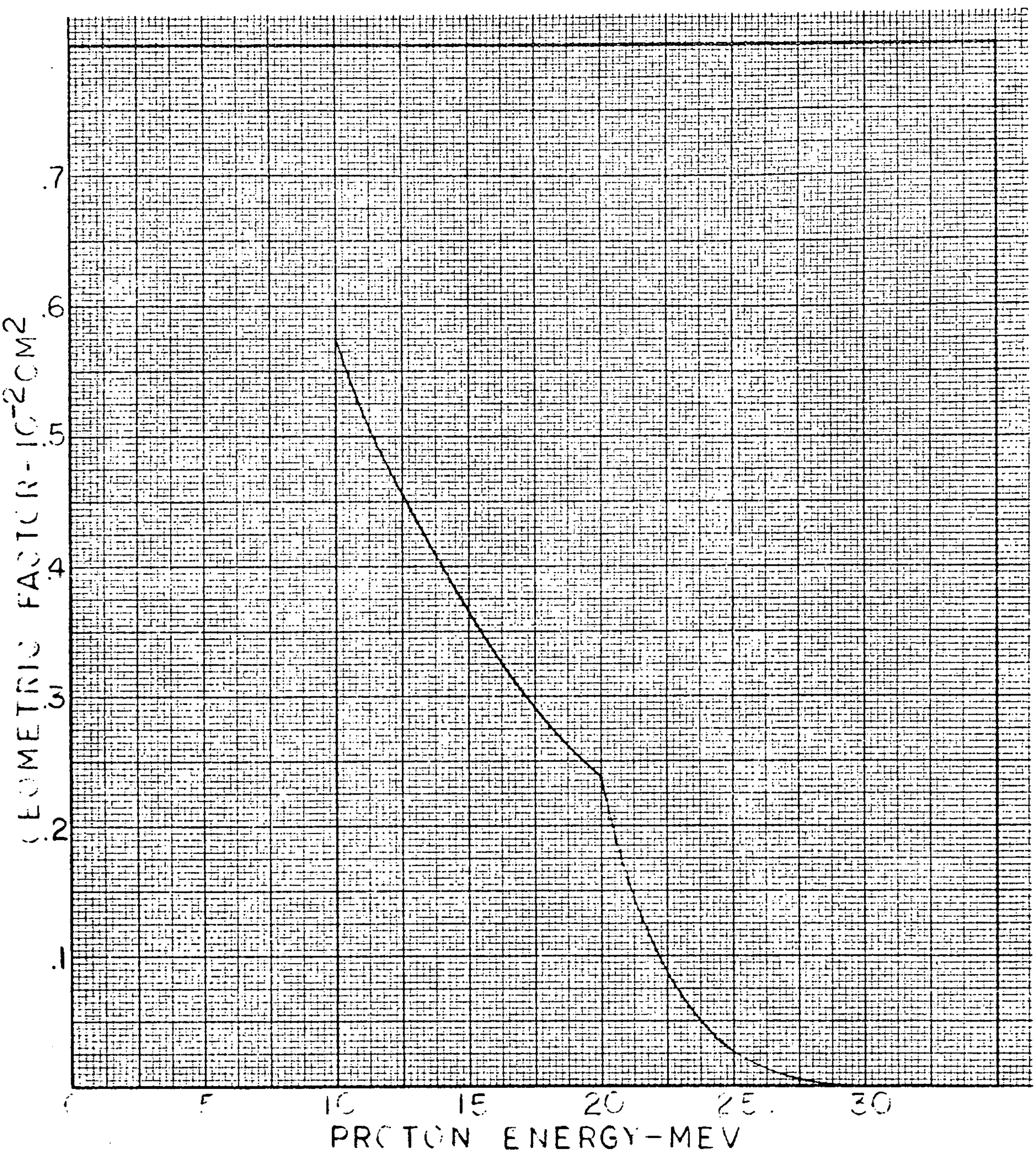


Figure 7. EPS CHANNEL 1 CALCULATED RESPONSE

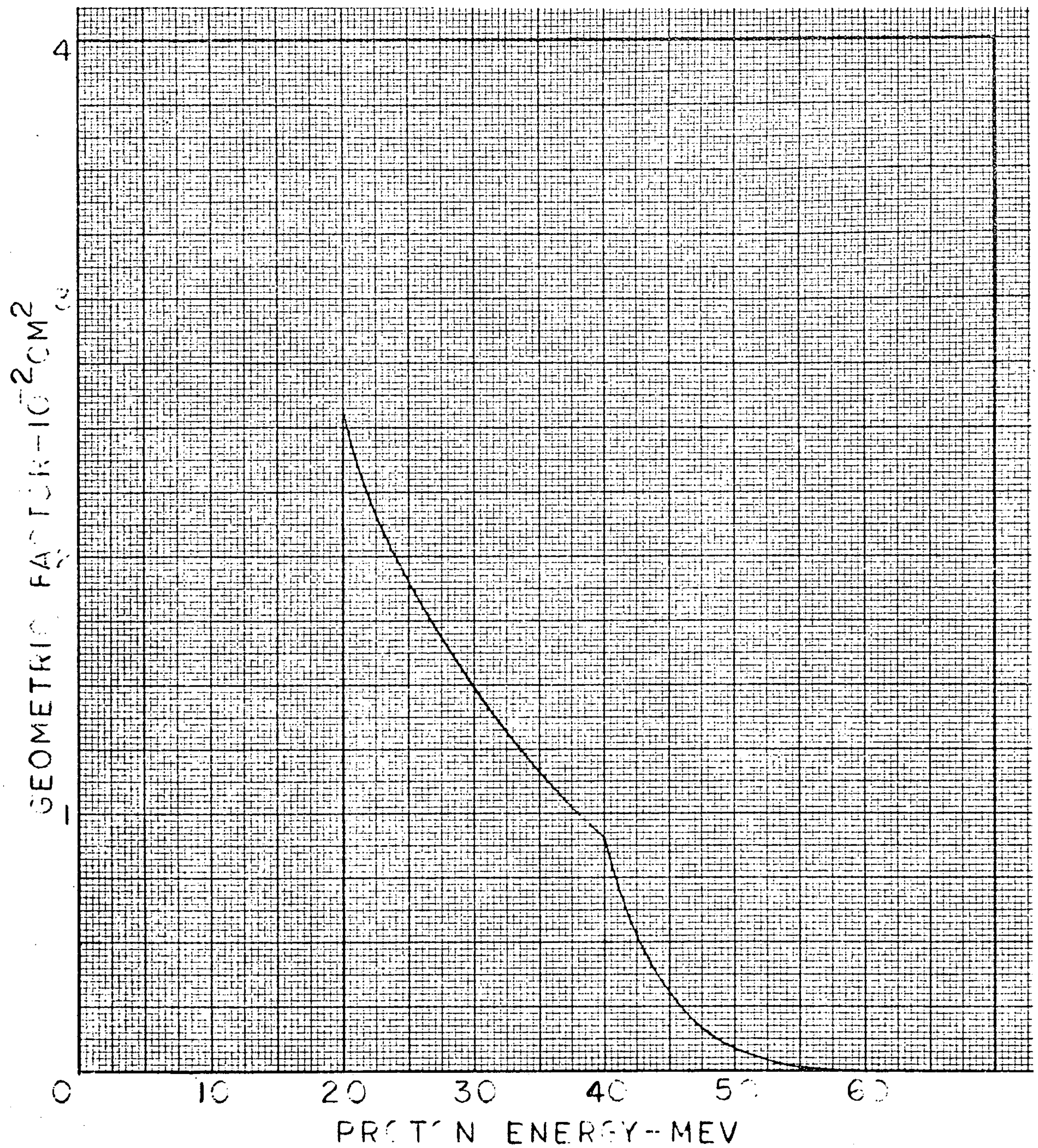


Figure 8. EPS CHANNEL 2 CALCULATED RESPONSE

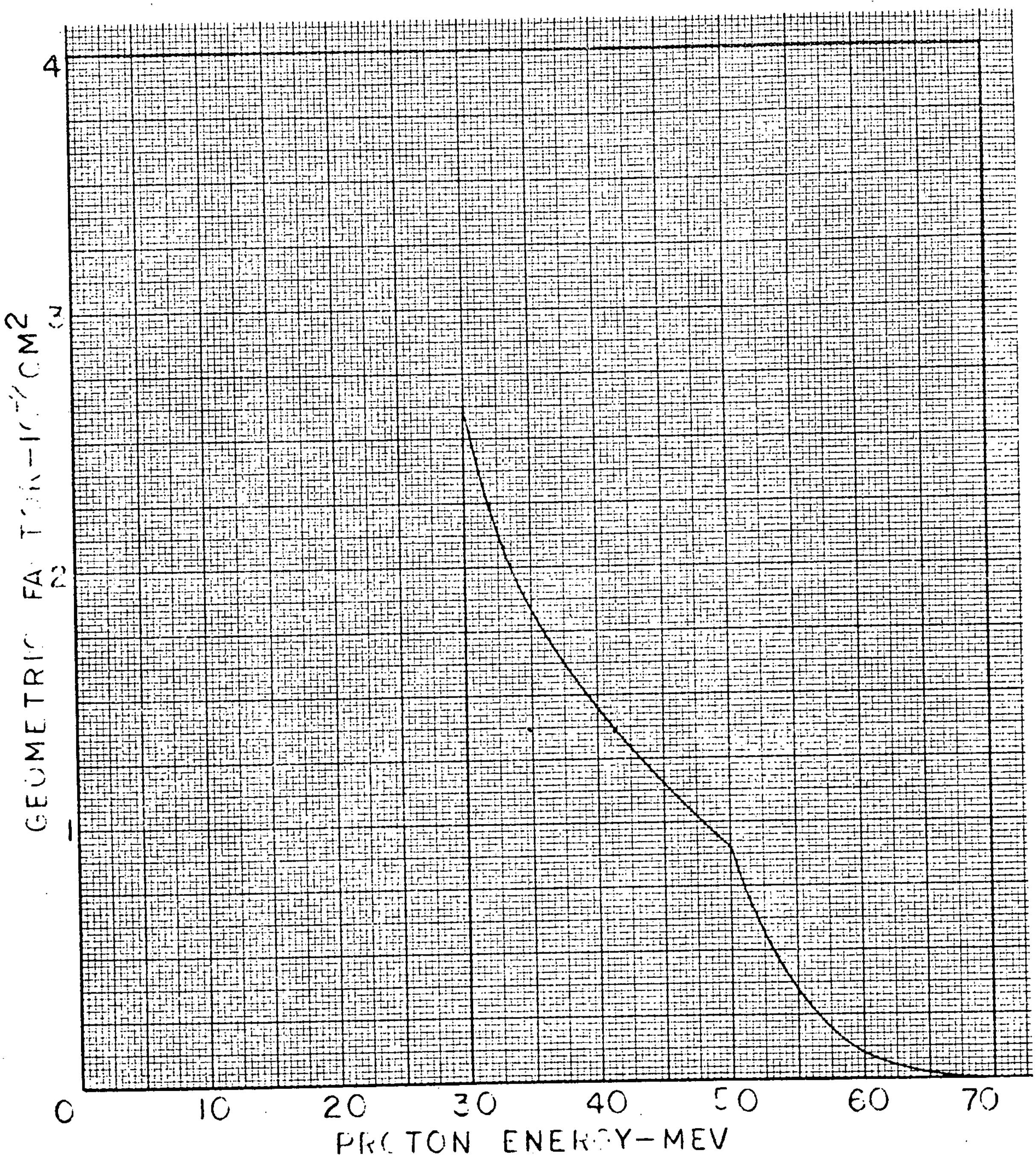


Figure 9. EPS CHANNEL 3 CALCULATED RESPONSE

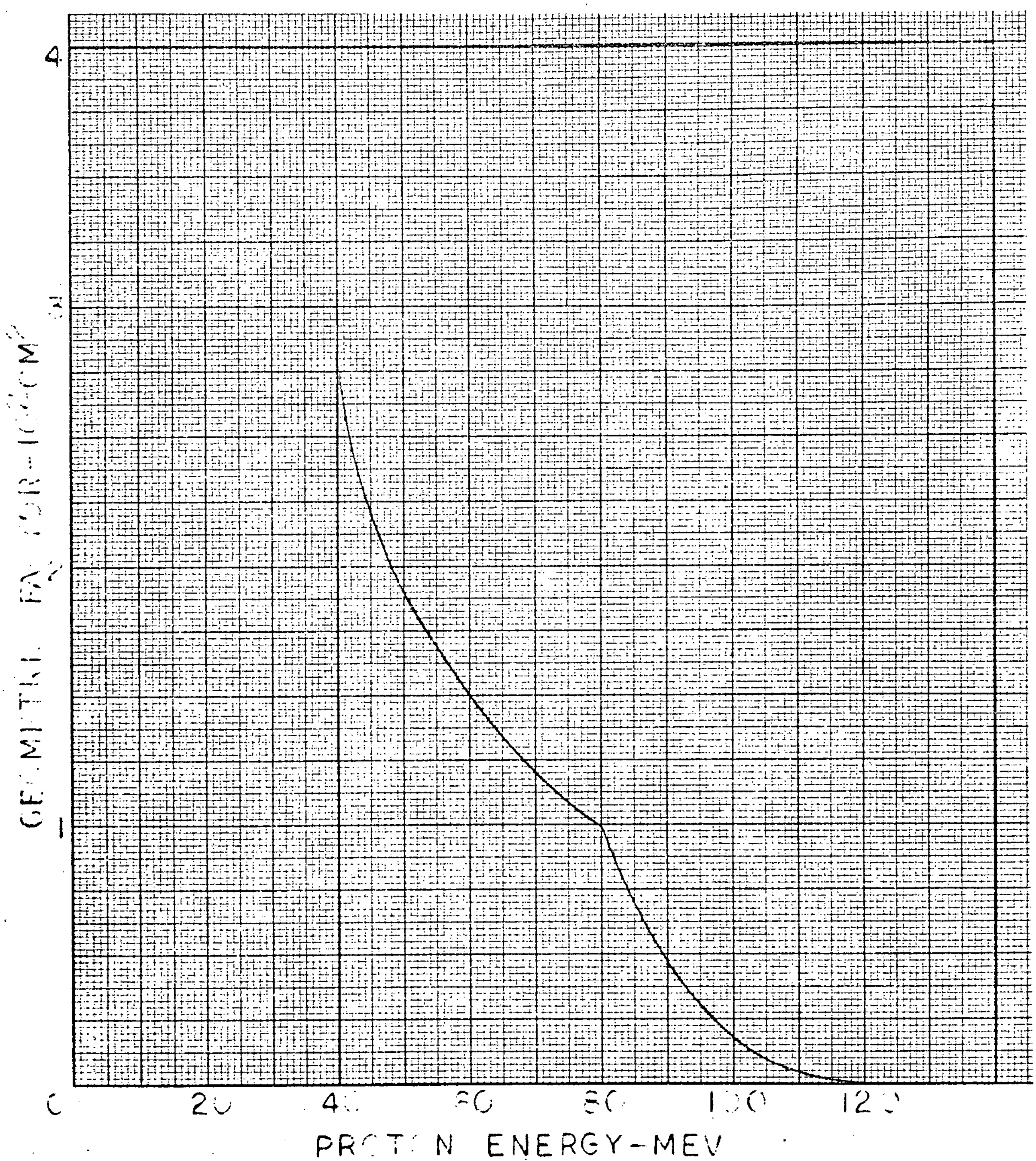


Figure 10. EPS CHANNEL 4 CALCULATED RESPONSE

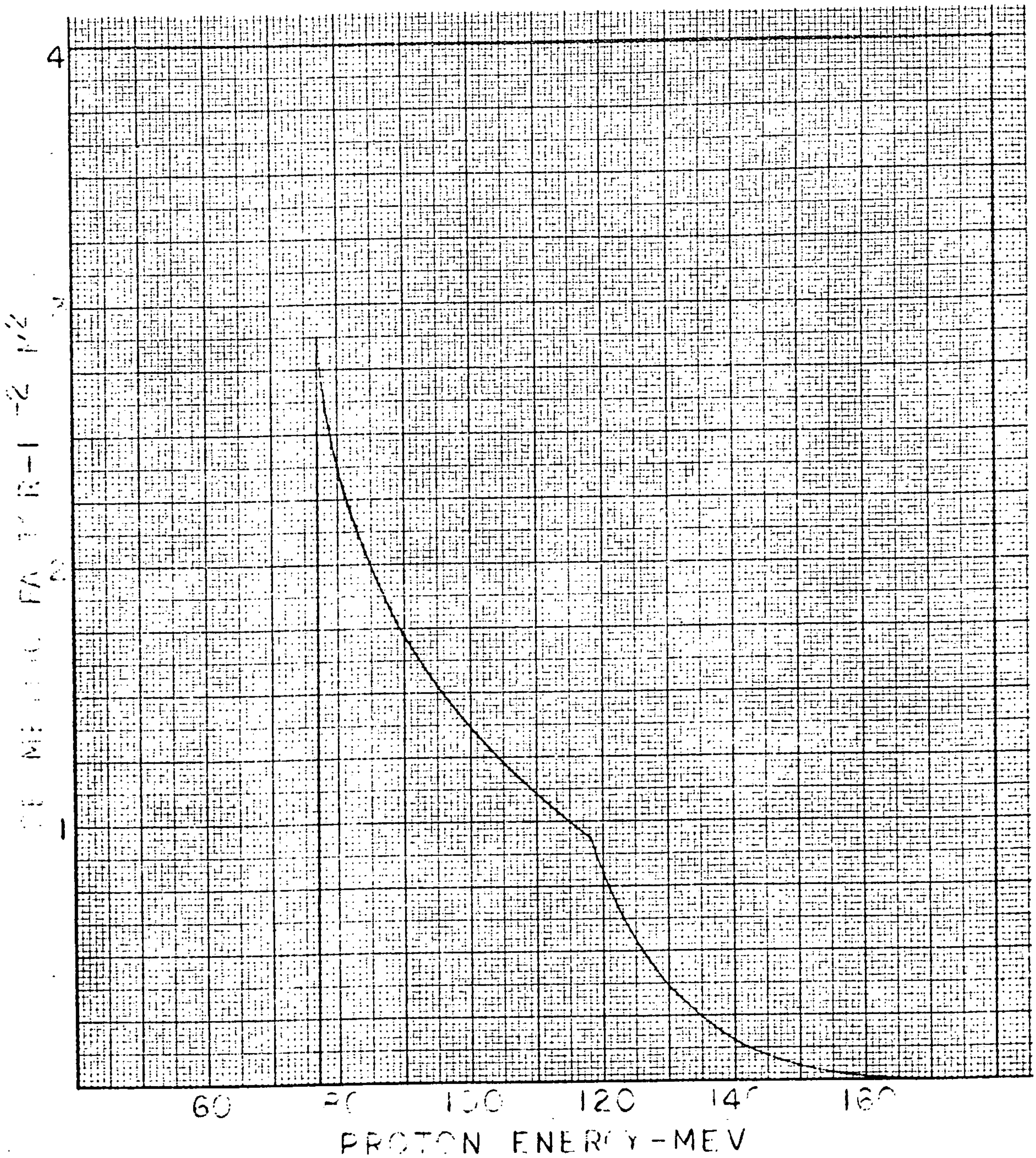


Figure 11. EPS CHANNEL 5 CALCULATED RESPONSE

be measured by means of penetrating protons from a cyclotron. Angular response data will be taken for protons to confirm or correct the analytic response functions. Electron angular response data will be taken in order to generate the electron response functions.

2. SENSOR DESIGN

2.1 DESCRIPTION AND PHYSICS OF DETECTORS

The detectors to be used on the EPS are constructed of lithium drifted silicon. This type of device is fabricated by starting with a moderately pure piece of P-type silicon of resistivity approximately 2500 OHM-CM. Lithium is deposited on one surface of the silicon and then diffused and drifted throughout the volume of silicon at elevated temperatures. The lithium, an N-Type (Donor) material compensates electrically the principal impurity, namely boron (acceptor) resulting in a structure of rather high resistivity.

The detector is operated basically as a reversed biased diode (Fig. 1). An ionizing particle, for example a proton, entering the detector loses energy by ionization in the silicon creating a series of hole-electron pairs along its path. Under the influence of the applied electric field (bias voltage) the holes move toward the negative electrode and the electrons toward the positive side setting up a voltage pulse across a load resistor. This pulse is then amplified and shaped by external circuitry. The number of hole-electron pairs created and hence the pulse output is linearly proportional to the energy lost in the active volume by the incident ionizing particle. In the case where the particle is stopped in the active volume the pulse output is linearly proportional to the incident particle energy. For particles energetic enough to penetrate the detector the pulse output will have a more complex energy dependency but will still be linearly proportional to the energy lost in the detector.

This type of detector has the ability to maintain a constant gain over a wide temperature range. Moreover it operates with a modest bias voltage of a few hundred volts and is relatively insensitive to bias voltage changes.

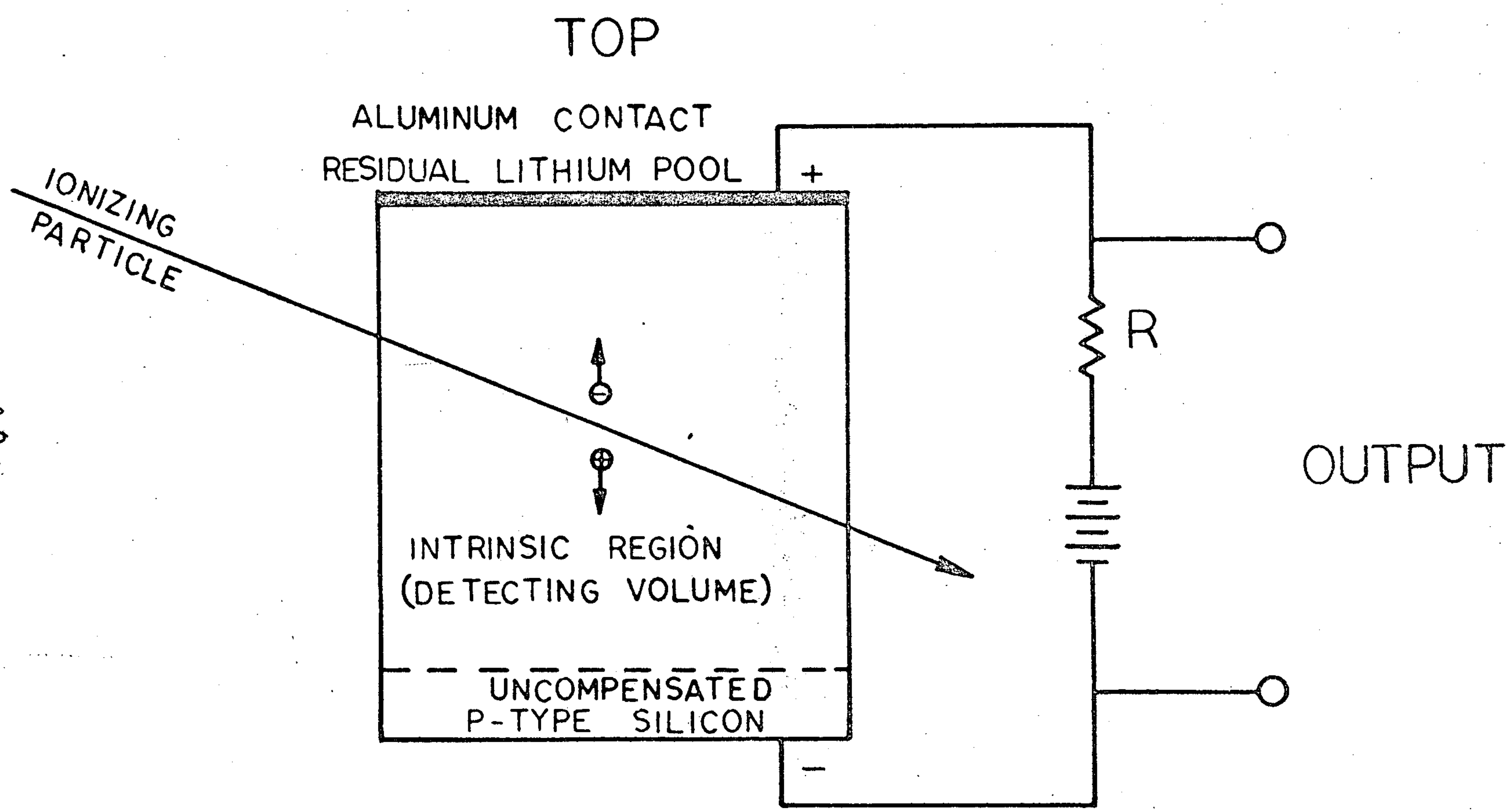


Figure 1 DETECTOR AND EXTERNAL CIRCUIT

2.2 LIMITATIONS OF THE DETECTORS

The EPS requirements of a 2 π steradian acceptance solid angle and omnidirectionality within this angle require a detector of open geometry. Figure 2 shows the geometry of an EPS detector. The silicon is mounted exposed on an aluminum oxide disc which is mounted on a T05 transistor header. Electrical contact is made to the top of the silicon by a fine gold wire bonded with conducting cement. The silicon cube is epoxy bonded to the aluminum oxide disc. The most probably point of mechanical failure, if incurred, would be at the bond between the cube and the disc during temp-cycling and/or vibration. It is intended to temperature cycle and vibration test each detector as part of the acceptance testing.

As in any type of solid state detector the EPS detectors exhibit a standing D.C. leakage current which in turn creates noise in the detector. The leakage current and hence the noise are directly proportional to temperature, although nonlinearly. Detector noise affects instrument operation in two ways: 1) By contributing to the energy resolution and, 2) By contributing false counts. Neither of these are expected, however, to be significant at the anticipated flight temperatures.

Construction of this type geometry detector requires leaving a region of uncompensated P-Type silicon to accomodate the continued drift of the lithium. The lithium drift rate is temperature and bias dependent. At the anticipated flight temperatures, however, the total drift during the mission is expected to be within tolerable limits.

In the EPS detectors particles will enter the five exposed sides of the silicon cube, and in the case of the more energetic particles, will completely penetrate. A knowledge therefore of the active volume of the detector is necessary. Previous measurements have shown that the lateral dimensions can be manufactured rather accurately. The thickness in the direction of the lithium drift, however, will be ascertained for each detector by means of nuclear thickness measurements with a particle accelerator.

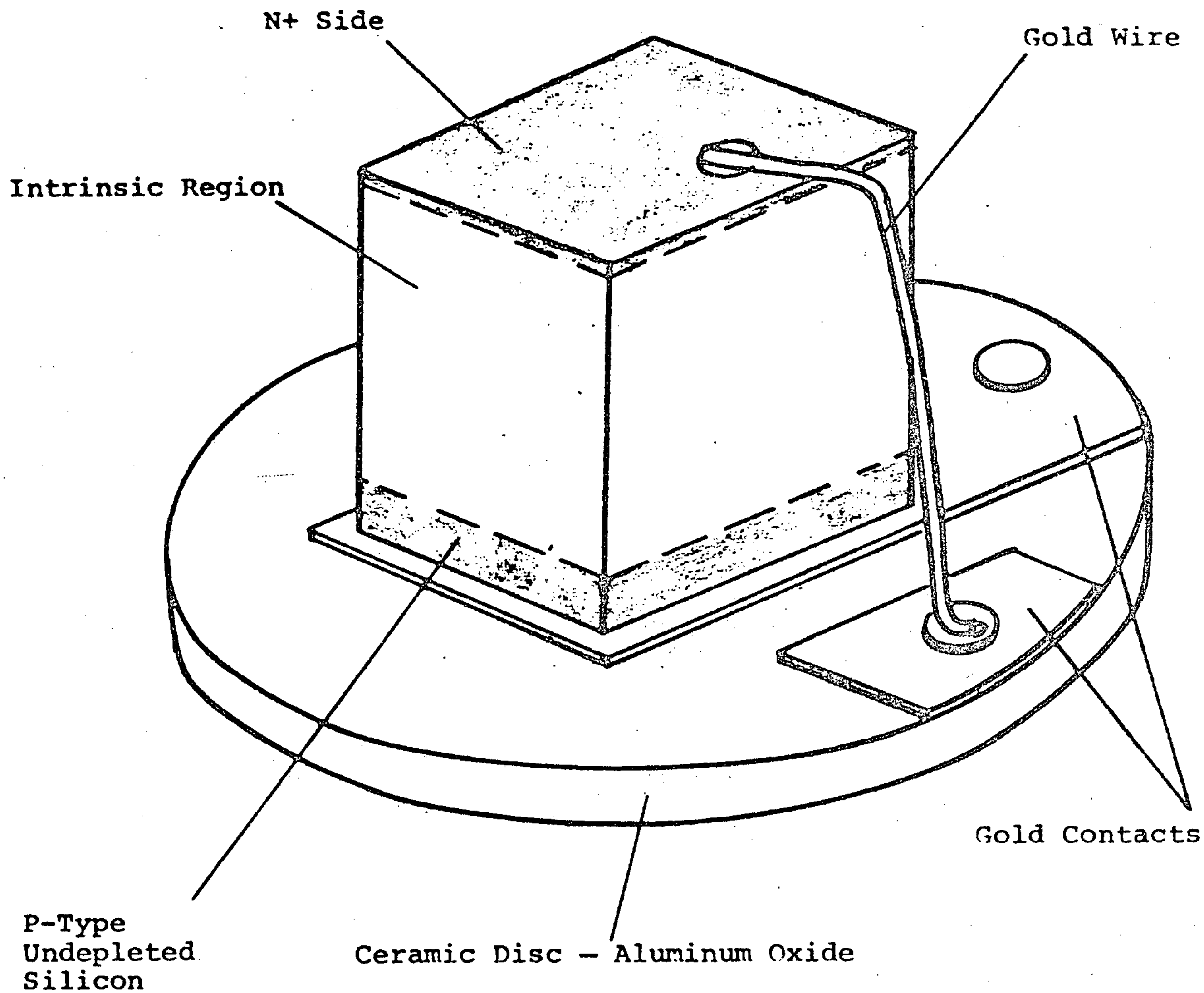


Figure 2 DETECTOR GEOMETRY

3. ELECTRICAL DESIGN

3.1 SYSTEM OPERATION

The EPS electrical package consists of five systems, namely:

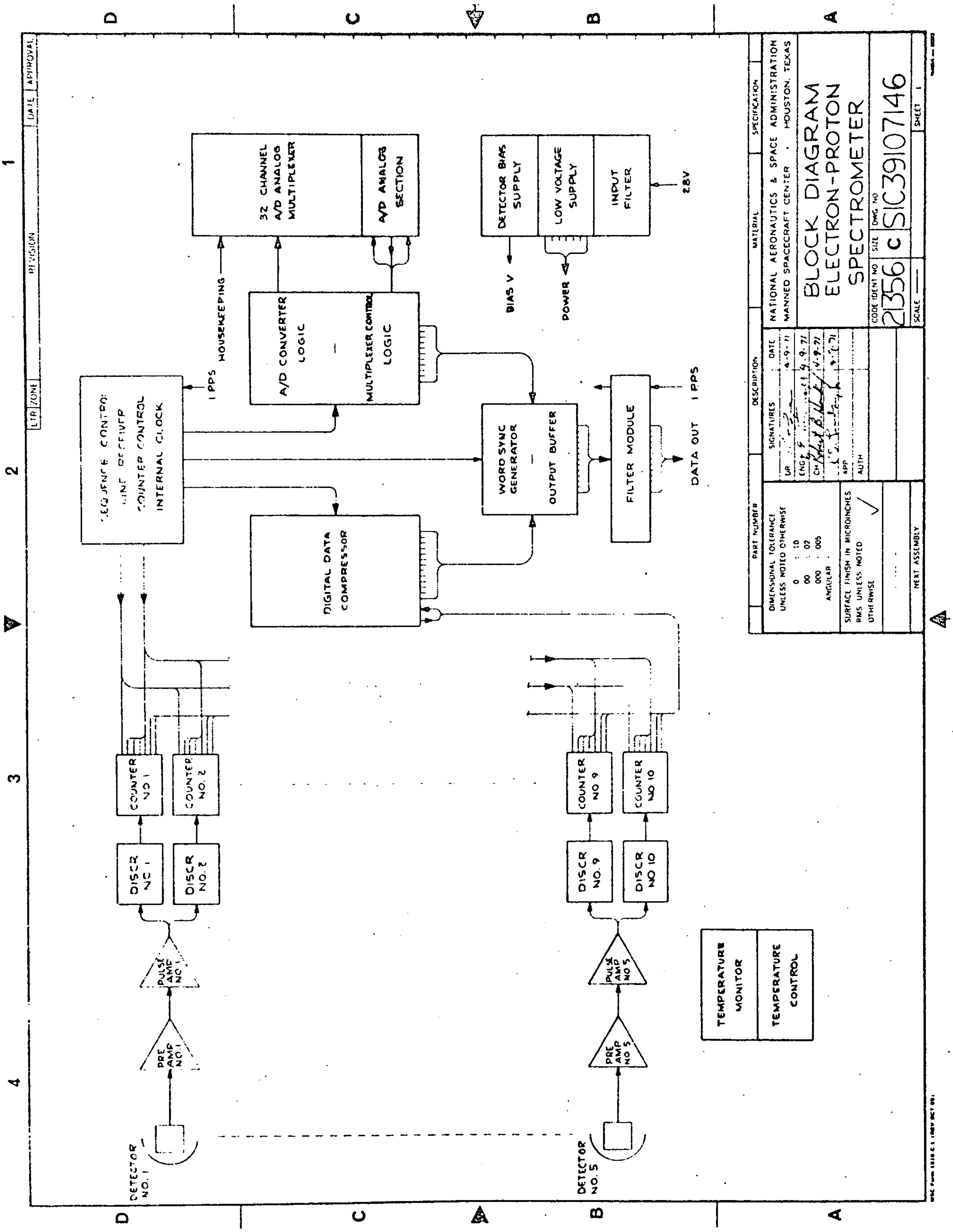
- Scientific Analog System
- Data Processor System
- Housekeeping System
- Power System
- Heater System

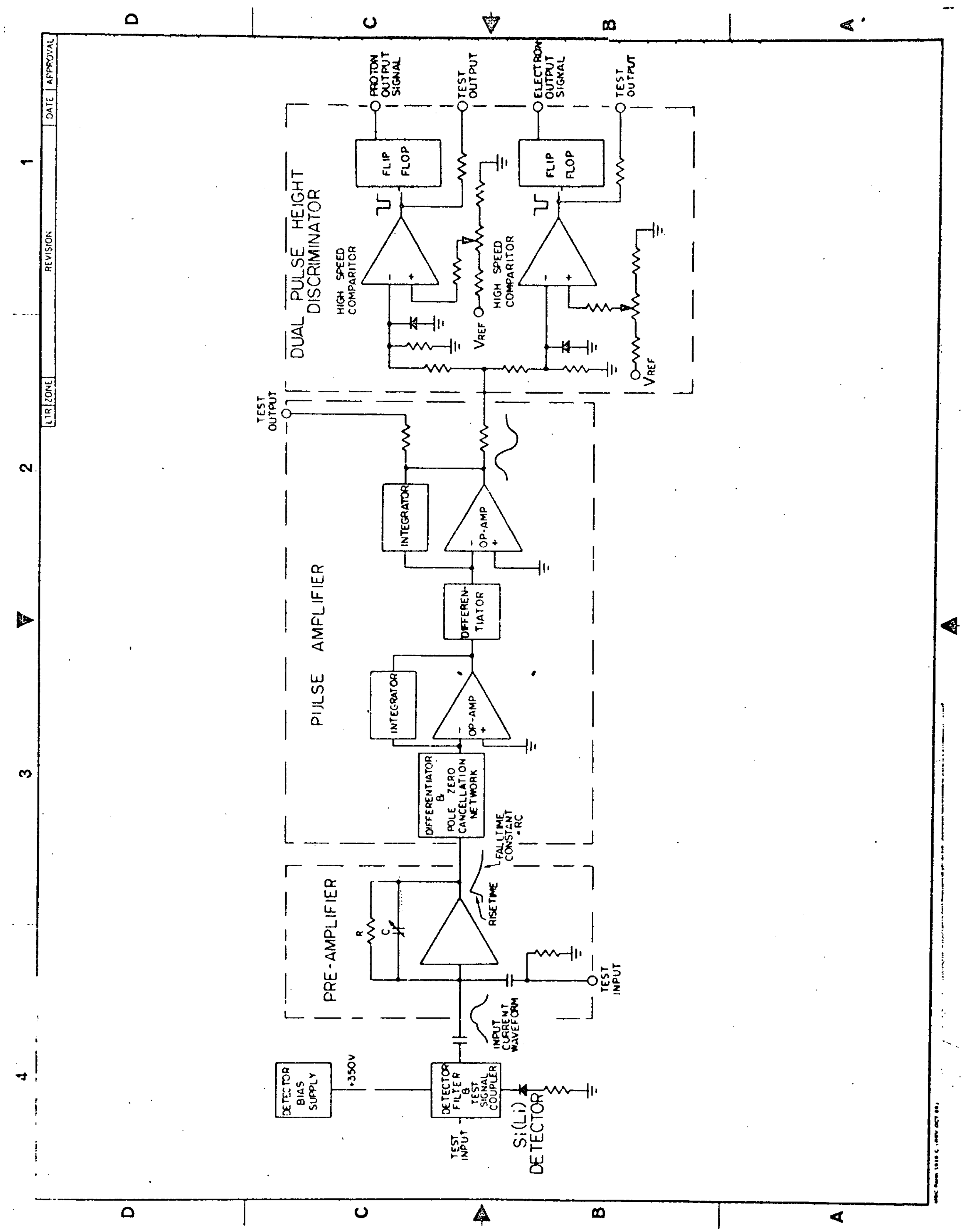
The functional interdependence of these systems is shown in Drawing SIC39107146, Block Diagram Electron-Proton Spectrometer.

The purpose of the Scientific Analog System (see block diagram) is to detect the random occurance of current impulses eminating from EPS detectors, determine if the total impulse charge exceeds a predetermined value, and if so submit an output signal for recording by the Data Processor. There are five scientific channels which are:

- Independent
- Adjustable in counting level to allow use with detectors having variable dimensions
- Capable of single valued counting-rate performance to 10^6 counts per second
- Immune to detector generated noise

Each scientific channel is made up of a preamplifier, a pulse amplifier, and a dual pulse height discriminator.


DETECTOR NO. 1
PRE AMP NO. 1
PULSE AMP NO. 1
DISCR NO. 1
DISCR NO. 2
COUNTER NO. 1
COUNTER NO. 2
DETECTOR NO. 5
PRE AMP NO. 5
PULSE AMP NO. 5
DISCR NO. 9
DISCR NO 10
COUNTER NO 9
COUNTER NO 10
SEQUENCE CONTROL
LINE RECEIVER
COUNTER CONTROL
INTERNAL CLOCK
1 PPS
HOUSEKEEPING
32 CHANNEL A/D ANALOG MULTIPLEXER
A/D ANALOG SECTION
A/D CONVERTER LOGIC
MULTIPLEXER CONTROL LOGIC
DIGITAL DATA COMPRESSOR
WORD SYNC GENERATOR
OUTPUT BUFFER
FILTER MODULE
DATA OUT
1 PPS
DETECTOR BIAS SUPPLY
LOW VOLTAGE SUPPLY
INPUT FILTER
28V
BIAS V
POWER
TEMPERATURE MONITOR
TEMPERATURE CONTROL
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER . HOUSTON, TEXAS
BLOCK DIAGRAM
ELECTRON-PROTON
SPECTROMETER
21356
C
SIC39107146


DUAL PULSE HEIGHT DISCRIMINATOR
HIGH SPEED COMPARITOR
FLIP FLOP
PROTON OUTPUT SIGNAL
ELECTRON OUTPUT SIGNAL
TEST OUTPUT
VREF
PULSE AMPLIFIER
INTEGRATOR
OP-AMP
DIFFEREN-TIATOR
DIFFERENTIATOR & POLE ZERO CANCELLATION NETWORK
FALLTIME CONSTANT =RC
PRE-AMPLIFIER
RISETIME
TEST INPUT
INPUT CURRENT WAVEFORM
DETECTOR BIAS SUPPLY
+350V
DETECTOR FILTER & TEST SIGNAL COUPLER
Si(Li) DETECTOR
LTR ZONE REVISION DATE APPROVAL

The preamplifier converts the detector's current impulse to a slowly decaying step function whose amplitude is proportional to the total charge input. The pulse amplifier filters this step input producing a bipolar waveform at its output. The dual pulse height discriminator compares the bipolar wave form to two reference levels. If the input wave form exceeds either of these two reference levels, a corresponding output pulse is directed to a presealer. The presealer generates an output signal for every other excitation of the discriminator.

The function of the Data Processor is to digitally integrate the prescaler outputs individually and present the information to the spacecraft telemetry system in an acceptable form under control of the spacecraft. This integration provides 12 seconds of counting for every 13 seconds of real time. In addition, the Data Processor accepts analog housekeeping signals, digitizes them sequentially and properly mixes this with the scientific information. The data processor utilizes high reliability, low power TTL logic in its digital section and high reliability low power amplifiers in its analog to digital converter section. The Data Processor consists of the following modules:

Sequence Control, Line Receiver, Counter Control
Counter/Memory Module (10)
Digital Data Compressor and Internal Clock
Analog Digital Converter
A/D Control
Multiplexer Module
Output Buffer and Word Sync Generator

The Housekeeping System provides signals to the Data Processor analog to digital converter that yield information concerning the operational status of all important EPS parameters. Those functions monitored include:

detector leakage currents
detector resolutions
electronic package temperature
detector plate temperature
power supply levels
heater status

A time of 208 seconds is required to transmit a complete cycle of housekeeping information. Ground based analysis of this data allows proper manual control of EPS mode of operation.

The EPS Power System accepts spacecraft power and converts it to levels required by the EPS. Major subsystems are the Low Voltage Converter and the Detector Bias Supply.

The Heater System functions in a temperature control capacity. An internal temperature sensor is continually monitored by control circuitry. If the package temperature drops below 0°C, six watts of power is dissipated in the inner housing structure by skin heaters. When the temperature rises above 10°C, the six watts of power is removed.

3.2 SCIENTIFIC ANALOG SYSTEM

3.2.1 PREAMPLIFIER

The EPS preamplifier (Schematic SIC39106631) was designed to provide amplification of signals from semiconductor detectors which were exposed to electron and proton radiation in the energy range between a few keV and several MeV.

The preamplifier was implemented using a charge sensitive configuration whereby an impulse of current produced by energy deposition in the detector is transformed into a fast rising and slow decaying (practically a step function) voltage signal at the output of the preamplifier where the peak of this voltage is directly proportional to the amount of energy deposited in the detector.

The charge sensitive preamplifier (see block diagram) is basically an operational amplifier with the loop closed through the charge coupling capacitor (Cf) and provides good gain stability, linearity, and a fast rise time.

Upon absorbing some amount of energy the detector gives off an impulse of current containing a charge Q.

The time domain output voltage is given by:

$$Vo(t) = \frac{Q}{Cf} e^{-\frac{1}{RfCf} t}$$

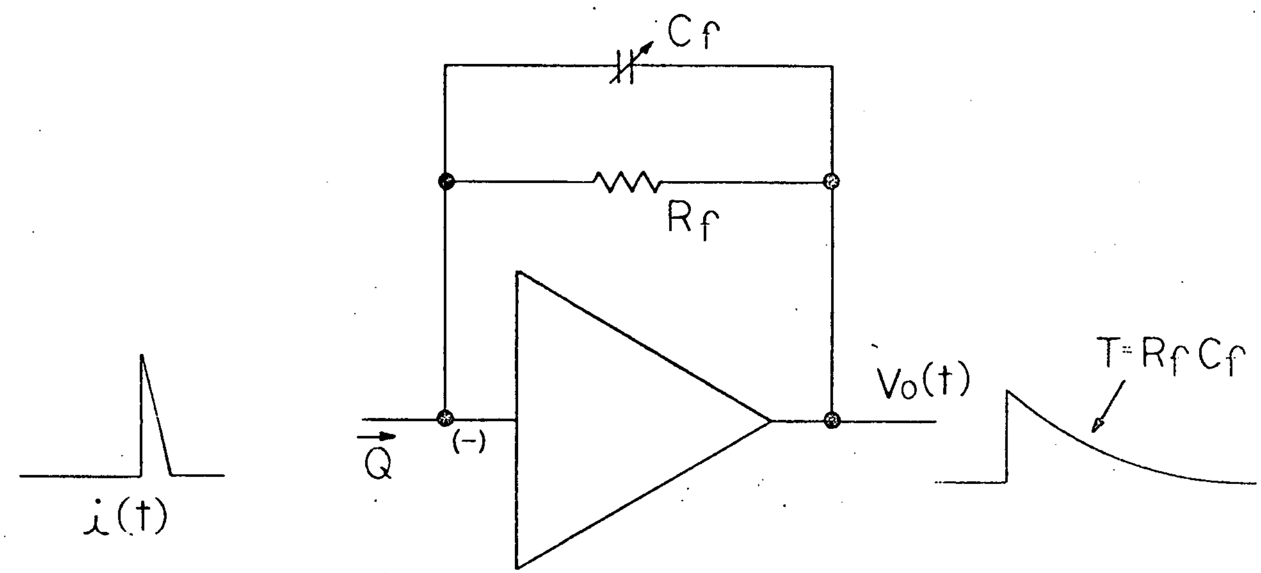
which shows that for very short times the exponential term will approach 1 and the output voltage be directly proportional to the input charge. The feedback capacitor serves as the constant of proportionality.

In the EPS preamplifier, Cf was made variable so as to provide a means of adjusting the charge conversion gain. To optimize the performance of the EPS preamplifier, a low noise, high transconductance FET (Q_1) is used as the input stage.

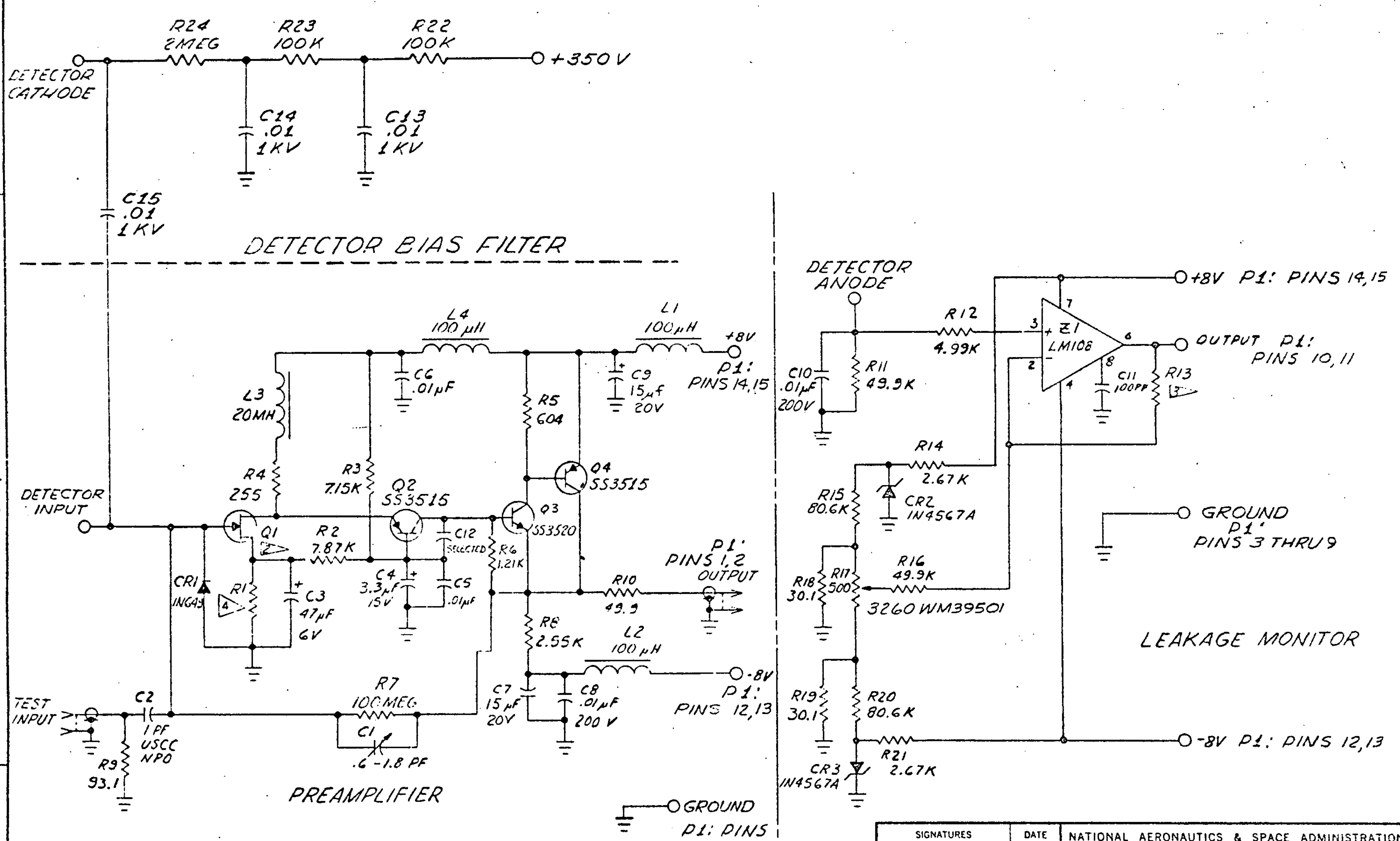
The detector and the detector bias filter are ac coupled to the FET's gate electrode.

The preamplifier was designed to operate from a dual power source, therefore, it is possible to dc couple the output to the pulse amplifier, thus improving the system's high count rate capabilities.

Overall power consumption of the preamplifier is low (144 mw) and the performance meet all the EPS specifications.



PREAMPLIFIER BLOCK DIAGRAM



NOTES: UNLESS OTHERWISE SPECIFIED.

1. INTERPRET PER MSC MANUAL MSCM8500.
2. Q1 SELECTED SSC6113
3. FOR 1µA INPUT R13 = 5.0 MEG. FOR 2µA INPUT R13 = 2.5 MEG. CADDOCK MK-132
4. SELECTED, DEPENDENT UPON Q1.
5. ALL RESISTORS ARE RNC50 EXCEPT FOR R4 AND R8, RNC55.

SIGNATURES	DATE
DR [signature]	3-22-71
ENG W.A.O.	5/25/71
CH [signature]	5-25-71
[signature]	7-21-71
APPR RELEASE RPD	8/13/71
AUTH	

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER · HOUSTON, TEXAS

SCHEMATIC, PREAMPLIFIER & DETECTOR LEAKAGE MONITOR

ELECTRON-PROTON SPECTROMETER

CODE IDENT NO.	SIZE	DWG NO.
21356	C	SIC 39106631

ELECTRON-PROTON SPECTROMETER

LTR | ZONE | REVISION | DATE | APPROVAL

EPS-186
Revised 9-22-71

EPS PREAMPLIFIER
SPECIFICATION

1. Preamplifier Conversion Gain: 29 ... .5 mV/Mev.

2. Output Rise Time vs Input Capacitance

0 pf	20 pf	68 pf
20 nsec	30 nsec	70 nsec

3. Output Amplitude vs Input Capacitance

0 pf	20 pf	88 pf	715 pf
100 ± 3%	100 ± 3%	100 ± 3%	98 ± 3%

4. Output Pulse Amplitude vs Power Supply Change:

+7 volts	+8 volts	+9 volts	+8 volts	+8 volts
-8 volts	-8 volts	-8 volts	-7 volts	-9 volts
100 ± 3%	100 ± 3%	100 ± 3%	100 ± 3%	100 ± 3%

5. Input Resolution vs Input Capacitance: See Figure #1.

6. Input Resolution vs Temperature: See Table #1, Fig. 2, Fig. 3.

7. Output dc Offset Voltage: 100 mV < Vdc < 300 mV

8. Output Pulse Decay Time Constant:

$R_f \times C_f = 150$ μsec.

9. PHA Peak Channel Number vs Preamplifier Input Capacitance:

.022%/pf
see Figure #4.

10. Output Resistance: 49.9 Ω

11. Power Dissipation:

+8 volts at 14 mA.
-8 volts at 4 mA.
$P_{TOTAL} = 144$ mw

EPS PREAMPLIFIER SPECIFICATION

Table 1

Preamp Resolution as a Function of Temp.

Temp.	Ch. #	Resol.	RMS mV	Res. VDC
-35°C	882	5.3 Kev	.88	.015 V
-20°C	880	5.65 Kev	.925	.022
0°C	878	6.0 Kev	1.00	.044
20°C	886	6.5 Kev	1.07	.086
35°C	900	6.66 Kev	1.15	.144
50°C	927	7.4 Kev	1.23	.213
57°C	939	7.6 Kev	1.27	.252

C_{IN} = 0 pf and 2N3251A for Q2 and Q4

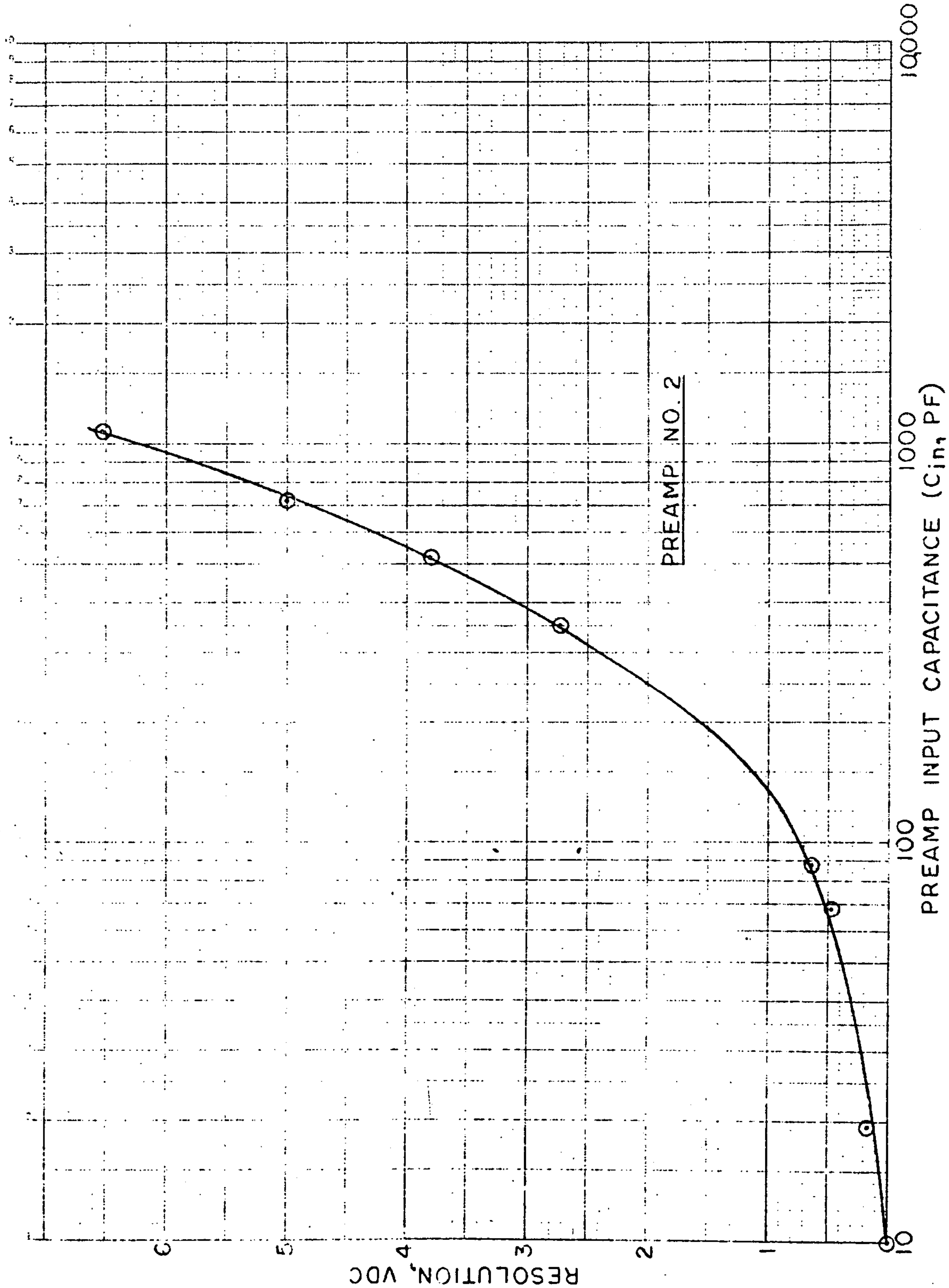


Figure 1 RESOLUTION Vdc VERSUS PREAMPLIFIER INPUT CAPACITY

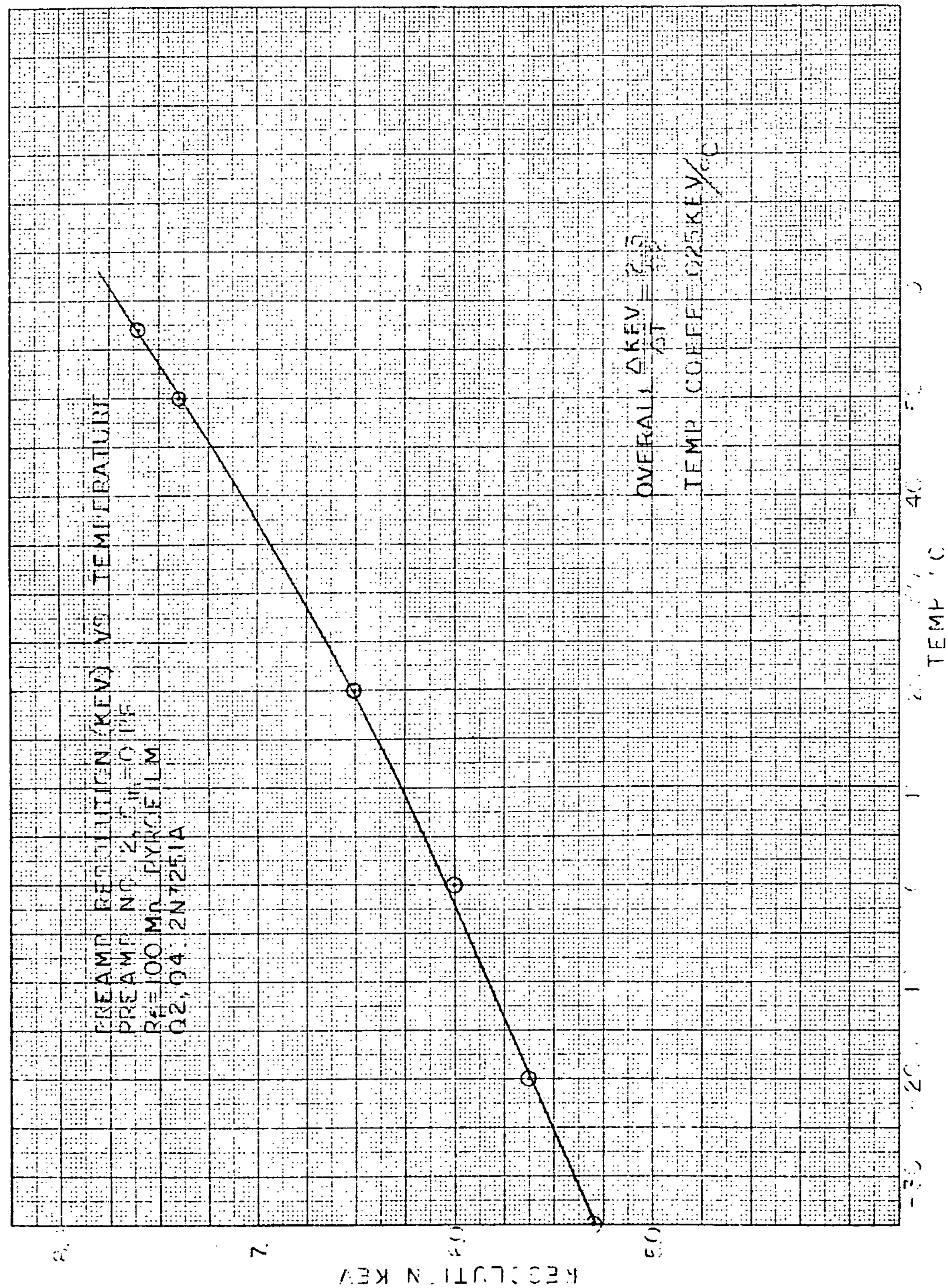


Figure 2 PREAMPLIFIER RESOLUTION (keV) VERSUS TEMPERATURE

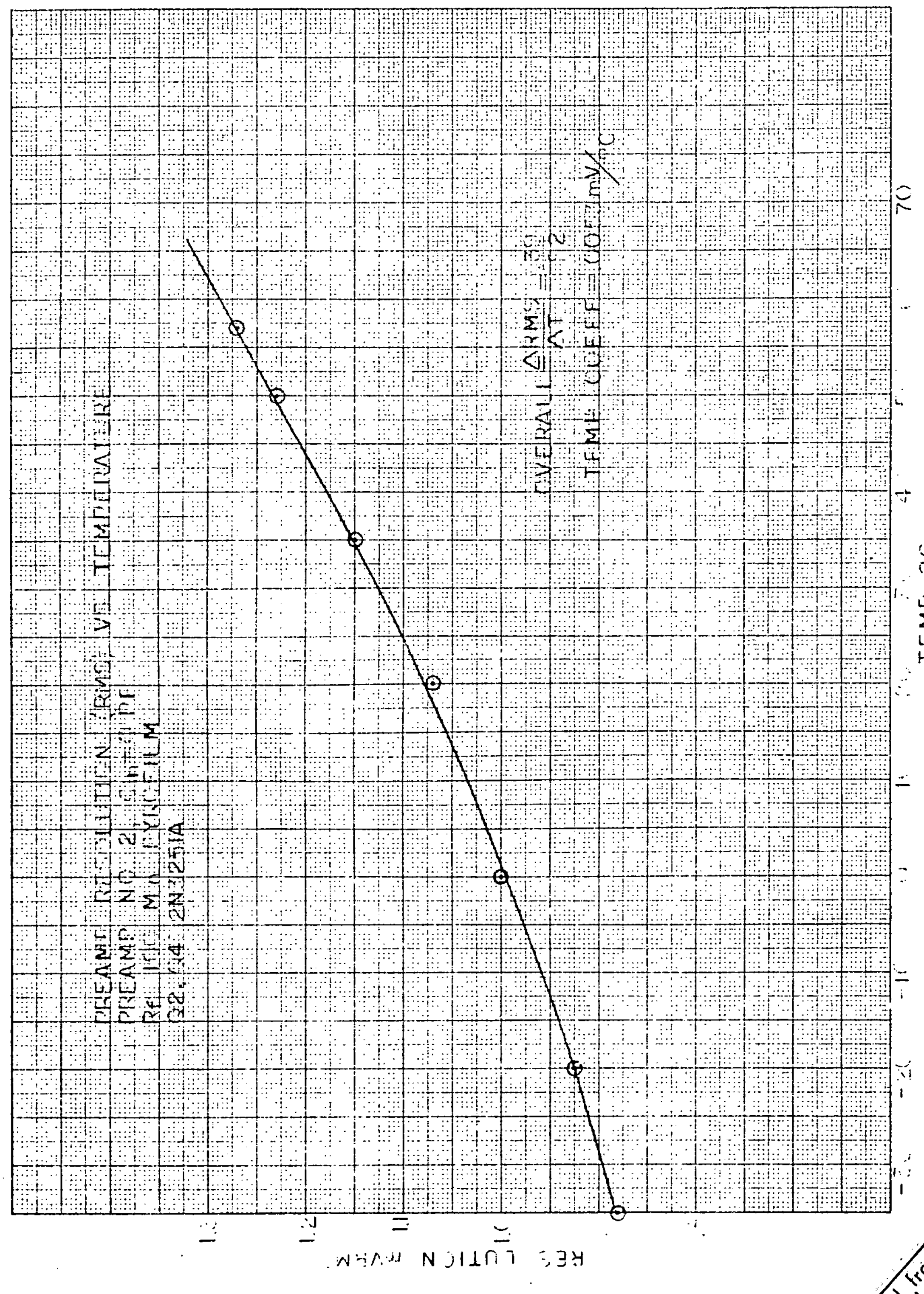


Figure 3 PREAMPLIFIER RESOLUTION (RMS) VERSUS TEMPERATURE

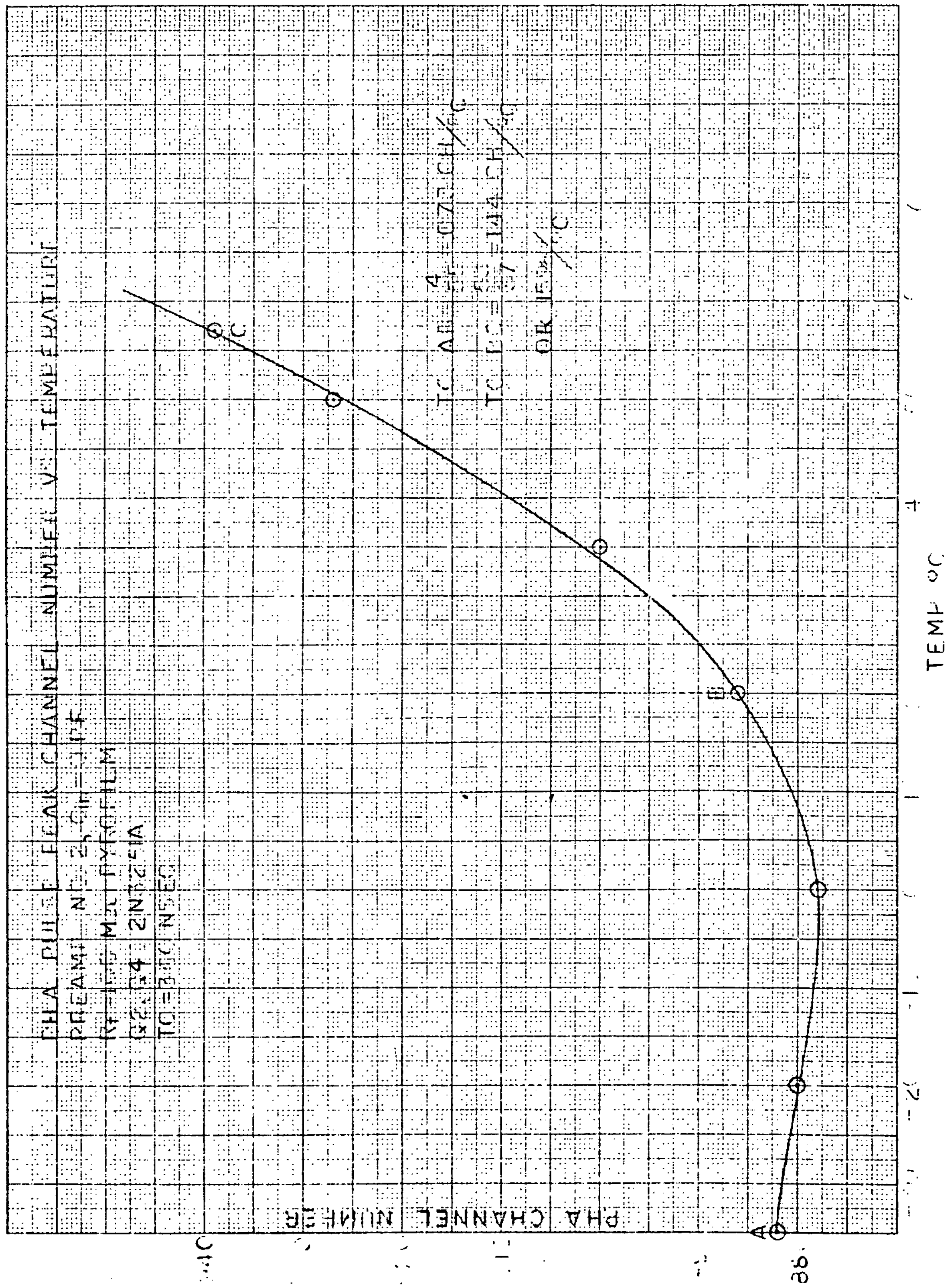


Figure 4 P.H.A. PULSE PEAK CHANNEL NUMBER VERSUS TEMPERATURE

3.2.2 PULSE AMPLIFIER

The pulse amplifier shapes the preamplifier's output and amplifies the signal to a level usable by the pulse height discriminators. Pulse shaping is necessary to minimize the system resolving time and narrow the bandwidth for good signal-to-noise ratio. The amplifier output is a bipolar pulse; this eliminates the need for a baseline restorer and reduces circuit complexity. Two pulse shaping time constants are used to obtain the best performance from each of the two detector sizes which have different collection times.

Other requirements are found in the "Pulse Amplifier Specifications" list. The circuit design has been optimized to meet these specifications with a minimum of power comsumption.

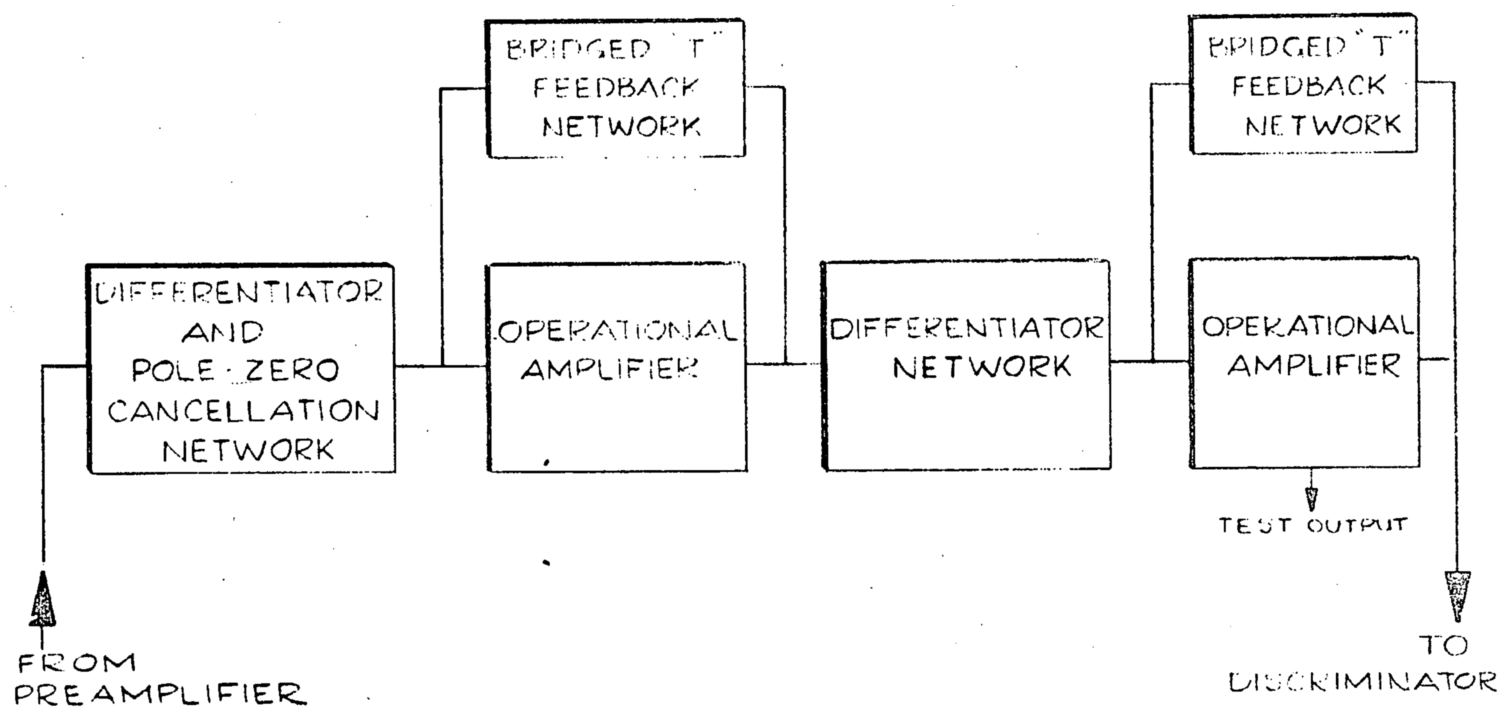
The pulse amplifier is composed of two cascaded active R-C filters (see pulse amplifier block diagram). Each filter contains a differentiator, an operational amplifier and feedback network.

The first differentiator is combined with an adjustable pole-zero cancellator which is set to cancel the decay time constant of the preamplifier. This network is shown in detail on the Schematic SIC39106627 and consists of R_1, R_2, R_3, and C_1. The second differentiator consists of C_{16} and R_{27}.

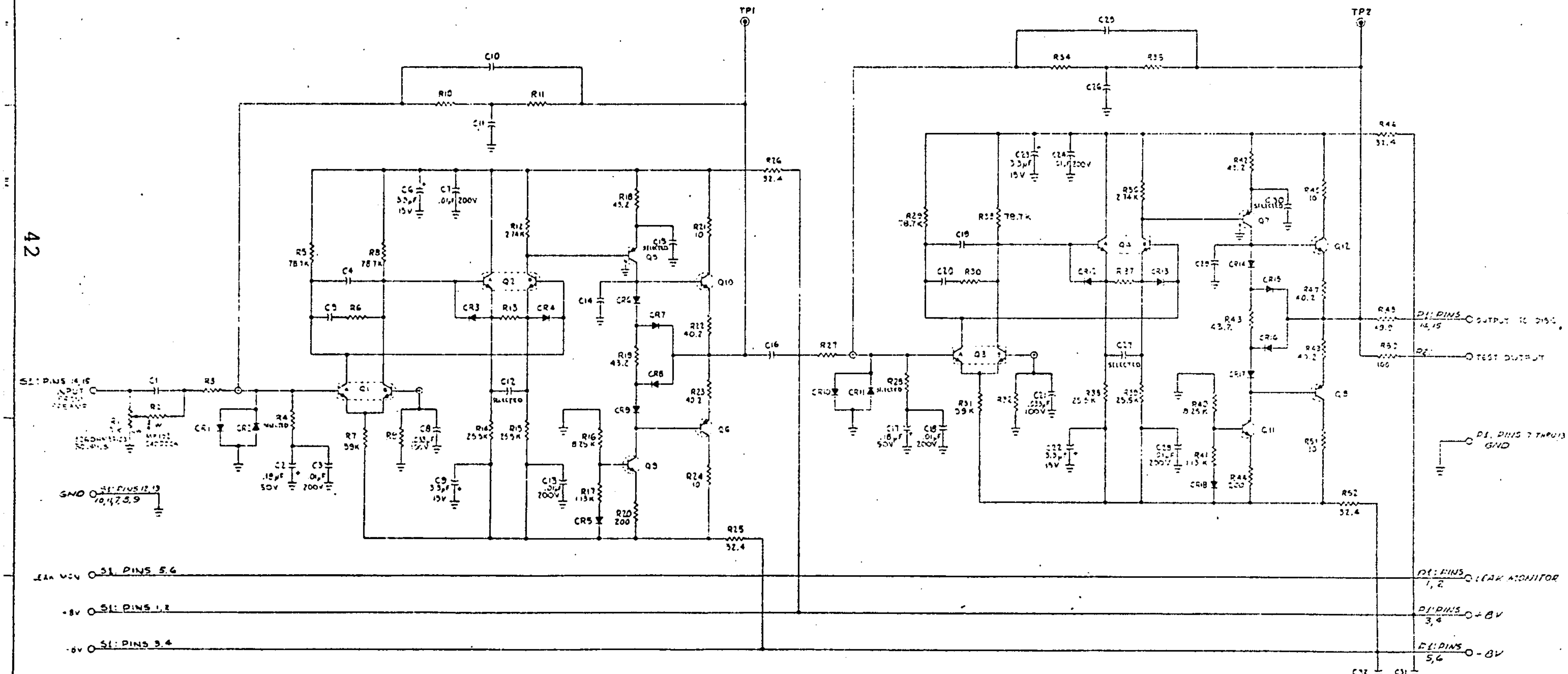
The feedback networks consist of C_{10}, C_{11}, R_{10}, R_{11}, C_{25}, C_{26}, R_{34}, and R_{35}.

The operational amplifiers are identical except for the test output of the second one. This test output is needed for calibration. To obtain sufficient slew rate with minimum power consumption the amplifiers are compensated for an open loop frequency response with a 12 dB/octave roll off. This requires the compensation to be tailored to the time constant. As in the case of the differentiator and feedback components the compensation values are not given in the basic schematic but are listed on the assembly drawing. Diodes CR_1, CR_2, CR_3, CR_4, CR_{10}, CR_{11}, CR_{12}, and CR_{13} are used for protection of the transistors. Short circuit protection is obtained with CR_7, CR_8, CR_{15}, and CR_{16}.

The bipolar pulse is obtained by the use of the second differentiator. Placing this differentiator between the amplifiers instead of after the second amplifier results in a requirement for a lower power supply voltage, therefore, reducing power consumption to about one half.



PULSE AMPLIFIER BLOCK DIAGRAM



NOTES: UNLESS OTHERWISE SPECIFIED.

1. INTERPRET PER MSC MANUAL MSCM8500.
2. CR1-CR18 ARE 1N4153; Q1-Q4 ARE 2N4878, Q5-Q8 2N4261, Q9-Q12 2N2708; ALL RESISTORS ARE RNC50
3. FOR VALUES OF R2,3,4,6,9,10,11,13,27,28,30,32,34,35,37, AND C1,4,5,10,11,12,14,15,16,19,20, C25,26,27,29, AND 30 SEE ASSY DWG SEC39107107.

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER · HOUSTON, TEXAS

SCHEMATIC DIAGRAM,
PULSE AMPLIFIER –
ELECTRON-PROTON SPECTROMETER

PULSE AMPLIFIER SPECIFICATIONS

Pulse Gain: 16.0 ± 8%

Gain Stability:

Temperature Stability: Less than .02%/°C

Stability as a Function of Supply Voltage: Less than .2% for 0.1V change in both supplies.

Linearity: Less than 1.2% deviation from best straight line to ± 5V out.

Input Polarity: Positive

Output Polarity: Positive

Preamp-Post Amp Calibration: +5 out = 10 mev

Pulse Shaping Time Constants: 220 ns and 360 ns

Pole-Zero Cancellation: Adjustable from 40 μs to infinity.

Overload Recovery: Recovers from X10 overload in $\leq$ 2 normal pulse widths to less than lower discriminator setting.

Output Noise: Less than 1.0 mV FWHM for no input.

Average Baseline Shift with Counting Rate: $\leq$ ± 5 mV

Baseline Stability Based on 10K Feedback Resistor +25°C Value:
6.6 mV max, 2 mV typ.
Temp. Stability: 72 μV/°C max.
As a function of supply voltage: 0.13 mV typ for a change in both supplies of 0.1V.

Output Coupling: Direct.

Discriminator Output Load: 1.3 KΩ min, 10 pf max.

Power Requirements: +8V @ 10.8 mA typ, -8V @ 12.2 mA typ, 200 mw max.

Output Short Circuit Protected

Test Output Load: 4kΩ min, 60 pf max.

Slew Rate: Greater than 36V/μs for a time constant of 220 ns,
Greater than 22V/μs for a time constant of 360 ns.

OPERATIONAL AMPLIFIER
SPECIFICATIONS

+25°C except as noted.

Open Loop Gain at 10 KC: 79 to 87 dB.

Open Loop Gain Stability: With temp. from +25°C to -25°C, less than 10%.

With supply voltage, less than 1% for 0.1 V charges in both supplies.

Linearity: Less than 12% from -5V to +5V out.

Output: ± 5V Maximum.

Input Offset Voltage (Max): 6.0 mv (2 mv typ.) +60 μV/°C

Input Offset Current (Max): 60 nA + 1.2 nA/°C

Minimum Load Resistance (including feedback network): 660Ω

Power Requirements:

± 8V, 100 mw max (90 mw typ).
+8V @ 5.4 ma typ.
-8V @ 6.1 ma typ.

Input Offset Voltage Change with Supply Voltage:

0.13 mv (typ) for any combination of 0.1V change in supply voltages.

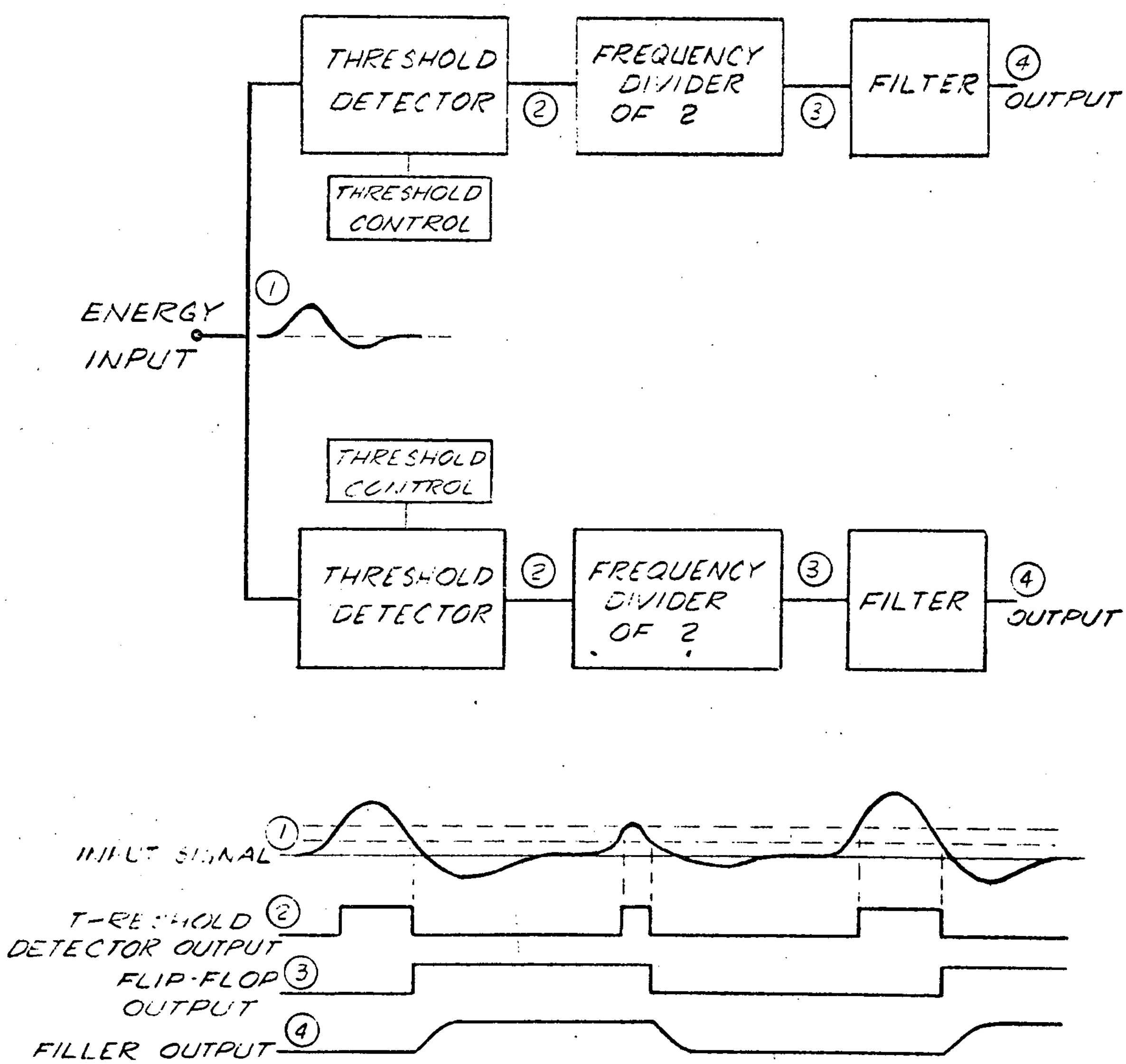
Short Circuit Protected.

For use in the inverting configuration.

3.2.3 DUAL DIFFERENTIAL PULSE HEIGHT DISCRIMINATOR

The dual pulse height discriminator consists of two functionally identical circuits whose purpose is to determine whether an energy deposition in the corresponding EPS detector exceeds two independently predetermined values. Electronically the two predetermined energy deposition values allow the detection of electron events above a known energy level and proton events within an energy window. A functional block diagram is included.

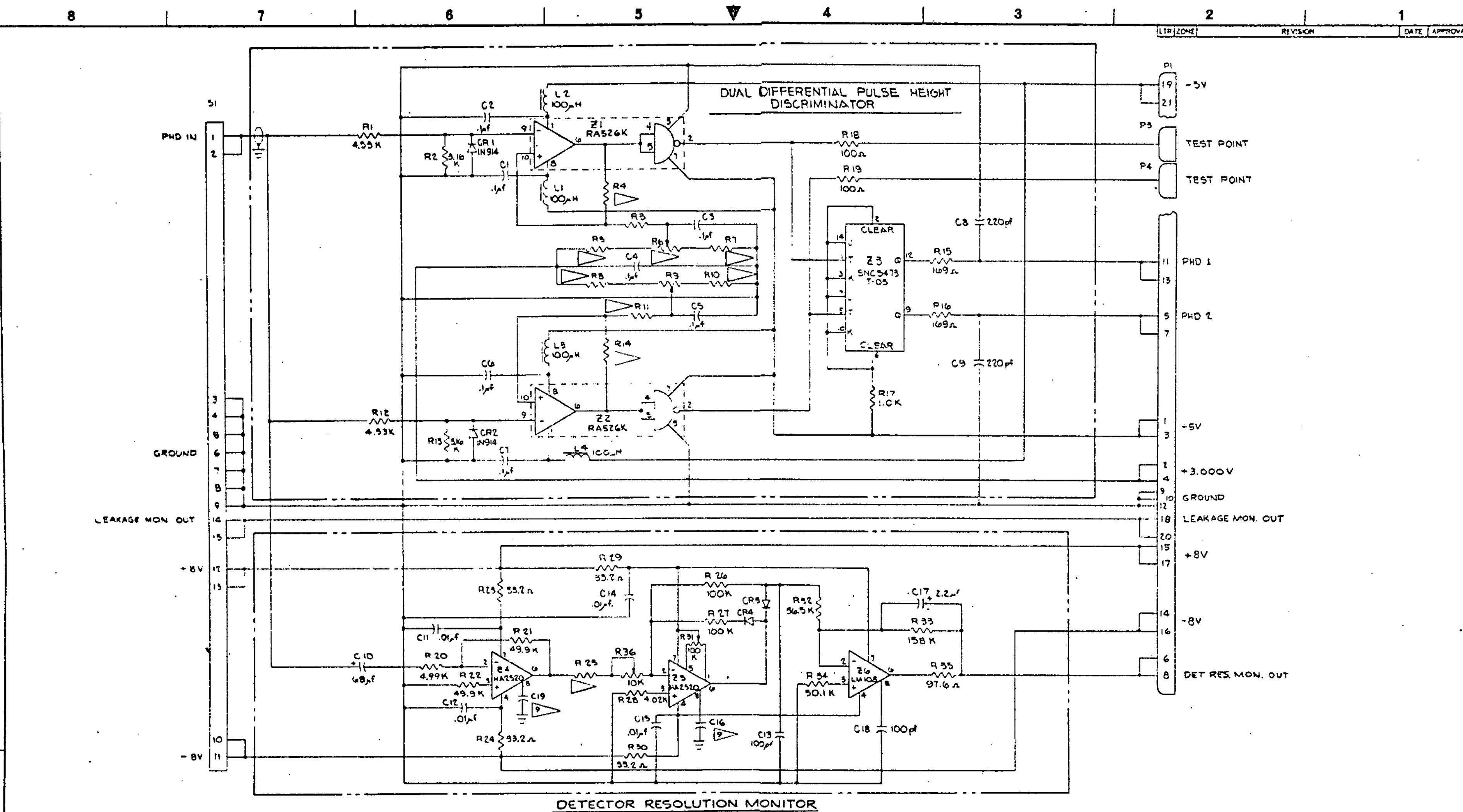
Due to counting-rate requirements, the portion of the input signal that is observed for analysis by the circuit is restricted to 660 nsec for channel one, and 1080 nsec for channels two through five. The time spent above the circuits threshold becomes vanishingly small for signals close to the threshold value, however. This requires the use of an exceptionally fast discriminator and resulting output signals may be as short as 20 nsec. Since these signals must eventually be recorded by the EPS Data Processor which is interconnected to the discriminator output by several inches of unshielded wire, a flip-flop is included to increase the pulse width to one capable of being handled by the lower frequency low-power counters. An output filter increases the rise time of signals transmitted to the data processor to approximately 30 nsec. In this way the possibility of internally generated EMI is minimized.



DUAL DIFFERENTIAL PULSE HEIGHT DISCRIMINATOR BLOCK DIAGRAM

The Dual Pulse Height Discriminator Performance Specification, included, presents the design criteria for this circuit. All design criteria have been met.

Drawing SIC 39106633 is the schematic diagram of the Dual Pulse Height Discriminator. Resistors R1 and R2/R12 and R13 serve as an input signal attenuator to reduce the value of the largest possible positive input signal to the derated maximum value of integrated circuit Z1/Z2. Diode CR1/CR2 serves to clamp the negative portion of any input signal to a value less than the derated maximum value of integrated circuit Z1/Z2. Integrated Circuit Z1/Z2 functions as a high speed differential amplifier. The input signal is directed to the amplifier's negative input terminal. Whenever the negative input terminal becomes more positive than the positive terminal, the amplifier's output switches from +4 volts to 0 volts. In this way the amplifier functions as a differential comparitor. The reference value (trip point) is determined by Resistors R5, R6, and R7/R8, R9, and R10 and the reference input voltage. By adjusting the values of these resistors, the threshold may be preset to any value from 50 keV equivalent energy to 10 MeV equivalent energy. Resistors R3 and R4/R11 and R14 provide the amplifier with positive feedback to ensure very crisp (non oscillating) response by making the amplifier reset point 50 keV equivalent energy less than the trip point. Integrated circuit Z1/Z2 includes a TTL compatible two input Nand Gate. This gate logically inverts the output signal to one of 0 volts to +4 volts. The gate's output is connected to the clock input of one of the flip-flops in Z3. This flip-flop



NOTES: UNLESS OTHERWISE SPECIFIED.

1. INTERPRET PER MSC MANUAL MSCM 8500.
2. [2]LEC LO-OHMAGE RESISTOR (SPECIAL ORDER)
3. [3]MEPCO RNC 50 H FR.
4. [4]CADDOCK MK-132 (±1%, ±50 ppm/°C).
5. [5]BOURNS 3260HM391C1
6. [6]BOURNS 3260HM39500
7. [7]BOURNS 3260HM392C1
8. CR3 & CR4 ARE H.P. P/N 5082-2123.
9. C16 / C19 ARE OPTIONAL AT ASSY-22 pF.

CHANNEL	R3[1]	R4[2]	R5[1]	R6	R7[1]	R8[1]	R9	R25[8] R10[8]	R11[1]	R14[2]
1	1.54 K	500 K	750Ω	200Ω[4]	464Ω	2.10 K	50Ω[4]	0Ω[4]	1.82 K	725 K
2	1.47 K	440 K	715Ω	"	604Ω	"	"	"	"	"
3	1.50 K	480 K	787Ω	"	487Ω	"	"	"	"	"
4	1.54 K	550 K	1.00 K	"	294Ω	"	"	"	"	"
5	"	580 K	1.13 K	100Ω[4]	267Ω	1.69 K	200Ω[4]	"	1.78 K	750 K

SIGNATURES	DATE
DR E. B. LOPEZ	6-11-71
ENG Geo RSF	
CH E. Brumfield	8-16-71
RPD	8/16/71
APP	
AUTH	

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER · HOUSTON, TEXAS

SCHEMATIC DIAGRAM, DUAL DIFFERENTIAL PULSE HEIGHT DISC AND DETECTOR RESOLUTION MONITOR

ELECTRON-PROTON SPECTROMETER

CODE IDENT NO 21356 | SIZE D | DWG NO SIC 39106633

SCALE ~ | 130-E5 | SHEET

changes state each time the comparitor transitions from 0 volts to +4 volts. The signals are transferred to much longer ones for processing by the EPS data processor. Resistor R15, R16 and Capacitor C8/C9 increase the rise time of the flip-flop output to approximately 30 nsec to remove the possibility of cross coupling in the wires connecting the data processor. Resistors R18/R19 serve as cable terminations for test points P3/P4. Inductors L1 and L2/L3 and L4 and Capacitors C1 and C2/C6 and C7 function as supply line filters to the differential amplifier Z1/Z2.

DUAL PULSE HEIGHT DISCRIMINATOR PERFORMANCE SPECIFICATION

1.0 Input Characteristics

A. Impedance: 3.85 kΩ

B. Coupling: Direct

C. Signal Range

1) Normal: 0 to +5 volts bipolar positive edge leading

2) Overload: +8.0 volts to -10.0 volts continuous

D. Threshold Range:

1) Electron 1	200 keV to 300 keV
2) Electron 2	200 keV to 300 keV
3) Electron 3	200 keV to 300 keV
4) Electron 4	200 keV to 300 keV
5) Proton 1	5.300 MeV to 6.400 MeV
6) Proton 2	6.100 MeV to 7.500 MeV
7) Proton 3	5.500 MeV to 6.700 MeV
8) Proton 4	3.330 MeV to 4.070 MeV
9) Proton 5	2.880 MeV to 3.520 MeV
10) Proton 6	0.600 MeV to 1.000 MeV

E. Pulse Pair Time Resolution: ≤ 100 nsec

F. Input Rate (Fixed Frequency): ≥ 5 MHz

2.0 Discriminator Level Stability

A. Temperature

1) 200 keV, -25°C to +50°C: $\leq {}^{+3.0\%}_{-1.5\%}$

2) 7.000 MeV, -25°C to +50°C: $\leq {}^{+0.2\%}_{-0.4\%}$

B. Power Supply Variation

1) 200 keV

A) +5.0 volt supply (+4.8 VDC to +5.3 VDC) $\leq {}^{+3.0\%}_{-3.5\%}$

B) -5.0 volt supply (-4.8 VDC to -5.3 VDC) $\leq {}^{+0.5\%}_{-1.2\%}$

C) +5.0 volt, -5.0 volt supply aggregate (4.8 VDC to 5.3 VDC) $\leq {}^{+3.5\%}_{-4.0\%}$

D) +3.000 volt supply — error equal to fractional error in supply value

2) 7.000 MeV

A) +5.0 volt supply (+4.8 VDC to +5.3 VDC) $\leq {}^{+0.5\%}_{-0.5\%}$

B) -5.0 volt supply (-4.8 VDC to -5.3 VDC) $\leq {}^{+0.1\%}_{-0.5\%}$

C) +5.0 volt, -5.0 volt supply aggregate (4.8 VDC to 5.3 VDC) $\leq {}^{+1.1\%}_{-0.6\%}$

D) +3.000 volt supply — error equal to fractional error in supply value

3.0 Discriminator Crispness: $\leq$ 10 keV

4.0 Discriminator Hysteresis: 50 keV

5.0 Prescale Factor: 2

6.0 Output Characteristics

A. Signal Output

1) DC levels: TTL

2) Fanout: $\geq$ 3

3) Rise Time Constant - Fall Time Constant: 10 nsec

B. Test Output

1) DC Levels: TTL

2) Output Impedance: 100Ω

7.0 Power Requirement

	-25°C	0°C	+25°C	+50°C
+5.0 VDC	43mA	44mA	44mA	42mA
-5.0 VDC	18mA	18mA	21mA	20mA
+3.000 VDC	4mA	4mA	4mA	4mA

3.3 HOUSEKEEPING SYSTEM

A definite requirement exists to measure three detector parameters in order to determine the quality of each detector. These parameter measurements are required periodically: during shelf storage of the EPS flight instruments, during the time each flight instrument is mounted on the spacecraft, and during flight. Having the capability for making these periodic measurements is of paramount importance to the overall accuracy of the EPS flight data.

Analysis of the data collected as a result of these measurements maximizes the probability of a successful mission, by providing the capability to detect and replace any degraded detector prior to flight, and by applying correction factors to the data, if required, during flight.

Because of the different non-related but dependent failure modes of the detector(s), three parameter measurements are required. None of these measurements can be eliminated due to their interdependence, as the remaining measurements will not give a positive indication of the parameter measurement or failure mode eliminated.

The required parameter measurements are: 1) detector temperature, 2) detector leakage current, and 3) detector resolution. These are discussed in detail below.

Detector Temperature Measurement

Measurement of the temperature of the detectors is required during flight as leakage current noise and lithium drift rates are dependent upon the temperature of the detectors. The leakage current increases 100 percent for approximately every 8°C increase in detector temperature, and the noise varies with leakage current, resulting in a deterioration of detector resolution, and thereby performance.

The lithium drift rate increases with an increase in temperature in addition to being linearly proportional to detector bias. Hence a knowledge of the temperature is required in order to

1) Partially or totally unbias the detector if the temperature rises too high and
2) Allow analytic corrections to the data to be made, if necessary, because of the increase of detector active volume caused by the continued lithium drift.

Detector Resolution Noise Monitor

Although the resolution of the detectors varies directly as a function of temperature, one failure mode of the detector results in a degradation of resolution which is independent of temperature. Therefore, a detector resolution (noise) monitor is required for each of the five detectors.

The detector noise monitors will be built into each of the EPS instruments. This approach eliminates any requirement to disconnect the instrument from the spacecraft to exercise and monitor the status of the detector resolution prior to launch. Instead, this measurement may be made by having spacecraft power applied to the EPS and interrupting the data fed out by the spacecraft telemetry system. Correction factors can also be applied to the flight data if required, by monitoring the detector resolution during flight.

Detector Leakage Current

The leakage current measurement provides a partial indication of the quality of the detector. Although leakage current varies directly with temperature, one particular failure mode of the detectors is that the leakage current can increase to prohibitive levels independent of the detector temperature. Therefore, a leakage current monitor is provided in the EPS for each detector.

Electronic Status Monitors

All voltages, electronics package temperature, and heater ON-OFF status are also monitored as part of the housekeeping data, and are necessary parameters for overall evaluation of the instrument prior to launch. All have redundant channels on the multiplexer. The voltage monitor data is especially helpful in evaluating malfunctions or questions relating to data validity in case unusual data occurs. Package temperature data is required in evaluating thermal design and in determining the environment experienced by the electronic circuitry, especially if the instrument power has been off for long periods in a cold, or hot environment. The heater monitor provides status of the heaters, whether in the "On" or "Off" condition. All housekeeping monitor voltages are conditioned to have a maximum value of 5 volts.

TABLE I. EPS DATA PROCESSOR HOUSEKEEPING SEQUENCE PARAMETER RANGE, ACCURACY, AND RESOLUTION CHART

PRIME FRAME NO.	HOUSEKEEPING ID BIT 2	HOUSEKEEPING ID BIT 3	MEASUREMENT		ACCURACY	RESOLUTION
1A	0	0	Package Temperature	-50°C to +50°C	±1.0°C	0.110°C
2A	0	0	Detector 1 Noise	0 to 50 Kev	±5 Kev	0.5 Kev
3A	0	0	Detector 1 Leakage	10^{-3} μA to 10^{0} μA	±5 x 10^{-3} μA	10^{-3} μA
4A	0	0	Detector Plate Temp	-50°C to +50°C	±1.0°C	0.110°C
5A	0	1	Detector 2 Noise	0 to 50 Kev	±5 Kev	0.5 Kev
6A	0	1	Detector 2 Leakage	2x10^{-3} μA to 2x10^{0}μA	±5 x 10^{-3}μA	2 x 10^{-3}μA
7A	0	1	+5 Volt Monitor	0 volts to +10 volts	±5 mv	10 mv
8A	0	1	Detector 3 Noise	0 to 50 Kev	±5 Kev	0.5 Kev
9A	1	0	Detector 3 Leakage	2x10^{-3}μA to 2x10^{0}μA	±5 x 10^{-3}μA	2x10^{-3}μA
10A	1	0	+8 Volt Monitor	0 volts to +10 volts	±5 mv	10 mv
11A	1	0	-8 Volt Monitor	*	*	*
12A	1	0	+25 Volt Monitor	0 volts to +55 volts	±27 mv	54 mv
13A	1	1	350 Volt Monitor	0 volts to 505 volts	±250 mv	500 mv
14A	1	1	-15 Volt Monitor	*	*	*
15A	1	1	-5 Volt Monitor	*	*	*
16A	1	1	Discrim. Ref. Mon.	0 V to 6.002 V	±3 mv	6 mv
1B	0	0	Package Temperature	-50°C to +50°C	±1.5°C	0.110°C
2B	0	1	Detector 4 Noise	0 to 50 Kev	±5 Kev	0.5 Kev
3B	1	0	Detector 4 Leakage	2x10^{-3}μA to 2x10^{0}μA	±5 x 10^{-3}μA	2x10^{-3}μA
4B	1	1	Detector Plate Temp	-50°C to +50°C	±1.0°C	0.110°C
5B	0	0	Detector 5 Noise	0 to 50 Kev	±5 Kev	0.5 Kev
6B	0	1	Detector 5 Leakage	2x10^{-3}μA to 2x10^{0}μA	±5 x 10^{-3}μA	2x10^{-3}μA
7B	1	0	+5 Volt Monitor	0 volts to +10 volts	±5 mv	10 mv
8B	1	1	Heater Monitor	On/Off	*	*
9B	0	0	Heater Monitor	On/Off	*	*
10B	0	1	+8 Volt Monitor	0 volts to +10 volts	±5 mv	10 mv
11B	1	0	-8 Volt Monitor	*	*	*
12B	1	1	+25 Volt Monitor	0 volts to +55 volts	±27 mv	54 mv
13B	0	0	350 Volt Monitor	0 volts to 505 volts	±250 mv	500 mv
14B	0	1	-15 Volt Monitor	*	*	*
15B	1	0	-5 Volt Monitor	*	*	*
16B	1	1	Discrim. Ref. Mon.	0 V to 6.0020 V	±3 mv	6 mv

3.3.1 DETECTOR LEAKAGE MONITOR

The EPS Detector Leakage Monitor provides a means of continually measuring the leakage current through the silicon energy sensing detector by amplifying the voltage drop across a resistor placed in series with the detector, as illustrated in the accompanying block diagram.

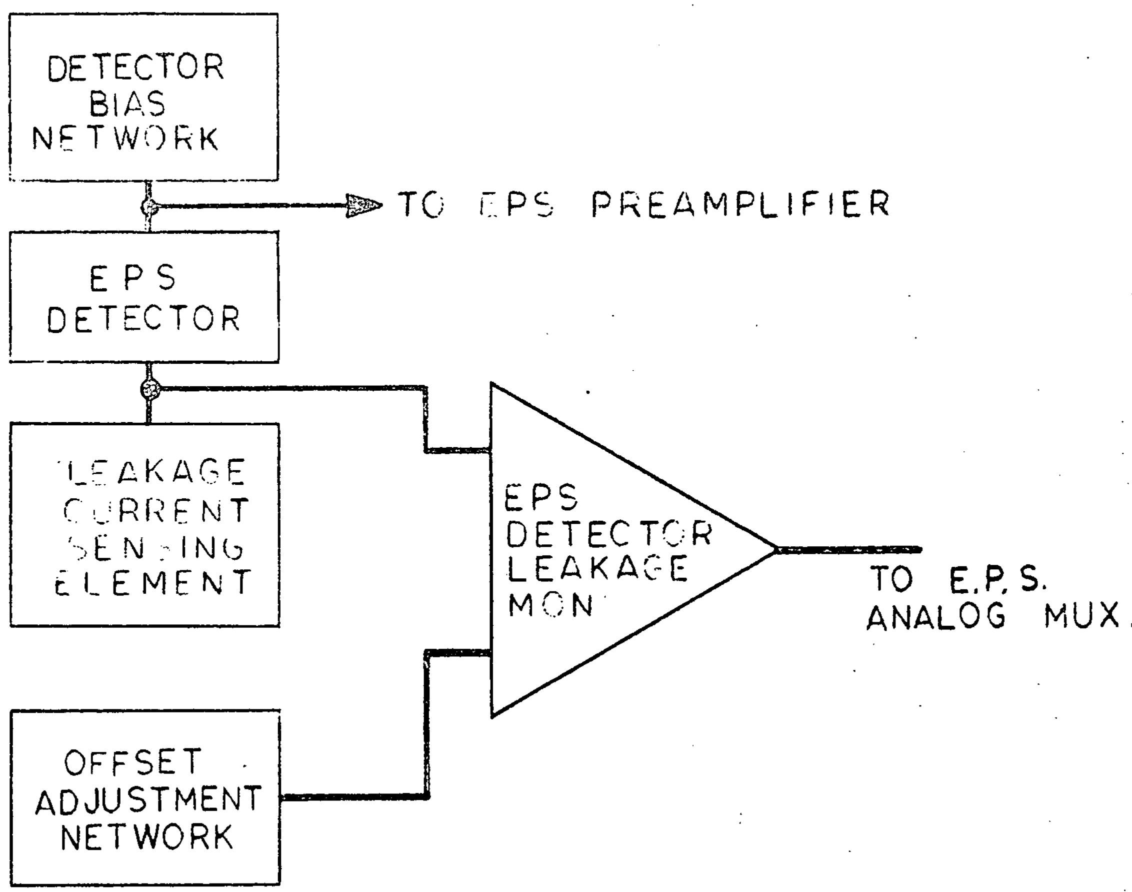
The Detector Leakage Current Monitor consists of a single gain stage utilizing a highly stable operational amplifier. This amplifier, LM 108/883, was specifically chosen because of its extremely low bias current (< 1mA) and offset characteristics (< .5mV).

The monitor is capable of responding to a current variation equal to 1/1000 of the maximum predicted current through the detector and still outputting a voltage equivalent to the least significant bit of the EPS A-D Converter (5 mV).

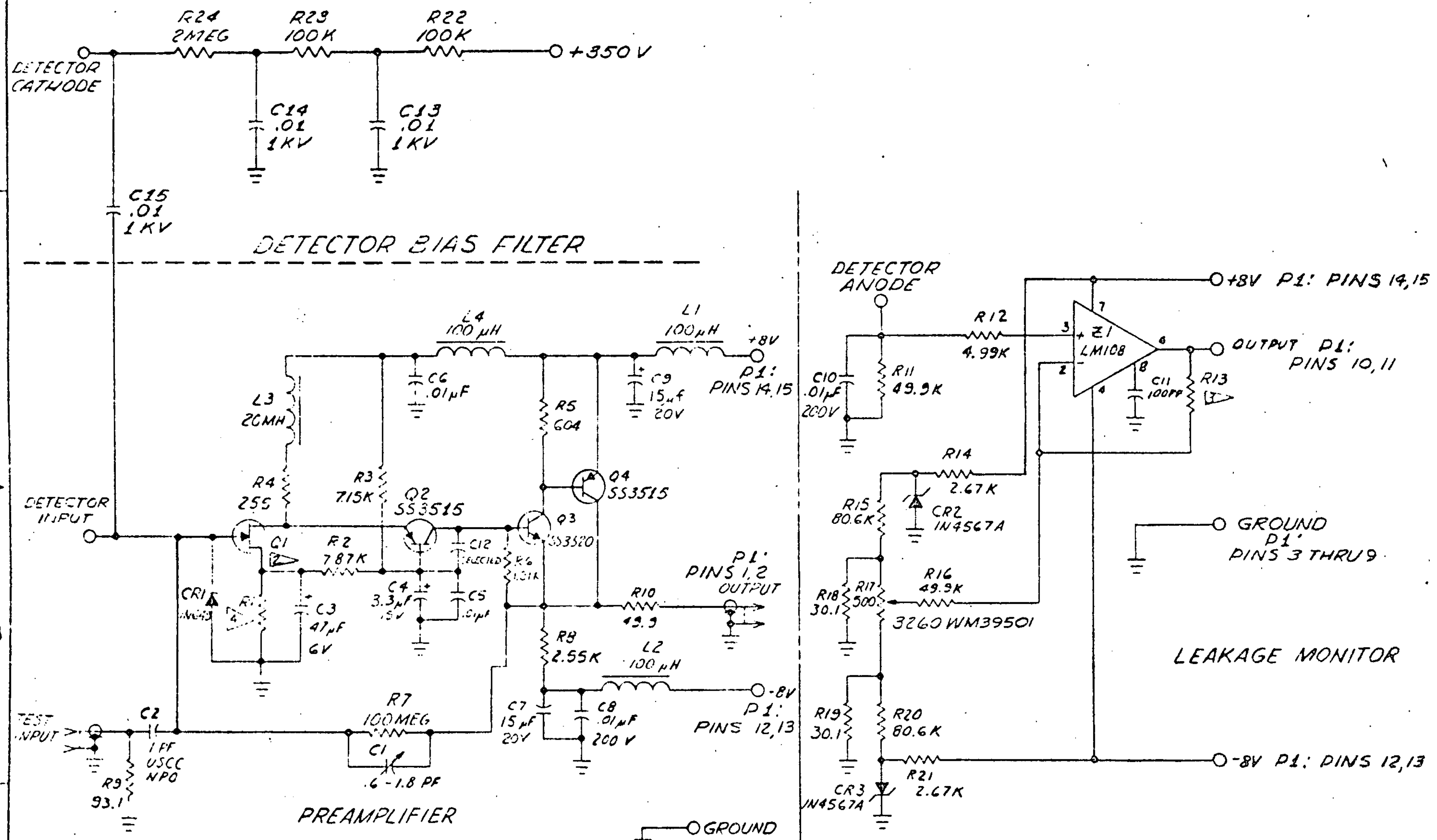
Any residual amplifier output offset can be trimmed to zero ± .5 mV with the offset adjustment network at the input of the leakage monitor.

Both inputs of the amplifier are protected by using two series resistors, R_{12} and R_{16} as shown on Schematic SIC39106631.

The amplifier's output has built-in protection; a short circuit of its output to ground for any length of time will cause no damage to the IC.



DETECTOR LEAKAGE MONITOR BLOCK DIAGRAM



NOTES: UNLESS OTHERWISE SPECIFIED.

1. INTERPRET PER MSC MANUAL MSCM8500.
2. Q1 SELECTED SSC6113
3. FOR 1μA INPUT R13 = 5.0 MEG. FOR 2μA INPUT R13 = 2.5 MEG. CADDOCK MK-132
4. SELECTED, DEPENDENT UPON Q1.
5. ALL RESISTORS ARE RNC50 EXCEPT FOR R4 AND R8, RNC55.

SIGNATURES	DATE
DR	3-22-71
ENG W.A.O.	5/25/71
CHK	5-23-71
	5-27-71
APP PRE-RELEASE R.P.D.	8/13/71
AUTH	

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER · HOUSTON, TEXAS

SCHEMATIC, PREAMPLIFIER & DETECTOR LEAKAGE MONITOR

ELECTRON-PROTON SPECTROMETER

CODE IDENT NO	SIZE	DWG NO
21356	C	SIC 39106631

SCALE — 1SD - EB SHEET

ELECTRON-PROTON SPECTROMETER

Power supply voltage changes have little effect on the monitor's output. A power supply change of ± 1 V results in a change of ± 1 mV at the output.

DETECTOR LEAKAGE MONITOR SPECIFICATION

1. Maximum Input Current Range:

   1a - 1 mm detector = 1 μA

   1b - 2 mm detector = 2 μA

2. Maximum Output Voltage into Multiplexer:

   5.0 volts

3. Amplifier Non-Inverting DC Voltage Gain:

   3a - 100 for 1 mm detector

   3b - 50 for 2 mm detector.

4. Amplifier Output Drift with Temperature:

   -58°C to +24°C → $\Delta V_{out}/°C$ = .32 mV/°C

   +24°c to +50°C → $\Delta V_{out}/°C$ = .43 mV/°C

5. Equivalent Input Current Drift with Temperature:

   -58°C to +24°C → $\Delta I_{in}/°C$ = .064 nA/°C

   +24°C to +50°C → $\Delta I_{in}/°C$ = .086 nA/°C

6. Transfer Characteristics: $\Delta V_{out}/\Delta I_{in}$

   6a - $\frac{\Delta V_{out}}{\Delta I_{in}}$ = 5 mV/nA for 1 mm detector

   6b - $\frac{\Delta V_{out}}{\Delta I_{in}}$ = 2.5 mV/nA for 2 mm detector.

7. Input Voltage Offset Control Range: from -2.1 mV to +2.1 mV.

8. Output Signal Power Supply Rejection:

   ΔV_{out} less than 1 mv for $\Delta V_{supply} = \pm$ 1.0 volt

9. Load Driving Capability: 1.3 mA maximum into 10KΩ load.

10. Power Requirements:

    +8 volts at .7 mA maximum

    -8 volts at .7 mA maximum

3.3.2 DETECTOR RESOLUTION MONITOR

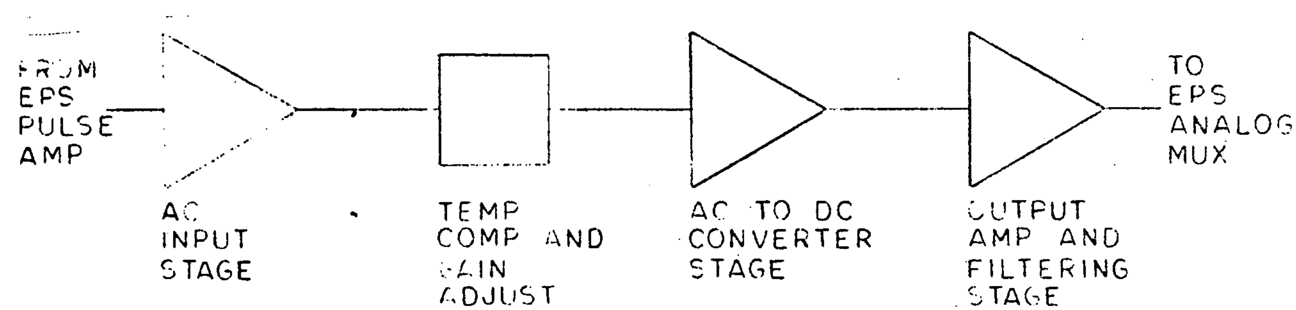
The EPS Detector Resolution Monitor provides a means of continually measuring the noise provenient from the EPS detectors. Thus allowing one to evaluate any degradation of the detectors which might occur during storage or during flight.

The resolution monitor senses this noise at the output of the EPS pulse amplifier and transforms it into a proportional DC voltage which is fed into the EPS multiplexer as shown in the accompanying block diagram.

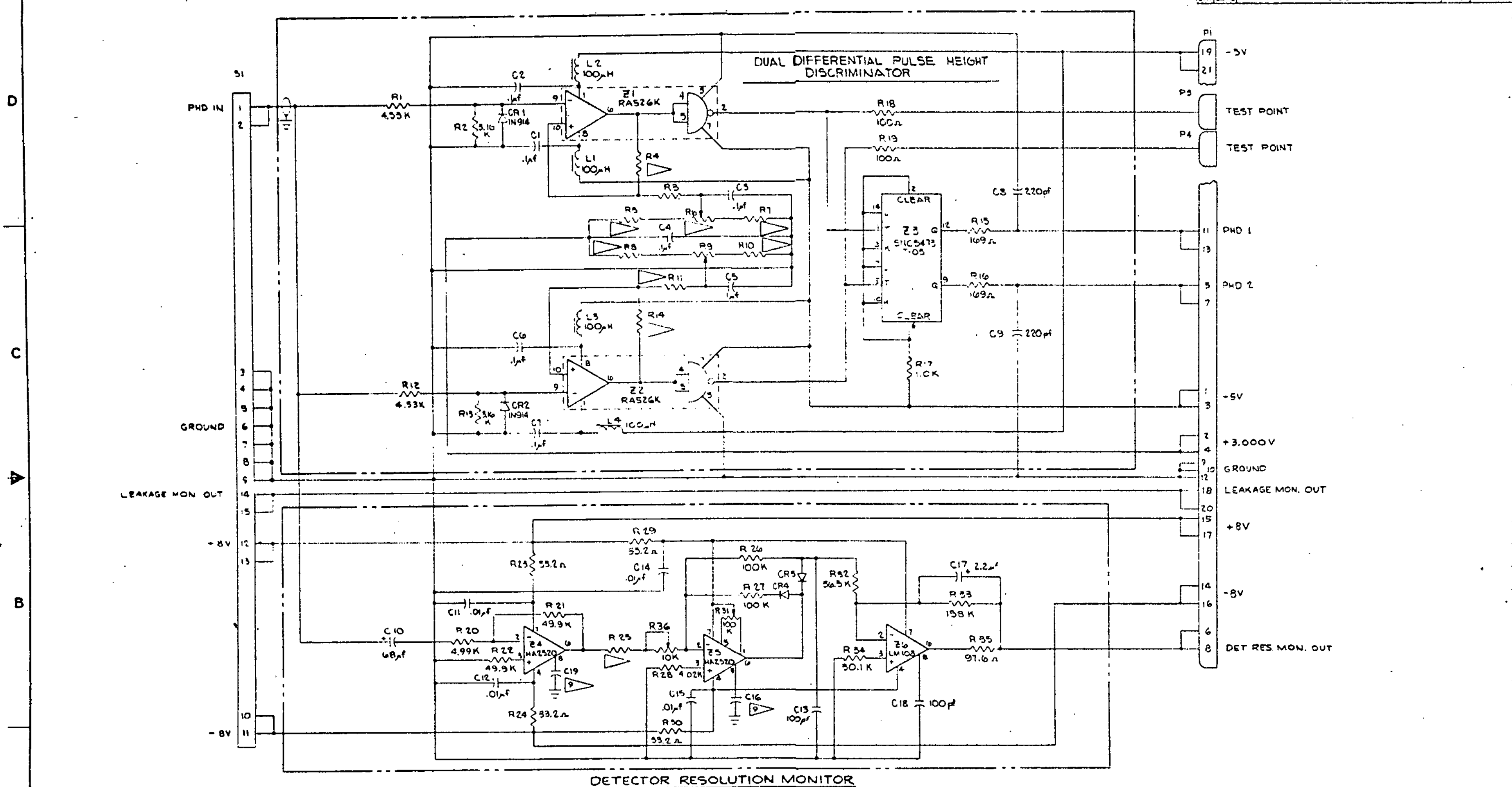
The EPS Detector Resolution Monitor averages the input noise and is implemented with three high performance operational amplifiers. It is capable of responding to high frequency noise signals, having a 3 dB bandwidth of 300 KHz.

Two hot carrier diodes, CR_3 and CR_4, shown on Schematic SIC39106633, are used as the rectifying Detector Resolution Monitor elements in the monitor's second stage because of their inherent low threshold voltages.

The output response curve is very nearly a straight line and is calibrated in volts per keV FWHM of resolution from the EPS detector. Its slope and intersect can be adjusted by varying the two potentiometers, R_{36} and R_{31} respectively, at the monitor's second stage.



DETECTOR RESOLUTION MONITOR BLOCK DIAGRAM



NOTES: UNLESS OTHERWISE SPECIFIED.
1. INTERPRET PER MSC MANUAL MSCM 8500.
2. [1]LEC LO-OHMAGE RESISTOR (SPECIAL ORDER)
3. [2]MEPCO RNC 50H FR.
4. [3]CADDOCK MK-132 (±1%, ±50 ppm/°C).
5. [4]BOURNS 3260HM391C1
6. [5]BOURNS 3260HM39500
7. [6]BOURNS 3260HM392C1
8. CR3 & CR4 ARE H.P. P/N 5082-2123.
9. C16 & C19 ARE OPTIONAL AT ASSY - 22 pF.

CHANNEL	R3[1]	R4[2]	R5[1]	R6	R7[1]	R8[1]	R9	R25[6] R10[6]	R11[1]	R14[2]
1	1.54 K	500 K	750 Ω	200 Ω[3]	464 Ω	2.10 K	50 Ω[4]	0 Ω[5]	1.82 K	725 K
2	1.47 K	440 K	715 Ω	"	604 Ω	"	"	"	"	"
3	1.50 K	480 K	787 Ω	"	487 Ω	"	"	"	"	"
4	1.54 K	550 K	1.00 K	"	294 Ω	"	"	"	"	"
5	"	580 K	1.13 K	100 Ω[3]	267 Ω	1.69 K	200 Ω[3]	"	1.78 K	750 K

SIGNATURES	DATE
DR E E LOPEZ	6-11-71
ENG Cisco 358	
CH E. Bramfield	8-16-71
R.P.D.	8-16-71
APP	
AUTH	

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER · HOUSTON, TEXAS

SCHEMATIC DIAGRAM, DUAL DIFFERENTIAL PULSE HEIGHT DISC AND DETECTOR RESOLUTION MONITOR

ELECTRON-PROTON SPECTROMETER

CODE IDENT NO 21356 | SIZE D | DWG NO. SIC 39106633
SCALE ~ | 150-EB | SHEET

The output stage can be short circuited to ground indefinitely and the overall circuit may be overloaded to any extent, without any damage being incurred by the components.

Temperature compensation of the circuit is done with a sensitor (R_{25}) at the input of the monitor's second stage.

Power supply voltage changes have little effect on the monitor's output response; A $\pm$ 1 volt power supply change results in less than 10 mV output voltage change.

DETECTOR RESOLUTION MONITOR SPECIFICATION

1. Overall Noise Gain:

50 keV FWHM equivalent noise at the input of the pre-amplifier will produce 5 volts DC at the output of the resolution monitor.

2. Minimum Input Sensitivity:

5.5 keV equivalent noise at the input of the preamplifier corresponds to 550 mV DC at the output of the resolution monitor.

3. Input Resolution Transfer Equation:

After calibration, the transfer function will be 100 mV DC at the output per keV FWHM at the preamplifier's input with an uncertainty of ±2 keV.

4. Temperature Coefficient: Measured data indicate an output worst case average temperature coefficient of .22%/°C of reading from -20°C to +25°C

5. Resolution Monitor Signal Bandwidth (-3 db): 300 KHz.

6. Resolution Monitor Input Impedance: 5 KΩ in series with 68 μf.

7. Power Requirements: ± 8 volts at ± 10 mA.

8. Output voltage offset control range: From -50 mV to +600 mV.

3.3.3 TEMPERATURE MONITORS (DETECTOR AND PACKAGE)

The EPS Temperature Monitors provide a means of accurately measuring the temperature surrounding the detectors and electronic hardware in the range between -50°C to +50°C.

The temperature sensors are the PNP transistors which are biased in their linear region by the resistive bias network as shown on the Block Diagram.

The transistor DC collector voltage is a linear function of the emitter-to-base junction voltage and its variation with temperature.

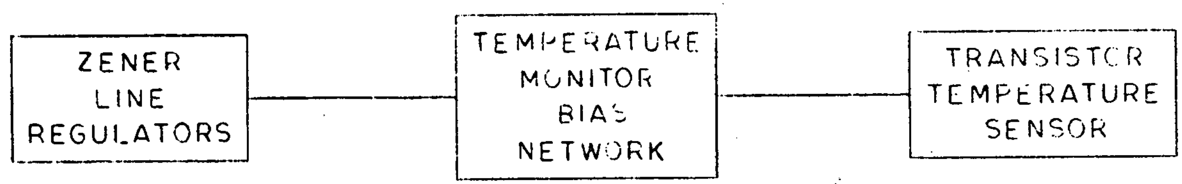
The temperature monitor response curve is a straight line given by:

$$V_o = 2{,}500 + 50 \times T \quad (\text{mV})$$

Where T is in °C.

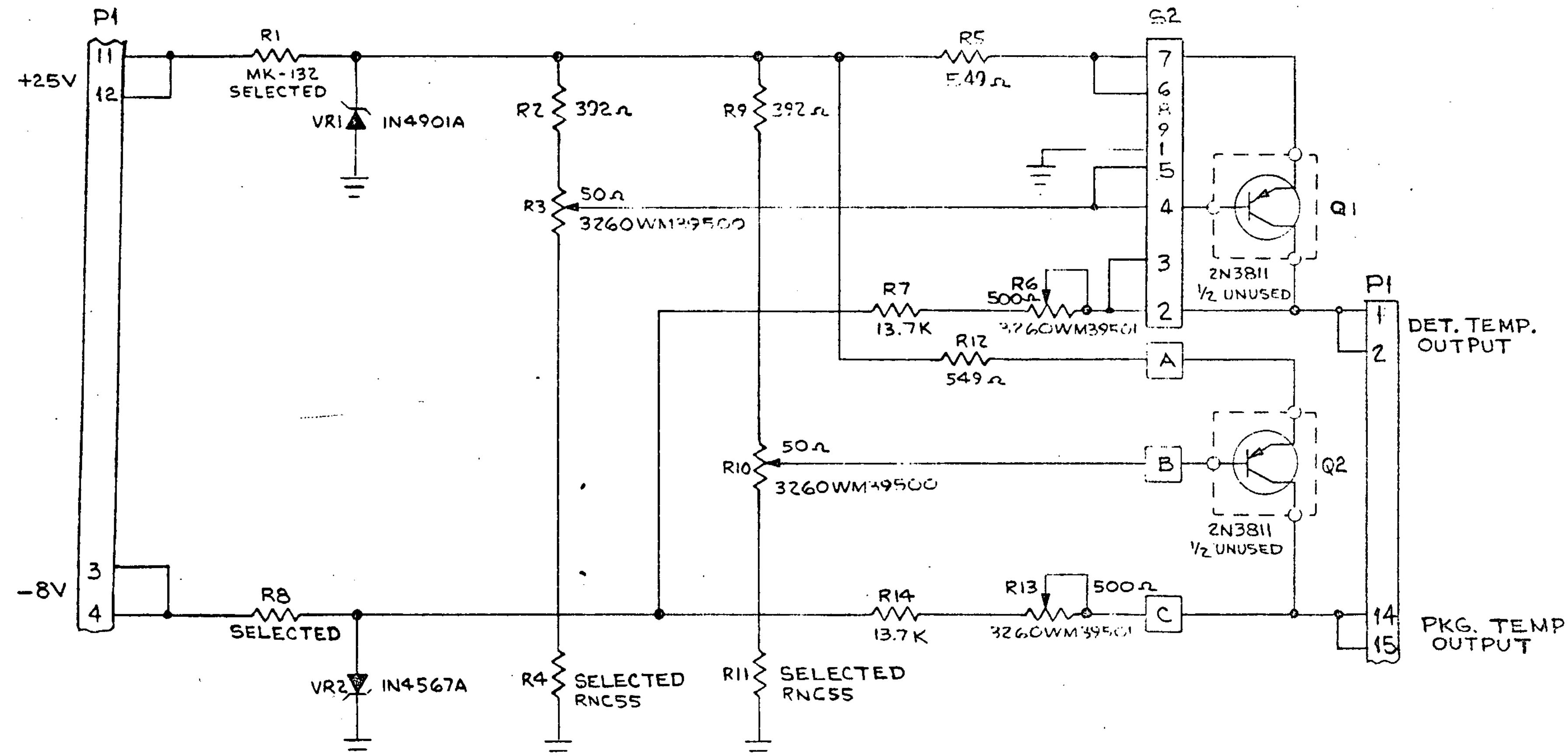
The response curve slope and intersect can be trimmed by adjusting R_3 (R_{10}) and R_6 (R_{13}) Potentiometers shown on Schematic SIC39107145.

In order to increase the circuit's ability to reject power supply variations, two zener diodes, VR_1 and VR_2, which are temperature compensated, are used to regulate the positive and negative supply voltages.



TEMPERATURE MONITOR BLOCK DIAGRAM

C-2



NOTES - UNLESS OTHERWISE SPECIFIED:

1. ALL RESISTORS ARE RNC50.
2. COMPONENTS ENCLOSED WITH BROKEN LINES ARE EXTERNALLY MOUNTED.

LTR	ZONE	REVISION	DATE	APPROVAL

SIGNATURES		DATE
DR	[signature]	4-8-71
ENG	[signature]	4-8-71
CH	[signature]	4-8-71
PRE-RELEASE	R.P.D.	8/13/71
APP		
AUTH		

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER · HOUSTON, TEXAS

SCHEMATIC -
TEMERATURE MONITORS

CODE IDENT NO.	SIZE	DWG NO.
21356	B	SIC39107145
SCALE —	E. P. S.	SHEET 1

MSC Form 1616 B (REV OCT 65

TEMPERATURE MONITORS (DETECTOR AND PACKAGE) SPECIFICATION

Wide Range:

1. Temperature Range: -50°C to +50°C.
2. Output Voltage Range: 0.0 to +5.0 Volts.
3. Output Voltage Temperature Sensitivity: 50 mV/°C.
4. Worst Case Accuracy: ± 1.0°C
5. Resolution: (.1°C).
6. Power Requirements:

   25 volts at 8.5 mA
   -81 volts at 2.3 mA

   Total power dissipation: 231 mw.

3.3.4 VOLTAGE MONITORS

As an aid in troubleshooting the instrument in the event of a failure and to determine the operational status during flight, the internal voltages utilized by the EPS are monitored and read out thru the telemetry link.

There are seven separate low voltages within the EPS instrument, four positive and three negative. As shown in the monitor module Schematic Diagram SIC39106643 the monitor outputs for the positive voltages are generated by resistive divider networks referenced to signal ground.

To generate the monitor signals for three negative voltages, the resistive dividers cannot be referenced to signal ground since the EPS multiplexer cannot multiplex a negative voltage. For this reason, these networks are tied to the +8 voltage supply, and the resistor values were selected to give positive voltages proportional to the negative voltages. The diodes attached to the negative voltage monitor outputs ensure that large negative voltages will not be applied to the input of the multiplexers.

The relationships for the various voltage monitors are:

+8 volt monitor: $V_{mon}\ (+8) = 0.5\ V_8$

+5 volt monitor: $V_{mon}\ (+5) = 0.5\ V_5$

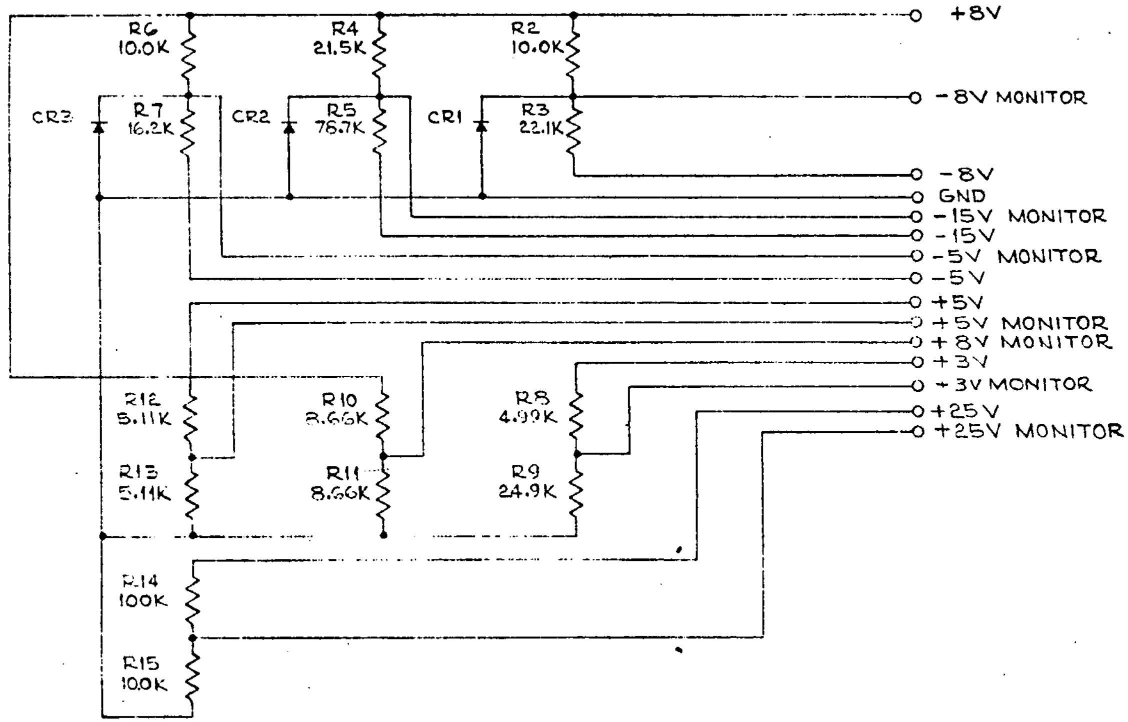
+3 volt monitor: $V_{mon}\ (+3) = 0.833\ V_3$

+25 volt monitor: $V_{mon}\ (+25) = 0.091\ V_{25}$

-8 volt monitor: $V_{mon}\ (-8) = 0.688\ V_8 - 0.312\ V_{-8}$

-5 volt monitor: $V_{mon}\ (-5) = 0.618\ V_8 - 0.382\ V_{-5}$

-15 volt monitor: $V_{mon}\ (-15) = 0.785\ V_8 - 0.215\ V_{-15}$



NOTES: UNLESS OTHERWISE SPECIFIED.

1. INTERPRET PER MSC MANUAL MSCM 8500.

2. RESISTORS ARE TYPE RNR50, 1/20W; DIODES ARE JANTX 1N914.

SIGNATURES	DATE
DR Bill L. Bell	6-17-71
ENG G.X. [illegible]	6-19-71
CHK J D STRINGER	6-29-71
PRE-RELEASE: R.P. Dunn	8/1/71
APP	
AUTH	

EPS

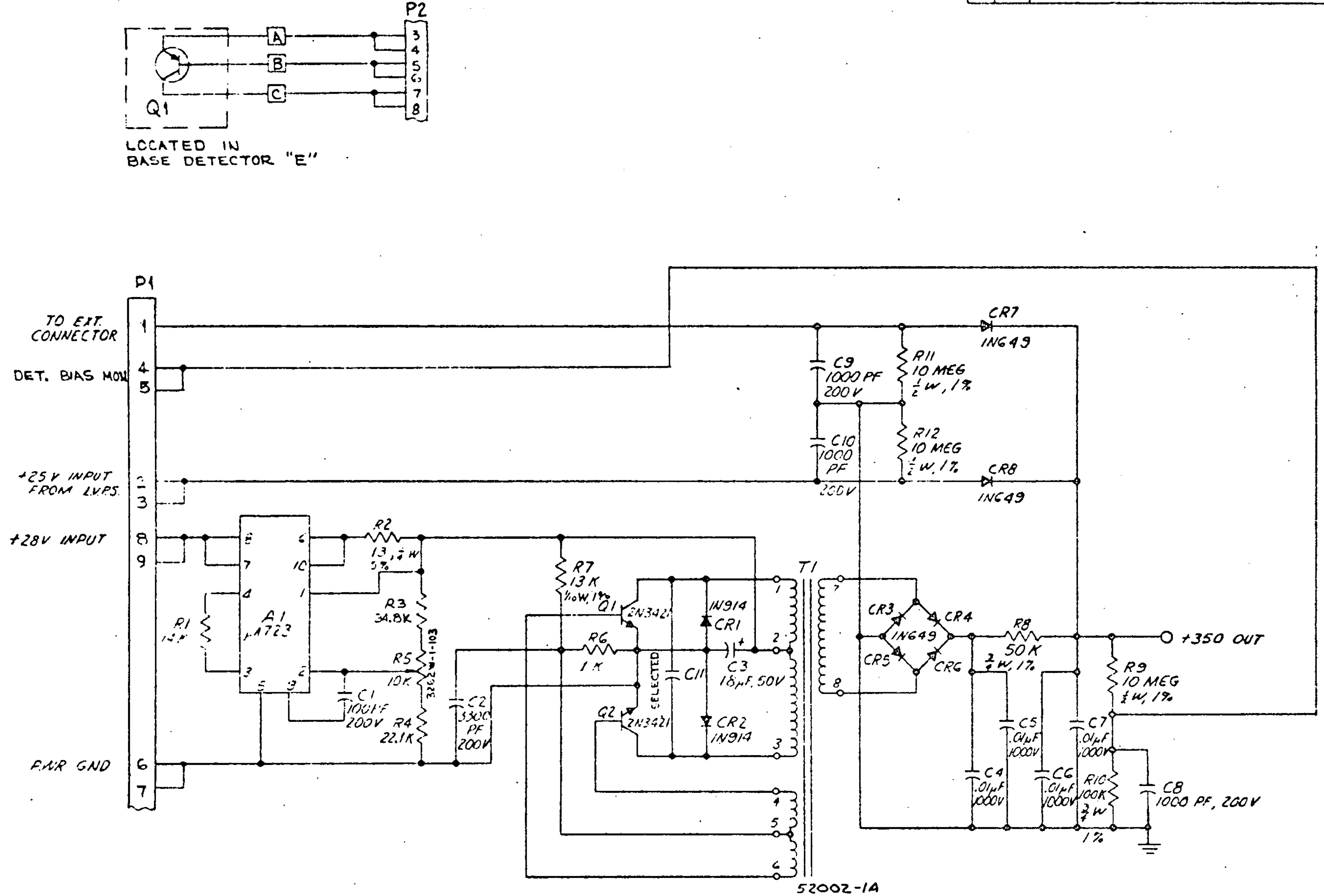
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER · HOUSTON, TEXAS

SCHEMATIC DIAGRAM
MONITOR MODULE, DATA PROCESSOR
EPS

CODE IDENT NO	SIZE	DWG NO
21356	C	SIC39106643

3.3.5 DETECTOR BIAS MONITOR SCHEMATIC SIC39106638

The status of the detector bias power supply is determined by the +350 volt monitor which is part of the housekeeping data. The voltage monitor resolution is 500 millivolts. Resistors R9 and R10 shown on drawing SIC39106638 set the voltage monitor output to 3.5 volts.



NOTES: UNLESS OTHERWISE SPECIFIED.

1. INTERPRET PER MSC MANUAL MSCM 8500.
2. ALL RESISTORS 1/20 W, 1%, VALUES IN OHMS.

SIGNATURES	DATE
DR [signature]	3-30-71
ENG B.E. Cutlinger	4-8-71
CH [signature]	[illegible]
R.P. Dunn	8/21/71
APP	
AUTH	

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER · HOUSTON, TEXAS

SCHEMATIC DIAGRAM,
DETECTOR BIAS SUPPLY-
ELECTRON-PROTON SPECTROMETER

CODE IDENT NO.	SIZE	DWG NO
21356	C	SIC39106638

ELECTRON-PROTON SPECTROMETER

3.3.6 HEATER CONTROL MONITOR

A buffered output from the schmitt trigger in the heater control circuit is fed to the data processor to provide the on or off status of heaters Schematic SIC39106639.

3.4 DATA PROCESSOR SYSTEM

The data processor is required to digitize all data and present it in the correct format and time to the telemetry system. The data must be identified so that after shutdown periods, specific data channels may be quickly recognized.

The data processor section is composed of seventeen modules mounted on a common motherboard. A pictorial view is shown in Fig. 1. The module breakdown is as follows:

Counter-Register	10 ea.
Sequence Control, Line Receiver, Counter Control	1 ea.
Data Compressor and Internal Clock	1 ea.
Output Buffer and Word Sync Generator	1 ea.
Analog - Digital Converter	1 ea.
A/D Control	1 ea.
Multiplexer	1 ea.
Monitor Module	1 ea.

The data processor block diagram is shown in Figure 2. Major interconnect lines are shown and identified to show the functional relationship between modules.

The data processor power requirement is as follows:

Voltage	Current	Power
+5	620 ma	3100 mW
-5	2.5 ma	12.5 mW
+8	7.5 ma	60 mW
-8	42 ma	336 mW
-15	1.8 ma	27 mW
	Total	3535 mW

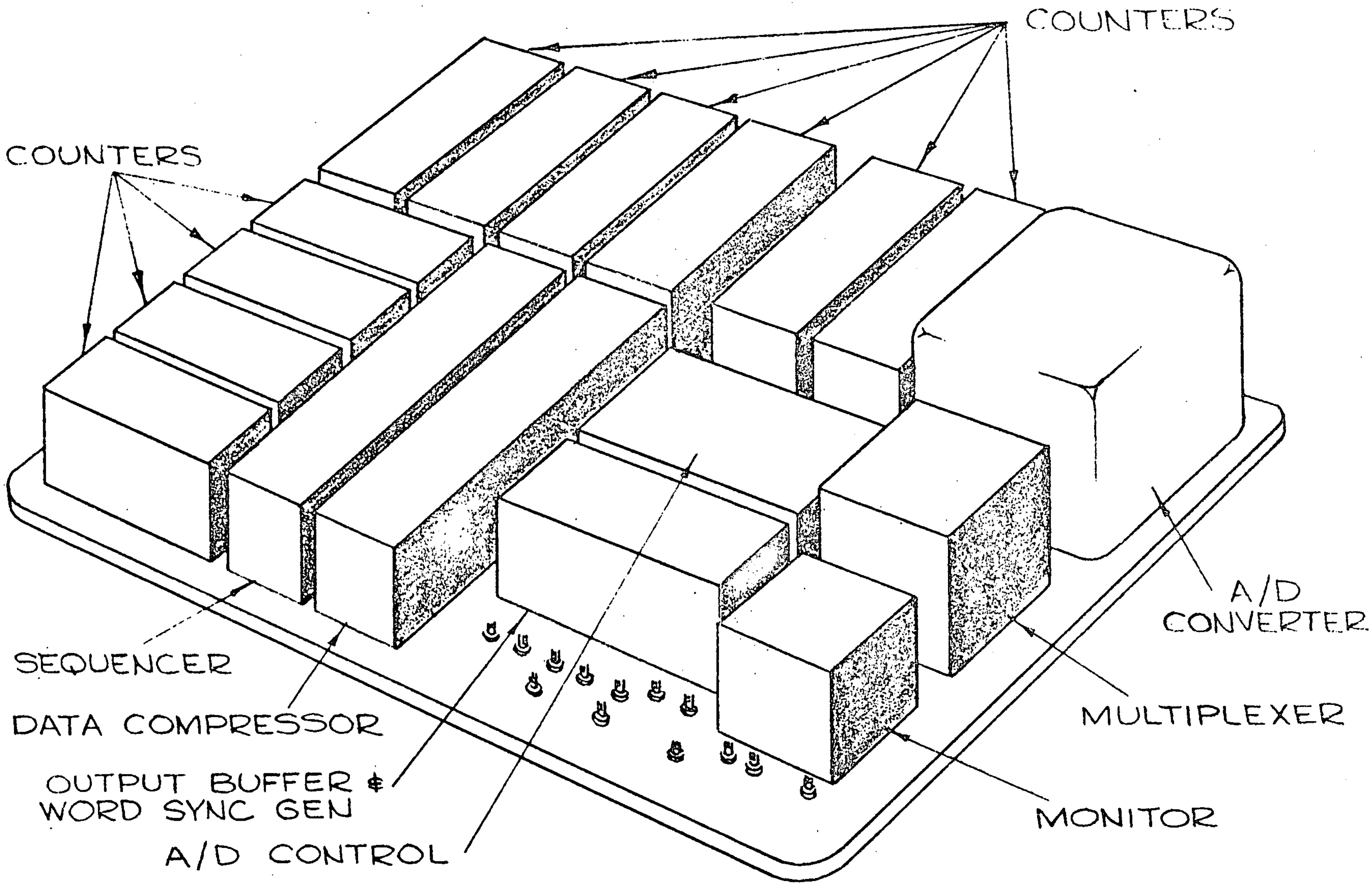


Figure 1 DATA PROCESSOR MOTHER BOARD

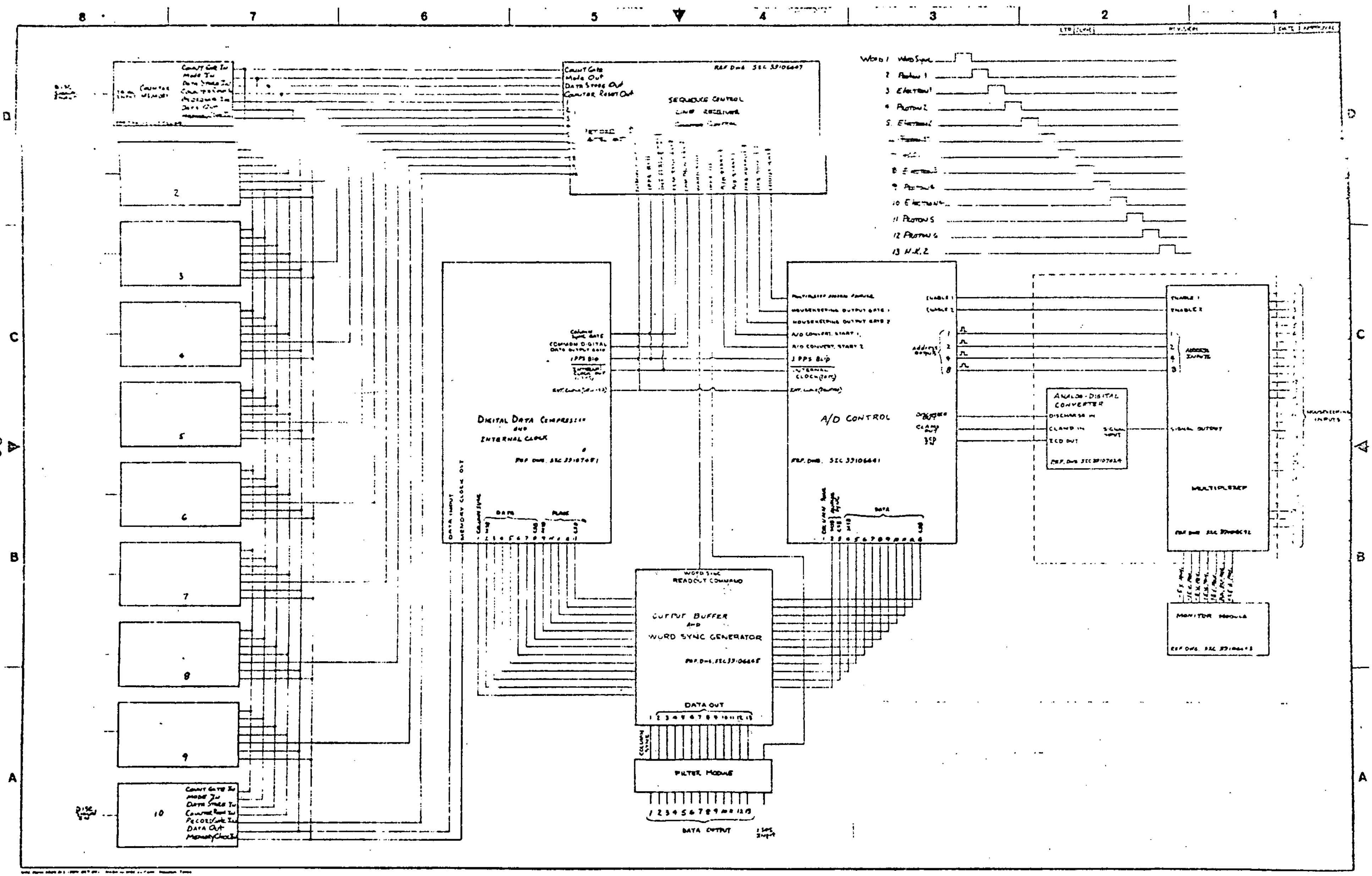


Figure 2 DATA PROCESSOR BLOCK DIAGRAM

There are ten channels of detector information, plus twenty-one sources of housekeeping information. This data is processed and formated to be read out on 13 data lines which are sampled 1 time per second. The EPS Word Format and Main Frame Format are shown in Figure 3 and 4 respectively. All timing sequences are referred to a single clock pulse of one Hertz, which is fed to the instrument from the CSM. This one Hertz timing signal is referred to in the interface control document Number NH04-02119-234 as the CTE timing signal.

The major events and related timing is shown in the timing diagram, Figure 5.

The data processor operates properly from -50°C to +70°C. All digital circuits operate properly over this temperature while V_{cc} is varied from 4.6 volts to 5.3 volts. The digital circuits are Texas Instrument low power T^2L logic, except for four standard power packages where more drive capability is required. There are also four low power one-shot packages from Advanced Micro, and one comparator from National.

EPS WORD FORMAT

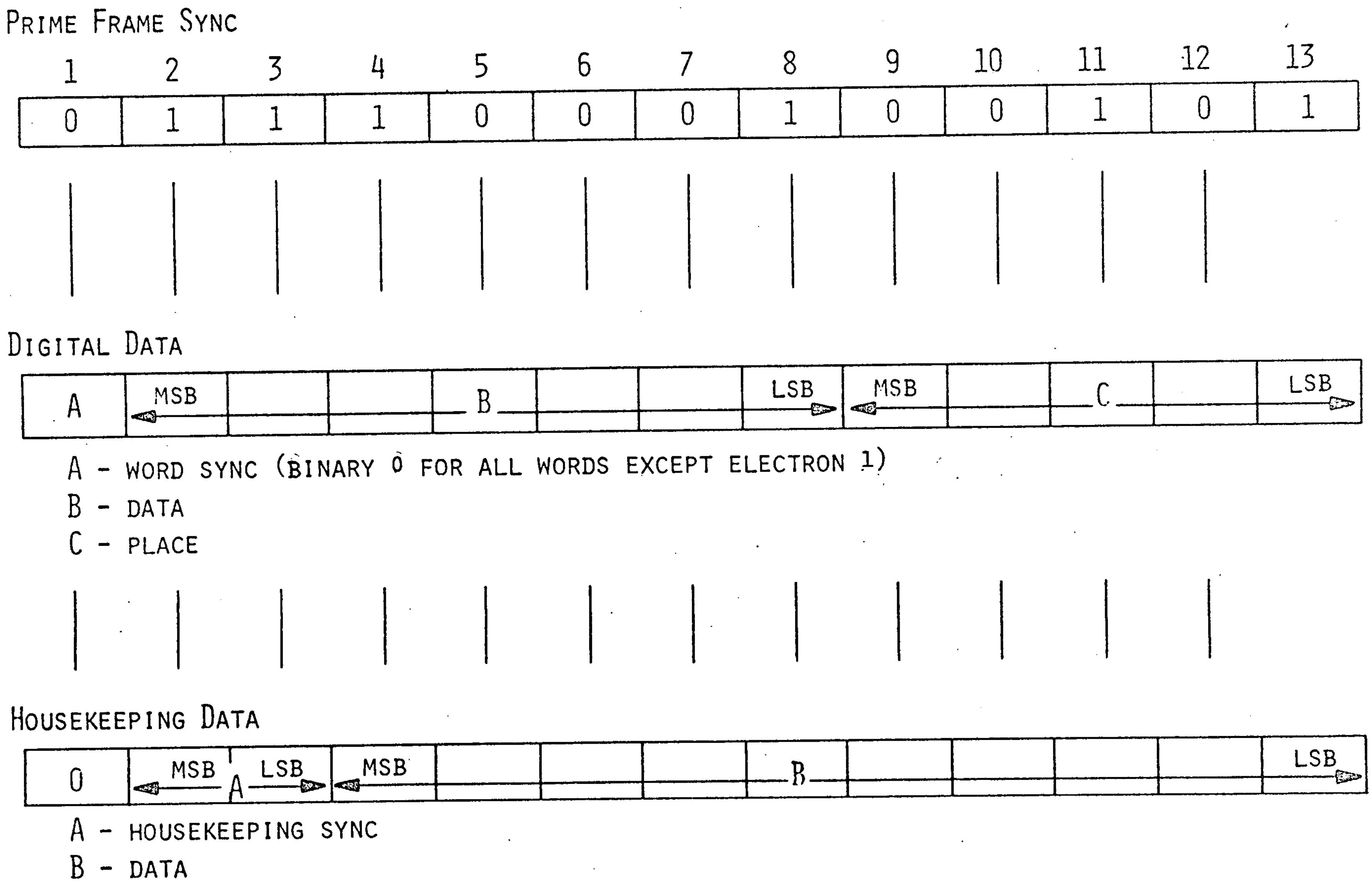


Figure 3 EPS WORD FORMAT

EPS MAIN FRAME

WORD LOCATION →

PRIME FRAME NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13
1	PRIME FRAME SYNC	DET 1 ELEC	DET 1 PROT	DET 2 ELEC	DET 2 PROT	DET 3 ELEC	HOUSE KPG 1A	DET 3 PROT	DET 4 ELEC	DET 4 PROT	DET 5 PROT	DET 5 PROT	HOUSE KPG 1B
2							2A						2B
3							3A						3B
4							4A						4B
5							5A						5B
6							6A						6B
7							7A						7B
8							8A						8B
9							9A						9B
10							10A						10B
11							11A						11B
12							12A						12B
13							13A						13B
14							14A						14B
15							15A						15B
16	PRIME FRAME SYNC	DET 1 ELEC	DET 1 PROT	DET 2 ELEC	DET 2 PROT	DET 3 ELEC	16A	DET 3 PROT	DET 4 ELEC	DET 4 PROT	DET 5 PROT	DET 5 PROT	16B

← 13 SECONDS →

MAIN FRAME = 208 SECONDS

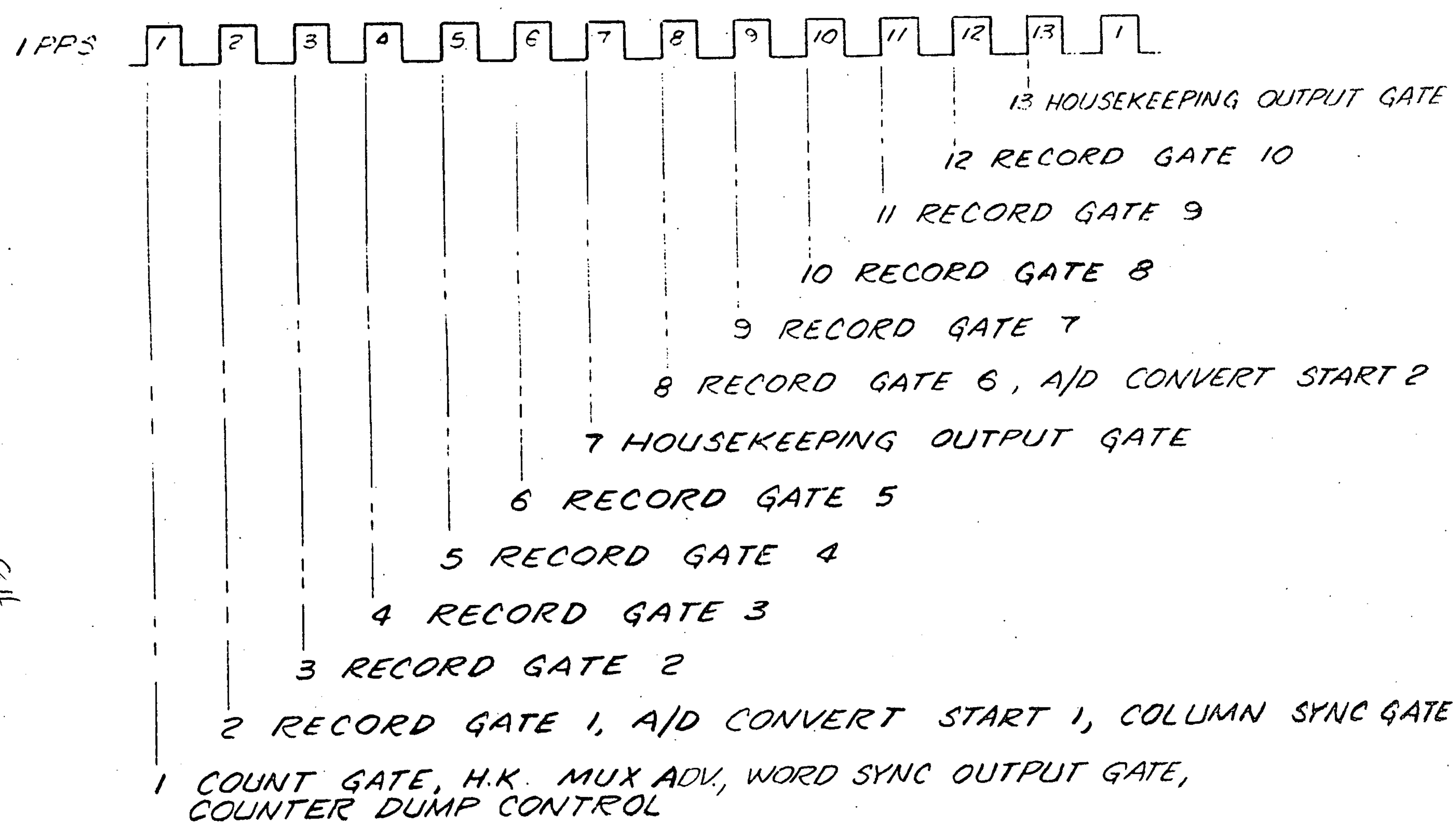


Figure 5 TIMING DIAGRAM - WORD SEQUENCE/EVENTS

GENERAL DATA PROCESSOR SPECIFICATION

The EPS Data Processor consists of a sequence controller, ten counter registers, a digital data compressor, an analog to digital converter, A/D control, a 32 channel analog multiplexer and a parallel output buffer. The spacecraft information interface consists of thirteen bilevel data lines and one synchronizing command line. The thirteen bilevel lines are sampled, in parallel, at a rate of 1 Hz with each sample occurring a minimum of 20 milliseconds after the positive going transition of the 1 Hz synchronizing command. Scientific data accumulation specifications are:

1. Counting Interval - 12 seconds
2. Recording Interval - 13 seconds
3. Fractional Counter Livetime - 92.3%
4. Counter Capacity - $2^{24}-1$ = 16,777,215 events/channel
5. Counting Rate Maximum -2.80×10^6 cps/channel for no overflow.
6. Readout Format - floating point binary compression, seven bit data word plus five bit place word.
7. Digital Accuracy - ±0.5% of value

The EPS Housekeeping data accumulation specifications are:

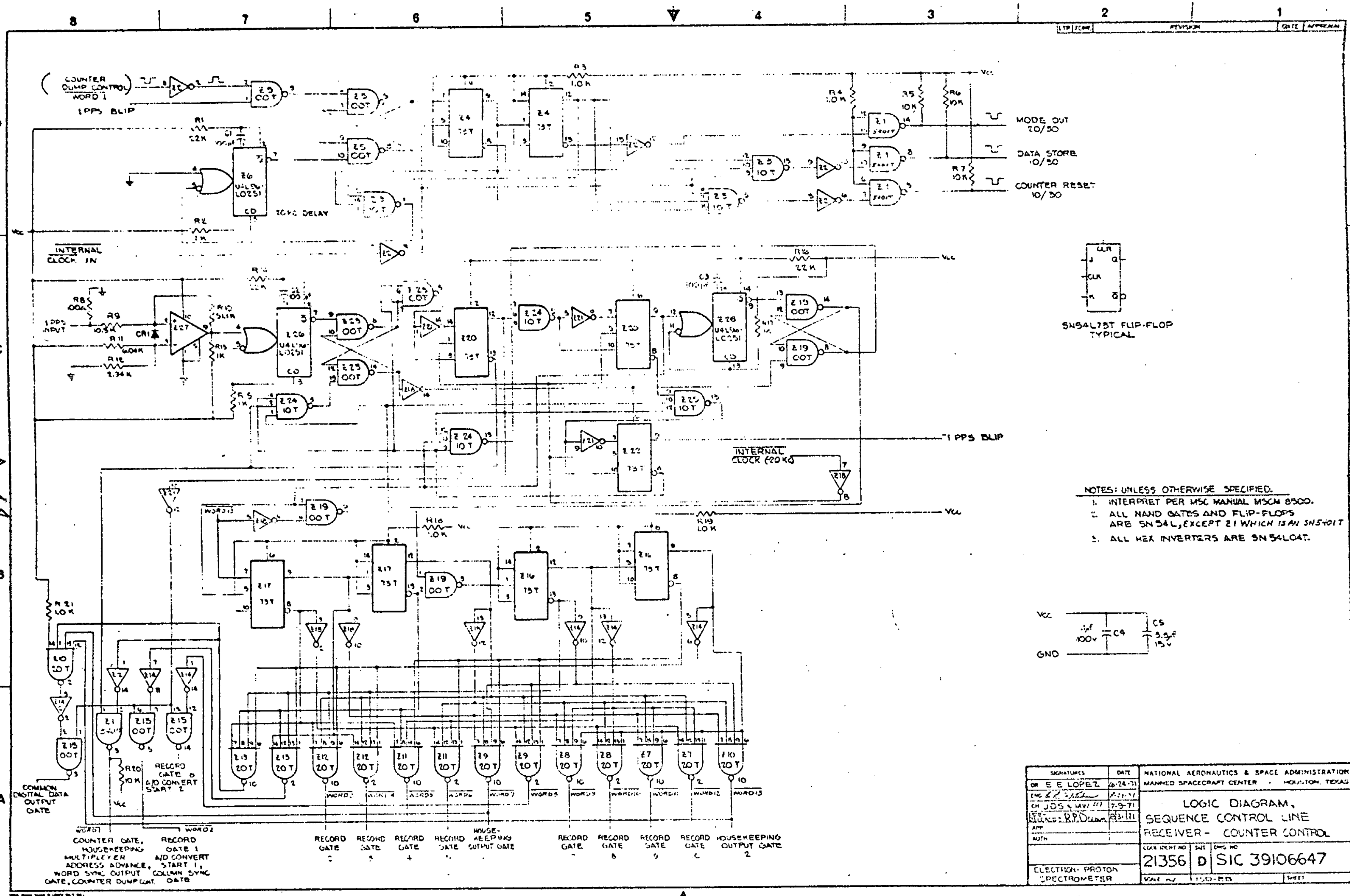
1. Sample Rate - .154/sec
2. Sample Rate Per Channel - .0048/sec
3. Conversion Gain - 10 bits
4. Number of Channels - 32
5. Address, Range, Resolution, Accuracy - See Table I

TABLE I. EPS DATA PROCESSOR HOUSEKEEPING SEQUENCE PARAMETER RANGE, ACCURACY, AND RESOLUTION CHART

PRIME FRAME NO.	HOUSE-KEEPING ID BIT 2	ID BIT 3	MEASUREMENT		ACCURACY	RESOLUTION
1A	0	0	Package Temperature	$-50°C$ to $+50°C$	$\pm 1.0°C$	0.110°C
2A	0	0	Detector 1 Noise	0 to 50 Kev	± 5 Kev	0.5 Kev
3A	0	0	Detector 1 Leakage	10^{-3} µA to 10^{0} µA	$\pm 5 \times 10^{-3}$ µA	10^{-3} µA
4A	0	0	Detector Plate Temp	$-50°C$ to $+50°C$	$\pm 1.0°C$	0.110°C
5A	0	1	Detector 2 Noise	0 to 50 Kev	± 5 Kev	0.5 Kev
6A	0	1	Detector 2 Leakage	2×10^{-3} µA to 2×10^{0} µA	$\pm 5 \times 10^{-3}$ µA	2×10^{-3} µA
7A	0	1	+5 Volt Monitor	0 volts to +10 volts	± 5 mv	10 mv
8A	0	1	Detector 3 Noise	0 to 50 Kev	± 5 Kev	0.5 Kev
9A	1	0	Detector 3 Leakage	2×10^{-3} µA to 2×10^{0} µA	$\pm 5 \times 10^{-3}$ µA	2×10^{-3} µA
10A	1	0	+8 Volt Monitor	0 volts to +10 volts	± 5 mv	10 mv
11A	1	0	-8 Volt Monitor	*	*	*
12A	1	0	+25 Volt Monitor	0 volts to +55 volts	± 27 mv	54 mv
13A	1	1	350 Volt Monitor	0 volts to 505 volts	± 250 mv	500 mv
14A	1	1	-15 Volt Monitor	*	*	*
15A	1	1	-5 Volt Monitor	*	*	*
16A	1	1	Discrim. Ref. Mon.	0 V to 6.002 V	± 3 mv	6 mv
1B	0	0	Package Temperature	$-50°C$ to $+50°C$	$\pm 1.5°C$	0.110°C
2B	0	1	Detector 4 Noise	0 to 50 Kev	± 5 Kev	0.5 Kev
3B	1	0	Detector 4 Leakage	2×10^{-3} µA to 2×10^{0} µA	$\pm 5 \times 10^{-3}$ µA	2×10^{-3} µA
4B	1	1	Detector Plate Temp	$-50°C$ to $+50°C$	$\pm 1.0°C$	0.110°C
5B	0	0	Detector 5 Noise	0 to 50 Kev	± 5 Kev	0.5 Kev
6B	0	1	Detector 5 Leakage	2×10^{-3} µA to 2×10^{0} µA	$\pm 5 \times 10^{-3}$ µA	2×10^{-3} µA
7B	1	0	+5 Volt Monitor	0 volts to +10 volts	± 5 mv	10 mv
8B	1	1	Heater Monitor	On/Off	*	*
9B	0	0	Heater Monitor	On/Off	*	*
10B	0	1	+8 Volt Monitor	0 volts to +10 volts	± 5 mv	10 mv
11B	1	0	-8 Volt Monitor	*	*	*
12B	1	1	+25 Volt Monitor	0 volts to +55 volts	± 27 mv	54 mv
13B	0	0	350 Volt Monitor	0 volts to 505 volts	± 250 mv	500 mv
14B	0	1	-15 Volt Monitor	*	*	*
15B	1	0	-5 Volt Monitor	*	*	*
16B	1	1	Discrim. Ref. Mon.	0 V to 6.0020 V	± 3 mv	6 mv

3.4.1 SEQUENCE CONTROL, LINE RECEIVER - COUNTER CONTROL

This module (Schematic SIC39106647) generates the timing sequence for the thirteen word intervals. The one Hertz Clock pulse is used in this module to synchronize all data to the CSM data requirements. The counter control pulses are also generated in this module and are used to start the counter, shift the data from the counters to the registers and reset the counters.


COUNTER DUMP CONTROL WORD 1
1 PPS BLIP
INTERNAL CLOCK IN
1 PPS INPUT
10 μs DELAY
MODE OUT 20/30
DATA STORE 10/30
COUNTER RESET 10/30
1 PPS BLIP
INTERNAL CLOCK (20 KC)
SN54L73T FLIP-FLOP TYPICAL
NOTES: UNLESS OTHERWISE SPECIFIED.
1. INTERPRET PER MSC MANUAL MSCM 8500.
2. ALL NAND GATES AND FLIP-FLOPS ARE SN54L, EXCEPT Z1 WHICH IS AN SN5401T
3. ALL HEX INVERTERS ARE SN54L04T.
VCC
GND
COMMON DIGITAL DATA OUTPUT GATE
COUNTER GATE, HOUSEKEEPING MULTIPLEXER ADDRESS ADVANCE, WORD SYNC OUTPUT GATE, COUNTER DUMP CONT.
RECORD GATE 1 A/D CONVERT START 1, COLUMN SYNC GATE
RECORD GATE 0 A/D CONVERT START 2
RECORD GATE
HOUSEKEEPING OUTPUT GATE
HOUSEKEEPING OUTPUT GATE 2
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER · HOUSTON, TEXAS
LOGIC DIAGRAM, SEQUENCE CONTROL LINE RECEIVER - COUNTER CONTROL
DR E. E. LOPEZ 6-24-71
CH JOS
21356 D SIC 39106647
ELECTRON- PROTON SPECTROMETER

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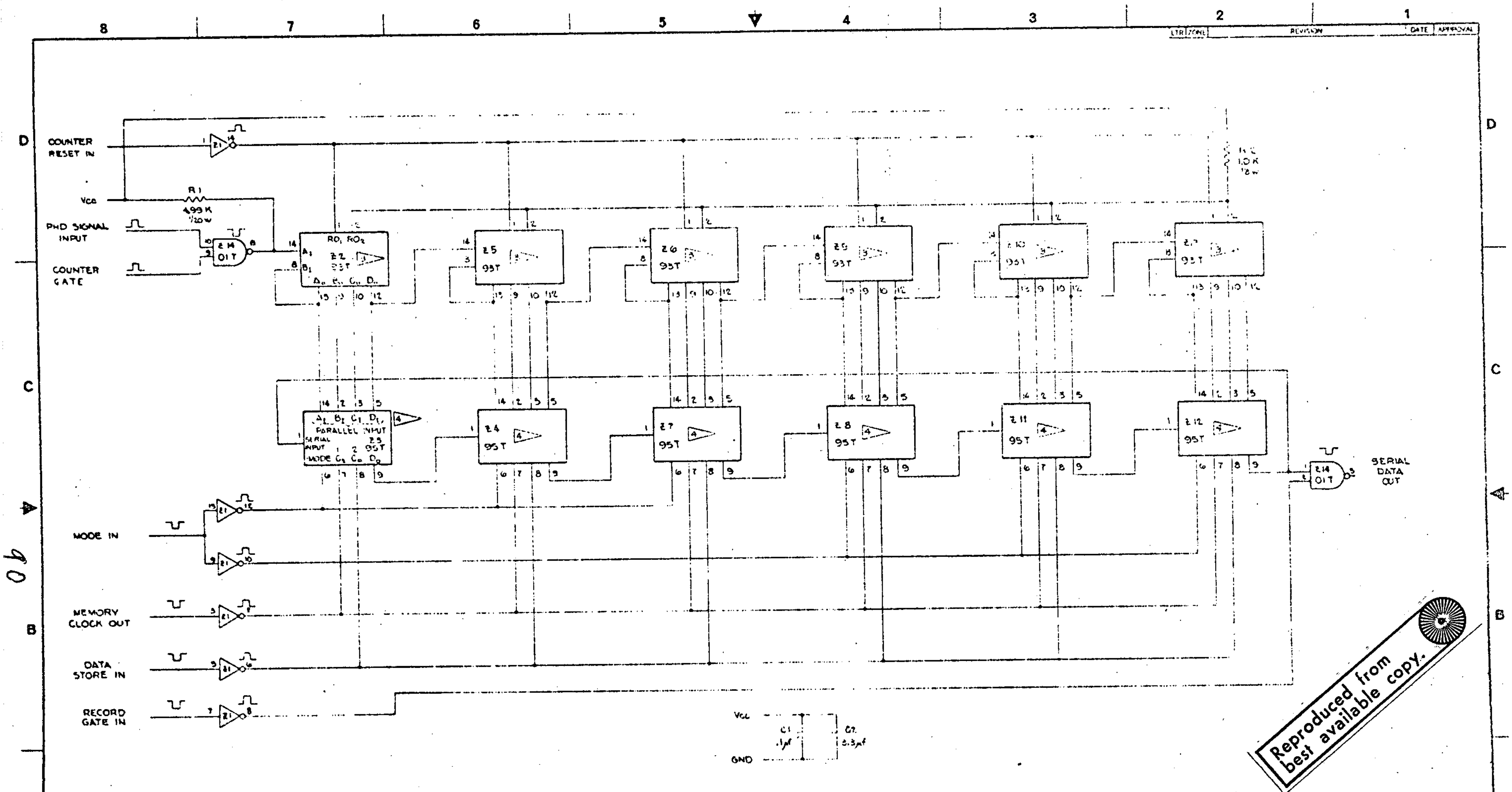
3.4.2 COUNTER-MEMORY

The Counter-Memory Module (Schematic SIC39106648) contains a 24-bit counter and 24-bit parallel entry, serial out shift register. The counter counts pulses fed in at the PHD input. The counter has a count rate capability of 2.3 Mega Hertz. The counter is gated on by a positive counter gate signal. The normal count time is 12 seconds. Data is shifted into the register by the two signals called Mode and Data Store. The counter is then reset and ready to start another count cycle. The data is shifted through the shift register with a 24-pulse train. If the Record Gate is on, the data stored in the shift register will appear at the Serial Data output. The 24 pulses per shift cycle circulate the data by the output gate and return the data to its original position in the shift register. The data remains in the shift register until it is replaced by new data from the counters during the next data shift operation. There are ten identical counter-memory modules in the EPS instrument.



NOTES: UNLESS OTHERWISE SPECIFIED.

1. INTERPRET PER MSC MANUAL MSCM 8500.
2. ALL NAND GATES, COUNTERS & REGISTERS ARE SN54L SERIES; INVERTER IS SN54L04T.
3. 4 BIT COUNTER TYPICAL 6 PLACES.
4. 4 BIT SHIFT REGISTER TYPICAL 6 PLACES.
5. Vcc PIN 4, GND P11 ON ALL PACKS.

SIGNATURES	DATE
DR E E LOPEZ	6/14/71
ENG	
CH JDS EMW	7-5-71
APP	
AUTH	

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER · HOUSTON, TEXAS

LOGIC DIAGRAM, EPS DATA PROCESSOR – COUNTER – MEMORY

ELECTRON PROTON SPECTROMETER

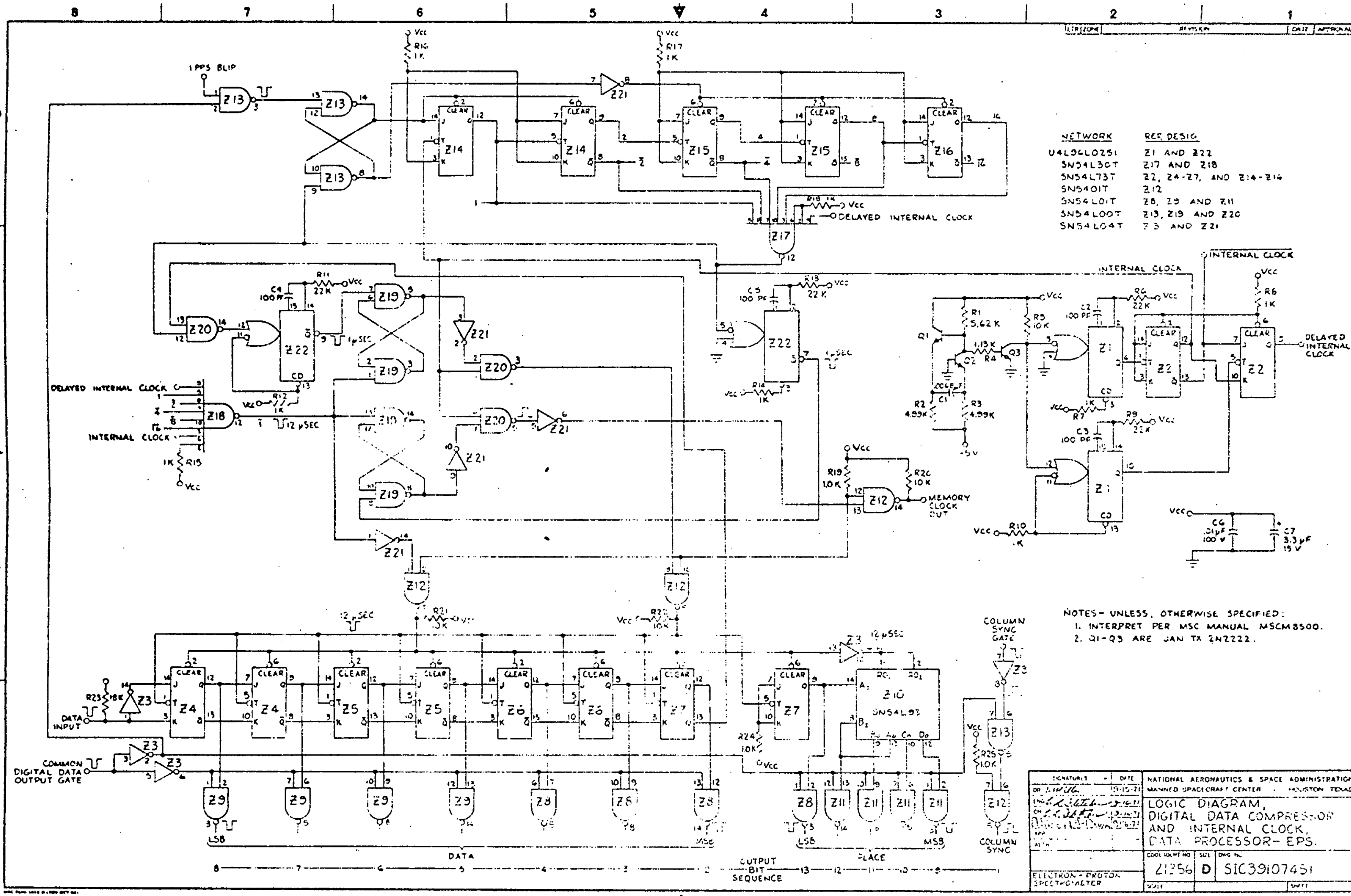
CODE IDENT NO	SIZE	DWG NO
21356	D	SIC39106648

SCALE ~ 150-E5 SHEET

3.4.3 DIGITAL DATA COMPRESSOR AND INTERNAL CLOCK

The Digital Data Compressor and Internal Clock module (Schematic SIC39107451) generates the memory clock (for shifting the digital data in the counter-memory modules), compresses the digital data so that the seven most significant bits are read out, and generates the internal, biphase clock pulses. The data from the shift register is shifted into the data compressor until a "1" is shifted into the MSB position, or until 24 shifts occur. The number of shifts which occur during any one shift cycle is counted by the 5-bit shift counter. Thus, the data output consists of 7 bits of data, 5 bits of shift data, or "place", and 1 bit which is called column sync. The column sync bit is a "0" except during the second word. Then it is a "1".

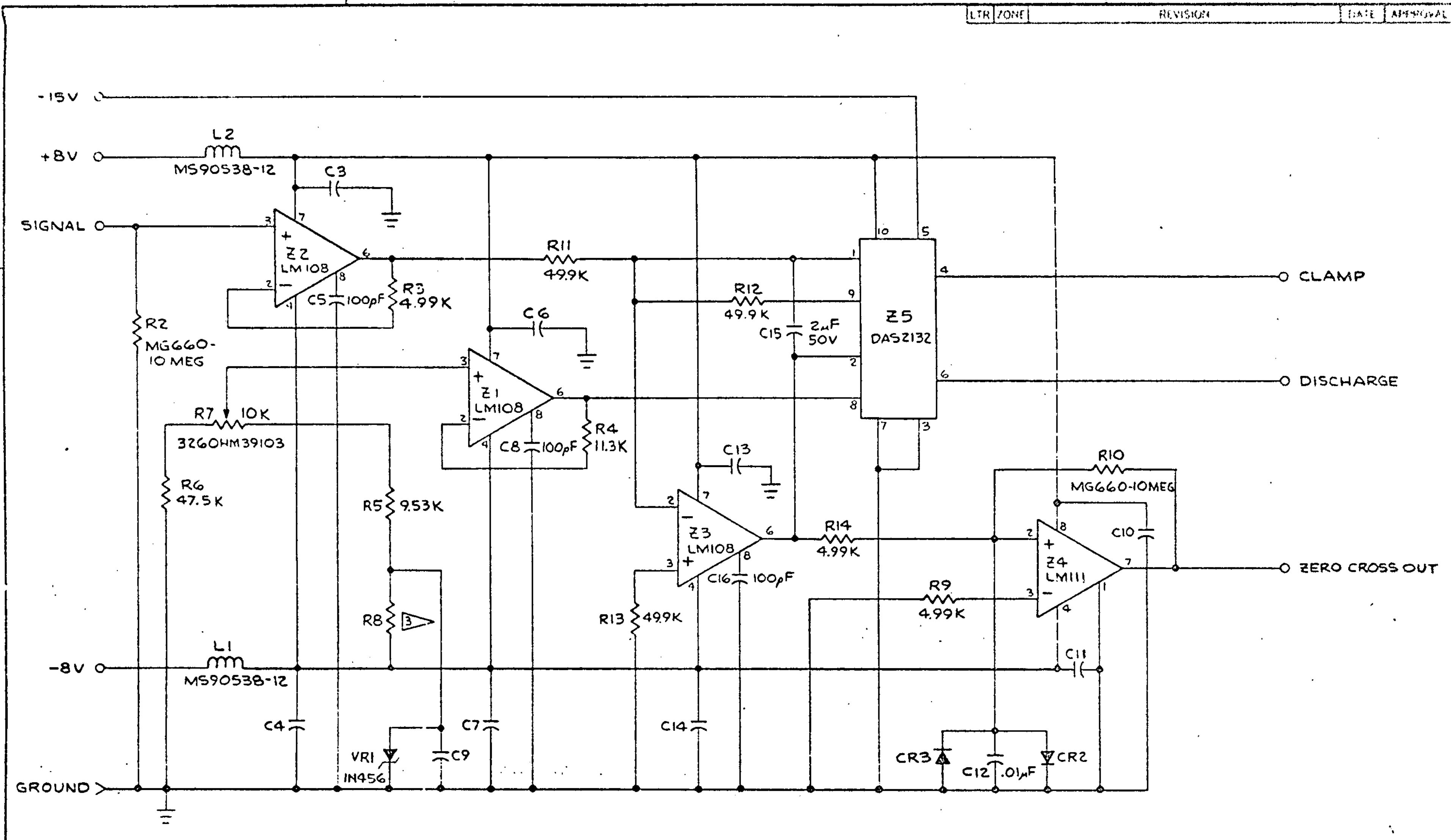
The bi-phase clock consists of a basic 40 k Hertz oscillator, two one-shots and a divide by two circuit, giving an internal clock frequency of 20 k Hertz. The delayed clock output lags the clock by 90 degrees and is used in decoding circuits to inhibit glitches on decoded outputs during flipflop transitions.


NETWORK / REF DESIG
U4L96L0251 — Z1 AND Z22
SN54L30T — Z17 AND Z18
SN54L73T — Z2, Z4-Z7, AND Z14-Z16
SN5401T — Z12
SN54L01T — Z8, Z9 AND Z11
SN54L00T — Z13, Z19 AND Z20
SN54L04T — Z3 AND Z21
NOTES- UNLESS OTHERWISE SPECIFIED:
1. INTERPRET PER MSC MANUAL MSCM8500.
2. Q1-Q3 ARE JAN TX 2N2222.
1 PPS BLIP
DELAYED INTERNAL CLOCK
INTERNAL CLOCK
MEMORY CLOCK OUT
DATA INPUT
COMMON DIGITAL DATA OUTPUT GATE
COLUMN SYNC GATE
COLUMN SYNC
LSB
MSB
DATA
PLACE
OUTPUT BIT SEQUENCE
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER HOUSTON TEXAS
LOGIC DIAGRAM, DIGITAL DATA COMPRESSOR AND INTERNAL CLOCK, DATA PROCESSOR- EPS.
ELECTRON - PROTON SPECTROMETER
21356
D
SIC39107451

3.4.4 ANALOG-DIGITAL CONVERTER (SCHEMATIC SIC39107024)

The analog to digital converter is a 10-bit unit utilizing the dual-slope principle and a zero-crossing detector. The basic circuits are a buffer amplifier, reference amplifier, integrating amplifier, dual J-FET switch, and a comparator. The buffer amplifier serves as interface between all house-keeping data sources and the integrating amplifier. The reference amplifier provides a very stable source of current and its reference is a temperature controlled Zener diode. One of the J-FET switches controls the reference current to the integrating amplifier. The other J-FET switch discharges the integrating capacitor and holds it in a zero charge state during the clamp time interval. The integrating capacitor is a 2 microfarad polycarbonate with very low leakage, low dissipation factor, and low temperature coefficient. The integrating amplifier provides drive to the comparator, which has approximately 10 mV of hysteresis to eliminate false zero-crossing output. The comparator output is used in the timing control of the A/D Control Logic.

The timing sequence of the conversion process is shown in the Analog-Digital Conversion Timing Chart, Fig. 6. The operation is as follows: The multiplexer is gated on (enabled) and an analog voltage is fed to the buffer amplifier, which charges the integrating capacitor through a 49.9 K ohm resistor for a fixed time (.051 sec.). The capacitor will assume a charge dependent upon the analog voltage level which is limited to a maximum of 5 volts. The multiplexer is then switched off, the reference current is switched in, and



NOTES - UNLESS OTHERWISE SPECIFIED:

1. ALL RESISTORS ARE RNC50 1/20 W.
2. ALL CAPACITORS ARE .1μF CKR06

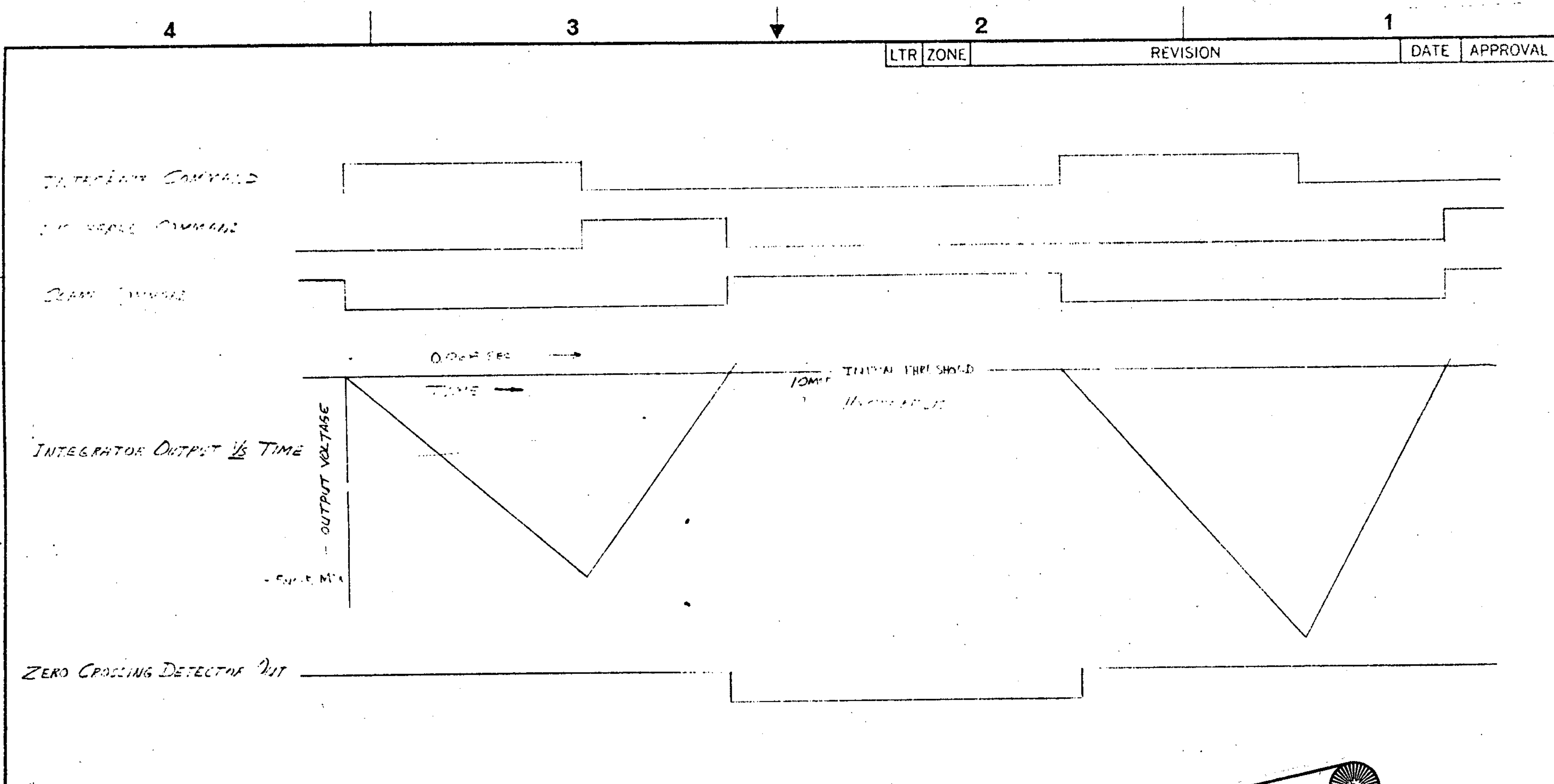
3. VALUE TO BE SELECTED DURING ACCEPTANCE TEST PER LEC DOCUMENT NO. EPS-403

SIGNATURES	DATE
DR	9-16-71
ENG	9-20-71
CH	9-20-71
	9/21/71
APP	
AUTH	

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER · HOUSTON, TEXAS

SCHEMATIC - ANALOG-DIGITAL CONVERTER

CODE IDENT NO. 21356 SIZE C DWG NO SIC39107024



*ASSUMES AN ABSOLUTE MINIMUM CLOCK FREQUENCY

Figure 6 ANALOG-DIGITAL CONVERSION TIMING CHART the capacitor is discharged at a constant rate from the reference circuit. When the capacitor charge passes through zero the comparator changes state and stops the conversion process. The digital word is generated in the A/D Control Logic and is discussed in Section 3.4.5.

Sources of error in the analog-digital conversion are offset voltages in the amplifiers, leakage current through the J-FET switches, variation in the reference circuit and comparator offset. The offset voltage of the amplifiers and comparator are specified to be less than 3 mV. Leakage current through the J-FET switches was measured and caused no error under actual circuit operation. The reference circuit has a temperature compensated Zener diode reference, and the actual measured temperature coefficient for the reference circuit is .0007%/°C over the -50°C to +70°C temperature range. The maximum analog voltage which may be measured is 5 volts. The resolution is 5 mV or 1 bit.

ANALOG-DIGITAL CONVERTER SPECIFICATION

1. ADC Analog Section

The analog to digital converter is a dual slope type, with the input range of 0 to 5 volts. The output is 10 bits with an accuracy of ± 1 LSB over the temperature range of -25° C to +50° C.

2. Reference Amplifier, Integrating Amplifier and Buffer Amplifier

V_{OFFSET}	3 mv max
V_{OFFSET} Temp. Coef.	15 µV/°C
I_{OFFSET}	.4 na max
Operating Temp. Range	-55°C to +125°C
Power Supply Requirement/Amplifier	±8 Volts @ .5 ma
Common Mode Rejection Ratio	85 dB min
Power Supply Rejection Rate	80 dB min
Large Signal Voltage Gain	300 V/mv typical

3. Analog Switch

The analog switches are J_{FET} devices with drivers. The DAS 2132 is a dual unit, each unit having separate control.

Power Supply Requirements	+8 volts	2 ma/switch "ON"
		0 ma/switch "OFF"
	-15 volts	1.6 ma/switch "ON"
		0 ma/switch "OFF"
Logic Level Required for "ON-OFF" Control (TTL Compatible)		"ON" + 3 Volt "OFF" 0 Volt
Operating Temp. Range		-55°C to +125°C
Resistance of Switch		"ON" = 80 ohms
		"OFF" 200 megohms
Turn-on Time	.5 μsec	
Turn-off Time	.5 μsec	

4. Integrating Capacitor

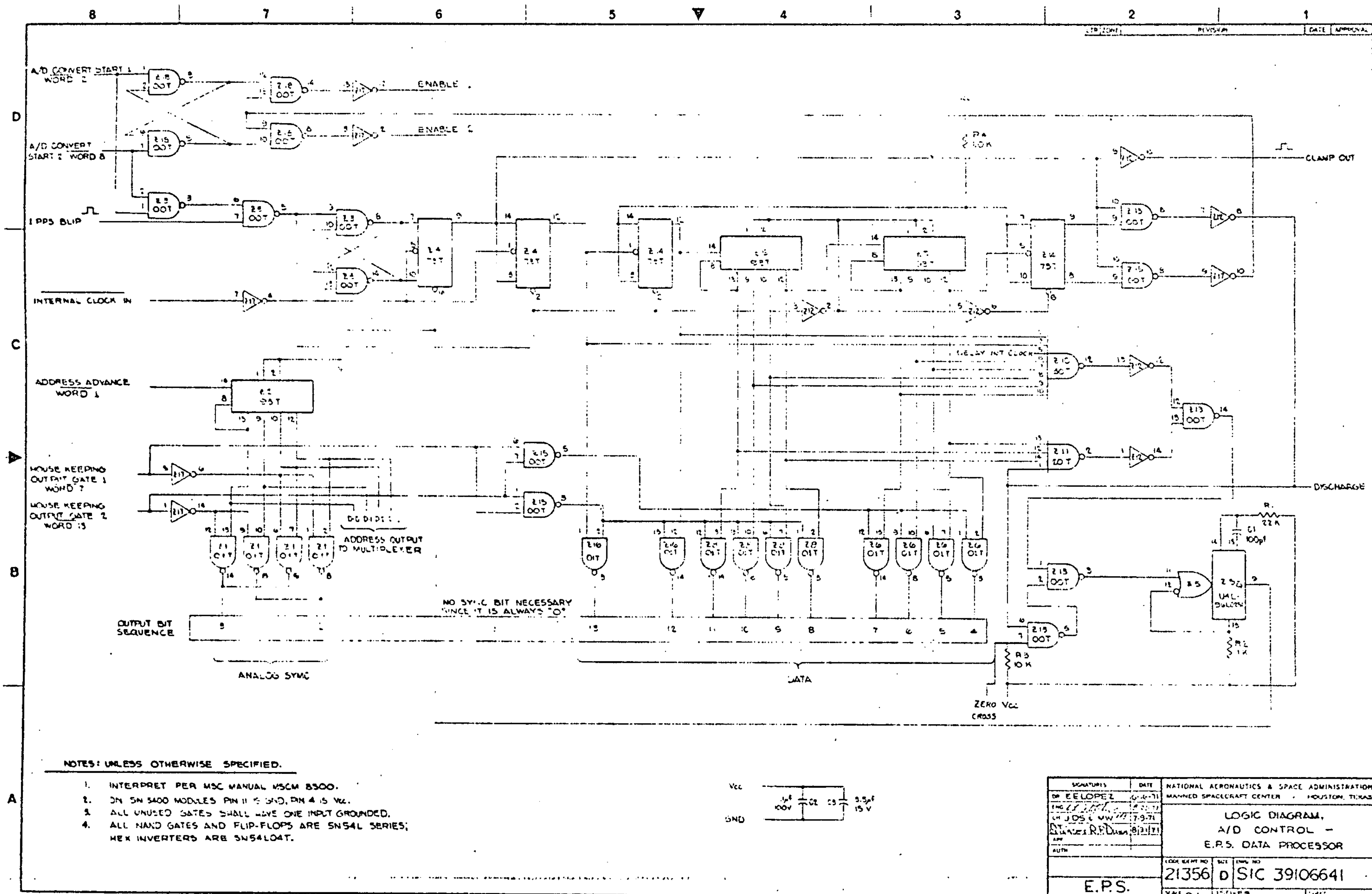
Capacitance/Voltage	2 μf/50 VDC
Insulation Resistance @ 60°C	3000 megohms - microfarads
Percentage Capacitance Change Over Temp. Range - 45°C to +90°C	+1%, -2%
Dissipation Factor (-50°C to +125°C)	+.5%, -0.0%
Capacitor Type	metalized polycarbonate

5. Comparator

Power Supply Requirements	+8 volts @ 10 ma
Operating Temp. Range	-55°C to +125°C
Input Offset Voltage	3 mv maximum
Input Offset Current	10 ηA maximum
Bias Current	100 ηA maximum

3.4.5 A/D CONTROL (SCHEMATIC SIC39106641)

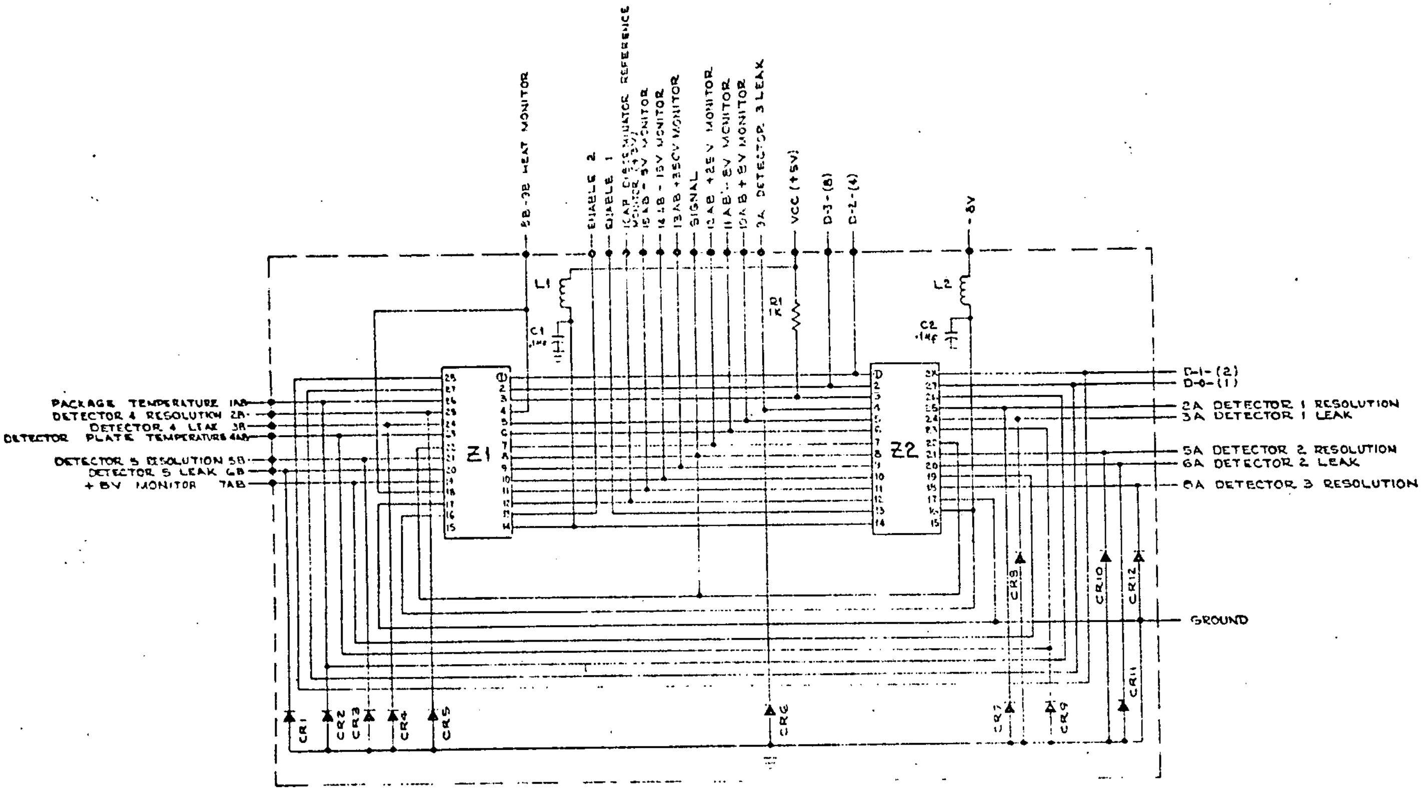
The A/D Control Module provides the control functions for the A/D converter, generates the 10 bit digital word plus two sync bits for the housekeeping data word, and provides four bits of address to the multiplexer. The A/D conversion occurs during intervals 2 and 8 and is initiated by the 1 pps. The latch circuit is set and remains on until the end of the conversion. The gate that sets the latch resets all counters to zero. When the latch is set, the 11 bit counter starts, the clamp signal goes low, and enable 1 or enable 2 goes high. When the eleventh bit goes to a high state (1024 clock pulses), the enable line goes low, and the discharge line goes high. The counter continues to count until "Zero Cross" occurs, which resets the latch and stops the counter. The number in the counter is the digitized equivalent of the analog input to the A/D converter. The data appears on the output gates and is read out during interval 7 or 13.



A/D CONVERT START 1 WORD 2
A/D CONVERT START 2 WORD 8
1 PPS BLIP
INTERNAL CLOCK IN
ADDRESS ADVANCE WORD 1
HOUSE KEEPING OUTPUT GATE 1 WORD 7
HOUSE KEEPING OUTPUT GATE 2 WORD 13
ENABLE 1
ENABLE 2
CLAMP OUT
DISCHARGE
DELAY INT CLOCK
ADDRESS OUTPUT TO MULTIPLEXER
NO SYNC BIT NECESSARY SINCE IT IS ALWAYS "0"
OUTPUT BIT SEQUENCE
ANALOG SYNC
DATA
ZERO Vcc CROSS
NOTES: UNLESS OTHERWISE SPECIFIED.
1. INTERPRET PER MSC MANUAL MSCM 8300.
2. ON SN 5400 MODULES PIN 11 IS GND, PIN 4 IS Vcc.
3. ALL UNUSED GATES SHALL HAVE ONE INPUT GROUNDED.
4. ALL NAND GATES AND FLIP-FLOPS ARE SN54L SERIES; HEX INVERTERS ARE SN54L04T.
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER · HOUSTON, TEXAS
LOGIC DIAGRAM, A/D CONTROL - E.P.S. DATA PROCESSOR
21356
D
SIC 39106641
E.P.S.

3.4.6 MULTIPLEXER MODULE (SCHEMATIC SIC39106642)

The Multiplexer Module consists of two integrated circuit packages each containing a 16-channel multiplexer. The two units are operated as a 32-channel unit. There are 21 sources of data fed through the multiplexer. However, all channels are used, which allows eleven channels of redundant data. The multiplexer package contains the decoding logic required for switching, so it can be operated by the binary outputs of a 4-bit counter. The multiplexer utilizes the J-FET device for switches. Diodes clamps are used to prevent negative bias being applied to the multiplexer.



NOTES: UNLESS OTHERWISE SPECIFIED.

1. INTERPRET PER MSC MANUAL MSCM 8500.
2. Z1 & Z2 - HARRIS HS-9-1000-7, 16 CHANNEL MULTIPLEXER, CAPACITORS ARE TYPE CK06; RESISTOR IS TYPE RCR05.
3. ALL DIODES ARE IN914.

SIGNATURES	DATE	
DR Bill L. Bell	6-17-71	NATIONAL AERONAUTICS & SPACE ADMINISTRATION MANNED SPACECRAFT CENTER · HOUSTON, TEXAS
ENG		SCHEMATIC, MULTIPLEXER MODULE, DATA PROCESSOR E.P.S.
J.D. STRINGER	6-29-71	
E.P. Dunn	8/11/71	
APP		
AUTH		

	CODE IDENT NO	SIZE	DWG NO
EPS	21356	D	SIC 39106642
	SCALE ~	190-E15	SHEET

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MULTIPLEXER SPECIFICATION

The Multiplexer Specifications are outlined below.

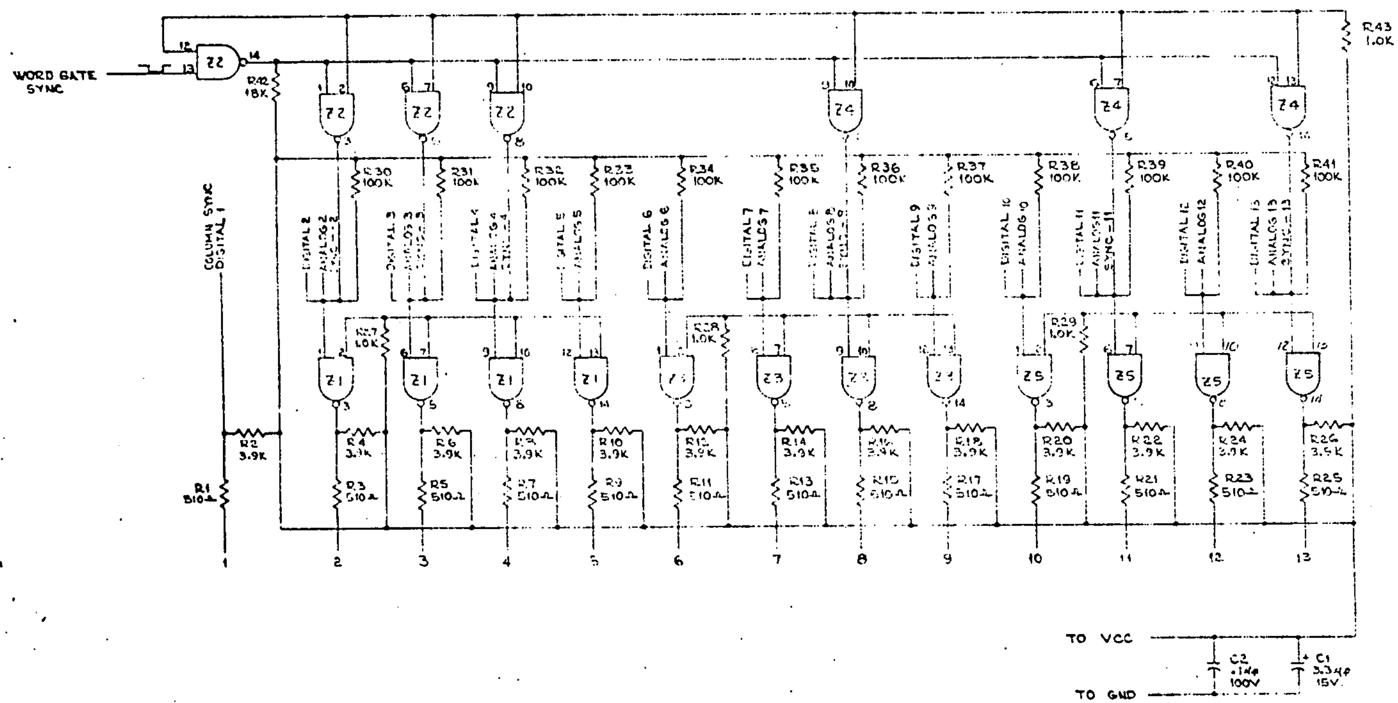
The multiplexer serves as a switching device to route various analog voltages to the analog-to-digital converter (ADC). The individual channel switches must have an "ON" resistance small such that the analog voltage being switched is not lowered significantly. The "OFF" resistance must be sufficiently high to avoid "cross-talk" or leakage from the "OFF" channels to the channel being measured.

Number of Channels	16 x 2 = 32
Power Requirement, Total	(+5 Volts @ 9.6 ma) x 2 = 96 mw (-8 Volts @ 16 ma) x 2 = 256 mw
"ON" Resistance	1200 ohms maximum
"OFF" Leakage Current	$\leq$ 250 Picoamps
Channel Addressing	Compatible to TTL Logic
Cross Talk with V_{in}	20 VP-P, 100 kHz - - - -80 dB
Environmental	MIL-STD 883, Condition B
Analog Voltage Range Input	0.0 to +5.0 Volts

3.4.7 OUTPUT BUFFER AND WORD SYNC GENERATOR (SCHEMATIC SIC39106645)

The Output Buffer and Word Sync Generator interfaces all data from the EPS to the CSM telemetry. The sync word is also generated in this module. During Word 1 time interval the word sync gate is enabled and the sync word (0111000100101) is fed out on the data lines. The output buffers are standard power T^2L logic chosen to special parameters so that they may be driven by derated low power logic. The inputs to the output buffer are connected in the WIRED-OR configuration, and input data originates in the Data Compressor Module (digital data), the A/D control module (analog data) and the word sync generator circuit. The output of the buffer is designed to meet the interface requirements as specified in the Electrical ICD MH04-02110-234.

The output bits are required to reach their sampled voltage level within 20 milliseconds after the positive going edge of the 1 Hertz clock pulse (Section 3.4.1). This allows approximately 9 charging time constants for the output positive going pulse. The pulse will rise to 3.5 volts in 5 time constants, giving a large safety margin. The discharge time constant for a data bit "0" is approximately 10 times shorter, so no timing problems occur for the "0" bit data. All output data lines are fed out through filters.



NOTES: UNLESS OTHERWISE SPECIFIED

1. INTERPRET PER MSC MANUAL MSCM 8500.
2. Z2 AND Z4 ARE SN54L01T, Z1,3, AND Z5 ARE SN5401T.
3. TYP FOR ALL NETWORK VCC IS PIN 4 & GND IS PIN 11.
4. ALL RESISTORS ARE 1/8 W

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER · HOUSTON, TEXAS

LOGIC DIAGRAM,
OUTPUT BUFFER & WORD SYNC GEN.
EPS DATA PROCESSOR

CODE IDENT NO	SIZE	DWG NO
21356	D	SIC 39106645

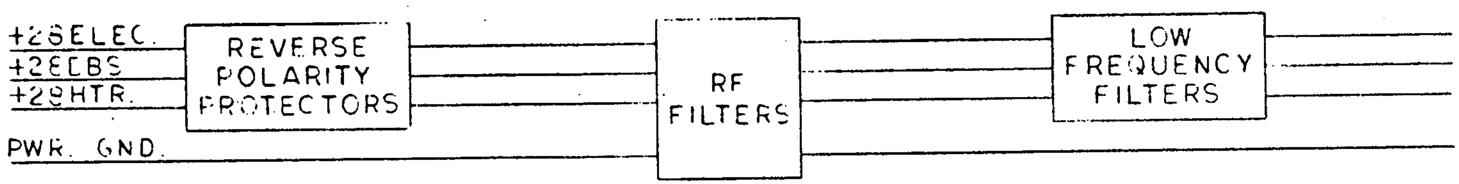
EPS

3.5 POWER SYSTEMS

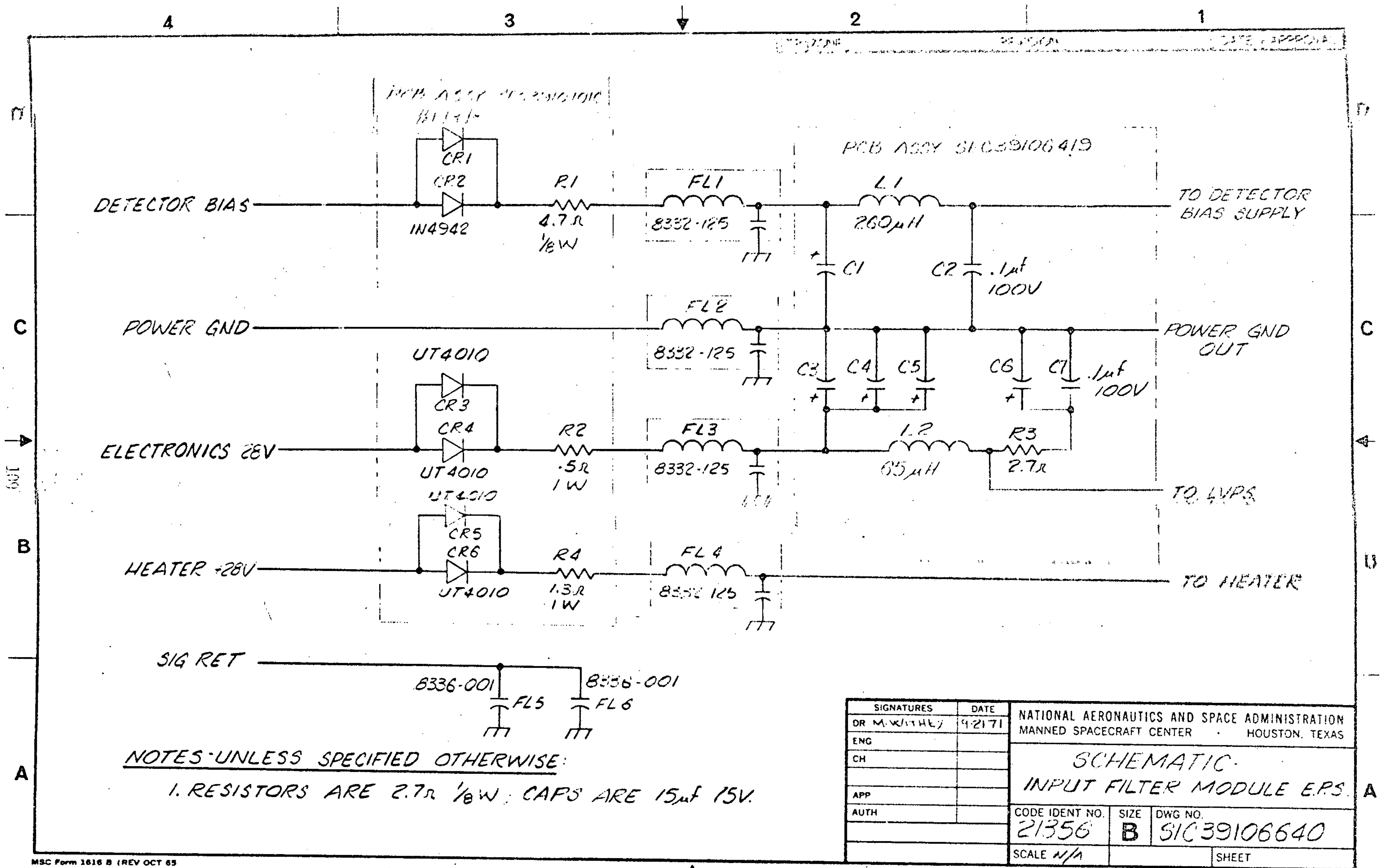
The EPS Power System was designed to receive the +28 V available from the spacecraft and provide the proper output voltages to both the EPS detectors and the electronic subsystems. The design criteria for the EPS power subsystems were partially specified in the EPS Electrical ICD NR #MH04-02119-234 and in the Electromagnetic Compatibility Design Criteria NR Document #MH04-0257-234.

3.5.1 INPUT FILTER

The three plus 28 Vdc power inputs and power ground from the CSM are routed to the EPS power input filter (see Block Diagram and Schematic SIC39106640). Within the Input Filter, all four lines are routed through circuits that protect the EPS from voltages of reverse polarity and from noise and interferences conducted into the EPS. The Input Filter also provides filtering for interference generated within the EPS and conducted out the power lines. The three power lines are then routed to the individual subassemblies.



INPUT FILTER MODULE BLOCK DIAGRAM



PCB ASSY SIC39106419
DETECTOR BIAS
CR1
CR2
1N4942
R1
4.7Ω
1/8W
FL1
8332-125
L1
260μH
C1
C2
.1μf
100V
TO DETECTOR BIAS SUPPLY
POWER GND
FL2
8332-125
POWER GND OUT
UT4010
CR3
CR4
UT4010
C3
C4
C5
C6
C7
.1μf
100V
ELECTRONICS 28V
R2
.5Ω
1W
FL3
8332-125
L2
65μH
R3
2.7Ω
TO LVPS
CR5
CR6
UT4010
HEATER +28V
R4
1.3Ω
1W
FL4
8332-125
TO HEATER
SIG RET
8336-001
FL5
8336-001
FL6
NOTES-UNLESS SPECIFIED OTHERWISE:
1. RESISTORS ARE 2.7Ω 1/8W; CAPS ARE 15μf 15V.
SIGNATURES
DATE
DR M. WITHEY
9-21-71
ENG
CH
APP
AUTH
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER · HOUSTON, TEXAS
SCHEMATIC-
INPUT FILTER MODULE E.P.S.
CODE IDENT NO.
21356
SIZE
B
DWG NO.
SIC39106640
SCALE N/A
SHEET
MSC Form 1616 B (REV OCT 65

ELECTRON-PROTON SPECTROMETER
INPUT FILTER MODULE SPECIFICATIONS

A. Inputs: The EPS Input Filter Module shall accept four separate inputs. These inputs are:

1. Electronics Power Input: 27.5 Vdc ± 2.5 Vdc
2. Detector Bias Power Input: 27.5 Vdc ± 2.5 Vdc
3. Heater Power Input: 27.5 Vdc ± 2.5 Vdc
4. Power Ground

B. Outputs: The Input Filter Module shall provide four separate filtered power outputs to the EPS. These outputs are:

1. Electronics Power (filtered)
2. Detector Bias Power (filtered)
3. Heater Power (filtered)
4. Power Ground (filtered)

C. RFI: The Input Filter Module shall provide the necessary electronic circuits to meet or exceed the requirements of North American Rockwell Corp., Space Division Document MH04-02057-234, Electromagnetic Compatibility Design Criteria.

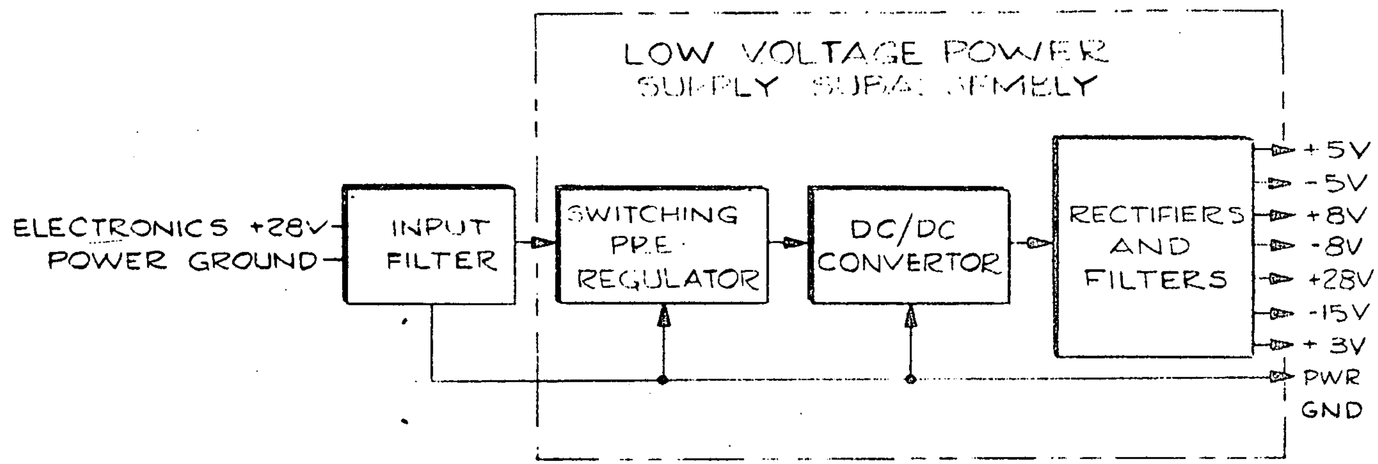
D. Operating Temperature Range: -25°C to +50°C

E. Survival Temperature Range: -50°C to +65°C

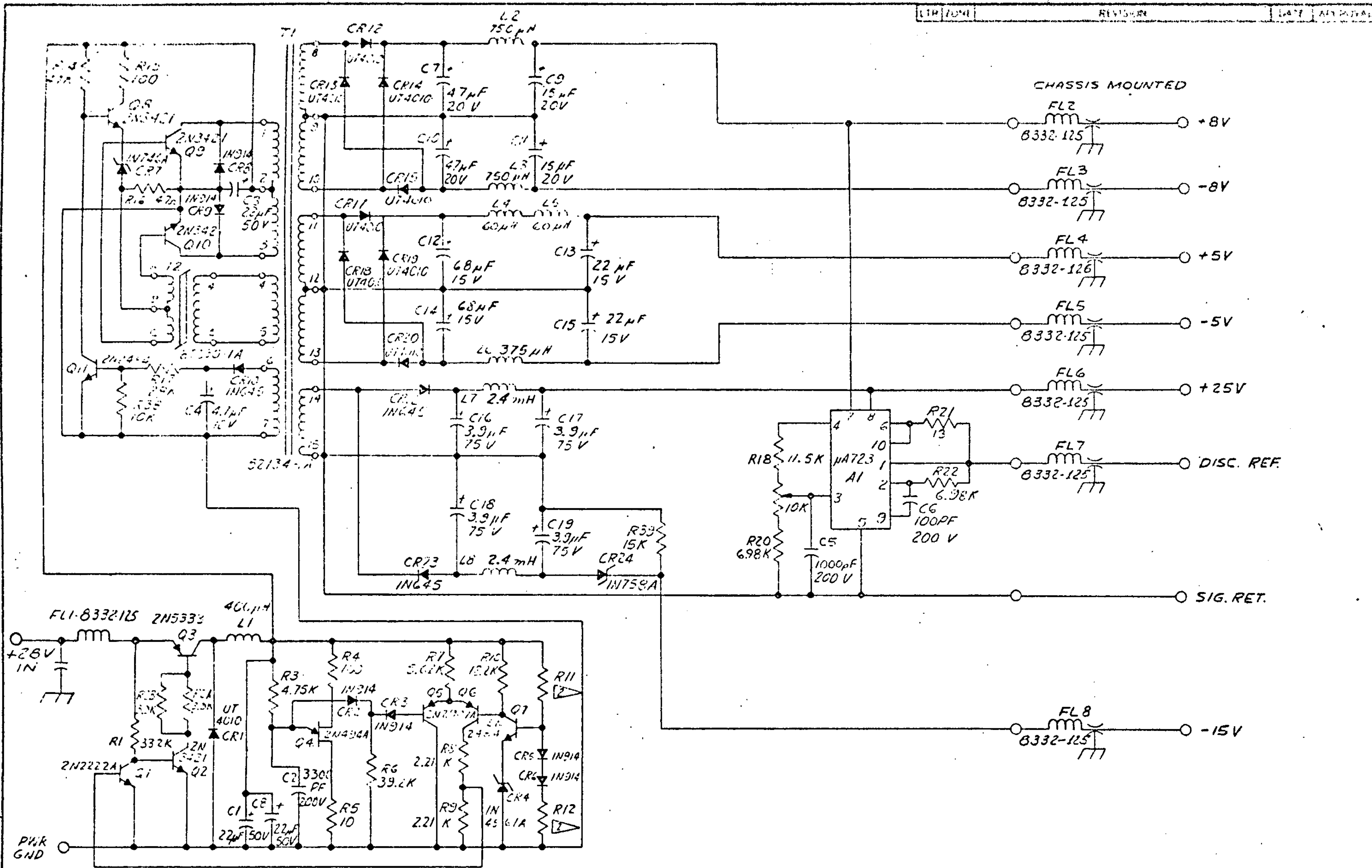
F. Ground Isolation: There shall be a minimum of 1 megohm resistance between the power ground and the EPS external structure (chassis ground).

3.5.2 LOW VOLTAGE POWER SUPPLY

The Low Voltage Power Supply (see Block Diagram and Schematic SIC39106637) receives filtered +28 V which is regulated down to +20 Vdc by utilizing a switching regulator. A switching regulator was used because of the efficiency required. The regulator output is then utilized by the dc/dc converter. There are three separate output windings on the dc/dc converter transformer. These windings produce six different output voltages. One of these outputs (the +8V) is also regulated down to +3.0 V to provide a stable reference voltage for the pulse-height discriminator subassemblies.



LOW VOLTAGE POWER SUPPLY BLOCK DIAGRAM



NOTES: UNLESS OTHERWISE SPECIFIED.

1. INTERPRET PER MSC MANUAL MSCM8500.

2. VALUES OF R11 AND R12 ARE DETERMINED BY ACTUAL VALUE OF V_Z OF CR4.

SIGNATURES	DATE
DR	3-30-71
ENG	4-8-71
CH R.P. Dunn	5/27/71
PRE-RELEASE: R.P. Dunn	8/31/71
APP	
AUTH	

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER · HOUSTON, TEXAS

SCHEMATIC DIAGRAM,
LOW VOLTAGE POWER SUPPLY—
ELECTRON-PROTON SPECTROMETER

CODE IDENT NO.	SIZE	DWG NO.
21356	C	SIC 39106637

SCALE ~ 150 - EB SHEET

ELECTRON-PROTON SPECTROMETER

LOW VOLTAGE POWER SUPPLY SPECIFICATIONS

A. Input Voltage: 27.5 ± 2.5 Vdc

B. Input Current: I_{in}(max) $\leq$ 557 ma @ 28 Vdc

C. RFI: Must meet or exceed the requirements of North American Rockwell Corp., Space Division Document MH04-02057-234, Electromagnetic Compatibility, Design Criteria.

D. Operating Temperature Range: $-25°C \leq T_{opp} \leq +50°C$

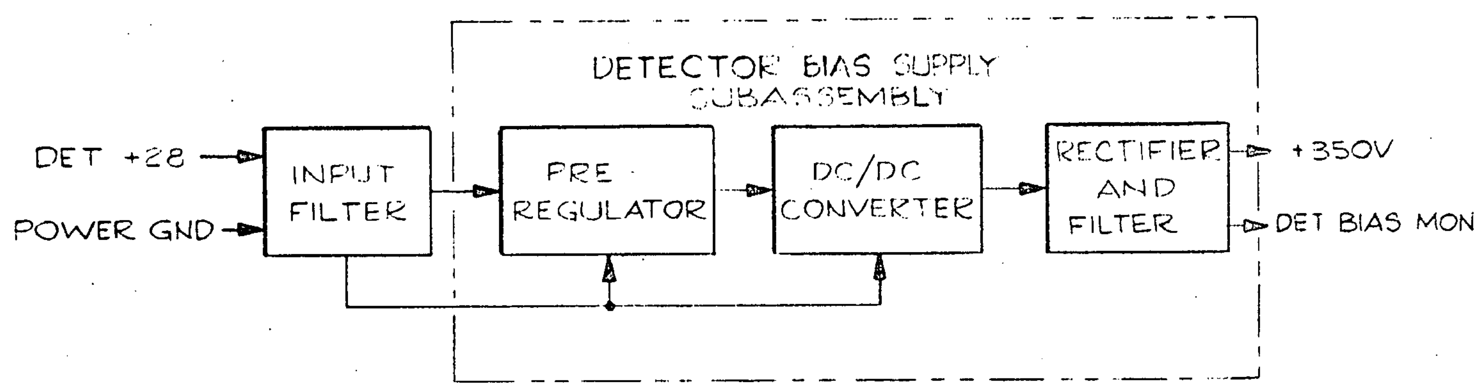
E. Survival Temperature Range: $-50°C \leq T_{surv} \leq +65°C$

F. Outputs: The LVPS must provide the following outputs (with the given specifications):

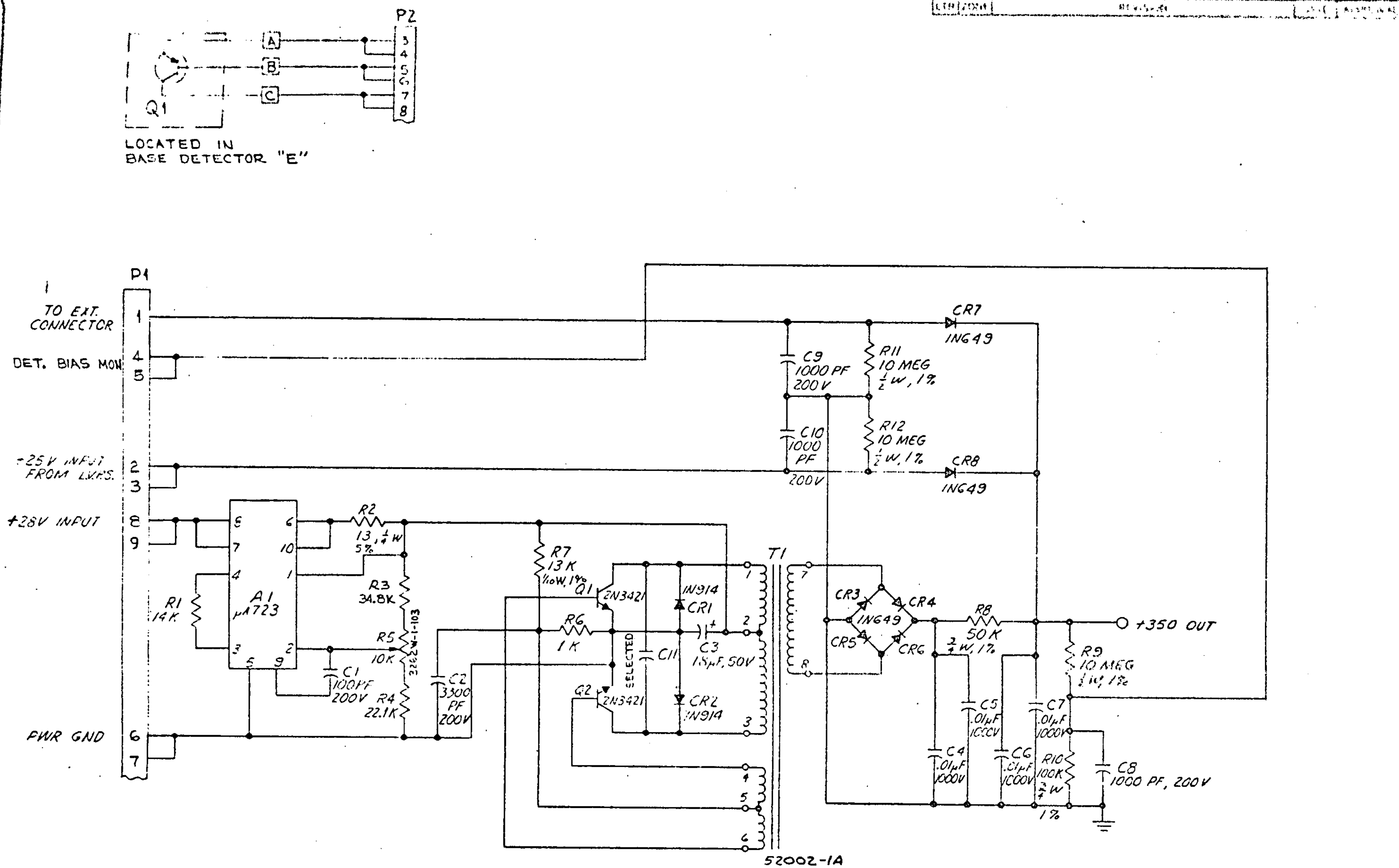
Voltage	Current	Regulation	Maximum Ripple	Maximum Spike
+8 Vdc	175 mamp	+0.2 Vdc -0.0 Vdc	25 mvpp	50 mvpp
-8 Vdc	150 mamp	+0.2 Vdc -0.0 Vdc	25 mvpp	50 mvpp
+5 Vdc	900 mamp	±0.3 Vdc	50 mvpp	50 mvpp
-5 Vdc	115 mamp	±0.3 Vdc	50 mvpp	50 mvpp
+25 Vdc	10 mamp	±2.0 Vdc	150 mvpp	50 mvpp
-15 Vdc	1 mamp	±2.0 Vdc	150 mvpp	50 mvpp
+3.0 Vdc	20 mamp	±0.01 Vdc	1.0 mvpp	5 mvpp

3.5.3 DETECTOR BIAS SUPPLY

The +28 Vdc for the Detector Bias Supply (see Block Diagram and Schematic SIC3910638) is regulated down to +21 Vdc in order that the bias applied to the EPS detectors will not be affected by fluctuations in the spacecraft power lines. This regulated +21 Vdc is then fed to the dc/dc converter which generates a 350 volt square wave. This is rectified, filtered and applied to the detectors cathode thru the bias filter subassembly.



DETECTOR BIAS SUPPLY BLOCK DIAGRAM



NOTES: UNLESS OTHERWISE SPECIFIED.

1. INTERPRET PER MSC MANUAL MSCM 8500.
2. ALL RESISTORS 1/20 W, 1%, VALUES IN OHMS.

SIGNATURES	DATE
DR	3-30-71
ENG	4-8-71
CHK	
RELEASE R.P. Dunn	
APP	
AUTH	

ELECTRON-PROTON SPECTROMETER

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER · HOUSTON, TEXAS

SCHEMATIC DIAGRAM,
DETECTOR BIAS SUPPLY-
ELECTRON-PROTON SPECTROMETER

CODE IDENT NO	SIZE	DWG NO
21356	C	SIC39106638

DETECTOR BIAS SUPPLY SPECIFICATIONS

A. Input Voltage: 27.5 ± 2.5 Vdc

B. Input Current: Maximum ≤ 50 ma @ 28 Vdc

C. RFI: Must meet or exceed the requirements of North American Rockwell Corp., Space Division Document MH04-02057-234, Electromagnetic Compatibility, Design Criteria.

D. Operating Temperature Range: -25°C to +50°C

E. Survival Temperature Range: -50°C to +65°C

F. Output: The Detector Bias Supply must provide the following output:

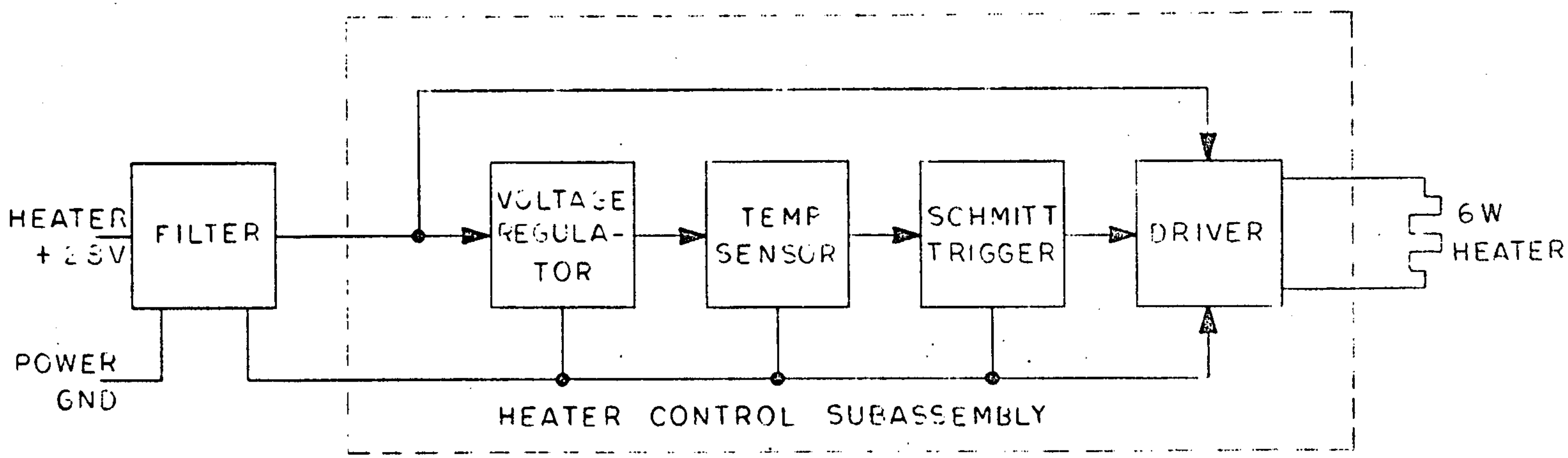
Voltage	Current	Regulation	Maximum Ripple	Maximum Spike
+350 Vdc	10 μa	±17.5 Vdc	500 mvpp	10 mvpp

G. Monitor Output: The detector bias supply must provide an analog output voltage that is directly proportional to the bias voltage. The monitor output must have the following characteristics:

Amplitude	Output Impedance
0 to 5 Vdc	≤ 1 Megohm

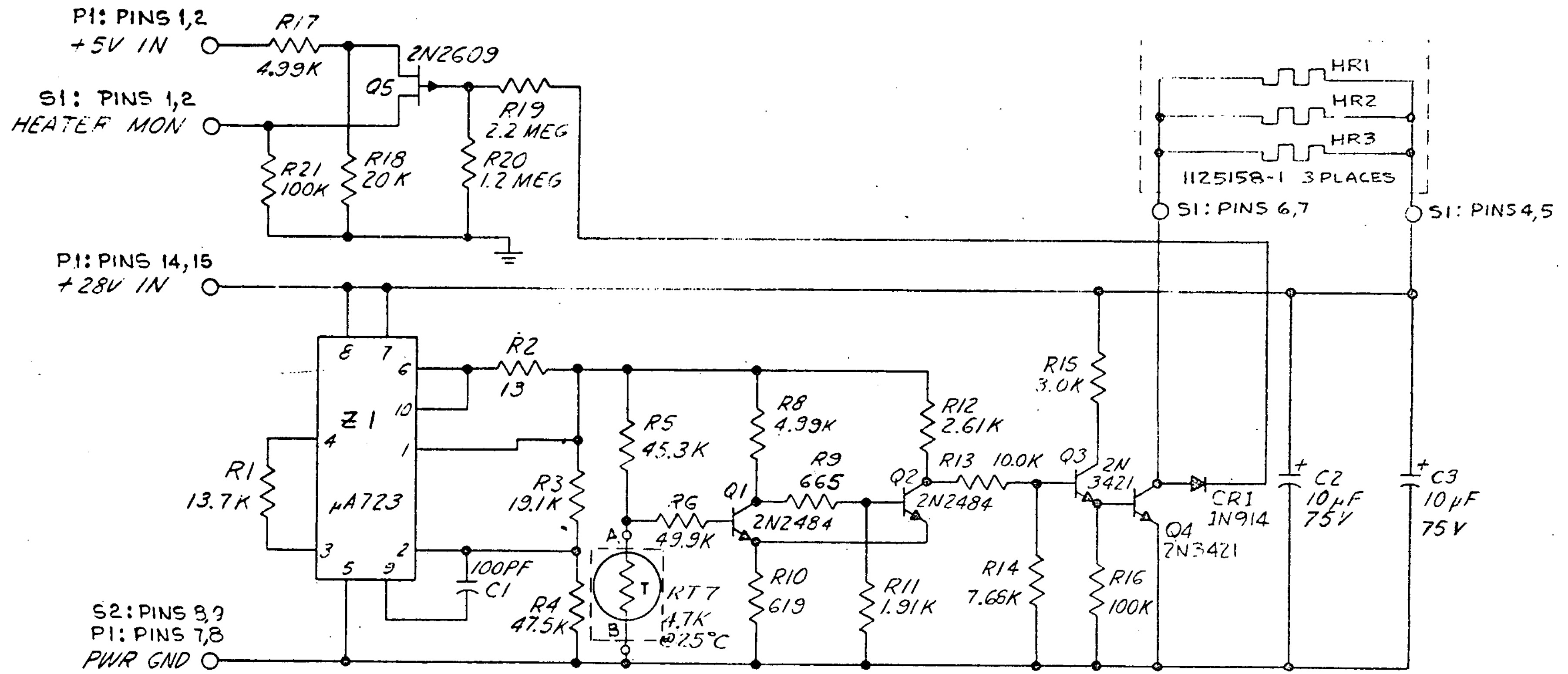
3.6 HEATER CONTROL SYSTEM

The Heater Power +28 Vdc line and power ground are routed to the Heater Control (see Block Diagram and Schematic SIC39106639) subassembly. The +28 Vdc is regulated to +10 Vdc for use as a stable reference for the temperature sensing circuit. The temperature sensing circuit consists of a thermistor and schmitt trigger, with the trip points set at 0° C (heater turn-on) and 10° C (heater turn-off). The output of the schmitt trigger is amplified and utilized to apply power, as necessary, to four individual skin heaters bonded to the electronics assembly housing. In addition to controlling the 6 watt heater, the schmitt output is also buffered and routed to the EPS Data Processor to provide the status of the EPS heaters (i.e., whether on or off).



HEATER CONTROL BLOCK DIAGRAM

LTR	ZONE	REVISION	DATE	APPROVAL



NOTES: UNLESS OTHERWISE SPECIFIED:

1. INTERPRET PER MSC MANUAL MSCM8700.
2. ALL RESISTOR VALUES IN OHMS.

SIGNATURES	DATE
DR [illegible]	3-31-71
ENG [illegible]	4-8-71
CH [illegible]	4/8/71
PRE RELEASE R.P. Dun[illegible]	6/15/71
APP	
AUTH	
E. P. S.	

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER · HOUSTON, TEXAS

SCHEMATIC DIAGRAM,
HEATER CONTROL–
ELECTRON-PROTON SPECTROMETER

CODE IDENT NO.	SIZE	DWG NO.
21356	B	SIC 39106639
SCALE ~	ISD-EB	SHEET

MSC Form 1616 B (REV OCT 65)

HEATER CONTROL
SPECIFICATIONS

A. Input Voltage: 27.5 ± 2.5 Vdc

B. Input Current: I in (Max) = 214 ma @ 28 Vdc

C. RFI: Must meet or exceed the requirements of North American Rockwell Corp. Document MH04-02057-234, Electromagnetic Compatibility, Design Criteria.

D. Operating Temperature Range:

$-25°C \leq T_{opp} \leq +50°C$

E. Survival Temperature Range:

$-50°C \leq T_{surv} \leq +65°C$

F. Operation: The Heater Control will sense the temperature of the EPS electronics package and provide 6 watts of heater power when the temperature drops below 0° C. When the temperature of the electronics package rises to 10° C, the Heater Control shall remove the 6 watts of heater power.

G. Outputs: The Heater Control shall provide a bi-level output to the EPS Data Processor indicating whether the heater is on or off.

3.7 PERFORMANCE OF THE EPS SCIENTIFIC DATA ACQUISITION SYSTEM

Errors, introduced by the EPS Scientific Analog and Data Processor Systems fall into two catagories, those errors affecting counting rate measurements and those errors affecting spectrum shape measurements. The following quantitative analysis is limited by the accuracy of measurements made to date.

3.7.1 ERRORS AFFECTING COUNTING RATE ACCURACY

3.7.1.1 Data Roundoff

This source is exactly known. Compensation is possible within ±0.4% as allowed by statistical variations. The error arises from the detail of the digital readout. Since only the seven most significatn bits of any counter-memory module are telemetered per recording the worst case data loss occurs when the preceeding insignificant counter-memory bits are all in a logic one condition and is the value of the least significant recorded bit. The minimum error occurs when the preceeding insignificant bits are in a logic zero condition. This error is zero. An illustration of these two conditions is:

		MSB	
Maximum Error	0 . . . 0 0	1 0 0 0 0 0 0	1 1 1 1 1 1 1 1
Minimum Error	0 . . . 0 0	1 0 0 0 0 0 0	0 0 0 0 0 0 0 0
	Nonrecorded Leading Zeroes	Recorded Information	Lost Information

Since, to a first approximation, all combinations of unrecorded bits are equally probable a simple solution is to arbitrarily increment the EPS digital output by one half the value of the least significant recorded bit. The error is now ± 1/2 least recorded significant bit.

3.7.1.2 Inaccuracy in Correction for Loss of Data Due to Pile-Up

Since the role of the EPS is to detect the random occurrance of charged particle events considerable care was exercised to insure proper performance in this regard. In nuclear particle detection systems measuring circuits exhibit a characteristic resolving time, τ. The effect of this resolving time is evidenced by an increasing loss of data as the true input count-rate increases. The mathematical relationship between the true, counting-rate, R, and the measured counting-rate, r is generally taken to be:

$$R = \frac{r}{1 - \tau r} .$$

In actual practice for systems operating at near capacity counting levels, τ is a complex function dependent upon the counting threshold value, input pulse height distribution, amplifier gain stability, amplifier offset stability and amplifier overload characteristics. τ has been experimentally determined for one set of conditions to be .26 ± .5μsec for the 220 nsec time constant amplifier (channel A) and 1 ± .5μsec for the 360 nsec time constant amplifier (channels B, C, D and E). These values were determined for 1 Mev monoenergetic input signals and a counting threshold of 300 keV. Graph (Figure 1) of measured counting-rate as a function of true input counting-rate, is included. Optimum values will be determined for an assumed pulse height spectrum and known counting threshold values. The error due to this source will then be reduced to approximately ±3% for an input rate of 250,000/sec.

The total error to counting rate should be less than ±3.4% at counting rates up to 250,000/sec.

3.7.2 ERRORS AFFECTING SPECTRUM SHAPE MEASUREMENT

3.7.2.1 Counting Threshold Settability

The accuracy to which a counting threshold can be set is determined by the accuracy of calibration data and the resolution of the threshold control potentiometer. Calibration data is known to within ±0.5% and the potentiometer resolution allows ±1.0% control. The total settability then is good to ±1.0 ±0.5%.

3.7.2.2 Counting Threshold Changes due to Temperature Variation

Data collected to date indicate a change in counting threshold of ±3% for a temperature range of -25°C to +50°C.

3.7.2.3 Counting Threshold Changes due to Power Supply Variation

Data collected to date indicate a change in counting threshold of 0.4% for worst case variation of all power supplies.

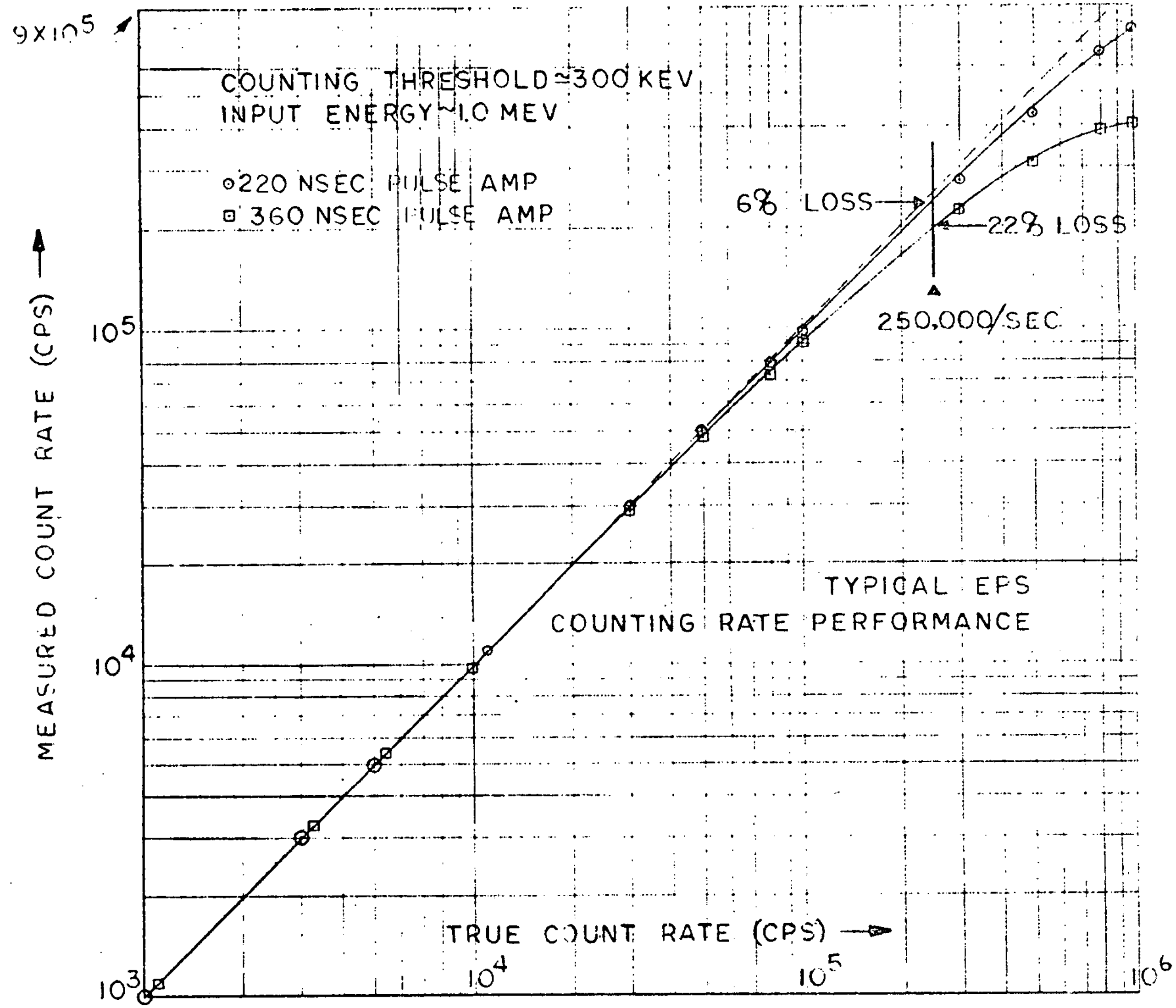


Figure 1 COUNTING RATE

3.7.2.4 Counting Threshold Changes due to Random Input Signals

Data collected to date indicate a change in counting threshold of +1.3% for the 360 nsec time constant amplifier channel at an input rate of 250,000/sec. Similar data taken for the 220 nsec time constant amplifier channel indicate a threshold change of +0.3% (Figure 2 and 3).

The worst case threshold shift is ±6.2% for the 360 nsec amplifier channels and ±5.2% for the 220 nsec amplifier channel.

3.7.3 MAXIMUM EPS ANALOG ELECTRONIC SYSTEM ERROR SUMMARY

Error Type		
Counting-Rate Errors		
Data Roundoff	±0.4%	
Pile-Up Correction	±3.0%	
	3.4%	
Spectral Shape Errors		
Counting Threshold Settability	±1.5%	
Counting Threshold Temperature Variations	±3.0%	
Counting Threshold Power Supply Variation	±0.4%	
Counting Threshold Rate Changes	+1.3%,	0.3%
	6.2%	5.2%

EPS ANALOG SYSTEM BASELINE SHIFT vs RANDOM INPUT RATE

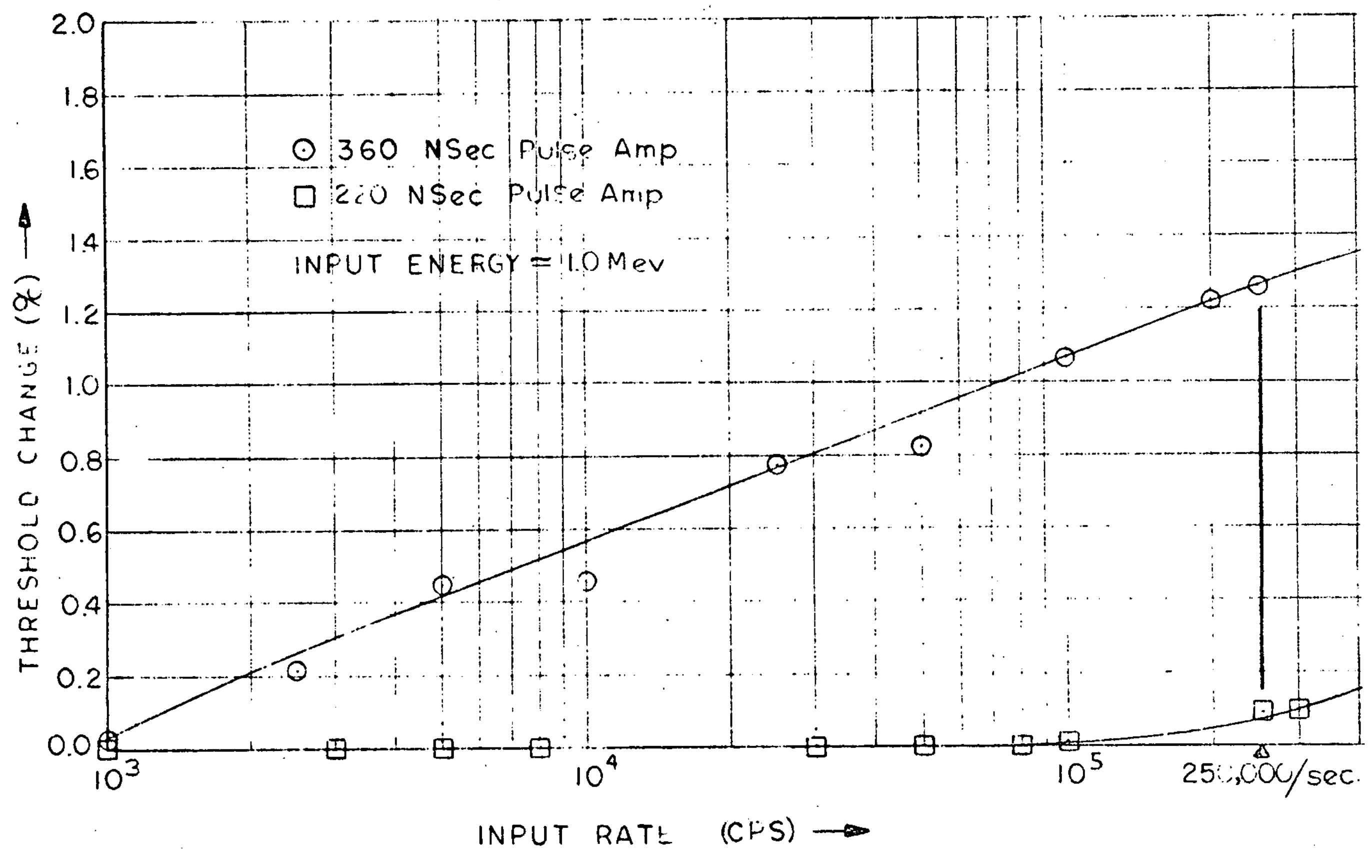


Figure 2 ANALOG SYSTEM BASELINE SHIFT VERSUS RANDOM INPUT RATE

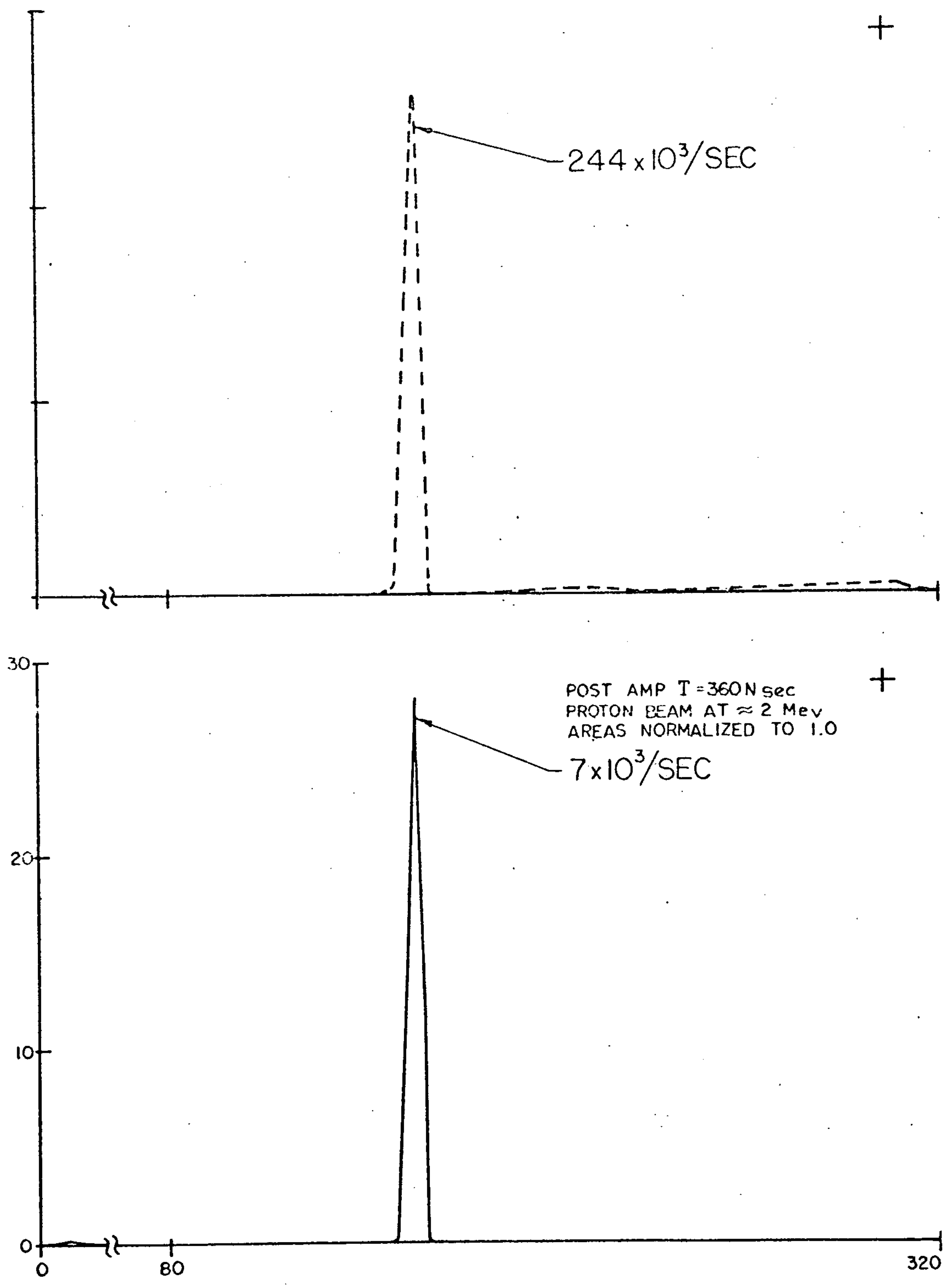


Figure 3 TYPICAL EPS DETECTOR/ANALOG ELECTRONICS
END TO END PERFORMANCE AT 2 INPUT RATES

4. THERMAL DESIGN

The thermal design of the Electron-Proton Spectrometer is based on providing thermal control of the instrument by passive techniques for normal continuous operation. An integral heater for maintaining the instrument at survival temperature in the event of the need to reduce power to the instrument is provided. This heater may be used to provide additional heating during cold orbits if required.

4.1 THERMAL SPECIFICATION

Temperature limits for the Electron-Proton Spectrometer shall be:

	Operational	Survival
Detectors	-58°F to +50°F	-58°F to +122°F
Electronics	-13°F to +122°F	-58°F to +150°F

Available heater power = 6.0 watts.

The thermal design shall provide adequate thermal control for normal continuous operation of the EPS when not directly oriented toward the sun.

4.2 DETAILED THERMAL DESIGN

As can be seen from the thermal control diagram (Figure 1), the instrument is isolated from the spacecraft structure by means of glass-fibre bushings at each of the hold-down bolt locations. This minimizes the effect that variations in the spacecraft skin temperature has upon the instrument temperature. The vibration isolators, by virtue of their material (silicone rubber) and construction, provide additional isolation of the electronics package from the outer structure of the instrument.

The top plate and electronics package comprise a unit that is isolated thermally from the rest of the structure. The thermal interface between the two assemblies has been designed to provide a temperature gradient of 30 - 50° F since the electronics assembly is required to run warmer than the detectors. Cat-a-lac black enamel is applied to the two opposing faces in order that about 50% of the internal power be radiated to the top plate. Radiant coupling increases with temperature, thus tending to prevent exceedingly high or low temperatures in the electronics assembly. The remainder of the internal power is conducted to the top plate through four electrical grounding straps and twenty-one glass-fiber spacers, whose size and material have been selected to provide a controlled thermal conductance.

The heaters are mounted in the bottom slice of the electronics package, and their operation is controlled by an internal sensor monitoring the temperature of the electronics. The heaters are programmed to turn on when the electronics temperature reaches +32°F and turn off when the temperature has risen to +50°F.

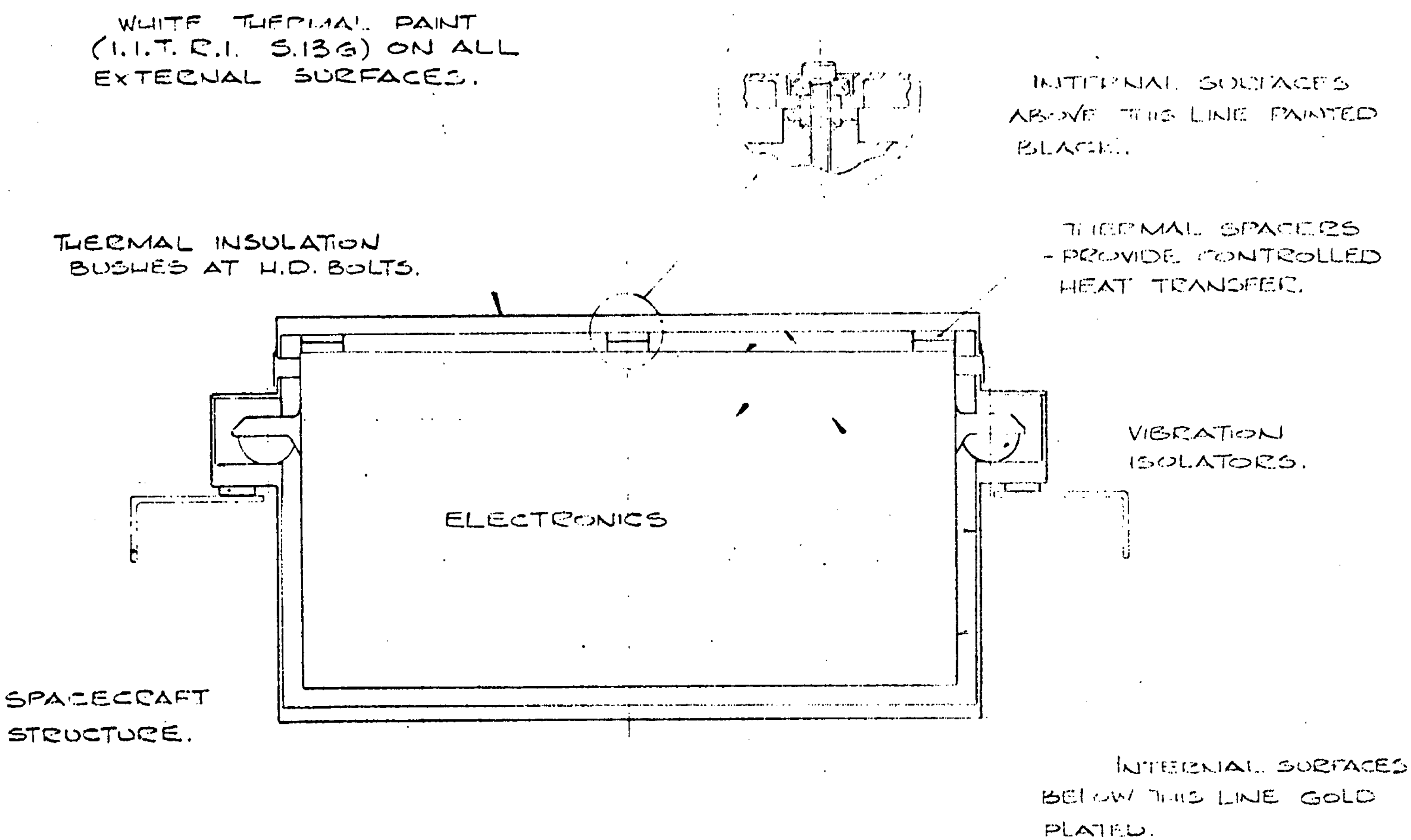


Figure 1 THERMAL CONTROL DIAGRAM

The anticipated temperatues for the Engineering Test Unit are shown in Table I.

TABLE I

EPS THERMAL VACUUM TEST - ANTICIPATED TEMPERATURES

			Power	Case (F°)	Det (F°)	Elect (F°)
1.	Cold - operating	B angle = 73 1/2°	13.4W	- 42F	- 12F	+ 20F
2.	Standby (6W heater)	B angle = 73 1/2°	6.3W	- 46F	- 52F	- 34F
3.	Standby - No Power	B angle = 73 1/2°	0W	- 50F	-100F	-100F
4.	Standby - No Power	B angle = 0°	0W			
5.	Hot - operating	B angle = 0°	13.4W	+ 56F	+ 28F	+ 79F
6.	Rendezvous & Docking	Direct sun exposure	0W	+120F	+ 75F	+ 75F
7.	Rendezvous & Docking	Direct sun exposure	13.4W	+120F	+130F	+170F
8.	Cold Operating	B angle = 73 1/2°	19.1W		+ 20F	+ 63F

4.3 THERMAL TEST UNIT RESULTS

For the thermal/vacuum test of the EPS Thermal Test Unit, seven test modes were run, simulating various flight conditions. These were:

Test Case 1.	Cold Orbit	(B = 73-1/2°)	13.4 W + 6W heater power available
Test Case 2.	Survival	(B = 73-1/2°)	6.0 W heater power only
Test Case 3.	Survival	(B = 73-1/2°)	No power
Test Case 4.	Survival	(B = 0°)	No power
Test Case 5.	Hot Orbit	(B = 0°)	13.4 W
Test Case 6.	Pre-Docking	(B = 73-1/2°)	Zero power
Test Case 7.	Pre-Docking	(B = 73-1/2°)	13.4 W

Heat inputs to the various test cases are shown in Table 2.

Test results for the detector and electronics temperature are as shown in the table of Table 3.

TABLE 2

HEAT LOADS AND BOUNDARY TEMPERATURES

TEST CASE	ABSORBED HEAT FLUX (BTU/HR-FT^2)		BOUNDARY TEMPERATURES (°F)	
	FRONT FACE	SIDES	SUPPORT PLATE	CAVITY
1	18.2	13.9	-75	0
2	18.2	13.9	-75	0
3	18.2	13.9	-75	0
4	26.8	12.9	-23	0
5	33.8	16.0	-23	75
6	128	13.9	250	75
7	128	13.9	250	75

TABLE 3

TEST RESULTS - THERMAL TEST UNIT

TEST CASE	FINAL TEMPERATURE	
	DETECTORS	ELECTRONICS
1	-24°F	54°F
2	-49°F	- 7°F
3	-73°F	-66°F
4	-45°F	-40°F
5	6°F	83°F
6	93°F	93°F
7	114°F	177°F

4.4 THERMAL ASPECTS OF DERATING REQUIREMENTS

During the design and development of the EPS printed circuit (pc) board and welded module subassemblies, due consideration was given to the elimination of thermal "hot spots" within these subsystems to comply with the derating requirements of the EPS. During the design and fabrication of the EPS Thermal Test Unit, an effort was also made to simulate, as close as possible, the actual heat profile of these subsystems. This was done, in part, to determine if there were components within certain subsystems, which might reach temperatures approaching the derating temperature limits of the electronic components.

Data from the thermal vacuum tests during a simulated "hot orbit" condition indicated that the pc board ground plane temperatures were only about 2°F higher than the 82°F temperature of the surrounding structure to which the boards were mounted. Evaluation and testing of the actual pc boards indicated that the worst-case "hot spot" of any pc board in the EPS was located on the discriminator pc board. This board contained two integrated circuits (IC); a SE526K Comparitor and a SNC5473T-03 dual flip-flop. These IC's experienced temperatures of 109°F and 136°F respectively which represented temperature increases of 25°F and 52°F above the pc board ground plane temperature (84°F).

The temperature of the data processor mother-board, measured during a simulated "hot orbit" condition, indicated that it was operating at 88°F, which was 6°F higher than the 82°F temperature of the surrounding structure to which it was mounted. The worst-case "hot spot" measured on the data processor was within the multiplexer module. This module dissipated 400 milliwatts and operated at a maximum temperature of 135°F, which was 47°F higher than the 88°F temperature of the mother-board.

5. MECHANICAL DESIGN

The mechanical design of the Electron-Proton Spectrometer is required to meet the Environmental ICD, NAR document MH04-02120-434 and the requirements of the end item specification. Additionally, the design must protect the electronics package from the extremes of the environmental requirements, where these are so severe as to be potentially damaging to the electronics, such as the random vibration requirements.

The intent has been to meet this requirement as simply as possible, using basic materials and making one component serve more than one function wherever possible. Many aspects of the design have been determined by thermal and packaging needs, together with the electronics requirements.

5.1 DESIGN SPECIFICATION

The environmental design specification is largely contained in the Environmental ICD, but portions of it are reproduced here. The basic requirements are random vibration, shock and acceleration. A pressure requirement also exists due to the controlled pressure leak from the spacecraft during launch.

The requirements for acceleration, vibration, shock, acoustic and pressure are shown in the accompanying Figures 1 through 6.

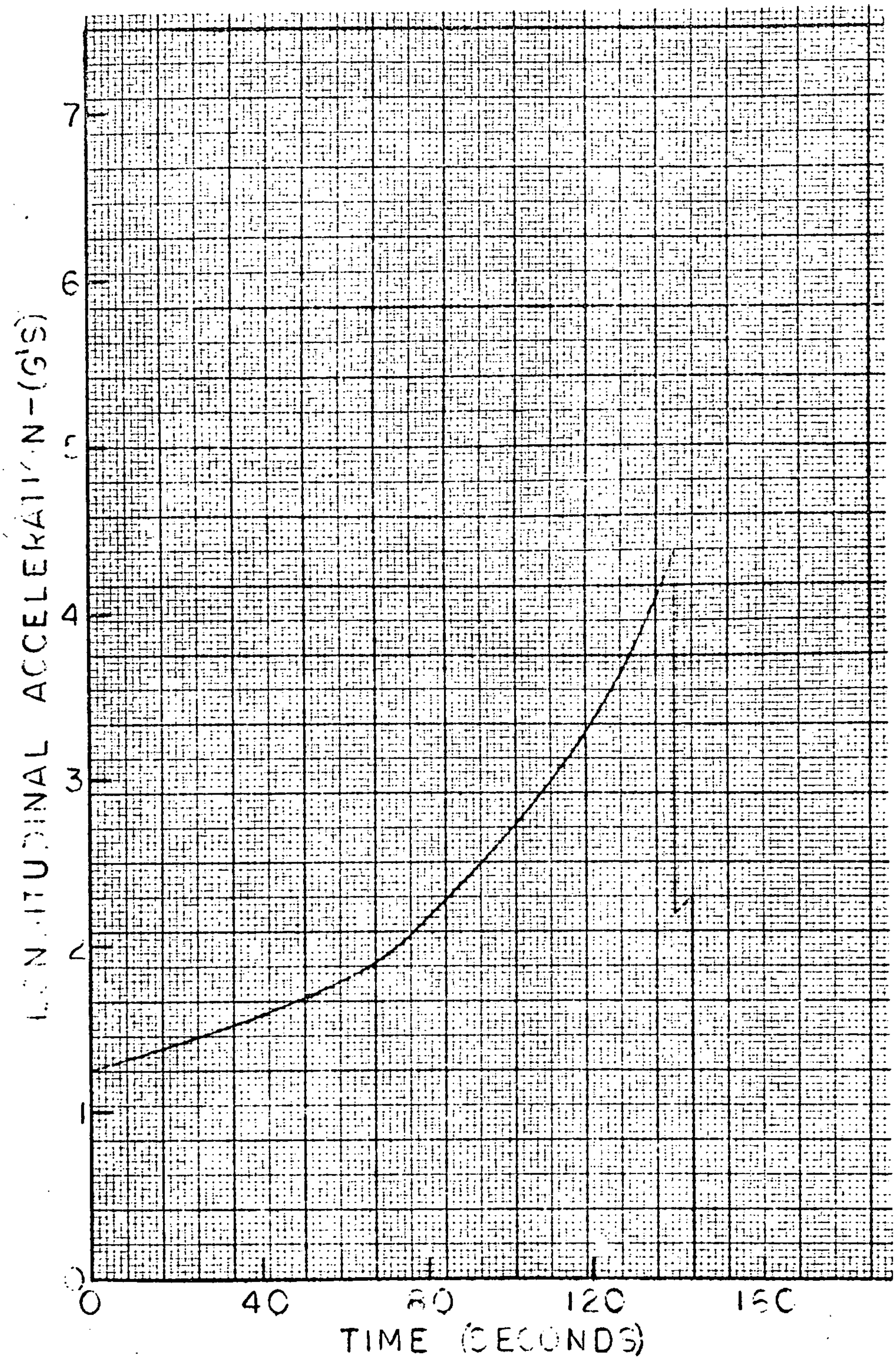


Figure 1. ACCELERATION - VARIATION WITH TIME.

Random:-

R-Axis

20 to 125 Hz	+12 dB/oct increase
125 to 500 Hz	2.0 g^2/Hz
500 to 670 Hz	-9 dB/oct decrease
670 to 1100 Hz	0.8 g^2/Hz
1100 to 2000 Hz	-9 dB/oct decrease

X-Axis

20 to 75 Hz	+6 dB/oct increase
75 to 175 Hz	0.085 g^2/Hz
175 to 300 Hz	+6 dB/oct increase
300 to 1000 Hz	0.25 g^2/Hz
1000 to 2000 Hz	-6 dB/oct decrease

T-Axis

20 to 100 Hz	+6 dB/oct increase
100 to 440 Hz	0.04 g^2/Hz
440 to 600 Hz	+18 dB/oct increase
600 to 900 Hz	0.3 g^2/Hz
900 to 2000 Hz	-12 dB/oct decrease

For each of the above axes, duration is 140 seconds plus 10 seconds at 4 dB above the nominal.

Sinusoidal:-

Sweep from 5 Hz to 35 Hz to 5 Hz at 3 oct/min. at .25 g.

Figure 2. VIBRATION QUALIFICATION LEVELS

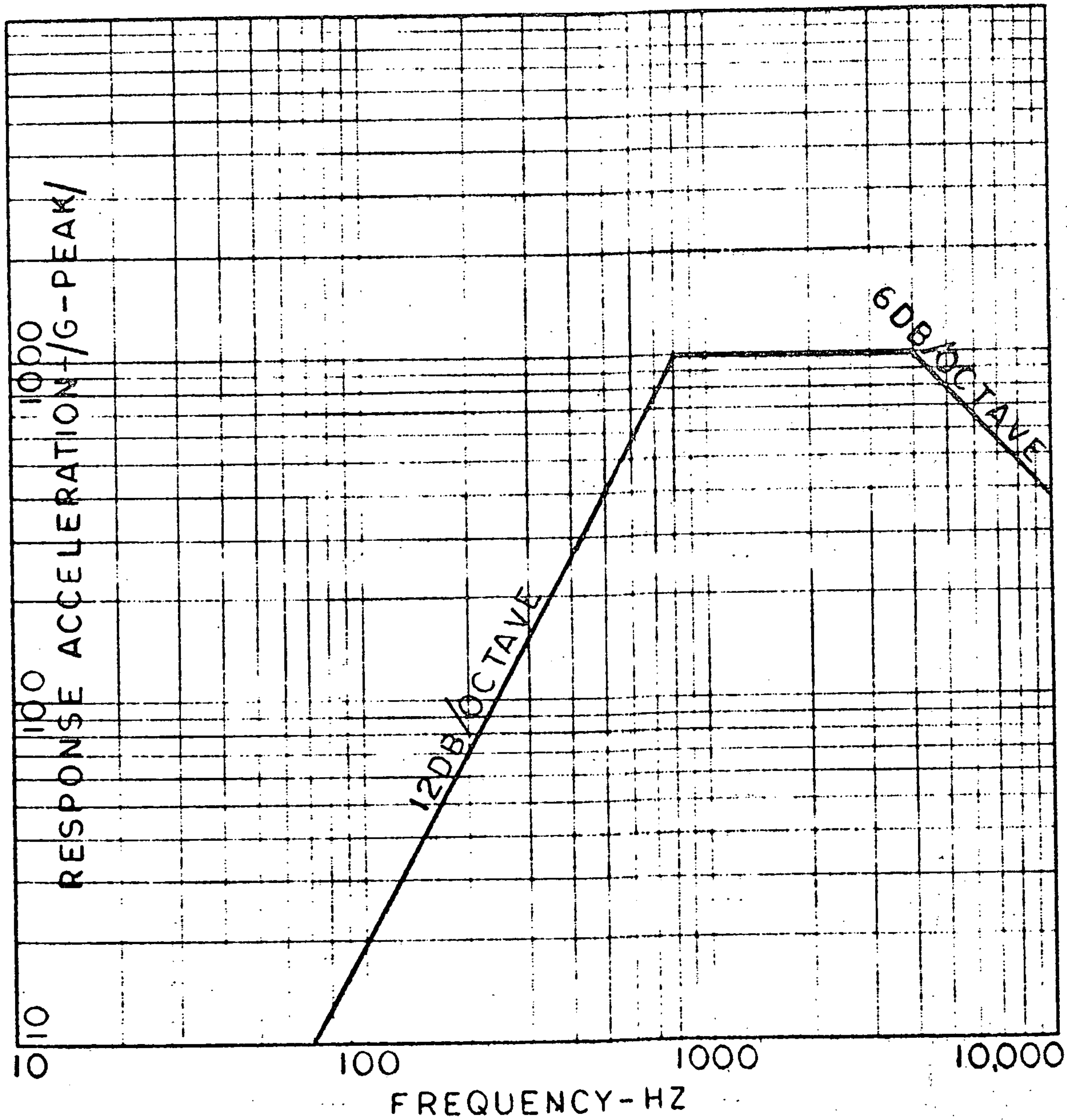
SHOCK

Qual. Test:- 20 g, 11 millisecond duration, terminal sawtooth to MIL-STD-810B, Method 516.1, Procedure 1.

Bench handling test to MIL-STD-810B, Method 516.1, Procedure V.

Additionally, to meet the requirement of the CSM fairing shock response spectrum.

Figure 3. SHOCK



CSM FAIRING

Figure 4. SHOCK RESPONSE SPECTRUM

ACOUSTIC ENVIRONMENT - CSM FAIRING EXTERNAL NOISE SPECTRA

1/3 OCTAVE BAND CENTER FREQUENCY (CPS)	1/3 OCTAVE BAND SOUND PRESSURE LEVEL - dBre 0.0002 uBar		
	BOOSTER ENGINE	MAXIMUM AERO-DYNAMIC PRESSURE	TRANSONIC BUFFETING
25	128	143	147
31.5	128	145	150
40	129	147	154
50	130	148	154
63	131	149	153
80	133	150	152
100	134	151	152
125	136	150	152
160	137	149	151
200	138	148	151
250	139	147	151
315	139	146	150
400	139	145	150
500	139	143	150
630	138	141	149
800	137	139	148
1000	136	137	147
1250	135	135	145
1600	134	133	143
2000	133	131	141
2500	132	129	139
3150	131	127	137
4000	130	125	135
5000	129	123	133
6300	128	121	131
8000	127	118	129
OVERALL	149	161	165

Figure 5. ACOUSTIC SPECIFICATION

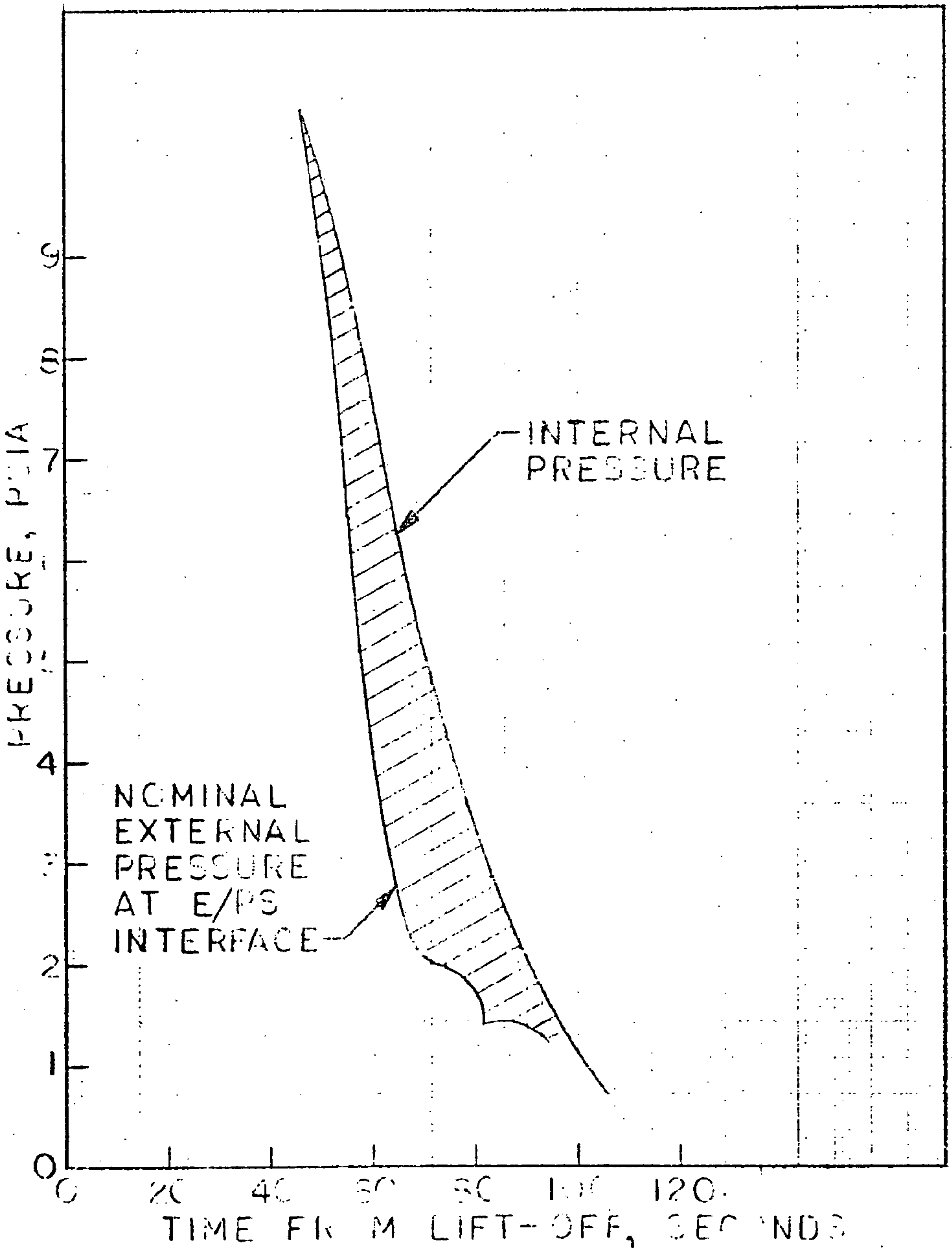


Figure 6. DIFFERENTIAL PRESSURE ON EPS

A pictorial representation of the instrument is shown in Figure 7, which indicates the axes of the instrument.

The instrument is required to meet the physical interface requirements of North American Rockwell drawing No. MH04-02118-134, Electron/Proton Spectrometer - Envelope/ Installation.

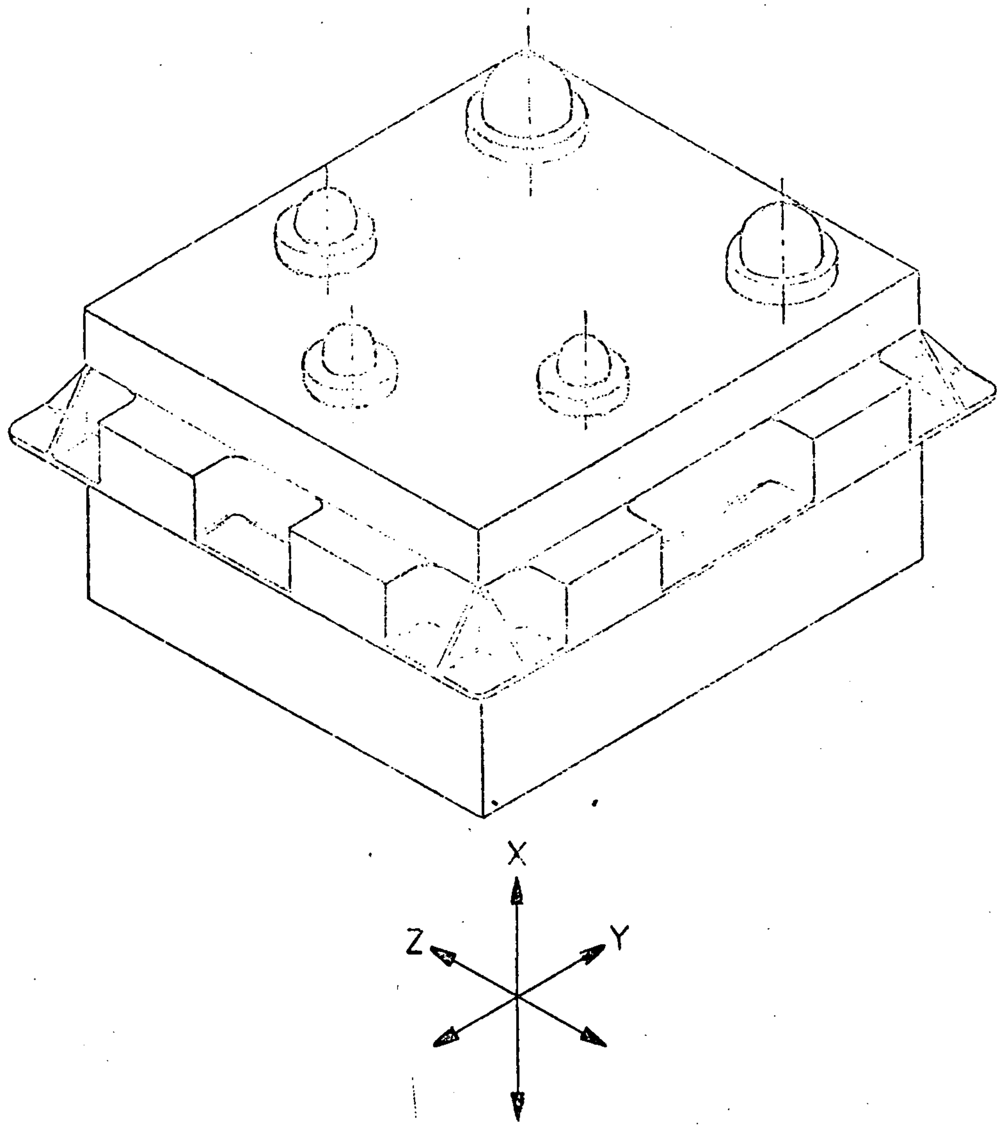


Figure 7. INSTRUMENT AXES

5.2 DETAILED MECHANICAL DESIGN

5.2.1 STRUCTURAL

As can be seen from Figure 8 Diagram of the EPS, the instrument package consists essentially of an outer housing and an electronics package.

The outer housing is combined with the mounting flange of the instrument, and is hard-mounted to the spacecraft support structure. As previously mentioned under thermal design, the mounting flange incorporates glass-fiber bushings at the hold-down bolt holes to isolate the instrument thermally from the spacecraft structure. Additionally, a silicon rubber 'O-ring' cord seal is provided on the underside of the flange to seal the 1/16" gap between the flange and spacecraft structure, to maintain N.A.R.'s differential pressure requirement for a controlled leak rate of the CSM. The baseplate is an integral part of the outer housing and carries the electrical connectors to interface with the spacecraft wiring. Two grounding straps are attached to the outer housing at two hold-down bolt locations and make contact with the spacecraft structure when the instrument is in position.

The electronics unit is supported within the outer housing by means of 8 vibration isolators. These isolators reduce the shock and vibration inputs to acceptable levels for survival of the various electronics within the unit, and also provide additional thermal and electrical isolation from the main structure.

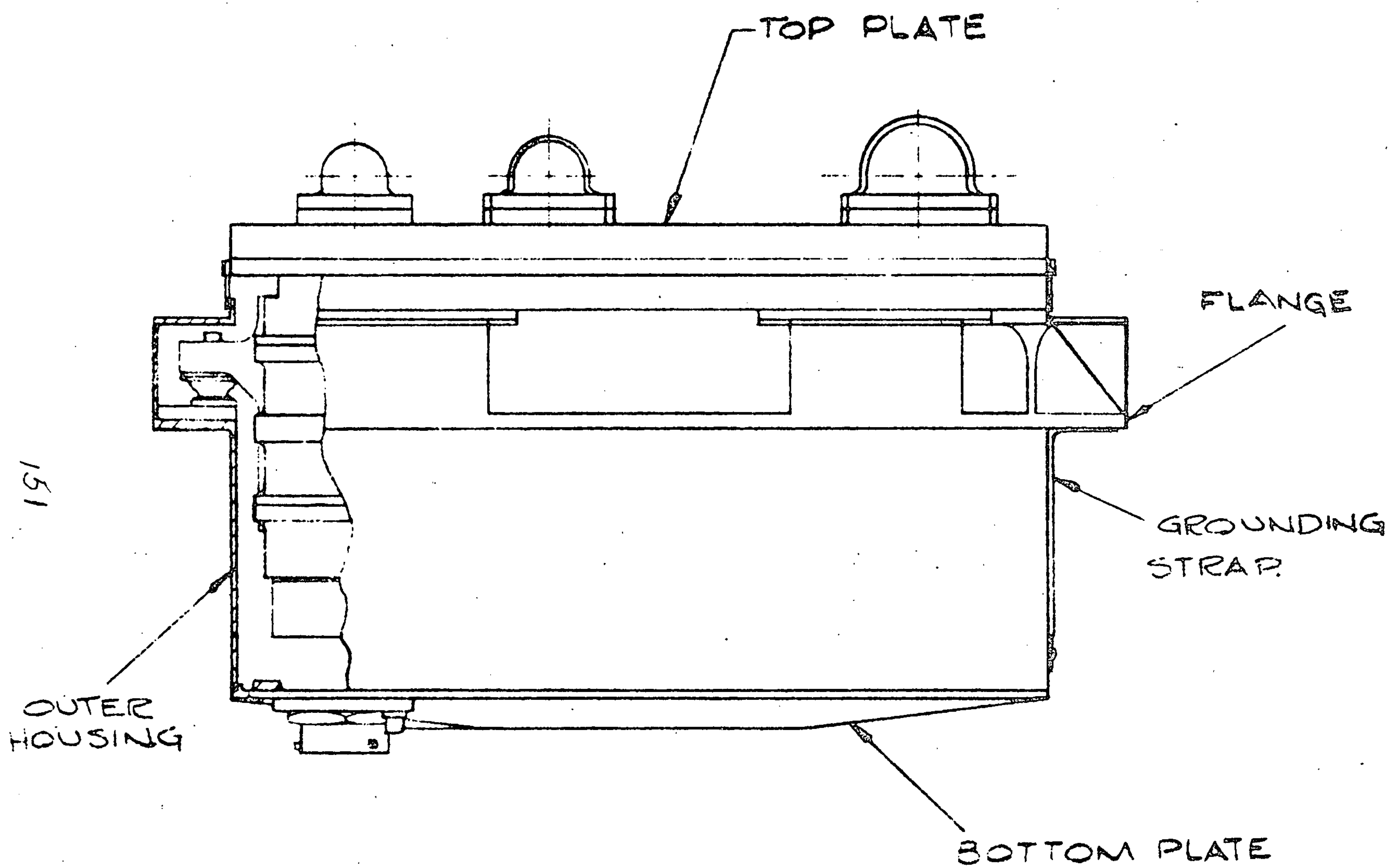


Figure 8. DIAGRAM OF EPS

The top plate and electronics housing comprise the electronics unit. Radiation detectors are mounted to the top plate and wired to their respective electronics, and the top plate is mounted on the electronics package as previously mentioned under thermal design. A reflective shield covers the gap between the top plate and outer housing required to accommodate the movement of the vibration isolators under shock, vibration and acceleration conditions. Figure 9, cross-section view of the EPS shows in more detail how the structure and electronics are arranged.

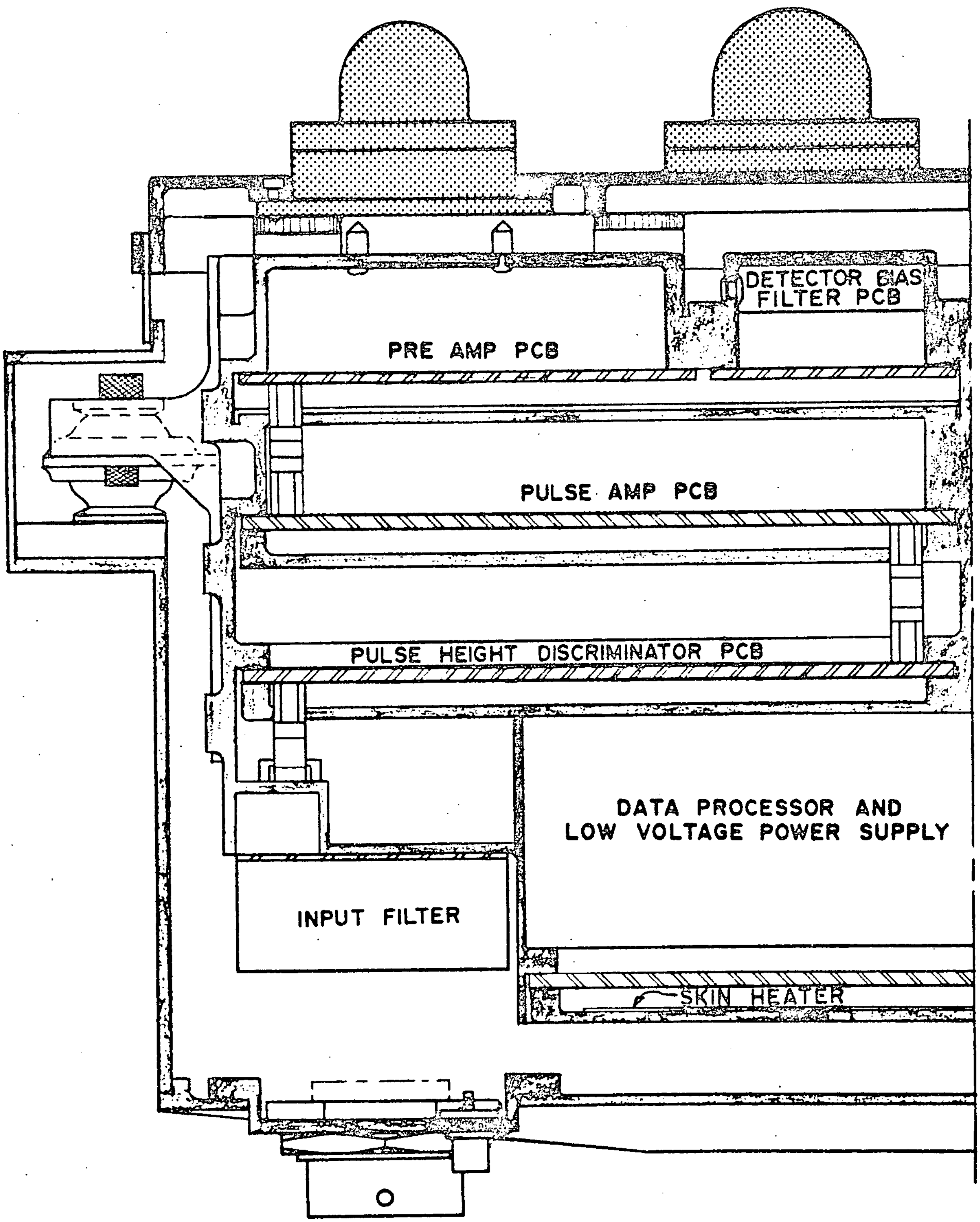


Figure 9. CROSS SECTION VIEW OF EPS

5.2.2 PACKAGING OF THE EPS

The Modular Electronic Packaging Design (Figure 10) made possible the separate development of the various portions as the circuit design for the individual functions became established.

Each slice incorporates its own housing, structural integrity, circuit board mounting thermal transfer paths, and its connectors.

Each slice is capable of being designed, built, assembled, and tested as an individual unit.

Each slice in the EPS has been designed for its electronic circuitry's own peculiar functional requirements.

Each printed circuit board mounts in a completely enclosed cavity in the slice (Figure 9). The cards' circuit ground plane around its perimeter is completely in contact with the slice mounting flange, thus providing excellent signal return and thermal transfer paths. This enables circuitry such as the detector bias supply, inherently noise, to be placed in the pre-amplifier slice, avoiding any interference with the pre-amplifier's sensitive circuitry. Each of the five data channels are electrostatically shielded from each other as well as from the other circuitry. The exceedingly large common ground (Ground Plane) areas reduces noise pickup and capacitance and also serves as a thermal transfer path thus reducing component hotspots and at the same time providing structural integrity at minimum weight.

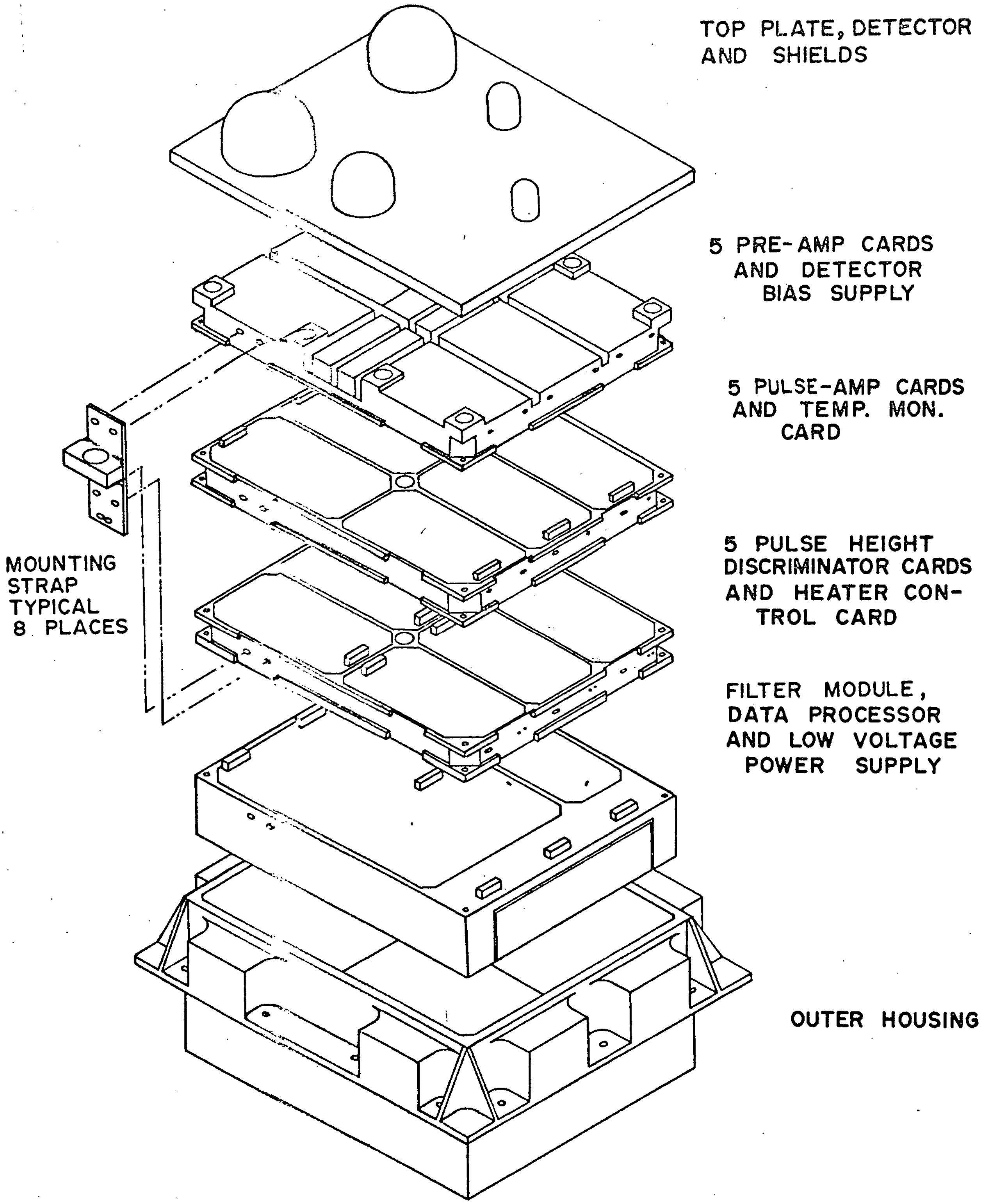


Figure 10. PACKAGING CONCEPT OF ELECTRON-PROTON SPECTROMETER

Each slice housing serves as a basic structure for the assembly, a chasis for mounting circuit boards and parts, a transfer medium for signal return, thermal heat sink, and shielding for electrostatic interference protection.

As can readily be seen, the slice housing must be fabricated as a precision machined unit. Each slice is machined from a solid billet of 6061-T651 aluminum alloy, chosen for its structural strength, light weight, thermal conductivity, machineability, and nominal cost. Such a fabrication design would have been prohibitively costly only a few years ago. However, today, with many common features between the slices and with tape-driven numerical-control machine tools, the costs are drastically reduced. Its cost effectiveness increases on the basis of design advantages and in comparison with other types of construction.

Among the advantages offered by this packaging design are:

- Provides accessibility to printed circuit boards and their components.
- Permits removal and replacement on individual slices without rewiring.
- Enabled the utilization of one printed circuit board layout for the detector bias filter, pre-amp, post amp, pulse height discriminator.

The slice module concept, as described, demonstrates its value in providing a soundly engineered packaging method for the many diverse types of circuitry required for the EPS, at the same time allowing for the changes and additions to circuitry without excessive delays in the delivery schedule.

5.3 MECHANICAL PERFORMANCE

The Structural Test Unit of the EPS has been subjected to the random vibration criteria of the qualification test requirements and successfully withstood the levels imposed. Prior to this, sinusoidal scans at 1 octave/min. from 5 - 2000 Hz at 3.0 g had been run, so that there is no question that the instrument will meet the .25 g level of the sinusoidal vibration requirements.

Additionally, the 20 g, 11 millisecond, terminal saw-tooth shock test has been conducted on the Structural Test Unit with no problems.

Typical responses of the electronic package to the random vibration input at the high energy level (4 dB above nominal) were:-

R axis	6.9 g rms	The responses are relatively higher in the X- and T-axes due to lower damping ratio in these axes
X axis	7.0 g rms	
T axis	4.0 g rms	

In response to the shock pulse, the electronics package response was in the order of 10 - 15 g peaks.

PACKAGING SPECIFICATION

1. Mechanical Requirements
   - A. Lightweight yet sufficiently rigid to withstand vibration environment of spacecraft.
   - B. Stress-relieving all solder connections on printed circuit boards.

2. Thermal Considerations

   Good internal heat transfer for electrical components providing adequate thermal management.

3. Electrical Requirements
   - A. Excellent shielding between analog circuitry and data channels.
   - B. A good common high frequency signal return path for the analog circuitry.

4. Cost/Functional Considerations
   - A. Modular packaging concept allowing for design and fabrication of each circuit through tests independent of other circuitry or changes elsewhere in the instrument.
   - B. Standarization of common printed circuit boards and other circuitry for minimum design, fabrication time, and minimum spare assembly requirements.
   - C. Access to circuitry test points, and adjustable components and easy maintenance.
   - D. Use of welded cordwood modules for circuitry requiring high packaging density for weight consideration.

PART IV
BENCH TEST EQUIPMENT

BENCH TEST EQUIPMENT DESCRIPTION

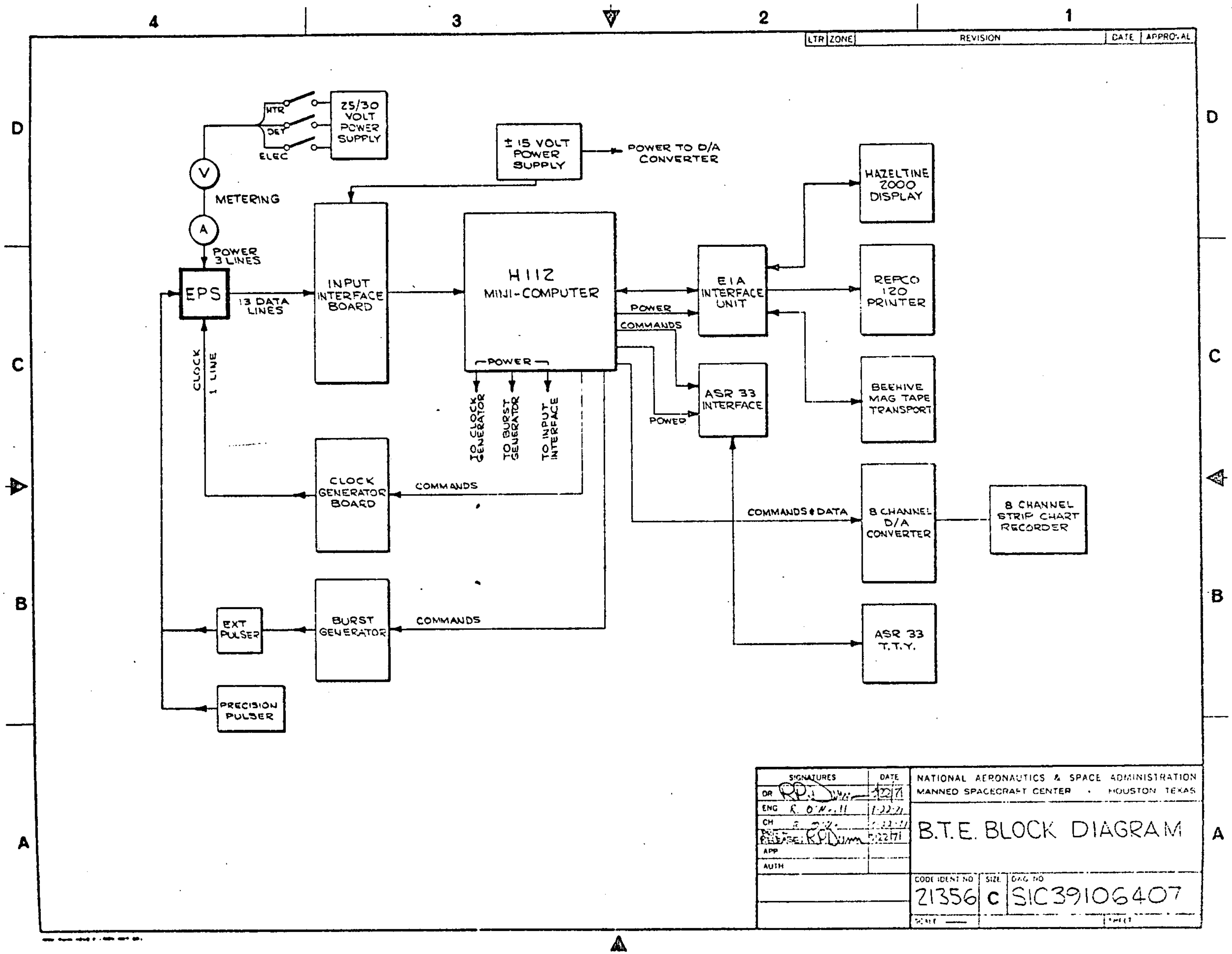
The specification was met by using a Honeywell H112 Minicomputer to process the data, make calculations, and format the output for display.

The tight schedule, wide range of requirements, and required ease of modification dictated the choice of a minicomputer to meet the requirements at minimum cost and within the alloted time.

The H112 is a relatively simple 12-bit 4000-word minicomputer which due to its rugged and compact construction and high quality components is an ideal choice for this application. Field service is available nationwide if required and any required components are readily available from Honeywell or local stock. A memory cycle of 1.6 microseconds provides ample speed to perform the required calculations, normalize the data, label the data, and control the interfaces. The instruction set is simple but adequate.

The resulting test equipment met the requirements and is easily adapted to meet additional requirements as they appear.

The following text refers to the B.T.E. Block Diagram SIC39106407. There are three sources of power in the B.T.E. which are used to power the various interfaces as well as the EPS itself. The computers internal 6 volt supply powers all logic used in the B.T.E., the ±15 volt dual supply powers the input interface board and the 8 channel digital to analog converter, and the 25 to 30 volt supply is used



25/30 VOLT POWER SUPPLY
HTR
DET
ELEC
V
METERING
A
POWER 3 LINES
EPS
13 DATA LINES
CLOCK 1 LINE
± 15 VOLT POWER SUPPLY
POWER TO D/A CONVERTER
INPUT INTERFACE BOARD
H112 MINI-COMPUTER
POWER
TO CLOCK GENERATOR
TO BURST GENERATOR
TO INPUT INTERFACE
CLOCK GENERATOR BOARD
COMMANDS
BURST GENERATOR
COMMANDS
EXT PULSER
PRECISION PULSER
EIA INTERFACE UNIT
POWER
COMMANDS
ASR 33 INTERFACE
POWER
HAZELTINE 2000 DISPLAY
REPCO 120 PRINTER
BEEHIVE MAG TAPE TRANSPORT
COMMANDS & DATA
8 CHANNEL D/A CONVERTER
8 CHANNEL STRIP CHART RECORDER
ASR 33 T.T.Y.
LTR ZONE REVISION DATE APPROVAL
SIGNATURES DATE
DR
ENG
CH
RELEASE
APP
AUTH
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER · HOUSTON TEXAS
B.T.E. BLOCK DIAGRAM
CODE IDENT NO 21356
SIZE C
DWG NO SIC39106407

exclusively to power the EPS. All power supplies have internal current limiting and over voltage protection to completely protect the EPS and the various subassemblies of the B.T.E. from damage due to power supply malfunction.

Two connectors are used to join the EPS and the B.T.E. A single coaxial line couples the clock to the EPS while a multiconductor cable supplies grounding, power, and couples the 13 data lines from the EPS to the B.T.E.

The clock generator which normally supplies a 1 pps square wave to the EPS is a programmable counter using the internal clock of the H112 and requires commands from the H112 to set the clock frequency from 1 pulse every 64 seconds to 32 pulses per second depending upon test requirements. The clock generator is serviced automatically each time the H112 is started. Information stored in core by the operator determines the clock frequency.

The input interface board contains 13 comparators used to reshape the signals from the EPS and convert them to DTL compatible levels so they can be presented to the H112 for processing. RF by-passing and internal hysteresis feedback provide excellent noise rejection by the comparators as borne out by the tests recently performed by NASA. The input interface board is serviced by the H112 each time a clock pulse is generated by the H112.

The burst generator provides trigger signals to drive a pulse generator to evaluate the performance of the counter, compressor, and output circuits of the EPS data processor as well as non-precision evaluation of the amplifier and discriminator circuits. The burst generator is reset after each prime frame sync is received to prevent pulses being sent to the EPS during the 1 second per prime frame dead period. The burst generator is given the quantity of pulses required from the H112 and immediately upon completion of resetting by the H112 begins outputting the pulses at a 175 kHz rate.

To evaluate preamp gain and discriminator setting stabilities a precision pulse generator is provided. Output pulse rates of 60 Hz and 90 Hz are available with an output voltage range of zero to 10 volts being the normal output amplitude range.

The EIA interface unit couples the H112 to the Hazeltine C.R.T. display, the printer, and the magnetic tape transport. An acoustic coupler or any other device conforming to EIA specification RS-232B may be similarly coupled to the H112 by this interface if required. A huge saving in time and cost was realized by using this interface and RS-232 compatible devices. The input-output data rate is 1200 baud or roughly 100 characters per second, ten times the speed of a standard ASR-33 Teletype.

The ASR-33 interface permits using an ASR-33 Teletype to load Honeywell software or provide a backup in case of CRT of printer failure. Paper tapes of the software may also be punched to test the EPS as an added measure of security.

The Hazeltine 2000 normally displays data and allows program modification through the keyboard using a core resident editing program. The Beehive Cassette Recorder may also be commanded from the Hazeltine Keyboard. Up to 2000 characters may be displayed on the screen of the Hazeltine.

The Repco 120 printer is an electrostatic printer of 100 character per second speed and very low operating noise level. It provides hard copy of data for permanent records of tests on the EPS.

The magnetic tape cassette transport enables the recording of test data on inexpensive, compact, cassettes for immediate retrieval and display or hard copy. If the test program is inadvertently destroyed it is normally reloaded from the magnetic tape in far less time than loading from an ASR-33 would require.

Continuous analog recording and plotting of up to 8 channels of data are provided by the 8 channel recorder interface consisting of 8 digital to analog converters and control electronics. The 8 desired parameters are selected from the keyboard of the Hazeltine before the program is started. During tests the 8 channels are gated as their appropriate data is transmitted to the B.T.E.

PRIMARY DATA DISPLAY

```
                       S              S                             S
                       y              y                             y
MODE: UPDATE           n              n                             n I
                       c              c Data   Place                c d   Data

                       1234567890123  C123456712345                 C1234567890

WORD  1  Sync . . . .  1010101010101
      2  Proton 1 . . . . . . . . . . 1010101010101
      3  Electron 1 . . . . . . . . . 1010101010101
      4  Proton 2 . . . . . . . . . . 1010101010101
      5  Electron 2 . . . . . . . . . 1010101010101
      6  Proton 3 . . . . . . . . . . 1010101010101
      7  H. K. 1  . . . . . . . . . . . . . . . . . IDENTIFICATION 1010101010101
      8  Electron 3 . . . . . . . . . 1010101010101
      9  Proton 4 . . . . . . . . . . 1010101010101
     10  Electron 4 . . . . . . . . . 1010101010101
     11  Proton 5 . . . . . . . . . . 1010101010101
     12  Proton 6 . . . . . . . . . . 1010101010101
     13  H. K. 2  . . . . . . . . . . . . . . . . . IDENTIFICATION 1010101010101
```

DATA DISPLAY

Test Title: THERMAL VACUUM

Date: 9-26-71

Time of Day: 0:30

Comments Prior to First Cycle

		TRUE OUT	0 33292288		Elec U.	Eng. U
WORD	1	Sync	.0111000100101			
	2	Electron 1	33292288			
	3	Proton 1	.0			
	4	Electron 2	33292288			
	5	Proton 2	.0			
	6	Electron 3	33292288			
	7	H. K. A		1 Package Temp.	3.750	+25.000 Deg C
	8	Proton 3	.0			
	9	Electron 4	33292288			
	10	Proton 4	.0			
	11	Proton 5	33292288			
	12	Proton 6	.0			
	13	H. K. B		1 Package Temp.	3.7500	+25.000 Deg C

HOUSEKEEPING DISPLAY

Test Title: THERMAL VACUUM

Date: 9-26-71

Time of Day: 0:35

Comment: Prior to First Cycle

Prime Frame	A	Elec U	Eng U	B	Elec U	Eng U
1	Package Temp	4.999	+49.999 Deg C	Package Temp	4.999	+49.999 Deg C
2	Det 1 Noise	1.879	+18.790 keV	Det 4 Noise	.978	19.560 keV
3	Det 1 Lkg	2.567	+ .513 UA	Det 4 Lkg	2.496	+ .499 UA
4	Det Plate Temp	3.543	+20.86 Deg C	Det Plate Temp	3.543	+25.000 Deg C
5	Det 2 Noise	1.765	17.650 keV	Det 5 Noise	1.757	+17.570 keV
6	Det 2 Lkg	2.469	+ .494 UA	Det 5 Lkg	2.389	.478 UA
7	+5V Monitor	2.515	+5.000 V	+5V Monitor	2.515	+ 5.000 V
8	Det 3 Noise	1.766	+17.660 keV	Heater Mon	3.650	On
9	Det 3 Lkg	2.265	+ .452 UA	Heater Mon	3.650	On
10	+8V Monitor	4.051	+8.000 V	+8V Monitor	4.051	+8.000 V
11	-8V Monitor	3.039	-8.000 V	-8V Monitor	3.039	-8.000 V
12	+25V Monitor	2.354	+25.000 V	+25V Monitor	2.354	+25.000 V
13	+350V Monitor	3.750	+350.000 V	+350V Monitor	3.750	+350.000 V
14	-15V Monitor	2.833	-15.000 V	-15V Monitor	2.833	-15.000 V
15	-5V Monitor	2.990	- 5.000 V	-5V Monitor	2.990	- 5.000 V
16	Disc Ref Mon.	2.505	+ 3.000 V	Disc Ref Mon.	2.505	+ 3.000 V

BENCH TEST EQUIPMENT (BTE) SPECIFICATION

1. INPUTS FROM EPS

1.1 13 data lines from EPS

1.1.1 Binary "1" 3.5 to 10 volts

1.1.2 Binary "0" 0 to ± .5 volts

2. OUTPUTS TO EPS

2.1 BTE Simulates Operation on CSM.

2.2 1 pulse per 64 seconds to 32 pulses per second clock timing.

2.3 Pulse bursts of from 1 to 3355431 pulses per prime frame period.

2.4 Precision voltage pulses for discriminator adjustment and testing.

2.5 Power

2.5.1 25 to 30 volts detector power.

2.5.2 25 to 30 volts electronic power.

2.5.3 25 to 30 volts heater power.

C-3

3. DISPLAY OUTPUTS FROM BTE

3.1 10 data and 32 housekeeping channels continually displayed in either of 3 formats (see illustration) on a CRT terminal.

3.2 8 housekeeping outputs 0 to 10 volts to drive an 8 channel strip chart recorder.

3.3 Printer to record data in 3.1.

3.4 Power to EPS continually displayed by voltage and current meters.

3.5 Magnetic tape cassette recorder used to record software and data for later use.

PART V

RELIABILITY AND QUALITY ASSURANCE

1. PROCUREMENT AND RELIABILITY REQUIREMENTS

Certain parts required for the EPS were not available as Established Reliability Parts. Procurement of these parts was handled in three different ways, i.e.

Vendors Specifications,
Procurement Specifications, and
Screen and Burn-In.

1.1 VENDORS SPECIFICATIONS

When vendors specifications were available, they were reviewed. If the specifications complied with NASA Reliability Requirements for flight hardware, parts were procured on this basis. Specification Test Sheets are available on request on these parts.

1.2 PROCUREMENT SPECIFICATIONS

To meet the requirements for High Reliability Parts when suitable vendors specifications were not available, procurement specifications were written to ensure that vendors' testing programs would be upgraded to qualify their parts under NASA requirements for High Reliability Flight parts. A list of Procurement Specifications follows:

EPS-125 - Procurement Specification for Lithium-Drifted Silicon Detectors.

EPS-124 - Procurement Specification for Bourns Potentiometers.

EPS-121 - Procurement Specification for Erie Capacitors Type 838-1KV-X5T-103M.

EPS-116 - Procurement Specification for Caddock Resistors Type MK, MG, and MS.

EPS-168 - Procurement Specification for Caddock Resistors Type 1712-100 Meg.

EPS-232 - Procurement Specification for Capacitor (Variable) RVC12.

EPS-167 - Procurement Specification for Nytronics Inductor PD-100.

EPS-356 - Procurement Specification for Barry Control Vibration Isolators.

1.3 SCREEN AND BURN-IN SPECIFICATIONS

Some parts did not lend themselves to these approaches and were purchased as commercial and JAN parts and subjected to a Screen and Burn-In to qualify them as Hi-Rel Parts. The Screen and Burn-In was conducted at the NASA White Sands Test Facility. These tests were designed to meet Specification for Semiconductors, MIL-S-19500; Test Requirements for Semiconductors, MIL-STD-750; Test Methods for Electronic Parts, MIL-STD-202D; and MSC Reliability Parts Program Requirements, MSC-3515. The Screen and Burn-In Specification was used on the following parts.

Type	P/N	Manufacturer	Specification
Transistor	SS3520	Motorola	EPS-128
Transistor	2N2609	T.I.	EPS-214
Transistor	2N5333	T.I.	EPS-179
Transistor	JAN 2N3811	Motorola	EPS-129
Transistor	2N4878	Intersil	EPS-175

2. QUALITY ASSURANCE PLAN

2.1 INTRODUCTION

The objective of this plan will be to ensure compliance with the quality assurance requirements and goals during development, production, and shipping of the EPS. The plan identifies the quality assurance task elements and methods for implementing the quality assurance program for the EPS.

2.2 APPLICABLE DOCUMENTS

MSCM 5312 Reliability and Quality Assurance Manual

NHB 5300.4 (1B) Quality Programs for Space System Contractors

MSC-KA-D-69-44 Apollo Applications Program Ancillary Hardware General Requirements

MSFC-STD-271 Fabrication of Welded Electronic Modules

MSFC-SPEC-270 Component Lead and interconnection Materials for Welded Electronic Modules

2.3 ORGANIZATION

LEC and NASA/MSC quality assurance personnel will be responsible for carrying out various tasks in support of the EPS quality assurance program. These tasks will be the responsibility of both organizations as shown in Table 1.

TABLE 1

TASK RESPONSIBILITIES

Task	LEC[a] Function	NASA[b] Function
Documentation	Implement	None
Drawings and Specifications Review	Implement	Monitor
Quality Planning	Implement	Monitor
Work Instructions	Implement	None
Records	Joint	Joint
Facilities and Standards	Implement	Monitor
Control of Purchases	Implement	Monitor
Fabrication Control	Joint	Joint
Handling and Storage	Implement	Monitor
Conformance	Assist	Implement
Solder	Assist	Implement
Inspection Status	Assist	Implement
Records of Inspection and Testing	Assist	Implement
Government Source Inspection	Assist	Implement
Nonconforming Articles	Joint	Joint
Failure Reporting	Joint	Joint
End Item Report	Joint	Joint
Identification	Assist	Implement

[a,b]These functions are defined on next page.

TABLE 1 (Concluded)

TASK RESPONSIBILITIES

	LEC Function	NASA Function
Acceptance Data Package	Assist	Implement
Contamination Control	Implement	Monitor
Equipment Logs	Assist	Implement
Radiation and Dye Penetration Inspection	Joint	Joint
EEE Parts Quality Verification	Implement	Monitor
Government Property Control	Implement	Monitor
Test and Fabrication Procedures Review	Joint	Joint

DEFINITIONS

Implement - The performance of work necessary to carry the task to completion.

Monitor - To provide assistance and advice, and exercise surveillance over the implementation of the task.

Joint - The responsibility of both organizations to jointly implement the task.

Assist - The performance of work necessary for the completion of the task.

2.4 DOCUMENTATION

LEC will provide all information, documents, records, reports, and assistance to NASA/MSC and its authorized representative as required by the contract.

2.5 DRAWING AND SPECIFICATIONS REVIEW

Each drawing, specification and procedure released for use on the EPS program will be reviewed for quality assurance provisions and inspectability, and will be approved by the LEC quality assurance engineer.

2.6 QUALITY PLANNING

All quality assurance planning will be developed by the quality assurance engineer. All inspections and tests will be planned on appropriate data sheets.

Each data sheet will identify the article under test; will provide instructions for performing the inspections and tests; will state criteria for acceptance or rejections; will provide for recording of required data; and will provide a means of recording status of test completion.

LEC will initially review all phases of the quality assurance requirements to ensure that timely provision is made for special controls, equipment, parts or skills, which will affect the quality of the deliverable hardware.

2.7 WORK INSTRUCTIONS

The quality assurance program will assure that all work affecting quality will be prescribed in clear and complete instructions pertaining to the particular type of effort. This includes purchasing, handling, machining, assembling, fabrication, testing, and any other procedure that involves the deliverable items.

2.8 RECORDS

Records will be maintained and used to assure economical and effective operation of the quality assurance program. The inspection and test records will indicate observations made and deficiencies encountered. Action taken on deficiencies will be recorded on the Discrepancy Record (DR/MRR), (MSC Form 2176).

2.9 FACILITIES AND STANDARDS

Procedures for assuring adequacy of drawings, documentation, and changes will generally follow existing NASA procedures and guidelines. Where it is found that the NASA document is not applicable or appropriate, a new procedure will be generated.

Test and measuring equipment will be used which has a current, valid calibration sticker applied. The objective is to make measurements with properly calibrated equipment which has a known relationship to national standards, and to replace or repair faulty equipment which is to be used in inspection or testing of deliverable items.

2.10 CONTROL OF PURCHASES

The quality assurance engineer will be responsible to assure that purchases of parts/materials will be of sufficient quality to conform to contractual and good workmanship requirements. Suppliers will be chosen on their ability to perform adequately to the quality requirements of the specified parts and materials. In all possible cases parts/materials will be purchased that conform to the Established Reliability designation. If a particular item is not available as an Established Reliability item, then a procurement document will be written which will assure conformance to strict controls to enable the part ot meet the quality requirements of the overall system. In all other cases, parts used will be subjected to screen and burn-in procedures at their respective rated parameters.

2.11 FABRICATION CONTROL

The quality assurance engineer will review and approve all work pertaining to the fabrication of the EPS for the adequacy and currency of all quality requirements of the contract. Materials procured before establishment of contract quality requirements will be reviewed to determine suitability for use in the EPS.

Requirements for supplier data, materials certifications, traceability, and source inspection will be stipulated on the purchase orders, as required.

2.12 HANDLING AND STORAGE OF MATERIALS

The material control system utilized will prevent damage, deterioration, or substitution of materials between receipt at LEC and delivery of the end item to NASA.

Parts and materials that are sensitive to age will be identified and controlled. This will be accomplished by a review of parts and materials lists. A log will be prepared to identify such items.

2.13 INSPECTION AND TESTS

2.13.1 CONFORMANCE

MSC quality assurance will monitor all tests and inspect each assembly, subassembly and module to ensure that each article conforms fully with released drawings, specifications and procedures.

2.13.2 SOLDERING

All hand soldering performed on the EPS will be in accordance with NASA specification NHB 5300.4 (3B) "Requirements for Soldering Electrical Connections."

2.13.3 INSPECTION STATUS

A step-by-step inspection status of the part under test will be indicated on the data sheet. Parts successfully completing the required tests and inspections will be positively identified in a manner appropriate to the size and fragility of the part. Rejected items will be routed for rework or for disposition by the Material Review Board (MRB).

2.13.4 RECORDS OF INSPECTION AND TESTS

Records of inspections and tests made during the development, fabrication, and assembly of the EPS will be maintained and be available for examination upon request. The records will include: part, component or system identification, inspection or tests involved, number of conforming articles, number of rejected articles, nature of defects and basic cause for rejections. The records will be suitable in format, accuracy, completeness and detail to permit analysis. The data will cover both conforming and defective items. Where variables data are required, the actual numerical results obtained will be indicated, including any instrument multiplier factors. Where data or information is required to be recorded, the film, tape or other media will be identified with the characteristic measured and any necessary multiplier factors. Where defective or nonconforming articles are involved, the records will include the results of analysis or basic causes and corrective action taken.

2.13.5 GOVERNMENT SOURCE INSPECTION

Applicable source inspections required by the Government at suppliers' facilities will be stated on purchase orders for new materials procured.

2.14 NONCONFORMING ARTICLES

A Material Review Board will be established which will consist of one engineering representative, the Quality Assurance engineer and the Government representative(s) (NASA/MSC). This Board will review, control and make disposition of all nonconforming end items. Nonconforming items will be carefully segrated to preclude their unauthorized use on the end item.

Positive identification of rejected material, where applicable, will be employed.

2.15 FAILURE REPORTING

The Failure Investigation Action Report (FIAR) (MSC Form 2174) shall be used to report all failures. The FIAR will be processed in accordance with MSCM 5312 (Reliability and Quality Assurance Manual) requirements.

Trouble, failure, and quality data on every part, component, equipment and system will be completely and accurately collected, processed, and disseminated in a minimum of time. The data required will include, but not be limited to, that specified in this section, and may be submitted in separate reports as generated.

Procedures and responsibilities will be established for the collection of failure and quality data resulting from testing, inspection and usage of the articles procured or produced. These procedures will include effective followup to ensure timely and adequate corrective action on all deficiencies throughout all tests programs.

Data will be collected and analyzed to:

a. Provide indicators of design and fabrication deficiencies so that early corrective action and preventive action can be initiated.

b. Provide corrective action and preventive action information to improve and maintain required quality and reliability.

c. Provide complete functional and performance history on all articles for use in design selection, qualification testing, and design improvements.

d. Evaluate quality aspects of specifications, drawings and other technical documents.

e. Determine the need for special investigations and analyses.

f. Establish the requirements for process control charts.

g. Determine the validity of inspections, test specifications and procedures, and process control.

h. Provide engineering, purchasing and fabrication personnel with information on actual quality assurance requirements.

i. Establish and maintain a realistic list of limited and critical life articles.

2.16 END ITEM REPORT

The Quality Assurance engineer will prepare a narrative end item report for each end item submitted under the contract schedule. The report will cover item test and inspection, weight, packaging, packing and shipment. The report will include, but not be limited to the following:

a. Final configuration.

b. Replacements made during installation, test and final checkout. Serial and part numbers of articles removed and those substituted will be indicated.

c. Corrective action taken or pending.

d. Nature of trouble and malfunctions encountered.

e. Total operating time of each end item.

2.17 IDENTIFICATION

Matierals, processes and design parameters will be so identified in the design configuration and documentation that the engineering features to be evaluated may be associated with the particular articles. Each article, including parts and components, will be identified by a unique part number and serial or lot number as may be required. These identification numbers will be consistent with the engineering drawings and change control system used throughout the contract. When the contract requires mechanized or electronic processing of data for distribution, the identification numbers will be suitable for processing.

2.18 ACCEPTACNE DATA PACKAGE (ADP)

An Acceptance Data Package (ADP) will be delivered with each hardware end item. The degree and contents of the ADP will vary depending upon hardware class, complexity and whether such hardware is deliverable by the contract, or deliverable but not contractually required.

LEC will submit an inventory with each end item, indicating which of the listed items are included in the package, which items have already been submitted, which items are excluded, and a statement covering exclusion.

2.19 CONTAMINATION CONTROL

Cleanliness of deliverable items will be controlled such that the requirements of interface, performance, and design are met. Contamination control documentation will be provided to outline methods and procedures to assure cleanliness of the end item hardware. A clean work area and clean bench will be utilized for fabrication and assembly of the deliverable hardware.

2.20 EQUIPMENT LOGS

Equipment logs will be maintained for all deliverable end items, including major components, subassemblies, and systems. The log will contain all information as required by Paragraph 8.3.5 of Document MSC-KA-D-69-44, Revision A.

2.21 RADIOGRAPHIC AND DYE PENETRANT INSPECTION

Inspection techniques will meet the requirements of good workmanship and applicable contractual documentation. Inspection techniques and requirements will be coordinated between the LEC Quality Assurance engineer and the Government Quality Assurance representative.

2.22 ELECTRICAL, ELECTRONIC, ELECTROMECHANICAL (EEE) PARTS QUALITY VERIFICATION

All EEE parts shall be Established Reliability and/or JAN TX where possible. If these parts are not available, procedures will be written for screen and burn-in of the parts. It will be required that all parts not having Established Reliability be subjected to screen and burn-in to assure a high degree of quality and reliability.

Lot traceability and certificates of compliance will be required on all parts, except in cases where this requirement is waived by NASA/MSC Quality Assurance.

2.23 GOVERNMENT PROPERTY CONTROL

LEC will be responsible for all Government furnished property/equipment in accordance with the provisions of the contract. LEC's responsibility will include, but not be limited to, protection of the property, and making provisions for calibration scheduling so as to minimize conflicts with work schedules. The calibration and repair facilities of MSC will be used for calibration and repair of the Government-owned equipment. The same property control system used on NASA Contract NAS 9-10950 will be utilized on this Contract, NAS 9-11373. The primary control point for property and audit is the HASD Accounting Manager.

EPS-469

ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

LEC Document Number EPS-469

Prepared by
Lockheed Electronics Company
Houston Aerospace Systems Division
Houston, Texas

Under Contract NAS 9-11373

for the

National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas

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EEE PARTS LIST

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Advanced Programs Department

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Houston, Texas

ELECTRON-PROTON SPECTROMETER

The Electron-Proton Spectrometer EEE Parts List catalogs the electrical, electronic, and electromechanical (EEE) parts used in the EPS. The list is divided into sections each representing a particular assembly. The parts of each assembly are grouped by their generic name. Parts are identified by size, rating, material, and part numbers as applicable. Drawing designation, manufacture, specification number, method of qualification, qualification status, and number required are also shown.

Parts used on the EPS are procured to user's specifications that include reliability and quality assurance for each application. Electronic parts have been derated to obtain the best operating levels for prolonged reliability.

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SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39107190
NAME PREAMPLIFIER SLICE

ASSEMBLY:
NUMBER SEC39107185
NAME PREAMPLIFIER

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY: SUB ASSEMBLY NUMBER SEC39107185-301	TOTAL REQUIRED PER ASSEMBLY
	R1	RESISTOR - Selected	Mepco		MIL-R-55182	Established Reliability	Q	1	5
	R2	RESISTOR - 7.87kΩ, 1%, 1/20W, Metal Film	Mepco	RNC50 K7871FR	MIL-R-55182	Established Reliability	Q	1	5
	R3	RESISTOR - 7.15kΩ, 1%, 1/20W, Metal Film	"	RNC50 K7151FR	"	Established Reliability	Q	1	5
	R4	RESISTOR - 255Ω, 1%, 1/20W, Metal Film	"	RNC55 K2550FR	"	Established Reliability	Q	1	5
	R5	RESISTOR - 604Ω, 1%, 1/20W, Metal Film	"	RNC50 K6040FR	"	Established Reliability	Q	1	5
	R6	RESISTOR - 1.21kΩ, 1%, 1/20W, Metal Film	"	RNC50 K1211FR	"	Established Reliability	Q	1	5
	R7	RESISTOR - 100MΩ, 5%	Caddock	1712-100 Meg.	"	LEC Spec #168	Q	1	5
	R8	RESISTOR - 2.55kΩ, 1%, 1/20W, Metal Film	Mepco	RNC55 K2551FR	"	Established Reliability	Q	1	5
	R9	RESISTOR - 93.1Ω, 1%, 1/10W, Metal Film	"	RNC50 K93R1FR	"	Established Reliability	Q	1	5
	R10	RESISTOR -49.9Ω, 1%, 1/10W, Metal Film	"	RNC55 K49R9FR	"	Established Reliability	Q	1	5
	R11, R16	RESISTOR - 49.9kΩ, 1%, 1/20W, Metal Film	"	RNC50H 4991FS	"	Established Reliability	Q	2	10
	R12	RESISTOR - 4.99kΩ, 1%, 1/20W, Metal Film	"	RNC50H 4991FS	"	Established Reliability	Q	1	5
	R13	RESISTOR - Selected	Caddock		"	LEC Spec #168	Q	1	5
	R14, R21	RESISTOR - 2.67kΩ, 1%, 1/20W, Metal Film	MEPCO	RNC50H 2671FS	"	Established Reliability	Q	2	10
	R15, R20	RESISTOR - 80.6kΩ, 1%, 1/20, Metal Film	"	RNC50H 8062FS	"	Established Reliability	Q	2	10
	R17	POTENTIOMETER - 500Ω	Bourns	3260W 1-501	MIL-R-27208	LEC Spec #124	Q	1	5

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SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39107190
NAME PREAMPLIFIER SLICE

ASSEMBLY:
NUMBER SEC39107185
NAME PREAMPLIFIER

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY — SUB ASSEMBLY NUMBER SEC39107185-301										TOTAL REQUIRED PER ASSEMBLY
	R18, R19	RESISTOR - 30.1Ω, 1%, 1/20W, Metal Film	Mepco	RNC50H 30R1FS	MIL-R-55182	Established Reliability	Q	1									5
	C1	CAPACITOR-Variable, .6-1.8pF, 750V	JFD	RVC-12	LEC Spec EPS-232	Screen and Burn-in	Q	1									5
	C2	CAPACITOR - NPO, 1.0pF, 25%, 50V	USCC	RC33C1ROD	MIL-C-39003	Screen and Burn-in	Q	1									5
	C3	CAPACITOR -47μF, 10%, 6V, Solid Tantalum	Kemet	T210B476 K006RS	MIL-C-39003	Established Reliability	Q	1									5
	C4	CAPACITOR-3.3μF, 10%, 15V, Solid Tantalum	Kemet	T210A335 K015RS	"	Established Reliability	Q	1									5
	C5, C6, C8	CAPACITOR - .01μF, 10%, 200V, ceramic	Kemet	CKR06BX 103KR	"	Established Reliability	Q	3									15
	C7, C9	CAPACITOR - 15μF, 10%	Kemet	T210B156 K020RS	"	Established Reliability	Q	2									10
	C10	CAPACITOR - .01μF, 10%	Kemet	CKR06BX 103MR	"	Established Reliability	Q	1									5
	C11	CAPACITOR - 100pF, 10%	Kemet	CKR05BX 101KR	"	Established Reliability	Q	1									5
	Q1	TRANSISTOR - FET	Texas Instrument	(JANTX-2N4858) Selected SSC6113	MIL-S-19500/385	Established Reliability	Q	1									5
	Q2, Q4	TRANSISTOR - PNP, Fast Switching, Silicon	Motorola	JAN-TX 2N-3251A	MIL-S-19500/323	Established Reliability	Q	2									10
	Q3	TRANSISTOR - NPN, Low Power, Silicon	Motorola	JANTX 2N-2708	MIL-S-19500/302	Hi-Rel Testing	Q	1									5
	CR1	DIODE - General Purpose, Silicon	Texas Instrument	JANTX 1N649	MIL-S-19500/240	Established Reliability	Q	1									5
	CR2, CR3	DIODE - Silicon	Dickson	1N4567A	Dickson Hi-Rel Spec.	Hi-Rel Testing	Q	2									10

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SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39107196
NAME PREAMPLIFIER SLICE

ASSEMBLY:
NUMBER SEC39107185
NAME PREAMPLIFIER

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY: SUB ASSEMBLY NUMBER SEC39107185-301										TOTAL REQUIRED PER ASSEMBLY
	L1, L2, L4	INDUCTOR - 100µH	J. W. Miller	9210-76	MIL-C-15305	Hi-Rel Testing	Q	3										15
	L3	INDUCTOR - 20mH	Collins	526-2930-130	MIL-C-15305	Established Reliability	Q	1										5
		CONNECTOR - Screw Mount	Microdot	MCDM1-15P4L4-0.5	MIL-C-38300A	Microdot Hi-Rel Tests MIL-STD-202D	Q	1										5
		CONNECTOR - Receptacle	Microdot	031-0070-.001	MIL-C-38300A	Microdot Hi-Rel Tests MIL-STD-202D	Q	1										5

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SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39107190
NAME PREAMPLIFIER SLICE

ASSEMBLY:
NUMBER SEC39107184
NAME DETECTOR BIAS-SUPPLY

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY: SUB ASSEMBLY NUMBER SEC39107184-301										TOTAL REQUIRED PER ASSEMBLY
	R1	RESISTOR - 14kΩ, 1%, 1/20W	Mepco	RNC50H 1402FR	MIL-R-55182	Established Reliability	Q	1										1
	R2	RESISTOR - 13Ω, 5%, 1/4W	Allen Bradley	RCR07G 130JP	MIL-R-39008	Established Reliability	Q	1										1
	R3	RESISTOR - 34.8kΩ, 1%, 1/20W	Mepco	RNC50H 3482FR	MIL-R-55182	Established Reliability	Q	1										1
	R4	RESISTOR - 22.1kΩ, 1%, 1/20W	Mepco	RNC50H 2212FR	"	Established Reliability	Q	1										1
	R5	POTENTIOMETER - 10kΩ, 5%	Bourns	3262WH 39103	MIL-R-27208	Hi-Rel Testing	Q	1										1
	R6	RESISTOR - 1.0kΩ, 1%, 1/20W	Mepco	RNC50H 1001FR	MIL-R-55182	Established Reliability	Q	1										1
	R7	RESISTOR - 13kΩ, 1%, 1/20W	Mepco	RNC50H 1302FR	"		Q	1										1
	C1	CAPACITOR - 100pf, 200V, 10%	Kemet	CKR05BX 101KP	MIL-C-39014		Q	1										1
	C2	CAPACITOR - 3300pf, 200V, 10%	Kemet	CKR06BX 332KP	"		Q	1										1
	C3	CAPACITOR - 18µf, 50V, 10%	Kemet	T210C186 K050PS	MIL-C-39003		Q	1										1
	C9, C10	CAPACITOR - 1000pf, 200V, 10%	Kemet	CKR050BX 102KP	MIL-C-39014		Q	2										2
	C11	CAPACITOR - Selected	Kemet	CKR06BX	"		Q	1										1
	CR1, CR2	DIODE	Texas Instruments	JAN-TX-1N914	MIL-S-19500		Q	2										2
	Q1, Q2	TRANSISTOR	Texas Instruments	JAN-TX-2N3421	"		Q	2										2
	Z1	VOLTAGE REGULATOR	Advance Micro	µA723/883	MIL-STD-883/Level A	Established Reliability	Q	1										1
	P1, P2	CONNECTOR	Microdot	MCDM1-9P4L-0.5	MIL-C-38300A	Hi-Rel Tested	Q	2										2

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SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39107184
NAME DETECTOR BIAS SUPPLY

ASSEMBLY:
NUMBER SEC39106694
NAME DETECTOR RECTIFIER & FILTER

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY: SUB ASSEMBLY NUMBER SEC39106694-301										TOTAL REQUIRED PER ASSEMBLY
	R8	RESISTOR - 50kΩ, 1%, 3/4W	Caddock	MK-132-50K	MIL-R-55182	Hi-Rel Testing	Q	1										1
	R9, R11, R12	RESISTOR - 10MΩ, 1%, 1/2W	Caddock	MG660-10MEG	"	Hi-Rel Testing	Q	3										3
	R10	RESISTOR - 100kΩ, 1%, 3/4W	Caddock	MK-132-100K	"	Hi-Rel Testing	Q	1										1
	C4 - C7	CAPACITOR - .01µf, 1000V	Erie	828-1KV-X5T-103M	MIL-C-39014	Hi-Rel Testing	Q	4										4
	C8	CAPACITOR - 1000pf, 200V	Kemet	CKR05BX102KP	MIL-C-39014	Established Reliability	Q	1										1
	CR3 - CR8	DIODE	Texas Instruments	JAN-TX-1N649	MIL-S-19500	Established Reliability	Q	6										6

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SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39106670
NAME PULSE AMPLIFIER SLICE

ASSEMBLY:
NUMBER SEC39107187
NAME PULSE AMPLIFIER

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY: SUB ASSEMBLY NUMBER SEC39107187-301	SEC39107187-302	TOTAL REQUIRED PER ASSEMBLY
	R1	POTENTIOMETER - 10kΩ, 5%	Bourns	3260HH1 39103	MIL-R-27208	Hi-Rel Testing	Q	1	1	5
	R2	RESISTOR - 44.2kΩ, 1%, 3/4W	Caddock	MK132	MIL-R-55182	Hi-Rel Testing	Q	1	1	5
	R2	RESISTOR - 140kΩ, 1%, 3/4W	Caddock	MK132	"	Hi-Rel Testing	Q		1	1
	R3	RESISTOR - 165Ω, 1%, 1/20W	Mepco	RNC50H 1650FR	"	Established Reliability	Q	1	1	5
	R4, R28	RESISTOR - 324Ω, 1%, 1/20W	"	RNC50H 3240FR	"		Q	2	2	10
	R4, R28	RESISTOR - 267Ω, 1%, 1/20W	"	RNC50H 2670FR	"		Q	2	2	10
	R4, R28	RESISTOR - 169Ω, 1%, 1/20W	"	RNC50H 1690FR	"		Q		2	2
	R5, R8 R29, R33	RESISTOR - 78.7kΩ, 1%, 1/20W	"	RNC50H 7872FR	"		Q	4	4	20
	R6, R30	RESISTOR - 80.6kΩ, 1%, 1/20W	"	RNC50H 8062FR	"		Q	2	2	10
	R7, R31	RESISTOR - 59kΩ, 1%, 1/20W	"	RNC50H 5902FR	"		Q	2	2	10
	R9, R32	RESISTOR - 4.87kΩ, 1%, 1/20W	"	RNC50H 4871FR	"		Q	2	2	10
	R10, R11 R34, R35	RESISTOR - 2.43kΩ, 1%, 1/20W	"	RNC50H 2431FR	"	Established Reliability	Q	4	4	20

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SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39106670
NAME PULSE AMPLIFIER SLICE

ASSEMBLY:
NUMBER SEC39107187
NAME PULSE AMPLIFIER

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY: SEC39107187-301	SEC39107187-302	TOTAL REQUIRED PER ASSEMBLY
	R12, R36	RESISTOR - 2.74kΩ, 1%, 1/20W	Mepco	RNC50H 2741FR	MIL-R-55182	Established Reliability	Q	2	2	10
	R13, R37	RESISTOR - 3.74kΩ, 1%, 1/20W	"	RNC50H 3741FR	"		Q	2	2	10
	R14, R15 R38, R39	RESISTOR - 25.5kΩ, 1%, 1/20W	"	RNC50H 2552FR	"		Q	4	4	20
	R16, R40	RESISTOR - 8.25kΩ, 1%, 1/20W	"	RNC50H 8252FR	"		Q	2	2	10
	R17, R41	RESISTOR - 1.13kΩ, 1%, 1/20W	"	RNC50H 1132FR	"		Q	2	2	10
	R18, R19 R42, R43	RESISTOR - 43.2Ω, 1%, 1/20W	"	RNC50K 43R2FR	"		Q	4	4	20
	R20, R44	RESISTOR - 200Ω, 1%, 1/20W	"	RNC50H 2000FR	"		Q	2	2	10
	R21, R24 R45, R51	RESISTOR - 10Ω, 1%, 1/20W	"	RNC50K 10R0FR	"		Q	4	4	20
	R22, R23, R47, R49	RESISTOR - 40.2Ω, 1%, 1/20W	"	RNC50K 40R2FR	"		Q	4	4	20
	R25, R26 R46, R52	RESISTOR - 32.4Ω, 1%, 1/20W	"	RNC50K 32R4FR	"		Q	4	4	20
	R27	RESISTOR - 215Ω, 1%, 1/20W	"	RNC50H 2150FR	"	Established Reliability	Q	1	1	5

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SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39106670
NAME PULSE AMPLIFIER SLICE

ASSEMBLY:
NUMBER SEC39107187
NAME PULSE AMPLIFIER

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	SUB ASSEMBLY NUMBER: SEC39107187-301	SEC39107187-302									TOTAL REQUIRED PER ASSEMBLY
	R48	RESISTOR - 49.9Ω, 1%, 1/20W	Mepco	RNC50K 49R9FR	MIL-R-55182	Established Reliability	Q	1	1									5
	R50	RESISTOR - 100Ω, 1%, 1/20W	"	RNC50H 1000FR	"	Established Reliability	Q	1	1									5
	C1, C16	CAPACITOR - 850pf, 50V	USCC	RC37C 851F	MIL-C-39014	Hi-Rel Testing	Q	2										8
	C1, C16	CAPACITOR - 51pf, 50V	"	RC37C 516F	"	Hi-Rel Testing	Q		2									2
	C2, C17	CAPACITOR - .18µf, 50V	Kemet	T2100A 184K050RS	MIL-C-39003	Established Reliability	Q	2	2									10
	C3, C7, C13, C18 C24, C28 C31, C32	CAPACITOR - .01µf, 200V	Kemet	CKR06BX 103KP	MIL-C-39014	Established Reliability	Q	8	8									40
	C4, C19	CAPACITOR - 5.0pf, 50V	USCC	RC37C5 ROD	MIL-C-39014	Hi-Rel Tests Qual.	Q	2										8
	C4, C19	CAPACITOR - 2.2pf, 50V	"	RC12C2 R2D	"		Q		2									2
	C5, C20	CAPACITOR - 22pf, 50V	"	RC37C 220J	"		Q	2										8
	C5, C20	CAPACITOR - 10pf, 50V	"	RC37C 100J	"	Hi-Rel Tests Qual.	Q		2									8
	C6, C9 C22, C23	CAPACITOR - 3.3µf, 200V	Kemet	T210A335-K015RS	MIL-C-39003	Established Reliability	Q	4	4									20
	C8, C21	CAPACITOR - .033µf, 100V	"	CKR06BX 333KP	MIL-C-39014	Established Reliability	Q	2	2									10
	C10, C11 C25, C26	CAPACITOR - 150pf, 50V	USCC	RC37151F	MIL-C-39014	Hi-Rel Test Qual.	Q	4										16

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SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39106670
NAME PULSE AMPLIFIER SLICE

ASSEMBLY:
NUMBER SEC39107187
NAME PULSE AMPLIFIER

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY: SEC39107187-301	SEC39107187-302	TOTAL REQUIRED PER ASSEMBLY
	C10, C11 C25, C26	CAPACITOR - 91pf, 50V	USCC	RC37C910F	MIL-C-39014	Hi-Rel Test Qual	Q		4	4
	C12, C27	CAPACITOR - 3.3pf, 50V	"	RC12C3R3D	"		Q	2		8
	C12, C27	CAPACITOR - 3.9pf, 50V	"	RC12C3R9D	"		Q	2		8
	C12, C27	CAPACITOR - 1.5pf, 50V	"	RC12C1R5D	"		Q		2	2
	C12, C27	CAPACITOR - 2.7pf, 50V	"	RC12C2R7D	"		Q	2		8
	C12, C27	CAPACITOR - 1.0pf, 50V	"	RC12C1R0D	"		Q		2	2
	C14, C29	CAPACITOR - 68pf, 50V	"	RC37C680J	"		Q	2		8
	C14, C29	CAPACITOR - 27pf, 50V	"	RC37C270J	"		Q		2	2
	C15, C30	CAPACITOR - 180pf	USCC	RC37C181J			Q	2	2	10
	C15, C30	CAPACITOR - 68pf	"	RC37C680J	"		Q		2	2
	C15, C30	CAPACITOR - 100pf	"	RC37C101J	"	Hi-Rel Test Qual	Q		2	2

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SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39106670
NAME PULSE AMPLIFIER SLICE

ASSEMBLY:
NUMBER SEC39107187
NAME PULSE AMPLIFIER

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY: SEC39107187-301	QUANTITY PER SUB ASSEMBLY: SEC39107187-302	TOTAL REQUIRED PER ASSEMBLY
	Q1 Thru Q4	TRANSISTOR - Dual	Intersil	2N4878	MIL-S-19500	LEC Hi-Rel Test Qual	Q	4	4	20
	Q5 Thru Q8	TRANSISTOR	Motorola	SS2638H (2N4261)	MIL-S-19500	Motorola MIL-STD-883	Q	4	4	20
	Q9 Thru Q12	TRANSISTOR	Motorola	SS3520 (2N2708)	MIL-S-19500	Motorola Hi-Rel Tests	Q	4	4	20
	CR1 Thru CR18	DIODE	Texas Instruments	JANTX-1N4153	MIL-S-19500	Established Reliability	Q	18	18	90
	P1	CONNECTOR	Microdot	MCDMI-15P-4L4-0.5	MIL-C-38300A	Hi-Rel Test Qual	Q	1	1	5
	S1	CONNECTOR	Microdot	MCDMI-15S-4L40.5	MIL-C-388300A	Hi-Rel Test Qual	Q	1	1	5

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SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39106670
NAME PULSE AMPLIFIER SLICE

ASSEMBLY:
NUMBER SEC39107189
NAME TEMPERATURE MONITOR

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY: SUB ASSEMBLY NUMBER SEC39107189-301										TOTAL REQUIRED PER ASSEMBLY
	R1	RESISTOR - Selected Value	Caddock	MK132 Selected	MIL-R-55182	Hi-Rel Test Qual	Q	1										1
	R2, R9	RESISTOR - 392Ω, 1%, 1/20W	Mepco	RNC50H 3920FR	"	Established Reliability	Q	2										2
	R3, R10	POTENTIOMETER - 50Ω	Bourns	3260WM 39500	MIL-R-22097	Hi-Rel Testing	Q	2										2
	R4, R11	RESISTOR - Selected Value	Mepco	RNC55H4 Selected	MIL-R-55182	Established Reliability	Q	2										2
	R5, R12	RESISTOR - 549Ω, 1%, 1/20W	"	RNC50H 5490FR	"	Established Reliability	Q	2										2
	R6, R13	POTENTIOMETER - 500Ω	Bourns	3260WM 39501	MIL-R-22097	Hi-Rel Testing	Q	2										2
	R7, R14	RESISTOR - 13.7kΩ, 1%, 1/2-W	Mepco	RNC50H 1372FR	MIL-R-55182	Established Reliability	Q	2										2
	R8	RESISTOR - Selected Value	Mepco	RNC50H Selected	"	Established Reliability	Q	1										1
	VR1	DIODE - Zener (1N4901A)	Dickson	DT710415D	MIL-S-19500	Hi-Rel Testing	Q	1										1
	VR2	DIODE - Zener (1N4567A)	Dickson	DT710415C	MIL-S-19500	Hi-Rel Testing	Q	1										1

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SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC391066425
NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39106675
NAME DISCRIMINATOR SLICE

ASSEMBLY:
NUMBER SEC39106664
NAME PULSE HEIGHT DISCRIMINATOR

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY: SEC39106664-301	SEC39106664-302	SEC39106664-303	SEC39106664-304	SEC39106664-305	TOTAL REQUIRED PER ASSEMBLY
	R1, R12	RESISTOR - 4.53kΩ, 1%, 1/20W	Mepco	RNC50H 4531FR	MIL-R-55182	Established Reliability	Q	2	2	2	2	2	10
	R2, R13	RESISTOR - 3160Ω, 1%, 1/20W	"	RNC50H 3161FR	"		Q	2	2	2	2	2	10
	R3	RESISTOR - 1540Ω, 1%, 1/20W	"	RNC50H 1541FR	"		Q	1			1	1	3
	R3	RESISTOR - 1470Ω, 1%, 1/20W	"	RNC50H 1471FR	"		Q		1				1
	R3	RESISTOR - 1500Ω, 1%, 1/20W	"	RNC50H 1501FR	"	Established Reliability	Q			1			1
	R4	RESISTOR - 580kΩ, 1%, 3/4W	Caddock	MK132	"	Hi-Rel Testing	Q	1					1
	R4	RESISTOR - 550kΩ, 1%, 3/4W	"		"	Hi-Rel Testing	Q		1				1
	R4	RESISTOR - 480kΩ, 1%, 3/4W	"		"	Hi-Rel Testing	Q			1			1
	R4	RESISTOR - 440kΩ, 1%, 3/4W	"		"	Hi-Rel Testing	Q				1		1
	R4	RESISTOR - 500kΩ, 1%, 3/4W	"	MK132	"	Hi-Rel Testing	Q					1	1
	R5 (1)	RESISTOR - 750Ω, 1%, 1/20W	Mepco	RNC50H 7500FR	"	Established Reliability	Q					1	1
	R5 (2)	RESISTOR - 715Ω, 1%, 1/20W	"	RNC50H 7150FR	"		Q				1		1
	R5 (3)	RESISTOR - 787Ω, 1%, 1/20W	"	RNC50H 7870FR	"		Q			1			1
	R5 (4)	RESISTOR - 1kΩ, 1%, 1/20W	"	RNC50H 1001FR	"		Q		1				1
	R5 (5)	RESISTOR - 1.13kΩ, 1%, 1/20W	"	RNC50H 1131FR	"	Established Reliability	Q	1					1

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ASSEMBLY:
NUMBER SEC39106664
NAME PULSE HEIGHT DISCRIMINATOR

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY: SEC39106664-301	SEC39106664-302	SEC39106664-303	SEC39106664-304	SEC39106664-305						TOTAL REQUIRED PER ASSEMBLY
	R6	POTENTIOMETER - 100Ω, 5%	Bourns	3260HM 39101	MIL-R-22097	Hi-Rel Testing	Q	1										1
	R6	POTENTIOMETER - 5%, 200Ω	"	3260HM 39201	MIL-R-22097	Hi-Rel Testing	Q		1	1	1	1						4
	R7 (1)	RESISTOR - 464Ω, 1%, 1/20W	Mepco	RNC50H 4640FR	MIL-R-55182	Established Reliability	Q					1						1
	R7 (2)	RESISTOR - 604Ω, 1%, 1/20W	"	RNC50H 6040FR	"		Q				1							1
	R7 (3)	RESISTOR - 487Ω, 1%, 1/20W	"	RNC50H 2940FR	"		Q			1								1
	R7 (4)	RESISTOR - 267Ω, 1%, 1/20W	"	RNC50H 2670FR	"		Q	1										1
	R7	RESISTOR - 294Ω, 1%, 1/20W	"	RNC50H 2940FR	"		Q		1									1
	R8	RESISTOR - 2.10kΩ, 1%, 1/20W	"	RNC50H 2101FR	MIL-R-55182	Established Reliability	Q	1										1
	R8	RESISTOR - 1.69kΩ, 1%, 1/20W	"	RNC50H 1691FR	"	Established Reliability	Q		1	1	1	1						4
	R9	POTENTIOMETER - 200Ω, 5%	Bourns	3260HM 39201	MIL-R-22097	Hi-Rel Testing		1										1
	R9	POTENTIOMETER - 50Ω, 5%	"	3260HM 39500	MIL-R-22097	Hi-Rel Testing	Q		1	1	1	1						4
	R10, R25	RESISTOR - 000Ω, Shorting Wire						2	2	2	2	2						10
	R11	RESISTOR - 1.82kΩ, 1%, 1/20W	Mepco	RNC50H 1821FR	MIL-R-55182	Established Reliability	Q		1	1	1	1						4
	R11	RESISTOR - 1.78kΩ, 1%, 1/20W	Mepco	RNC50H 1781FR		Established Reliability	Q	1										1
	R14	RESISTOR - 725kΩ, 1%, 3/4W	Caddock	MK132	MIL-R-55182	Established Reliability	Q		1	1	1	1						4

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SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39106675
NAME DISCRIMINATOR SLICE

ASSEMBLY:
NUMBER SEC39106664
NAME PULSE HEIGHT DISCRIMINATOR

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	SEC39106664-301	SEC39106664-302	SEC39106664-303	SEC39106664-304	SEC39106664-305	TOTAL REQUIRED PER ASSEMBLY
	R14	RESISTOR - 750kΩ, 1%, 3/4W	Caddock	MK132	MIL-R-55182	Hi-Rel Testing	Q	1					1
	R15, R16	RESISTOR - 169Ω, 1%, 1/20W	Mepco	RNC50H 1690FR	"	Established Reliability	Q	2	2	2	2	2	10
	R17	RESISTOR - 1.0kΩ, 1%, 1/20W	"	RNC50H 1001FR	"		Q	1	1	1	1	1	5
	R18, R19	RESISTOR - 100Ω, 1%, 1/20W	"	RNC50H 1000FR	"		Q	2	2	2	2	2	10
	R20, R21, R22	RESISTOR - 49.9kΩ, 1%, 1/20W	"	RNC50H 4992FR	"		Q	3	3	3	3	3	15
	R23, R24												
	R29, R30	RESISTOR - 33.2Ω, 1%, 1/20W	"	RNC50K 33R2FR	"		Q	4	4	4	4	4	20
	R26, R27	RESISTOR - 100kΩ, 1%, 1/20W	"	RNC50H 1003FR	"		Q	2	2	2	2	2	10
	R28	RESISTOR - 4.02kΩ, 1%, 1/20W	"	RNC50H 4021FR	"	Established Reliability	Q	1	1	1	1	1	5
	R31	POTENTIOMETER - 100kΩ, 5%	Bourns	3262WM 39104	MIL-R-22097	Hi-Rel Testing	Q	1	1	1	1	1	5
	R32	RESISTOR - 36.5kΩ, 1%, 1/20W	Mepco	RNC50H 3652FR	MIL-R-55182	Established Reliability	Q	1	1	1	1	1	5
	R33	RESISTOR - 158kΩ, 1%, 1/20W	"	RNC50H 1583FR	"	Established Reliability	Q	1	1	1	1	1	5
	R34	RESISTOR - 30.1kΩ, 1%, 1/20W	"	RNC50H 3012FR	"	Established Reliability	Q	1	1	1	1	1	5
	R35	RESISTOR - 97.6Ω, 1%, 1/20W	"	RNC50H 97R6FR	"	Established Reliability	Q	1	1	1	1	1	5
	R36	POTENTIOMETER - 10k, 5%	Bourns	3260HM 39103	MIL-R-22097	Hi-Rel Testing	Q	1	1	1	1	1	5

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SKYLAB ELECTRON-PROTON SPECTROMETER
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TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39106675
NAME DISCRIMINATOR SLICE

ASSEMBLY:
NUMBER SEC39106664
NAME PULSE HEIGHT DISCRIMINATOR

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	SEC39106664-301	SEC39106664-302	SEC39106664-303	SEC39106664-304	SEC39106664-305	TOTAL REQUIRED PER ASSEMBLY
	C1 thru C7	CAPACITOR - 1μf, 10%, 100V	Kemet	CKR06 BX104KR	MIL-C-19014	Established Reliability	Q	7	7	7	7	7	35
	C8, C9	CAPACITOR - 220pf, 10%, 200V	Kemet	CKR05 BX221KR	"		Q	2	2	2	2	2	10
	C10	CAPACITOR - 68μf, 10%, 15V	"	T210C68 6K015RS	MIL-C-39003		Q	1	1	1	1	1	5
	C11, C12 C14, C15	CAPACITOR - .01μf, 10%, 200V	"	CKR06 BX103KP	MIL-C-19014		Q	4	4	4	4	4	20
	C13, C18	CAPACITOR - 100pf, 10%, 200V	"	CKR05 BX101KP	"		Q	2	2	2	2	2	10
	C17	CAPACITOR - 2.2μf, 10%, 20V	"	T210A225 K020RS	MIL-C-39003	Established Reliability	Q	1	1	1	1	1	5
	L1 thru L4	INDUCTOR - 100μH	J. W. Miller	9210-76	MIL-C-15305	J. W. Miller Hi-Rel Spec	Q	4	4	4	4	4	20
	Z6	AMPLIFIER	Advance Micro	LM108/ 883	MIL-STD 883-Level A	Established Reliability	Q	1	1	1	1	1	5
	CR1, CR2	DIODE - Silicon, Switching	Texas Instruments	JAN-TX 1N914	MIL-S-19500/116	JAN-TX Hi-Rel	Q	2	2	2	2	2	10
	CR3, CR4	DIODE - Silicon Hot Carrier	Hewlett Packard	SN5473T	MIL-S-19500	Hi-Rel Special Test	Q	1	1	1	1	1	5
	Z1, Z2	AMPLIFIER	Signetics	SE526K	MIL-STD 883/Level A	Established Reliability	Q	2	2	2	2	2	10
	Z3	JK Flip-Flop	Texas Instruments	SN5473S	MIL-STD 883/Level A	Established Reliability	Q	1	1	1	1	1	5
	Z4, Z5	AMPLIFIER	Harris Semiconductor	HA-2-2520-2	MIL-STD 883/Level A	Established Reliability	Q	2	2	2	2	2	10
	P3, P4	CONNECTOR - PCB Receptacle	Microdot	031-0070-001	MIL-C-38300A	Hi-Rel Testing	Q	2	2	2	2	2	10
	S2	CONNECTOR - Screw Mount	Microdot	MCDM1-15S4L4-.5	MIL-C-38300A	Hi-Rel Testing	Q	1	1	1	1	1	5
	P1	CONNECTOR - Screw Mount	Microdot	MCDM1-21P4L4-.5	MIL-C-38300A	Hi-Rel Testing	Q	1	1	1	1	1	5

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EEE PARTS LIST

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NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39106675
NAME DISCRIMINATOR SLICE

ASSEMBLY:
NUMBER SEC39106669
NAME HEATER CONTROL

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	SUB ASSEMBLY NUMBER SEC39106669-301 (QUANTITY PER SUB ASSEMBLY)	TOTAL REQUIRED PER ASSEMBLY
	R1	RESISTOR - 13kΩ, 1%, 1/20W	Mepco	RNC50H 1372FR	MIL-R-55182	Established Reliability	Q	1	1
	R2	RESISTOR - 33Ω, 5%, 1/4W	Allen Bradley	RCR07G 330JP	MIL-R-39008		Q	1	1
	R3	RESISTOR - 19.1kΩ, 1%, 1/20W	Mepco	RNC50H 1912FR	MIL-R-55182		Q	1	1
	R4	RESISTOR - 47.5kΩ, 1%, 1/20W	"	RNC50H 4752FR	"		Q	1	1
	R5	RESISTOR - 45.3kΩ, 1%, 1/20W	"	RNC50H 4532FR	"		Q	1	1
	R6	RESISTOR - 49.9kΩ, 1%, 1/20W	"	RNC50H 4992FR	"		Q	1	1
	R8	RESISTOR - 4.99kΩ, 1%, 1/20W	"	RNC50H 4991FR	"		Q	1	1
	R9	RESISTOR - 66Ω, 1%, 1/20W	"	RNC50H 6650FR	"		Q	1	1
	R10	RESISTOR - 619Ω, 1%, 1/20W	"	RNC50H 6190FR	"		Q	1	1
	R11	RESISTOR - 1.91kΩ, 1%, 1/20W	"	RNC50H 1911FR	"		Q	1	1
	R12	RESISTOR - 2.61kΩ, 1%, 1/20W	"	RNC50H 2611FR	"		Q	1	1
	R13	RESISTOR - 10kΩ, 1%, 1/20W	"	RNC50H 1002FR	"		Q	1	1
	R14	RESISTOR - 7.68kΩ, 1%, 1/20W	"	RNC50H 7681FR	"		Q	1	1
	R15	RESISTOR - 3.0kΩ, 1%, 1/20W	"	RCR07G 302JS	MIL-R-39008		Q	1	1
	R16	RESISTOR - 100kΩ, 5%, 1/4W	Allen Bradley	RCR07G 104JR	"	Established REliability	Q	1	1

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SKYLAB ELECTRON-PROTON SPECTROMETER
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NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39106675
NAME DISCRIMINATOR SLICE

ASSEMBLY:
NUMBER SEC39106669
NAME HEATER CONTROL

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY: SUB ASSEMBLY NUMBER SEC39106669-301	TOTAL REQUIRED PER ASSEMBLY
	R17	RESISTOR - 4.99kΩ, 1%, 1/20W.	Mepco	RNC50H 4991FR	MIL-R-55182	Established Reliability	Q	1	1
	R18	RESISTOR - 20.0kΩ, 1%, 1/20W	"	RNC50H 2002FR	"		Q	1	1
	R19	RESISTOR - 2.2MΩ, 5%, 1/4W	Allen Bradley	RCR07G 225JR	MIL-R-39008		Q	1	1
	R20	RESISTOR - 1.2MΩ, 5%, 1/4W	"	RCR07G 125JR	"		Q	1	1
	R21	RESISTOR - 100kΩ, 5%, 1/4W	"	RCR07G 104JR	"		Q	1	1
	C1	CAPACITOR - 100pF, 10%, 200V	Kemet	CKR05 BX101KR	MIL-C-39014		Q	1	1
	C2	CAPACITOR - 10μF, 10%, 75V	"	CSR13G 186KR	MIL-C-39003		Q	1	1
	Q1, Q2	TRANSISTOR - NPN, Amplifier	Teledyne	JAN-TX 2N2484	MIL-S-19500/376		Q	2	2
	Q3, Q4	TRANSISTOR - NPN, Power	Texas Instruments	JAN-TX 3421	MIL-S 19500/393	Established Reliability	Q	2	2
	Q5	TRANSISTOR - FET, Silicon	Texas Instrument	JAN 2N2609	MIL-S 19500/296	LEC Spec #214	Q	1	1
	A1	AMPLIFIER	Advance Micro	μA723 1883	MIL-STD-883/Level A	Established Reliability	Q	1	1
	CR1	DIODE - Switching, Silicon	Texas Instruments	JAN-TX 1N914	MIL-S 19500/116	Established Reliability	Q	1	1

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NEXT ASSEMBLY: NUMBER SEC39106690
NAME DATA PROCESSOR LVPS SLICE

ASSEMBLY:
NUMBER SEC39106980
NAME LOW VOLTAGE PWR SUPPLY

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY: SUB ASSEMBLY NUMBER SEC39106980-301	TOTAL REQUIRED PER ASSEMBLY
	FL4	FILTER	Potter	8332-126	MIL-C-15305	Hi-Rel Testing	Q	1	1
	FL2, FL3, FL5 - FL8	FILTER	Potter	8332-125	MIL-C-15305	Hi-Rel Testing	Q	6	6
	Q3	TRANSISTOR	Motorola	2N5333	MIL-S-19500	LEC Spec EPS-179	Q	1	1
	C20, C21	CAPACITOR - 15pf, 75V	Kemet	T210P156K 075PS	MIL-C-39014	Established Reliability	Q	2	1

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SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39106980
NAME LOW VOLTAGE POWER SUPPLY

ASSEMBLY:
NUMBER SEC39106671
NAME PRIMARY SIDE

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY: SUB ASSEMBLY NUMBER SEC39106671-301										TOTAL REQUIRED PER ASSEMBLY
	CR1, CR12-CR15 CR17-CR20	DIODE	Unitrode	UT4010	MIL-S-19500	Hi-Rel Testing	Q	9										9

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NAME PRIMARY SIDE

ASSEMBLY:
NUMBER SEC39106676
NAME PREREGULATOR MODULE

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART. NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY: SUB ASSEMBLY NUMBER SEC39106676-301	TOTAL REQUIRED PER ASSEMBLY
	R1	RESISTOR - 33.2kΩ, 1%, 1/10W	Mepco	RNC55H-3322FR	MIL-R-55182	Established Reliability	Q	1	1
	R2A, R2B	RESISTOR - 3.9kΩ, 5%, 1/2W	Allen Bradley	RCR20G 392SP	MIL-R-39008		Q	2	2
	R3	RESISTOR - 4.75kΩ, 1%, 1/10W	Mepco	RNC55H 4751FR	MIL-R-55182		Q	1	1
	R4	RESISTOR - 100Ω, 5%, 1/4W	Allen Bradley	RCR07G 101JP	MIL-R-39008		Q	1	1
	R5	RESISTOR - 10Ω, 5%, 1/4W	Allen Bradley	RCR07G 100JP	MIL-R-39008		Q	1	1
	R6	RESISTOR - 39.2kΩ, 1%, 1/20W	Mepco	RNC50H 3922FR	MIL-R-55182		Q	1	1
	R7	RESISTOR - 5.62kΩ, 1%, 1/10W	Mepco	RNC50H 5621FR	"		Q	1	1
	R8, R9	RESISTOR - 2.21kΩ, 1%, 1/20W	Mepco	RNC50H 2211FR	"		Q	2	2
	R10	RESISTOR - 18.2kΩ, 1%, 1/20W	Mepco	RNC50H 1822FR	"		Q	1	1
	R11	RESISTOR - To Be Determined	Mepco	RNC50H	"		Q	1	1
	R12	RESISTOR - To Be Determined	Mepco	RNC50H	"		Q	1	1
	C1, C8	CAPACITOR - 22μf	Kemet	T210D226 K050PS	MIL-C-39003		Q	2	2
	C2	CAPACITOR - 3300pf	Kemet	CKR06 BX332KP	MIL-C-39014		Q	1	1
	Q1	TRANSISTOR	Texas Instruments	JAN TX 2N2222A	MIL-S-19500		Q	1	1
	Q2	TRANSISTOR	Texas Instruments	JAN TX 2N3421	"		Q	1	1
	Q4	TRANSISTOR	Texas Instruments	JAN TX 2N494A	"	Established Reliability	Q	1	1

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SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39106671
NAME PRIMARY SIDE

ASSEMBLY:
NUMBER SEC39106676
NAME PREREGULATOR MODULE

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY: SUB ASSEMBLY NUMBER SEC39106676-301										TOTAL REQUIRED PER ASSEMBLY
	Q5, Q6	TRANSISTOR	Texas Instruments	JAN TX 2N2907A	MIL-S-19500	Established Reliability	Q	2										2
	Q7	TRANSISTOR	Teledyne	JAN TX 2N2484	MIL-S-19500	Established Reliability	Q	1										1
	CR1	DIODE	Unitrode	UT4010	MIL-S-19500	Hi-Rel Spec. Tests	Q	1										1
	CR2, CR3 CR5, CR6	DIODE	Texas Instruments	JAN TX 1N914	MIL-S-19500	Established Reliability	Q	4										4
	CR4	DIODE - Zener	Dickson	1N4567A	MIL-S-19500	Hi-Rel Spec. Tests	Q	1										1

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NEXT ASSEMBLY: NUMBER SEC39106671
NAME PRIMARY SIDE

ASSEMBLY:
NUMBER SEC39106677
NAME CORE DRIVER MODULE

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY: SUB ASSEMBLY NUMBER SEC39106677-301	TOTAL REQUIRED PER ASSEMBLY
	R14	RESISTOR - 4.7kΩ, 5%, 1/4W	Dale	RCR07G 472JP	MIL-R-39008	Established Reliability	Q	1	1
	R15	RESISTOR - 100Ω, 5%, 1/4W	Dale	RCR07G 101JP	MIL-R-39008	↑	Q	1	1
	R16	RESISTOR - 47Ω, 5%, 1/4W	Dale	RCR07G 470JP	MIL-R-39008		Q	1	1
	R17	RESISTOR - 28kΩ, 1%, 1/20W	Mepco	RNC50H 283FR	MIL-R-55182		Q	1	1
	R38	RESISTOR - 10kΩ, 1%, 1/20W	Mepco	RNC50H 103FR	"		Q	1	1
	C3	CAPACITOR - 22μf, 50V	Kemet	T210D226 K050PS	MIL-C-39003		Q	1	1
	C4	CAPACITOR - 4.7μf, 10V	Kemet	T210A475 K010RS	"		Q	1	1
	CR7	DIODE	Texas Instruments	JAN-TX-1N746A	MIL-S-19500		Q	1	1
	CR8, CR9	DIODE	Texas Instruments	JAN-TX-1N914	"		Q	2	2
	CR10	DIODE	Texas Instruments	JAN-TX-1N645	"		Q	2	2
	Q8, Q9 Q10	TRANSISTOR	Texas Instruments	JAN-TX-2N3421	"	↓	Q	3	3
	Q11	TRANSISTOR	Texas Instruments	JAN-TX-2N2484	"	Established Reliability	Q	1	1

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SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39106671
NAME PRIMARY SIDE

ASSEMBLY:
NUMBER SEC39106678
NAME RECTIFIER-FILTER MODULE

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY: SUB ASSEMBLY NUMBER SEC39106678-301										TOTAL REQUIRED PER ASSEMBLY
	C7, C10	CAPACITOR - 47µf, 20V	Kemet	T210C476 K020RS	MIL-C-39008	Established Reliability	Q	2										2
	C16, C18	CAPACITOR - 3.9µf, 75V	Kemet	T210B395 K075PS	"	Established Reliability	Q	2										2
	C12, C14	CAPACITOR - 68µf, 15V	Kemet	T210CG86 K015RS	"	Established Reliability	Q	2										2
	CR22, CR23	DIODE	Texas Instruments	JAN TX 1N645	MIL-S-19500	Established Reliability	Q	2										2

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SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39106980
NAME LOW VOLTAGE POWER SUPPLY

ASSEMBLY:
NUMBER SEC39106672
NAME SECONDARY SIDE

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY: SUB ASSEMBLY NUMBER SEC39106672-301										TOTAL REQUIRED PER ASSEMBLY
	R19	POTENTIOMETER - 10k	Bourns	3262W-1-103	MIL-R-27208	Hi-Rel Testing	Q	1										1
	Z1	VOLTAGE REGULATOR	Fairchild	μ723	MIL-STD-883/Level A	Established Reliability	Q	1										1

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SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39106672
NAME SECONDARY SIDE

ASSEMBLY:
NUMBER SEC39106688
NAME DISCRIMINATOR REG. MODULE

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY: SUB ASSEMBLY NUMBER SEC39106638-301										TOTAL REQUIRED PER ASSEMBLY
	R18	RESISTOR - 11.5kΩ, 1%, 1/20W	Mepco	RNC50H 1152FR	MIL-R-55182	Established Reliability	Q	1										1
	R20, R22	RESISTOR - 6.98kΩ, 1%, 1/20W	Mepco	RNC50H 6981FR	"		Q	2										2
	R21	RESISTOR - 13Ω, 5%, 1/4W	Allen Bradley	RCR07G 130JP	MIL-R-39008		Q	1										1
	R39	RESISTOR - 15kΩ, 1%, 1/20W	Mepco	RNC50H 153FR	MIL-R-55182		Q	1										1
	C5	CAPACITOR - 1000pf, 200V	Kemet	CKR05BX 102KP	MIL-C-39014		Q	1										1
	C6	CAPACITOR - 100pf, 200V	Kemet	CKR05BX 101KP	MIL-C-39014		Q	1										1
	C9, C11	CAPACITOR - 15μf, 20V	Kemet	T210B156 K020RS	MIL-C-39003		Q	2										2
	C13, C15	CAPACITOR - 22μf, 15V	Kemet	T210B226 K015RS	"		Q	2										2
	C17, C19	CAPACITOR - 3.9μf, 75V	Kemet	T210B395 K075PS	"		Q	2										2
	CR24	DIODE - Zener	Texas Instruments	JAN TX 1N758A	MIL-S-19500	Established Reliability	Q	1										1

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SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39106690
NAME DATA PROCESSOR LVPS SLICE

ASSEMBLY:
NUMBER SEC39107473
NAME INPUT FILTER MODULE

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY — SUB ASSEMBLY NUMBER SEC39107473-301										TOTAL REQUIRED PER ASSEMBLY
		FILTER	Potter	8336-001	MIL-C-15305	Hi-Rel Testing	Q	2										2
		FILTER	Potter	8332-125	MIL-C-15305	Hi-Rel Testing	Q	4										4

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SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER
NEXT ASSEMBLY: NUMBER SEC39107473
NAME INPUT FILTER MODULE

ASSEMBLY:
NUMBER SEC39107014
NAME INPUT FILTER

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY: SUB ASSEMBLY NUMBER SEC39107014-301										TOTAL REQUIRED PER ASSEMBLY
	R3	RESISTOR - 2.7Ω, 1%, 1/8W	Allen Bradley	RCR05G 2R7JS	MIL-R-39008	Established Reliability	Q	1										1
	C1, C3 - C6	CAPACITOR - 15pf, 75V	Kemet	T210D156 K075PS	MIL-C-39003	Established Reliability	Q	5										5
	C2, C7	CAPACITOR - .1μf, 100V	Kemet	CKR06 BX104KP	MIL-C-39014	Established Reliability	Q	2										2

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SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39107473
NAME INPUT FILTER MODULE

ASSEMBLY:
NUMBER SEC39107016
NAME FILTER SURGE LIMITERS

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY: SUB ASSEMBLY NUMBER SEC39107016-301										TOTAL REQUIRED PER ASSEMBLY
	CR1, CR2	DIODE	Unitrode	1N4942	MIL-S-19500	Hi-Rel Testing	Q	2										2
	CR3 - CR6	DIODE	Unitrode	UT4010	MIL-S-19500	Hi-Rel Testing	Q	4										4
	R1	RESISTOR - 4.7Ω, 1%, 1/8W	Allen Bradley	RCR05G 4R7JS	MIL-R-39008	Established Reliability	Q	1										1
	R2	RESISTOR - .5Ω, 1%, 1W	Dale	RWR81S R500FR	"	Established Reliability	Q	1										1
	R4	RESISTOR - 1.3Ω, 1%, 1W	Dale	RWR81S 1R300FR	"	Established Reliability	Q	1										1

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SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39106673
NAME DATA PROCESSOR

ASSEMBLY:
NUMBER SEC39106991
NAME MULTIPLEXER MODULE

ITEM NO	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO OR DRAWING NO	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY: SUB ASSEMBLY NUMBER SEC39106991-301										TOTAL REQUIRED PER ASSEMBLY
	Z1, Z2	MULTIPLEXER - 16-Channel	Harris Semi-Conductor	HS-9-1000-2	MIL-STD-883	MIL-STD-883 Level A	Q	2										2
	L1, L2	INDUCTOR - 100μH	J. W. Miller	9210-76	MIL-C-15305	Hi-Rel Testing	Q	2										2
	C1 - C2	CAPACITOR - .1μf, 100V	Union Carbide	CKR06BK 104KP	MIL-C-39014	Established Reliability	Q	2										2
	R1	RESISTOR - 1kΩ, 10%, 1/8W	Allen Bradley	RCR05G 102JS	MIL-R-39008	Established Reliability	Q	1										1
	CR1 - CR12	DIODE	Texas Instruments	JAN-TX 1N914	MIL-S-19500	Hi-Rel Testing		12										12

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SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39106673
NAME DATA PROCESSOR

ASSEMBLY:
NUMBER SSEC39107003
NAME A/D CONVERTER

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY: SUB ASSEMBLY NUMBER SEC39107003-301	TOTAL REQUIRED PER ASSEMBLY
	R3, R9, R14	RESISTOR - 4.99kΩ, 1%	Mepco	RNC50H 4992FR	MIL-R-55182	Established Reliability	Q	3	3
	R5	RESISTOR - 9.53kΩ, 1%	Mepco	RNC50H 9532FR	"	Established Reliability	Q	1	1
	R8	RESISTOR - Selected	Mepco	RNC50H	"	Established Reliability	Q	1	1
	R7	POTENTIOMETER - 10kΩ	Bourns	3260HM 39103	MIL-R-27208	Hi-Rel Testing	Q	1	1
	R4	RESISTOR - 11.3kΩ, 1%	Mepco	RNC50H 1132FR	MIL-R-55182	Established Reliability	Q	1	1
	R2, R10	RESISTOR - 10MΩ, 1%	Caddock	MG660	MIL-R-55182	Hi-Rel Testing	Q	2	2
	R6	RESISTOR - 47.5kΩ, 1%	Mepco	RNC50H 4752FR	"	Established Reliability	Q	1	1
	R11, R12, R13	RESISTOR - 49.9kΩ, 1%	Mepco	49922FR	"	Established Reliability	Q	3	3
	Z1 thru Z3	INTEGRATED CIRCUIT	Advance Micro	LM108/ 883	MIL-STD-883/Level A	Hi-Rel Testing	Q	3	3
	Z4	INTEGRATED CIRCUIT	Advance Micro	LM 111/ 883/Level A	MIL-STD-883/Level A	Hi-Rel Testing	Q	1	1
	Z5	INTEGRATED CIRCUIT	Dickson	DAS2132	MIL-STD-883/Level A	Hi-Rel Testing	Q	1	1
	VR1	DIODE - Zener	Dickson	1N4567A	MIL-S-19500	Hi-Rel Testing	Q	1	1
	CR2, CR3	DIODE	Texas Instruments	JANTX 1N914	"	Established TX Testing	Q	2	2
	L1, L2	INDUCTOR	Miller	MS90538-12	MIL-C-15305	Hi-Rel Testing	Q	2	2
	C15	CAPACITOR - 2μf	TRW	X483G	MIL-C-39014	Established Reliability	Q	1	1

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SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39106673
NAME DATA PROCESSOR

ASSEMBLY:
NUMBER SEC39107003
NAME A/D CONVERTER

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY: SUB ASSEMBLY NUMBER SEC39107003-301										TOTAL REQUIRED PER ASSEMBLY
	C3, C4, C6, C7, C9, C10 C11, C13, C14	CAPACITOR - .1µf	Kemet	CKR06BX 104KP	MIL-C-39014	Established Reliability	Q	9										9
	C12	CAPACITOR - .01µf	Kemet	CKR06BX 103KP	MIL-C-39014	Established Reliability	Q	1										1
	C5, C8, C16	CAPACITOR - 100pf	Kemet	CKR05BX 101KP	MIL-C-39014	Established Reliability	Q	3										3

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SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39106673
NAME DATA PROCESSOR

ASSEMBLY:
NUMBER SEC39107005
NAME A/D LOGIC MODULE

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	SUB ASSEMBLY NUMBER SEC39107005-301	TOTAL REQUIRED PER ASSEMBLY
	Z1, Z6, Z8, Z16	INTEGRATED CIRCUIT	Texas Instruments	SNH54L 01-02	MIL-STD-883 Level H	Hi-Rel Testing	Q	4	4
	Z2, Z7, Z9	" "	Texas Instruments	SNH54L 93T-02	MIL-STD-883 Level H		Q	3	3
	Z3, Z13, Z15, Z18	" "	Texas Instruments	SNH54L 00T-02	MIL-STD-883 Level H		Q	4	4
	Z4, Z14	" "	Texas Instruments	SNH54L 73T-02	MIL-STD-883 Level H		Q	2	2
	Z5	" "	Advance Micro	U4L96L 0251	MIL-STD-883 Level H		Q	1	1
	Z10	" "	Texas Instruments	SNH54L 30T-02	MIL-STD-883 Level H		Q	1	1
	Z11	" "	Texas Instruments	SNH54L 20T-02	MIL-STD-883 Level H		Q	1	1
	Z12, Z17	" "	Texas Instruments	SNH54L 04T-02	MIL-STD-883 Level H	Hi-Rel Testing	Q	2	2
	R1	RESISTOR - 22kΩ, 1%, 1/20W	Mepco	RNC50H 2202FR	MIL-R-55182	Established Reliability	Q	1	1
	R2, R4	RESISTOR - 1.0kΩ, 1%, 1/20W	"	RNC50H 1001FR	"		Q	2	2
	R3	RESISTOR - 10kΩ, 1%, 1/20W	"	RNC50H 1002FR	"		Q	1	1
	C1	CAPACITOR - 100pf	USCC	RC10G 101J	MIL-C-39014		Q	1	1
	C2	CAPACITOR - .1µf	Kemet	CKR06BX 104KP	"		Q	1	1
	C3	CAPACITOR - 3.3µf	Kemet	T210A335 K015R3	MIL-C-39003	Established Reliability	Q	1	1

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SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39106673
NAME DATA PROCESSOR

ASSEMBLY:
NUMBER SEC39106992
NAME VOLTAGE MONITOR

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY: SUB ASSEMBLY NUMBER SEC39106992-301	TOTAL REQUIRED PER ASSEMBLY
	R14	RESISTOR - 100kΩ, 1%	Mepco	RNC50H 1003FR	MIL-R-55182	Established Reliability	Q	1	1
	R12, R13	RESISTOR - 5.11kΩ, 1%	"	RNC50H 5111FR	"		Q	2	2
	R10, R11	RESISTOR - 8.66kΩ, 1%	"	RNC50H 8661FR	"		Q	2	2
	R9	RESISTOR - 24.9kΩ, 1%	"	RNC50H 2492FR	"		Q	1	1
	R8	RESISTOR - 4.99kΩ, 1%	"	RNC50H 4991FR	"		Q	1	1
	R7	RESISTOR - 16.2kΩ, 1%	"	RNC50H 1622FR	"		Q	1	1
	R5	RESISTOR - 78.7kΩ, 1%	"	RNC50H 7872FR	"		Q	1	1
	R4	RESISTOR - 21.5kΩ, 1%	"	RNC50H 2152FR	"		Q	1	1
	R3	RESISTOR - 22.1kΩ, 1%	"	RNC50H 2212FR	"		Q	1	1
	R2, R6, R15	RESISTOR - 10.0kΩ, 1%	"	RNC50H 1002FR	"	Established Reliability	Q	3	3
	CR1, CR2, CR3	DIODE	Texas Instruments	JANTX 1N914		Established Reliability	Q	3	3

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SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39106673
NAME DATA PROCESSOR

ASSEMBLY:
NUMBER SEC39106994
NAME COUNTER CONTROL

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY: SUB ASSEMBLY NUMBER SEC39106994-301	TOTAL REQUIRED PER ASSEMBLY
	Z1	INTEGRATED CIRCUIT	Texas Instruments	SNH54L 04T-02	MIL-STD-883 Level H	Hi-Rel Testing	Q	1	1
	Z2, Z5, Z6, Z9, Z10, Z13	" "	Texas Instruments	SNH54L 93T-02	MIL-STD-883 Level H	Hi-Rel Testing	Q	6	6
	Z3, Z4, Z7, Z8, Z11, Z12	" "	Texas Instruments	SNH54L 95T-02	MIL-STD-883 Level H	Hi-Rel Testing	Q	6	6
	Z14	" "	Texas Instruments	SNH54L 01T-02	MIL-STD-883 Level H	Hi-Rel Testing	Q	1	1
	C1	CAPACITOR - 0.1µf	Kemet	CKR06BX 104KP	MIL-C-39014	Established Reliability	Q	1	1
	C2	CAPACITOR - 3.3µf, 15V	Kemet	T210A335 K015RS	MIL-C-39003		Q	1	1
	R1	RESISTOR - 4.99kΩ, 1%	Mepco	RNC50H 4991FR	MIL-R-55182		Q	1	1
	R2	RESISTOR - 10kΩ, 1%	Allen Bradley	RCR05G 102JS	MIL-R-39008	Established Reliability	Q	1	1

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SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER
NEXT ASSEMBLY: NUMBER SEC39106673
NAME DATA PROCESSOR

ASSEMBLY
NUMBER SEC39106997
NAME SEQUENCER MODULE

ITEM NO	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG S PART NO OR DRAWING NO	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	SUB ASSEMBLY NUMBER (QUANTITY PER SUB ASSEMBLY)	TOTAL REQUIRED PER ASSEMBLY
	Z4, Z16, Z17, Z20, Z22	INTEGRATED CIRCUIT	Texas Instruments	SNH54L 73T-02	MIL-STD-883 Level B	Hi-Rel Testing	*	5	5
	Z7, Z13	" "	Texas Instruments	SNH54L 20T-02	MIL-STD-883 Level B		Q	2	2
	Z3, Z[illegible]4, Z25	" "	Texas Instruments	SNH54L 10T-02	MIL-STD-883 Level B		Q	3	3
	Z2, Z14, Z18, Z21	" "	Texas Instruments	SNH54L 04T-02	MIL-STD-883 Level B		Q	4	4
	Z5, Z15, Z19, Z[illegible]	" "	Texas Instruments	SNH54L 00T-02	MIL-STD-883 Level B		Q	4	4
	Z1	" "	Texas Instruments	SNC54-01T-02	MIL-STD-883 Level B		Q	1	1
	Z6, Z26	" "	Advance Micro	04L96L0251	MIL-STD-883 Level B		Q	2	2
	Z27	" "	National	LM111F	MIL-STD-883 Level B	Hi-Rel Testing	Q	1	1
	R2, R4, R17, R19, R13, R15, R21	RESISTOR - 1K, 5%	Allen Bradley	RCR05G 102JS	MIL-R-39008	Established Reliability	Q	7	7
	R5, R6, R7, R20	RESISTOR - 10KΩ, 5	Allen Bradley	RCR05G 103JS	"		Q	4	4
	R1, R14, R16	RESISTOR - 22KΩ, 5%	Allen Bradley	RCR05G 223JS	"		Q	3	3
	R8	RESISTOR - 100Ω, 1%, 1/20W	Mepco	RNC50H 1000FR	MIL-R-55182		Q	1	1
	R12	RESISTOR - 2.94KΩ, 1%, 1/20W	Mepco	RNC50H 2941FR	MIL-R-55182	Established Reliability	Q	1	1

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SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39106673
NAME DATA PROCESSOR

ASSEMBLY
NUMBER SEC39106997
NAME SEQUENCER MODULE

ITEM NO	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY (SUB ASSEMBLY NUMBER: SEC39106997-201)	TOTAL REQUIRED PER ASSEMBLY
	R11	RESISTOR - 6.04kΩ, 1%, 1/20W	Mepco	RNC50H 6041FR	MIL-R-55182	Established Reliability	Q	1	1
	R9	RESISTOR - 10.5kΩ, 1%, 1/20W	Mepco	RNC50H 1052FR	"	Established Reliability	Q	1	1
	R10	RESISTOR - 51.1kΩ, 1%, 1/20W	Mepco	RNC50H 5112FR	"	Established Reliability	Q	1	1
	C1, C2, C3	CAPACITOR - 100pf, 50V	USCC	RC10C101J	MIL-C-39014	Hi-Rel Vendor Test	Q	3	3
	C5	CAPACITOR - 3.3μf, 15V	Kemet	T210335 K015RS	MIL-C-39003	Established Reliability	Q	1	1
	C4	CAPACITOR - 0.1μf, 100V	Kemet	CKR06BX 104KP	MIL-C-39014	Established Reliability	Q	1	1
	CR1	DIODE	Hewlett Packard	HP5082-2827	MIL-S-19500	Hi-Rel Vendor Test	Q	1	1

REVISION LETTER ____ PAGE ____ OF ____

SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39106673
NAME DATA PROCESSOR

ASSEMBLY:
NUMBER SEC39107000
NAME COMPRESSOR

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY: SUB ASSEMBLY NUMBER SEC39107000-301										TOTAL REQUIRED PER ASSEMBLY
	Q1, Q2 Q3	TRANSISTOR	Texas Instruments	JANTX 2N222	MIL-S-19500	Hi-Rel JANTX Test	Q	3										3
	C1	CAPACITOR - 6800 pf, 50V	USCC	RC10C 682J	MIL-C-39014	Hi-Rel Testing	Q	1										1
	C2, C3, C4, C5	CAPACITOR - 100pf, 50V	USCC	RC10C 101J	MIL-C-39014	Hi-Rel Testing	Q	4										4
	C6	CAPACITOR - 0.1µf, 100V	Kemet	CKR06BX 104KP	MIL-C-39014	Established Reliability	Q	1										1
	C7	CAPACITOR - 3.3µf, 15V	Kemet	T210A335 K015RS	MIL-C-39003	↑	Q	1										1
	R1	RESISTOR - 5.62kΩ, 1%	Mepco	RNC50H 5621FR	MIL-R-55182		Q	1										1
	R2, R3	RESISTOR - 4.99kΩ, 1%	Mepco	RNC50H 4991FR	"		Q	1										1
	R4	RESISTOR - 1.13kΩ, 1%	Mepco	RNC50H 1131FR	"		Q	2										2
	R5, R20 R21, R22	RESISTOR - 10kΩ, 5%	Allen Bradley	RCR05G 103JS	"		Q	1										1
	R23	RESISTOR - 18kΩ, 5%	Allen Bradley	RCR05G 183JS	"		Q	4										4
	R6, R9, R11, R13	RESISTOR - 22kΩ, 5%	Allen Bradley	RCR05G 223JS	"	↓	Q	1										1
	R14, R19, R7, R8, R8, R10, R12, R24, R25	RESISTOR - 1.0kΩ, 5%	Allen Bradley	RCR05G 102JS	"	Established Reliability	Q	13										13

REVISION LETTER ____

PAGE ____ OF ____

SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39106673
NAME DATA PROCESSOR

ASSEMBLY:
NUMBER SEC39107000
NAME COMPRESSOR

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY: SUB ASSEMBLY NUMBER SEC39107000-301	TOTAL REQUIRED PER ASSEMBLY
	Z1, Z22,	INTEGRATED CIRCUIT	Advance Micro	U4L96L 0251	MIL-STD-883 Level A	Hi-Rel Testing	Q	2	2
	Z10	" "	Texas Instruments	SNH54L 93T-02	MIL-STD-883 Level H		Q	1	1
	Z2, Z4, Z7, Z14 Z16	" "	Texas Instruments	SNH54L 73T-02	MIL-STD-883 Level H		Q	5	5
	Z17, Z18	" "	Texas Instruments	SNH54L 30T-02	MIL-STD-883 Level H		Q	2	2
	Z3, Z21	" "	Texas Instruments	SNH54L 04T-02	MIL-STD-883 Level H		Q	2	2
	Z8, Z9, Z11	" "	Texas Instruments	SNH54L 01T-02	MIL-STD-883 Level H		Q	3	3
	Z13, Z19, Z20	" "	Texas Instruments	SNH54L 00T-02	MIL-STD-883 Level H		Q	3	3
	Z12	" "	Texas Instruments	SNC54 01T-02	MIL-STD-883 Level H	Hi-Rel Testing	Q	1	1

REVISION LETTER ____

PAGE ____ OF ____

SKYLAB ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39106673
NAME DATA PROCESSOR

ASSEMBLY:
NUMBER SEC39107008
NAME WORD SYNC GENERATOR

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY: SUB ASSEMBLY NUMBER SEC39107008-301										TOTAL REQUIRED PER ASSEMBLY
	R1, R3, R5, R7, R9, R11, R13, R15, R17, R19, R21, R23, R25	RESISTOR - 510Ω, 5%	Allen Bradley	RCR05G 510JS	MIL-R-39008	Established Reliability ▲	Q	13										13
	R2, R4, R6, R8, R10, R12, R14, R16, R18, R20, R22, R24, R26	RESISTOR - 3.9kΩ, 5%	Allen Bradley	RCR05G 392JS	MIL-R-39008		Q	13										13
	R27, R28, R29, R43	RESISTOR - 1.0kΩ, 5%	Allen Bradley	RCR05G 102JS	MIL-R-39008		Q	4										4
	R42	RESISTOR - 18kΩ	Allen Bradley	RCR05G 183JS	MIL-R-39008		Q	1										1
	C1	CAPACITOR - 3.3μf	Kemet	T210A335 K015RS	MIL-C-39003		Q	1										1
	C2	CAPACITOR - .1μf	Kemet	CKR06BX 104KP	MIL-C-39014	Established Reliability	Q	1										1
	Z2, Z4	INTEGRATED CIRCUIT	Texas Instruments	SNH54L 01T-02	MIL-STD-883 Level H	Hi-Rel Testing	Q	2										2
	Z1, Z3, Z5	INTEGRATED CIRCUIT	Texas Instruments	SNH54 01T-02	MIL-STD-883 Level H	Hi-Rel Testing	Q	3										3

ELECTRON-PROTON SPECTROMETER
FAILURE MODE EFFECTS ANALYSIS

LEC Document Number EPS-470

Prepared by

Lockheed Electronics Company, Inc.
Houston Aerospace Systems Division
Houston, Texas

Under Contract NAS 9-11373

For

National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas

September 1971

FAILURE MODE EFFECTS ANALYSIS

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FAILURE MODE EFFECTS ANALYSIS

1. GENERAL

1.1 SCOPE

This Document defines the various types of failure modes and their effects on the Electron-Proton Spectrometer. The material presented is based on NASA Program office requirements. The Failure Mode Effects Analysis presented here was analyzed in terms of application to a subassembly level and does not constitute a complete component failure analysis.

The information which is required to perform a critical analysis in strict compliance with Skylab procedure, is lacking in numerous respects at this level of analysis. In lieu of a detailed analysis and criticality computations, failure rates are computed and supplied on a subassembly level based on environmental and operational stresses. (Operational stress are those nominal operating conditions to which all electronic parts and subassemblies are exposed during system operation).

1.2 FUNCTIONAL DESCRIPTION

1.2.1 Detector Assemblies

The EPS incorporates five independent detector assemblies each consisting of a lithium-drifted silicon detector and an energy moderating dome. The function of the dome is to reject particles having less than a predetermined minimum energy. Since proton energy deposition is a strong function of incident proton energy, counting protons, whose corresponding energy deposition exceeds a predetermined value, establishes an overall counting window of known width. Electrons, due to their low mass, tend to scatter heavily resulting in a rather constant energy deposition independent of incident energy over the range of electron energies covered by the EPS. This physical phenomenon results in single-sided electron energy channels (integral channels). Table I gives the nominal boundary values for both proton and electron counting. As is seen from Table I there are six proton channels and four electron channels.

TABLE I

CHANNEL BOUNDARIES AND ENERGY LEVELS

Detector Channel	Detector Size (mm)	Proton Boundaries (Mev)	Shield Thickness (cm)	Pisc. Level (Mev)	Electron Threshold Energy
1	1	10 - 20	.037	5.9	0.45
2	2	20 - 40	.180	6.8	1.22
3	2	30 - 50	.406	6.1	2.38
4	2	40 - 80	.710	3.7	3.90
5	2	80 - 120	.890 BR	3.2	
		> 120		~1.0	

1.2.2 Electronic Systems Operation

The EPS electrical package consists of five systems, namely:

- Scientific Analog System
- Data Processor System
- Housekeeping System
- Power System
- Heater System

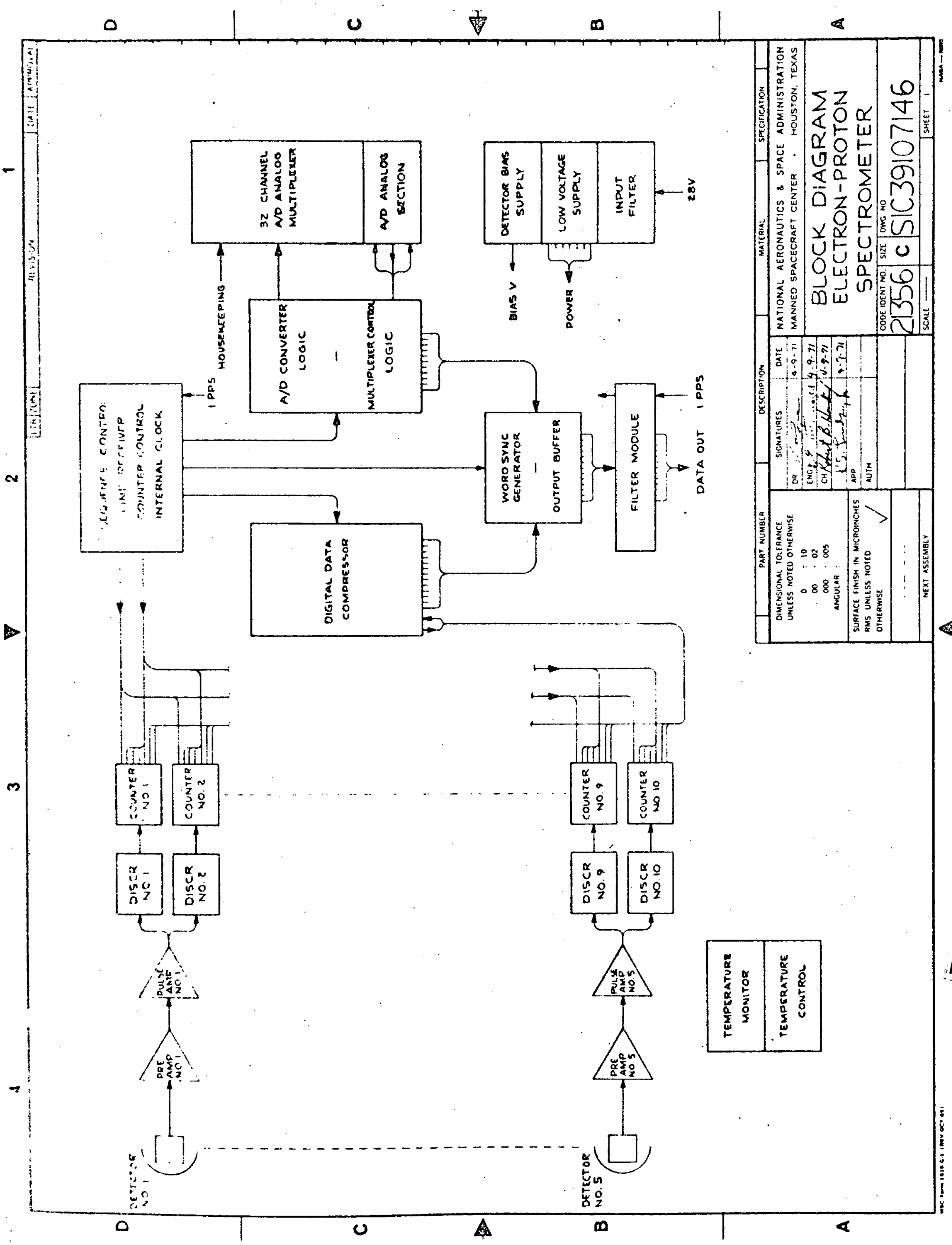
The functional interdependence of these systems is shown in Drawing SIC39107146, Block Diagram Electron-Proton Spectrometer.

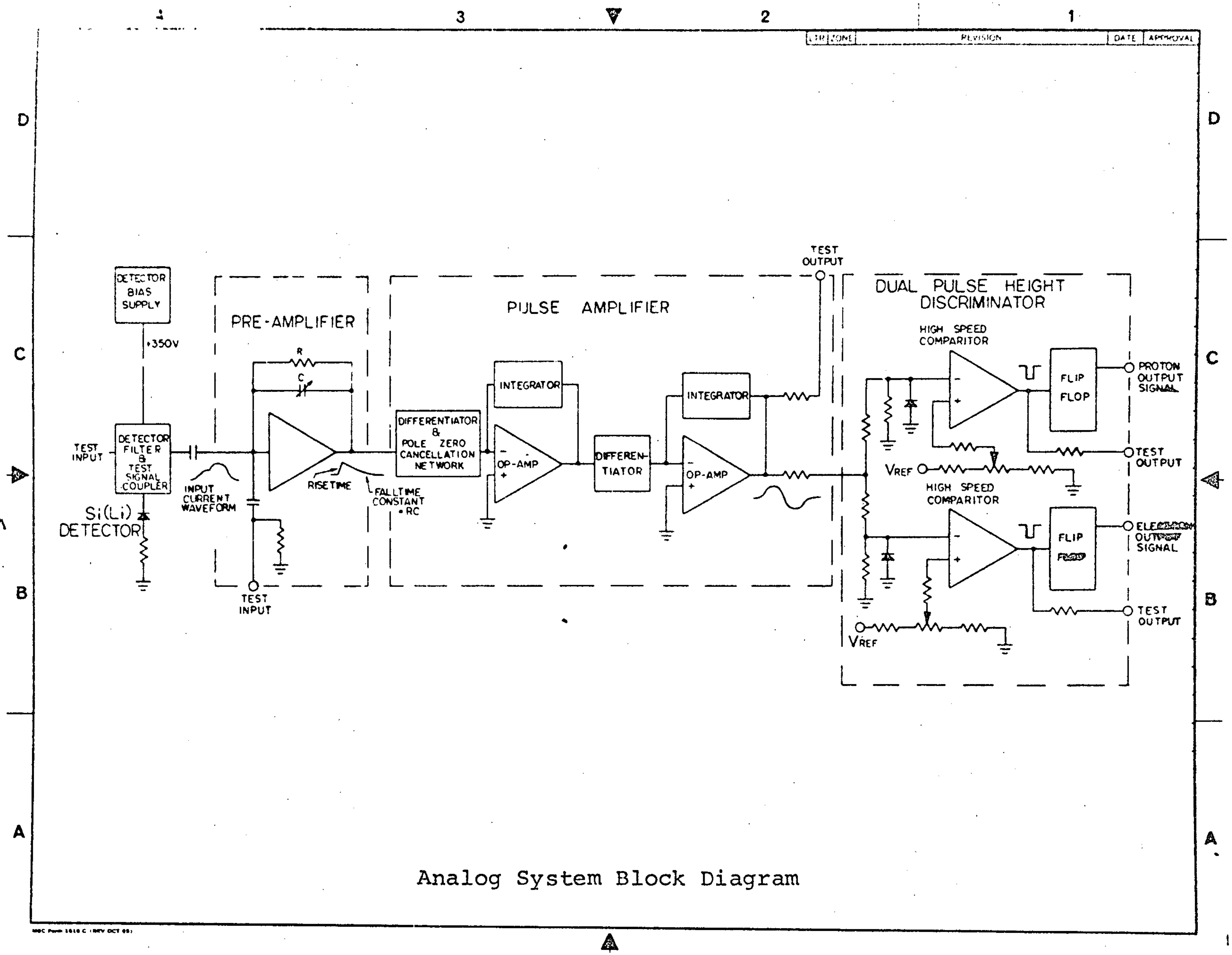
1.2.2.1 Scientific Analog System

The purpose of the Scientific Analog System is to detect the random occurance of current impulses eminating from EPS detectors, determine if the total impulse charge exceeds a predetermined value, and if so submit an output signal for recording by the Data Processor. There are five scientific channels which are:

- Independent
- Adjustable in counting level to allow use with detectors having variable dimensions
- Capable of single valued counting-rate performance to 10^6 counts per second
- Immune to detector generated noise

Each scientific channel is made up of a preamplifier, a pulse amplifier, and a dual pulse height discriminator.


BLOCK DIAGRAM
ELECTRON-PROTON
SPECTROMETER
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER · HOUSTON, TEXAS
CODE IDENT NO. 21356
SIZE C
DWG NO SIC39107146
SCALE
SHEET 1
32 CHANNEL A/D ANALOG MULTIPLEXER
A/D ANALOG SECTION
DETECTOR BIAS SUPPLY
LOW VOLTAGE SUPPLY
INPUT FILTER
28V
BIAS V
POWER
HOUSEKEEPING
A/D CONVERTER LOGIC
MULTIPLEXER CONTROL LOGIC
1 PPS
SEQUENCE CONTROL
COUNTER CONTROL
INTERNAL CLOCK
WORD SYNC GENERATOR
OUTPUT BUFFER
FILTER MODULE
DATA OUT
DIGITAL DATA COMPRESSOR
COUNTER NO. 1
COUNTER NO. 2
COUNTER NO. 9
COUNTER NO. 10
DISCR NO. 1
DISCR NO. 2
DISCR NO. 9
DISCR NO. 10
PULSE AMP NO. 1
PULSE AMP NO. 5
PRE AMP NO. 1
PRE AMP NO. 5
DETECTOR NO. 1
DETECTOR NO. 5
TEMPERATURE MONITOR
TEMPERATURE CONTROL
DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
SURFACE FINISH IN MICROINCHES RMS UNLESS NOTED OTHERWISE
NEXT ASSEMBLY
PART NUMBER
DESCRIPTION
MATERIAL
SPECIFICATION
SIGNATURES
DATE
DR
ENG
CH
APP
AUTH
4-9-71
REVISION
DATE
APPROVAL



Analog System Block Diagram

The preamplifier converts the detector's current impulse to a slowly decaying step function whose amplitude is proportional to the total charge input. The pulse amplifier filters this step input producing a bipolar waveform at its output. The dual pulse height discriminator compares the bipolar wave form to two reference levels. If the input wave form exceeds either of these two reference levels, a corresponding output pulse is directed to a presealer. The presealer generates an output signal for every other excitation of the discriminator.

1.2.2.2 Data Processor System

The function of the Data Processor is to digitally integrate the prescaler outputs individually and present the information to the spacecraft telemetry system in an acceptable form under control of the spacecraft. This integration provides 12 seconds of counting for every 13 seconds of real time. In addition, the Data Processor accepts analog housekeeping signals, digitizes them sequentially and properly mixes this with the scientific information. The data processor utilizes high reliability, low power TTL logic in its digital section and high reliability low power amplifiers in its analog to digital converter section. The Data Processor consists of the following modules:

- Sequence Control, Line Receiver, and Counter Control
- Counter/Memory Module (10)
- Digital Data Compressor and Internal Clock
- Analog Digital Converter
- A/D Control
- Multiplexer Module
- Output Buffer and Word Sync Generator

1.2.2.3 Housekeeping System

The Housekeeping System provides signals to the Data Processor analog to digital converter that yield information concerning the operational status of all important EPS parameters. Those functions monitored include:

detector leakage currents
detector resolutions
electronic package temperature
detector plate temperature
power supply levels
heater status

A time of 208 seconds is required to transmit a complete cycle of housekeeping information. Ground based analysis of this data allows proper manual control of EPS mode of operation.

1.2.2.4 Power System

The EPS Power System accepts spacecraft power and converts it to levels required by the EPS. Major subsystems are the Low Voltage Power Supply and the Detector Bias Supply.

The Low Voltage Power Supply (LVPS) provides the following outputs:

Voltage	Current
+ 5 Vdc	905 ma
- 5 Vdc	116 ma
+25 Vdc	11 ma
+ 8 Vdc	175 ma
- 8 Vdc	152 ma
-15 Vdc	2 ma

The Low Voltage Power Supply provides analog voltage monitor outputs directly proportional to the various outputs.

The Detector Bias Supply provides the following output:

Voltage	Current
+350 Vdc	10 μa

1.2.2.5 Heater System

The Heater System functions in a temperature control capacity. An internal temperature sensor is continually monitored by control circuitry. If the package temperature drops below 0°C, six watts of power is dissipated in the inner housing structure by skin heaters. When the temperature rises above 10°C, the six watts of power is removed.

2. SYSTEM - SUB-SYSTEM

2.1 SUMMARY METHODS AND EFFECTS

A study of parts and materials has been made to determine the best high-reliability parts possible. All parts were selected from established reliability parts, specific Hi-Rel and TX programs, and parts that were 100% screened and burned-in according to reliability requirements. Each part was further screened to include lowest failure rate possible.

Alerts, failure data and other sources were consulted to determine part selection.

2.2 CIRCUIT ELECTRICAL STRESS

The term electrical stress and the possible value of derating the circuit according to this stress standard were studied. In discrete circuit components, derating has a definite value in prolonging component life or increasing the Mean Time Between Failures (MTBF) by using components below designed capacity. Where current or power are stress criteria, such as in the case of resistors or transistors, derating results in a longer life through a lower operating temperature as a result of less dissipated power. The established criterion for capacitors is the applied voltage or electrical field. Derating is accomplished by reducing this voltage or field, which will result in a longer margin for transients and slower ionization effects.

As a precaution and to assure increased reliability of the intergrated circuits, fan-in and fan-out loading were held to 75% of manfacturer's rated load whenever possible. Voltage swings of the power supply and input signals are held to 75% of the acceptable limits of the manufacturer's data sheet.

3. FMEA SHEETS

The FMEA sheets included herein are performed at the major Sub-system level only. Criticality ranking and failure modes are general and do not reflect a component level analysis and its effect on the systems.

SYSTEM NUMBER ____________
ASSEMBLY NAME ELECTRON-PROTON SPECTROMETER
ASSEMBLY NUMBER ____________

FAILURE MODE EFFECTS ANALYSIS

DATE
BY.

NAME and PART NUMBER	DIAGRAM NUMBER AND PART SYMBOL	FUNCTION	FAILURE MODE	FAILURE EFFECT ON SYSTEM	FAILURE RATE	PARAMETERS	REMARKS
Noise Monitor		Monitors Detector Noise	Discrete Component Failures	This is a housekeeping event and will not effect the output of critical data. Useful in processing the telemetry data in relation to detector operation.	1.36 X 10^6 hours	All components derated for extended operation	High Reliability Components Failure Category 3B
Voltage Monitor		Used to Monitor Various EPS Voltages		A Failure would not effect the critical data output of the EPS. Used as housekeeping event(s). (Part of Data Processor)	1.98 X 10^6 hours	All components derated for extended operation	High Reliability Components Failure Category 3B
Temperature Monitor		Monitor Detector Temperature		Monitor does not control temperature. Temperature above limits could cause failure of detectors and consequent loss of critical data.	1.87 X 10^6 hours	All components derated for extended operation	High Reliability Components Failure Category 3B
Leakage Current Monitor(s)		Monitor Detector Leakage Current	Failure of Discrete Components and IC's	Failure of the Leakage Current Monitor would cause a loss of housekeep- events. Effects on the operational data of the EPS would be minor.	2.28 X 10^6 hours	Components derated for increased life	High Reliability Components used Failure Category 3B
Heater Circuit		EPS Heater Circuit	Failure of Discrete Components and IC's	Failure of the Heater Circuit could result in temperature variations that would cause degradation of the EPS operation and loss of data and/or erroneous data.	1.78 X 10^6 hours	Components derated for increased life	High Reliability Components used Failure Category 3A
Pulse Height Discriminator (10 Each)		Detector Signal Processing	Failure of Discrete Components and IC's	Failure of any one of the Pulse Height Discriminator Circuits would result in loss of 10% of the primary data. Single Point Failure	4.26 X 10^6 hours	Components derated for increased life	High Reliability Components used Failure Category 3A
Data Processor Counter Register Memory (10 each)		Signal Conditioning and Shift Register Operation	Integrated Circuit Failure	Failure of one Counter Register would result in a loss of either one Electron or one Proton Channel or 10% of critical EPS data.	3.26 per 10^6 hours	4-Bit Counters, 4-Bit Shift, Registers, Gates, derated 25% of High Unit, Low ~~Unit Load~~	High Reliability Screening to MIL-STD 883 Level A Failure Category 3A
Data Processor Sequence Control Counter Control		Data Processor Control System	Integrated Circuit and Discrete Components Failures	Failure of the Sequence Control/Counter Control would result in 100% loss of the Data Processor functions. Loss of all EPS data. Single Point Failure	3.48 per 10^6 hours	Integrated Circuits derated 25% of High Unit, Low Unit Load	High Reliability Screening to MIL-STD 883 Level A Failure Category 3A
Data Processor Digital Data Compressor & Internal Clock		Internal Clock Signal Data Compression for processing to telemetry	Integrated Circuit Failures	Failure of the Data Compressor would result in complete loss of EPS Data. Single Point Failure	4.37 per 10^6 hours	Integrated Circuits derated 25% of High Unit Low Unit Load	High Reliability Screening to MIL-STD 883 Level A Failure Category 3A

SYSTEM NUMBER ____
ASSEMBLY NAME ELECTRON-PROTON SPECTROMETER
ASSEMBLY NUMBER ____

FAILURE MODE EFFECTS ANALYSIS

DATE
BY.

NAME and PART NUMBER	DIAGRAM NUMBER AND PART SYMBOL	FUNCTION	FAILURE MODE	FAILURE EFFECT ON SYSTEM	FAILURE RATE	PARAMETERS	REMARKS
Data Processor Word Sync Generator		Output of Data Processor	Integrated Circuit Failures	Failure of Word Sync Generator and output buffer would result in loss of all critical and all housekeeping data. Single Point Failure	2.24 per 10^6 hours	Integrated Circuits derated 25% of High Unit, Low Unit Loads	High Reliability Screening to MIL-STD 883 Level A Failure Category 3A
Data Processor Filter Module		Output of Data Processor	Integrated Circuit Failures	Failure of output filter would result in loss of output data.	1.36 per 10^6 hours	Integrated Circuits derated 25% of High Unit, Low Unit Loads	High Reliability Screening to MIL-STD 883 Level A Failure Category 3A
Data Processor A/D Converter & Multiplexer Control		Housekeeping Events Processing	Discrete & IC logic Failures	Failure of A/D Converter would not effect the critical data of the EPS. Housekeeping events would be effected.	4.47 per 10^6 hours	All Components derated	High Reliability Components used. Failure Category 3B
Data Processor A/D Analog Section		Housekeeping Events Processing	Discrete & IC logic Failures	Failures of A/D Converter would not effect the critical data of the EPS. Housekeeping events would be effected.	3.51 per 10^6 hours	All Components derated	High Reliability Components used. Failure Category 3B
Data Processor Multiplexer		Housekeeping Events Processing	Discrete & IC logic Failures	Failure of A/D Converter would not effect the critical data of the EPS. Housekeeping events would be effected.	1.48 X 10^6 hours	All Components derated	High Reliability Components used. Failure Category 3B
Bias Power Supply		Detector Bias Supply	Discrete Component Failures	Failure of Bias Supply could render Detectors useless. No data to EPS.	5.54 X 10^6 hours	All Components derated	High Reliability Components used. Failure Category 3A
Input Filter		Vehicle Power Protection	Discrete Component Failure	Possible spikes from EPS operation to Vehicle Power Supply.	4.84 X 10^6 hours	All Components derated	High Reliability Components used. Failure Category 3A
Preamplifier (5 each)		Amplifies Detector Signal	Discrete Component Failures	Failure of one preamplifier would result in loss of 20% of Electron or Proton Data critical to the EPS. Single Point Failure	4.26 X 10^6 hours	All Components derated for extended operation	High Reliability Components Failure Category 3A
Pulse Amplifier (5 each)		Amplifies Preamp Output	Discrete Component Failures	Failure of one Pulse Amplifier would result in loss of 20% of Electron or Proton Data critical to the EPS. Single Point Failure	4.96 X 10^6 hours	All Components derated for extended operation	High Reliability Components Failure Category 3A

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SYSTEM NUMBER ______
ASSEMBLY NAME ______
ASSEMBLY NUMBER ______

FAILURE MODE EFFECTS ANALYSIS

DATE
BY.

NAME and PART NUMBER	DIAGRAM NUMBER AND PART SYMBOL	FUNCTION	FAILURE MODE	FAILURE EFFECT ON SYSTEM	FAILURE RATE	PARAMETERS	REMARKS
Inductor Assy Low Voltage Power Supply		Voltage Filters for Various Voltage Outputs	Discrete Component Failures	Failure of an Inductor Assembly could result in erratic output, degradation of output, or loss of one of the power supply outputs.	2.86 per 10^6 hours	All Components derated for extended operation	All Components High Rel. Screened or Established Reliability parts. Failure Category 3A
Pre-Regulator		Regulation Control. Input Power Regulation	Discrete Component Failures	Erratic voltage output to Regulator. Loss of regulation to EPS Power Supply. Possible loss of primary power.	3.78 per 10^6 hours	All Components derated for extended operation	All Components High Rel. Screened or Established Reliability parts. Failure Category 3A
Discriminator Reference Regulator		DC-DC-Regulator	Discrete Component Failure	A failure of the Regulator Assembly would result in the total loss of primary data.	3.24 per 10^6 hours	All Components derated for extended operation	All Components High Rel. Screened or Established Reliability parts. Failure Category 3A
Transformer Assembly		Power Transformation	Discrete Component Failures	A failure of the transformer assembly could result in reduced power of all Low Voltage power.	1.35 per 10^6 hours	All Components derated for extended operation	All Components High Rel. Screened or Established Reliability parts. Failure Category 3A
Coredriver		Power Supply Control		A failure would cause degradation of voltage to Regulator with possible loss of all power.	2.14 per 10^6 hours	All Components derated for extended operation	All Components High Rel. Screened or Established Reliability parts. Failure Category 3A
13							

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SYSTEM NUMBER ______
ASSEMBLY NAME ______
ASSEMBLY NUMBER ______

FAILURE MODE EFFECTS ANALYSIS

DATE
BY

NAME and PART NUMBER	DIAGRAM NUMBER AND PART SYMBOL	FUNCTION	FAILURE MODE	FAILURE EFFECT ON SYSTEM	FAILURE RATE	PARAMETERS	REMARKS
1 PPS		Sync Clock Pulse & Data Out Signal from spacecraft Timing to Data Processor	Open Lead-Connector Failure	Telemetry signal used as clock pulse for snyc and Data Processing of data information. A failure of this signal would result in complete loss of instrument data.			Hi-Rel Tested Connector Failure Category 3A
Input to Detector Bias Supply		Detector Bias Supply Control from Spacecraft	Open Leads-Connector Failure	Astronaut switch control to instrument. Failure of this signal would result in loss of Bias Power. Detectors would not work.			Hi-Rel Tested Connector Failure Category 3A
Input 28 Vdc to Instrument		Furnishes Raw 28 Vdc to Instrument Power Supply	Open Leads-Connector Failure	A failure of input power would result in no power to instrument.			Hi-Rel Tested Connector Failure Category 3A
14							

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9-24-71

ELECTRON-PROTON SPECTROMETER
SINGLE-POINT FAILURE REPORT

LEC Document Number EPS-424

Prepared by

Lockheed Electronics Company, Inc.
Houston Aerospace Systems Division
Houston, Texas

Under Contract NAS 9-11373

For

National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas

August 1971

EPS-424

SINGLE-POINT FAILURE REPORT

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B. C. Hall
Program Manager

Electron-Proton Spectrometer Program
Advanced Programs Department
Lockheed Electronics Company, Inc.
Houston Aerospace Systems Division
Houston, Texas

SINGLE-POINT FAILURE
ELECTRON-PROTON SPECTROMETER

1. PURPOSE

A single point failure summary identifies the critical areas that will, as a result of a single assembly failure, cause a complete or partial loss of the experiment, questionable data, or complete loss of data acquisition. The following information must be delineated:

Corrective action taken
Experiment objective and,
Justification for retaining a single point failure

2.0 CORRECTIVE ACTION

The requirements of the Electron-Proton Spectrometer (EPS), such as weight to power limitations, logic, and electronic circuit packaging, limit redundant circuits and components. As a result, corrective action to reduce the possibility of critical failures is applied through careful selection of the best available high-reliability components, screen and burn-in tests, and derating of components used in the circuits.

3.0 JUSTIFICATION FOR RETAINING SINGLE POINT FAILURES

Space and weight are important factors in the EPS; consequently, there are no redundant logic and electronic circuits. Most of the components used have a long life expectancy. Hi-Rel micro circuits have a predicted Mean-Time-To-Failure (MTTF) rate of five to ten years.

Discrete components have been selected to the high reliability requirements of MIL-STD 883, MIL-STD 202, established reliability programs, or have been screened to Hi-Rel requirements. Component derating further increases the life span. Worst case analysis of the entire system estimates a MTTF of 21,500 hours. This is several times the hours required by mission objectives. The above MTTF does not include the detectors.

4.0 MISSION OBJECTIVE

To measure electron and proton radiation the instrument accepts charge pulses from the detectors. These pulses are shaped and amplified and trigger discriminators at different energy levels. The discriminators outputs are fed into the data processor for telemetry processing.

5.0 SINGLE-POINT FAILURE ANALYSIS

5.1 DATA PROCESSOR

5.1.1 Counter Memory

Ten channels of input information from the discriminators are processed and shifted to the Sequence Control and Digital Data Compressor. The data consists of 4 channels of electron and 6 channels of proton information. A failure of any one channel would result in 10 percent loss of data critical to the mission.

5.1.2 Sequence Control

A failure of the Sequence Control could result in no data output from the Data Processor, including housekeeping events. All common Digital Data Output, Column Sync, Word Sync, Multiplexer Address Advance, housekeeping gates, A/D Converter Start, etc., are dependent on the Sequence Control.

5.1.3 Digital Data Compressor

Failures in the Digital Data Compressor could result in no output data from the Word Sync Generator and Output Buffer, resulting in no data readout to telemetry.

5.1.4 Multiplexer A/D Analog Section

This section of the Data Processor handles housekeeping events. A failure in any part of the Multiplexer would have very little effect on the mission critical data.

5.1.5 Multiplexer A/D Converter Logic

A failure in this section would not effect mission critical data.

5.1.6 Word Sync Generator and Output Buffer

Failure in this section of the Data Processor could result in complete loss of output to telemetry.

5.1.7 Filter Module

This module contains one Output Filter for each telemetry data channel. Failure of a data point filter would result in no data out on one telemetry data channel.

5.1.8 Voltage Monitor

A failure of the Voltage Monitor would have negligible effect on the mission critical data of the EPS.

5.2 LOW VOLTAGE POWER SUPPLY

5.2.1 Preregulator

Failure of the Preregulator could result in erratic output or no output from Preregulator with a possible loss of power to the EPS.

5.2.2 Core Driver

A failure of this driver would result in erratic operation, loss of switching or possible loss of power to the EPS.

5.2.3 Transformer Assembly

A failure of the Transformer Assembly could result in possible loss of a portion of the power to the EPS or possible loss of all low voltage power.

5.2.4 Discriminator Reference Regulator

A failure of the Regulator could result in reduced power input to the Transformer Assembly, power loss to transformer, or possible loss of all low voltage functions.

5.2.5 Inductor Assemblies

Failure in an Inductor Assembly could result in erratic output or loss of one or more of the power supply outputs.

5.3 DETECTOR BIAS POWER SUPPLY

Loss of Detector Bias would result in no primary data. Detectors would not function. Secondary data (housekeeping information would still be obtained).

5.4 HEATER

5.4.1 Heater Control

Loss of the Heater Control Circuit would result in a possible temperature variation that could cause loss of or erroroneous data.

5.4.2 Heater Circuit

The Heater Circuit is not normally on during EPS operation. During down or storage time the effect of failure in the Heater Circuit would depend on orbit mode. At Beta 0° no effect would be noticed. At Beta 73° the EPS survival could be effected.

5.5 NOISE MONITOR (5 each)

Failure of the Noise Monitor function would result in a loss of housekeeping events. Effect on the operational data of the EPS would be minor.

5.6 LEAKAGE CURRENT MONITOR (5 each)

Failure of the Leakage Current Monitor would cause a loss of housekeeping events. This event would have minor effects on the primary data received from the EPS.

5.7 PREAMPLIFIER (5 each)

Failure of any one Preamplifier would cause a loss of 20 percent of the primary data inputs to the Data Processor.

5.8 PULSE AMPLIFIER (5 each)

Failure of any one Pulse Amplifier would result in the loss of 20 percent of the primary data to the data processor.

5.9 PULSE HEIGHTS DISCRIMINATOR (5 each)

Failure of any one of the Pulse Height Discriminators would result in 20 percent loss of primary data to the Data Processor.

5.10 INPUT FILTER

Failure of the Input Filter would cause the loss of either all data, primary data only, or Heater Control only.

5.11 DETECTORS

If one of the Detectors failed, two channels of information would be lost (1 Electron, 1 Proton). Twenty percent of mission critical data would be lost.

5.12 CONNECTORS

5.12.1 <u>1 PPS</u>

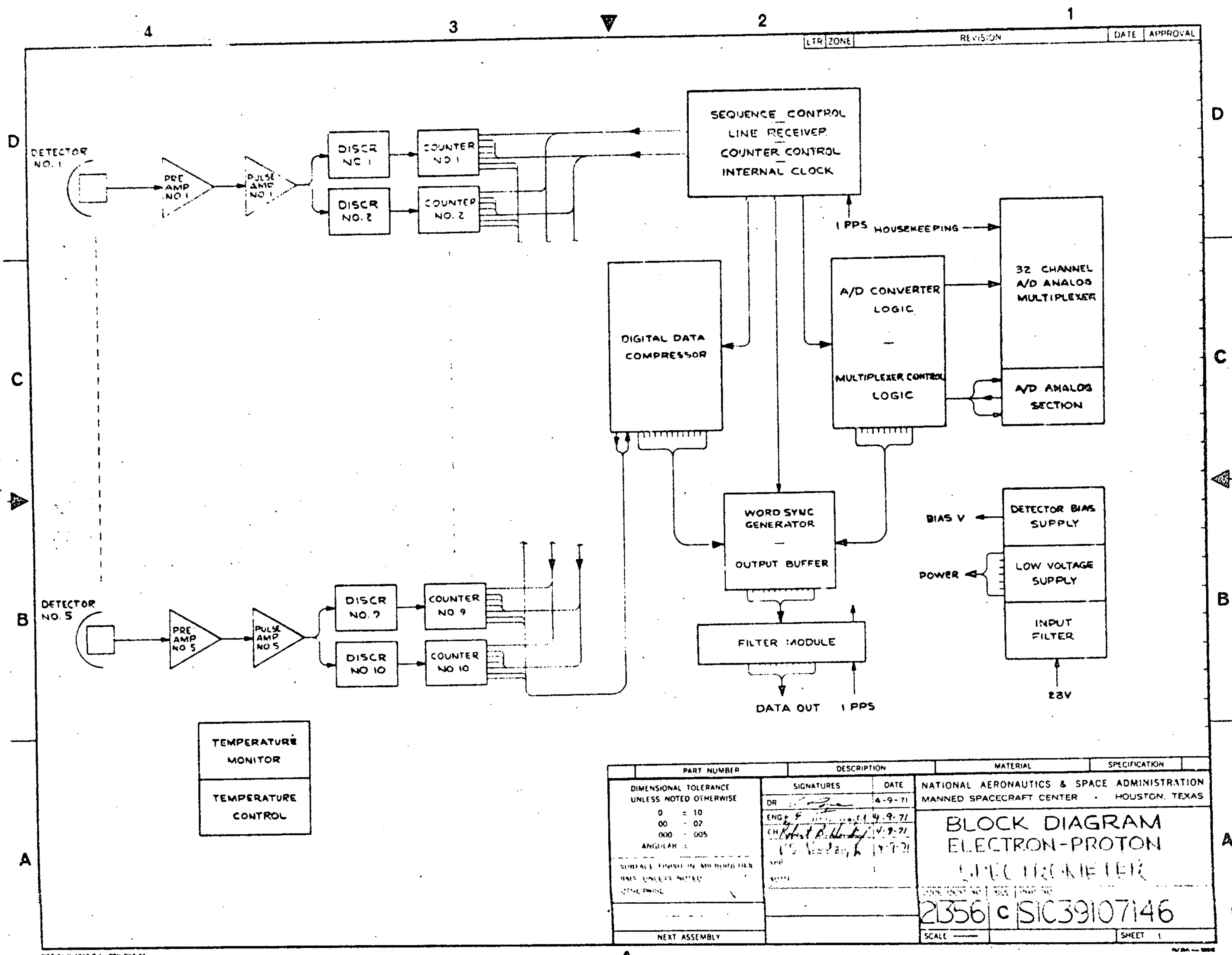
Clock Sync Pulse for cycling data and timing for data processor. Failure of 1 PPS would result in loss of all data.

5.12.2 <u>Input, Detector Bias Supply</u>

Failure of input to bias supply would result in loss of detector operation.

5.12.3 <u>Input 28 Vdc To Instruments</u>

A failure of input power would result in loss of all power to instrument.


DETECTOR NO. 1
PRE AMP NO 1
PULSE AMP NO 1
DISCR NO 1
DISCR NO. 2
COUNTER NO 1
COUNTER NO. 2
SEQUENCE CONTROL
LINE RECEIVER
COUNTER CONTROL
INTERNAL CLOCK
1 PPS
HOUSEKEEPING
32 CHANNEL A/D ANALOG MULTIPLEXER
A/D ANALOG SECTION
A/D CONVERTER LOGIC
MULTIPLEXER CONTROL LOGIC
DIGITAL DATA COMPRESSOR
WORD SYNC GENERATOR
OUTPUT BUFFER
FILTER MODULE
DATA OUT
1 PPS
DETECTOR BIAS SUPPLY
LOW VOLTAGE SUPPLY
INPUT FILTER
BIAS V
POWER
28V
DETECTOR NO. 5
PRE AMP NO 5
PULSE AMP NO 5
DISCR NO. 9
DISCR NO 10
COUNTER NO 9
COUNTER NO 10
TEMPERATURE MONITOR
TEMPERATURE CONTROL
LTR ZONE
REVISION
DATE APPROVAL
PART NUMBER
DESCRIPTION
MATERIAL
SPECIFICATION
DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
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ANGULAR
SIGNATURES
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4-9-71
NEXT ASSEMBLY
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER · HOUSTON, TEXAS
BLOCK DIAGRAM
ELECTRON-PROTON
SPECTROMETER
21356 C SIC39107146
SCALE
SHEET 1

ELECTRON-PROTON SPECTROMETER
QUALITY ASSURANCE PROCEDURES
FOR
EQUIPMENT AND PARTS

LEC Document Number EPS-434

Prepared by

Lockheed Electronics Company, Inc.
Houston Aerospace Systems Division
Houston, Texas

Under Contract NAS 9-11373

For

National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas

July 1971

QUALITY ASSURANCE PROCEDURES

FOR

EQUIPMENT AND PARTS

Prepared by: P. Gleeson
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Assurance Engineer

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1. INTRODUCTION

The purpose of the "Quality Assurance Procedures for Equipment and Parts" procedure is to establish guidelines and procedures for Lockheed Electronics Company (LEC) and NASA/MSC personnel who are concerned with receiving, storage, transfer, inspection and use of flight or mission related hardware within LEC on the Electron/Proton Spectrometer (EPS) Program. While general guidelines, designed to cover all situations, exist (see MSC "Manned Spacecraft Center Reliability and Quality Assurance Manual", MSCM 5312) this document provides guidelines and procedures specifically designed to supplement the QA activity on the EPS Program. It is the purpose of this document to insure that all equipment, parts and other hardware received and/or used in the EPS program meet or surpass the standards and requirements established by cognizant authorities.

2. ADMINISTRATION

2.1 Scope

The procedures in this document are restricted primarily to the quality aspects of receiving, storage, transfer, inspection, usage, and delivery of flight-oriented items.

2.2 Issuance and Maintenance

The LEC Quality Assurance and Reliability Engineer has the responsibility of the issuance, maintenance and revision of "Quality Assurance Procedures for Equipment and Parts", with the approval of the Program Manager. Adherence to the guidelines in this document shall become effective the date of official approval.

2.3 MSC Inspection

All drawings, procedures, and specifications used on the EPS Program will be reviewed by MSC Quality Assurance Organization before work begins. The assigned Q. C. Representative or his alternate will monitor all tests, inspect each module, subassembly, and assembly to ensure conformance to released drawings, procedures and specifications.

2.4 Test Preparation Sheets

All work will be authorized and documented by Test Preparation Sheet (TPS) and modification sheets where applicable. TPS's will be signed by Contractor Representatives. All TPS's and mod sheets will be reviewed by the assigned Q. C. Representative or his alternate prior to start of work. The review will be designated by MSC Q. C. conformance stamp and date in block number 18 of the TPS. All worked steps of the TPS will be initialed and dated or stamped and dated (block 21) by the person performing the work. Final acceptance and close out of work will be stamped and dated by the assigned Q. C. Representative or his alternate.

3. RECEIVING AND STORAGE OF FLIGHT ITEMS

Each component, subassembly, and completed assembly to be utilized in flight hardware shall be received, processed and stored according to the following procedure.

3.1 Visual Inspection

Incoming components, subassemblies, and completed assemblies will be checked for shipping damage, proper identification, and count as specified on the purchase order. Unacceptable items or shipments from vendors will be returned to the vendor for replacement.

3.2 Card File Log

The receipt of all acceptable flight items by LEC shall be entered in a card file log. Each card shall contain all applicable information listed below.

Part name
Part number
Value, Serial No.
Manufacturer
Quantity ordered
Quantity received
Lot number-Date Code
Date ordered
Purchase request number
Purchase order number
Date order received
Location
Certification of Compliance status

3.3 Quality Assurance Data File

All relevant quality assurance and reliability inspection data for a particular item or group of items received prior to withdrawal for use will be filed in a Q. A. Data File. This material will be filed by manufacturer with the following subordination:

- Manufacturer
  - Purchase Order Number
    - Line item on P. O.
      - Partial shipment as received

At the time of release from the controlled access area one copy of the releasing document will be inserted in this file under Releasing Documents. These records shall be retained for the duration of the program and then turned over to the cognizant NASA engineer.

3.4 Controlled Storage

A controlled storage area with limited access (referred to in LEC as bonded stores) will be located in the immediate vicinity of the fabrication area. All parts, subassemblies, and complete assemblies to be used in qualification or flight units will be stored in this area.

4. RELEASE OF FLIGHT ITEMS

4.1 Documents for Release

Flight or mission related items will be released from the controlled storage area on receipt of one or more of the following documents, properly executed:

Test Preparation Sheet (TPS (MSC Form 1225)
Discrepancy Report (DR)
Failure Investigation Action Report (FIAR)
Material Review Record (MRR)

All TPS, DR, FIAR, and MRR number will be issued and controlled by Lockheed. One copy of the form (s) (TPS, DR, FIAR or MRR) shall be retained in the Q. A. Data file.

4.2 Card File Log

The release of the item(s) shall be entered into the card file log. Each item released by the TPS or other release document, shall be entered on the appropriate card and shall include quantity issued, person issued to, serial number(s) (if applicable), date issued, circuit to be used in, TPS number, and balance on hand.

4.3 Acceptance Data Pack

All Quality Control records orginated after original removal of components from the controlled access storage shall be accumulated in an Acceptance Data Pack which will travel with the hardware and will be delivered with each Hardware End Item. The data packs for the various subassemblies, and assemblies shall be combined as the hardware is assemblied. However, care will be taken to ensure that the data pack for a particular subassembly or assembly does not lose its identity. This will be accomplished by assigning a part number and serial number to each module, subassembly, and assembly.

SAFETY ASSESSMENT

FOR

EPS ELECTRON-PROTON SPECTROMETER

LEC Document Number EPS-425

Prepared by

Lockheed Electronics Company, Inc.
Houston Aerospace Systems Division
Houston, Texas

Under Contract NAS 9-11373

For

National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas

August 1971

EPS-425

SAFETY ASSESSMENT

FOR

EPS ELECTRON-PROTON SPECTROMETER

Prepared by: P. Gleeson

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Reliability and Quality
Assurance Engineer

Approved by: Bruce E. Curtsinger

B. E. Curtsinger
Engineering Supervisor

Approved by: B C Hall

B. C. Hall
Program Manager

Electron-Proton Spectrometer Program
Advanced Programs Department

Lockheed Electronics Company, Inc.
Houston Aerospace Systems Division
Houston, Texas

SAFETY ASSESSMENT

1. PURPOSE

The purpose of this safety analysis is to identify the efforts required to assure relatively hazard free operation of the EPS and to meet the safety requirements of the program.

Safety engineering criteria, principles, and techniques in applicable disciplines is stressed in the performance of system and subsystem studies; in test planning, and in the design, development, test, evaluation, and checkout of the equipment, and the operating procedures for the EPS program.

2. DATA

There are no formal data submittal requirements specifically associated with the EPS system safety engineering program listed in the contract. However, letter reports and safety assessment requiring the attention of NASA/MSC will be transmitted when appropriate and any accident/incident reports prepared in response to NASA/MSC direction will be submitted.

3. SYSTEM SAFETY ASSESSMENT

3.1 TOXIC FLUIDS OR MATERIALS

No toxic fluids or materials will be used during the processes of manufacturing, testing, or handling of the EPS.

3.2 FLAMMABLE FLUIDS AND MATERIALS

No flammable fluids or material will be used in the manufacturing, testing, or handling processes of the EPS, except isopropyl alcohol for cleaning the electronic subassemblies.

3.3 NUCLEAR COMPONENTS/RADIATION

The EPS instrument itself does not contain any nuclear components; however, the laboratory equipment will contain radiation sources. LEC has been licensed to use radioactive sources.

3.4 RADIOACTIVE SOURCES

Radioactive Material		Quantity
Barium-133*	Solid, Elemental	2 sources not to exceed 100 microcuries each
Cesium-137*	Solid, Elemental	4 sources, each of three not to exceed 100 microcuries, one not to exceed 1 microcurie
Bismuth-207*	Solid, Elemental	4 sources, each of three not to exceed 100 microcuries, one not to exceed 1 microcurie
Americium-241**	Solid, Elemental	1 source not to exceed 0.1 microcurie

*Evaporated onto plastic film (Typical Bionuclear Inc., Houston, Texas.)

**Electrodeposited onto platinum foil (Typical Ortec Inc.)

These radioactive sources will be used for routine checks and calibrations of lithium-drifted silicon detectors, either in air or in a vacuum chamber. Because of their solid form and low activity, it is necessary to handle the sources with only a pair of small tongs.

3.4.1 Radiation Protection Program

The sources will be stored in locked, appropriately marked cabinets when not in use, with access to authorized users only. While the sources are not in use, they will be stored in a locked cabinet such that the dose level at the surface of the cabinet is $\leq$ 2 mr/hr. While in use, appropriate radiation signs will be placed at the 2 mr/hr locations.

In addition, personnel using the sources on a routine basis will wear film badges available from R. S. Laudauer, Jr. and Company.

3.4.2 Waste Disposal

At the end of the EPS program, the sources will be turned over to the NASA/MSC Health Physics Group for either storage or disposal. No wastes or disposal are expected to be necessary for these sources during the duration of the EPS program.

3.5 VAN DE GRAAFF FACILITY

An adequate safety program is already in existance at the Van de Graaff facility, and consists of the following:

(1) The first time the accelerator is operated in each of the three modes, (low energy proton, high energy proton, and electron mode) Health Physics will be notified to perform a radiation survey for that mode.

(2) Prior to each accelerator startup, the operating supervisor or his alternate shall be responsible to see that the following control procedure is accomplished:

a. Physically check each entrance into the target area to insure that the interlock system is functioning correctly.

b. Inspect the target room before each accelerator startup to verify that no one is present.

c. Check the visual warning system to insure that all units are operating correctly.

d. Check the area monitoring system panel to insure that all monitors are operating.

e. Announce over the building intercom system, two (2) minutes prior to each startup, that accelerator operations will commence immediately.

f. Check the roof area for occupancy restrictions when required for a particular mode of operation.

g. Insure that an approved operator is at the console panel during accelerator operation.

3. It shall be the responsibility of the facility supervisor to maintain an OPERATION LOG. This record will indicate modes of operation and duration of each operation, e.g., target used, current, voltage and time spent on each mode of operation.

4. Approval must be received from the Radiological Control Officer (RCO) before anyone is allowed in the target room during radiation producing operations.

5. During the period covered by Machine Use Request 000225 (April 15, 1971 to February 1, 1972), no modifications will be performed on the accelerator facilities without authorization from the RCO.

6. In the event of a RADIOLOGICAL EMERGENCY, operations will be suspended and Health Physics notified immediately.

7. The roof area will be roped off and posted "Caution Radiation Area" during electron, proton and neutron production.

8. The doors to the accelerator target room will be posted as restricted areas at all times and will be posted "Caution High Radiation Area."

3.6 ENVIRONMENTAL CHAMBERS FACILITIES

NASA/MSC Environmental Facilities will be used for Qualification Testing and other environmental testing. These facilities have their own safety program approved by NASA/MSC.

3.7 CONTROL SYSTEM TEST FACILITIES

All environmental chambers located in the Lockheed Facility test area have been checked for safety features, and personnel using these facilities are aware of the procedures and cautions.

3.8 END ITEM ASSEMBLY

Maximum efforts have been made during design to ensure that the optimum degree of inherent safety has been included in all equipment designed, procured, or leased for the EPS Program through the selection of appropriate equipment components and design features, and through the use of materials which are known to be hazard free.

Appropriate action has been taken to assure that necessary functions of the system will occur as required, and that no primary failures will cause a chain of dependent failures which would degrade system safety and create hazardous conditions.

The environmental and acceptance test procedures will be designed to reflect safety considerations in their testing operations. The safety of the operations as well as the ability of the procedures to enhance the inherent safety achieved in the subsystems and equipment is a prime consideration.

3.9 RADIO FREQUENCY (RF) RADIATION HAZARDS

The limit for equipment exposure to RF radiation has been established at 0.01 watt/square centimeter (CM^2) at any frequency. It is possible to encounter even higher power densities than this established safe maximum limit during the tests required by the Radio Frequency interference (RFI) tests; however, these high densities are localized. Susceptibility to fields and voltages from other circuits and equipment in the spacecraft was reduced to a practical minimum in the basic design of each assembly and sub-assembly. Primary consideration was given to components and circuits that are inherently free of susceptibility to magnetic fields at dc and audio frequencies. Preference was also given to circuits and components which are optimally free of susceptibility to transient voltage fluctuations and response to signals outside the intended operating frequency bands. The EPS is designed to withstand the transient supply voltage changes caused by the operation of other equipment in the spacecraft without degradation of operation. All digital logic has been designed to operate at as high a triggering voltage as feasible, definitely above the millivolt level. This design objective will provide optimum freedom from inadvertent operation due to stray pulses.

PART VI
CONFIGURATION CONTROL

1. CONFIGURATION MANAGEMENT

1.1 PURPOSE

The purpose of this plan will be to establish uniform configuration management methods and procedures which will accurately define the hardware at any point in time.

1.2 SCOPE

The requirements established herein will be applicable to all personnel participating in the Electron-Proton Spectrometer Program.

1.3 GENERAL

Configuration Control is the systematic evaluation, coordination and approval or disapproval of proposed changes to the baseline. Configuration Control involves the technical documentation of the approved configuration of the Electron-Proton Spectrometer throughout design, development, manufacture and testing. Formal control of the configuration, therefore, will commence with the establishment of the baseline and will continue through the completion of all project objectives. The baseline will be established upon completion of the Critical Design Review and the specific documentation constituting this baseline will be recorded. The configuration of the end item at any later date will be identified by the original baseline configuration plus all of the ensuing changes approved and incorporated since that time.

1.4 AUTHORITIES AND RESPONSIBILITIES

1.4.1 CONFIGURATION CONTROL MANAGER

The Configuration Control Manager will have overall responsibility for the Electron-Proton Spectrometer configuration management, including issuing policies and requirements and assuring that followup action is taken on Engineering Change Proposals approved by the Change Control Board. This includes maintaining a log book containing all of the Engineering Change Proposals and processing Engineering Change Orders. The Configuration Control Manager will also exercise complete control over drawings and other associated documents. The issuance and maintenance of these functions will be the responsibility of the engineering supervision.

1.4.2 CHANGE CONTROL BOARD

The Change Control Board will have the responsibility of reviewing and approving/disapproving all changes submitted on an Engineering Change Proposal or Specification Change Notice. The Board will be responsible for preparing any documents required and for securing approval of NASA when required. The Change Control Board will consist of the Program Manager, Project Engineer, Engineering Supervisor, Cognizant Engineer, and the Configuration Control Manager.

1.5 CONFIGURATION MANAGEMENT SYSTEM REQUIREMENTS

1.5.1 ENGINEERING DRAWING SYSTEM

Although formal control of the configuration begins at the Critical Design Review (baseline), Configuration Control will be exercised from the End Item Specification by means of the controlled drawing system.

Engineering drawings will be prepared to normal drafting standards using NASA Engineering Drawing System Manual MSCM 8500 as a guide. The numbering and coding of the drawings, associated lists, and documents and revisions to the drawings will comply with MSCM 8500. It will be necessary to release manufacturing specifications and drawings prior to the establishment of the configuration baseline due to the limited time span of the contract.

The Configuration Control Manager will exercise complete control over the drawing system throughout the program. He will permit only those persons having authorized sign-out approval access to drawings and associated documents. A locked file system will be used to secure the drawings and documents. After the Critical Design Review, no changes or additions to drawings will be made without an Engineering Change Order from the Configuration Control Manager preceded by an Engineering Change Proposal approved by the Change Control Board. In addition, configuration control will be further enforced by requiring the release signature of the Configuration Control Manager. prior to release for manufacture of any item occurring after the Critical Design Review. The drawings will be prepared in a tree which progresses from the top assembly drawing to detail component and part drawings. They will provide directly, or by reference, all data required for use in conjunction with other technical data such as specifications, test and screening procedures, test reports, inspection procedures, acceptance and rejection criteria, processes, manuals, operational procedures, etc.

1.5.2 PART AND SERIAL NUMBERING

The part number of all parts, assemblies, and installation detailed on engineering drawings will consist of the engineering drawing number, a dash, and three numerical digits as outlined in MSCM 8500. All deliverable end items, assemblies and subassemblies will also have a serial number which will consist of four numerical digits. As indicated in the drawing tree, a change of a part or component changes the part number of the assembly or subassembly of which it is a part, which in turn changes the next higher assembly, etc., until the final (or top) assembly receives a change in part number. The Configuration Control Manager will keep a log of all items and their associated part and serial numbers.

2. DRAWING TREE

- EPS FINAL ASSY SEC39106425-301
  - SDC39106616-001 TOP PLATE
  - SDC39106636-001,003 COVER PLATES
  - SEC39107164-701 REFLECTIVE SHIELD
  - SEC39107165-701 REFLECTIVE SHIELD
  - SDC39107457-001 INS BUSHING
  - SDC39107465-001 GROUNDING STRAP
  - **SEC39106422-301 INNER ELECT ASSY**
  - SEC39107462-701 OUTER HSG ASSY
  - SDC39107466-001 FLANGE COVER
  - SDC39107456-001,002 MTG WASHERS
  - SDC39107455-001,002 INS BUSHINGS
  - SDC39107458-001,002 MTG WASHERS
  - SDC39106614-001 DET STANDOFF

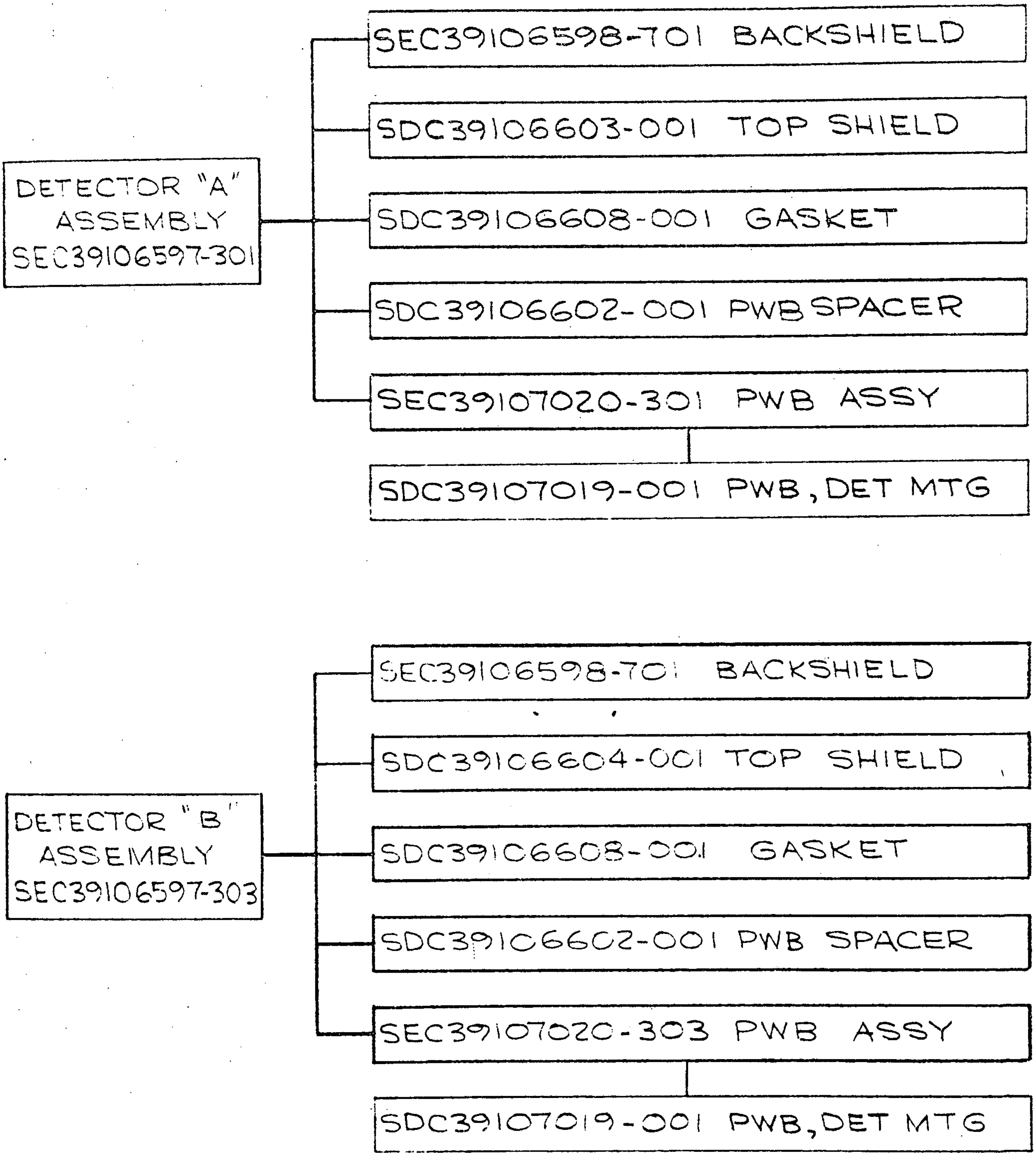
NOTE: A BOLD OUTLINE INDICATES A FOLLOWING BREAKDOWN

DRAWING TREE SHEET 1

- INNER ELECT ASSEMBLY SEC39106422-301
  - SEC39106597-301 DET "A" ASSY
  - SEC39106597-303 DET "B" ASSY
  - SEC39106597-305 DET "C" ASSY
  - SEC39106613-301 DET "D" ASSY
  - SEC39106612-301 DET "E" ASSY
  - SEC39107190-301 PRE-AMP SLICE ASSY
  - SEC39106670-301 AMP SLICE ASSY
  - SEC39106675-301 DISC SLICE ASSY
  - SEC39106690-301 DP/LVPS SLICE ASSY
  - SDC39107452-001 VIB ISO MTG STRAP
  - SDC39107453-001 VIB ISO MTG STRAP
  - SDC39107454-001 VIB ISO MTG STRAP

DRAWING TREE

SHEET 2



DRAWING TREE SHEET 3

- DETECTOR "C" ASSEMBLY SEC39106597-305
  - SEC39106599-701 BACKSHIELD
  - SDC39106605-001 TOP SHIELD
  - SDC39106608-003 GASKET
  - SDC39106602-001 PWB SPACER
  - SEC39107020-303 PWB ASSY
    - SDC39107019-001 PWB, DET MTG

- DETECTOR "D" ASSEMBLY SEC39106613-301
  - SEC39106600-701 BACKSHIELD
  - SDC39106606-001 TOP SHIELD
  - SDC39106608-005 GASKET
  - SDC39106602-001 PWB SPACER
  - SEC39107020-303 PWB ASSY
    - SDC39107019-001 PWB, DET MTG

DRAWING TREE

SHEET 4

- DETECTOR "E" ASSEMBLY SEC39106612-301
  - SEC39106601-701 BACKSHIELD
  - SDC39106607-001 TOP SHIELD
  - SDC39106608-007 GASKET
  - SDC39106602-001 PWB SPACER
  - SEC39107020-303 PWB ASSY
    - SDC39107019-001 PWB, DET MTG
  - SEC39106611-301 TEMP DET ASSY
    - SDC39106610-001 PWB TEMP DET
  - SDC39106602-003 PWB SPACER

DRAWING TREE

SHEET 5

- PRE-AMPLIFIER SLICE ASSY SEC39107190-301
  - SEC39106618-701 PRE-AMP SLICE ASSY
  - SDC39106619-001 PRE-AMP COVER
  - SEC39107184-301 DET BIAS SUPPLY
  - SEC39107185-301 PRE-AMP ASSY
  - SEC39107186-301 DET BIAS FILTER
  - SEC39107485-301 DET BIAS FILTER
  - SEC39107486-301 DET BIAS FILTER
  - SEC39107487-301 DET BIAS FILTER
  - SEC39107488-301 DET BIAS FILTER

DRAWING TREE

- AMPLIFIER SLICE ASSY SEC39106670-301
  - SEC39106620-701 AMP SLICE
  - SEC39107187-301 AMP PCB ASSY
  - SEC39107189-301 TEMP MON PCB
  - SDC39106621-001 TOP AMP COVER
  - SDC39106621-003 BOT AMP COVER
  - SDC39106621-009 TEMP MON COVER
  - SDC39106621-013 TEMP MON COVER

- DISCRIMINATOR SLICE ASSY SEC39106675-301
  - SEC39106675-701 DISC SLICE
  - SEC39106664-301 DISC PCB SLICE
  - SEC39106669-301 HEAT CONT PCB
  - SDC39106621-005 DISC COVER
  - SDC39106621-007 HEAT CONT COVER

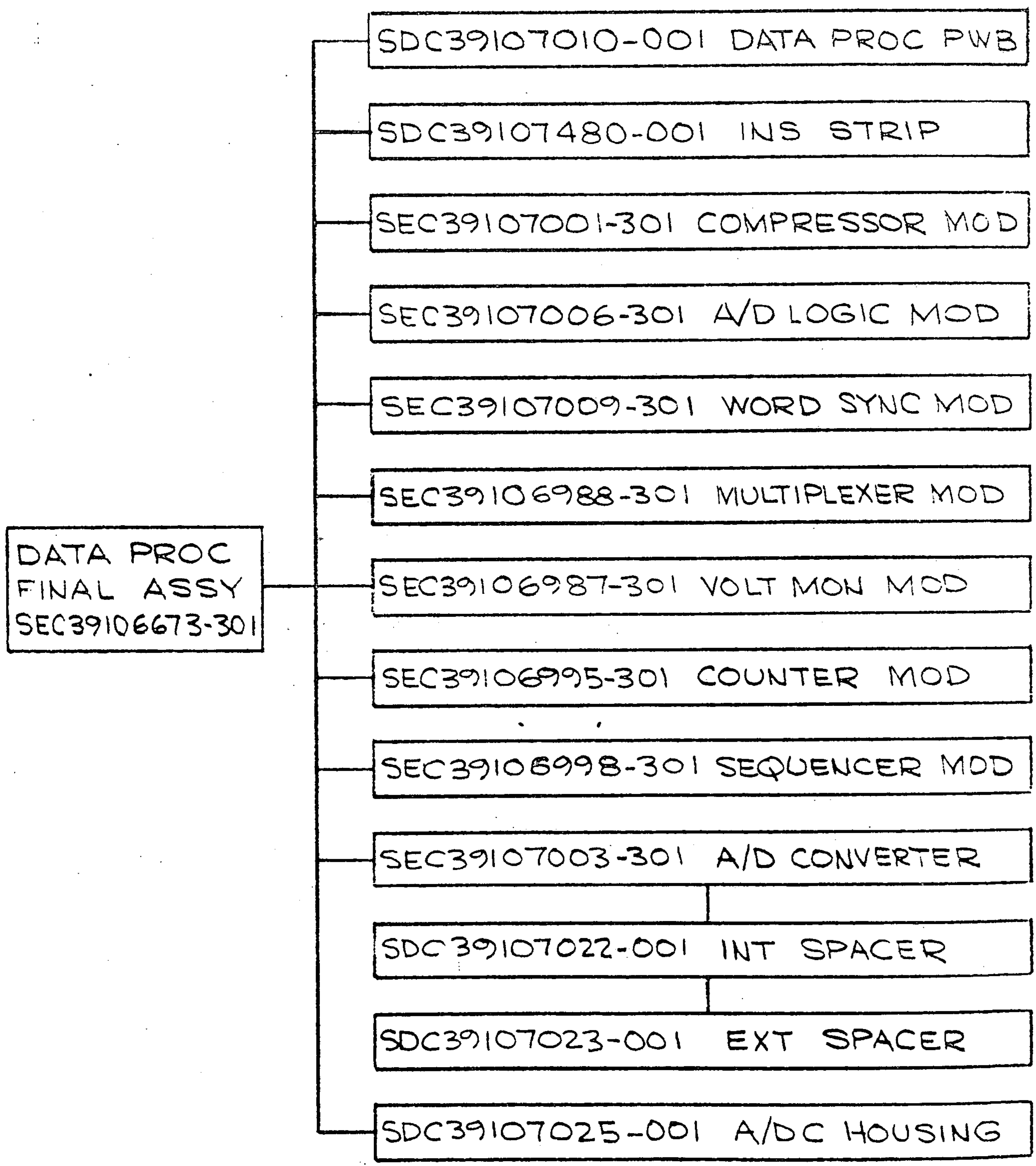
DRAWING TREE

SHEET 7

- DATA PROC/LVPS SLICE ASSY SEC39106690-301
  - SEC39107147-701 DATA PROC/LVPS SLICE
  - SEC39106673-301 DATA PROC ASSY
  - SEC39107518-301 INNERCONNECT PWB
  - SEC39106980-301 LVPS ASSEMBLY
  - SEC39107473-301 INPUT FILTER ASSY
  - SDC39107464-001 CONNECTOR TRAY
  - SDC39107467-001 CONNECTOR BRKT
  - SDC39107468-001 DATA SYNC HSG
  - SDC39107469-001 CABLE TIE STRAP
  - SDC39107470-001 DATA SYNC COVER
  - SDC39107471-001 FILTER MOD INS
  - SDC39107472-001 CABLE TIE STRIP
  - SDC39107474-001 BACKSHIELD LVPS
  - SDC39107476-001 DATA PROC COVER
  - SDC39107477-001 INS BUSH FILTER MOD
  - SDC39107478-001 MTG WASHER F.M.
  - SDC39107479-001 LVPS ACCESS COVER

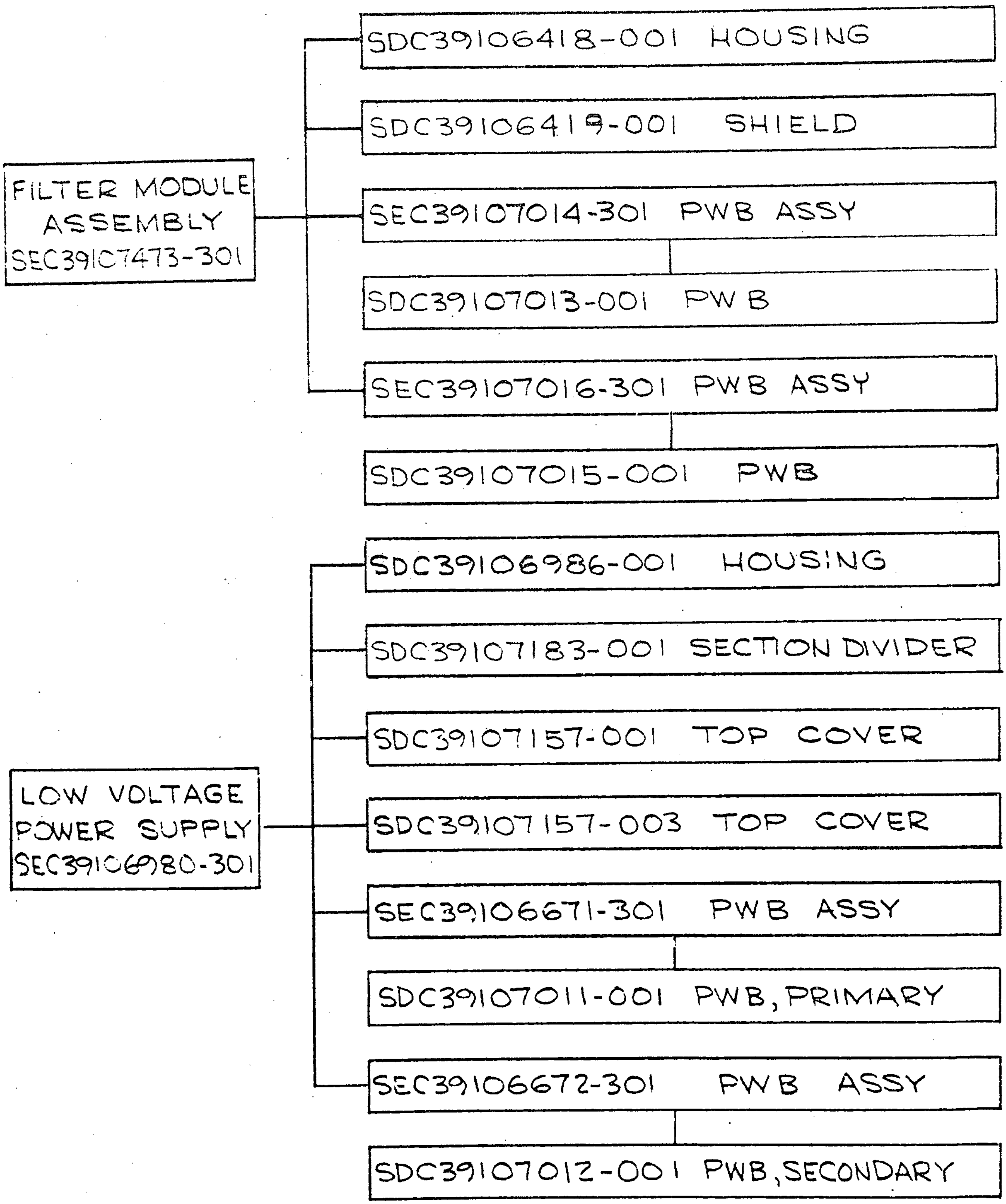
DRAWING TREE

SHEET 8



DRAWING TREE

SHEET 9



DRAWING TREE SHEET 10

PART VII

VERIFICATION PLAN

VERIFICATION PLAN
FOR
ELECTRON-PROTON
SPECTROMETER

LEC Document Number EPS-435

Prepared by

Lockheed Electronics Company
Houston Aerospace Division
Houston, Texas

Under Contract NAS 9-11373

For

National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas
September 1971

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VERIFICATION PLAN

FOR

ELECTRON-PROTON

SPECTROMETER

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EPS VERIFICATION PLAN

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EPS VERIFICATION PLAN

1. INTRODUCTION

The Verification Plan shall define the specific methods to be used to verify that the Electron-Proton Spectrometer meets the overall system and subsystem performance in terms of required functions and design limits. Verification by test shall be used to demonstrate that the EPS will meet the applicable technical requirements. The tests shall include the significant parameters that define the expected performance of the hardware.

2. DEVELOPMENT TESTS

2.1 STRUCTURAL UNIT TEST

2.1.1 Objectives

The test objectives are:

a. to verify the integrity of structural design of the EPS to withstand the imposed vibration criteria.
b. to provide additional data on the vibration levels experienced by the EPS electronics and detectors.

2.1.2 Description of Test Unit

The EPS test article will consist of a simulated electronics unit housed within a proposed "flight-type" outer structure.

2.1.3 Instrumentation

Approximately 17 channels of vibration data will be recorded during the tests. The accelerometer locations will be determined prior to start of the tests when the EPS and vibration fixture are setup for tests.

2.1.4 Vibration and Shock Tests

The test unit will be subjected to the vibration levels specified in Appendix A and the shock levels specified in Appendix E.

2.1.5 Success Criteria

The structural development testing of the EPS will be deemed satisfactory if no major structural failure of the EPS structure occurs. The fulfillment of objective (b) of paragraph no. 2.1.1 will be the recording of accelerometer data in the locations selected.

2.1.6 Test Reports

The test program shall be documented by photographs including general test setups, instrumentation installation, and details of any failures. The only report required shall consist of a compilation of the testing and a data appendix. The data appendix shall consist of read-outs of all accelerometers for all vibration test conditions.

2.2 THERMAL UNIT TEST

2.2.1 Objectives

The objectives of the thermal engineering test series is to verify the analytically predicted electronics and detector temperatures for the specified flight cases defined below, and to determine whether isolated "hot spots" on some circuit boards within the electronics unit will be a potential problem.

2.2.2 Description of Test Unit

The test unit will consist of an electronics unit housed within the proposed "flight-type" outer housing. The outer housing will exactly simulate the proposed flight unit, both in materials and exterior finishes. The electronics unit will be comprised of printed circuit boards of similar configuration to those to be used in the flight unit, with the power distribution for each board being simulated by an equivalent resistor network. If an actual circuit is available, this will be used within the Thermal Test Unit. These circuits will be mounted within electronics housings identical to those proposed for the flight unit, so that the electronics unit is a close simulation of the EPS.

2.2.3 Instrumentation

Thermocouples will be used to measure temperature at points within the electronics assembly which are indicative of critical elements, at points on the electronics module structure, on the baseplate, the EPS outer structure walls, mounting flange, and on the detector housings. For control purposes, the temperatures will be measured at points on both the simulated CSM fairing support structure and the simulated cavity enclosure.

An estimate of the thermocouple requirements is as follows:

Electronics	20
Case	4
Detector Plate	6
Base Plate	2
Flange	4
Structure & Shields	14
	50 maximum

2.2.4 Test Apparatus

The test apparatus will be installed in a vacuum chamber with a LN_2 cold wall and heat source capability (to be defined). Hardware shall be provided to simulate the NAR CSM fairing to which the EPS will be attached, as in flight. An enclosure consisting of metal shields shall be placed around the EPS on the "inboard" side to simulate the interior cavity formed by the CM heat shield and the SM.

To simulate the external environment, a lamp bank (to be defined) and shields shall be provided. The lamp bank system will require calibration through use of calorimeters on the detector plate and sides of the

EPS Thermal Test Unit. Design of the lamp support system will take into account the view of the EPS to the cold wall of the vacuum chamber.

The test apparatus should be designed to allow insertion of the Thermal Test Unit and subsequent engineering test and flight qualification units.

2.2.5 Thermal Test

The test unit will be subjected to the thermal-vacuum tests specified in Appendix B.

2.2.6 Test Reports

The report shall consist of a compilation of all testing data and details of any failures. The data appendix shall consist of read-outs of all of the thermocouples and thermal/vacuum test instrumentation.

2.3 ENGINEERING TEST UNIT TEST

2.3.1 Electromagnetic Interference

The anticipated electromagnetic interference tests are specified in Appendix C.

2.3.3 Vibration and Shock Tests

The Engineering Test Unit will be subjected to the vibration levels specified in Appendix A and the shock levels specified in Appendix E.

2.3.3 Thermal-Vacuum Tests

The Engineering Test Unit will be subjected to the Thermal-Vacuum Tests specified in Appendix B.

2.3.4 Humidity

Humidity Tests will be run in accordance with the methods specified in Appendix D.

2.3.5 End-to-End Testing

End-to-end testing will be performed on the completed Engineering Test Unit. This testing will enable experimental verification of the analytical detector shielding configuration design. It will also provide a complete functional performance check of the instrument from the excitation of the sensors to and including the data processor and equipment test set.

To fully exercise all channels of the instrument the following tests are currently planned:

a. Low energy proton tests will be performed over the energy range from 13 to 60 MeV at the Texas A & M University Isochronous Cyclotron Facility.
b. High energy proton tests over the energy range from 50 to 135 MeV will be performed at the Harvard University Cyclotron Facility.
c. Electron tests will be performed over the energy range from 0.6 to 4.2 MeV at the National Bureau of Standards Van de Graaff, Washington D.C. Laboratory.

3. QUALIFICATION TESTS

A qualification test procedure shall be prepared and submitted to NASA/MSC for review. Complete acceptance testing will be conducted on qualification test hardware prior to qualification tests. Tests to determine whether the qualification test hardware is performing within specified tolerances shall be conducted before and after each environmental exposure. Qualification tests shall be performed under strict control of environmental and test procedures.

All general tests such as, humidity, shock, vibration acoustics, thermal-vacuum, and EMI tests will be conducted on the completed end item. Subassembly acceptance tests will be run on each subassembly during and after fabrication. These subassembly tests will be identical to those used for the flight hardware.

A formal report of the test results shall be submitted for approval within 30 days of qualification test completion.

3.1 QUALIFICATION TEST UNIT

The qualification tests will be conducted on one end item and its component subassemblies. The qualification test hardware will be identical in configuration and production processing to flight hardware.

3.1.1 Subassembly Acceptance Test

Design specifications for the various modules and/or subassemblies are not a contractual requirement, therefore, a detailed fabrication and test procedure must be prepared for each module and/or subassembly. Each will be a detailed step-by-step procedure for fabrication and for conducting and recording the tests. An individual test procedure will be developed for each type of module and/or subassembly. If space for recording test data is not incorporated in the test procedure, a test data sheet shall be used in conjunction with the test procedure. If used, the test data sheet will include required test parameters, tolerances, and an approval block for NASA/MSC inspection personnel.

3.1.2 Humidity

The humidity test will be run as specified in Appendix D.

3.1.3 Shock

The Qualification Test Unit will be subjected to the shock levels specified in Appendix E.

3.1.4 Vibration Test

The Qualification Unit will be subjected to the Vibration levels specified in Appendix A.

The test program shall be documented by photographs including general test set-up, instrumentation installation, and details of any failures. The report required shall consist of a compilation of the testing and a data appendix.

3.1.5 Acoustic Test

MIL-STD-810B, Method 515, Procedure I, shall apply except that test time shall be ten minutes for each of the three orthogonal axes. If the test facility permits exposure to all sides, the total test time may be limited to ten minutes.

The acoustic test will consist of exposure of the test unit on each of its three orthogonal axes to a sweep of from 25 to 8000 cps at 160 dB for ten minutes (total exposure of 30 minutes). At the conclusion, the unit shall be functionally tested and the results compared with previous functional test results.

3.1.6 Thermal-Vacuum Test

The Qualification Test Unit consists of an electronics unit housed within the outer housing. The outer housing will exactly simulate the proposed flight unit, both in materials and exterior finishes. The electronics unit will be comprised of printed circuit boards of the exact configuration to those to be used in the flight unit. These circuits will be mounted within electronics housings identical to those proposed for the flight unit.

The test criteria are specified in Appendix B.

3.1.7 Electromagnetic Interference

The Qualification Unit will be subjected to the electromagnetic interference tests specified in Appendix C.

4. ACCEPTANCE TESTS

Acceptance tests consisting of thermal, vibration, and functional tests shall verify that each complete end item for flight use meets the requirements of the end item specification and intent of the EPS requirements.

The acceptance test procedure shall define the limits and methods for each test and shall be submitted to NASA/MSC for review. The severity, duration, and number of tests shall not result in overstressing or degradation of the hardware capability.

4.1 THERMAL TESTS

Each end item shall be temperature cycled over the range specified in the following table allowing specified times at each temperature. After each temperature soak, proper electronic operation shall be verified.

TEMP. °C	TIME MINUTES
-50	30
+25	15
+50 (detectors not operating)	30
+25	15

Note: All temperature ranges +5° C. All times minimal. Exceeding -50° voids detector warranty

4.2 VIBRATION TESTS

Each complete end item will be subjected to an acceleration spectral density (ASD) increasing at the rate of 3 db per octave from 20 to 80 Hz. CONSTANT at 0.04 g^2/Hz from 80 to 350 Hz; and decreasing at the rate of 3 db per octave from 350 to 2000 Hz (Figure 1). The vibration test duration will be 90 ± 10 seconds per axis, including specimen equalization time in each of three orthogonal axes. Should reruns be required in any axis following rework or modification, the duration will be reduced, wherever possible, to 15 seconds minimum per axis, and the total accumulative vibration test time in any axis will not exceed 5 minutes.

Functional/continuity tests will be conducted on all items before, and after acceptance vibration tests. Where possible, vibration fixtures previously approved for use in qualification tests will be used for AVT. The acceptance vibration test tolerance will be as follows:

1. Overall root mean square (rms) acceleration: (with a sharp cutoff filter employed to eliminate acceleration responses occurring above 2 KHz from the g rms readout).	+10 percent, -15 percent

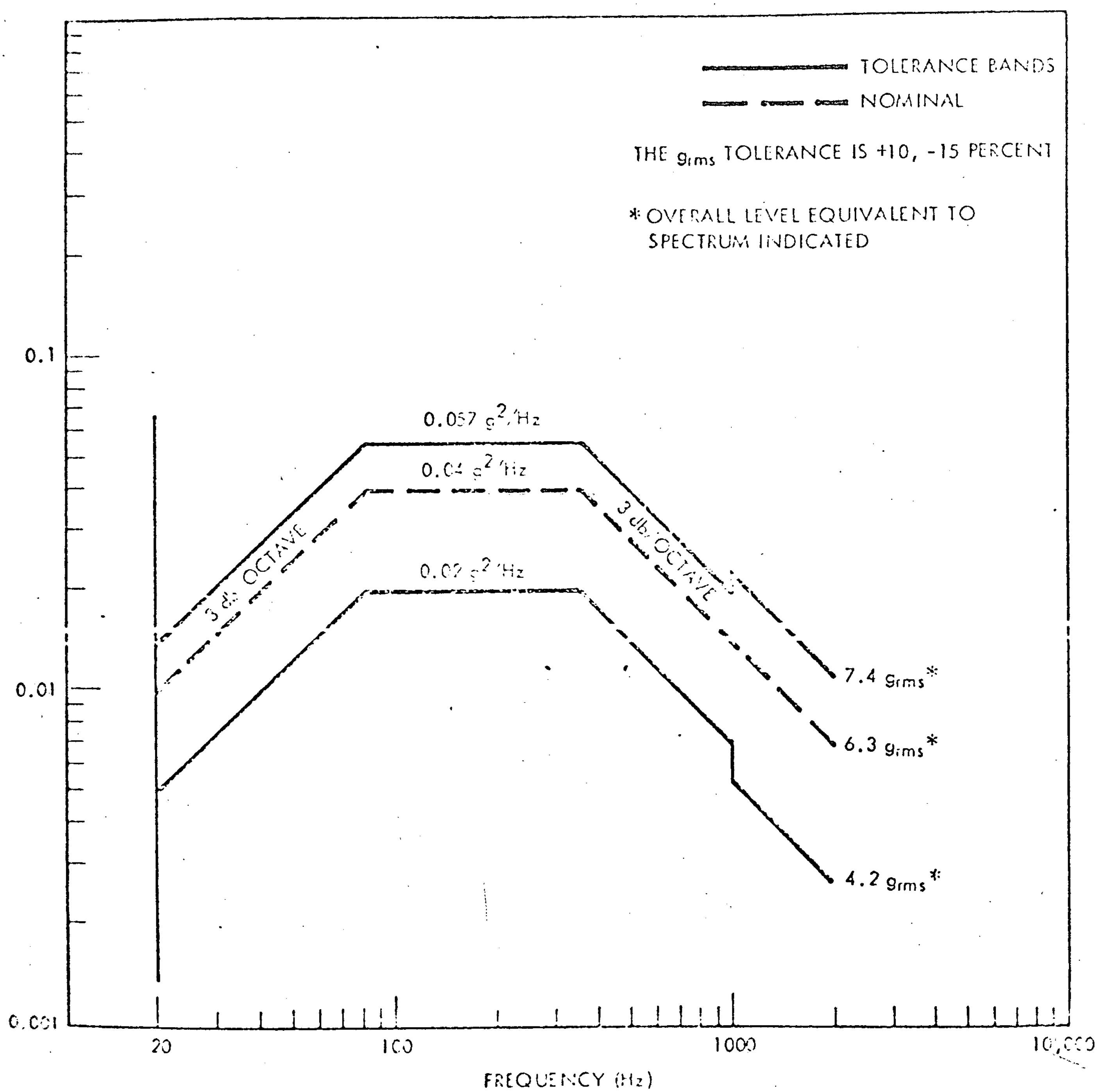

Figure 1. Acceptance Test Vibration Spectrum Requirements

2. Acceleration spectral density: +1-1/2 db, - 3 db from 20 to 1000 Hz

+2 db, -4 db from 1000 to 2000 Hz

The following additional ground rules will apply to the evaluation of acceptance vibration test results.

1. Acceptance test levels that exceed the specification by more than 2 db at frequencies below those of the known resonances are acceptable if the level achieved is less than that of the known response at resonance during qualification testing or overstress testing.

2. Acceptance test levels that exceed the above tolerances are acceptable if limited to three separate instances where the bandwidth is less than 5 percent of center frequency. Bandwidth to be measured at the point where the tolerance is exceeded.

3. In cases where fixture resonances limit capability to meet the above tolerances, the input level should be reduced at the resonant frequenceis rather than overtesting the component.

4. Any other instances of acceptance test levels being exceeded which are considered to not disqualify the unit for flight will be justified using the normal procedures for handling test deviations.

5. Reduction in acceptance test level above 500 Hz to lower than the minimum tolerance at demonstrated critical fixture decoupled frequencies are acceptable if the maximum capability of the shaker has been used.

6. Reduction in acceptance test levels to no more than 2 db below the minimum tolerance is permitted at any of three separate bandwidths no wider than the filter used in the spectrum shaping network.

7. Reduction in acceptance test levels other than given above will require a delta test to make up only that part of the spectrum for which the reduction occurred.

8. Equipment will be operated and monitored as specified in applicable specification during the acceptance vibration test.

4.3 FUNCTIONAL TESTS

The test procedures will include a list of the test equipment (name, quantity and number) required for the test, as well as calling out any particular environmental facilities that are required to support the test.

A description of what visual inspections (calibration stamps, equipment damages) and functional tests are required to validate the test equipment prior to the start of the test will be included.

Precautions to be observed while handling test equipment and test unit will be included in order to prevent injury to personnel and damage to hardware involved.

4.3.1 Test Setup

The test setup will describe the test equipment or console with which the complete end item will be tested and will include any schematics or drawings necessary for clarification. Inspection and/or validation checks to verify that all components and test equipment have been properly connected into the test setup will be provided. This will include test preparation sheets specifying methods to validate integrated test setup prior to commencing test.

4.3.2 Test Procedure

The test procedure will be a detailed step-by-step procedure for conducting and recording the test. Where possible, all normal, alternate, redundant and emergency operational modes shall be tested. The end item shall be electronically calibrated, and aligned prior to conducting acceptance tests. Acceptance tests shall be performed under strict control of environment and test procedures. Adjustment of end items will not be permitted during tests unless it is normal to inservice operation.

Any repairs, modifications, or replacement after completion of acceptance testing shall require retesting to assure the acceptability of the change. The degree of retest necessary shall be proposed and submitted for approval.

A test data sheet will be used in conjunction with the test procedure to record the test data obtained while the test is being accomplished. Upon completion, test data sheet(s) will be kept with the end item being tested.

If the test data sheets do not provide a record of necessary test data, test summary sheets containing supplementary information, such as downtime, peculiar difficulties encountered, replacement of components, etc., may be used. These sheets if used should include test certification statement, to be signed by the test conductor and MSC inspector, verifying the successful completion of the test.

5. DETECTORS

The detectors proposed for use in the EPS are made by only one known manufacturer and are not available as established reliability parts. Therefore, an intensive screen and burn-in program is planned during Qualification testing to qualify the detectors as part of the instrument. The performance of this program will follow the recommendations of "Sensor Design and Calibration, Electron-Proton Spectrometer", LEC Document No. 0A5005. Test levels are shown in "Detector Screen and Burn-In Test Plan", LEC Document EPS-456.

5.1 DETECTOR SCREEN AND BURN-IN

Detector screening will encompass all testing performed on the detectors from their receipt to their mounting on the spectrometer units, with the exception of calibrations at accelerator facilities. It will encompass additional testing on the detectors to be used for spares.

5.1.1 Visual, Thermal and Vibration Tests

- Visual

The detectors will be mounted individually and examined under magnification for broken or loose silicon elements, loose or broken leads, bent mounts, or any other visually observable defect which might impair performance.

- Thermal

Detectors which pass the visual tests will be mounted on a plate and subjected to a thermal cycle over their anticipated environmental range in order to flex the mounting bond, the silicon cube, and the electrical contacts.

- Vibration

The detectors will be subjected to anticipated vibration levels for their projected use, in order to ascertain the integrity of the bond between the silicon cube and its mount.

- Visual Recheck

Each detector will be rechecked visually under magnification for loose leads or loose silicon cubes.

5.1.2 Electrical Tests

These tests are typical of those which will be performed routinely throughout the program. They are designed to measure the leakage current, noise, and response of the detectors to a radioactive source.

- Leakage

The leakage current of each detector will be measured at specified temperatures.

- Response and Noise Tests

The response of the detectors will be measured, utilizing appropriate conversion electron sources, such as Cesium-137 and Bismuth-207. Also, a pulser will be fed into the electronic system, yielding information on the detector noise.

5.1.3 Short Term Burn-In

Short term burn-in tests will be performed over a period of approximately 30 days. The detectors will be subjected to their full operating bias during this time, and the leakage, noise tests and response tests of 5.1.2 will be performed five times during the 30 days.

Continuous operation of the detectors for 30 days should eliminate the detectors of poor quality, and also provide data toward the determination of failure rates.

5.1.4 Storage

Detectors which survive the 30 day burn-in of 5.1.3 and which are not required for other purposes, i.e. calibration, qualification and flight EPS units, will be placed in long term storage until needed. During this period the detectors will be kept under bias, and the leakage and noise tests of 5.1.2 will be performed weekly. The response tests will be performed approximately monthly. Detectors surviving this extended operation should be well qualified to serve as spares for refurbishment of the flight spectrometers as needed until launch.

5.1.5 Detector Charge Collection/Radiation Effects Tests

Because lithium-drifted silicon detectors show a deterioration in response to large integrated proton radiation doses, the response of several of the detectors will be examined for doses of the order of those expected on the Skylab mission.

5.1.6 Detector Selection

Immediately prior to the need for detectors for the qualification and flight spectrometer units, data accrued on the detectors will be reviewed. Detectors for these units will be selected on the basis of the history of the best values of bias, leakage and response*. Leakage, noise and

*Results of the detector thickness measurements from the Calibration Program will also be considered.

response tests of 5.1.2 will then be repeated at this time on the selected detectors.

Data on the remaining detectors will be reviewed and suitable spares will be chosen. The leakage, noise, and response measurements will be repeated on the chosen spare detectors.

5.2 CALIBRATION

A series of calibration tests will be performed to provide data needed to prepare and confirm the analytic response functions. Data will be taken from two different cyclotrons to cover the required proton energy range. A Van de Graaff accelerator will be used which can provide electrons with energies up to 3 MeV.

5.2.1 Low Energy Proton Calibration

The low energy proton calibration measurements will be made with a cyclotron such as the one at Texas A&M University. This machine has a maximum energy capability of about 60 MeV and is adjustable so that the required lower energies can be supplied.

5.2.2 High Energy Proton Calibration

The high energy proton calibration measurements will be made with a cyclotron such as the one at Harvard University. The Harvard Cyclotron has a fixed energy of 160 MeV, but the beam can be degraded to provide lower energies. The beam energy can be satisfactorily degraded enough to overlap with the energies available from the Texas A&M Cyclotron, but because of the energy broadening, cannot be satisfactorily degraded enough to cover the entire energy range of the EPS.

5.2.3 Electron Calibration

The electron detection efficiencies will be measured as a function of energy and angle over the sensitive range of the instrument. Since the electron channels are all integral discriminators with a relatively low discrimination level (200-300 keV), the detector response function will not be as sensitive to the incident direction as the proton channels. Also, the much greater scattering of the electrons in the shields reduces the effect of the shape of the detector itself on the angular response. The computer programs are not suitable for calculating energy loss by electrons, hence the primary emphasis will be placed on experimental calibration.

The electron response function of each type sensor will be determined by data at the calculated threshold level, the calculated effective level, and four higher levels. For each energy, angular data at four angles (0°, 45°, 67.5° and 90°) will be taken and should adequately determine the angular response.

5.2.4 Sensor Response and Selection

A computer program will be selected to calculate the omnidirectional response of each of the five EPS sensors over their energy ranges for each of the several discriminator levels. From the plot of these response functions, the discriminator settings which give the best combination of response functions will be selected. The unidirectional response function will be calculated for each of the EPS sensors using the selected discriminator level to aid in the selection of experimental calibration energies and to permit comparison with the experimental results.

5.2.5 Detector Thickness Measurements

Each detector requires a set of measurements to determine the nuclear thickness of its sensitive volume in order to permit the calculation of its sensor's energy response function. In effect, the thickness neasurements permit a calculation of correction factors necessary to be applied to the energy response functions determined on other detectors.

All of the detectors which would be used either in the calibration program or could conceivably be used in a flight instrument will be measured by penetrating each detector with a proton beam normal to a surface in each of three orthogonal directions. The known proton energy and measured energy disposition in the detector will permit the determination of the detector thickness.

5.2.6 Data Analysis and Response Calculation

The calibration data will be utilized to generate experimental response functions and to further evaluate the computer program. Analytic response functions will be calculated from the thickness parameters and normalized by the experimental response functions.

The experimental data consists of three different types of data: thickness measurements, proton calibration, and electron calibration. The thickness data must be converted from energy loss data to equivalent physical thicknesses and the detectors categorized according to the spectral shape for purposes of later selection for use in the EPS.

5.3 DETECTOR RESOLUTION

A method to suitably evaluate detector resolution is under study. Definite plans for testing detector resolution are awaiting outcome of this study.

5.4 DOCUMENTATION

5.4.1 Procedures

A detailed procedure will be written to cover handling, transportation and testing of the detectors for the thickness measurements.

5.4.2 Reports

A final report will be written describing the techniques and procedures associated with, and the results of, the calibration of the detectors.

VERIFICATION MATRIX

VERIFICATION METHOD:

1. TEST
2. ASSESSMENT
   - A. SIMILARITY
   - B. ANALYSIS
   - C. INSPECTION
   - D. DEMONSTRATION

TEST TYPE

- NR - NO REQUIREMENT
- A - DEVELOPMENT
- B - QUALIFICATION
- C - ACCEPTANCE
- D - PRE-INSTALLATION
- E - INTEGRATED SYSTEMS
- F - PRELAUNCH
- G - OTHER

Section 3.0 End Item Specification Reference	VERIFICATION METHOD								Verification Plan Reference
	NR	A	B	C	D	E	F	G	
3.0	X								
3.1	X								
3.1.1	X								
3.1.1.1	X								
3.1.1.1A		1							2.3.5
3.1.1.1B		1							2.3.5
3.1.1.1C		1							2.3.5
3.1.1.1D		1							2.3.5
3.1.1.1E		1							5.2 & 5.3
3.1.1.1F		1							2.3.5
3.1.1.1G		2B							
3.1.1.2	X								
3.1.1.2.1		1	1						2.1 & 3.1
3.1.1.2.2			1	1					2.3.5 & 4.3
3.1.1.2.3		2B							
3.1.2	X								

Section 3.0 End Item Specification Reference	VERIFICATION METHOD								Verification Plan Reference
	NR	A	B	C	D	E	F	G	
3.1.2.2	X								
3.1.2.2.1	X								
3.1.2.2.1a		2C							
3.1.2.2.1b		2C							
3.1.2.2.1d		2C							
3.1.2.3		2B							
3.1.2.4				1					4.
3.1.2.5			1						3.
3.1.2.6			1						3.1.2 & 3.1.3
3.1.2.7	X								
3.1.2.8		2B							
3.2	X								
3.2.1	X								
3.2.1.1	X								
3.2.1.1.1		2B							
3.2.1.1.2		2B							
3.2.1.1.4		2B							
3.2.1.1.5		2B							
3.2.1.1.6		2B							
3.2.1.5	X								
3.2.1.5C		2B							
3.2.1.6		2B							
3.3	X								
3.3.1	X								
3.3.1.6		2C							
3.3.1.7	X								
3.3.1.7.1		1							2.1
3.3.1.8		2B							
3.3.2	X								

Section 3.0 End Item Specification Reference	VERIFICATION METHOD								Verification Plan Reference
	NR	A	B	C	D	E	F	G	
3.3.2.3			2C						
3.3.2.4		2B							
3.3.2.5			2C						
3.3.2.6		2B							
3.3.2.7		2B							
3.3.2.9		2B							
3.3.2.10		1							2.3.3 & 3.1.6
3.3.2.11			1						3.1.2
3.3.2.12		2B							
3.3.2.13			1	1					4.3
3.3.2.14		2B	1						2.3.3 & 3.1.6
3.3.2.15		2B							
3.3.2.16		2B							
3.3.4	X								
3.3.4a		2B							
3.3.4b		2B							
3.3.4d		2B							
3.3.5		2C							
3.3.6	X								
3.3.6.1		2B	2C						
3.3.6.2		2B	2D						
3.3.7		2B							
3.3.8	X								
3.3.8.1		2B							
3.3.8.2	X								
3.3.9		2B							
3.3.10		2B	2C						

Section 3.0 End Item Specification Reference	VERIFICATION METHOD								Verification Plan Reference
	NR	A	B	C	D	E	F	G	
3.3.10.1	X								
3.3.10.2		2B							
3.3.10.3		2B	2C						
3.3.10.4		2B	2C						
3.3.10.5		2B	2C						
3.3.10.6		2B	2C						
3.3.10.7		2B	2C						
3.3.10.8		2B							
3.3.10.9		2B							
3.3.10.9.1		2B							
3.3.11		2B							
3.3.12		2B							
3.3.13		2B	2C						
3.3.14		2B							
3.3.15		2C							
3.3.16		1	1						2.3.1 & 3.1.7
3.3.17		2C							
3.3.18		2B							
3.3.19	X								

Appendix A
Vibration Tests

Appendix A
Vibration Tests

The test article will be mounted on a vibration fixture V6-1-166, with a dimensionally similar mounting hole pattern to the EPS location on the CSM. The fixture in turn will be bolted to a vibration exciter.

Prior to test article installation on the test fixture, a vibration survey will be performed to insure that the fixture is capable of transmitting the required vibration levels and to determine the optimum control accelerometer location.

All tests shall be performed under the prevailing laboratory conditions.

The tolerances on the test conditions shall be:

a. The test tolerances for equalization bursts at any level are 2 dB above full levels from 20 to 1000 Hz and 4 dB above full levels from 1000 to 2000 Hz. There are no minimum tolerance requirements.

b. The test tolerances for full level test runs are ±2 dB from 20 to 1000 Hz and -4 dB from 1000 to 2000 Hz.

c. The overall g rms tolerance is +15% and -5%, applicable both to bursts and test runs. (Note: g rms values are to be read out of the control console meter).

d. Compliance with the tolerance shall be verified by analysis of the input spectrum.

e. Three separate exceedances whose bandwidth is less than that of the shaping filter (up to 25 Hz) or less than 5% of the center frequency, whichever is larger, are acceptable.

f. Reductions below tolerance, whose bandwidth is less than that of the shaping filter (up to 25 Hz) are acceptable, provided the maximum capability of the shaker system has been used.

The test article shall be subjected to the following vibration levels along the three orthogonal axes (Figure A-1) in the order shown below. This sequence may be altered at the discretion of the test conductor with concurrence of the NASA/MSC and LEC representatives.

Random:

X-Axis

20 to 125 Hz	+12 dB/oct increase
125 to 500 Hz	2.0 g^2/Hz
500 to 670 Hz	-9 dB/oct decrease
670 to 1100 Hz	0.8 g^2/Hz
1100 to 2000 Hz	-9 dB/oct decrease

Y-Axis

20 to 75 Hz	+6 dB/oct increase
75 to 175 Hz	0.085 g^2/Hz
175 to 300 Hz	+6 dB/oct increase
300 to 1000 Hz	0.025 g^2/Hz
1000 to 2000 Hz	-6 dB/oct decrease

Z-Axis

20 to 100 Hz	+6 dB/oct increase
100 to 440 Hz	0.04 g^2/Hz
440 to 600 Hz	+18 dB/oct increase
600 to 900 Hz	0.3 g^2/Hz
900 to 2000 Hz	-12 dB/oct decrease

The excitation shall act along each of the above axes for a duration of 140 seconds per axis. In addition, the spectral density shall be increased by 4 dB above the nominal for a duration of 10 seconds per axis.

Sinusoidal:

5-35 Hz @ ± .25 along each of three orthogonal axes as follows: Sweep at 3 octaves per minute from 5 to 35 to 5 Hz.

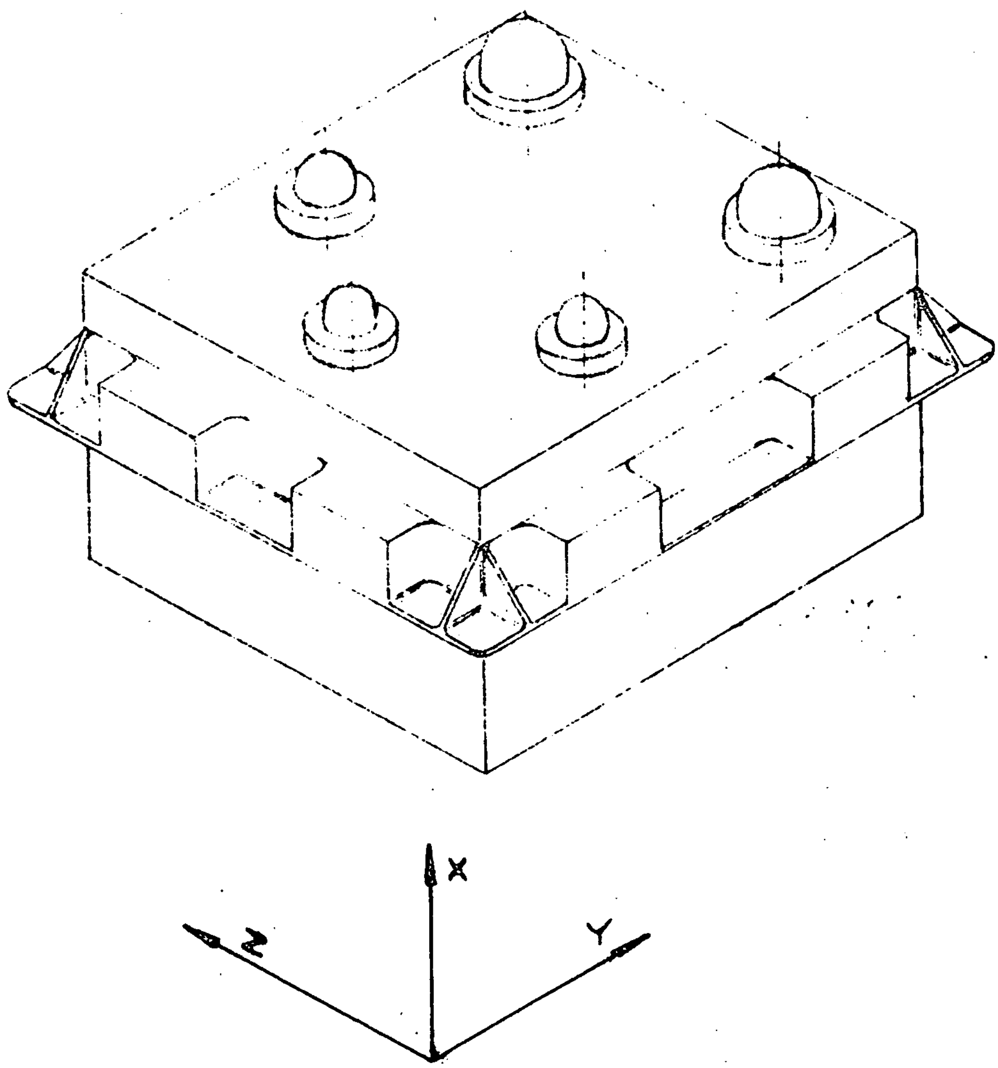

FIGURE A-1 - INSTRUMENT AXES.

Appendix B
Thermal-Vacuum Tests

Appendix B
Thermal-Vacuum Tests

The tests will be conducted in a vacuum by applying the prescribed heat loads via the lamp banks and simulating the EPS interface with the CSM via temperature control (strip heaters) and application of the prescribed internal power levels.

It is anticipated that all test modes will be of a steady-state nature; i.e. variations resulting from orbit position will not be simulated. The time required to reach a steady-state condition has not been defined, but is anticipated to be in the order of three to eight hours.

The following test cases are prepared for the test unit:

1.	Cold - operating:	B angle = ±73-1/2°
2.	Standby - 6W heater power:	B angle = ±73-1/2°
*3.	Standby - no power:	B angle = ±73-1/2°
*4.	Standby - no power:	B angle = 0°
5.	Hot - operating:	B angle = 0°
6.	Rendezvous & Docking - Power off:	Direct sun exposure
7.	Rendezvous & Docking - Power on:	Direct sun exposure

(The above is the sequence in which the tests will be run.)

* Test cases 3 and 4 are required on the Thermal Test Unit only. These tests will not be run on units containing flight type electronics.

Appendix C
Electromagnetic Interference

The tests outlined describe the anticipated design and test requirements for the electromagnetic compatibility (EMC) with the operational environment of the EPS, the associated ground support equipment (GSE), and with other space modules.

INTERFERENCE TESTING

TYPE OF TEST	PARAGRAPH REFERENCES MH04-02057-234	PARAGRAPH REFERENCES MSC 00168	FREQUENCY RANGE	SPECIFICATION LIMITS	REMARKS
Conducted Interference Using Oscilloscope	3.6.1.1	N/A 10 MHz Scope in parallel with power Leads at power input connector	0 Hz-15 kHz	0.8 V P-P	Line Stabilization Capacitors (LSC) removed for this test
Conducted Interference using Current Probe	3.6.1.1	Paragraph 4.4.b Test Method CI-02	BB 0 Hz-25 MHz CW 30 Hz-25 MHz	Figure 5 of MH04-02057-234	LSC in circuit these tests
Radiated Interference Rod Antenna	3.6.1.1	4.5a Test Method RI-01	BB 15kHz-25MHz CW 15kHz-25MHz	Figures 3 & 4 of MH04-02057-234	
Radiated Interference Dipole Antenna	3.6.1.1	4.5.b Test Method RI-02	BB 25MHz-400MHz CW 25MHz-1000 MHz	Figures 6 & 8 of MH04-02057-234	
Radiated Interference Directive Antenna	3.6.1.1	4.5.c Test Method RI-03	CW 1000MHz-10,000MHz	Figure 7 of MH04-02057-234	

SUSCEPTIBILITY TESTING

TYPE OF TEST	PARAGRAPH REFERENCES MH04-02057-234	PARAGRAPH REFERENCES MSC 00168	FREQUENCY RANGE	SPECIFICATION LIMITS	REMARKS
Conducted Susceptibility RF	3.6.1.1	NA Use method of paragraph 4.3.4.1.1 of MC999-0002C	50kHz-400MHz	100,000µV	LSC removed for these tests
Audio	3.6.1.3.1.2	4.6.a Test Method CS-01	20Hz-50kHz	Paragraph 3.6.1.3.1.2 of MH04-02057-234	
50 V Transient	3.6.1.3.1.3	4.6.c Test Method CS-03	10PPS-10	50 V peak	
0.5 V Transient	3.6.1.3.3	N/A Transient injected between each return and chassis ground	10PPS-10 sec.	0.5 V peak	
Radiated Susceptibility Rod Antenna	3.6.1.4.1	4.7.c Test Method RS-03	0.14 to 20MHz 1.0 V/M		LSC in circuit for these tests. Antenna 1 meter from test sample. Measuring antenna 1 meter from transmitting antenna
Biconical Antenna	3.6.1.4.1	4.7.e Test Method RS-05	20 to 200 MHz 1.0 V/M		

SUSCEPTIBILITY TESTING

TYPE OF TEST	PARAGRAPH REFERENCES MH04-02057-234	PARAGRAPH REFERENCES MSC 00168	FREQUENCY RANGE	SPECIFICATION LIMITS	REMARKS
Conical Log Spiral	3.6.1.4.1	4.7.g Test Method RS-07	20 to 10,000 MHz	1.0 V/M except as follows: 250-300 MHz-2V/M 2270-2290-15V/M 9800-9850-7V/M	
Induced Field Susceptibility Equipment	3.6.1.5.1	N/A	400 Hz	10 amperes through 4.5 feet of wire	
Cabling	3.6.1.5.2	N/A	400 Hz	40 ampere feet.	

Appendix D
Humidity Tests

Appendix D
Humidity Tests

The humidity test will be run to MIL-STD-810B. Method 507, Procedure I, except that the minimum temperature shall be 68° F and the maximum temperature shall be 120° F. This test shall be repeated for five cycles only.

In general Procedure I consists of exposing the unit under test to the following conditions.

1. Raise temperature and humidity from ambient to 120° F and humidity to 95% over a two hour period.
2. Reduce temperature to 68° F and 85% or greater relative humidity. Maintain this condition for 16 hours.
3. Repeat steps 1 and 2 for 5 cycles (120 hours).
4. Functionally operate test unit at ambient conditions and compare with previous results.

Appendix E
Shock Tests

Appendix E
Shock Tests

The shock test will be run to MIL-STD-810B, Method 516, Procedures I and V. The shock pulse shape for Procedure I shall be as shown in figure 516.1-1 of MIL-STD-810B. The peak value for Procedure I shall be 20 g's and the nominal duration shall be 11 milliseconds.

Procedure I consists of three shocks in each direction applied along three mutually perpendicular axes of the test item (total of 18 shocks). The shock pulse shall be of a saw tooth shape with an amplitude of 20 g's and a duration of 11 milliseconds. The unit shall be operated after the test and the results compared with functional test results obtained before the shock test.

Procedure V consists of placing the unit on a wooden bench top at least 1 5/8 inches thick and performing the following: With the unit resting on its one flat surface lift one edge of the unit four inches and allow the unit to drop back freely to the horizontal bench top. Repeat using the other three edges as pivot points for a total of four drops. Functionally test unit and compare with previous test results.

PART VIII
END ITEM SPECIFICATION

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

END ITEM SPECIFICATION
FLIGHT HARDWARE
FOR
ELECTRON/PROTON SPECTROMETER

DECEMBER 15, 1970

SKYLAB PROGRAM

MANNED SPACECRAFT CENTER

HOUSTON, TEXAS

END ITEM SPECIFICATION

FLIGHT HARDWARE

FOR

ELECTRON/PROTON SPECTROMETER

DECEMBER 15, 1970

Approved by:

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Manned Spacecraft Center
Houston, Texas 77058

1.0 INTRODUCTION

The AAP Ancillary Hardware General Requirements document MSC-KA-D-69-44, Revision A, dated February 4, 1970, is applicable as noted herein. Each paragraph number of this end item specification corresponds to the same number in the AAP Ancillary Hardware General Requirements document except that additional paragraphs are included to specify special requirements which are not contained in the AAP Ancillary Hardware General Requirements. Each paragraph number of this end items specification which corresponds with a paragraph number of the AAP Ancillary Hardware General Requirements states one of the following:

A. Applicable

B. Applicable with the following changes (Note: Identify the change, i.e., "add," "delete," "change to read," or "added as required by script instructions.")

C. Not applicable

D. Applicability to be determined

Consecutive paragraphs which are "applicable" and consecutive paragraphs which are "not applicable" are indicated as shown in the following example:

6.3.2

through

6.3.2.2.14 - Applicable

Flight hardware, backup hardware, qualification test hardware and flight type training hardware shall be developed in accordance with the requirements of this flight hardware end item specification. This specification shall be changed only after approval of engineering change proposals/specification change notices (see section 7.2). Other end item specifications shall be prepared in accordance with the requirements of section 8.1.1.

1.1 Criticality of Ancillary Hardware - Applicable

1.1.1 Category I - Not applicable

1.1.2 Category II - Not applicable

1.1.3 Category IIIA - Applicable

1.1.4 Category IIIB - Not applicable

1.2 Ancillary Hardware Definitions - Applicable

1.2.1 Flight Hardware - Applicable

1.2.2 Backup Hardware - Applicable

1.2.3 Qualification Test Hardware - Applicable

1.2.4 Mockup Hardware - Applicable but revised as follows: That hardware which is a model of the Flight Hardware with the same external dimensional configuration, mounting provisions, and external color.

1.2.5 Mass Mockup Hardware - Applicable

1.2.6 Training Hardware

through

1.2.6.4.2 Simulators - Not applicable
Add the following new paragraph:

1.2.7 Ground Support Equipment - That support equipment which is required for servicing, testing, handling, maintaining, and transporting the deliverable end items.

1.3 Applicability of the AAP Ancillary Hardware General Requirements - Applicable with the following change. Add: Paragraph 1.2.7, and delete: Paragraphs 1.2.6 through 1.2.6.4.2.

2.0 APPLICABLE DOCUMENTS

2.1 Specifications

2.1.1 Military - Applicable

2.1.2 Federal - Applicable

2.2 Standards - Applicable

2.2.1 Military - Applicable with the following changes:

Number	Comment
MIL-STD-100A	Delete and substitute MSCM 8500, Volumes I and II
MIL-STD-130C	Delete and substitute MSC-SPEC-M-1, Revision A, dated June 1967

2.3 Other Documents - Applicable

2.3.1 NASA - Applicable with following changes:

Number	Comment
MSC-KA-D-68-1 Rev. B	Delete

2.3.2 Military - Applicable

2.3.3 Other - Applicable

3.0 TECHNICAL REQUIREMENTS

3.1 Performance - Applicable

3.1.1 Functional - Applicable

3.1.1.1 Overall System Requirements

A. Proton Spectral Measurements - The spectrometer will measure proton fluxes in five differential energy increments in the energy range from 10 MeV to 150 MeV and the total flux greater than 150 MeV.

B. Electron Spectral Measurements - The spectrometer will measure integral electron fluxes in four increments in the energy range of 0.5 MeV to 4 MeV.

C. Viewing Angle - Total viewing angle by each detector will be 2π steradians with less than 3% of the viewing angle loss due to adjacent detector's shields.

D. Count Rate - The spectrometer will process count rates up to 250,000 counts per second nominal or as limited by the detector configuration.

E. The EPS sensors are manufactured by only one known company and are not available as a high-reliability component. The contractor will attempt to qualify the sensors as part of the instrument during the Qualification Test Program. Therefore, there will be no separate Qualification Test Program for the sensors. The contractor will acquire a supply of sensors and screen them during the design phase to determine the identity of those sensors most likely to function satisfactorily for the required instrument life.

F. An end-to-end test will be performed to verify that the electron/proton spectrometer functions.

G. No requirement is included in this specification to calibrate the instrument using actual electron or proton sources. All calibration shall be made using simulated charge pulses at the output of the electron/proton detectors. An analysis shall be made and submitted to NASA to determine the probable accuracy of the total instrument.

3.1.1.2 Subsystem Requirements - Applicability to be determined.

3.1.1.2.1 Mechanical - Applicable as specified in the mechanical ICD.

3.1.1.2.2 Electrical/Electronic - Applicable as specified in the electrical and instrumentation and communications ICD's.

3.1.1.2.3 Other - Applicable with the following change. Add: "The Flight Hardware with the exception of the electron/proton detectors shall have a minimum life of 1500 hours of operating time over a period of one year. No reliability verification and testing of the electron/proton detectors is included in this program. A portion of the 1500 hours of operating time is assumed to be utilized in the standby mode of the system in orbit, and may not necessarily mean that the system is operating on other than internal heaters to insure survival of the system in the space environment. The orbital useful life of the Flight Hardware shall be sufficient for a total mission consisting of a 28-day mission (48 hours of operation minimum), a two-month orbital storage, a 56-day mission (80 hours of operation minimum), one-month orbital storage, and a 56-day mission (80 hours of operation minimum) without preventive maintenance.

3.1.2 Operability - Applicable

3.1.2.1 Reliability Design Goals (Numerical) - Not applicable

3.1.2.2 Maintainability - Applicable

3.1.2.2.1 General Requirements

through

3.1.2.2.1b Applicable

3.1.2.2.1c Not applicable

3.1.2.2.1d Applicable

3.1.2.2.2 Additional Requirements for In-flight Maintainability - Not applicable

3.1.2.3 Minimum Useful Life - Applicable
The minimum useful life of the Ancillary Equipment Hardware shall be as follows: To be determined.

3.1.2.4 Natural Environment - Applicable
The experiment hardware shall be capable of successfully performing the required functions while or after, as applicable, being subjected to the natural environmental conditions specified in Table I (to be determined).

3.1.2.5 Induced Environment - Applicable
The experiment hardware shall be capable of successfully performing the required function while or after, as applicable, being subjected to the induced environmental conditions specified in Table I (to be determined).

3.1.2.6 Transportability - Applicable

3.1.2.6a Not applicable

3.1.2.6b Not applicable

3.1.2.7 Human Engineering - Applicable

3.1.2.8 Safety

through

3.1.2.8i Applicable

3.2 Interface Requirements - Applicable

3.2.1 Flight Hardware - Applicable, to be determined.

3.2.1.1 Flight Vehicle Interface - Applicable, to be determined.

3.2.1.1.1 Location, Envelope, Weight, and Center of Gravity - Applicable, to be determined.

3.2.1.1.2 Structural - Applicable, to be determined.

3.2.1.1.3 Fluid - Not applicable

3.2.1.1.4 Electrical - Applicable, to be determined.

3.2.1.1.5 Communications and Instrumentation - Applicable, to be determined.

3.2.1.1.6 Environmental Control - Applicable, to be determined.

3.2.1.1.7 Controls and Displays - Not applicable

3.2.1.1.8 Lighting - Not applicable

3.2.1.1.9 Other - Not applicable

3.2.1.2 Interfacing with Other Experiments - Not applicable

3.2.1.3	Ground Communications Interfacing - Not applicable
3.2.1.4	Flight Crew Interfaces - Not applicable
3.2.1.5	Mission Interfaces - Applicable
3.2.1.5a	Not applicable
3.2.1.5b	Not applicable
3.2.1.5c	Times of Hardware Operation - Applicable Operating lifetime of the Spectrometer is specified in paragraph 3.1.1.2.3.
3.2.1.5d through 3.2.1.5k	Not applicable
3.2.1.6	Ground Support Equipment Interfaces - Applicable To be determined
3.2.2 through 3.2.4.2	Zero Gravity Type Training Hardware Simulators - Not applicable
3.3	Design and Construction - Applicable
3.3.1	Mechanical - Applicable
3.3.1.1 through 3.3.1.5	Rigging Devices Mechanical Locks - Not applicable
3.3.1.6	Weight and Size - Applicable
3.3.1.7	Factors of Safety - Applicable
3.3.1.7.1	Structural - Applicable
3.3.1.7.2	Fluid Systems (Gas and Liquid) - Not applicable
3.3.1.8	Lubrication - Applicable

3.3.2	Electrical and Electronic - Applicable
3.3.2.1	Flammability of Wiring Insulation, Materials and Accessories - Not Applicable
3.3.2.2	Toxicity of Wiring Insulation, Materials and Accessories - Not applicable
3.3.2.3	Electrical Connectors - Keying
through	
3.3.2.7	Electrical and Electronic Piece Parts -- Closure - Applicable
3.3.2.8	Protection of Exposed Electrical Circuits - Not applicable
3.3.2.9	Protection of Electrical and Electronic Devices - Applicable
3.3.2.10	Corona Suppression - Applicable
3.3.2.11	Moisture Protection of Electrical and Electronic Devices - Applicable
3.3.2.12	Redundant Electrical Circuits - Applicable
3.3.2.13	Electrical Operating Requirements - Applicable
3.3.2.14	Temperature Control - Applicable
3.3.2.15	Wire Splicing - Applicable
3.3.2.16	Wire Bundle and Harness Protection - Applicable
3.3.3	Fluid (Gas and Liquid)
through	
3.3.3.11	Hazardous Fluids System - Not applicable
3.3.4	Debris Protection - Applicable with the following change:
3.3.4c	Not applicable
3.3.5	Cleanliness - Applicable
3.3.6	Test Provisions - Applicable
3.3.6.1	Test Points - Applicable

3.3.6.2	Test Equipment - Applicable
3.3.7	Single Point Failures - Applicable
3.3.8	Redundancy
through	
3.3.8.2	Redundant Paths - Applicable
3.3.9	Selection of Specifications and Standards
through	
3.3.10	Materials, Parts and Processes - Applicable
3.3.10.1	Toxicity of Materials - Applicable
3.3.10.2	Restriction on Use of Transistors and Capacitors
through	
3.3.10.9	Parts and Material Selection - Applicable
3.3.10.9.1	Applicable with the following: Add "Select MIL-STD qualified parts as a minimum with active components aged 167 hours at rated voltage and current."
3.3.10.9.2	Non-metallic Materials - Not applicable
3.3.11	Standard Parts
through	
3.3.16	Electromagnetic Interference (EMI) - Applicable
3.3.17	Identification and Marking - Applicable with the following changes: Delete specification reference "MIL-STD-130" and insert "MSC-SPEC-M-1."
3.3.18	Storage - Applicable
3.3.19	Pyrotechnic Devices - Applicable (Pyrotechnic devices will not be used in the Electron/Proton Spectrometer.)

4.0 QUALITY ASSURANCE REQUIREMENTS

4.1	Quality Assurance Requirements for Major Ancillary Hardware - Not applicable
4.2	Quality Assurance Requirements for Minor Ancillary Hardware
through	
4.2.9.4	Handling, Storage and Delivery - Applicable
4.2.9.5	Sampling Plans - Not applicable
4.2.9.6	Indication of Inspection Status - Applicable with the following: Add "Government Inspection may be performed in accordance with MSC standard practices."
4.3	Inspection System Requirement for Ancillary Hardware - Not applicable
4.4	General Quality Assurance Requirements for Ancillary Hardware - Applicable
4.4.1	Government Source Inspection
through	
4.4.6	Contamination Control - Applicable
4.4.6.1	Contamination Control Plan - Applicable
4.4.6.2	Fluid Systems
through	
4.4.6.7	Other Requirements - Not applicable
4.4.7	Equipment Logs
through	
4.4.11.5	Contractor Quality Assurance Action - Applicable

5.0 RELIABILITY REQUIREMENTS

5.1 through 5.2 — Organization

5.2 Reliability Plan - Applicable

5.3 Government Furnished Property - Applicable

5.4 Reliability Tradeoff Studies - Not applicable

5.5 Failure Mode and Effect Analysis Single Failure Point Summary and Hazards Summary - Applicable

5.5.1 Failure Mode and Effect Analysis - Applicable

5.5.1.1 FMEA Procedure - Applicable with the following: Add "FMEA will be supplied on a major subassembly level and include modes of operation, channels, and functions."

5.5.2 Single Failure Point Summary - Applicable

5.5.3 Hazards Summary - Not applicable. Will be satisfied by Safety Assessment Report per paragraph 3.1.2.8.

5.6 Non-conformance Reporting and Corrective Action - Applicable

5.7 Subcontractor and Supplier Control - Applicable

5.8 Design Review Program - Applicable

5.8.1 Subcontractor and Supplier Design Reviews - Not applicable

5.8.2 Engineering Design Changes - Applicable

5.9 Standardization of Design Practices - Applicable

6.0 VERIFICATION REQUIREMENTS

6.1	Verification and Technical Requirements
through	
6.3.2	Qualification Tests - Applicable
6.3.2.1	Flight Hardware - Applicable with following change: Delete the sentence, "Qualification Test Hardware shall not be used as Flight Hardware or Backup Hardware" and "Qualification Test Specifications shall be prepared and submitted for review."
6.3.2.1.1	General Requirements
through	
6.3.2.1.2	Test Environments and Methods - Applicable
6.3.2.1.2.1	Humidity - Applicable with the following change. Test shall be conducted for 5 cycles only.
6.3.2.1.2.2	Salt Fog - Not applicable
6.3.2.1.2.3	High Temperature - Not applicable
6.3.2.1.2.4	Low Temperature - Not applicable
6.3.2.1.2.5	Shock - Applicable with the following changes: Test shall include procedures I and V only.
6.3.2.1.2.6	Fungus - Not applicable
6.3.2.1.2.7	Pressure (Positive) - Not applicable
6.3.2.1.2.8	Acceleration - Not applicable
6.3.2.1.2.9	Vibration - Applicable
6.3.2.1.2.9a	Sinusoidal Resonant Search - Applicable
6.3.2.1.2.9b	Sinusoidal Cycling - Not applicable
6.3.2.1.2.9c	Random Vibration - Applicable, to be determined.

6.3.2.1.2.10 Acoustic Noise - Applicable

6.3.2.1.2.11 Altitude - Not applicable

6.3.2.1.2.12 Space Simulation - Applicable with the addition of the complete thermal/vac environment. To be determined.

6.3.2.1.2.13 Atmosphere Compatibility - Not applicable

6.3.2.1.2.14 Other Test Environments and Methods - Applicable with the following: Add "Electromagnetic Compatibility - Shall be verified in accordance with the requirements of MIL-STD-461."

6.3.2.2 Other Ancillary Hardware - Not applicable

6.3.3 Acceptance Tests - Applicable with the following: Add "Environmental test shall include thermal and vibration as specified in enclosure 1."

6.3.4 Preinstallation Tests

through

6.3.6 Prelaunch Tests - Applicable

6.3.7 Other Tests - Not applicable

7.0 CONFIGURATION MANAGEMENT REQUIREMENTS

7.1 Configuration Identification - Applicable

7.1.1 Preliminary Design Reviews (PDR) - Applicable with the following: Add: "The intent of the PDR can be satisfied by a TDR (Technical Design Review) with submittal of the normal program documentation at the appropriate milestone. Documentation requirements shall be as specified in section 8."

7.1.2 Critical Design Reviews (CDR)

through

7.3 Configuration Accounting - Applicable

8.0 DOCUMENTATION REQUIREMENTS

Add the following between first and second sentences of the first paragraph:

> "All documents required by this section should be submitted in the format normally used internally by the contractor, i.e., the documents should not be retyped, reformatted, edited, or upgraded through the addition of illustrations for purposes of the NASA submittal provided the original form of the document meets the content requirements defined in this section."

In the first paragraph, change: "14 days" to "7 days."

8.1 Configuration Management Documentation

through

8.1.1a Flight Hardware - Applicable

8.1.1b Mockup Hardware - Not applicable. A data sheet describing the mockup will be provided.

8.1.1c Mass Mockup Hardware - Not applicable. A data sheet describing the mass mockup will be provided.

8.1.1d Zero Gravity Type Training Hardware - Not applicable

8.1.1e Neutral Buoyancy Type Training Hardware - Not applicable

8.1.1f Simulation Device - Not applicable.

8.1.1g Simulators - Not applicable

8.1.1h Ground Support Equipment - Not applicable. A data sheet describing the equipment will be provided.

8.1.2 Configuration Specifications

through

8.1.2.4 Section IV - Configuration Status - Not applicable, however, a design summary that includes the drawing tree and top level drawings will be provided to satisfy the intent of the Configuration Specifications Sections I, II, and IV. Section III (Qual Status) will be provided as part of the bimonthly progress report.

8.1.3 Engineering Change Proposals (ECP) - Applicable

8.1.4 Specification Change Notice - Applicable, however, the change wording will be compatible with the requirements of paragraph 8.1.2.4.

8.1.5 Specification Change Logs - Not applicable, however, a change log will become part of the design summary.

8.1.6 Specification Revision Charts - Not applicable

8.1.7 Engineering Drawings - Applicable with the following change: Delete the last two sentences of the paragraph.

8.1.7.1 General Requirements

through

8.1.7.2 Standards - Applicable with the following change: Delete section 3 and 5, Chapter I of MIL-STD-100 and substitute MSC-8500 Volume I and II.

8.1.8 Technical Reports - Applicable with the following changes: (1) Delete the second sentence starting with "The reports shall ...." (2) Add the following sentence, "Submittal of the material to be incrementally as the reports are complete."

8.1.9 Review Minutes - Applicable

8.1.10 Acceptance Review Reports - Not applicable

8.2 Management Plan - Applicable with the following: Add: A brief narrative Management Plan may be provided as long as each major item is included.

8.2.1 Section I - General Management

through

8.2.8 Section VIII - Development Schedule - Applicable

8.2.9 Section XI - Nonmetallic Materials - Not applicable

8.2.10 Section X - System Safety - Applicable

8.3 Quality Assurance - Applicable

8.3.1 Failure and Unsatisfactory Condition (UC) Reports - Applicable with the following: Add: The failure or unsatisfactory condition will be reported on the Failure Investigation and Action Report (FIAR) MSC Form 2174.

8.3.2 FA and CA Reports - Applicable with added sentence: The contractor shall not be responsible for analysis of part failure.

8.3.3 Acceptance Data Package

through

8.3.3.g Listing of all Material Review Records - Applicable

8.3.3.h Configuration Specification - Applicable as redefined in paragraph 8.1.2.4.

8.3.3.i Certification That The Hardware......

through

8.3.5 Equipment Logs - Applicable

8.4 Reliability Documentation - Applicable

8.4.1 Failure Mode and Effects Analysis Report - Applicable with the following changes: Delete the last sentence of the paragraph.

8.4.2 Electrical, Electronic and Electromechanical (EEE) Parts List - Applicable

8.4.3 Nonmetallic Materials List - Not applicable

8.4.4 Electrical, Electronic and Electromechanical Parts Specifications

through

8.5.1 Verification Plan - Applicable

8.5.2 Test Specifications - Not applicable

8.5.3 Test Procedures - Applicable

8.5.4 Test Reports - Applicable

8.5.5 Calibration Data Reports - Applicable

8.6 Development Status Reports

through

8.6.5 Delivery Status - Applicable

8.7 Operating, Maintenance and Handling Procedures - Applicable with the following changes: Add the following between the first and second sentences:

"The contents of these manuals shall be restricted to those operations which will be performed by the flight or ground crew during installation, checkout, and operation. It is expected that the hardware will be returned to the factory for any significant maintenance or repair which may be required, and therefore procedures for this type of activity need not be included."

8.7.1 Preparation

through

8.7.1.1b Section 2 - Subsystems - Applicable

8.7.1.1c Section 3 - Controls and Displays - Not applicable

8.7.1.2 Volume II

through

8.7.1.3 Volume III - Applicable

8.8 Ancillary Hardware Support Requirements - Applicable

8.8.1 Flight Crew Requirements - Not applicable

8.8.2 Base Support Requirements - Applicable

8.9 Spare Requirements - Applicable

REQUIREMENT	DOCUMENTS	INITIAL SUBMITTAL	CHANGES	DOCUMENT TYPE
8.1.1	End Item Specifications			
	a. Flight Hardware	This document will be prepared and approved prior to the initiation of any development effort	As required - by ECP/SCN	I
	Data Sheets			
	b. Mockup Hardware	Provided with hardware delivery	"	I
	c. Mass Mockup Hardware	"	"	I
	h. Ground Support Equipment	"	"	I
8.1.2	Design Summary	2 weeks prior to applicable CDR	As required - by ECP/SCN	II
8.1.3	Engineering Change Proposals (ECP's)	As required	As required prior to approval of ECP	I
8.1.4	Specification Change Notices (SCN's)			
	a. Preliminary	As required	As required prior to approval of SCN	I

Table 8-1. - Documentation Schedule
Page 1 of 6

REQUIREMENT	DOCUMENTS	INITIAL SUBMITTAL	CHANGES	DOCUMENT TYPE
	b. Final	1 week after receipt of approval of Preliminary SCN	Not applicable	II
8.1.7	Engineering Drawings (including referenced documents)	As completed	Engineering Orders immediately after approval and revisions immediately after incorporation on the drawings	II
8.1.8	Technical Reports Load analyses, stress analyses, tradeoff studies, results of design reviews, EEE parts design deratings and screening procedures, etc.	Incremental submittal	As required	III
8.1.9	Review Minutes			
	a. Part A	1 week after completion of applicable Review	As required	II
	b. Part B	No later than 1 month after the applicable Review	As required	II

Table 8-1. - Documentation Schedule
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REQUIREMENT	DOCUMENTS	INITIAL SUBMITTAL	CHANGES	DOCUMENT TYPE
8.2	Management Plan	2 months after contract award	As required	I
8.3.1	Failure and Unsatisfactory Condition Reports			
	a. All	Within 5 days after failure isolation	As required	II
	b. Significant Nonconformances	Within 24 hours after failure isolation - by telephone	As required	II
8.3.2	Failure Analysis and Corrective Action Reports			
	a. Those not requiring baseline changes	Within 25 days after failure isolation	As required	II
	b. Those requiring baseline changes	Within 10 days after failure isolation-with ECP	As required	I
		Final - within 15 days after ECP approval		II

Table 8-1. - Documentation Schedule
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REQUIREMENT	DOCUMENTS	INITIAL SUBMITTAL	CHANGES	DOCUMENT TYPE
8.3.3	Acceptance Data Package	To be available at applicable Acceptance Review - to be delivered with applicable hardware after acceptance	As required as the result of action items from the Acceptance Review	II
8.3.4	Material Review Records	To be available at all times for inspection and review with the equipment	As required	III
8.3.5	Equipment Logs	To be available at all times for inspection and review with the equipment - to be delivered with applicable hardware after acceptance	As required as the result of inspection and reviews	II
8.4.1	Failure Mode and Effects Analyses Report	Final Submittal at CDR	As required	II
8.4.2	EEE Parts List	Final Submittal at at CDR	As required	II

Table 8-1. - Documentation Schedule

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REQUIREMENT	DOCUMENTS	INITIAL SUBMITTAL	CHANGES	DOCUMENT TYPE
8.4.4	EEE Parts Specifications	Final Sumbittal at CDR	As required	III
8.5.1	Verification Plan	Final Submittal at CDR	As required	I
8.5.3	Test Procedures			
	a. Development Test Procedures	Not required	As required	III
	b. Qualification Test Procedures	4 week prior to start of qualification tests	As required	II
	c. Acceptance Test Procedures	4 week prior to start of acceptance tests	As required	II
	d. Preinstallation Test Procedures	2 months after submittal of Preinstallation Test Specification	As required	II
8.5.4	Test Reports			
	a. Development Test Reports	Not required	As required	III
	b. Qualification Test Reports	1 month after completion of test	As required	I

Table 8-1. - Documentation Schedule
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REQUIREMENT	DOCUMENTS	INITIAL SUBMITTAL	CHANGES	DOCUMENT TYPE
8.5.5	Calibration Data Reports	2 weeks prior to applicable Acceptance Review	As required	II
8.6	Development Status Reports	3 months after start of development effort - once/ two months thereafter	Not applicable	II
8.7	Operating, Maintenance and Handling Procedures	When requested	As required	II
8.8	Ancillary Hardware Support Requirements	Final Submittal at CDR	As required	II
8.9	Spares Requirements	2 weeks prior to applicable CDR	As required	I

Table 8-1. - Documentation Schedule
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ENVIRONMENTAL ACCEPTANCE TEST
GROUND RULES

ACCEPTANCE THERMAL

Components identified as requiring acceptance thermal testing will be subjected to such tests in accordance with the following ground rules:

1. The thermal envelope specified for acceptance testing of a specific component will not exceed that employed for part certification/ verification (C/V) and should approximate the profile shown in Figure 1. The upper and lower thermal plateaus will be limited to levels at least 20 F above the minimum and below the maximum C/V temperature extremes, and the minimum temperature excursion between the upper and lower thermal plateau shall be 100^{o}F.

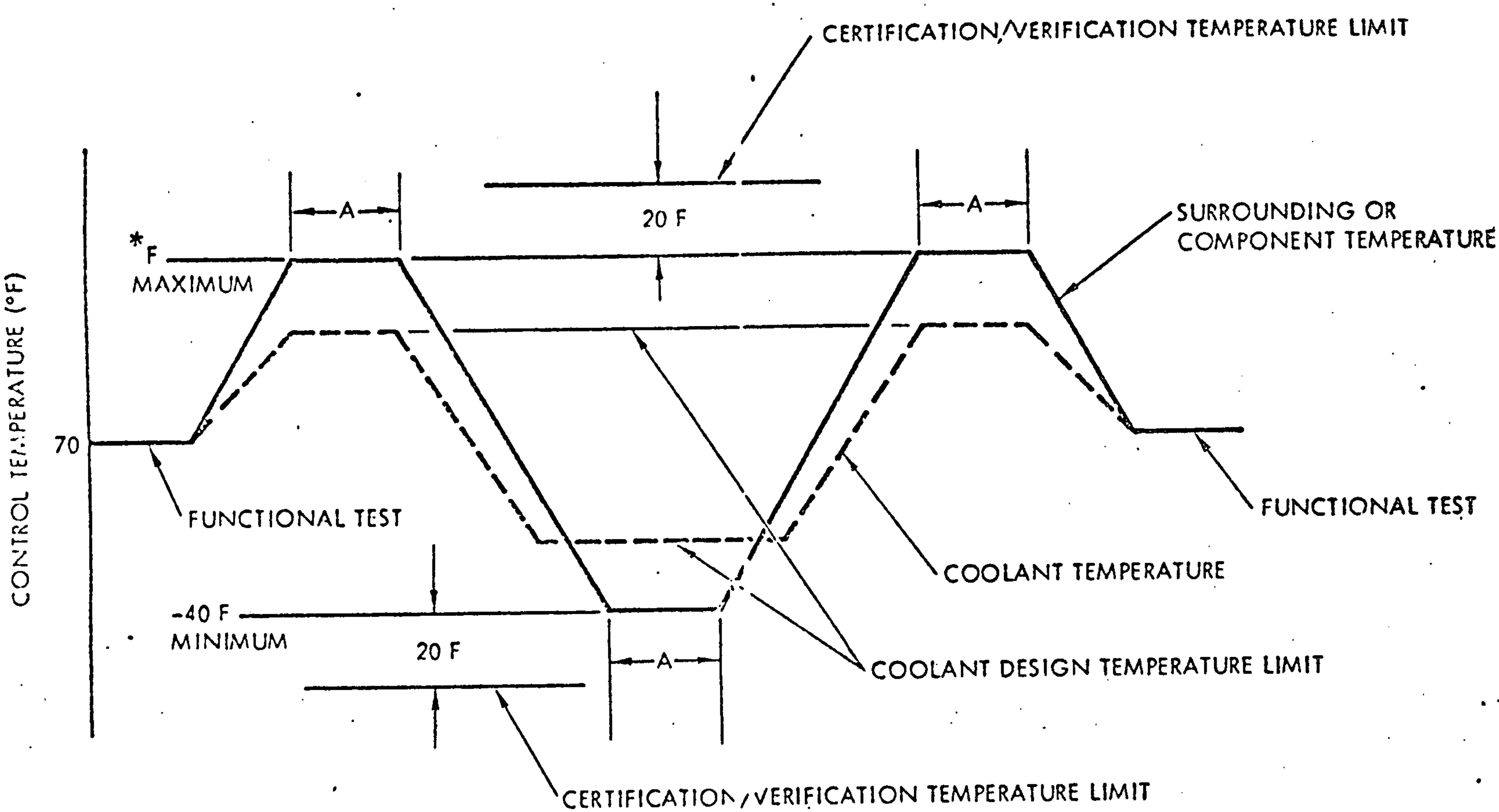
2. The test item will be placed in the test chamber so that the heat is transferred in the correct vehicle mode. Equipment that is not coldplate-mounted will be supported in the test chamber so that heat flow in the holding fixture is negligible compared to the required heat transfer mode.

3. The high- and low-temperature soak periods will be of sufficient duration to bring the test time temperature to equilibrium, but will not be less than one hour.

4. The control temperature for ambient pressure tests with forced convective heat exchange will be measured within three inches of the test article or directly on the test article, but not between the test article and the heat exchanger.

5. For coldplate-mounted equipment, coldplates will be used when required to protect the equipment. The requirement for coldplate operation will be avoided wherever practical.

6. The control temperature for coldplate-cooled equipment will be measured at the coolant inlet to the coldplate. Where the equipment mounting and coldplate configuration cannot thermally simulate the flight vehicle configuration, the temperature at the mounting flange root may be used as the control temperature.



- A = TIME TO STABILIZE EQUIPMENT TEMPERATURE PLUS 1 HOUR MINIMUM
- FUNCTIONAL TESTS TO BE PERFORMED AS SHOWN

* 150 F FOR H AND J MISSIONS
175 F FOR SKYLAB

Baseline Thermal Cycle Acceptance Test

When flange root temperature is used, the temperature limits will be adjusted to account for the difference in temperature between the coolant and the flange. Where the surrounding environment deviates significantly from the coolant temperature for coldplate-mounted equipment, both the surrounding temperature (not on the equipment) and the coolant temperature will be used for temperature control. For coldplate-mounted equipment, the coolant temperature will cycle in-phase with the surrounding temperature to the coolant design temperature extremes.

7. Major repair or modification to equipment will require rerun through the thermal acceptance test cycle. The number of thermal cycles permissible for flight equipment will be specified, where necessary. Minor rework that is readily inspected by normal techniques will not require a rerun of the thermal cycle test. Requirements for retest will be specified for each applicable case.

8. The stabilizing temperature, which is the temperature of the largest centrally located thermal mass of the test article, is achieved when the temperature at this point does not change more than 3 F per hour. When instrumentation to ascertain temperature stabilization is not practical, the detailed test procedure will specify soak time for stabilization.

9. The initial temperature excursion may be in the direction of the equipment nominal operating temperature (hot or cold) so that the specified temperature extreme is achieved twice in this direction during test.

10. The rate of temperature change during transient phases will be the predicted maximum rate during flight for the article being tested, but deviations are permissible under the following conditions:

    a. Higher rates may be used if the qualification test has substantiated the capability of the equipment to operate at that rate.

    b. A rate of 10 F per hour may be used where the maximum flight rate is less.

11. Equipment will be operated continuously during the entire test cycle, except where this would result in excessive operating of life-limited equipment. Life-limited circuits or equipment may remain nonoperating during transition and stabilization phases, and operated only during the functional tests.

12. Equipment primary circuits will be monitored continuously for continuity during the thermal cycle. A pre and postfunctional test will be conducted at ambient room temperature (70 F) on each component.

13. A functional test will be performed at least once at each temperature extreme after the temperature has stabilized. If a temperature extreme occurs twice, and only one functional test is to be performed, the functional test will be performed at the last cycle to that temperature extreme.

Where the article has two or more modes of operation, all combinations of temperature and modes of operation will be selected during the test. The changing of operating modes during the test will be programmed so that the total test duration is not increased due to operation in more than one mode.

14. Where complete functional tests for complex test articles would result in excessive test time, an abbreviated functional test of critical circuits may be performed, within the following constraints:

> The abbreviated functional tests will include all operations affecting crew safety. Selection of other operations to be included in the abbreviated functional test will be based on descending order of mission criticality. The detailed test plan or procedure will list all circuits and modes of operation not tested.

15. The actual control temperatures at the extreme temperature levels will be within 10 F of the specified levels. In no case will the control temperature exceed the maximum nor be less than the minimum equivalent qualification test temperature. The average temperature during the soak periods will be 20 F below the maximum and above the minimum qualification temperature. The average rate of temperature change between successive temperature levels will be within ±20 percent of the specified rate, but not more than ±10 F per hour. The instantaneous rate of change will not exceed the specified rate by more than 40 percent. The actual average and instantaneous rates will not exceed the temperature change rates in the qualification test.

ACCEPTANCE VIBRATION TESTING

Components identified as requiring acceptance vibration testing will be subjected to an acceleration spectral density (ASD) increasing at the rate of 3 db per octave from 20 to 80 Hz; CONSTANT at 0.04 g^2/Hz from 80 to 350 Hz; and decreasing at the rate of 3 db per octave from 350 to 2000 Hz (Figure 2). The vibration test duration will be adequate to perform functional and/or continuity tests, but will not be less than 1 minute nor greater than 5 minutes per axis, including specimen equalization time in each of three orthogonal axes. Should reruns be required in any axis following rework or modification, the duration will be reduced, wherever possible, to 15 seconds minimum per axis, and the total accumulative vibration test time in any axis will not exceed 5 minutes.

Functional/continuity tests will be conducted on all items before, during, and after acceptance vibration tests. Functional verification during the vibration test will be made for those outputs significant to the mode of flight being simulated. All other electrical circuits will be continuity monitored during the vibration test to check for intermittents and opens. Where complex multi-mode equipment requires testing in more than one phase/axis, the vibration time per phase per axis will be 15 seconds minimum. Where possible, vibration fixtures previously approved for use in qualification tests will be used for AVT. The acceptance vibration test tolerance will be as follows:

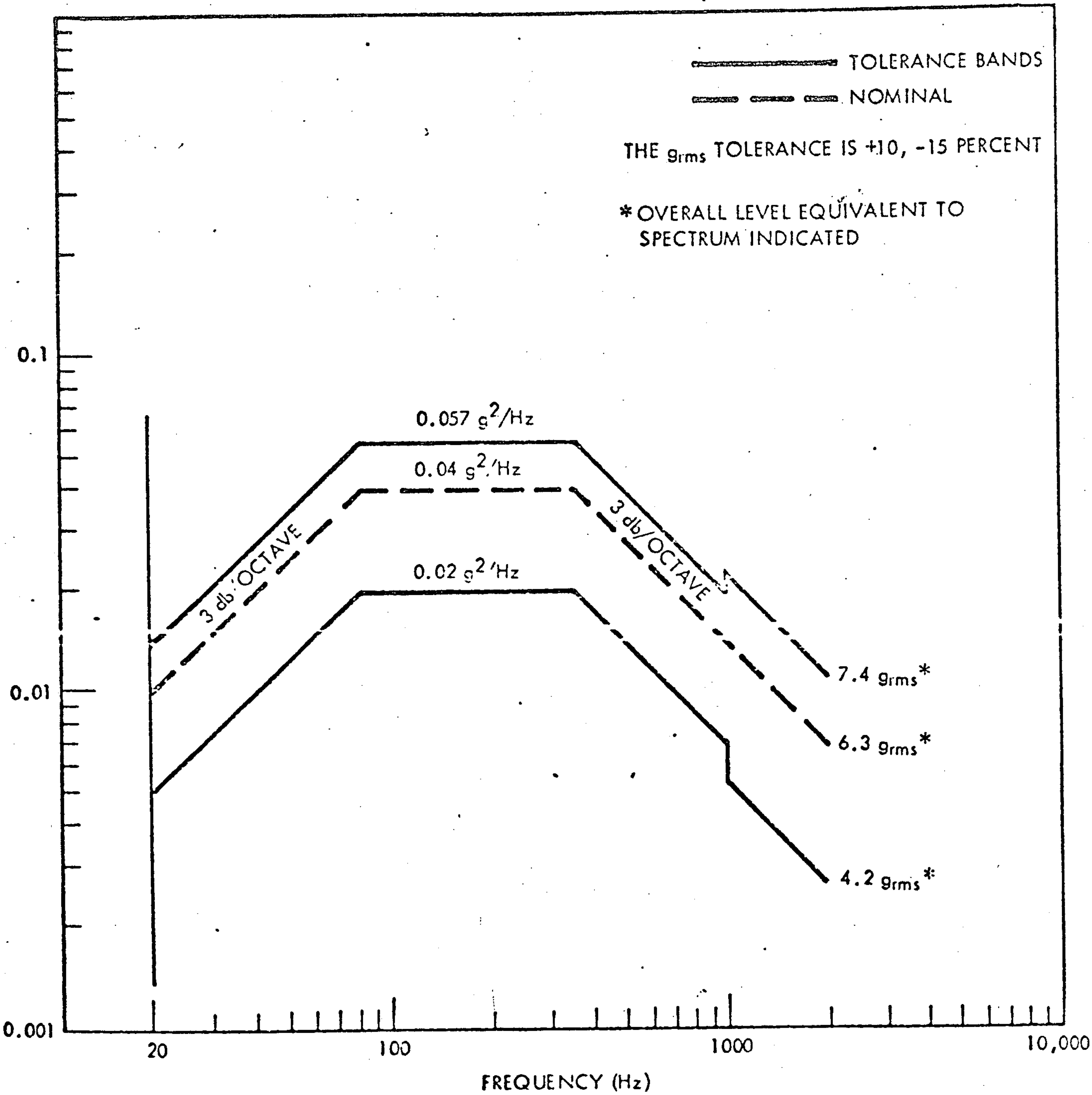
1. Overall root mean square (rms) acceleration: +10 percent, -15 percent

   (with a sharp cutoff filter employed to eliminate acceleration responses occurring above 2 KHz from the g rms readout).

2. Acceleration spectral density: +1-1/2 db, -3 db from 20 to 1000 Hz

   +2 db, -4 db from 1000 to 2000 Hz

This acceleration spectral density tolerance is based on analyzer filters with the following maximum effective bandwidths:



Acceptance Test Vibration Spectrum Requirements

Frequency Range (Hz)	Maximum Effective Bandwidth (Hz)
10 to 100	5
100 to 500	10
500 to 2000	20

Sample record time or tape loop time (T) will be a minimum of 5 seconds, and preferably 10 seconds. Analyzer filter scan rate (SR) will not exceed B/T (Hz/second), where B is the effective bandwith of the filter used. It is recommended the averaging be obtained by using linear integration with an integration time of T. However, if averaging is obtained by smoothing with an equivalent RC low-pass filter, a time constant RC $\geq$ T/2 will be used. In this case, the scan rate will be B/4RC. To reduce equalization time, it will be permissible to utilize one-third octave bandwidth (maximum effective bandwidth) analyzer filters for acceptance tests.

To assure a margin of safety, certification/verification test items that are to be subjected to acceptance vibration tests will be tested for 5 minutes per axis minimum at the following minimum vibration level:

1. ASD increasing at the rate of 3 db/octave from 20 Hz to 0.067 g^2/Hz at 80 Hz
2. Constant at 0.067 g^2/Hz from 80 Hz to 350 Hz
3. Decreasing at a rate of 3 db/octave from 350 Hz to 2000 Hz.

The test tolerances will be as follows:

1. Overall rms acceleration: ±10 percent
2. Acceleration spectral density:

   20 Hz to 1000 Hz ~+5 db, -3/4 db
   1000 Hz to 2000 Hz ~+6 db, - zero db

These tolerances are based on analysis methods as specified in the previous paragraph, except that 1/3-octave filters will not be used. This test is in addition to the vibration tests required for certification/verification.

The following additional ground rules will apply to the evaluation of acceptance vibration test results:

1. Acceptance test levels that exceed the above tolerances are acceptable if the level achieved does not exceed the qualification specification.

2. Acceptance test levels that exceed the qualification specification by more than 2 db at frequencies below those of the known resonances are acceptable if the level achieved is less than that of the known response at resonance during qualification testing or overstress testing.

3. Acceptance test levels that exceed the above tolerances are acceptable if limited to three separate instances where the bandwidth is less than 5 percent of center frequency. Bandwidth to be measured at the point where the tolerance is exceeded.

4. In cases where fixture resonances limit capability to meet the above tolerances, the input level should be reduced at the resonant frequencies rather than overtesting the component.

5. Any other instances of acceptance test levels being exceeded which are considered to not disqualify the unit for flight will be justified using the normal procedures for handling test deviations.

6. Reduction in acceptance test level above 500 Hz to lower than the minimum tolerance at demonstrated critical fixture decoupled frequencies are acceptable if the maximum capability of the shaker has been used.

7. Reduction in acceptance test levels to no more than 2 db below the minimum tolerance is permitted at any of three separate bandwidths no wider than the filter used in the spectrum shaping network.

8. Reduction in acceptance test levels other than given above will require a delta test to make up only that part of the spectrum for which the reduction occurred.

9. Equipment will be operated and monitored as specified in applicable specification during the acceptance vibration test.

10. The maximum allowable relay switch chatter during AVT will be based on the applicable system design requirements as determined by the responsible design engineer.

NASA — MSC — Coml., Houston, Texas

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