IMP H, J EXPERIMENT REQUIREMENTS DOCUMENT

CHARGED PARTICLES MEASUREMENT EXPERIMENT

THE JOHNS HOPKINS UNIVERSITY
APPLIED PHYSICS LABORATORY

Prepared By: R. E. Cashion

Date Prepared: August 1969

Date Revised: August 1970

IMP H, J EXPERIMENT REQUIREMENTS DOCUMENT

TABLE OF CONTENTS

VI. MECHANICAL INTERFACE

A. OUTLINE DRAWING

B. LOOK ANGLES

C. MAGNETIC DESIGN

D. POTTING METHODS

E. HANDLING & MECHANICAL RESTRAINTS

F. HAZARDOUS MATERIAL

VII. GSE

A. BLOCK DIAGRAM & DESCRIPTIONS

B. SUMMARY TECHNICAL DATA

VIII. TEST DATA REQUIREMENTS

IX. TEST PROCEDURES

X. OTHER DOCUMENTATION

IMP H, J EXPERIMENT REQUIREMENTS DOCUMENT

I. ORGANIZATION

A. KEY PERSONNEL

Dr. S. M. Krimigis, APL Principal Investigator	Office Home	301 953-7100 x2626 301 593-8307
Dr. T. A. Armstrong, Univ. of Kansas Co-Investigator	Office Home	913 864-3226 842-5189
Dr. J. A. Van Allen, Univ. of Iowa Co-Investigator	Office Home	319 353-4531 338-2883
R. E. Cashion, APL Project Engineer	Office Home	301 953-7100 x 2068 301 439-7975
S. A. Gary, APL Electronics Design	Office Home	301 953-7100 x2350 301 588-4245
R. S. Glaeser, APL Mechanical Design	Office Home	301 953-7100 x2196 301 465-2426
J. W. Kohl, APL Experimenter	Office Home	301 953-7100 x2179 301 593-5674

Approved R E Cashion Date June 18, 1970

I. ORGANIZATION

B. SUBCONTRACTING PLAN

Ball Brothers Research Corporation, Boulder, Colorado
Contract Date: 15 July 1969, Total Amount $74,632
Project Manager - Reggie Dawson, Engineer - Eldon Stogstill

This subcontract is for the mechanical design, fabrication, and environmental testing of the Proton Electron Telescope (PET) detector for the Charged Particles Measurement Experiment. Units to be delivered are one prototype PET and two flight models.

Schedule summary is as follows:

Contract Date - July 15, 1969
Critical design review - September 15, 1969
Prototype delivery - January 31, 1970
Flight Unit delivery - April 15, 1970

Applicable Documents:

NPC-200-3 - Inspection Systems Provisions for Suppliers of Space Materials, Components, and Services

NHB-5300.4(3A) - Requirements for Soldered Electrical Connections (formerly NPC-200-4)

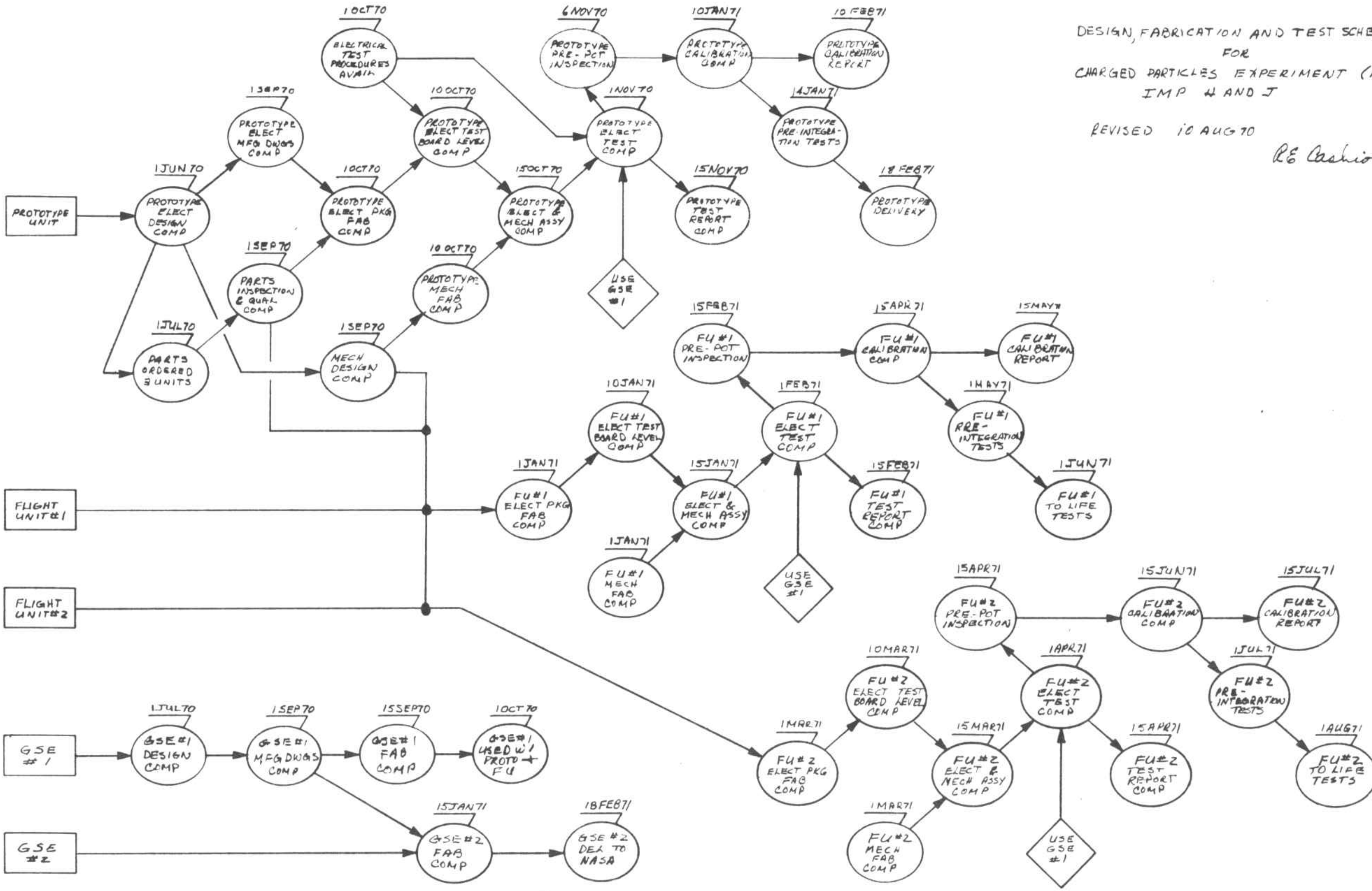
GSFC Publication - Environmental Test Specifications for AIMP H and J Proto-Flight and Spare Subsystems

Approved Roy E Cashion Date June 18, 1970

DESIGN, FABRICATION AND TEST SCHEDULE
FOR
CHARGED PARTICLES EXPERIMENT (APP)
IMP H AND J

REVISED 10 AUG 70

R.E. Cashion



Approved R. E. Cashion Date August 6, 1970

III. EXPERIMENT DESCRIPTION

A. BRIEF DESCRIPTION

The main objective of the CPME is to measure protons, alpha particles, electrons, and X-rays in a wide energy interval. The experiment is primarily designed to study radiations of solar origin, but with sufficient dynamic range and resolution to measure cosmic ray and magnetospheric tail particles.

The experiment is made up of the detector assemblies, the electronics for processing signals due to charge depositions in the detectors, power supplies for generating required DC voltage levels, an internal calibration system which permits in-flight test of the electronic circuits and an analog performance commutator which monitors the condition of the detectors and the electronic system.

The primary detector assembly (PET) consists of a set of three solid state detectors placed inside a plastic scintillator cup. In addition to the PET, five thin window GM tubes have been included to extend measurements of electrons down to approximately 15 Kev. Three GM tubes are placed inside a plastic scintillator cup assembly which collectively is named the GM Telescope (GT). The two additional GM tubes are in separate mounts directed to look along the spacecraft spin axis. These detectors are named North-South Telescope (NST). The combined set of detectors makes it possible to separately identify charged particles in the energy levels given in Table I.

Approved Roy E. Cashion Date June 17, 1970

Detector Designation	Detector Type	Particle Type	Channel Designation	Energy Interval	Geometric Factor cm^2 sr	Dynamic Range $(cm^2 \text{ sec sr})^{-1}$	Signal Name
PET (Proton-Electron Telescope)	Solid State Detectors and anticoincidence plastic scintillators	Electrons	E4	$0.2 \le E_e \le 2.5$ Mev	0.956	$0 - 10^6$	R-14, APL-S3*
			E5	$0.4 \le E_e \le 2.5$	0.956		R-15
			E6	$0.7 \le E_e \le 2.5$	0.956		R-16
		Proton	P1	$0.3 \le E_p \le 0.5$ Mev	2.5		APL-S3*
			P2	$0.5 \le E_p \le 0.9$	2.5		R-19
			P3	$0.9 \le E_p \le 1.9$	2.5		R-20
			P4	$1.9 \le E_p \le 3.9$	0.956		R-21
			P5	$3.9 \le E_p \le 8.0$	0.956		R-22
			P6	$8.0 \le E_p \le 14.0$	0.956		R-23
			P7	$14.0 \le E_p \le 30$	0.956		R-4
			P8	$30 \le E_p \le 50$	0.956		R-24
			P9	$50 \le E_p \le 100$	0.956		R-3
			P10	$100 \le E_p \le 170$	0.956		R-13, APL-S4*
			P11	$170 \le E_p \le 500$	0.956		R-12, APL-S4*
		Alphas	A1	$2.0 \le E_\alpha \le 3.6$ Mev	0.956		APL-S4*
			A2	$3.6 \le E_\alpha \le 7$	0.956		R-11
			A3	$7 \le E_\alpha \le 17$	0.956		R-10
			A4	$17 \le E_\alpha \le 32$	0.956		R-9
			A5	$32 \le E_\alpha \le 60$	0.956		R-8
			A6	$60 \le E_\alpha \le 120$	0.956		R-7, APL-S4*
			A7	$120 \le E_\alpha \le 200$	0.956		R-6
		Integral Protons and Alphas	M	$E > 50$ Mev/Nucleon ($9\ cm^2$)			R-1
		Particles with $3 \le Z \le 5$	Z1	$E > 8$ Mev	2.5		R-5
		$6 \le Z \le 8$	Z2	$E > 32$ Mev	2.5		R-25
GM-1	704 GM Tube	Electrons	E1	$E_e > 45$ keV	0.03	$10 - 10^8$	APL-S1
		Protons		$E_p > 500$ keV	0.03	$10 - 10^8$	
		X-Rays		$1.5 < \lambda < 11Å$			
GM-2A GM-2B GM-2C	705 GM Tube (3)	Electrons	E2A E2B	$E_e > 15$ keV	0.02	$10 - 10^8$	APL-S2* R-17
		Protons	E2C	$E_p > 250$ keV	0.02	$10 - 10^8$	~~R-17~~ R-18
		X-Rays		$4 < \lambda < 16Å$			~~R-18~~
GM-3	LND-D1887A GM Tube (foil)	Electrons	E3	$E_e > 120$ keV	0.03	$10 - 10^8$	APL-S2*
		Protons		$E_p > 2800$ keV	0.03	$10 - 10^8$	
		X-Rays		$2 < \lambda < 10Å$			
	Scintillator	Integral Protons and Alphas	S	$E > 50$ Mev/Nucleon ($6\ cm^2$)			R-2

*Notes signals that are subcommutated into these words

Table 1 APP Measurements Summary

Approved Roy E Cashion Date August 6, 1970

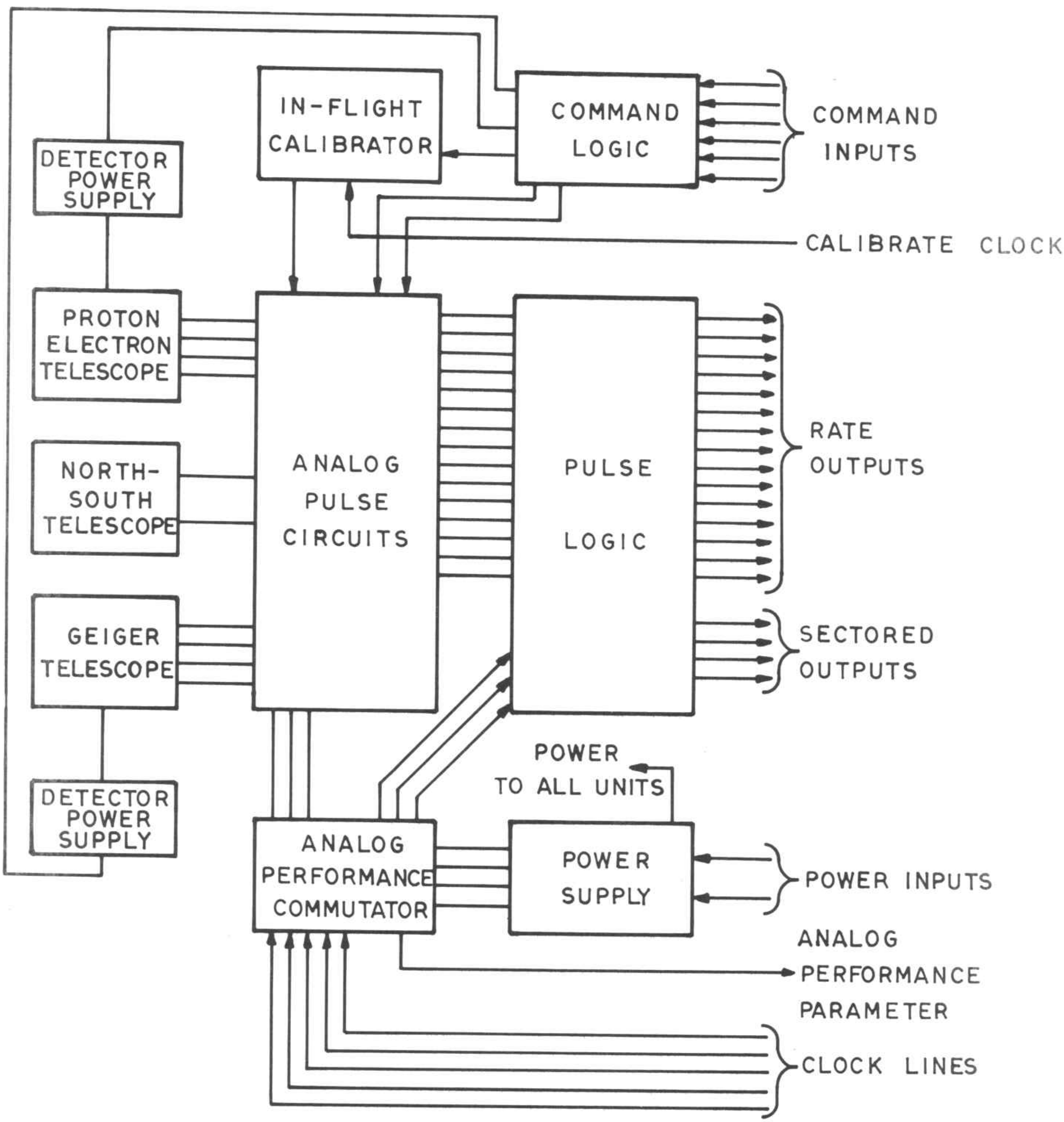
Detector Designation	Detector Type	Particle Type	Channel Designation	Energy Interval	Geometric Factor cm^2 sr	Dynamic Range $(cm^2\ sec\ sr)^{-1}$	Signal Name
PET (Proton-Electron Telescope)	Solid State Detectors and anticoincidence plastic scintillators	Electrons	E4	$0.2 \le E_e \le 2.5$ Mev	0.956	$0 - 10^6$	R-14, APL-S3*
			E5	$0.4 \le E_e \le 2.5$	0.956		R-15
			E6	$0.7 \le E_e \le 2.5$	0.956		R-16
		Proton	P1	$0.3 \le E_p \le 0.5$ Mev	2.5		APL-S3*
			P2	$0.5 \le E_p \le 0.9$	2.5		R-19
			P3	$0.9 \le E_p \le 1.9$	2.5		R-20
			P4	$1.9 \le E_p \le 3.9$	0.956		R-21
			P5	$3.9 \le E_p \le 8.0$	0.956		R-22
			P6	$8.0 \le E_p \le 14.0$	0.956		R-23
			P7	$14.0 \le E_p \le 30$	0.956		R-4
			P8	$30 \le E_p \le 50$	0.956		R-24
			P9	$50 \le E_p \le 100$	0.956		R-3
			P10	$100 \le E_p \le 170$	0.956		R-13, APL-S4*
			P11	$170 \le E_p \le 500$	0.956		R-12, APL-S4*
		Alphas	A1	$2.0 \le E_\alpha \le 3.6$ Mev	0.956		APL-S4*
			A2	$3.6 \le E_\alpha \le 7$	0.956		R-11
			A3	$7 \le E_\alpha \le 17$	0.956		R-10
			A4	$17 \le E_\alpha \le 32$	0.956		R-9
			A5	$32 \le E_\alpha \le 60$	0.956		R-8
			A6	$60 \le E_\alpha \le 120$	0.956		R-7, APL-S4*
			A7	$120 \le E_\alpha \le 200$	0.956		R-6
		Integral Protons and Alphas	M	E > 50 Mev/Nucleon (9 cm^2)			R-1
		Particles with $3 \le Z \le 5$	Z1	E > 8 Mev	2.5		R-5
		$6 \le Z \le 8$	Z2	E > 32 Mev	2.5		R-25
GM-1	705 GM Tube	Electrons	E1	E_e > 15 keV	0.02	$10 - 10^8$	APL-S1
		Protons		E_p > 250 keV	0.02	$10 - 10^8$	
		X-Rays		$2 < \lambda < 10$Å			
GM-2A GM-2B GM-2C	6213 GM Tube (3)	Electrons	E2A E2B	E_e > 45 keV	0.03	$10 - 10^8$	APL-S2*
		Protons	E2C	E_p > 500 keV	0.03	$10 - 10^8$	R-17
		X-Rays		$2 < \lambda < 10$Å			R-18
GM-3	LND-D1887A GM Tube (foil)	Electrons	E3	E_e > 120 keV	0.03	$10 - 10^8$	APL-S2*
		Protons		E_p >2800 keV	0.03	$10 - 10^8$	
		X-Rays		$2 < \lambda < 10$Å			
	Scintillator	Integral Protons and Alphas	S	E > 50 Mev/Nucleon (6 cm^2)			R-2

*Notes signals that are subcommutated into these words

Table 1 APP Measurements Summary

III. EXPERIMENT DESCRIPTION

B. BLOCK DIAGRAM



APP BLOCK DIAGRAM

Approved R. E. Cashion Date July 7, 1970

III. <u>EXPERIMENT DESCRIPTION</u>

C. SUMMARY DATA SHEET

Weight: 8.5 lbs.
Height: 4.0 inches
Power Summary:
Average input: 2.3 watts from +28 volts buss
Peak input: 2.5 watts during calibrate sequence
Duty cycle (calibrate): 160 seconds/46.6 hrs.
Thermal restraints:
Operating temperature: $-30^{\circ}C$ to $+40^{\circ}C$
Storage temperature: $-60^{\circ}C$ to $+40^{\circ}C$
Humidity restraints: Performance of detectors is unknown for long term storage above 20% relative humidity. The experience of other experimenters indicates that 50% humidity is tolerable. We are presently investigating operation and storage at 50% humidity.
High voltage operation: Sea level to 10,000 feet altitude and ambient pressure less than 10^{-5} TORR.
Vacuum and Vacuum venting restraints: As above. Venting is around detector openings.
Special cleanliness restraints: Normal spaceflight equipment handling required.
Protective covers: Detector cover should remain in place for all routine testing. Remove for TV.

Approved Roy E Cashion Date June 17, 1970

III. EXPERIMENT DESCRIPTION

D. SECTION VIEW OF DETECTOR ASSEMBLIES

Figure III.2 Section view of APP

Figure III.3 Section view of Proton Electron Telescope

Figure III.4 Section view of Geiger Telescope

Figure III.5 Section view of North-South Telescope

Approved Roy E Cashion Date June 18, 1970

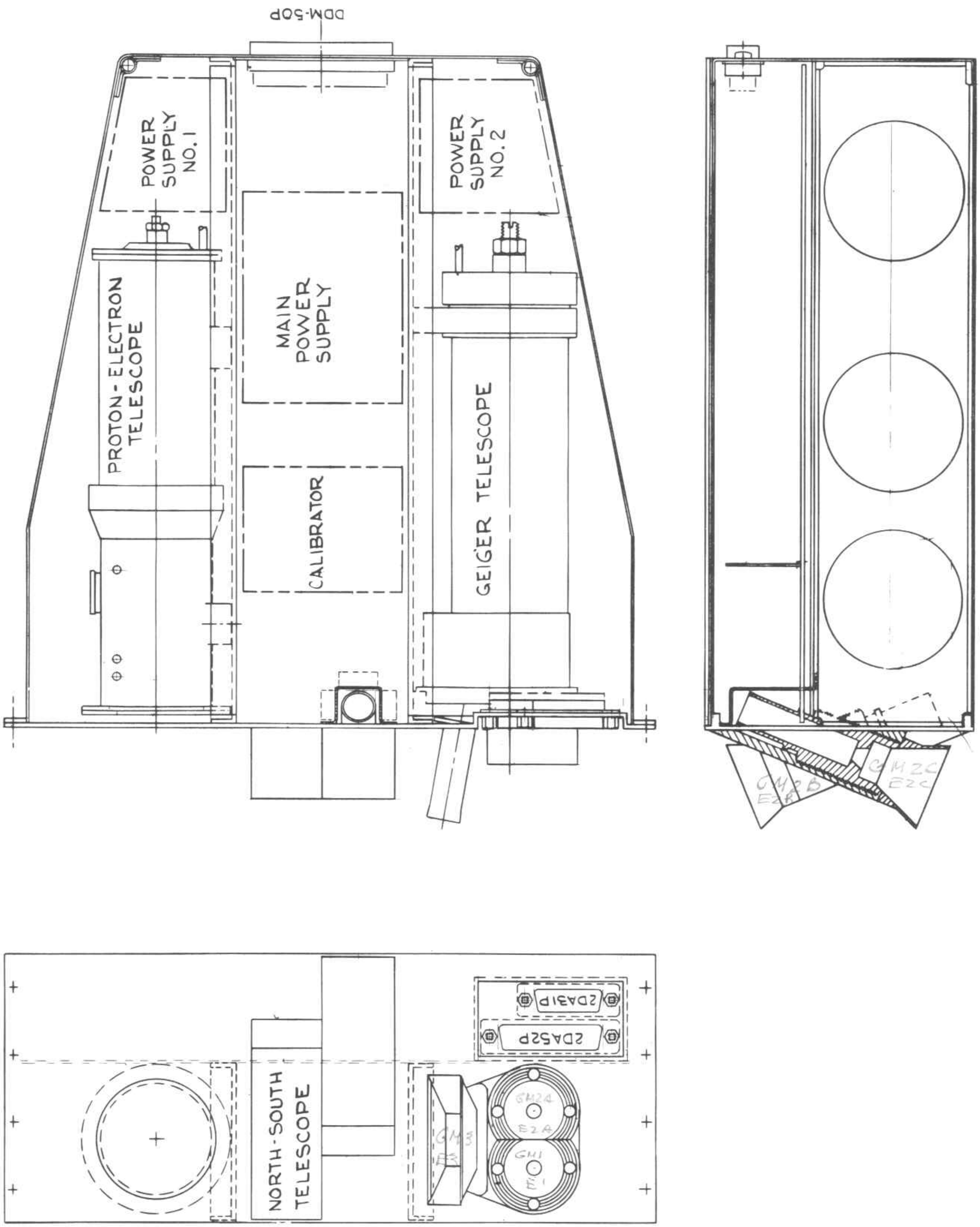


Figure III.2 Section view of APP

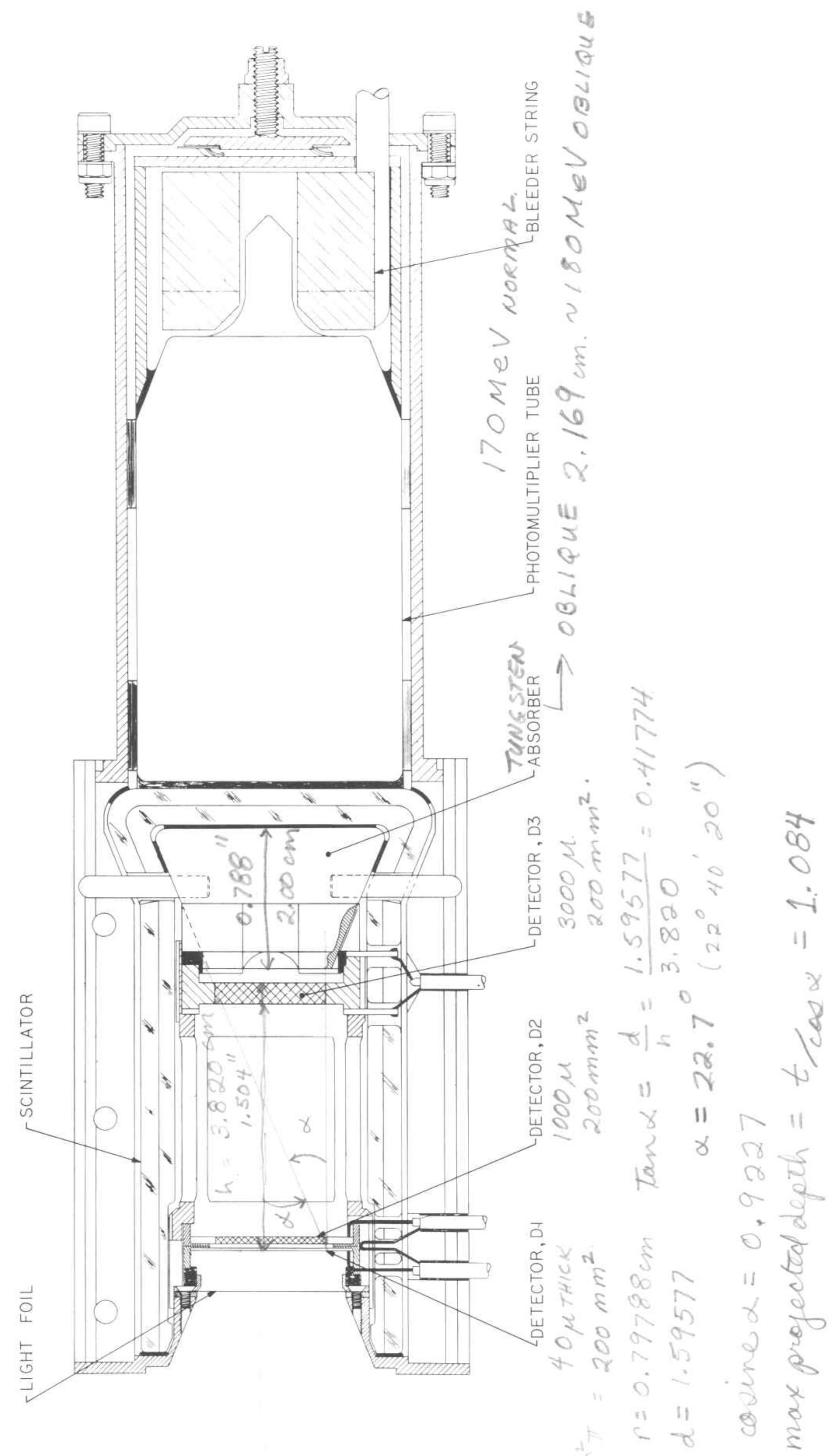


Figure III.3 Section view of Proton Electron Telescope

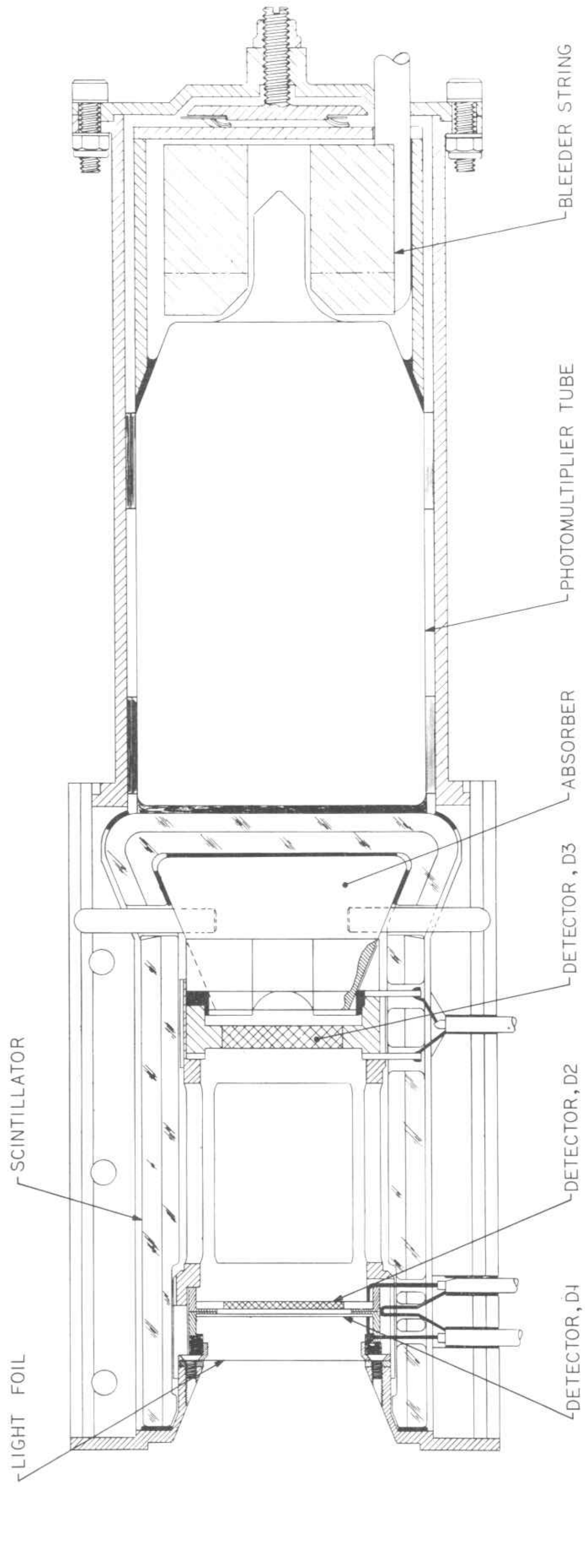


Figure III.3 Section view of Proton Electron Telescope

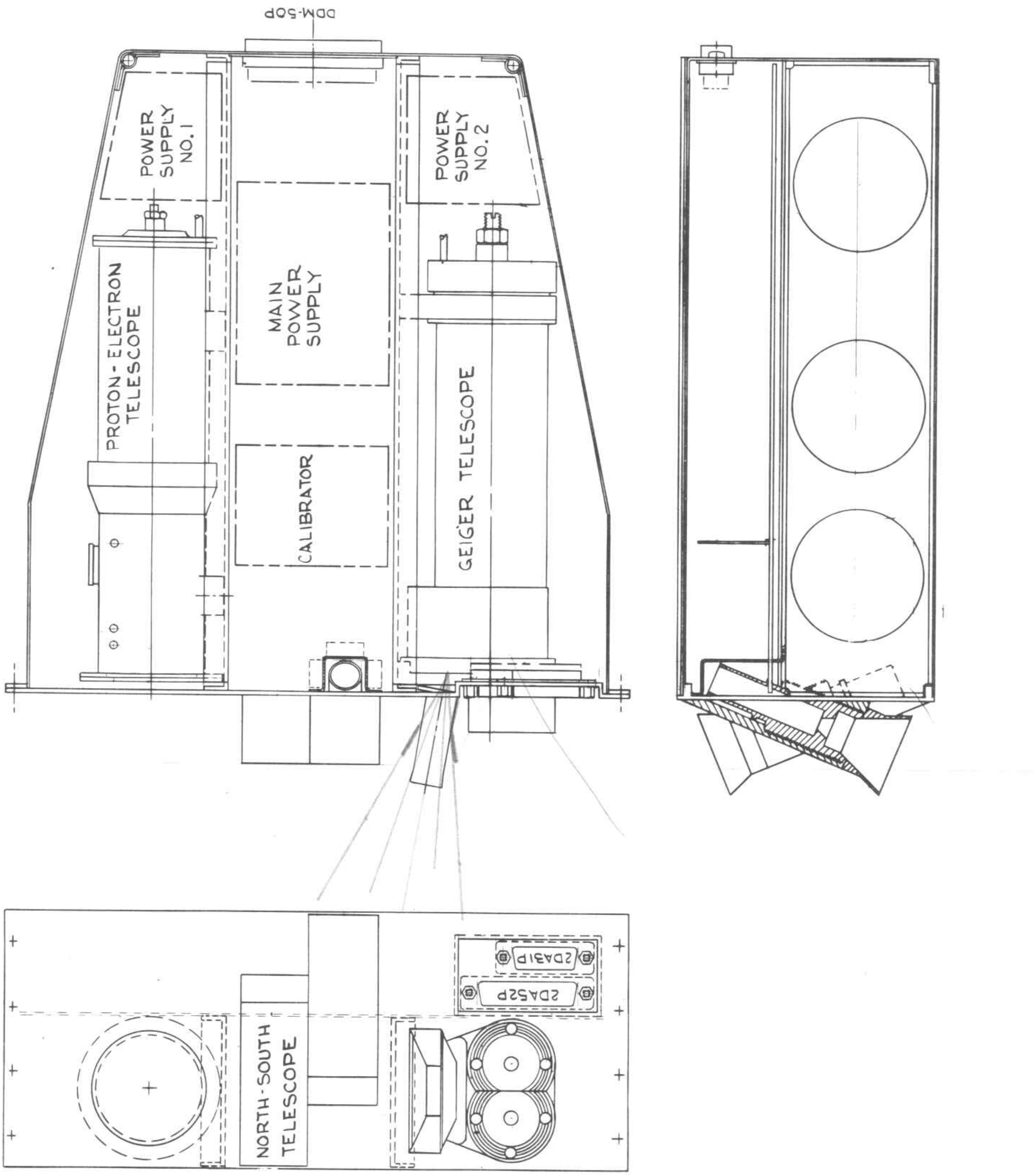


Figure III.2 Section view of APP

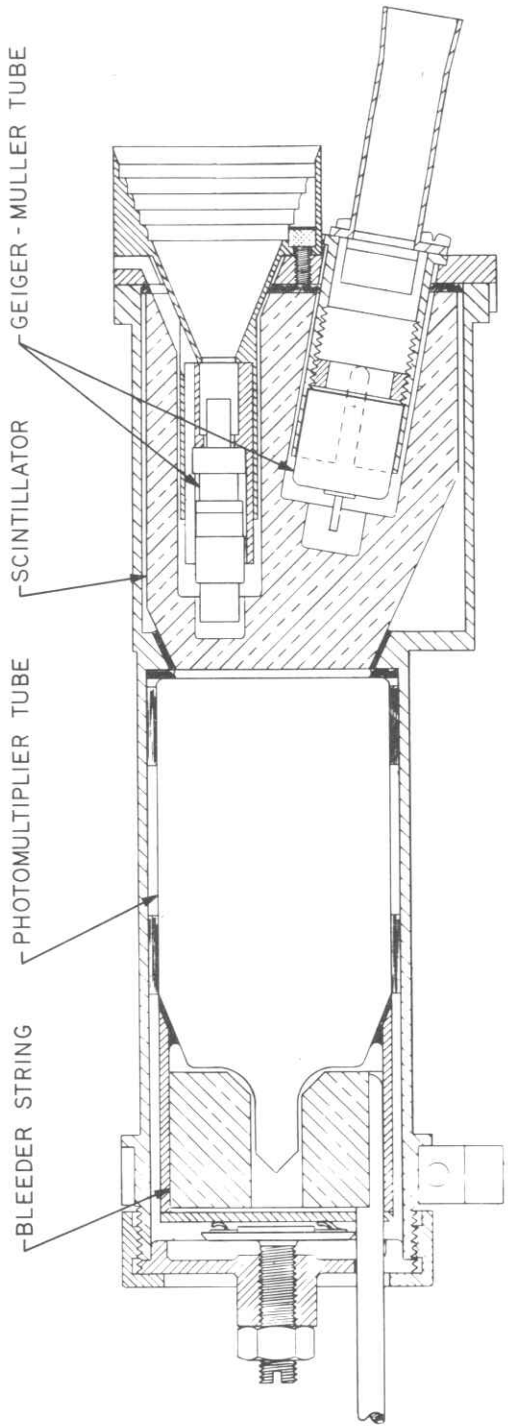


Figure III.4 Section view of Geiger Telescope

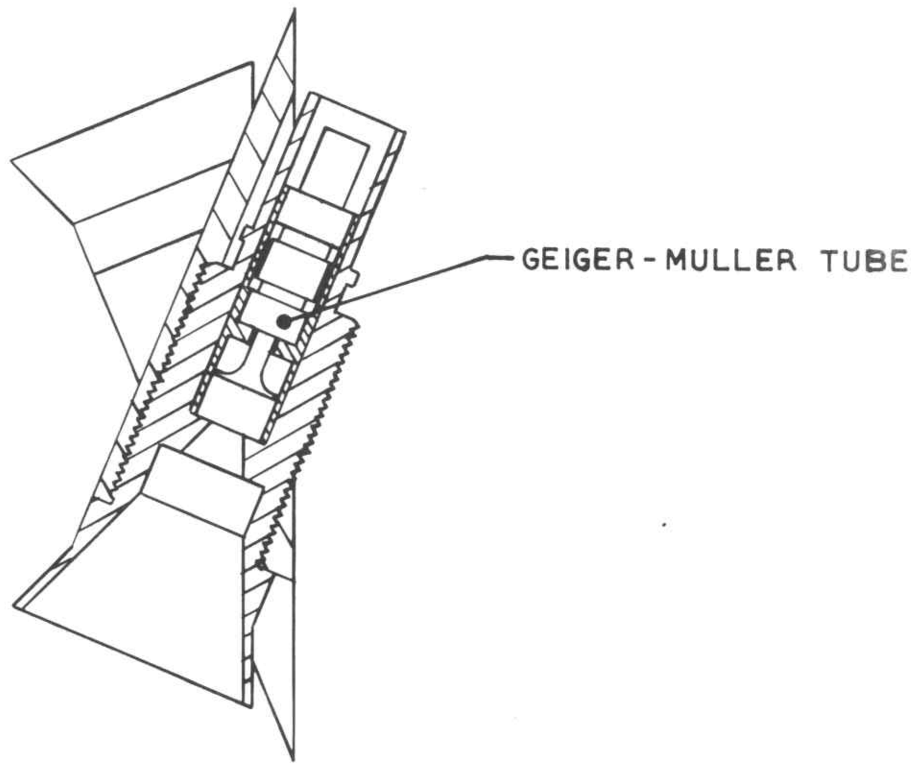


Figure III.5 Section view of North-South Telescope

Approved R. E. Cashion Date June 18, 1970

IV. EXPERIMENT REQUIREMENTS

A. ORBIT AND ORIENTATION

The proposed orbit of 30 to 40 R_E at inclination of 28.5° is suited to the APP measurements. Orientation of field of view is defined by the placement of experiment collimators perpendicular to the spin axis.

Approved Roy E Cashion Date June 18, 1970

IV. EXPERIMENT REQUIREMENTS

B. COMMAND REQUIREMENTS AND DESCRIPTION

The following commands are required for APP control:

1. HV 1 on (GT photomultiplier power supply switch)
2. HV 2 on (PET photomultiplier power supply switch)
3. Gain A down (Detector D1 amplifier gain control)
4. Gain B down (Detector D2 amplifier gain control)
5. Power on/Reset
6. Power Off
7. Calibrator Disable

Calibrator disable will be used only in the event of failure.

Launch condition for APP should be with power off and command relays 1 through 4 in the reset position.

Command states will be verified by subcommutated AP readings.

Approved Roy E Cashion Date June 18 1970

IV. EXPERIMENT REQUIREMENTS

C. PERFORMANCE PARAMETERS

1. Analog Performance Parameter - One AP reading is required for the experiment. This AP will have eight (8) measurements commutated into the output which is sampled each 20.48 seconds. One complete CPME commutator readout will require 161.84 seconds.

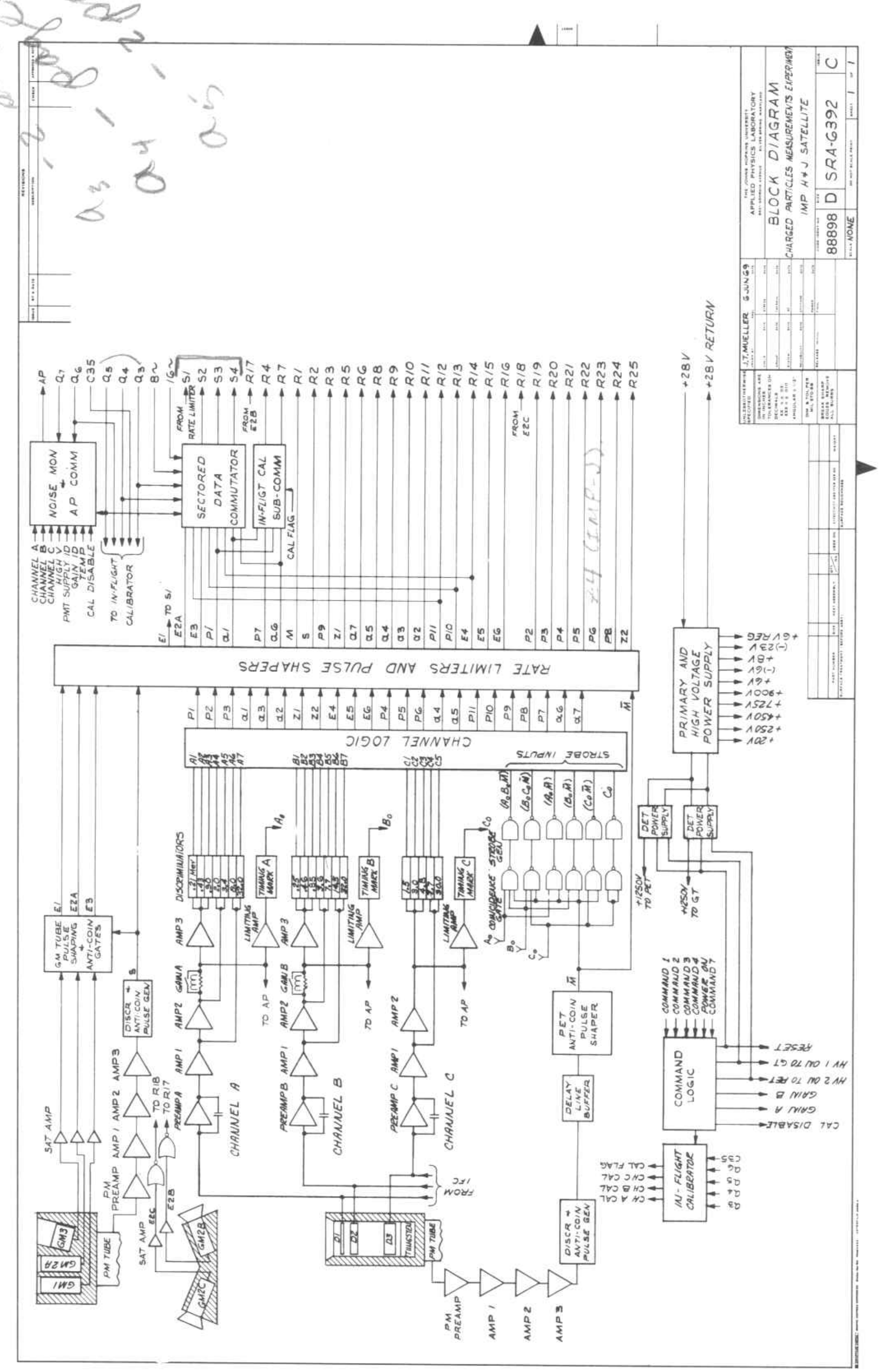
Commutator assignment is as follows:

1. D1 RMS noise (sent during clock logic $a_3a_4a_5 = 1$)
2. D2 RMS noise
3. D3 RMS noise
4. PET Temperature
5. High Voltage Supply
6. Gain Identification (Commands 3 and 4)
7. PMT Power Supply verification (Commands 1 and 2)
8. Calibrator Disable Verify (Command 7)

Approved R. E. Cashion Date Jan. 27, 1971

V. ELECTRICAL INTERFACE

A. BLOCK DIAGRAM



Approved ________________ Date August 6, 1970

V. ELECTRICAL INTERFACE

B. CABLE AND CONNECTOR REQUIREMENTS

Table 2A -- J1, Flight Connector Wiring List
(Connector type DDM-50P-NMC-2-A134)

Pin No.	Assignment	Pin No.	Assignment
1	Chassis GND	26	R9 Channel $\alpha4$
2	+28V Input	27	R10 Channel $\alpha3$
3	+28V Return	28	R11 Channel $\alpha2$
4	Signal Ground	29	R12 Channel P11
5	C35 (Calibrate)	30	R13 Channel P10
6	a_3	31	R14 Channel E4
7	a_4	32	R15 Channel E5
8	a_5	33	R16 Channel E6
9	a_6	34	R17 Channel E2B
10	a_7	35	R18 Channel E2C
11	Command 1 (HV1 ON)	36	R19 Channel P2
12	Command 2 (HV2 ON)	37	R20 Channel P3
13	Spare	38	R21 Channel P4
14	APP-Sector 1	39	R22 Channel P5
15	APP-Sector 2	40	R23 Channel P6
16	APP-Sector 3	41	R24 Channel P8
17	APP-Sector 4	42	R25 Channel Z2
18	R1 Channel M	43	Command 3 (Gain A Down)
19	R2 Channel S	44	Command 4 (Gain B Down)
20	R3 Channel P9	45	Command 5 (Power on/Reset)
21	R4 Channel P7	46	Spare
22	R5 Channel Z1	47	Command 7 (Calibrate Disable)
23	R6 Channel $\alpha7$	48	AP
24	R7 Channel $\alpha6$	49	Spin $\div$ 8
25	R8 Channel $\alpha5$	50	Spin $\div$ 16

Approved R E Cashion Date June 18, 1970

V. ELECTRICAL INTERFACE

B. CABLE AND CONNECTOR REQUIREMENTS

Table 2B -- J2, Test Connector Wiring List
(Connector type 2DA31P-NMC-2-A134)
(Cannon D-Double Density)

Pin No.	Assignment	Pin No.	Assignment
1	Chassis GND	16	+450V Test
2	HV1 Test	17	Spare
3	HV2 Test	18	Spare
4	Signal Common	19	Spare
5	C35 Override	20	AP a_5 Override
6	a_3 Override	21	AP a_6 Override
7	a_4 Override	22	20 kHz Test
8	a_5 Override	23	Command 1 (HV1)
9	a_6 Override	24	Command 2 (HV2)
10	a_7 Override	25	Command 3 (Gain A)
11	+6V Regulator Test	26	Command 4 (Gain B)
12	Calibrate Flag	27	Command 5 (Reset)
13	-23V Test	28	Command 7 (Command Disable)
14	+20V Test	29	AP Test
15	+250V Test	30	Spin ÷ 8 Override
		31	Spin ÷ 16 Override

Approved R E Cashion Date June 18, 1970

B. CABLE AND CONNECTOR REQUIREMENTS

Table 2C -- J3, Test Connector Wiring List
(Connector type 2DB52P-NMC-2-A134)

Pin No.	Assignment
1	Timing Mark A ($D1\overline{M}$)
2	Timing Mark B ($D2\overline{M}$)
3	Timing Mark C ($D3\overline{M}$)
4	Coincidence AB ($D1D2\overline{M}$)
5	Coincidence BC ($D2D3\overline{M}$)
6	Spare
7	Spare
8	Spare
9	Spare
10	Spare
11	Spare
12	Spare
13	Spare
14	S1
15	S2
16	S3
17	S4
18	R1
19	R2
20	R3
21	R4
22	R5
23	R6
24	R7
25	R8
26	R9
27	R10
28	R11
29	R12
30	R13
31	R14
32	R15
33	R16
34	R17
35	R18
36	R19
37	R20
38	R21
39	R22
40	R23
41	R24
42	R25
43	Signal Common
44	Signal Common
45	Channel A AMP Test Output
46	Channel B AMP Test Output
47	Channel C AMP Test Output
48	PMT 1 AMP Test Output
49	PMT 2 AMP Test Output
50	Pulser Mode
51	Pulser Ref Input
52	Pulser Return

Approved A. E. Cashion Date June 18, 1970

V. ELECTRICAL INTERFACE

C. RFI DESIGN

The mechanical design of the APP package has been directed to eliminate interferring signals from entering low level APP circuits and also from producing interference that could escape. The electronic circuits are enclosed in an RFI tight section which is at chassis ground, and the circuits themselves are built up on a ground plane that is at signal ground. Low level preamplifier circuits are enclosed in separate signal ground cans. The lowest level preamplifier is used for signal reference point.

All power supply circuits are enclosed in magnetic shielding enclosures.

Approved Roy E Cashion Date June 18, 1970

V. <u>ELECTRICAL INTERFACE</u>

D. RFI SUSCEPTIBILITY

The CPME detectors themselves can be susceptible to radiated RF signals from transmitters whose antennas are in close proximity to the PET opening. Pulse shaping in detector amplifier circuits has been designed to reduce this interference to acceptable limits.

Approved R. E. Cashion Date June 18, 1970

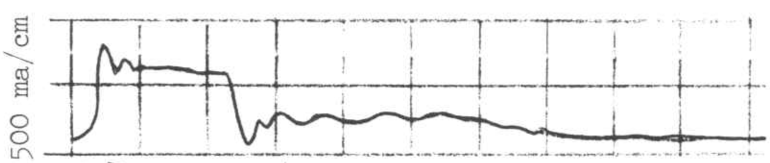
V. <u>ELECTRICAL INTERFACE</u>

E. POWER REQUIREMENTS

Input Voltage: +28 volts ± 2% with separate power return.

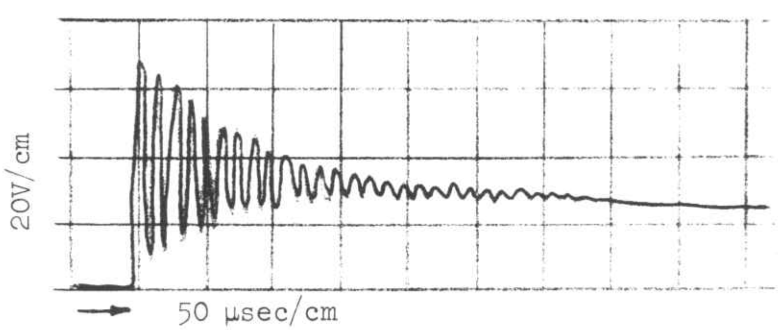
Input Current: ≃ 82 ma nominal

Current limiting: 600 ma



2 msec/cm

Turn-On Current Surge



50 μsec/cm

Turn-off Voltage Transient

Approved R. E. Cashion Date July 7, 1970

V. ELECTRICAL INTERFACE

F. INTERNAL POWER SUPPLIES

1. Name and type: Primary Power Supply - Preregulator and DC-DC Converter. Drawing SRA-6603 and SRA-6611.

Input voltage:	28 Volts ± 2%
Output voltage:	+ 6 Volts DC
	- 6 Volts DC
	+ 8 Volts DC
	+ 20 Volts DC
	- 23 Volts DC
	+ 23 Volts DC
	+250 Volts DC
	+450 Volts DC
	+715 Volts DC
	+735 Volts DC
	+900 Volts DC
	20 Volts AC
Frequency:	20 kHz ± 1%
Efficiency:	65%
Duty Cycle:	100%

2. Name and type: High Voltage Power Supply - Cockcroft - Walton cascade multiplier with VR tube regulation.

Input voltage:	10 Volts AC
Output voltage:	1250 Volts DC
Frequency:	20 kHz ± 1%
Efficiency:	30%
Duty cycle:	100% in orbit

Note: Two (2) each type 2 high voltage supplies are used in the APP experiment.

Approved R. E. Cashion Date July 7, 1970

V. ELECTRICAL INTERFACE

G. HIGH VOLTAGE DESIGN

The following is a list of all supply voltages developed in the CPME of greater than 150 volts.

1. + 250 volts - bias for Detector D2
2. + 450 volts - bias for Detector D3
3. + 730 volts - supply for GM-1
4. + 715 volts - supply for GM-2A
5. + 715 volts - supply for GM-2B
6. + 715 volts - supply for GM-2C
7. + 900 volts - supply for GM-3
8. +1250 volts - supply for Photomultiplier 1
9. +1250 volts - supply for Photomultiplier 2

All high voltage points are either vacuum encapsulated or conformal coated for corona protection. Encapsulation material is both Stycast 1090 SI and RTV 11. Conformal coating is silicon varnish, NARMCO epoxy resin, and RTV 1062.

Approved R. E. Cashion Date June 18, 1970

V. ELECTRICAL INTERFACE

H. OPTICAL ASPECT REQUIREMENTS

It is required that the angle between the sun command slit and the PET be known to $\pm 1^\circ$. This angle can be calculated from the relative locations of the APP and the optical aspect sensor. No special mirror surface has been included on the experiment front panel.

The APP requires that the sun slit command be located in the center of one sector. This is accomplished by locating the APP package in an odd numbered facet. The present location in facet 3 meets this requirement.

The 16 cycles per spin and 8 cycles per spin are used in the experiment to subsector the sectored data from the S2 output when it is reading the E3 data. The experiment determines the subsector to be read by addressing from the clock lines a_4 and a_5. The encoder will determine the sectoring into 8 primary sectors. The experiment subsectors this by 4, so that the look direction for E3 is stepped through 32 sectors of 11.25 degrees each. The logic is as follows:

$$\text{Subsector } 1 = a_3 \cdot a_4 \cdot a_5 \cdot 8 \cdot 16$$

$$2 = a_3 \cdot \overline{a_4} \cdot a_5 \cdot \overline{8} \cdot 16$$

$$3 = a_3 \cdot a_4 \cdot \overline{a_5} \cdot 8 \cdot \overline{16}$$

$$4 = a_3 \cdot \overline{a_4} \cdot \overline{a_5} \cdot \overline{8} \cdot \overline{16}$$

The optical aspect signals are obtained from the encoder electronics.

Approved R. E. Cashion Date July 7, 1970