NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
AMES RESEARCH CENTER
MOFFETT FIELD, CALIFORNIA 94035

REPLY TO ATTN OF: PAF-2-37(244-8)

August 2, 1972

Mr. Bonnard Teegarden
Code 61 Building 2 Room 23
Goddard Space Flight Center
Greenbelt, Maryland 20771

Subject: Redefinition of EDR Formats for File 3 and 4

Recently it has come to our attention that the spacecraft attitude and pointing data supplied in File 3 of your Experiment Data Record (EDR) is not sufficient to resolve the reference-axis phase error for computing your instrument sectoring. A detailed analysis performed on the spacecraft data from launch to the first of June has revealed that this problem is quite complex. The analysis has revealed that a number of other parameters and status bits must be checked in order to determine the type and extent of correction that must be made. We recognize that each investigator has different requirements for the accuracy required in the solution of this problem. We, therefore, have attempted to carry the solution, for at least those cases we have identified, down to the finest detail. From this, it is your prerogative to select the depth of detail you desire for the accuracy you require. The net effect of this whole problem is that we have been forced to modify, to a small extent, the format and content of the data in your EDR's for File 3, which contains the spacecraft attitude data, and File 4, which contains the science data from your instrument. The enclosed package, therefore, is essentially broken down into two parts. They are:

1. The new File 3 format contains the spacecraft attitude data along with an explanation of the parameters contained therein. The essential difference between this format and the previous one is that we have deleted the Celestial Latitude Drift of the spin axis and added the clock angle of the sun (CKAH) and the clock angle of the star, Canopus (CKAS).

2. The new File 4 format contains a minor change wherein we have inserted additional information into a spare word in the fixed words of the data record. These two pieces of information are:

a. Bits 5 and 6 of engineering word C-431. These two bits indicate whether the spacecraft is operating from the star sensor, sun sensor A, or sun sensor B. The configuration of bits are interpreted as:

00 - Error

01 - Star

10 - Sun B

11 - Sun A

b. Engineering words C-419 and C-420. These two words together contain a 2^{12} counter indicating the star delay. The conversion of this counter to an angular off-set is:

$$\text{Star Delay (degrees)} = \frac{\text{(Contents of C-419 \& C-420) } 360°}{256 \quad \text{(spin period)}}$$

At the present time a review of the results of the detailed analysis, which includes working equations for the solution of the reference-axis phase error for computing your instrument look angles, is being conducted. This information will be sent to you upon completion of this review.

You will note that the items discussed above are marked as "draft". We are sending this rough form to you in the interest of saving some time; however, all of this information will eventually be published in the appropriate sections of document PC-262, Pioneer F/G: Off-Line Data Processing System.

I would like to point out that on June 22, we ran the Acceptance Test on a JPL produced Master Data Record (MDR) tape. This, of course, is a superior and more complete data source than the System Data Record (SDR) tape which we were forced to use in generating the first 30 EDR's that we sent to you. It is our intention to regenerate all EDR's that we have sent to you using these new source tapes. We will follow the philosophy for generating EDR's that was outlined at the Quarterly Review on April 24. That is, we will send you EDR's on the most current data we have; and this will probably begin with Day 176 (June 24). We will maintain the current flow of data and then, in parallel, we will regenerate all the past data starting at launch. The production flow of the new data will commence during the first week of July. It necessarily follows, of course, that all of these new data tapes will be in the form and format given in the enclosures discussed earlier. We request that you return the earlier EDR's that we sent you when you receive the regenerated data. This will eliminate future confusion because of the difference in the data formats.

Charles F. Hall

Charles F. Hall
Manager, Pioneer Project

Enclosures:
1. EDR File 3 Data Format
2. EDR File 4 Data Format

DRAFT

GODDARD SPACE FLIGHT CENTER

Enclosure 1

EDR File 3

Format and Definition

DRAFT

DRAFT

File 3 (See Figure) File 3 is binary and contains S/C attitude data for the past 31 days. There is a ten-word entry for each day. All words are right adjusted unless otherwise stated. Missing entries will be filled with zeros. The first entry is the least current and the last entry in the file is the most current.

1. Word 1 (DAY-GMT) Elapsed days since start of year

2. Word 2 (GMT) Elapsed time in milliseconds since start of day for time of first data word in record

3. Word 3 (SPARE) Blanks

4. Word 4 (FLAG) The flag interpretation is as follows:

   00=Special Refinement (±0.1 degree accuracy)
   01=High-Gain Antenna (±0.3 degree accuracy)
   10=Medium-Gain Antenna (±1.3 degree accuracy)
   11=Dynamic Position for Delta V Maneuver (±3.0 degree accuracy)

5. Word 5 (CLON-Celestial Longitude degrees of the spin axis) Floating point form as used on customers computer

6. Word 6 (CLAT-Celestial Latitude degrees of the spin axis) Floating point form as used on customers computer

7. Word 7 (CKAH-Clock Angle of Sun, degrees) Floating point form as used on customers computer

8. Word 8 (CKAS-Clock Angle of Star, degrees) Floating point form as used on customers computer

9. Words 9 - 10 (SPARE) Blanks

DRAFT

Word	Bits 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32	
1	DAY	LEAST CURRENT ENTRY
2	GMT	
3	SPARE	
4	FLAG	
5	CLON	
6	CLAT	
7	CKAH	
8	CKAS	
9	SPARE	
10	SPARE	
	REPEAT WORDS 1-10 TWENTY-NINE	
	TIMES FOR WORDS 11-300	
300		
301	DAY	MOST CURRENT ENTRY
302	GMT	
303	SPARE	
304	FLAG	
305	CLON	
306	CLAT	
307	CKAH	
308	CKAS	
309	SPARE	
310	SPARE	
	EOF	

GSFC/CRT FILE 3 ATTITUDE DATA

TYPE-BINARY

LOGICAL RECORD LENGTH - 10 WORDS

PHYSICAL RECORD LENGTH - 310 WORDS

FILE SIZE - 1 PHYSICAL RECORD

DRAFT

DRAFT

GODDARD SPACE FLIGHT CENTER

Enclosure 2

EDR File 4

Format and Definition

DRAFT

DRAFT

d. File 4 (See Figure 5-12) - All words are right justified and binary unless otherwise stated.

(1) Word 1 (GMT) - Time in elapsed milliseconds from start of day for time of the first data word in the record.

(2) Word 2 (Day of Year) - Self explanatory.

(3) Word 3 (TCF) - Time correction flag. The following codes are in binary: 000 = no correction, 111 = suspect time or corrected time.

(4) Word 4 (AREFSELS) - Reference Select Status - 2 bits. Fill value of "all ones" indicates value missing.

Bits	Meaning
00	ERROR
01	STAR
10	SUNB
11	SUNA

(5) Word 5 (SNR) - (Signal + Noise)/Noise in floating point form as used on customer's computer.

(6) Word 6 (DSS) - Deep space station which was tracking. See Figure 5-50.

(7) Word 7 (Bit Rate) - Bit rate at which data record was taken. See Figure 5-51.

(8) Word 8 (MOD-FMT) - Mode and Format are two data values, three bits and five bits respectively, packed to form, eight bits right justified of Word 8.

Mode: The following codes are in binary: 000 or 001 = real time; 100 or 101 = telemetry store; 010 or 011 = memory readout.

Format: See Figure 5-52.

(9) Word 9 (RTLT) - The Round Trip Light Time will be given in total milliseconds.

(10) Word 10 (ESC Subcom ID) - The Extended Frame Counter will be a combined word from the S/C telemetry of both the subcommutator identification word and the extended frame counter word. Together they comprise a counter from 0 to 8191.

DRAFT

(11) Word 11 (ASTDLYC) - Star Delay Time (1/256 second resolution) in DN. Twelve bits with the telemetry bits reversed to give proper bit weighing. Latest available value - Fill of "all ones" indicates value missing.

(12) Word 12 (Flag 1, Flag 2, Flag 3, Flag 4) - These are flags for RAT, ASPNPDC, SPF, ARIPPHEC, respectively. Each flag is eight bits. Flag values are: 0 = OK, 1 = old value, 10 = value missing, and 11 = corrected value.

(13) Word 13 (RAT - Roll Attitude Timer) - Engineering Subcom Words C-112 and C-116. This time permits correlation of the attitude of the roll index reference line with given telemetered science and engineering data. (Floating point form as used on customer's computer.)

(14) Word (ASPNPDC - Spin Period) - The time between two successive roll pulses of the spacecraft. (Engineering Words C-405, C-406, C-407.) Floating point form as used on customer's computer.

(15) Word 15 (SPF) - Engineering Word C-417 is the flag for spin period (three bits). If bit 30 is 0, then SPSG (Spin Period Sector Generator) roll reference = 0°, if set to 1 = 180°.

Bits 31 and 32	SPSG Modes
00	Non-Spin Averaging
01	ACS
10	Spin Averaging

(16) Word 16 (ARIPPHEC - Roll Pulse/Roll-Index Pulse Phase Error) - The phase error measurement between the Roll Pulse and Roll-Index Pulse with up to a maximum of 60 msec of phase error may be a plus or a minus quantity and is generated by the Spin Period Sector Generator (SPSG). Floating point form including sign as used on customer's computer.

(17) Word 17 (Time of C-112) - GMT time that C-112 was received (RAT). All "ones" indicate time was missing.

(18) Word 18 (DC Bus Voltage - C-107) - Range 26-30 VDC. Floating point form as used on customer's computer. Floating point fill value of 1×10^6 indicates data was missing.

(19) Word 19 DC Bus Current - C-129) - Range 0-6A. Floating point form as used on customer's computer. Floating point fill value of 1×10^6 indicates data was missing.

DRAFT

(20) Word 20 (C-108/GMT of C-108) - Located in Bit 5 of Word 20. It indicates the power status of the GSFC/CRT instrument: 1 = on, 0 = off. GMT of C-108 is located in Bits 6-32 of Word 20. It is the time that C-108 was received. If Word 20 is all "ones", C-108 was missing for this subcom cycle.

(21) Word 21 (PT - S/C Platform Temperature #6) - -20°F to 110°F. Floating point form as used on customer's computer. Floating point fill value of 1 x 10^6 indicates data was missing.

(22) Word 22 (F, DQ) - Bit 1 of Word 22 is the fill indicator: 0 equals data, 1 equals fill. Bits 2 and 3 of Word 22 are dependent on Bit 1 of Word 22. If Bit 1 equals 0, then Bits 2 and 3 (DQ) are the Data Quality Indicator. The following codes in binary: 11 equals all indicators are good, data is good; 10 equals at least one indicator is bad, data is suspect; 01 equals at least two indicators are bad, data is suspect; 00 equals data is bad. See Figure 5-49. If Bit 1 equals 1, then Bit 2 will indicate extent of filler: 0 equals at least this frame of data is filled with "ones" and data resumes in this physical record; 1 equals the rest of this physical record is filled with "ones".

DRAFT

DRAFT

Word	Fields (bits 1–32, left to right)
1	GMT
2	DAY OF YEAR
3	TCF
4	AREFSELS
5	SNR
6	DSS
7	BIT RATE
8	(blank) / MOD / FMT
9	RTLT
10	(blank) / ESC
11	ASTDLYC
12	FLAG4 / FLAG3 / FLAG2 / FLAG1
13	RAT
14	ASPNPDC
15	SPF
16	ARIPPHEC
17	GMT OF C-112
18	DC BUS VOLTAGE
19	DC BUS CURRENT
20	C-108 / GMT OF C-108
21	PT
22	F / DQ / GMT OF SCID 0
23	FILL / 9 / 10 / 11 / 12 / FILL / 14 / 15 / 16 / 17
24	(blank) / FILL / 41 / 42 / 43 / 44
⋮	REPEAT WORDS 22-24 FOR WORDS 25-90 SCIDS 1-22
91	F / DQ / GMT OF SCID 23
92	FILL / 9 / 10 / 11 / 12 / FILL / 14 / 15 / 16 / 17
93	(blank) / E-124 / FILL / 41 / 42 / 43 / 44
94	F / DQ / GMT OF SCID 24
95	FILL / 9 / 10 / 11 / 12 / FILL / 14 / 15 / 16 / 17

GSFC/CRT
TYPE - BINARY
LOGICAL RECORD LENGTH - 384 WORDS
PHYSICAL RECORD LENGTH - 1301 WORDS
FILE SIZE - VARIABLE

FILE 4

EXPERIMENT DATA
FORMAT A

DRAFT

Figure 5-12. GSFC/CRT File 4 (Sheet 1 of 4)

DRAFT

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
96											E-125						FILL				41			42			43			44		
97	F	DQ		GMT OF SCID 25																												
98	FILL				9			10			11			12			FILL				14			15			16			17		
99											E-126						FILL				41			42			43			44		
100	F	DQ		GMT OF SCID 26																												
101	FILL				9			10			11			12			FILL				14			15			16			17		
102											E-127						FILL				41			42			43			44		
103	F	DQ		GMT OF SCID 27																												
104	FILL				9			10			11			12			FILL				14			15			16			17		
105											E-128						FILL				41			42			43			44		
106	F	DQ		GMT OF SCID 28																												
107	FILL				9			10			11			12			FILL				14			15			16			17		
108											E-129						FILL				41			42			43			44		
109	F	DQ		GMT OF SCID 29																												
110	FILL				9			10			11			12			FILL				14			15			16			17		
111											E-130						FILL				41			42			43			44		
⋮	REPEAT FORMAT OF WORDS 22-24 FOR WORDS 112-213																															
213																																
214																																
⋮	REPEAT FORMAT OF WORDS 22-213 FOR WORDS 214-405																															
405																																
406																																
⋮	REPEAT FORMAT OF WORDS 22-405 TWO TIMES FOR WORDS																															
1173	406-1173 SCIDS 128-383																															
1174																																
⋮	128 WORDS OF FILLER FOR WORDS 1174-1301																															
1301																																
	EOR																															

GSFC/CRT FILE 4 EXPERIMENT DATA FORMAT A (CONTD)

Figure 5-12. GSFC/CRT File 4 (Sheet 2 of 4)

DRAFT

DRAFT

Word	Bits 1–32						
1	GMT						
2	DAY OF YEAR						
3	TCF						
4	AREFSELS						
5	SNR						
6	DSS						
7	BIT RATE						
8		MOD	FMT				
9	RTLT						
10		ESC					
11	ASTDLYC						
12	FLAG4	FLAG3	FLAG2	FLAG1			
13	RAT						
14	ASPNPDC						
15	SPF						
16	ARIPPHEC						
17	GMT OF C-112						
18	DC BUS VOLTAGE						
19	DC BUS CURRENT						
20	C-108	GMT OF C-108					
21	PT						
22	F	DQ	GMT OF SCID 0				
23		FILL	14	15	16	17	
⋮	REPEAT WORDS 22,23 FOR WORDS 24-67						
⋮	SCIDS 1-22						
68	F	DQ	GMT OF SCID 23				
69		E-124	FILL	14	15	16	17
70	F	DQ	GMT OF SCID 24				
71		E-125	FILL	14	15	16	17
72	F	DQ	GMT OF SCID 25				
73		E-126	FILL	14	15	16	17

GSFC/CRT FILE 4 EXPERIMENT DATA FORMAT B

TYPE - BINARY

LOGICAL RECORD LENGTH - 256 WORDS

PHYSICAL RECORD LENGTH - 1301 WORDS

FILE SIZE - VARIABLE

DRAFT

Figure 5-12. GSFC/CRT File 4 (Sheet 3 of 4)

DRAFT

Word	1	2–3	4–10	11–16	17–20	21–23	24–26	27–29	30–32
74	F	DQ	GMT OF SCID 26						
75				E-127	FILL	14	15	16	17
76	F	DQ	GMT OF SCID 27						
77				E-128	FILL	14	15	16	17
78	F	DQ	GMT OF SCID 28						
79				E-129	FILL	14	15	16	17
80	F	DQ	GMT OF SCID 29						
81				E-130	FILL	14	15	16	17
⋮	REPEAT FORMAT OF WORDS 22-23 FOR WORDS 82-149								
149									
150									
⋮	REPEAT FORMAT OF WORDS 22-149 FOR WORDS 150-277								
277									
278									
⋮	REPEAT FORMAT OF WORDS 22-277 FIVE TIMES FOR WORDS 278-1301 SCIDS 128-639								
1301									
	EOR								

GSFC/CRT FILE 4 EXPERIMENT DATA FORMAT B (CONTD)

Figure 5-12. GSFC/CRT File 4 (Sheet 4 of 4)

DRAFT

DRAFT

VALUE (BINARY)	BCD	MEANING
11	3	ALL INDICATORS ARE GOOD, DATA IS GOOD
10	2	AT LEAST ONE INDICATOR IS BAD, DATA IS SUSPECT
01	1	AT LEAST TWO INDICATORS ARE BAD, DATA IS SUSPECT
0	0	DATA IS BAD - NO SYNC

THIS VALUE IS COMPUTED BY THE FOLLOWING LOGIC:

QI = FS (1+S+H), where:

FS = 1 IF DATA STREAM IS IN SYNC IN 360
0 IF DATA STREAM NOT IN SYNC

S = 1 IF AVERAGE SNR OVER FRAME IS ≥ A SPECIFIED MINIMUM
0 IF AVERAGE SNR OVER FRAME IS < A SPECIFIED MINIMUM

H = 1 IF HSD BLOCK WAS RECEIVED WITH NO ERROR INDICATORS
0 IF ANY BIT ERRORS WERE DETECTED IN HSD BLOCK

Figure 5-49. Quality Indicator (Binary)

	VALUE (BINARY)
DSS 11	00001011
DSS 12	00001100
DSS 14	00001110
DSS 21	00010101
DSN SIMULATION CENTER (SIMCEN) DSS 27	00011011
DSS 41	00101001
DSS 42	00101010
DSS 51	00110011
DSS 61	00111101
DSS 62	00111110
DSS 71	01000111
CAPE BUILDING AO (DSS 70)	01000110
SFOF (DSS 00)	00000000
MERRITT ISLAND MSFN (MIL) (DSS 90)	01011010
USNS VANGUARD MSFN (VAN) (DSS 91)	01011011
BERMUDA MSFN (BDA) (DSS 92)	01011100
ASCENSION MSFN (ACN) (DSS 93)	01011101
CANARY ISLAND MSFN (CYI) (DSS 94)	01011110
BOULDER, COLORADO (DSS 99)	01100011

Figure 5-50. DSS Codes (Source Codes)

DRAFT

DRAFT

VALUE (BINARY)	BCD	RATE IN BITS PER SECOND
0000	0	16
0001	1	32
0010	2	64
0011	3	128
0100	4	256
0101	5	512
0110	6	1024
0111	7	2048

Figure 5-51. Rate of Data Transmission From Spacecraft (Binary)

DRAFT

DRAFT

FORMAT ID	BCD	FORMAT
0100Ø	8 OR 9	A
0000Ø	0 OR 1	B
0X100	4 OR 12	C 1
0X101	5 OR 13	C 2
0X110	6 OR 14	C 3
0X111	7 OR 15	C 4
11000	24	D1 WITH A
10000	16	D1 WITH B
11001	25	D2 WITH A
10001	17	D2 WITH B
11010	26	D3 WITH A
10010	18	D3 WITH B

Ø = DON'T CARE STATE (MAY BE A ONE OR A ZERO)
X = 1 WHEN IN ROTARY C (OPERATIONALLY FORCED)

Figure 5-52. Format ID Assignments

DRAFT

Specifications for the Pioneer GSFC/CRT Data Reduction System

December 1971

Prepared by

J.A. Novitsky

International Business Machines Corporation
Federal Systems Division
18100 Frederick Pike
Gaithersburg, Maryland 20760

for

Goddard Space Flight Center
Contract No. NAS 5-11874
Greenbelt, Maryland

ABSTRACT

This document outlines the design specifications of the Pioneer GSFC/CRT Data Reduction Program (PIODRP) and briefly defines the supplemental programs which comprise the Pioneer GSFC/CRT Data Reduction System. PIODRP has as its main input the Pioneer Experimenter Data Record (EDR) tapes received from Ames Research Center in Moffett Field, California and its main output the Pulse Height Analysis (PHA) tapes and the Events per second (RATES) tapes. The PHA and RATES tapes contain the GSFC/CRT experiment data in a readily accessible format for subsequent analysis programs.

TABLE OF CONTENTS

i	Abstract	
ii	Table of Contents	
Section		Page
1	INTRODUCTION	1-1
1.1	System Description	1-1
1.2	System Philosophy	1-1
1.3	System Design Specifications and Assumptions	1-2
2	DEFINITIONS AND ABBREVIATIONS	2-1
2.1	Definitions	2-1
2.2	Abbreviations	2-3
3	OBJECTIVES AND REQUIREMENTS	3-1
3.1	Objectives	3-1
3.2	Operational Requirements	3-1
3.3	Functional Requirements	3-2
4	SYSTEM FLOW	4-1
5	INPUT AND OUTPUT FORMATS	5-1
5.1	GSFC/CRT EDR Tapes	5-1
5.2	PHA Tapes	5-6
5.3	RATES Tapes	5-9
5.4	CATALOG Tapes	5-15
5.5	Tape Catalog (Disk)	5-17
5.6	Catalog Pointer (Disk)	5-18
5.7	Parameter Cards	5-19

Section		Page
6	PRINTOUTS AND REPORTS	6-1
6.1	Processing Messages	6-1
6.2	Daily Data Quality Summary Report	6-2
6.3	Current Status of D.R.S. Report	6-3
7	SUPPLEMENTARY PROGRAMS	7-1
7.1	Catalog Maintenance Program (CATMNT)	7-1
7.2	EDR Tape List Program (EDRLST)	7-1
7.3	PHA Tape List Program (PHALST)	7-1
7.4	RATES Tape List Program (RATLST)	7-2
7.5	CATALOG Tape List Program (CATLST)	7-2
7.6	Trajectory Tape List Program (TRJLST)	7-2
7.7	Backup Tape Generation Program (DUPPRT)	7-3

Section 1

INTRODUCTION

1.1 SYSTEM DESCRIPTION

The Pioneer GSFC/CRT Data Reduction System is a collection of programs which aid in the reduction and analysis of the Pioneer GSFC/CRT experiment data. Included in this system is the main data reduction program (PIODRP) which creates the PHA, RATES and CATALOG tapes, as well as a number of utility and maintenance programs which perform the following functions:

a. Allocate disk space for the tape catalogs
b. Initialize and modify the tape catalogs
c. List and create backups for the various tapes used by the D. R. S.
d. Save the tape catalogs which reside on disk onto backup tapes and restore them from tape.

The main data reduction program (PIODRP) reads the EDR tapes and produces time-ordered PHA and RATES tapes, printed daily summaries, printed processing messages, and time-ordered CATALOG tapes containing the logistics, command and attitude information. A catalog of all the tapes used by PIODRP is kept on the disk and updated each time the program is run. Using this catalog, PIODRP determines the location (tape volume) of previously processed data when merging or adding new data with the old. At the end of each run, information pertaining to the tape catalog is printed, indicating the current status of the D.R.S.

1.2 SYSTEM PHILOSOPHY

The following considerations were included in the system design:

a. The Trajectory data will be maintained in a separate tape data set and not merged with the PHA and RATES data since all the Trajectory data for the entire Pioneer mission is expected to be contained on four tape volumes. However, the location (tape volume) and time periods of this data will be maintained in the Tape Catalog.

b. The PHA and RATES tapes are created in a one pass system rather than a two pass system to eliminate duplication of the setup functions inherent to a D.R.S., the computer time required to process the same data a second time and the tapes required for the intermediate storage of the experiment data.

1.3 SYSTEM DESIGN SPECIFICATIONS AND ASSUMPTIONS

a. PIODRP is designed to run on an IBM S/360 computer and utilize three 9-track tape drives (one for the input EDR tape and two for merging of the PHA data, one input and one output) and two 7-track tape drives (for merging the RATES data, one input and one output), five permanent IBM 2314 direct access data sets (four Tape Catalog Data Sets and one Catalog Pointer Data Set), three temporary IBM 2314 direct access dats sets (one each for the logistics, command and attitude information), one card reader/punch and one printer.

[illegible]? do PHA data [illegible] do Rates data?

b. The CATALOG tapes will utilize the three 9-track tape drives listed above (one for input and two for output of the primary and backup CATALOG tapes) after all processing for the current run has been completed.

Section 2

DEFINITIONS AND ABBREVIATIONS

2.1 DEFINITIONS

Many of the following terms have several meanings; however, only the definition pertinent to this report is given.

Absolute File - All the data processed for a particular day residing on one or more EDR tapes.

Absolute File Number - A number assigned to each absolute file (consists of data for an entire day) of experiment data processed by PIODRP. Each file processed is assigned an absolute file number one larger than the previous file; therefore, each file is uniquely identified.

Album - One complete sampling of the GSFC/CRT experiment data. An album consists of the following:

1 Album = 4 pages (each page represents a unique priority sequence)

1 Page = 2 Snapshots (each snapshot represents 1/8 sample of RATES information)

1 Snapshot = 32 Frames (Format A)/64 Frames (Format B)

Catalog Pointer - A disk data set which contains the character (1, 2, 3, or 4) indicating which of the four Tape Catalogs is the most recent (see Section 5.6).

CATALOG Tape - Tape(s) containing all the time-ordered logistics, command and attitude information related to the Pioneer mission (see Section 5.4).

Events per second (RATES) Tape - Tape(s) containing all the time-ordered events per second information from the GSFC/CRT experiment (see Section 5.3).

Experiment Data Record (EDR) Tape - Input tape received from Ames Research Center in Moffett Field, California (see Section 5.1).

Pulse Height Analysis (PHA) Tape - Tape(s) containing all the time-ordered pulse height analysis information from the GSFC/CRT experiment (see Section 5.2).

Relative Modified Julian Day (RMJD) - Date assigned to each day of data referenced from day 0 of launch year, 1972 (Modifed Julian Day 41316).

Tape Catalog - A disk data set which contains pointers to all the tapes used by the D. R. S. along with certain control information (see Section 5.5).

2.2 ABBREVIATIONS

D.R.S	Data Reduction System
DSS	Deep Space Station
EDR	Experimenter Data Record
GMT	Greenwich Mean Time (UT)
GSFC/CRT	Goddard Space Flight Center/Cosmic Ray Telescope
HET	High Energy Telescope
LET	Low Energy Telescope
LSB	Least Significant Bit
MF	Main Frame
MS	Milliseconds
MSB	Most Significant Bit
PHA	Pulse Height Analysis
RTLT	Round Trip Light Time
SCID	Subcommutator Identification
TLM	Telemetry
UT	Universal Time (GMT)

Section 3

OBJECTIVES AND REQUIREMENTS

3.1 OBJECTIVES

a. The major objective of this system is to process the Pioneer EDR tapes received from Ames Research Center in Moffett Field, California and generate tapes containing the GSFC/CRT experiment data and related spacecraft information in a readily accessible format for subsequent analysis programs.

b. The function of the Tape Catalog and CATALOG tapes is to render the system self-sustaining and thus reduce the amount of manual intervention required for normal data processing.

3.2. OPERATIONAL REQUIREMENTS

The following data sets are needed as input to PIODRP:

a. Experiment Data Record (EDR) tape(s)

b. Old CATALOG tape(s)

c. Old Pulse Height Analysis (PHA) tape(s)

d. Old Events per second (RATES) tape(s)

e. Tape Catalog indicated by the Catalog Pointer

f. Parameter cards indicating which EDR tape(s) are to be processed.

The following data sets and reports are generated by PIODRP:

a. New Pulse Height Analysis (PHA) tape(s)

b. New Events per second (RATES) tape(s)

c. Updated CATALOG tape(s)

d. Updated Tape Catalog and Catalog Pointer

e. Daily Data Quality Summary Report

f. Appropriate error messages

g. Current Status of D.R.S. Report

3.3 FUNCTIONAL REQUIREMENTS

The following functions are performed by the Pioneer GSFC/CRT D.R.S.

a. Read and Unpack the EDR tapes

b. Save pertinent information from EDR file 1 (logistics), file 2 (command) and file 3 (attitude) on CATALOG tape

c. Check time continuity of data records in EDR file 4 (experiment data)

d. Establish experiment synchronization

e. Decompress the logarithmic compressed RATES data

f. Process the PHA and RATES data into a condensed and accessible format for the PHA and RATES tapes.

g. Merge new data with data previously processed

h. Create automatic backups for all tapes used by the D.R.S.

i. Produce data quality summary reports

j. Provide an easy re-run capability

k. Dynamically assign all PHA and RATES tapes

l. Generate a time-ordered data base for the PHA and RATES data and provide the capability for selective retrieval of the data.

Section 4

SYSTEM FLOW

The Pioneer Data Reduction Program (PIODRP) is used to process the Pioneer GSFC/CRT EDR tapes and generate time-ordered PHA, RATES and CATALOG tapes. Before this program can be submitted for the first run, disk space must be allocated for the Tape Catalogs and Catalog Pointer and they must be initialized. Once this is accomplished, PIODRP is submitted for normal production runs.

A production run begins with PIODRP reading in from card the time limits (start and stop days) over which data is to be processed for the current run. The latest Tape Catalog, indicated by the Catalog Pointer, is then accessed and the information necessary for processing to continue is verified and retained. The CATALOG Tape associated with the latest Tape Catalog is then mounted and any information for the time span being processed is retained, so that new information may be added when necessary.

Once the set-up procedures are performed, PIODRP reads in from card the EDR tape label and processing options to be used when processing the specified tape. The EDR tape is then mounted and the identification record, contained in file one, is unpacked and verified. If the tape contains data outside the processing time limits or data that is not in time sequence with data previously processed in the current run, the tape is rejected. PIODRP then attempts to read another data card containing the label of the next EDR tape to be processed. If one is not available, PIODRP generates the Current Status of D.R.S. Report, updates the Tape Catalog to reflect the data processed and terminates the job.

When the EDR tape is accepted for processing, PIODRP maintains the pertinent information from file one for the File/Logistics catalog. The data contained in files two and three of the EDR tape is then processed and appropriate entries are made in the Command and Attitude catalogs, respectively. Next, the experiment data contained in file four of the EDR tape is processed and the PHA and RATES information is added to the appropriate tape data set.

When processing the experiment data contained in file four of the EDR tape, several quality and validity checks are performed on each data record. These checks are performed in order of priority and whenever a data record fails a particular check, it is discarded. Statistics are maintained for all data records discarded and this information is printed in the Daily Data Quality Summary Report after the processing for an entire EDR tape is completed. The first check to be performed validates the time assigned to the data record and assures continuity with the times assigned to the preceding records. Appropriate checks are then made to determine whether the experiment power is "on" or "off". Next, a check is made to determine whether the data record contains any good data or consists entirely of padded data. Finally, experiment synchronization is determined for all good records (records with correct time assigned, experiment power on and good experiment data).

After a data record has successfully passed the preceding checks, the experiment data, consisting of the Pulse Height Analysis (PHA) data and the Events per second (RATES) data, is formatted and added to the appropriate tape data sets in a time-ordered fashion. PIODRP then acquires the next data record and repeats the above process of validating the data and producing the appropriate output records. After the last data record for a particular day has been processed, the Daily Data Quality Summary Report is printed. PIODRP then determines whether there is another EDR tape to process and if so, repeats the above process of validating the date assigned to the data, generating the appropriate catalog entries, and processing the experiment data. If no more EDR tapes are to be processed, the Current Status of D.R.S. Report is printed, the Tape Catalogs are updated to reflect the data processed and the job is terminated.

Section 5

INPUT AND OUTPUT FORMATS

Section 5 describes the format of the tapes and cards required by the main data reduction program PIODRP.

5.1 GSFC/CRT EDR Tapes

5.1.1 Description

The GSFC/CRT EDR tapes are 9-track 800 B.P.I. tapes which contain the Pioneer GSFC/CRT experiment data and related spacecraft information. Each tape contains four files, separated by end-of-file indicators and a double end-of-file indicator signifying tape end. Files one through four contain the logistics, command, attitude and experiment data, respectively. Each tape contains data for an entire day (time 0 to time 2400) based on ground receipt time, that is, the time the data was received at a particular tracking station.

5.1.2 Logistics Data

The Logistics Data is contained in file one of the EDR tape and consists of one physical record containing the following information represented in EBCDIC.

Item	Contents
1	Pioneer F EDR
2	Number of acquisitions
3	Name of experimenter and organization
4	Spacecraft identification
5	Date of EDR generation
6	Date of EDR regeneration
7	Year and day of year
8	Deep Space Stations (DSS)
9	Telemetry bit rates
10	Telemetry formats

Item	Contents
11	Operating modes
12	Start time of data for day (GMT) (HR. MIN.)
13	Stop time of data for day (GMT) (HR. MIN.)
14	Tape Sequence Number

5.1.3 Command Data

The Command Data is contained in file two of the EDR tape and consists of one or more 310 word physical records containing the following information represented in EBCDIC (average of 55 commands are expected for each day).

Item	Contents
1	File length
2	GMT time (day, hr., min., sec.)
3	First Command Mnemonic with flag (V-verified, N-not verified, C-unverifiable)
4	GMT time (day, hr., min., sec.)
5	Second Command Mnemonic with flag
6-109	Repeat of 2-3 for commands 3-54 (Items 1-109 repeated for additional records)

5.1.4 Attitude Data

The Attitude Data is contained in file three of the EDR tape and consists of one physical record containing the following information in binary representation (data coverage provided for current day and previous 30 days).

Item	Contents
1	GMT time of day and flag (00-special refinement ($\pm$ 0.1^{o}), 01-high gain antenna ($\pm$ 0.3^{o}), 10-low gain antenna ($\pm$ 1.0^{o}), 11-dynamic position ($\pm$ 3.0^{o}))
2	Celestial latitude
3	Celestial longitude
4	Celestial latitude drift/day
5-120	Repeat items 1-4 to complete coverage for previous 30 days
121	GMT for current day and flag
122	Celestial latitude for current day
123	Celestial longitude for current day
124	Celestial latitude drift/current day

5.1.5 Experiment Data

The Experiment Data is contained in file four of the EDR tape and consists of one or more physical records containing the spacecraft and experiment information in binary representation. Each physical record consists of 21 fixed words of header information followed by the experiment data in one of two formats (A or B).

5.1.5.1 Fixed Words in Header

Word	Contents
1	Time of day in MS for first non filler data word
2	Day of year
3	Time correction flag (0-no correction, 111-suspect time or corrected time)
4	Spare
5	Signal to noise ratio
6	Deep space station which was tracking
7	Bit rate at which data record was taken

Word	Contents
8	Mode (000-real time, 001-telemetry store, 100-memory read-out) and Format (000-A, 001-B)
9	RTLT in total milliseconds
10	Extended SCID counter
11	Spare
12	Four Flags (to be defined by A.R.C.)
13	Roll attitude timer
14	Spin Period
15	Roll Pulse/Roll Index Phase Error
16	GMT in MS of C-112
17	Spare
18	DC Bus Voltage (C-107)
19	DC Bus Current (C-129)
20	Spacecraft Platform Temperature (C-320)
21	GMT of C-108

5.1.5.2 Experiment Data for Format A

The GSFC/CRT experiment data is assigned twelve (9, 10, 11, 12, 14, 15, 16, 17, 41, 42, 43, 44) MF data words (3 bits each) for Format A and these appear on the EDR tape along with the subcom information (E-1, 24-E-1, 30 inclusive) as follows:

Word	Contents
22	GMT of SCID 0

```
     0(MSB)                                    31 (LSB)
23   |0000XXXXXXXXXXXX|0000XXXXXXXXXXXX|
          9  10  11  12     14  15  16  17

     0(MSB)                              31 (LSB)
24   |0000000000000000|XXXXXXXXXXXX0000|
                       41  42  43  44
```

Word	Contents
25-90	Repeat Words 22-24 for SCID 1-22
91	GMT of SCID 23
92	Same as Word 23
93	0(MSB) 31 (LSB) |0000000000XXXXXX|XXXXXXXXXXXX0000| S/CE-1,24 41 42 43 44
94-111	Repeat Words 91-93 for SCID 24-29 (contains S/CE-1,25 - S/CE-1,30 respectively)
112-213	Repeat Words 22-24 for SCID 30-63
214-405	Repeat Words 22-213 for SCID 64-127
406-1173	Repeat Words 22-405 for 2 additional subcom sequences (SCID 0-127)
1174-1301	Filler - all bits on

5.1.5.3 Experiment Data for Format B

The GSFC/CRT experiment data is assigned four (14, 15, 16, 17) MF data word (3 bits each) for Format B and these appear on the EDR tape along with the subcom information (E-1,24-E-1,30 inclusive) as follows:

Word	Contents
22	GMT of SCID 0
23	0 (MSB) 31 (LSB) |0000000000000000|0000XXXXXXXXXXXX| 14 15 16 17
24-67	Repeat Words 22-23 for SCID 1-22
68	GMT of SCID 23
69	0(MSB) 31 (LSB) |0000000000XXXXXX|0000XXXXXXXXXXXX| S/CE-1,24 14 15 16 17

Word	Contents
70-81	Repeat Words 68-69 for SCID 24-29 (contains S/C E-1, 25-S/C E-1, 30 respectively)
82-149	Repeat Words 22-23 for SCID 30-63
150-277	Repeat Words 22-149 for SCID 64-127
278-1301	Repeat Words 22-277 for 4 additional subcom sequences (SCID 0-127)

5.2 PHA Tapes

5.2.1 Description

The PHA tapes are 9-track 1600 B.P.I. tapes which contain the time-ordered Pioneer GSFC/CRT Pulse Height Analysis (PHA) data, corresponding events per second (RATES) data and related spacecraft information. Each logical record contains selected spacecraft information and all the PHA data and associated RATES data for an album (one complete experiment cycle). Each PHA event for the HET and LET requires 3 halfwords (48 bits) and consists of the event type bits, three 12-bit PHA readouts, the sector identification bits and the priority identification bits. These bits are organized in the 3 halfwords for the HET and LET events as follows:

	0(MSB) → 15 (LSB)
HET-Halfword 1	00TTAAAAAAAAAAAA
Halfword 2	00BBBBBBBBBBBBCC
Halfword 3	CCCCCCCCCCRSSSPP

where: TT = 00 $A_1\overline{A_2}BCIII$

= 01 A_2BCIII

= 10 $(A_2K_1+A_1CI)B\overline{CIII}$

= 11 $A_1BK_2\overline{CIII}$

R = 0 CII threshold not exceeded

= 1 CII threshold is exceeded

SSS = 0-7 Sectors 1-8 respectively

PP = 0-3 Priorities 1-4 respectively

	0(MSB) 15 (LSB)
LET-Halfword 1	000TAAAAAAAAAAAA
Halfword 2	0000BBBBBBBBBBBB
Halfword 3	CCCCCCCCCCCCSSSP

where: T = 0 DI DII $\overline{F}$

= 1 DI DII Σ D $\overline{F}$

SSS = 0-7 Sectors 1-8 respectively

P = 0-1 Priorities 1-2 respectively

5.2.2 Logical Record Format

Word	Contents
1	Time of day (MS) of first HET PHA event
2	Halfword 1 - Day of data (RMJD) Halfword 2 - Number of HET PHA events
3	Halfword 1 - Number of frames between first HET event and first LET event Halfword 2 - Number of LET PHA events
4	Halfword 1 - Time correction flag (0-no correction, 111-suspect time or corrected time) Halfword 2 - DSS identification
5	Halfword 1 - Bit rate Halfword 2 - Format (0-A, 1-B)
6	Halfword 1 - Two flags (see Section 5.4 word 12) Halfword 2 - Two flags (see Section 5.4 word 12)
7	Extended SCID counter
8	Roll attitude timer
9	Spin period
10	Roll pulse/Roll index phase error

Word	Contents		
11	Roll attitude time (MS of C-112)		
12	DC Bus Voltage		
13	DC Bus Current		
14	Spacecraft Platform Temperature		
15	Signal to noise ratio		
16-17	Spares		
18-N	N = 45 (Format A)/73 (Format B) -4 (Format A)/8 (Format B) sets of the following information:		
	E1-24	Bilevel	
	E1-25	Elect. Temp.	
	E1-26	Housekeeping	
	E1-27	Calibration Voltage	
	E1-28	Detector Temperature	
	E1-29	Sec. Voltage	
	E1-30	Sequence Identification	
N+1-N+8		HET Rate $(A_2K_1+A_1CI)B\overline{CIII}$	(8 readouts)
N+9-N+12		HET Rate A_1A_2BCIII	(4 readouts)
N+13-N+16		HET Rate $A_1BK_2\overline{CIII}$	(4 readouts)
N+17-N+20		HET Rate A_2BCIII	(4 readouts)
N+21-N+24		LET Rate $DIDII\overline{F}$	(4 readouts)
N+25-N+28		LET Rate $DIDII\Sigma D\overline{F}$	(4 readouts)
N+29-NN		NN= 237 (Format A)/169 (Format B) - Array of halfwords containing HET PHA data followed by LET PHA data dimensioned (3 x 128) (a negative first halfword for an event indicates the number of data frames missing before the next good event.)	

5.3 RATES Tapes

5.3.1 Description

The RATES tapes are 7-track 800 B.P.I. tapes which contain the time-ordered Pioneer GSFC/CRT Events per second (RATES) data and related spacecraft information. Each logical record contains selected spacecraft information and all the RATES data for an album (one complete) experiment cycle). A negative one (-1) for a particular rate indicates padded data.

5.3.2 Logical Record Format

Word	Contents
1	Time of day (MS) of first rate readout (snapshot)
2	Halfword 1 - Day of data (RMJD) Halfword 2 - (0) when complete sample of RATES data is present for album - ($\neq 0$) when one or more sets of 16 rates (sectored or unsectored) is either missing (padded) or redundant (sectored rates only when sector sync not inhibited) where bits 1-16 represent the 16 sets of rates respectively (8 sectored and 8 unsectored).
3	Halfword 1 - Time correction flag (0-no correction, 111-suspect time or corrected time) Halfword 2 - DSS identification
4	Halfword 1 - Bit rate Halfword 2 - Format (0-A, 1-B)
5	Halfword 1 - Two flags (see Section 5.4 word 12) Halfword 2 - Two flags (see Section 5.4 word 12)
6	Extended SCID counter
7	Roll attitude timer
8	Spin period
9	Roll pulse/Roll index phase error
10	Roll attitude time (MS of C-112)

Word	Contents		
11	DC Bus Voltage		
12	DC Bus Current		
13	Spacecraft Platform Temperature		
14	Signal to noise ratio		
15-16	Spares		
17-N	N=44 (Format A)/72 (Format B) -4 (Format A)/8 (Format B) sets of the following information:		
	E1-24	Bilevel	
	E1-25	Elect. Temp.	
	E1-26	Housekeeping	
	E1-27	Calibration Voltage	
	E1-28	Detector Temperature	
	E1-29	Sec. Voltage	
	E1-30	Sequence Identification	
N+1-N+8		Sectored rate S1A(1 of 2)-$A_1\overline{A}_2BCI\overline{CIII}$	Set 1
N+9-N+16		Sectored rate S2A(1 of 1)-$SI_5\overline{SII}\ \overline{SII}_a\ \overline{SIII}$	Set 1
N+17		Unsectored rate R1(1 of 8)-$(A_2K_1+A_1CI)B\overline{CIII}$	
N+18		Unsectored rate R2A(1 of 4)-A_1A_2BCIII	
N+19		Unsectored rate R3A(1 of 4)-A_2BCIII	
N+20		Unsectored rate R4A(1 of 4)-$A_2BK_2CI\ \overline{CII}$	
N+21		Unsectored rate R5A(1 of 4)-$A_2BK_2CI\ CII\ \overline{CIII}$	
N+22		Unsectored rate R6A(1 of 4)-$A_1\overline{A}_2B\overline{CI}$	
N+23		Unsectored rate R7A(1 of 4)-$A_1\overline{A}_2BCI\ CII\ \overline{CIII}$	
N+24		Unsectored rate R8A(1 of 4)-$A_2BK_1CI\ \overline{CII}$	
N+25		Unsectored rate R9A(1 of 2)-B	

Word	Contents	
N+26	Unsectored rate R10A(1 of 1)-DI_1	Set 2
N+27	Unsectored rate R11A(1 of 4)-DI DII $\overline{F}$	
N+28	Unsectored rate R12A(1 of 4)-DI DII E_1 $\overline{F}$	
N+29	Unsectored rate R13A(1 of 4)-DI DII E_2 $\overline{F}$	
N+30	Unsectored rate R14A(1 of 1)-DI	
N+31	Unsectored rate R15A(1 of 2)-SI_1 $\overline{SII}\,\overline{SII}_a\,\overline{SIII}$	
N+32	Unsectored rate R16A(1 of 2)-SI SII_1 $\overline{SII}_a\,\overline{SIII}$	
N+33-N+40	Sectored rate S1B(1 of 2)-A_2 BK_1 $\overline{CIII}$	Set 3
N+41-N+48	Sectored rate S2B(1 of 1)-SI_6 $\overline{SII}\,\overline{SII}_a\,\overline{SIII}$	
N+49	Unsectored rate R1 (2 of 8)	Set 4
N+50	Unsectored rate R2B(1 of 4)-A_1BK_2 $\overline{CIII}$	
N+51	Unsectored rate R3B(1 of 4)-A_2BK_2 $\overline{CI}$	
N+52	Unsectored rate R4B(1 of 4)-A_1	
N+53	Unsectored rate R5B(1 of 4)-A_2BK_2 CI CII $\overline{CIII}$	
N+54	Unsectored rate R6B(1 of 4)-$A_1\overline{A}_2$B CI $\overline{CII}$	
N+55	Unsectored rate R7B(1 of 4)-A_2BK_1 $\overline{CI}$	
N+56	Unsectored rate R8B(1 of 4)-A_2BK_1 CI CII $\overline{CIII}$	
N+57	Unsectored rate R9B(1 of 2)-CI	
N+58	Unsectored rate R10B(1 of 1)-DI_2	
N+59	Unsectored rate R11B(1 of 4)-DI DII Σ D $\overline{F}$	
N+60	Unsectored rate R12B(1 of 4)-DI DII Σ DE_3 $\overline{F}$	
N+61	Unsectored rate R13B(1 of 4)-DI DII Σ D E_4 $\overline{F}$	
N+62	Unsectored rate R14B(1 of 1)-DII	
N+63	Unsectored rate R15B(1 of 2)-SI_2 $\overline{SII}\,\overline{SII}_a\,\overline{SIII}$	
N+64	Unsectored rate R16B(1 of 2)-SI SII_2 $\overline{SII}_a\,\overline{SIII}$	

Word	Contents	
N+65-N+72	Sectored rate S1C(1 of 2)-DI DII $\overline{F}$	Set 5
N+73-N+80	Sectored rate S2C(1 of 1)-SI_7 $\overline{SII}$ $\overline{SII}_a$ $\overline{SIII}$	
N+81	Unsectored rate R1(3 of 8)	Set 6
N+82-N+88	Unsectored rates R2A-R8A(2 of 4)	
N+89	Unsectored rate R9C(1 of 2)-CII	
N+90	Unsectored rate R10C(1 of 1)-DI_3	
N+91-N+93	Unsectored rates R11A-R13A(2 of 4)	
N+94	Unsectored rate R14C(1 of 1)-E_1	
N+95	Unsectored rate R15C(1 of 2)-SI_3 $\overline{SII}$ $\overline{SII}_a$ $\overline{SIII}$	
N+96	Unsectored rate R16C(1 of 2)-SI SII_3 $\overline{SII}_a$ $\overline{SIII}$	
N+97-N+104	Sectored rate S1D(1 of 2)-DI DII E_1 $\overline{F}$	Set 7
N+105-N+112	Sectored rate S2D(1 of 1)-SI_8 $\overline{SII}$ $\overline{SII}_a$ $\overline{SIII}$	
N+113	Unsectored rate R1(4 of 8)	Set 8
N+114-N+120	Unsectored rates R2B-R8B(2 of 4)	
N+121	Unsectored rate R9D(1 of 2)-CIII	
N+122	Unsectored rate R10D(1 of 1)-DI_4	
N+123-N+125	Unsectored rates R11B-R13B(2 of 4)	
N+126	Unsectored rate R14D(1 of 1)-F	
N+127	Unsectored rate R15D(1 of 2)-SI_4 $\overline{SII}$ $\overline{SII}_a$ $\overline{SIII}$	
N+128	Unsectored rate R16D(1 of 2)-SI SII_4 $\overline{SII}_a$ $\overline{SIII}$	
N+129-N+136	Sectored rate S1A(2 of 2)	Set 9
N+137-N+144	Sectored rate S2E(1 of 1)-$\overline{SI}$ SII_5 $\overline{SII}_a$ $\overline{SIII}$	

Word	Contents	
N+145	Unsectored rate R1(5 of 8)	
N+146-N+152	Unsectored rates R2A-R8A(3 of 4)	
N+153	Unsectored rate R9A(2 of 2)	
N+154	Unsectored rate R10E(1 of 1)-DI_5	Set 10
N+155-N+157	Unsectored rates R11A-R13A(3 of 4)	
N+158	Unsectored rate R14E(1 of 1)-SI	
N+159-N+160	Unsectored rate R15A-R16A(2 of 2)	
N+161-N+168	Sectored rate S1B(2 of 2)	Set 11
N+169-N+176	Sectored rate S2F(1 of 1)-$\overline{SI}$ SII_6 $\overline{SII}_a$ $\overline{SIII}$	
N+177	Unsectored rate R1(6 of 8)	
N+178-N+184	Unsectored rate R2B-R8B(3 of 4)	
N+185	Unsectored rate R9B (2 of 2)	
N+186	Unsectored rate R10F(1 of 1)-DI_6	Set 12
N+187-N+189	Unsectored rates R11B-R13B(3 of 4)	
N+190	Unsectored rate R14F(1 of 1)-SII	
N+191-N+192	Unsectored rate R15B-R16B(2 of 2)	
N+193-N+200	Sectored rate S1C(2 of 2)	Set 13
N+201-N+208	Sectored rate S2G (1 of 1)-$\overline{SI}$ SII_7 $\overline{SII}_a$ $\overline{SIII}$	
N+209	Unsectored rate R1(7 of 8)	
N+210-N+216	Unsectored rates R2A-R8A(4 of 4)	
N+217	Unsectored rate R9C(2 of 2)	
N+218	Unsectored rate R10G(1 of 1)-DI_7	Set 14
N+219-N+221	Unsectored rates R11A-R13A(4 of 4)	
N+222	Unsectored rate R14G(1 of 1)-SIII	
N+223-N+224	Unsectored rates R15C-R16C(2 of 2)	

Word	Contents	
N+225-N+232	Sectored rate S1D(2 of 2)	Set 15
N+233-N+240	Sectored rate S2H(1 of 1)- $\overline{SI}$ SII_8 $\overline{SII}_a$ $\overline{SIII}$	
N+241	Unsectored rate R1(8 of 8)	Set 16
N+242-N+248	Unsectored rates R2B-R8B(4 of 4)	
N+249	Unsectored rate R9D(2 of 2)	
N+250	Unsectored rate R10H(1 of 1)-DI_8	
N+251-N+253	Unsectored rates R11B-R13B (4 of 4)	
N+254	Unsectored rate R14H(1 of 1)-SII_a	
N+255-N+256	Unsectored rates R15D-R16D(2 of 2)	

5.4 CATALOG Tapes

5.4.1 Description

The CATALOG tapes are 9-track 1600 B.P.I. tapes which contain the time-ordered logistics, command and attitude information related to the Pioneer mission in three separate catalogs, each one being a separate CATALOG tape file (data set). Within each catalog, the information associated with an absolute file (all the data for a particular day processed from the same EDR tape(s)) is stored in sequential groups of records (1 or more). A unique number is assigned to each absolute file called the ABSOLUTE FILE NUMBER and is used to identify the catalog information associated with each absolute file on the catalog tape. For each absolute file processed through PIODRP, there is one associated file/logistics catalog entry (logical record), and one or more associated command and attitude catalog entries (logical records) on the CATALOG tape, containing the same Absolute File Number.

There are four possible arrangements in which the three separate catalogs can be arranged on as many as three different CATALOG tapes. This is illustrated in Table 5.1 below by reading each column from top to bottom.

	1	2	3	4
CATALOG	Tape/File	Tape/File	Tape/File	Tape/File
File/Logistics	1/1	1/1	1/1	1/1
Command	1/2	1/2	2/1	2/1
Attitude	1/3	2/1	2/2	3/1

Table 5.1 Possible Arrangements of Catalog Information on CATALOG Tape

5.4.2 File/Logistics Catalog

The File/Logistics Catalog consists of one logical record (10 words) for each absolute file processed through the D.R.S. which contains the following information:

Word	Contents
1	Halfword 1 - Absolute File Number Halfword 2 - Date of data (RMJD)
2	Start time of data (MS)
3	End time of data (MS)
4	EDR tape sequence number
5	Halfword 1 - Date of EDR generation (RMJD) Halfword 2 - Date of EDR regeneration (RMJD)
6	Halfword 1 - Date of EDR processing by PIODRP (RMJD) Halfword 2 - (0) Current data on PHA and RATES tapes (1) Data deleted from PHA and RATES tapes and replaced with data from subsequent EDR tape.
7	Halfword 1 - Total number of EDR file 4 data records in Format A Halfword 2 - Total number of EDR file 4 data records in Format B
8	Halfword 1 - Total number of EDR file 4 data records in Format A with time errors Halfword 2 - Total number of EDR file 4 data records in Format B with time errors
9	Halfword 1 - Total number of data records in Format A with power off Halfword 2 - Total number of data records in Format B with power off
10	Spare

5.4.3 Command Catalog

The Command Catalog consists of one or more logical records (201 word maximum) for each absolute file processed through the D.R.S. which contains the following information:

Word	Contents
1	Halfword 1 - Absolute File Number Halfword 2 - Date of data (RMJD)
2	Time of command (MS)
3	Halfword 1 - Command code Halfword 2 - Command flag (0-verified, 1-not verified, 2-unverifiable)
4-201	Repeat Words 2-3 for additional commands

5.4.4 Attitude Catalog

The Attitude Catalog consists of one logical record (5 words) for each absolute file processed through the D.R.S. which contains the following information:

Word	Contents
1	Halfword 1 - Absolute File Number Halfword 2 - Date of data (RMJD)
2	Time of data (MS) and flag affixed (high order two bits) (see section 6.1.4)
3	Celestial latitude
4	Celestial longitude
5	Celestial latitude drift

5.5 Tape Catalog (Disk)

5.5.1 Description

The Tape Catalog is a permanent disk data set which provides the D.R.S. with pertinent information about the PHA, RATES and CATALOG tapes previously created and the blank tapes currently available to the system. This provides the system with the capability to locate data previously processed and dynamically assign all new PHA and RATES tapes. The four latest versions of the Tape Catalog are maintained on the disk to facilitate the continual updating of the catalog and to provide a rerun/recover capability. Each time PIODRP is run, the latest version of the Tape Catalog, indicated by the Catalog Pointer (see Section 6.6), is read from the disk, updated to reflect the data processed, and written onto the disk replacing the most outdated version.

5.5.2 Contents

The Tape Catalog contains the following information:

Item	Contents
1	Array containing CATALOG tape labels dimensioned (IXJ) I = 1 - File/Logistics J = 1 - Primary I = 2 - Command J = 2 - Backup I = 3 - Attitude
2	Array containing PHA tape labels
3	Array containing RATES tape labels
4	Array containing blank tape labels
5	Arrays containing start and end times for PHA and RATES tapes
6	Arrays containing the amount of space used on PHA and RATES tapes.
7	Variables indicating the number of PHA, RATES and blank tapes currently available to the D.R.S.
8	Variable indicating the last Absolute File Number assigned to data on the CATALOG tape.

5.6 Catalog Pointer (Disk)

5.6.1 Description

The Catalog Pointer is a permanent disk data set which contains the character (1, 2, 3, or 4) as the first byte of an 80 byte record. This data set indicates which of the four Tape Catalogs is the latest (see Section 6.5) and is updated by PIODRP each time the most outdated version of the Tape Catalog is replaced with a new version.

5.7 Parameter Cards

5.7.1 Description

The Parameter Cards are used to identify the data that is to be processed. The first data card contains the processing time limits, that is, the start and stop dates (year and day of year) of data to be processed for the current run. Each subsequent data card will be a NAMELIST card with the NAMELIST name PIODAT specifying which EDR tape to process along with certain program variables and options to be used in processing the tape.

Section 6

PRINTOUTS AND REPORTS

Section 6 describes the printouts and reports generated by the main data reduction program PIODRP.

6.1 Processing Messages

6.1.1 Description

The Processing Messages produced by the main data reduction program (PIODRP) provide a history of all the EDR tapes processed and the errors (abnormal conditions) encountered. Each page of the printout contains the following standard header information:

a. Name of the spacecraft and experiment - PIONEER GSFC/CRT

b. Type of report - Processing Messages

c. Date of run - YYMMDD

d. Page number - XX

Each message produced has a standard format (reading left to right) as follows:

a. Time the message was generated - HHMMSS

b. Name of the routine generating the message

c. Label of the EDR tape being processed

d. Tape sequence number for current run

e. Number of file being processed from EDR tape

f. Number of record being processed

g. Message content

6.1.2 Contents

The Processing Messages produced by PIODRP provide the following information:

a. Indication of I/O errors and related status information

b. Indication of wrong length records

c. Indications of time backups in file 4 of EDR tape

d. Indications of invalid keywords (bit rate, format, etc. indicators) in the data

e. Indications of internal program errors (abnormal conditions)

f. Indication that normal end-of-tape was encountered.

6.2 Daily Data Quality Summary Report

6.2.1 Description

The Daily Data Quality Summary Report generated by PIODRP provides an indication of the quality and status of the Pioneer GSFC/CRT experiment data on a daily basis. Each page of the printout contains the standard header information (see Section 6.1.1) with the type of report indicating Daily Data Quality Summary Report.

6.2.2 Contents

The Daily Summary Report provides the following information for each absolute file processed by PIODRP.

a. Absolute File Number assigned to data

b. EDR tape label - source of data.

c. Start and end time of data coverage for day

d. Total records for Format A and Format B

e. Number of good records

f. Number of records containing redundancies

g. Number of records completely padded

h. Number of records rejected due to time errors

i. Number of records when experiment power was off

j. Number of records when experiment was operating in low power mode (no PHA data)

k. Number of records when experiment synchronization could not be determined

l. Number of records when experiment was operating with Sector Sync not inhibited

m. Percentage of records (item l) when redundant RATES readouts did not agree

n. Number of HET and LET PHA events of a particular type and priority mode

o. Number of padded frames

6.3 Current Status of D.R.S. Report

6.3.1 Description

This report is printed at the end of each production run of PIODRP to provide the current status of all tapes available to the D.R.S. The purpose of this report is to assist the data technician in the processing of subsequent EDR tapes. Each page of the printout contains the standard header information (see Section 6.1.1) with the type of report indicating Current Status of D.R.S. Report.

6.3.2 Contents

This report provides the following information at the end of each production run of PIODRP.

a. Total number of PHA and RATES tapes currently in system

b. Total number of blank tapes currently available to system

c. Listing of all PHA and RATES tapes giving start and end times and amount of tape (feet) used on each

d. List of all blank tapes currently available to system

e. List of PHA and RATES tapes created in current run

f. List of PHA and RATES tapes copied in current run which may later be entered into the blank tape queue

g. Last Absolute File Number assigned to data on the CATALOG tape

h. Current value of the Catalog Pointer (1, 2, 3 or 4) indicating which Tape Catalog is the latest

Section 7

SUPPLEMENTARY PROGRAMS

Section 7 defines the purpose of the supplemental programs belonging to the Pioneer GSFC/CRT Data Reduction System. These programs are not part of PIODRP.

7.1 Catalog Maintenance Program (CATMNT)

7.1.1 Purpose of CATMNT

The Catalog Maintenance Program (CATMNT) performs three basic functions. The first is to initialize the Catalog Pointer data set and/or the four Tape Catalog data sets. When initializing the Tape Catalogs, it creates tape catalog entries containing the blank tape list, catalog tape labels and program variables to be used by the main data reduction program (PIODRP). The second function of CATMNT is to add blank tape labels to the Tape Catalog and the third function is to delete certain entries from the Tape Catalog or modify the Catalog Pointer.

7.2 EDR Tape List Program (EDRLST)

7.2.1 Purpose of EDRLST

The purpose of the EDR Tape List Program (EDRLST) is to provide a formatted listing of all pertinent information contained on a particular Pioneer GSFC/CRT EDR tape. The data will be listed by record number or time period. In addition, the time associated with each data record on the tape will be checked for time backups and various quality checks will be performed on the experiment data contained in file 4 of the EDR tape.

7.3 PHA Tape List Program (PHALST)

7.3.1 Purpose of PHALST

The PHA Tape List Program (PHALST) provides a formatted listing of the information contained on one or more PHA tapes. The data will be listed by record number or time periods and as many as twenty separate sets of records may be listed from each PHA tape in the same run. The program also insures that no time backups exist on the PHA tapes and performs various quality checks of the data.

7.4 RATES Tape List Program (RATLST)

7.4.1 Purpose of RATLST

The RATES Tape List Program (RATLST) provides a formatted listing of the information contained on one or more RATES tapes. The data will be listed by record number or time periods and as many as twenty separate sets of records may be listed from each RATES tape in the same run. The program also insures that no time back-ups exist on the RATES tapes and performs various quality checks of the data.

7.5 CATALOG Tape List Program (CATLST)

7.5.1 Purpose of CATLST

The purpose of the CATALOG Tape List Program (CATLST) is to access the Tape Catalogs and CATALOG Tapes generated by PIODRP and produce listings or quality reports of the data requested. Only one Tape Catalog and the associated CATALOG Tape may be processed in the same run and listings may be obtained from any one or all three of the separate catalogs (File/Logistics, Command, and Attitude). The data will be listed by Absolute File Number or time period and a quality check will be performed on each data set accessed.

7.6 Trajectory Tape List Program (TRJLST)

7.6.1 Purpose of TRJLST

The purpose of the Trajectory Tape List Program (TRJLST) is to read, interpret, verify and produce formatted listings of the information contained on the Pioneer Trajectory tapes. The data will be listed by time period or record number.

7.7 Backup Tape Generation Program (DUPPRT)

7.7.1 Purpose of DUPPRT

The Backup Tape Generation Program (DUPPRT) produces backup copies of the PHA and RATES tapes created by PIODRP. This program may be run as the second job step of the main data reduction program (PIODRP) or by itself. Various quality checks of the data are performed for each tape duplicated.

Pioneer Data Analysis Programs

1. Intermediate Flux Program

This program generates a data tape consisting of counts of event occurrence within defined areas of the range of the experiment packages on a time interval basis.

2. Flux Display Program

This program creates displays of the data contained on the tape generated by the Intermediate Flux Program.

√3. PHA Summarizer

This program creates a data base of sorted PHA readings for the entire range of the experiment packages. The sort is performed over a constant time period and is based on event type, PHA values, sector, and priority mode.

4. PHA Analysis Program

This program produces two dimensional plots of the PHA data as contained in the PHA summary data base for one time period or for combinations of time periods. A histogram showing the distribution of actual data values around an assigned standard curve is also created.

5. PHA Time Period Merge Program

This program creates a data set of merged time intervals of summarized PHA data.

6. Plot Program

This program creates two dimensional plots of summarized PHA data according to event type.

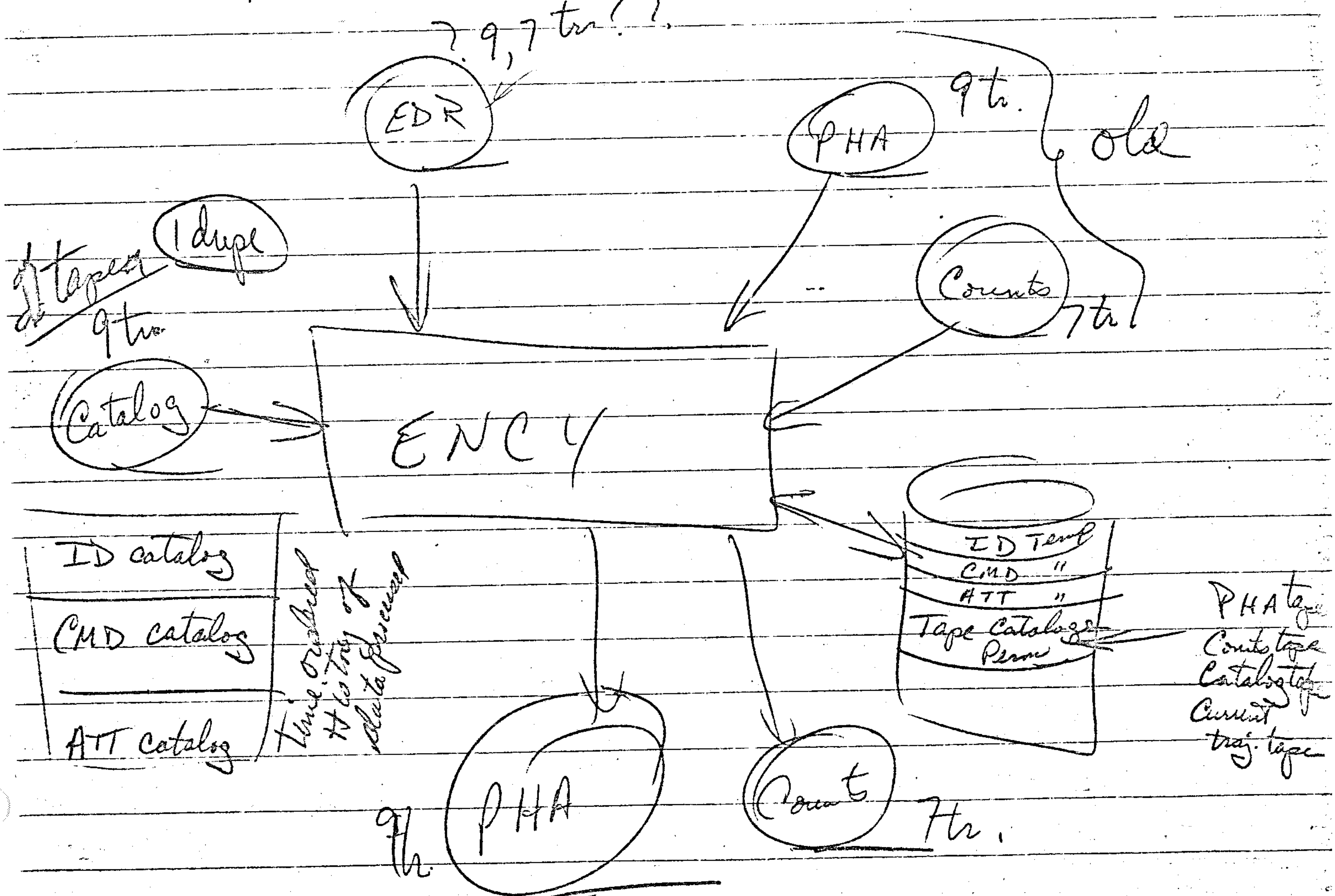
AMES Document	A
EDR format	A
PHA format	T
EDR 7 or 9 track?	A
Dates	A

File#
1 ID file - 1 record EBCDIC

2 CMD file - short, undefined - EBCDIC

3 Attitude file = previous 30 days + current day
no predictive

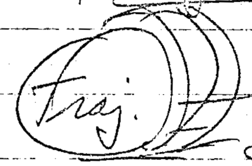
4 Data records
PHA & Counts



+ generate dupes

Mission 2yrs — 600 days

4 day sampling rate



4 tapes for entire mission

EDR Tape
4 files

{ 1 days data
no overlap
padded when out of sync.
Time continuous

Tape ID

1a Command Data

Attitude Data

Data

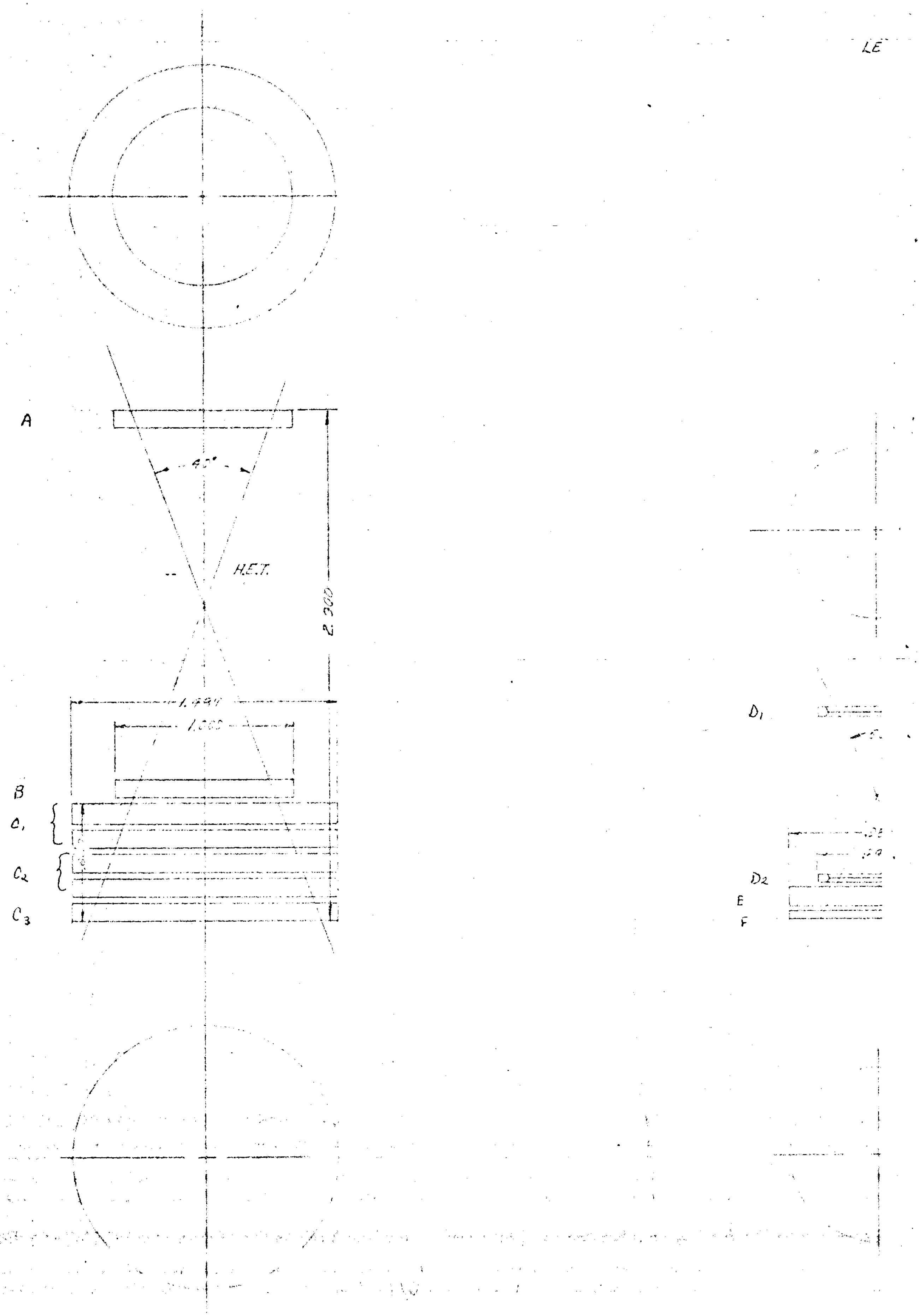
1b dupe

Special routines to be written last

High Energy Telescope

Pioneer F/G

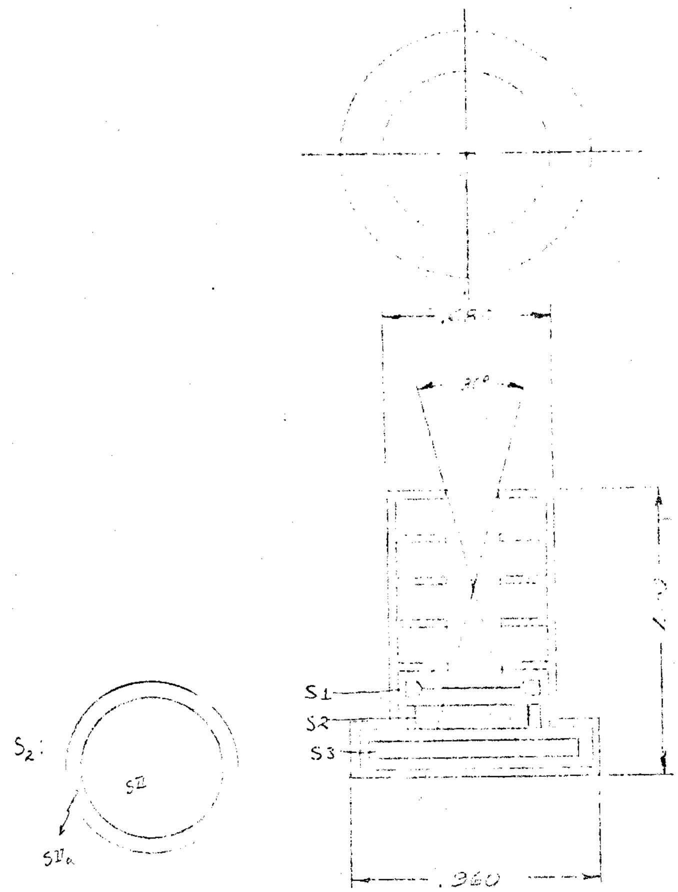
LE

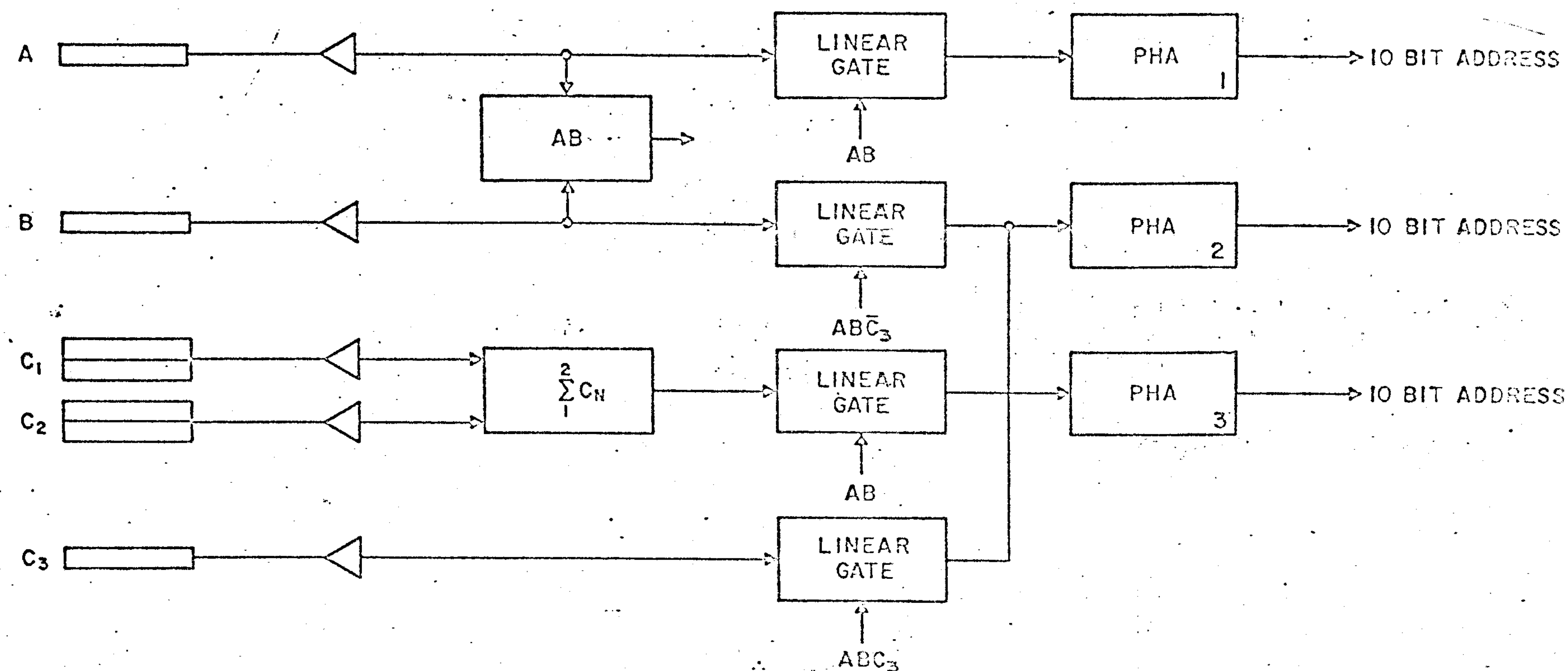


A, B 300 mm² Li DRIFT

$C_1 - C_3$ 850 mm² Li DRIFT

LETR





PHA data only

PRIORITY MODES

$AB\bar{C}_3$

$AB\bar{C}_3$ *(A > 2× min)*

ABC_3 (A AND C > 2x MIN.)

ABC_3

RATES

A (*2*) LEVELS

B, C_1, C_2, C_3

$AB\bar{C}_1\bar{C}_2\bar{C}_3$ *(2 levels on A)*

$ABC_1\bar{C}_2\bar{C}_3$ (")

$ABC_1C_2\bar{C}_3$ (")

$ABC_1C_2C_3$ (")

2 BITS REQUIRED TO IDENTIFY PRIORITY MODE.
1 BIT REQUIRED TO IDENTIFY PHA DATA AS H.E.T.
1 BIT REQUIRED TO DETERMINE IF PHA 2 ADDRESS IS B OR C_3
3 BITS REQUIRED TO IDENTIFY SECTOR.
1 BIT REQUIRED FOR RANGE.

FIG. IV-3
SIMPLIFIED HIGH ENERGY DETECTOR

TABLE III

Event Type	Particle	Event $I2=2^1$	Code $I1=2^0$	Relative Priority (1=highest) S1=S2=0	S1=1,S2=0	S1=0,S2=1	S1=S2=1
$A_1BK_2\overline{CIII}$	Stopping particles $Z\geq2$	1	1	1*	2	2	2
$(A_2K_1 + A_1C1)\ B\overline{CIII}$	Stopping e^-, or stopping p^+ and heavier	1	0	2	1	3	3*
A_2B CIII	Penetrating particles $Z\geq2$	0	1	3	3	1	4*
$A_1\overline{A_2}$ B CIII	Penetrating e^-	0	0	4*	4*	4*	1

* Each event is analyzed as often as it occurs unless marked with *, in which case that event type is analyzed only once per readout.

A COSMIC RAY DETECTOR SYSTEM
FOR THE
ANALYSIS OF ENERGY SPECTRA, CHARGE COMPOSITION AND GENERAL FLOW PATTERNS
OF
SOLAR, GALACTIC AND JOVIAN ENERGETIC PARTICLES
DURING THE
PIONEER EARTH/JUPITER MISSIONS

BY

FRANK B. MC DONALD

BONNARD J. TEEGARDEN

JAMES H. TRAINOR

NASA/GODDARD SPACE FLIGHT CENTER

AND

EDMOND C. ROELOF

WILLIAM B. WEBBER

UNIVERSITY OF NEW HAMPSHIRE

SEPTEMBER, 1970

I. SCIENTIFIC OBJECTIVES

The proposed Pioneer F and G mission offers a unique opportunity to study the extended regions of the interplanetary medium. The possibility of approaching interstellar electromagnetic conditions must be contemplated and regarded with great interest. These points, coupled with the opportunity to study the Jovian environment, call for a carefully coordinated set of studies in each scientific discipline.

This instrument is designed to exploit to the fullest practical degree the proposed trajectories of Pioneer F and G. The significance of these measurements will be greatly enhanced by concurrent measurements with similar particle telescopes scheduled for flights on satellites of the IMP or similar series in near-earth orbits.

The principal scientific objectives of this experiment are:

1. To measure the flow patterns of energetic solar and galactic particles separately in the interplanetary field. To interpret this measurement, simultaneous determination of the energy spectrum, radial gradient, angular distribution, and streaming parameters is required for each nuclear species and over as wide an energy range as is practicable.

2. To measure the energy spectra, and isotopic composition of galactic and solar cosmic rays from the lowest practical energies up to ~ 800 MeV/nucleon and (by use of objective 1) to unfold the primary flare and interstellar spectrum.

3. To measure the time variations of the differential energy

spectra of electrons, hydrogen and helium nuclei over the corresponding energy intervals. During flare events, to obtain time histories; during quiet times, to relate gross time variations to those near earth thus deducing a spatial gradient for galactic cosmic rays.

4. To study the energy spectra, time variations and spatial gradients associated with recurrent and non-flare associated interplanetary proton and helium streams and to define the related solar or interplanetary acceleration processes.

5. To provide information on the energetic particle distribution surrounding Jupiter.

6. To try to determine the extent of the solar cavity, the energetic particle phenomena occurring at this interface and the cosmic ray density in nearby interstellar space.

The spatial/temporal structure of solar and interplanetary events can only be deduced from continuous monitors at a variety of radial and azimuthal locations. Co-rotating particle streams, interplanetary plasma shocks and Forbush decreases are obvious examples in addition to customary flare events. Quiet-time fluxes measured on the outward journey cannot be interpreted in terms of a galactic gradient unless a sound "base-line" for the solar cycle-dependent time variation of fluxes can be derived from comparable detectors in near-earth orbits. Fortunately such detectors are scheduled for a concurrent period on IMP H and J, and potentially IMP KK'.

The strong collimation of solar particle flow along magnetic field lines during all but the late phases of solar flare events is well established near 1 AU. However, at 5 AU the field may be quite tangled due to the "winding up" of the Archimedean spiral field; it would make an average angle of ~ 80° with the solar radius vector. If the field at this distance is more disordered than at earth, the reverse situation to that at the earth may hold; angular flare particle distributions may aid interpretation of complicated magnetic field measurements. The need for associated magnetic field measurements in interplanetary shocks and Forbush decreases is self-evident. Recent theoretical work (Gleeson, 1969; Roelof, 1969) has shown that the average magnetic field direction governs the flow of quiet-time particles, so simultaneous particle-field observations are required.

II. PHENOMENA TO BE MEASURED

In the field of energetic particles we have tried to design an instrument that will provide the maximum-possible diagnostic power to examine the complex field-particle interactions occurring in the interplanetary environment as well as the Jovian magnetosphere.

To accomplish this we propose a coordinated set of two solid state detector telescopes to study charged particles. The telescopes are designated as:

a. the high energy telescope (H.E.T.),

b. two low energy dE/dx vs. E telescopes (L.E.T. I and L.E.T. II).

Charged particle spectra and angular distributions will be measured over an extended energy interval. These intervals are briefly listed below in Table 1, and are shown graphically in Figure 1.

TABLE 1

Particle Component	Energy Range
Galactic cosmic ray protons	4.5 - 800 MeV
Solar protons	.05 - 800 MeV
Galactic cosmic ray Helium	4.5 - 600 MeV/nucleon
Solar Helium	1.0 - 600 MeV/nucleon
He^3/He^4, D/H	4.5 - 50 MeV/nucleon
Galactic and Solar Electrons	.050- 5.0 MeV
Li, Be, B, C, N, O, F, Ne and their isotopic composition	6 MeV/nuc- 200 MeV/nucleon
Integral flux	> 800 MeV

Energy Ranges for Angular Distribution Studies

Hydrogen	.05 - 120 MeV
Helium	4.5 - 120 MeV/nucleon
Electrons	.05 - 5 MeV

Geometrical Factors

High Energy Telescope	0.220 cm^2 - ster.
Low Energy Telescope I	0.155 cm^2 - ster.
Low Energy Telescope II	0.015 cm^2 - ster.

III. DETECTOR SYSTEM

We shall now discuss these three telescopes in some detail and how the measurements are coordinated to provide a comprehensive and redundant set of cosmic ray measurements. The redundance of the separate sets of measurements as well as the self-calibration are important features of the system we are proposing. It is a total necessity in view of the prolonged nature of the Pioneer F and G missions and the controversy that currently exists over the interpretation of gradient and anisotropy measurements made in the 0.7 - 1.5 AU interval.

Figure 2 is a picture of the completed experiment with handling fixtures and detector covers attached. The LET-II telescope within its radiation shield is in the center with the LET-I telescope partially visible through the side face. The HET telescope is within the package, directly above the other two telescopes, and looks through the front and side faces shown into the same plane as the LET telescopes. All telescopes look perpendicular to the Pioneer spin axis and thus are always scanning the celestrial sphere.

High Energy Telescope:

The high energy telescope is a four element array and is shown schematically in Figure 3. Two of these elements (A and B) are single, lithium-drifted silicon detectors, 300 mm^2 in area and 2.5 mm thick. The third element is a stacked arrangement of four 850 mm^2, 2.5 mm thick lithium drifted silicon detectors (C_1 and C_2), while the fourth element C_3 is a similar detector which identifies events as stopping somewhere in the telescope ABC_1C_2 or as penetrating the entire telescope. For particles which come to rest within the telescope (20 - 50 MeV/nucleon) three measurements are made - energy loss (dE/dx), total energy, and range. The simultaneous measurement of total energy and range provides a very powerful method for rejecting detector background, which is a particularly significant problem in this energy regime. For particles which penetrate completely through the stack of solid state devices, three separate dE/dx measurements are made. This will allow the differential energy spectra to be obtained for helium and hydrogen from 50 - 800 MeV/nucleon. Charge resolution for penetrating particles will be possible up to approximately 200 MeV/nucleon.

Figure 3 also shows a simplified logic drawing for the HET. In addition to the three 10-bit addresses associated with the pulse height analysis of an HET event, we require additional bits as noted to identify the priority mode, identify the data as HET, specify PHA_2, identify the spin sector in which the event occurred, and to determine if the event penetrated to C_2. The priority mode is the state of a time sharing system based on the four logic conditions shown on Figure 3 which identify stopping particles, stopping heavies (He and above), penetrating heavies, and all penetrating particles. Since these detectors will usually be telemetry-readout limited, the priority system will select these rare particles for analysis on a time shared basis, thus artificially enhancing the fraction of alpha particles and heavies in the data. The many rates which are commutated and counted will allow us to determine the true ratios of these particles in interplanetary space. Certain rates are sectored, e.g., counted into eight different counters corresponding to eight equal sectors (45°) of spin, synchronized to the see-sun direction.

Low Energy Telescope (LET-I):

LET-I is a three element dE/dx vs E telescope plus an anti-coincidence detector. It will cover the energy range from 3 to 22 MeV/nucleon, and in this interval charge resolution will be possible from Z = 1 (hydrogen) to Z = 8 (oxygen). The telescope is designed to measure both the energy spectra and angular distributions over these intervals. This telescope represents a modification to the original LET design to take into account the effects of the Pioneer radioisotope power supply vs the original solar array. Effectively, the very low energy particle information is now taken by LET-II which is quite small and can be shielded.

The detector configuration is shown in Figure 4. Detectors D_1 and D_2 are identical silicon surface barrier devices each 100 microns thick and 100 mm^2 in area. They serve the dual purposes of defining the geometry of the detector telescope and also providing a redundant double dE/dx measurement. Detector E is a lithium drifted silicon device 2.5 mm in thickness and 300 mm^2 in area. It serves as a total energy measuring element. The F detector, another 2.5 mm thick lithium drifted silicon device, simply acts as an anticoincidence. Events of the type $D_1D_2\overline{E}$ and $D_1D_2E\overline{F}$ will be analyzed. The $D_1D_2\overline{EF}$ events correspond to protons between 3 and 5 MeV whereas the $D_1D_2E\overline{F}$ events include the 5 to 22 MeV range for protons, for instance.

Figure 4 also outlines the pulse height analysis system, conditions and the auxilliary bits required. A priority system similar to HET is incorporated to emphasize rare events, and many different count rates are monitored. Several rates are also sectored by eight to allow us to reconstruct an angular scan.

This detector, like the HET, will be self-calibrating. In addition the telescopes have been designed such that an overlap in the individual energy responses of the detectors does exist. This will then allow cross calibrations between detectors.

Low Energy Telescope (LET-II):

This telescope is designed to study low energy protons and electrons in the Jovian radiation belts and particles of solar origin in the interplanetary region. A schematic of this detector is shown in Figure 5.

There are three elements:

S_1	50μ	-	50 mm^2	Silicon Surface Barrier
S_2	2.5 mm	-	50 mm^2	Lithium-drifted Silicon
S_3	2.5 mm	-	200 mm^2	Lithium-drifted Silicon

The S_1 thickness was chosen to minimize the electron response without making an unreasonable sacrifice in the detector performance.

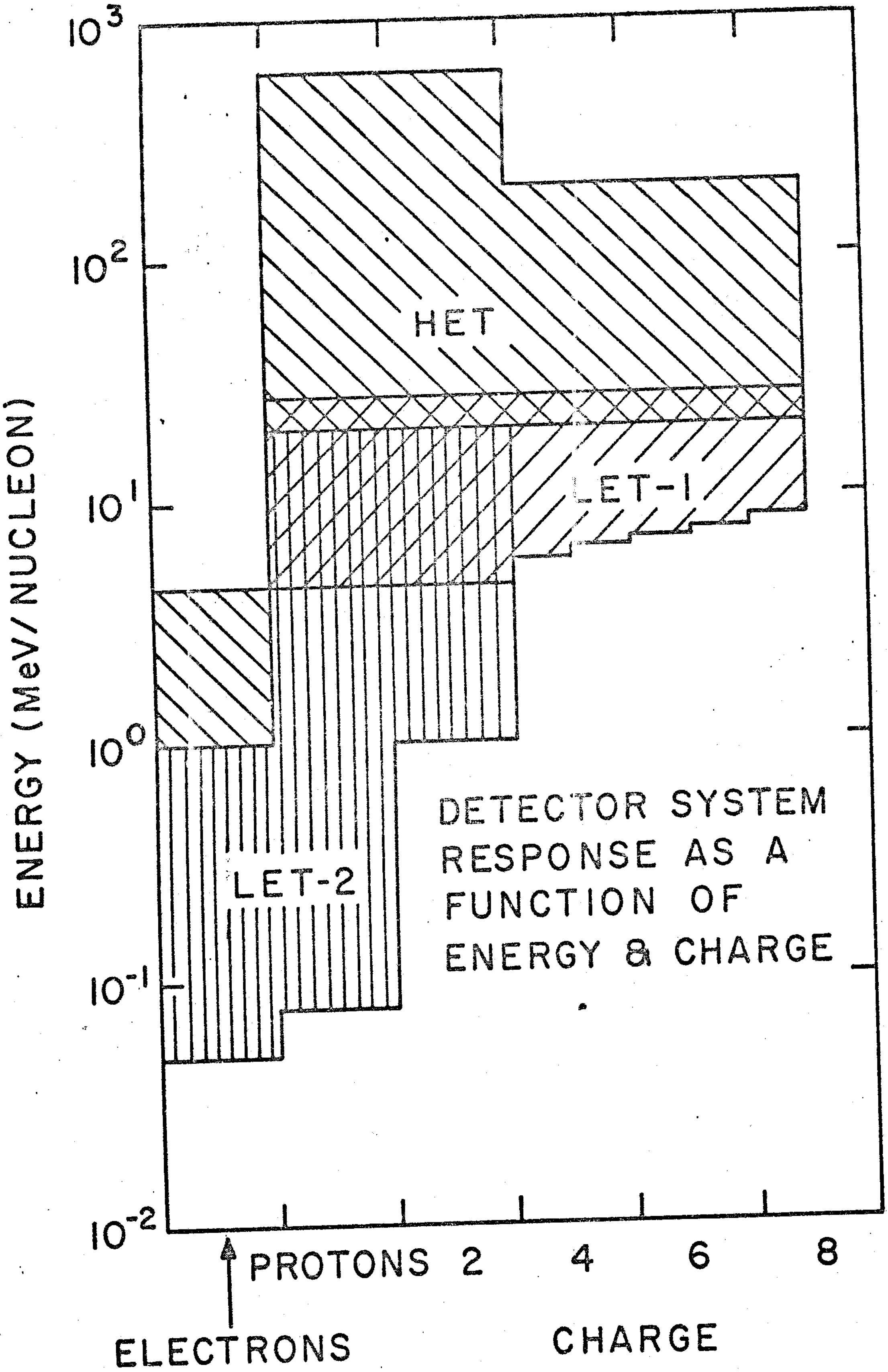
The detectors S_1 and S_2 are used individually and in coincidence as total absorption spectrometers. S_3 operating in an anticoincidence mode insures that only stopping particles are analyzed. In addition, S_2 is made with a coaxial detector enclosing the center active region so as to provide anticoincidence to particles coming from the sides. S_1 will stop electrons in the range 50 - 150 KeV and protons in the range 50 KeV - 3 MeV. The S_2 detector will respond to electrons in the energy interval 150 KeV - 1 MeV and the proton interval is 3 MeV - 20 MeV, and in these ranges an unambiguous separation of electrons and protons is possible. Figure 5 also lists the large number of rates and sectored rates that are monitored for this detector. Stopping alphas in the S_1 detector will have a unique response from 1 MeV - 3 MeV/nucleon for solar alpha events.

Considerable precautions have been taken to minimize the effects of radiation damage in all the telescopes. The primary concern is for the trapped radiation belts about Jupiter. There is no reliable prediction of proton fluxes and low energy electrons (< 1 MeV) in the Jovian magnetosphere. This experiment can tolerate the high energy electrons inferred from radio data, however, the proton and lower energy electron fluxes could be large enough to seriously damage many solid state detectors. The detectors in this experiment are in all cases fully depleted devices having average electric field strengths in the range 150 volts/mm to 200 volts/mm. Additionally, all detectors directly exposed or with minimum shielding are oriented in the telescope so that the rear or aluminum contact will be irradiated primarily.

IV. INSTRUMENTATION

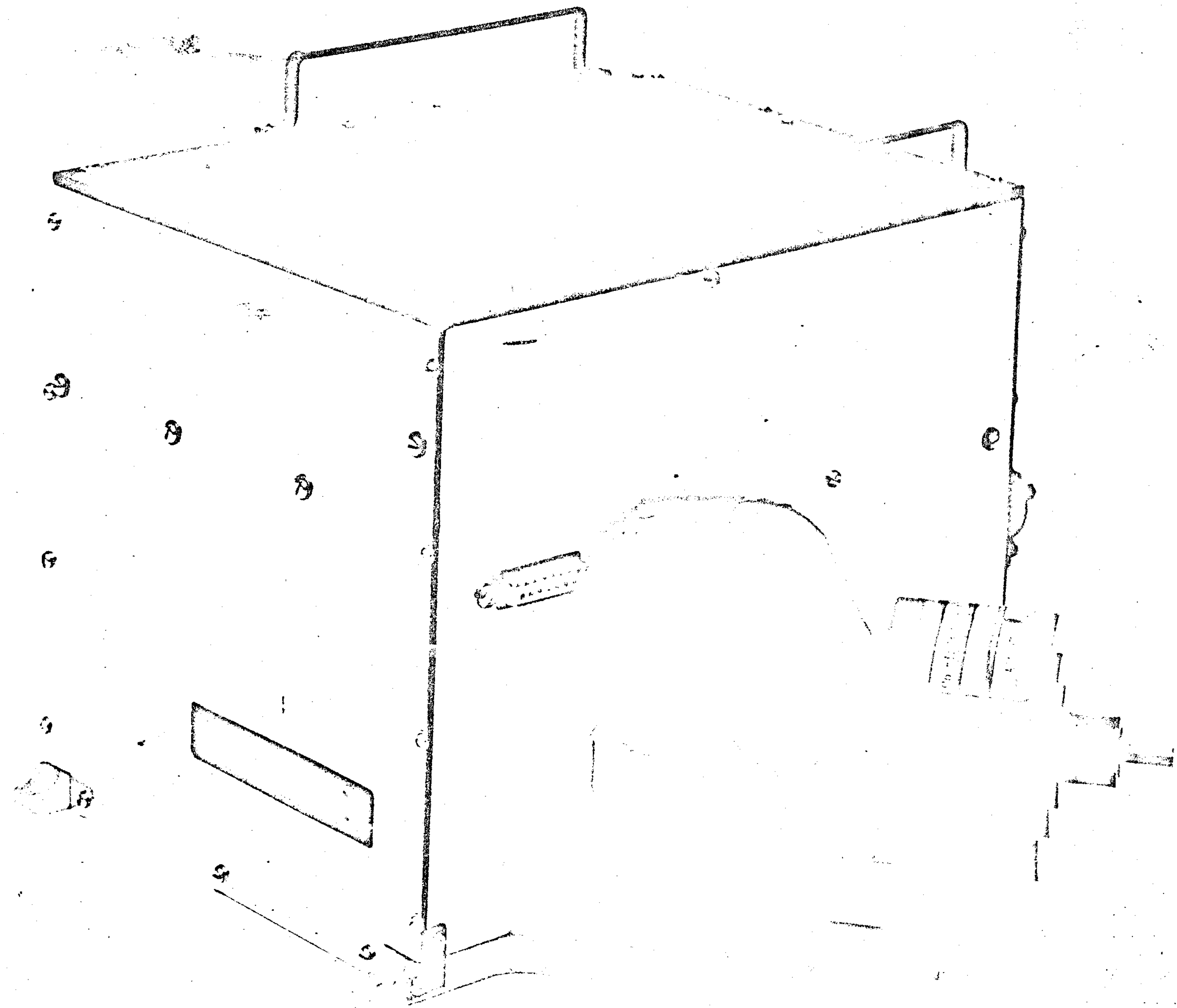
The charge sensitive preamplifiers, shaping amplifiers, the output data system and the power supplies are constructed primarily of small or miniature components soldered to "daughter" boards which are then soldered to a "mother" board which provides the interconnect. The linear gates, threshold discriminators, pulse height analyzers, integral analyzers and priority and control matrices are constructed by soldering dual transistors and diodes in discrete, miniature ceramic or glass packages to hybrid, thick film substrates. The extensive data system is constructed primarily of P channel, enhancement mode MOSFETS using both medium scale integration (MSI) and large scale integration (LSI). Much of the interfacing circuitry is done with T^2 L integrated circuits. There are more than 40,000 transistors in the data system.

This entire experiment including the LET-II radiation shield weighs 6.9 pounds and consumes 2.28 watts at 28 volts.

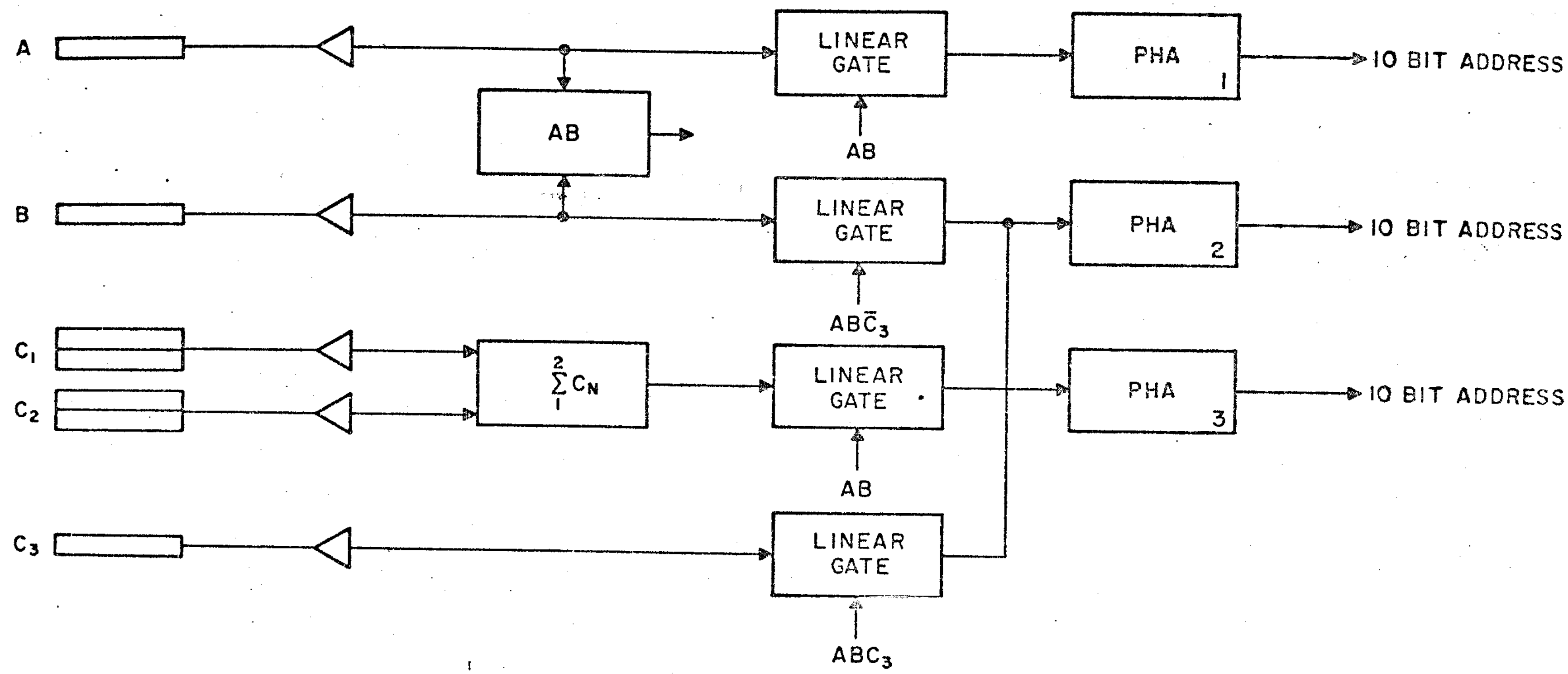


ENERGY (MeV/NUCLEON)
10^3
10^2
10^1
10^0
10^-1
10^-2
HET
LET-1
LET-2
DETECTOR SYSTEM RESPONSE AS A FUNCTION OF ENERGY & CHARGE
PROTONS 2
4
6
8
ELECTRONS
CHARGE

FIG. 1



NASA G-71- 1216



PRIORITY MODES

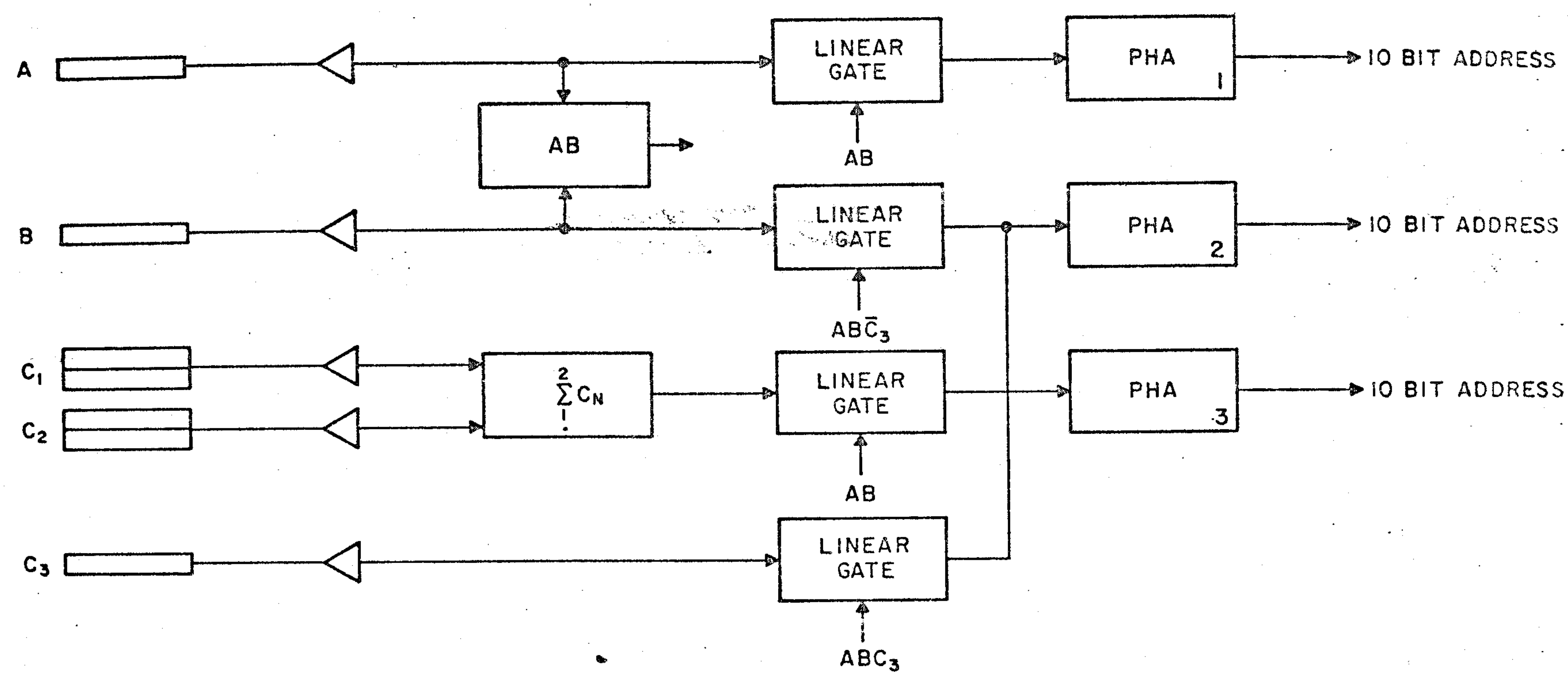
$AB\bar{C}_3$
$AB\bar{C}_3$ (A > 2 x MIN.)
ABC_3 (A AND C > 2x MIN.)
ABC_3

RATES

A (2 LEVELS)
B, C_1, C_2, C_3
$AB\bar{C}_1\bar{C}_2\bar{C}_3$ (2 LEVELS ON A)
$ABC_1\bar{C}_2\bar{C}_3$
$ABC_1C_2\bar{C}_3$
$ABC_1C_2C_3$

2 BITS REQUIRED TO IDENTIFY PRIORITY MODE.
1 BIT REQUIRED TO IDENTIFY PHA DATA AS H.E.T.
1 BIT REQUIRED TO DETERMINE IF PHA 2 ADDRESS IS B OR C_3
3 BITS REQUIRED TO IDENTIFY SECTOR.
1 BIT REQUIRED FOR RANGE.

FIG. 3
SIMPLIFIED HIGH ENERGY DETECTOR



PRIORITY MODES

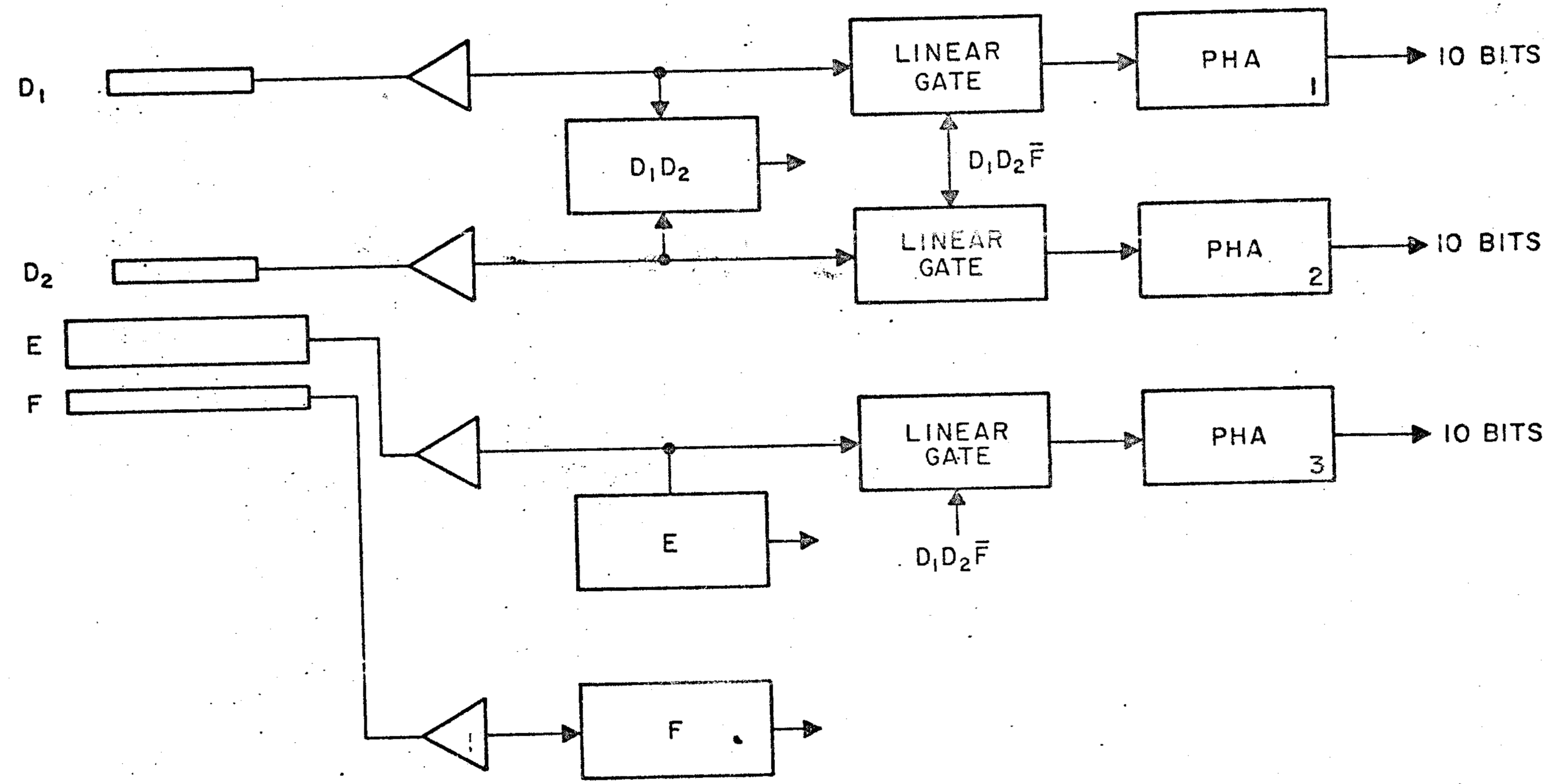
$AB\bar{C}_3$
$AB\bar{C}_3$ (A > 2 x MIN.)
ABC_3 (A AND C > 2x MIN.)
ABC_3

RATES

A (2 LEVELS)
B, C_1, C_2, C_3
$AB\bar{C}_1\bar{C}_2\bar{C}_3$ ⎫
$ABC_1\bar{C}_2\bar{C}_3$ ⎬ (2 LEVELS ON A)
$ABC_1C_2\bar{C}_3$ ⎪
$ABC_1C_2C_3$ ⎭

2 BITS REQUIRED TO IDENTIFY PRIORITY MODE.
1 BIT REQUIRED TO IDENTIFY PHA DATA AS H.E.T.
1 BIT REQUIRED TO DETERMINE IF PHA 2 ADDRESS IS B OR C_3
3 BITS REQUIRED TO IDENTIFY SECTOR.
1 BIT REQUIRED FOR RANGE.

FIG. 3
SIMPLIFIED HIGH ENERGY DETECTOR

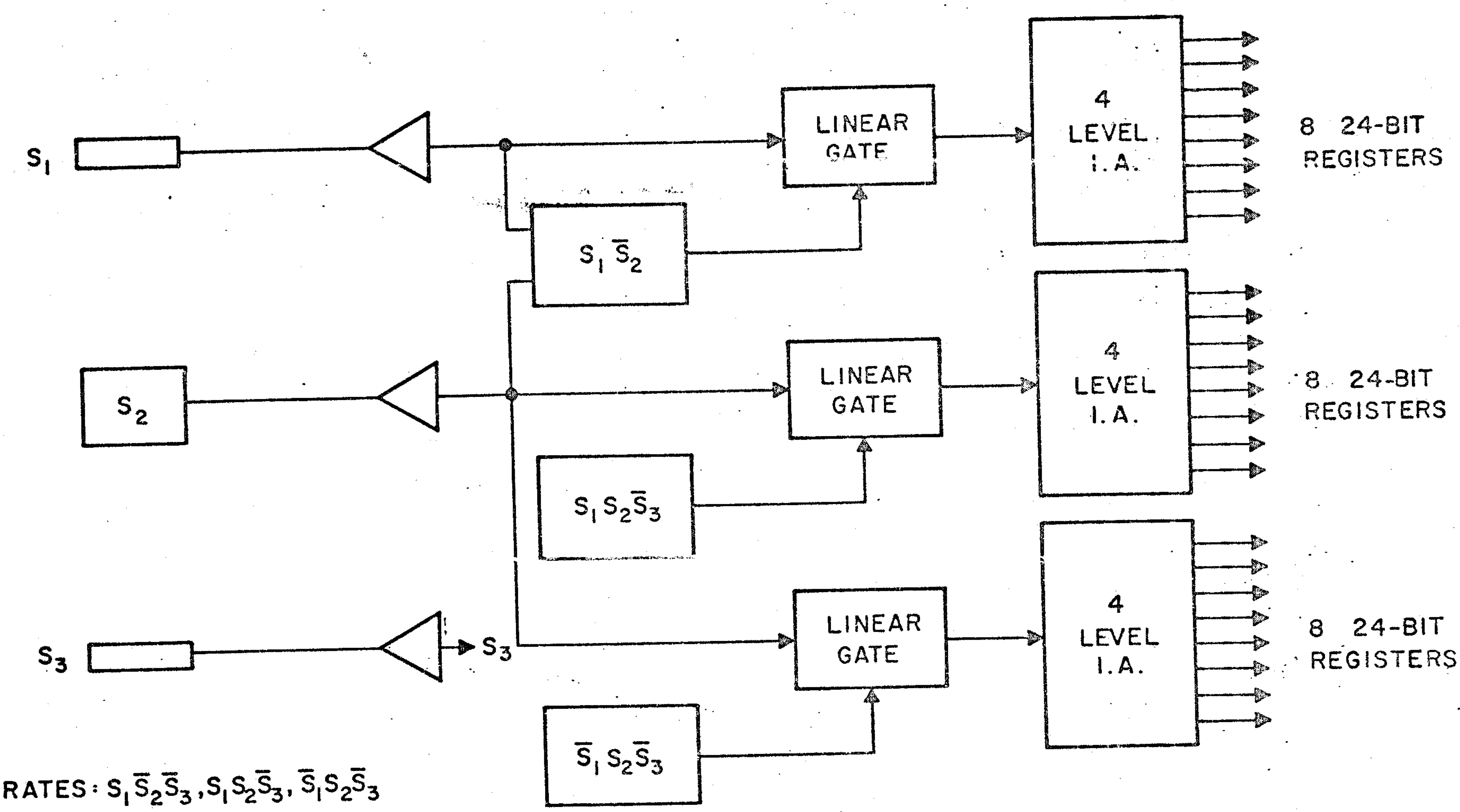


RATES
$D_1D_2(D_1+D_2)E\overline{F}$ (2 LEVELS ON E)
$D_1D_2E\overline{F}$ (2 LEVELS ON E)
D_1 (8 LEVELS)
$\overline{D}_1\overline{D}_2E\overline{F}$

2 BITS REQUIRED TO IDENTIFY PRIORITY MODE.
1 BIT REQUIRED TO IDENTIFY PHA DATA AS LET-I.
3 BITS REQUIRED TO IDENTIFY SECTOR.

FIG. 4
SIMPLIFIED LET-I DETECTOR

LOW ENERGY DETECTOR-II



RATES: $S_1\overline{S}_2\overline{S}_3$, $S_1S_2\overline{S}_3$, $\overline{S}_1S_2\overline{S}_3$

SECTOR x 8: $S_1\overline{S}_2\overline{S}_3$ LOW ENERGY PROTONS } 4 ENERGY LEVELS ON EACH ACTIVE TERM

$\overline{S}_1S_2\overline{S}_3$ ELECTRON SLICE

FIG. 5

A COSMIC RAY DETECTOR SYSTEM FOR THE ANALYSIS OF ENERGY SPECTRA, CHARGE COMPOSITION AND GENERAL FLOW PATTERNS OF SOLAR, GALACTIC AND JOVIAN ENERGETIC PARTICLES DURING THE PIONEER EARTH/JUPITER MISSION

~~KENNETH G. McCRACKEN~~
WILLIAM R. WEBBER
FRANK B. McDONALD
EDMOND C. ROELOF
BONNARD J. TEEGARDEN
JAMES H. TRAINOR

REVISED JUNE 1969

A Cosmic Ray Detector System for the Analysis of Energy Spectra, Charge Composition and General Flow Patterns of Solar, Galactic and Jovian Energetic Particles during the Pioneer Earth/Jupiter Mission

by

Kenneth G. McCracken
University of Adelaide

William R. Webber
University of New Hampshire

and

Frank B. McDonald
Edmond C. Roelof
Bonnard J. Teegarden
James H. Trainor
NASA/Goddard Space Flight Center

Revised June 1969

INDEX

		Page
I.	Introduction	1
II.	Scientific Objectives	5
III.	Detector System	14
IV.	Instrumentation	23
	Electronics	25
	Mechanical Systems	28
	Thermal Requirements	29
	Environmental Problems	29
	Commands, Telemetry Assignment	33
	Weight, Power	34
	Staff Assignment	34
V.	Data Policy	36
VI.	RTG Impact on Experiment	37

I. INTRODUCTION

The proposed Pioneer F and G mission offers a unique opportunity to study the extended regions of the interplanetary medium. Furthermore the possibility of approaching interstellar electromagnetic conditions must be contemplated and regarded with great interest. These points, coupled with the opportunity to study the Jovian environment, call for a carefully coordinated set of studies in each scientific discipline. In the field of energetic particles we have tried to design an instrument that will provide the maximum possible diagnostic power to examine the complex field-particle interactions occurring in the interplanetary environment as well as the Jovian magnetosphere.

To accomplish this we propose a coordinated set of two solid state detector telescopes to study charged particles. The telescopes are designated as:

a. the high energy telescope (H.E.T.),

b. two low energy dE/dx vs. E telescopes (L.E.T. I and L.E.T. II).

Charged particle spectra and angular distributions will be measured over an extended energy interval. These intervals are briefly listed below, and are shown graphically in Figure I-1.

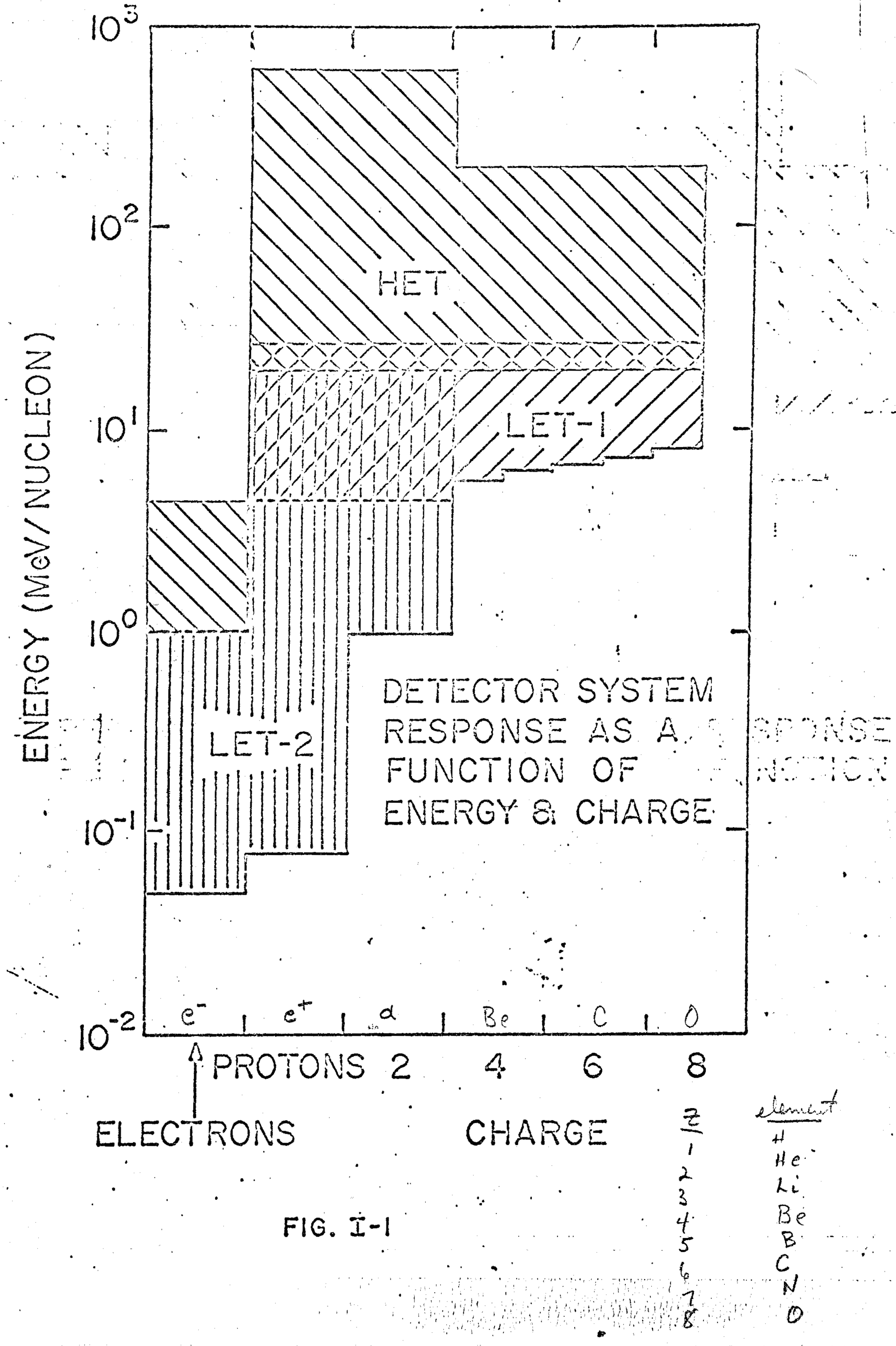

10^3
10^2
10^1
10^0
10^-1
10^-2
ENERGY (MeV/NUCLEON)
HET
LET-1
LET-2
DETECTOR SYSTEM
RESPONSE AS A
FUNCTION OF
ENERGY & CHARGE
e⁻
e⁺
α
Be
C
O
PROTONS 2
4
6
8
ELECTRONS
CHARGE
Z
1
2
3
4
5
6
7
8
element
H
He
Li
Be
B
C
N
O

FIG. I-1

Particle Component	Energy Range
Galactic cosmic ray protons	4.5 - 800 MeV
Solar protons	.05 - 800 MeV
Galactic cosmic ray Helium	4.5 - 600 MeV/nucleon
Solar Helium	1.0 - 600 MeV/nucleon
He^3/He^4, D/H	4.5 - 50 MeV/nucleon
Galactic and Solar Electrons	.050 - 5.0 MeV
Li, Be, B, C, N, O, F, Ne and their isotopic composition	6 MeV/nuc - 200 MeV/nucleon

Energy Ranges for Angular Distribution Studies

Hydrogen	.05 - 120 MeV
Helium	4.5 - 120 MeV/nucleon
Electrons	.05 - 5 MeV

The above measurements extend the work of the principal investigators on previous Pioneer vehicles as well as numerous studies on IMPs and OGOs. It is anticipated that each investigator will bring to bear his full experience on previous spacecraft in his area of competence. The collaborative effort already undertaken to design these telescope systems and prepare this proposal will be extended to the preparation and testing of the instruments and the analysis of of the data. The operational modes of each of the telescopes are as follows:

High Energy Telescope: The HET consists of a multi-element array of solid state detectors. For particles which come to rest within this stack (20 - 50 MeV/nucleon) three measurements are made - energyloss (dE/dx), total energy, and range. The simultaneous measurement of total energy and range provides a very powerful method for rejecting detector background, which is a particularly significant problem in this energy regime. The telescope is also designed to measure the energy and charge of particles which penetrate completely through the stack of solid state devices. In this mode three separate dE/dx measurements are made. Charge resolution for penetrating particles will be possible up to approximately 200 MeV/nucleon.

Low Energy Telescope I: The LET I is a double dE/dx vs. E. solid state detector. Two thin (100 micron) surface barrier detectors serve to define the geometry and to provide a double dE/dx measurement. A thick (2.5 mm) lithium drift detector provides a total energy measurement. LET I will cover the energy range from 3 to 22 MeV/nucleon. In this interval charge resolution will be possible from Z = 1 to 8. In addition angular distributions for different charge species and energies will be obtained.

Low Energy Telescope II: Two solid state detectors, one thin and one thick, are used individually and in coincidence as total absorption spectrometers. A third detector operating in an anticoincidence mode insures that only stopping particles are analyzed. The thin detector will respond to protons between 50 KeV and 3 MeV and electrons between 50 and 150 KeV. The thick detector will be sensitive to protons between 3 and 20 MeV and electrons between 150 KeV and 1 MeV, and in these latter energy intervals an unambiguous separation of protons and electrons will be possible. This telescope is intended to be primarily a monitor of solar particle fluxes.

We have developed these telescope systems specifically for a mission such as Pioneer F and G where a reliable operation over a period of several years is required. In particular the high energy telescope is self-calibrating. We refer the reader to section III for a more detailed description of the instrument.

II. SCIENTIFIC OBJECTIVES

This instrument is designed to exploit to the fullest practical degree the proposed orbit of Pioneer F and G. The significance of these measurements will be greatly enhanced by concurrent measurements with similar particle telescopes scheduled for flights on satellites of the IMP or similar series in near-earth orbits.

The principal scientific objectives of this experiment are:

1. To measure the flow patterns of energetic solar and galactic particles separately in the interplanetary field. To interpret this measurement, simultaneous determination of the energy spectrum, radial gradient, angular distribution, and streaming parameters is required for each nuclear species and over as wide an energy range as is practicable.

2. To measure the energy spectra, and isotopic composition of galactic and solar cosmic rays from the lowest practical energies up to $\sim$800 MeV/nucleon and (by use of objective 1) to unfold the primary flare and interstellar spectrum.

3. To measure the time variations of the differential energy spectra of electrons, hydrogen and helium nuclei over the corresponding energy intervals. During flare events, to obtain time histories; during quiet times, to relate gross time variations to those near earth thus deducing a spatial gradient for galactic cosmic rays.

4. To study the energy spectra, time variations and spatial gradients associated with recurrent and non-flare associated interplanetary proton and helium streams and to define the related solar

or interplanetary acceleration processes.

5. To provide information on the energetic particle distribution surrounding Jupiter.

6. To try and determine the extend of the solar cavity, the energetic particle phenomena occurring at this interface and the cosmic ray density in nearby interstellar space.

We shall now consider these scientific objectives in more detail and examine how they will be achieved by the proposed experiment system.

OBJECTIVE 1:

To measure the flow patterns of energetic solar and galactic particles separately in the interplanetary field.

The telescopes are designed with appropriate directional response to define the quiet time flow pattern of galactic (and probably solar) cosmic rays both in and out of the ecliptic plane.

Quiet-time: At high energies, the galactic particle streaming is expected to be negligible. At medium energies, the detailed angular resolution obtainable by sectoring the high energy telescope will allow comparison of particle flow patterns with the general field structure which collimates them. The directional properties of the low energy telescope will be helpful in sorting out a possible outward streaming quiet-time solar component at very low energies. The quiet-time flow patterns which the experiment will measure may be more complicated than currently thought (particularly at larger distances from the sun), possibly involving flow out of the ecliptic plane (unmeasured to date) and hence directional measurements pointing off of the ecliptic plane are essential. The net result will be an estimate of the cross circulatory pattern of cosmic rays in the solar system.

The radial gradient measurements will be made by monitoring the differential energy spectra of particle species throughout the flight and carefully correlating them with comparable data ~~simultaneously~~ recorded by ~~similar instruments near E~~arth. With a firmly established temporal "base-line" which removes solar cycle and flare event effects, a true spatial gradient may be derived. However, a direct estimate of the gradients of the separate species is available from the measurements of the streaming current and the energy spectrum made by the medium and high energy telescopes. Recent theories (Axford and Gleeson, 1967; Gleeson, 1969; Roelof, 1969) show that the gradient is linearly related to the particle streaming current through the diffusion coefficient of the scattering magnetic irregularities and to the solar wind velocity through the energy spectrum (the Compton-Getting effect). Since the spectrum will be measured in detail and the current flow may be derived from the velocity anisotropy measurements of the HET, the gradient may be estimated if the statistical parameters of the magnetic field are available. Thus an independent

where does this data come from

estimate of the gradient is available from spectrum, flow and field measurements, as a result of the velocity anisotropy sensitivities of the particle telescopes. The above considerations are particularly important for the separation of the solar and galactic particle population at low energies where a continuous low level flux of solar particles may greatly modify the features of the galactic particle gradient and spectrum.

Flare events: A fundamental problem relating to solar cosmic rays - that of deducing the flare particle spectrum and composition - requires isolation of the effects of interplanetary propagation. Early in flare events, the low and medium energy velocity anisotropies are extremely well correlated with the local direction of the magnetic field at 1 AU. As the orbit nears 5 AU the magnetic field structure may not be as well defined as near earth and flare particle velocity anisotropies could well be the best means of tracing out the connection of field lines back to the sun.

Measurements over a wide range of energies covered by the high, and low energy telescopes will provide tests of models of interplanetary propagation unavailable with only near-earth observations. Time histories recorded by similar detectors near earth and enroute to Jupiter will define the azimuthal spread of flare particles (or the radial variation when the spacecraft are on proximate field lines).

OBJECTIVES 2 & 3:

To measure the hydrogen and helium energy spectra and isotopic composition for galactic and solar cosmic rays in the charge range from the lowest practical energies up to ~800 MeV/nucleon.

To measure the time variations of the differential spectra of electrons and hydrogen and helium over the corresponding energy intervals.

Since the particle telescopes will cover two to three decades in energy for hydrogen and helium nuclei (and also electrons), demodulation of solar induced changes will yield extensive interstellar spectra for these particles. Of course, if the modulation region terminates within the Jovian orbit (as do, for instance, some comet-tail interactions), then the high charge and spectral resolution of the detector system is capable of directly obtaining detailed interstellar spectra.

Modulation theories can be critically examined by comparing the spatial dependence and time variations of spectra of particles with different charge to mass ratios such as protons/electrons, protons/alphas, and the He^3/He^4 with solar wind velocity and magnetic field measurements.

However, current ideas on modulation which describe it in terms of a statistical interaction with a spectrum of magnetic irregularities may be incomplete by not including the effects on energy loss as has been suggested by recent theoretical and experimental work (Webber, 1968; Roelof, 1969). If this is so, the measurement of the energy spectrum over a large range of energies but particularly at low energies, (including electrons) will be invaluable in separating energy loss processes from simple diffusion processes. This "local" energy loss may mask the ionization energy loss occurring in interstellar space. In the latter, ionization losses (which vary as Z^2) predominate at low energies, while in the former interactions are with the interplanetary electromagnetic field (which current theory predicts vary only as Z). Thus the variation with distance from the sun of the lower end of the energy spectra of different elements may be the only definite test of the magnitude of the local modulation. The question is, of course, a very important one, since the interstellar spectra contain the interstellar propagation history and source spectra of galactic cosmic rays. The derived interstellar charge and isotopic composition and energy spectra will be a stringent test of theories of cosmic ray origin.

OBJECTIVE 4:

To study the energy spectra, time variations and spatial gradients associated with recurrent and non-flare associated interplanetary proton and helium streams, and to define--the related solar or interplanetary accleration processes.

The low energy telescope will be particularly useful in monitoring and examining the anisotropies associated with the wide variety of non-flare associated low energy proton, helium and electron events at positions away from earth: These include energetic storm particle events (Bryant et al, 1962; Rao et al, 1967), recurrent and long lived particle streams (Bryant et al, 1965), and active center associated events (Fan et al, 1968; Anderson, 1969). These provide evidence for continuous acceleration processes on the sun or in interplanetary space which may be similar to small-scale flare acceleration or could be an entirely different process. Only with spacecraft both near earth and in interplanetary space can spatial and temporal variations be separated so that the evoluton of these events can be followed throghout their lifetimes (which may be several solar revolutions).

OBJECTIVE 5:

To provide information on the energetic particle distribution surrounding Jupiter.

The proposed trajectories for Pioneers F and G, the proposed spin axis alignment, and the look angle directions of the detectors are ideal in terms of studying the Jovian radiation belts with this set of detectors. Jupiter offers the unique opportunity in that it has the only other known planetary magnetosphere in our solar system. In a sense it offers the opportunity for a "second point on the curve;" a chance to study the generation, acceleration and loss of particles in a magnetosphere with different boundary conditions from that of the earth. Estimates for the boundary of the Jovian magnetosphere on the Sun side range around 40 Jupiter radii (R_J). It is probably not unreasonable to expect that the Jovian magnetosphere also possesses an extended tail.

We expect that this experiment can provide a variety of rapid proton and electron flux measurements, together with pitch angle distributions and rapid 8 channel spectra in the low and medium energy regimes deep within the Jovian magnetosphere. Much of this information could not be supplied by a typical trapped radiation detector sized for a 3 R_J pass because of the detector geometrical factor which is several orders of magnitude smaller. The low energy telescope detector system can handle penetrating fluxes approaching 5 x 10^5 particles/cm^2-sec-ster before pulse pile-up becomes a major correction problem.

OBJECTIVE 6:

To try to determine the extent of the solar cavity, the energetic particle phenomena occurring at this interface and the cosmic ray density in nearby interstellar space.

The termination of the modulation region is a lower bound on the extent of the solar plasma, and a useful one since the extent is presently uncertain within (at least) an order of magnitude. By careful analysis of the energy spectrum flow pattern and gradient throughout the flight, such a termination may be detected if it is $\leq$ 10 AU from the sun.

CORRELATED MEASUREMENTS:

Correlation with near-earth particle measurements. The spatial/temporal structure of solar and interplanetary events can only be deduced from continuous monitors at a variety of radial and azimuthal locations. Co-rotating particle streams, interplanetary plasma shocks and Forbush decreases are obvious examples in addition to customary flare events. Quiet-time fluxes measured on the outward journey cannot be interpreted in terms of a galactic gradient unless a sound "base-line" for the solar cycle-dependent time variation of fluxes can be derived from comparable detectors in near-earth orbits. Fortunately such detectors are scheduled for a concurrent period on IMP H, J and K.

Correlation with on-board magnetometer and plasma measurements. The strong collimation of solar particle flow along magnetic field lines during all but the late phases of solar flare events is well established near 1 AU. However, at 5 AU the field may be quite tangled due to the "winding up" of the Archimedean spiral field; it would make an average angle of $\sim 80^{\circ}$ with the solar radius vector. If the field at this distance is more disordered than at earth, the reverse situation to that at the earth may hold; angular flare particle distributions may aid interpretation of complicated magnetic field measurements. The need for associated magnetic field measurements in interplanetary shocks and Forbush decreases is self-evident. Recent theoretical work (Gleeson, 1969; Roelof, 1969) has shown that the average magnetic field direction governs the flow of quiet-time particles, so simultaneous particle-field observations are required.

when does mag field data come from

III. DETECTOR SYSTEM

A set of 3 solid state detector telescopes is proposed to accomplish the scientific objectives listed above. We shall now discuss these telescopes in some detail and how the measurements are coordinated to provide a comprehensive and redundant set of cosmic ray measurements. The redundance of the separate sets of measurements as well as the self-calibration are important features of the system we are proposing. It is a total necessity in view of the prolonged nature of the Pioneer F and G missions and the controversy that currently exists over the interpretation of gradient and anisotropy measurements made in the 0.7 - 1.5 AU interval.

High Energy Telescope:

The high energy telescope is a three element array (figure III-1). Two of these elements are single lithium drift detectors, 300 mm^2 area and 2.5 mm thick. The third element is a stacked arrangement of five 850 mm^2, 2.5 mm thick lithium drift detectors. This telescope has two basic modes of operation - penetrating and stopping particle modes. For penetrating particles differential energy spectra are obtained for helium and hydrogen from 50 - 800 MeV/nucleon. The stopping particle mode covers the range from 22 - 50 MeV. We will consider each of these modes separately.

High Energy Mode:

The primary mode of operation is triggered by a particle traversing

A, B and the complete C element as identified by ABC_3 coincidence. The quiet time distribution of galactic cosmic rays is such that a well defined minimum ionizing peak is obtained from A, B and C. The position of this peak in both the proton and alpha particle region provides a self-calibration feature which allows for the detection and correction either in the detector or associated electronics.

This detector can measure the quiet time flux of galactic cosmic ray protons inthe region 20 - 800 MeV. The ability to perform such a measurement has been amply demonstrated by the analysis of the August 1961 quiet time data from Explorer XII. Since the relative calibration throughout the flight can be determined within 4%, it is felt that the flux changes greater than 3% can be detected in the 20 - 400 MeV region. In the interval 400 - 800 MeV long term flux changes greater than 5% can be measured. The detector system proposed here has a factor of ~1.8 improvement in resolution over that of the Explorer XII telescope. This should lead to a well defined alpha peak (which we now detect in our OGO V $(dE/dx)^3$ telescope). This will provide information on the relative flux of alpha particles inthe region 20 - 800 MeV/nucleon.

In the energy range 20 - 120 MeV/nucleon it is possible to identify the direction the particle traverses the telescope. This makes it possible to measure angular distributions over this interval. An accurate intergral flux of both hydrogen and helium above 800 MeV/nucleon is also determined. Differential spectra will be measured between 120 and ~800 MeV/ nucleon.

The look angles for this telescope are defined by figure IV-4. There are two primary constraints set by this position of the experiment which are also discussed in the environment section:

a. There must be a bi-directional look angle. The experiment can tolerate ~.050 g/cm^2 of additional material in the forward direction, and .25 gm/cm^2 in the back direction.

b. The maximum temperature must be less than 40°C. Consideration will be given to providing micrometeorite shielding after consultation with the project.

Stopping Particle Mode:

Stopping particles are identified by the coincidence requirement $AB\overline{C_3}$. This covers H and He from 20 - 50 MeV/nucleon and electrons from 1 - 5 MeV. The A and B detectors define the particle acceptance cone while the stacked array, C, measures both the residual energy and the range.

All elements in the telescope are pulse height analyzed. There are four measurements for each event, 2 dE/dx, residual energy and range, while there are 3 dE/dx measurements for penetrating particles. This provides the ability to use selection techniques to improve resolution and provide discrimination against unwanted spurious events. We believe that this improvement in resolution may be sufficient to allow us to resolve the isotopes of H and He. We, further, believe that this combination of dE/dx, E and range totally eliminates the need for a "guard" counter. On IMP-IV we have flown a three element E vs. dE/dx where the anti-coincidence requirement is relaxed on alternate readouts. With the anticoincidence relaxed adequate resolution is obtained in the

H and He range from 4.5 - 22 MeV/nucleon. With the addition of a well defined aperture, and the particle range we feel confident that the added complexity of a "guard" counter would not offer any improvement in detector resolution.

We have supplemented the pulse height data with a number of different rates. The rate data has two important uses. They should provide a method for determining energy spectra of solar cosmic rays on a very short time scale. They will also provide a means of measuring the anisotropy of these particles on a short time scale by sectoring some of the rates.

The telescope is essentially self-calibrating. For example, the measurement of residual energy and range allows us to accurately determine end-points for various particle species in each element of the range array. The A element can be calibrated in-flight for stopping particles in the usual way.

2. Low Energy Telescopes: (LET I)

The low energy telscope (LET I) is a three element dE/dx vs. E detector sensitive to protons and higher Z particles in the range 3 to 22 MeV/nucleon. The telescope is designed to measure both energy spectra and angular distributions over this energy interval. This represents a modification of the previous LET design to take into account the effects of an isotope power supply.

The detector configuration is shown in figure III-2. Detectors D_1 and D_2 are identical silicon surface barrier devices each 100 microns thick. They serve the dual purposes of defining the geometry of the detector telescope and also providing a redundant double dE/dx measurement. Detector E is a lithium drifted silicon device 2.5 mm in thickness. It serves as a total energy measuring element. The F detector, a 1 mm thick lithium drifted silicon device, simply acts as an anticoincidence. Events of the type $D_1D_2\overline{E}$ and $D_1D_2E\overline{F}$ will be analyzed. The $D_1D2\overline{EF}$ events correspond to protons between 3 and 5 MeV whereas the $D_1D_2E\overline{F}$ events include the 5 to 22 MeV range for protons.

An important innovation in this telescope (as in the HET) is the absence of a guard counter. With our well-defined geometry and redundant dE/dx measurements the background intensity should be minimized. In addition the low mass, and small geometry for particles entering the E element from the side will further reduce background levels relative to larger, more massive detectors flown in the past. This technique allows us to do away with the weight and power consuming photomultiplier-scintillator systems used in the past.

This low energy telescope will cover the charge range Z = 1 to 8 (excluding electrons). This will require circuitry having a single linear region with a dynamic range of 1000.

State of the art technology will be used with all solid state devices. This laboratory has had a great deal of experience with such detectors used in spaceflight applications. Overall system noise levels (detector + electronics) should be in the neighborhood of 30 KeV for each detector. The minimum energy losses of interest will be ~400 KeV. This then gives us a worst case resolution better than 10% FWHM. Precautions will be taken to minimize the effects of radiation damage. In all cases fully depleted devices having electric field strengths in excess of 150 V/mm will be used.

We intend to sector several rates from the LET I. Division of the data into 8 equal sectors will be commensurate with our viewing cone half angle of 25°. To obtain an angular scan we require mounting such that the LET look direction is perpendicular to the spin axis of the spacecraft.

A priority system will be incorporated into the electronics to give preferential coverage to the rarer events e.g., alpha particles, heavies. During large solar events the detectors will almost certainly be readout limited. The priority system will select these rate particles for analysis thus artifically enhancing the fraction of alpha particles and heavies in our data. Of course, rate counters will allow us to determine the true ratios of these particles in interplanetary space.

This detector, like the HET, will be self-calibrating. In addition the detectors will be designed such that an overlap in the individual energy responses of the detectors will exist. This will allow cross calibrations between detectors.

3. Low Energy Telescope: (LET II) (only rate info)

This low energy detector system is designed to study very low energy protons and electrons in interplanetary space. Studies in interplanetary space will be primarily limited to particles of solar origin. Energy spectra and angular distributions are measured. A schematic of the detector is shown in figure III-3.

There are three elements:

S_1	100μ	-	$50\ mm^2$ Silicon Surface Barrier
S_2	2 mm	-	$50\ mm^2$ Lithium-drifted Silicon
S_3	1 mm	-	$200\ mm^2$ Lithium-drifted Silicon

The S_1 thickness was chosen to minimize the electron response without making an unreasonable sacrifice in the detector performance. A total resolution of 15 - 20 KeV will be easily attainable. We have determined in the laboratory that specially constructed detectors of this type are insensitive to sunlight. Using this technique, we can have detectors exposed to sunlight with proton thresholds of 75 KeV. Mechanical collimation is used to limit the detector's field of view to $\pm$ 15° and thus provide a reasonably fine grained measurement of angular distributions.

The top detector S_1 will stop electrons in the range 50 - 150 KeV and protons in the range 50 KeV - 3 MeV. The S_2 detector will respond to electrons in the energy interval 150 KeV - 1 MeV and the proton interval is 3 MeV - 20 MeV. Stopping alphas in the S_1 detector will have a unique response from 1 MeV - 3 MeV/nucleon for solar alpha events.

The proton and electron responses for the very low energy system are summarized in figure III-4. Note that the electron response curves are idealizations and do not include the effects of electron scattering which are significant at these energies. We have calibrated similar detectors in 50 KeV and 2 MeV electron beams.

There are three basic operating modes for this system that are specified by the following logic:

$S_1\overline{S}_2\overline{S}_3$	50 KeV $< E_e <$ 150 KeV 50 KeV $< E_p <$ 3 MeV	/ 8 levels
$\overline{S}_1S_2\overline{S}_3$	150 KeV $< E_e <$ 1 MeV/ 8 levels	
$S_1S_2\overline{S}_3$	3 MeV $< E_p <$ 20 MeV/ 8 levels	

where E_e = electron energy and E_p = proton energy.

The advantages of this system are twofold:

1. The double valued response of the usual one-dimensional detector is eliminated by removing all penetrating particles.

2. Electrons and protons are unambiguously separated over a significant energy range.

Each of the three logic modes is connected to an 8 level integral analyzer. This should provide ample energy resolution for spectral measurements.

It is proposed that two levels for each logic mode be sectored. This might be as follows:

$S_1\overline{S}_2\overline{S}_3$	50 KeV $< E_p <$ 3 MeV 500 KeV $< E_p \leq$ 3 MeV
$\overline{S}_1S_2\overline{S}_3$	150 KeV $< E_e <$ 1 MeV 500 KeV $< E_e <$ 1 MeV
$S_1S_2\overline{S}_3$	3 MeV $< E_p <$ 20 MeV 10 MeV $< E_p <$ 20 MeV

We have allocated the weight and power for the sector accumulators in the weight and power budgets.

A detector of the S_1 type has been integrated into the IMP-G spacecraft by the Goddard Space Flight Center group. A system of the type $S_1\bar{S}_3$ has already been developed with all logic elements designed for IMP-"eye". This includes both 8 level analyzers and sectoring. We are merely adding S_2 to an already developed detector.

The proposed mounting schemes are shown in Figure IV-4. The viewing angles are obtained should allow the determination of complete pitch angle distributions from 1 - 5 AU.

IV. INSTRUMENTATION

A. Introduction:

The instrumentation described here uses existing, proven, low power circuitry with some available improvements in semiconductors and, in general, more efficient and lighter packaging. Our flight experience with similar equipment in the past several years is consistent with the required lifetimes for these missions. We will approach the description of the instrumentation by describing the operation of each of the telescopes first, followed by a description of the individual circuits, the data system, parts, the mechanical system, thermal requirements, environmental problems, the spacecraft interfaces, quality assurance provisions, and the weight and power analyses.

B. Low Energy Telescope II:

Figure IV-1 is a simplified block diagram of the detection system and shows the logical conditions. The charge signal from each detector is integrated and converted to a voltage pulse, then shaped and amplified; discriminators fire if their thresholds are exceeded, providing the inputs to the various logic circuits; and if the conditions are met, the proper linear gate is opened, and the signal is analyzed into one of 8 channels by the integral analyzer.

A 24 bit register accumulates the data for each channel of each analyzer. Additionally, two more registers are used to monitor the rates $S_1 \overline{S}_2 \overline{S}_3$, $S_1 S_2 \overline{S}_3$ and $\overline{S}_1 S_2 \overline{S}_3$, and 8 more are shared in accumulating sectored (x8) information for $S_1 \overline{S}_2 \overline{S}_3$, $S_1 S_2 \overline{S}_3$ and $\overline{S}_1 S_2 \overline{S}_3$.

LET-I: (Figure IV-2)

As with the LET-II, charge pulses from each of the solid state detectors are converted into voltage pulses by low noise charge sensitive preamplifiers. The outputs of threshold circuits for the D_1, D_2 and F elements are fed into logic circuitry which produces a pulse when the $D_1 D_2 \overline{F}$ condition is met. This pulse is in turn used to open the D_1, D_2 and E linear gates. Each of the analog D_1, D_2 and E pulses are then fed into three 1000 channel pulse height analyzers. Ten bits will be required for each PHA and two bits for priority level identification, plus an additional bit to identify this group as data from LET-I. This is necessary since we share the differential pulse height analyzers between LET-I and the HET. One 8-level integral analyzer is shared between D_1 and $\overline{D}_1$ $\overline{D}_2$ E $\overline{F}$. Sixteen accumulators are shared between the various rates and sectored rates.

C. High Energy Telescope:

Figure IV-3 is a simplified block diagram of this system, and the logic is shown. Again each detector has its own charge sensitive preamplifier, shaping amplifier and threshold discriminators. Detectors A, B, and C_1 - C_3 each have two threshold discriminators selecting protons, and He and above, respectively.

To discuss the logical arrangement, consider a particle entering through A, B. Pulse height analyzers 1 and 3 analyze the A and $\sum_1^2 C_N$ pulses respectively, while PHA 2 analyzes B or C_3, depending on whether one has a penetrating event (C_3) or not. In addition to the three 10 bit addresses associated with an HET event, we require 2 bits to identify the priority mode; 1 bit to identify the data as HET; 1 bit to determine if the PHA 2 address is B or C_3; 1 bit to determine if C_2 was penetrated (range); and 3 bits to identify the spin sector in which the event occurred. The time-shared priority modes listed on Figure IV-3 refer to stopping particles ($AB\overline{C}_3$), stopping heavies ($AB\overline{C}_3$, thresholds for He and above), penetrating heavies ABC_3 (A and C_3 > 2x minimum), and all penetrating particles (ABC_3). The many rates listed will be internally commutated into registers.

Note that while PHA 1, 2 and 3 are shown both on Figure IV-2 and Figure IV-3, there are in fact only three differential pulse height analyzers within the experiment and they are block shared between the HET and LET-I.

D. Electronics:

1. Charge Sensitive Preamplifiers: The charge signals from each solid state detector are integrated and converted to voltage pulses in these amplifiers which are similar to the units used successfully on IMP's F and G and OGO-F. While the existing noise performance easily exceeds the requirements of any of the detectors, modifications have been made in some units to accommodate the very wide range over which linear response is required.

2. Shaping Amplifiers and Linear Mixers: The voltage signals from the preamplifiers are shaped by actively differentiating, integrating and differentiating at equal time constants while being amplified as necessary. The time constants will probably be chosen to be ~ 0.8 μsecs, allowing for the charge collection time for some of the thicker detectors

while still giving adequate signal-to-noise and high count rate capability. The High Energy Datector also requires a linear mixer to sum C_1 and C_2 linearly for pulse height analysis.

3. Discriminators and Logic Circuitry: Very stable, tunnel diode discriminators are used as threshold devices to set up the required logic conditions amongst the various detectors. We have used these circuits extensively in the IMP and OGO series. The coincidence/anticoincidence logic which follows is quite conventional.

4. Pulse Height Analyzers: Fast integral pulse height analyzers are required for LET-I and LET-II. The 3 differential pulse height analyzers required are our standard units using a 2MHZ ADC. Conversion will be to 10 bits. The pulse height analyzer consists of a linear gate, buffer amplifier, delay circuitry and the A to D converter.

5. Data System: This experiment uses an extensive digital data system to acquire the mass of spectral and flux information required. Nonetheless, the system is low weight and low power. The basic building-block used throughout the system is an 8-bit counter with companion 8-bit shift register, transfer gates and control logic. One of these is used to accept each ADC output directly and together with the gain change bit, makes up a 9-bit pulse height word. Three of the basic blocks are connected together to form a 24-bit counter for the rate channels, and the interconnect of the shift register allows for logarithmic compression to 10 or 12 bits. The inclusion of a shift register for each counter register allows us to take data based on timing or sectoring information and store it in the shift register to

await telemetry. The same MOS technology proposed here has been proven by > 300 million device hours in space on IMP's D, E, F and G with only 2 possible device failures. Analysis has shown that it is improbably that the failure was in the MOS device in these cases. They are extremely reliable devices. The circuit layout and interconnect are exactly those which have been used on IMP-I. A larger chip containing the circuits of three present chips is currently undergoing qualification testing for use on IMP H and J and the Planetary Explorers. If the qualification continues successfully, we would plan to use the larger devices to simplify the interconnect and give us more weight margin.

6. Power Supplies: The experiment will require approximately six low voltages to supply the electronics systems and five higher voltage biases for the solid state detectors. These will range from ~ 25 volts to ~ 600 volts with a capability of up to 5 μ amp per detector.

7. Sectoring System: Since Pioneers F & G will supply sectoring pulses, we will use the see-Sun/Star pulse and the x8 pulses to generate electronically 8 equal sectors in the rotation of the spacecraft, organized around the detectors see-Sun/Star.

8. Solid State Detectors: All devices included in this proposal are commercially available devices which are procured to our rigid specifications. They are then tested and analyzed in our special laboratories. Our experience with these devices over the past 4 years in OGO and IMP experiments has been excellent. Other experimenters have had greater than 5 years successful flight history on a large group of these devices (Williams et al., 1963 38C). The extensive testing of these devices in severe radiation environments by a group at the Goddard

Space Flight Center (Love, Trainor and Williams) and the National Bureau of Standards (Coleman), has resulted in much new knowledge on how to best use these devices (Coleman, Love, Trainor and Williams, 1968a; 1968b). This work is continuing, as is the collaboration with Dr. Joseph Coleman of NBS. When purchased from a reliable company to a stringent specification and when carefully tested and analyzed, we have shown that these devices are excellent and reliable particle detectors for space research.

E. Mechanical Systems:

Our proposed mounting for the experiment detector systems is shown schematically in Figure IV-4. LET-I and II are unidirectional and look out perpendicular to the spin axis as shown. If there were a need to tilt them towards the spin axis in the away-from-earth sense, in order to avoid a possible solar array or boom, this can be done.

On the other hand, the HET is bi-directional in its response, and can tolerate only ~ 0.050 gm/cm^2 of material forward of detector A, and ~ 0.25 gm/cm^2 in the back direction. Actually we intend to use a multiple thin titanium foil approach, as has proven successful on IMP and OGO. As shown in Figure IV-4(B), the detector assembly must be in some sort of bubble or enclosure outside the main body in order to get the clear look angles. Additionally, if we were mounted on face 1 (Figure IV(A)) and a boom was also extended away from this face, then we would have to cant the detectors look cone to the right or left to avoid the obstruction.

The specifics of the mechanical mounting (for the detector assemblies) are quite unclear in our minds at this time, since spacecraft drawings are not available. Conversations with the engineering representatives of the Pioneer project office have led us to assume that our detectors will be mounted to our honeycomb baseplate which extends from the main body of the spacecraft. The entire assembly will be enclosed by a bubble or a box of some sort. We have included the weight of the honeycomb baseplate within our weight analysis.

We estimate the electronics systems will require $\sim$ 300 cu. in. with a large number of form factors available. The actual form taken can be determined in order to efficiently use the available space. In view of the large number of wires carrying low noise signals from the detector assembly, it is clear that it is necessary for the main electronics assembly to be quite close to the detector assembly.

Thermal Requirements

The absolute maximum temperature must be less than 40°C to insure long life for the solid state detectors. The Pioneer F & G compartment specification of -20° to +90°F is acceptable, but we would prefer a -10° to +20°C region if a choice is available. The performance of our detectors and electronics are such that changes due to temperature over these ranges are not observable in the data.

G. Environmental Problems:

In addition to possible problems with micrometeoroids which we have already discussed, the possible problems of radiation damage concerned with the Jovian encounter must be evaluated. Since this is intimately involved with the trajectory, we can begin by saying that we feel the trajectories outlined for Pioneer F and Pioneer G in P-200 are excellent choices. Additionally, the high energy electron belt predictions by Eggen are probably conservative. However, the proton predictions Eggen which are repeated in P-200 are derived in a much different fashion and are subject to huge uncertainties. In short, we have no confidence that the protons will be limited to a belt as suggested in Section 4.2.2 of P-200 but expect to find them throughout the region where the electrons are shown as well. At this time we know of no one who has been able to predict the details of such a proton belt. Additionally, while Eggen's proton model deals with protons from 100 KeV to 4 MeV, we are much more concerned with the protons from ~ 4 MeV to ~ 100 MeV, for instance.

The two most sensitive devices within this experiment to radiation damage are the detectors themselves and the MOS transistors in the data system. Integration of the electron fluxes shown in Figure 4.2.2 of P-200 leads to an integrated worst case flux greater than ~ 5 MeV of $\lesssim 10^{11}/\text{cm}^2$. This can be compared with an acceptable fluence of $\sim 10^{14}/\text{cm}^2$ of penetrating electrons before damage effects become noticeable at all for our solid state detectors. Since we have no energetic proton flux predictions, we can only calculate what is required to do damage to our detectors. Detailed radiation damage testing on solid state detectors has been carried out at the Goddard Space Flight Center over the past two years and is continuing in conjunction with the National Bureau of Standards. This work has led to two recent, comprehensive papers (Coleman, Love, Trainor and Williams, 1968a; 1968b). For protons less than ~ 1 MeV, we can easily tolerate an integrated flux or fluence of 10^{17} protons/cm^2 in the way in which we operate the detectors. For protons with energies greater than 4 or 5 MeV, our detectors could tolerate a fluence of at least 10^{13} protons/cm^2 before any noticeable effects occurred. The Eggen proton model predictions would be several orders of magnitude below these limits for a Pioneer F or G trajectory, but as previously noted, we have no faith in that model. Thus, while it seems that we have a comfortable margin, the fluxes there will be known only when someone sends an instrument there.

The case for the MOS transistors is somewhat more complicated. They are better shielded than the solid state detectors, so that probably only protons with energies greater than ~ 30 MeV or electrons with energies greater than 3 MeV will penetrate. Much of the solid angle will be shielded even from more energetic particles. With this in mind, we estimate that the electron damage effects will dominate, just as in the case of a system orbiting in the Earth's radiation belts. Detailed work done at the Goddard Space Flight Center on the radiation damage effects of penetrating electrons on these MOSFETS has shown that they can tolerate $\gtrsim 10^{12}$ electrons/cm^2 of several MeV before gate threshold effects begin to affect circuit performance. Flight experiments on IMP D, E and especially F have shown that the degradation effects measured in space for a given fluence have been smaller than those measured in the laboratory for the same fluence (Wolfgang, 1968). This may be due to rate of irradiation effects on the ground or possibly annealing. In any event, it again seems that we have a comfortable margin, probably much greater than an order of magnitude.

Of more concern to us at this time is the problem of "maverick" semiconductor devices ragardless of their type. Since we will be going into a radiation regime more severe than we normally have to contend with, the problem may be severe. By the word "maverick" we refer to those semiconductor components who individually are orders of magnitude more sensitive to the radiation damage effects of a given fluence than the mormal device of that type. The data available to use (New Moons Program for the use of RTG's in space) suggests that this is particularly a problem with bipolar transistors and junction diodes. Our approach here has been to design an electronics system that has many parallel paths leading to data output to the spacecraft, so that a particular device failure leads to a minimum loss of information from the experiment. Alternatively, if desired by the project, we could use semiconductors which have been screened by radiation exposure and test in order to discover such "mavericks.'

H. Electromagnetic Interference:

Our past experience leads us to be confident that this experiment will not be a source of electromagnetic interference. Similarly, we are able to build this experiment so that we are virtually immune to such interference. As an example, one of us has a solid state detector experiment with thresholds set at 30 KeV and seeing no interference on OGO-F, one of the dirtiest spacecraft from the point of view of electromagnetic interference.

I. Commands:

In addition to the normal power command, we anticipate the use of two other commands in controlling various modes of the experiment. We are assuming that the sharing of telemetry with Filluis et al., will not require a command by this experiment.

J. Telemetry Assignments:

Our implementation of this experiment leads to a desirable experiment data word of 12 bits. The data scheme worked out at the April 1969 Working Group Meeting was to assign a 12-bit block/frame to this experiment alone and to assign an additional, sequential, 27-bit block to this experiment when the Univ. Cal. trapped radiation experiment is not on. It is anticipated that the Univ. Cal. experiment will be on short time each day when possible, and on all the time at encounter.

We require that the 12-bit block precede the 27-bit block, and that we be furnished an "anticipate pulse" beginning one or two words before our 12-bit word gate. This anticipate pulse tells the experiment to stop data computations/transfers and freeze the data in the output registers in anticipation of readout. Similarly, we prefer the 27-bit block to come to us as a 12-bit gate word plus a 12-bit gate word plus a 3-bit gate word.

Internal to the experiment, we will commutate the various pha addresses and the many rates into a synchronized sequence of 12-bit words which are read out as one word per frame or three words per frame depending on whether the Univ. Cal. experiment is on or off respectively.

For housekeeping and status measurements, we require 4 analog subcom words, 1 digital subcom and one bi-level indicator.

K. Weight Analysis:

Our assignment of 4.3 pounds still appears to be adequate, but with some uncertainty in view of the many unknowns of the mechanical mounting schemes. Additionally, as pointed out in our original proposal, our developed, proven circuitry uses many parts which are not on the Pioneer Parts List, and changes in many of these parts will significantly affect the weight. Most of the data system is to be built using MSI/LSI MOS. Most of the linear circuitry will be built using thick film substrates. Efficient packaging of these thick film circuits requires the use of low profile, dual transistors in TO-89 ceramic packages, for instance. A very detailed parts list, parts qualification and weight analysis is in preparation.

L. Power Requirements:

Based on a 28 volt, 1% power source to drive the converters, we calculate the required power from that 28 volt bus as 2.2 watts.

M. Project Engineer:

As defined in Document P-200 of the Ames Research Center, the Project Engineer for this experiment is Donald Stilwell, Code 611, Goddard Space Flight Center.

N. Quality Engineer:

Mr. Harry Doyle, Code 312, Quality Engineering Branch, GSFC, has been assigned temporarily to oversee the quality engineering aspects of the experiment. The work of he and his associates to date has consisted of a thorough review of the extensive Pioneer quality specifications. Permanent assignment of a Goddard Q. E. engineer to this experiment will have to await center manpower reviews which should be complete in early August, 1969. If Code 312 is not able to supply the engineer, then we will contract for the support.

V. DATA POLICY:

In Section I under "Correlative Studies" we indicated the importance of knowing the magnetic field magnitude and direction. In addition the solar plasma density and velocity would be important. We would propose making portions of our data available on a short time scale or perhaps on the original data tape. In return we would like to obtain similar averaged quantities from the plasma and magnetic field experiments.

VI. Effects of RTG

We understand that there is a definite possibility that a radioisotope power supply (RTG) will be used as the spacecraft power source on Pioneers F &G. To determine whether radiation from the RTG would impair the operation of our detectors we exposed some sample detectors similar to those we will use in flight to the radiation from a SNAP-27 generator at TRW Systems. The devices used were a 25 mm^2 area, 50 micron thick silicon surface barrier detector and a 500 mm^2 area, 3 mm thick lithium drift detector. Pulse height spectra were taken at various distances from the RTG. Integral count rate for these devices at a distance of 10 ft. (the most probable distance in the spacecraft) are shown in Figs. VI-1 & VI-2. The effects we expect on each of our detectors are outlined as follows:

1. HET: The data in Fig. VI-1 from the lithium drift device is relevant for the HET. From this data we expect that no effect will be seen in the coincidence mode of operation of the telescope (50-500 Mev/nucleon). The background intensity from the RTG is much too small to produce any accidental coincidences. We expect, however, that single rates in all elements of the telescope will be affected. Our lowest threshold in these devices will be $\sim$ 100 kev. From Fig. VI-1 the count rate above this threshold from the RTG will be $\sim$ 60 cts/sec. A factor of four reduction in this intensity may be possible by proper orientation

of the RTG giving a rate of ~ 15 cts/sec. One of the functions of the single rates is a monitor of detector performance. The increased detector background from the RTG will probably eliminate this as a useful function. In addition the sensitivity of this rates to small solar events will be reduced.

2. LET-I: The effects of the RTG on the LET-I will in general be similar to those on the HET. The coincidence mode (3-20 Mev/sec) will not be affected, but the usefullness of the singles rates will be significantly reduced.

3. LET-II: The data in Fig. II-2 (corrected for differences in detector area and thickness and RTG orientation) predict ~ 1 ct/sec for a 50 kev S_1 detector threshold. The detector sensitivity to protons in the .05 - 3 Mev interval ($S_1 \bar{S}_2 \bar{S}_3$) will then be reduced. The most serious problem occurs for electron measurements in the S_2 detector. RTG background will probably be of the order of 5 cts/sec. This will certainly eliminate the possibility of galactic electron measurements in the .15 - 1 Mev interval and also reduce the sensitivity to solar electrons.

In summary, we expect no difficulties with protons and heavier particle measurements in the 3-500 Mev/nucleon interval. In the 50 kev to 3 Mev region detector sensitivity to both protons and electrons will be seriously reduced. We would estimate that the total usefulness of the experiment would be reduced by about 25%. For this reason we would strongly prefer a solar cell rather than RTG spacecraft power source.

At present we find it difficult to assess the effects of shielding. There are a large number of unknowns, e.g. orientation of the RTG, positioning of our experiment in the spacecraft, orientation of our experiment with respect to the RTG, and spectral changes due to passage through shielding. We note that a weight estimate of 1.38 lb of lead for shielding our experiment has been made by TRW. This estimate apparently was only sufficient for shielding the LET-II with no allowance made for the LET-I and HET. Even with the more comprehensive test data obtained by us we feel that it is still impossible to make an accurate shielding weight estimate. These questions can probably only be resolved with a much more elaborate testing program including a more accurate simulation of the experimental environment in the spacecraft.

REFERENCES

Anderson, K. A., Solar Physics (in press).

Axford, W. I. and L. J. Gleeson, Ap. J., 149, L115, 1967.

Bryant, D. A., T. L. Cline, U. D. Desai and F. B. McDonald, J. Geophys. Res., 67, 4983 (1962).

Bryant, D. A., T. L. Cline, U. D. Desai and F. B. McDonald, Ap. J., 141, 478 (1965).

Coleman, J. A., D. P. Love, J. H. Trainor and D. J. Williams, IEEE Trans. Nuc. Sci., NS-15, No. 1, Feb. (1968a).

Coleman, J. A., D. P. Love, J. H. Trainor and D. J. Williams, IEEE Trans. Nuc. Sci., NS-15, No. 3, June (1968b).

Fan, C. Y., M. Pick, R. Pyle, J. A. Simpson and D. R. Smith, J. Geophys. Res., 73, 1555 (1968).

Gleeson, L. J., in preparation (1969).

Rao, U. R., K. G. McCracken and R. P. Bukata, J. Geophys. Res., 72, 4325 (1967).

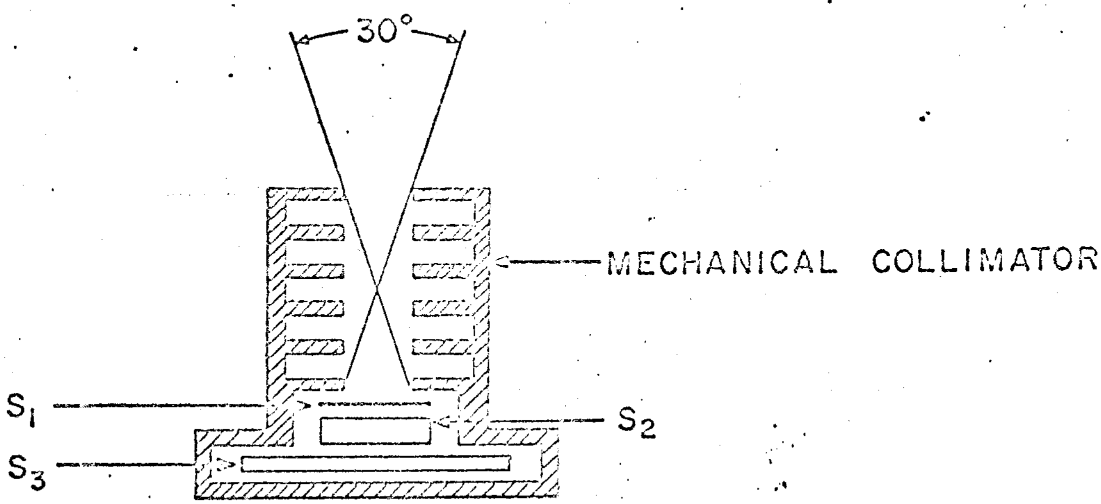
Roelof, E. C., in preparation (1969a).

Roelof, E. C., in preparation (1969b).

Webber, W. R., Can. J. Physics (Proc. Calgary Cosmic Ray Conf.), 1968.

Woldgang, J. L., Jr., Results from the Radiation Damage Effects on MOSFETS Experiment on Explorer XXXIV (IMP-F), Internal Report of the Goddard Space Flight Center, 1968.

VERY LOW ENERGY DETECTOR-II



ENERGY RANGES		
	PROTONS	ELECTRONS
$S_1\bar{S}_2\bar{S}_3$	.075-3 MeV	50-150 keV
$S_1S_2\bar{S}_3$	3-20 MeV	——
$\bar{S}_1S_2\bar{S}_3$	——	150-500 keV

DETECTOR	AREA (mm^2)	THICKNESS(mm)	TYPE
S_1	50	.05	SURFACE BARRIER
S_2	50	2	LITHIUM DRIFT
S_3	300	1	LITHIUM DRIFT

Figure III - 3

ENERGY RESPONSE: LOW ENERGY DETECTOR - II

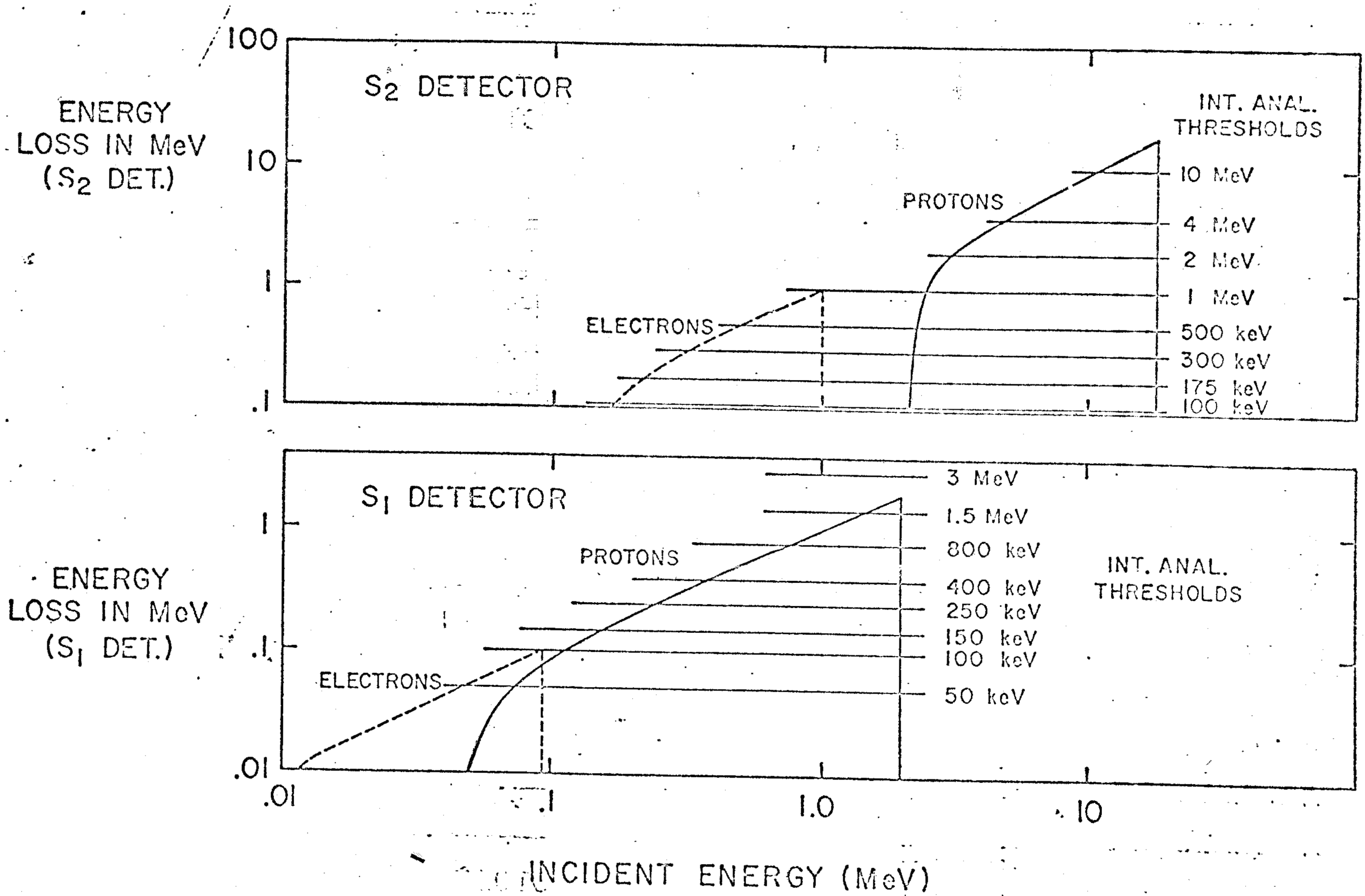
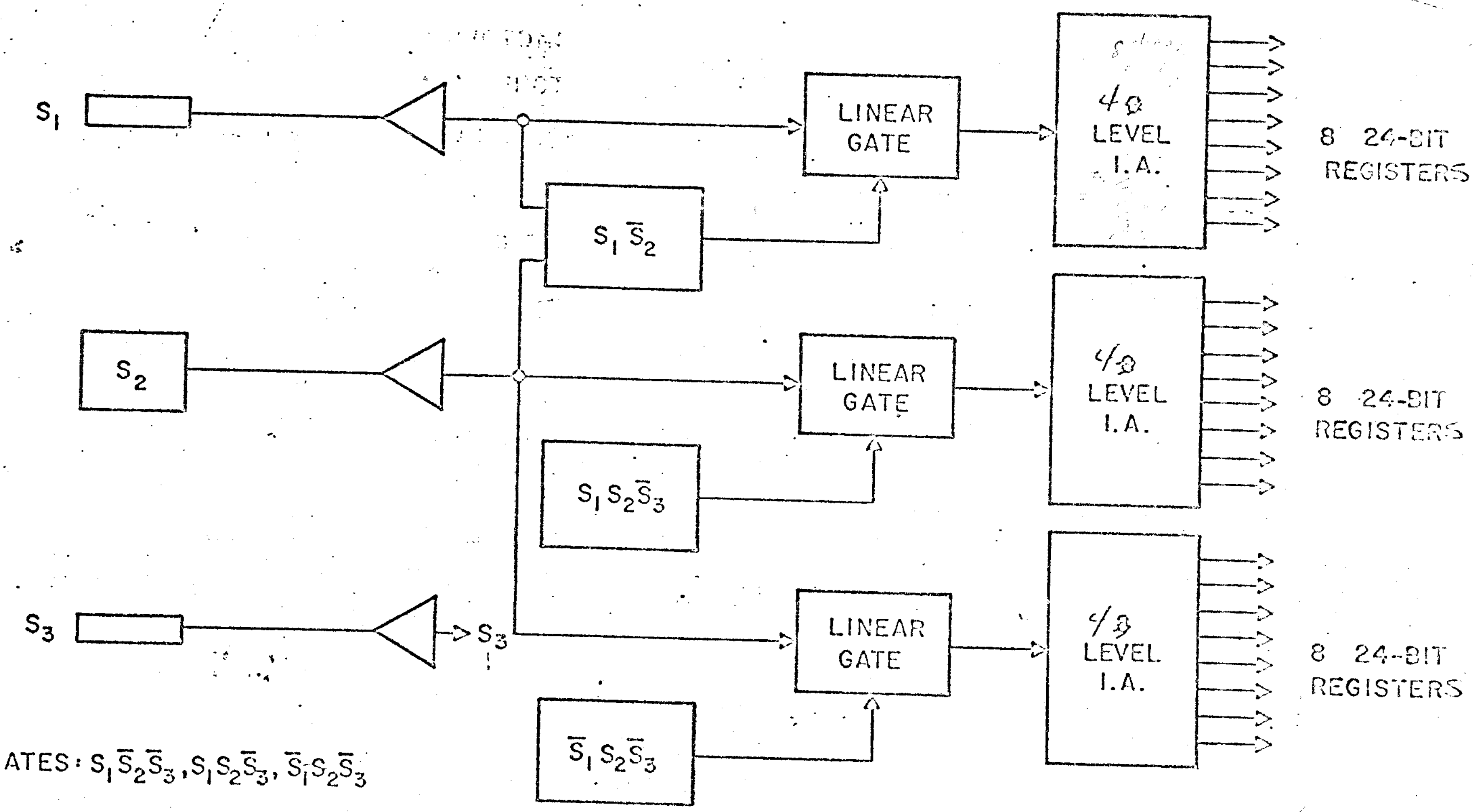


FIG. III - 4

LOW ENERGY DETECTOR-II



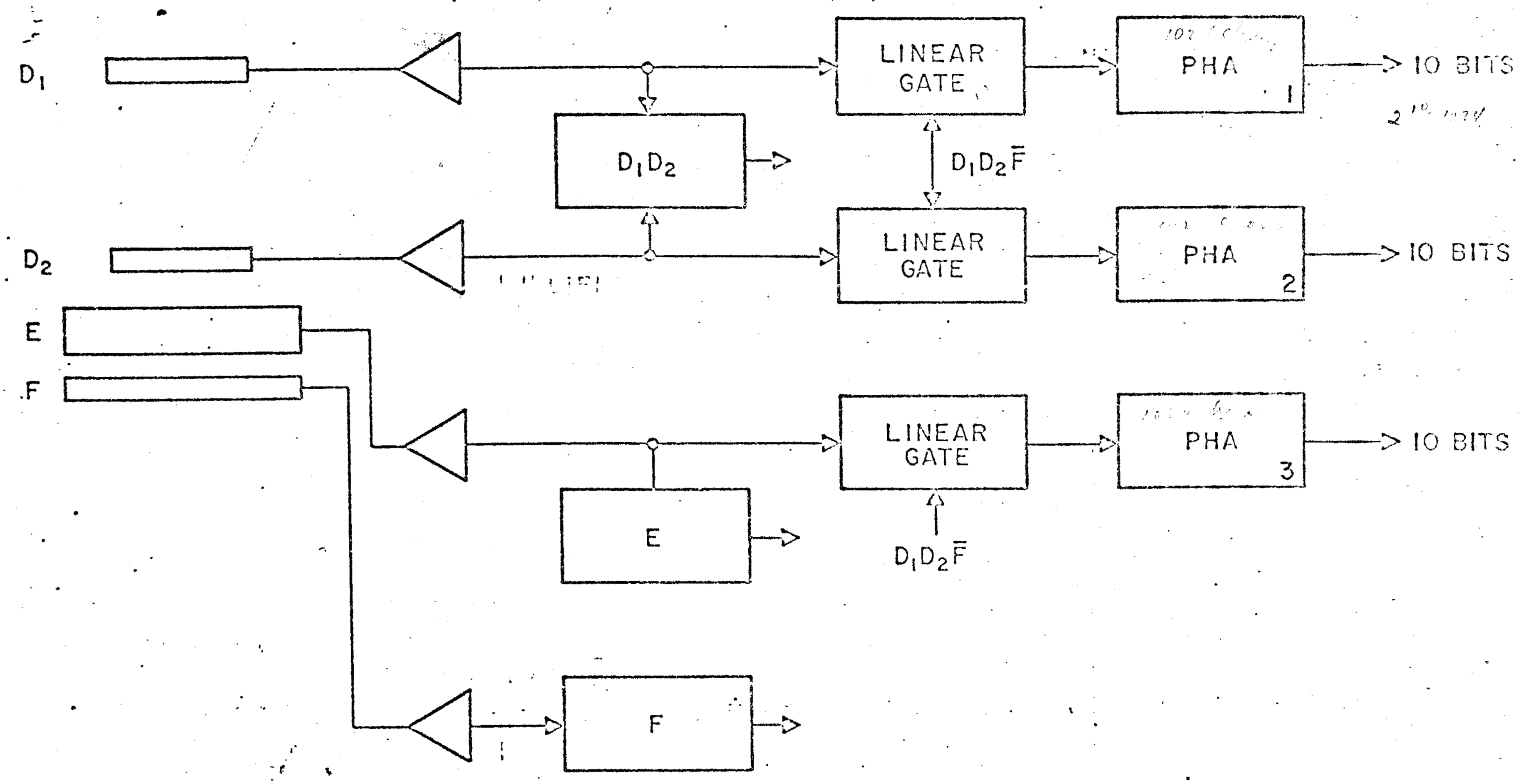
RATES: $S_1\bar{S}_2\bar{S}_3$, $S_1S_2\bar{S}_3$, $\bar{S}_1S_2\bar{S}_3$

SECTOR x 8: $S_1\bar{S}_2\bar{S}_3$ LOW ENERGY PROTONS
~~$S_1S_2\bar{S}_3$ HIGHER ENERGY PROTONS~~
$\bar{S}_1S_2\bar{S}_3$ ELECTRON SLICE

} 4 energy levels on each active term.

~~Figure~~

Fig 5



RATES

$D_1D_2(D_1+D_2)E\bar{F}$ ~~$D_1D_2\bar{E}\bar{F}$ (2 LEVELS)~~ (2 levels on E)

$D_1D_2E\bar{F}$ (2 levels on E)

D_1 (8 LEVELS)

$\bar{D}_1\bar{D}_2E\bar{F}$

2 BITS REQUIRED TO IDENTIFY PRIORITY MODE.

1 BIT REQUIRED TO IDENTIFY PHA DATA AS LET-I.

3 BITS REQUIRED TO IDENTIFY SECTOR.

~~FIG. IV-2~~

SIMPLIFIED LET-I DETECTOR

Fig 4

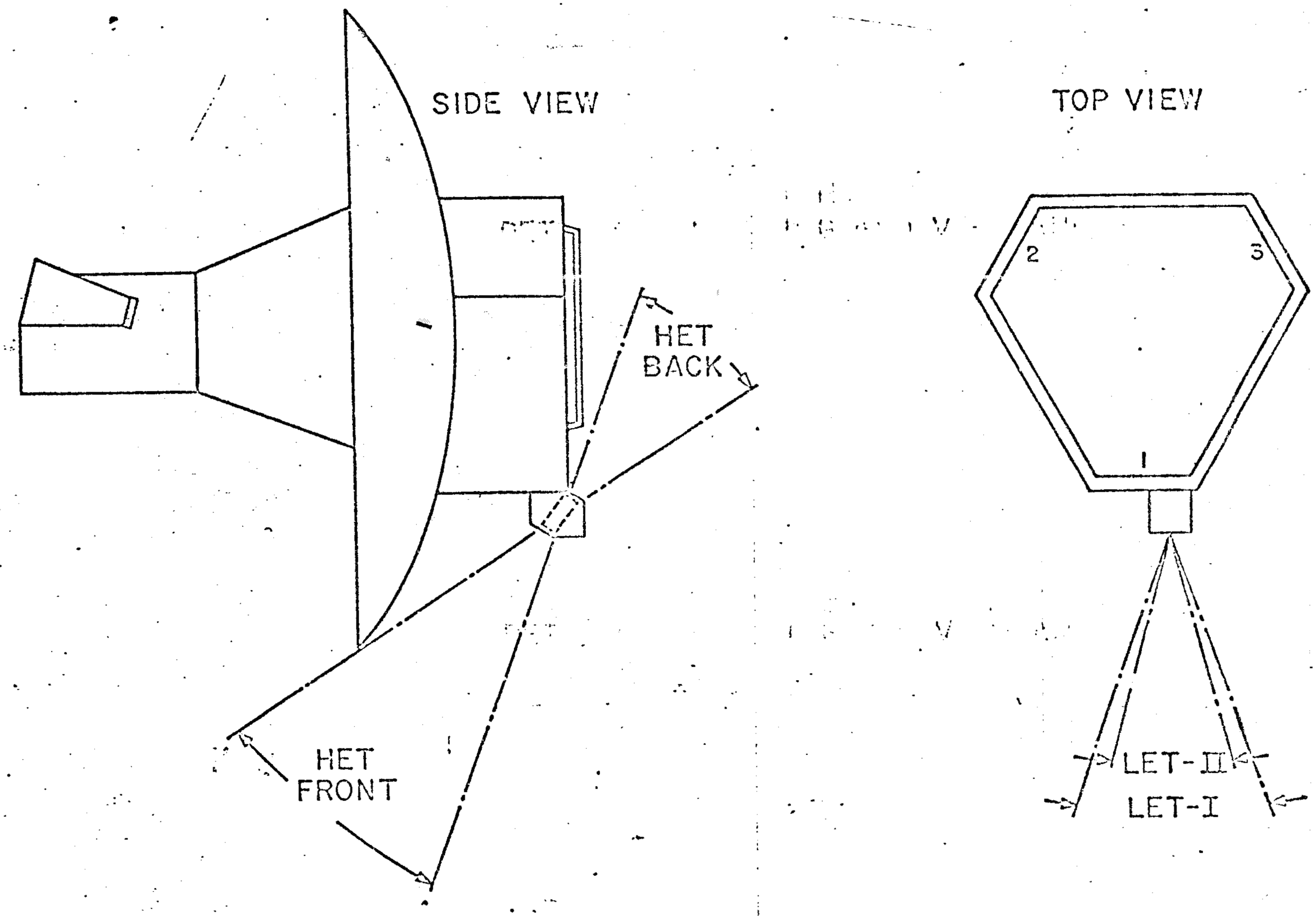


FIG. IV-4
DETECTOR MOUNTING AND VIEW ANGLES

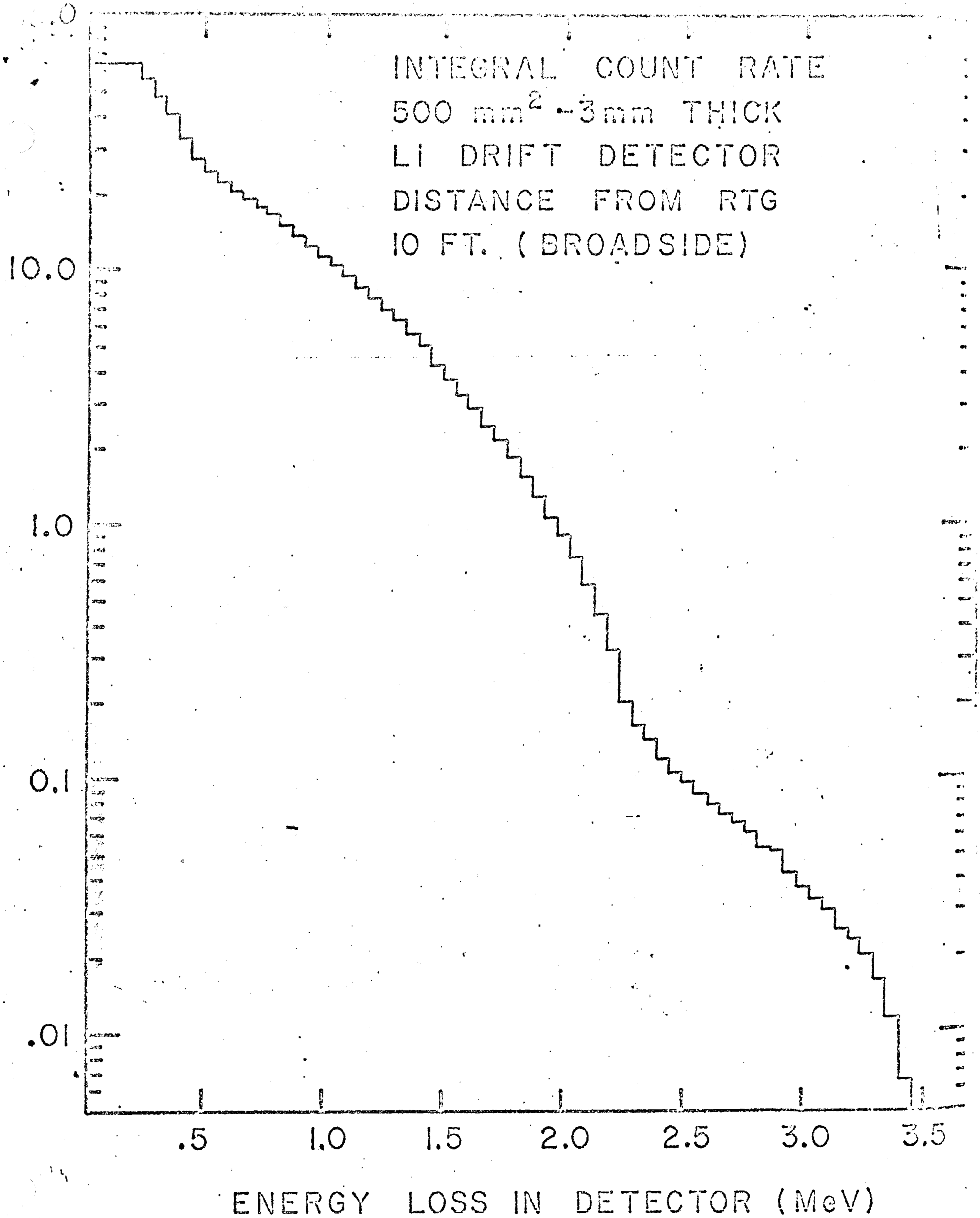

INTEGRAL COUNT RATE
500 mm² - 3mm THICK
LI DRIFT DETECTOR
DISTANCE FROM RTG
10 FT. (BROADSIDE)
10.0
1.0
0.1
.01
.5
1.0
1.5
2.0
2.5
3.0
3.5
ENERGY LOSS IN DETECTOR (MeV)

FIG. VI-1

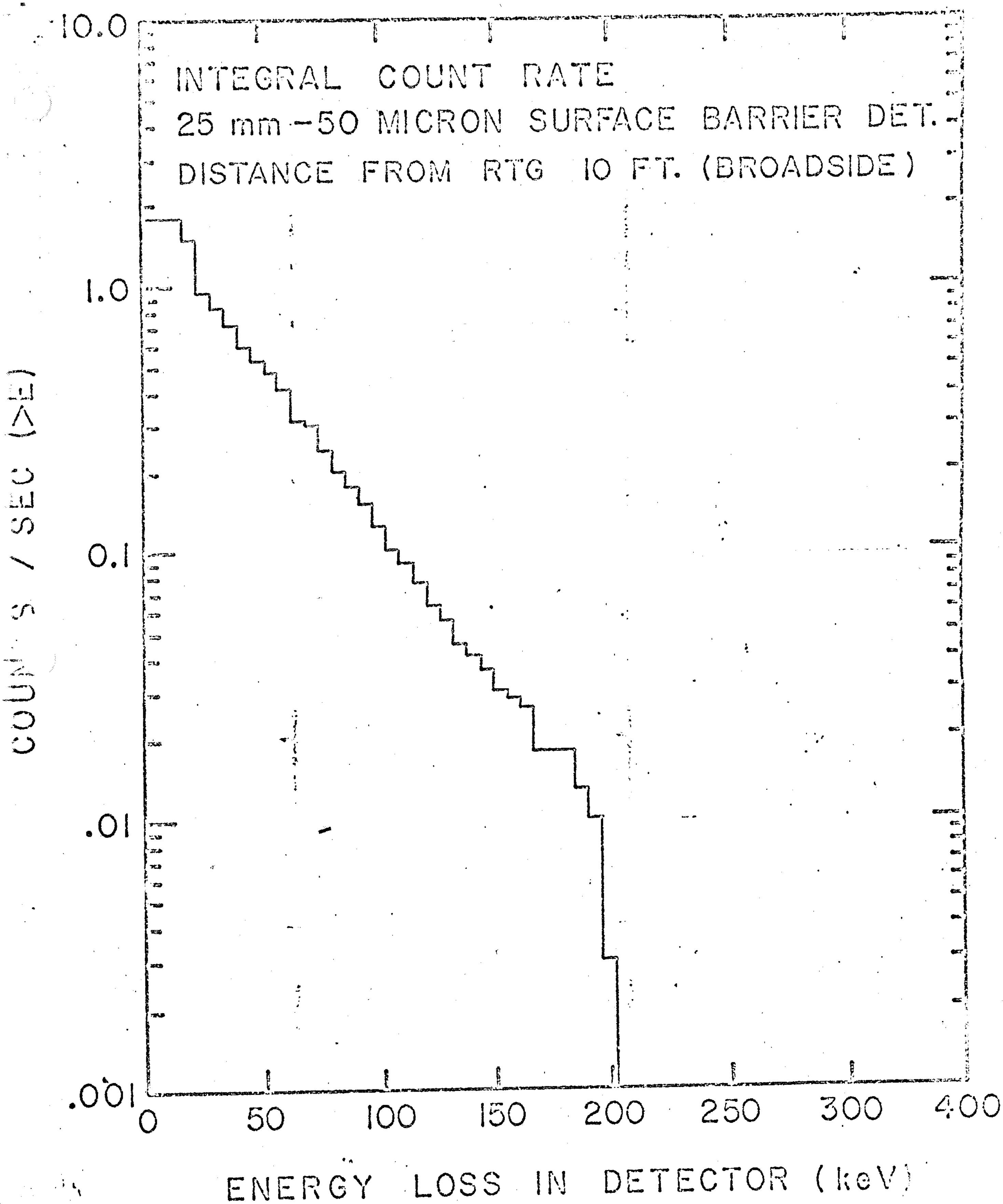

10.0
1.0
0.1
.01
.001
INTEGRAL COUNT RATE
25 mm - 50 MICRON SURFACE BARRIER DET.
DISTANCE FROM RTG 10 FT. (BROADSIDE)
COUNTS / SEC (>E)
0
50
100
150
200
250
300
400
ENERGY LOSS IN DETECTOR (keV)

FIG. VI-2

P. Bracken

The GSFC experiment on the Pioneer spacecraft consists of the "Cosmic Ray Telescopes" and their associated electronics.

1. High Energy Telescope (HET)
2. Low Energy Telescope 1 (LET-1)
3. Low Energy Telescope 2 (LET-2)

The data derived from these telescopes are of two basic forms:

1. Pulse Height Analysis (PHA)
2. Events per second (rates)

The solid state detectors comprising each of the three telescopes are shown in table 1.

HET	LET-1	LET-2
A	DI	SI
B	DII	SII
CI	E	SIIa
CII	F	SIII
CIII		

Table #1 Solid State Detectors Names

The charge liberated, in the detector, by the passage of particle is summed in a charge sensative preamplifier which produces an output voltage pulse whose height is linearly related to the incident particle energy loss in the detector.

The output of the preamplifier is then passed through a post amp where it is given the optimum realizable shape for discrimination and analysis while preserving the amplitude-energy relationship.

The pulses out of the amplifier are fed to their associated linear electronics card where they are differentially buffered and applied to a host of amplitude discriminators. The nominal detection threshold for each of the discriminators is shown in Table 2.

HET		LET-1		LET-2	
Discrim.	Threshold (MeV)	Discrim.	Threshold	Discrim.	Threshold
A1	0.2	DI	.2	SI	.15
A2	2.0	DI_1	.2 .3 .43 .64	SI_1	.15 .7 1.2 2.5
		•		•	
		•	.94	•	.05
		•	1.4	•	.5
		•	2.0	•	1.0
B	0.2	DI_8	3.0	SI_8	1.5
CI	1.0	DII	.2	SII	.06
CII	1.0	ΣD	54.	SII_1	2.0 5.0 15 2.5
				•	
				•	.05
				•	.70 .35
CIII	0.2	E1	2.0	SII_8	1.0
*K1	13.6<T<36	E2	9.0	SIIa	.2

Table 2 (cont.)

HET		LET-1		LET-2	
Discrim.	Threshold (MeV)	Discrim.	Threshold	Discrim.	Threshold
*K2	57<T<150	E3	9.0	SIII	.1
		E4	40.0		
		F	.2		

*K = A+B+1.8 (CI+CII)

It can be seen that A1, A2, E1 ....E4 are separate and simultaneous discriminations while DI1...DI8, SI_1....SI8, and SII_1...SI8 are programmable discriminators. These programmable discriminators are slaved either to the telemetry frame rate or to the spacecraft roll rate.

In order to examine as large a portion of the Cosmic Ray Spectrum as possible, and to distinguish between the various species therein, the experiment has built in an elaborate scheme to share it's 32 available rate counting channels and six PHA channels. This is done by imposing coincidence/anticoincidence requirements upon the pulses appearing in any telescope. These requirements are now discussed on an individual telescope basis.

HET SYSTEM

<u>PHA Data</u>

There are four separate coincidence conditions which will initiate a pulse height analysis. They are:

1) $(A_2K_1 \text{ or } A_1CI)\ \overline{BCIII}$

2) $A_1BK_2\ \overline{CIII}$

3) $A1\overline{A}_2\ BCIII$

4) $A_2\ BCIII$

Since there are five detectors to be analyzed and the experiment has only three channels, call them A, B, and C, the available channels are shared as follows: If either of the first two coincidence conditions cause the analysis, CIII has no pulse, therefore; channel A contains the analysis of detector A's pulse, channel B the analysis of detector B's pulse, while channel C contains the analysis of the sum of the pulses appearing in detectors CI and CII two coincidence conditions which cause the analysis, CIII has a pulse Channel A is switched to analyze this CIII pulse. The other channels produce the same analysis.

The PHA's are of the linear, capacitive discharge type, using a gated delay line oscillator to produce a string of pulses whose frequency is 666 KHz and length (Channel #) is related to incident particle energy as follows:

A'	0.2 MeV/Channel
B	0.2 MeV/Channel
CI & CII	1.0 MeV/Channel
CIII	0.2 MeV/Channel

In order to enhance the number of rare particles analyzed, a priority system is built into the HET system. The priority assigned to the four event types is a function of the telemetry frame and is changed every 64 frames as shown in Table 1H.

I_1, I_2 readout in HETTAG

SEQUENCE ID BITS		EXTERNAL ID BITS		INTERNAL ID BIT	REMARKS
S1	S2	I_1	I_2	I_3	
0	0	0	0	0	SYSTEM WILL ACCEPT $A_1\overline{A_2}BC_{III}$ FOR ANALYSIS.
0	0	0	0	1	ACCEPT A_2BC_{III}
0	0	1	0	1	ACCEPT A_2BC_{III} AS MANY TIMES AS IT APPEARS OR $(A_2K_1+A_1C_I)\overline{BC_{III}}$
0	0	0	1	1	ACCEPT $(A_2K_1+A_1C_I)\overline{BC_{III}}$ AS MANY TIMES AS IT APPEARS OR $A_1BK_2\overline{C_{III}}$
0	0	1	1	1	I.D. BITS INDICATE $A_1BK_2\overline{C_{III}}$ WAS ACCEPTED FOR ANALYSIS BUT NO MORE OF THESE EVENTS WILL BE ACCEPTED. PHA'S REMAIN INACTIVE UNTIL COMPLETION OF THE NEXT READ-OUT.
1	0	0	0	0	ACCEPT $A_1\overline{A_2}BC_{III}$
1	0	0	0	1	ACCEPT A_2BC_{III}
1	0	1	0	1	ACCEPT A_2BC_{III} AS MANY TIMES AS IT APPEARS OR $A_1BK_2\overline{C_{III}}$
1	0	1	1	1	ACCEPT $A_1BK_2\overline{C_{III}}$ AS MANY TIMES AS IT APPEARS OR $(A_2K_1+A_1C_1)\overline{BC_{III}}$
1	0	0	1	1	ACCEPT $(A_2K_1+A_1C_I)\overline{BC_{III}}$ AS MANY TIMES AS IT APPEARS.
0	1	0	0	0	ACCEPT $A_1\overline{A_2}BC_{III}$
0	1	0	0	1	ACCEPT $(A_2K_1+A_1C_I)\overline{BC_{III}}$
0	1	0	1	1	ACCEPT $(A_2K_1+A_1C_I)\overline{BC_{III}}$ AS MANY TIMES AS IT APPEARS OR $A_1BK_2\overline{C_{III}}$
0	1	1	1	1	ACCEPT $A_1BK_2\overline{C_{III}}$ AS MANY TIMES AS IT APPEARS OR A_2BC_{III}
0	1	1	0	1	ACCEPT A_2BC_{III} AS MANY TIMES AS IT APPEARS
1	1	0	0	0	ACCEPT A_2BC_{III}
1	1	1	0	1	ACCEPT $(A_2K_1+A_1C_I)\overline{BC_{III}}$
1	1	0	1	1	ACCEPT $A_1BK_2\overline{C_{III}}$
1	1	1	1	1	ACCEPT $A_1BK_2\overline{C_{III}}$ AS MANY TIMES AS IT APPEARS OR $A_1\overline{A_2}BC_{III}$
1	1	0	0	1	ACCEPT $A_1\overline{A_2}BC_{III}$ AS MANY TIMES AS IT APPEARS

To uniquely "tag" a PHA event it is necessary to readout the "Seq. I.D." and "External I.D. bits" shown in table 1H. "Internal ID bits" is not read out but this does not produce an ambiquity. Referring to table 1H for S1=S2=0: If I_1=1 and I_2=0 (lowest Priority) the event is the last A2BCIII event encountered (note that the system will continue to accept new A2BCIII events without shanging ID bits). If I_1=0, I_2=1 the event is the last (A_1BK2CI) BCIII event encountered. If I_1=I2=1, (highest priority) the PHA's contain the first A_1BK2CIII event encountered. Table 1H may be read in similar fashion for the other three combination of S1 and S2 where, it is seen, the priorities are reorder for each combination.

As a further aid in determining the species of particle analyzed the HET electronic produces a 1 bit of the CII threshold has been exceeded which is also read out in the associated tag word.

To meet the scientific objective of the CRT some indication of the direction of the incoming particle is also necessary. Therefore, for each PHA event an indication of the orientation of the spacecraft (one of eight possible sectors is also placed in the tag word of PHA event.

Rate Data

The HET system has assigned to it, 9 accumulators (R_1-R_9) exculsively and shares 8 accumulators (SR1) on a fifty-fifty basis with the LET-1 system. (See Table 2H.

TABLE 1H

Event Type	Particle	Event $I2=2^1$	Code $I1=2^0$	Relative Priority (1=highest) S1=S2=0	S1=1,S2=0	S1=0,S2=1	S1=S2=1
$A_1BK_2\overline{CIII}$	Stopping particles Z≥2	1	1	1*	2	2	2
$(A_2K_1 + A_1CI)\ B\overline{CIII}$	Stopping e⁻, or stopping p+ and heavier	1	0	2	1	3	3*
A_2B CIII	Penetrating particles Z≥2	0	1	3	3	1	4*
$A_1\overline{A_2}$ B CIII	Penetrating e⁻	0	0	4*	4*	4*	1

* Each event is analyzed as often as it occurs unless marked with *, in which case that event type is analyzed only once per readout of PHA channels.

Table 2H.

GATE OUTPUT	GATE EQUATION	A/B	S1	S2	SS1	SS2	SS3
R1	$(A_2 K_1 + A_1 CI) B \overline{CIII}$						
R2A	$\bar{A}_2 A_1 B\ CIII$	0					
" B	$A_1 B K_2 \overline{CIII}$	1					
R3A	$A_2 B\ CIII$	0					
" B	$A_2 B K_2 \overline{CI}$	1					
R4A	$A_2 B K_2\ CI\ \overline{CII}$	0					
" B	A_1	1					
R5A	$A_2 B K_2\ CI\ CII\ \overline{CIII}$	0					
" B	A_2	1					
R6A	$A_1 \bar{A}_2 B \overline{CI}$	0					
" B	$A_1 \bar{A}_2 B\ CI\ \overline{CII}$	1					
R7A	$A_1 \bar{A}_2 B\ CI\ CII\ \overline{CIII}$	0					
" B	$A_2 B K_1 \overline{CI}$	1					
R8A	$A_2 B K_1\ CI\ \overline{CII}$	0					
" B	$A_2 B K_1\ CI\ CII\ \overline{CIII}$	1					
R9A	B	0	0				
" B	CI	1	0				
" C	CII	0	1				
" D	CIII	1	1				
SR1A	$A_1 \bar{A}_2 B\ CI\ \overline{CIII}$				0	0	
" B	$A_2 B K_1 \overline{CIII}$				1	0	

Table 2H - HET Rates

① How many bits in accumulator

Referring to Table 2H it is seen that: only rate 1 is not commutated, rate 9 is commutated between four rate equations by the bit labeled A/B, and SR1 is commutated between two rate equations by the bits SS1 and SS2. All other rates are toggled equally between the two rate equations shown in Table 2H by bit A/B except rate SR1 which is controlled by bits SS1 and SS2.

Bits A/B, S1, and S2 are derived in the experiment data system and their periods are bit rate and format dependent i.e. A/B changes every 32 S/C frames in format A, every 64 frames in format B and A/D, and every 128 S/C frame in format B/D. S1 changes every other A/B and S2 every other S1. (Standard binary ripple through counter)

Bits SS1, SS2, and SS3 also come from the data system but in normal operation are simultaneously bit rate, format, and S/C spin rate dependent.

See data system section for operation of Sector Synchronizer. For the present only note that in normal operation the SS1, SS2, and SS3 bits may only change after an integral number of S/C revolutions. Again SS1, SS2, and SS3 are generated in a binary ripple counter.

LET-1 SYSTEM

PHA Data

There are two separate coincidence conditions which will initiate a pulse height analysis. They are:

1) DI DII $\overline{F}$
2) DI DII ΣD $\overline{F}$

In LET-1 there are four detectors. Since only three channels (again A, B, and C) are available they are assigned to detectors DI, DII, and E respectively. Since the above PHA equations require detector F to have no pulse nothing is lost. The LET-1 PHA's, like the HET PHA's are the linear, capacitive descharge type using the fated delay line oscillator to produce 66 KHz channel address advance pulses. The channel number is related to incident particle energy loss in each detector as follows:

DI - 0.1 MeV/Channel
DII - 0.1 MeV/Channel
E - 1.0 MeV/Channel

The LET-1 PHA system is, like the HET system, priority oriented. The LET-1 system operates in response to the S1 bit as follows:

S1=0 Analyze either type of event as often as they occur.
S1=1 Analyze DI DII $\overline{F}$ type events as often as they occur until a DI DII ΣD event occurs, then analyze only the ΣD events until data is readout.

The S1 bit is the same bit that was applied to the HET linear electronics and hence, changes every 64 S/C frames.

Rate Data

The LET-1 system is assigned four rate accumulators exclusively and shares 8 accumulators with the HET system on a fifty-fifty basis and 1 accumulator is shared with the LET-2 system on an equal basis.

RATE OUTPUT	RATE EQUATION	A/B	S1	S2	SS1	SS2
R10A	DI_1	0	0	0		
″ B	DI_2	1	0	0		
″ C	DI_3	0	1	0		
″ D	DI_4	1	1	0		
″ E	DI_5	0	0	1		
″ F	DI_6	1	0	1		
″ G	DI_7	0	1	1		
″ H	DI_8	1	1	1		
R11A	$DI\ DII\ \bar{F}$	0				
″ B	$DI\ DII\ \Sigma D\ \bar{F}$	1				
R12A	$DI\ DII\ E_1\ \bar{F}$	0				
″ B	$DI\ DII\ \Sigma D\ E_3\ \bar{F}$	1				
R13A	$DI\ DII\ E_2\ \bar{F}$	0				
″ B	$DI\ DII\ \Sigma D\ E_4\ \bar{F}$	1				
R14A	DI	0	0	0		
″ B	DII	1	0	0		
″ C	E_1	0	1	0		
″ D	F	1	1	0		
SR1C	$DI\ DII\ \bar{F}$				0	1
″ D	$DI\ DII\ E_1\ \bar{F}$				1	1

Table 1L1

Table 1L1 shows that rate 10 is the accumulation of an integral analyzer which is commutated through eight levels by bits A/B, S1 and S2; 11, 12, and 13 are commutated two ways between the indicated rate equations by bit A/B. Rate 14 has 4 levels of communication in the LET-1 system and another four in the LET-2 system for a total of 8 levels of commutation controlled by bits A/B, S1, and S2. SR1 is commutated through the last two, of four levels, by bits SS1, and SS2. The other two comutator positions are assigned to the HET system.

LET-2 SYSTEM

PHA Data

There are no pulse height analyses associated with the LET-2 telescope.

Rate Data

Three rate accumulators are dedicated to LET-2 data while one accumulator is shared with the LET-1 system on a fifty-fifty basis. (See Table 1L2.)

Table 1L2 shows that R14 is assigned to LET-2 for the last four of it's eight levels of commutation. The commutation of R14 is controlled by bits A/B, S1, and S2 from the experiment data system.

R15 and R16 are commutated through four levels each, as shown in table 1L2, by bits A/B and S1.

The sectored accumulator SR2 is switched between eight rate equations by bits SS1, SS2, SS3, from the data system.

Sectored Rate Accumulators.

SR1 and SR2, in addition to being commutated through their respective energy levels, are directionally resolved into eight equal sectors of 45°. The sectors are generated as the spacecraft spins with the first beginning at the time fo the roll index pulse. Each sector is assigned a separate accumulator.

R10 - R14* Let 1

R14* - R16 Let 2

Table 1L2

RATE OUTPUT	RATE EQUATION	A/B	S1	S2	SS_1	SS_2	SS_3
R14E	SI 5	0	0	1			
" F	SII 6	1	0	1			
" G	$SIII$ 7	0	1	1			
" H	SII_a 8	1	1	1			
R15A	$SI_1\,\overline{SII}\,\overline{SII_a}\,\overline{SIII}$	0	0				
" B	$SI_2\,\overline{SII}\,\overline{SII_a}\,\overline{SIII}$	1	0				
" C	$SI_3\,\overline{SII}\,\overline{SII_a}\,\overline{SIII}$	0	1				
" D	$SI_4\,\overline{SII}\,\overline{SII_a}\,\overline{SIII}$	1	1				
R16A	$SI\,SII_1\,\overline{SII_a}\,\overline{SIII}$	0	0				
" B	$SI\,SII_2\,\overline{SII_a}\,\overline{SIII}$	1	0				
" C	$SI\,SII_3\,\overline{SII_a}\,\overline{SIII}$	0	1				
" D	$SI\,SII_4\,\overline{SII_a}\,\overline{SIII}$	1	1				
SR2A	$SI_5\,\overline{SII}\,\overline{SII_a}\,\overline{SIII}$				0	0	0
" B	$SI_6\,\overline{SII}\,\overline{SII_a}\,\overline{SIII}$				1	0	0
" C	$SI_7\,\overline{SII}\,\overline{SII_a}\,\overline{SIII}$				0	1	0
" D	$SI_8\,\overline{SII}\,\overline{SII_a}\,\overline{SIII}$				1	1	0
" E	$\overline{SI}\,SII_5\,\overline{SII_a}\,\overline{SIII}$				0	0	1
" F	$\overline{SI}\,SII_6\,\overline{SII_a}\,\overline{SIII}$				1	0	1
" G	$\overline{SI}\,SII_7\,\overline{SII_a}\,\overline{SIII}$				0	1	1
" H	$\overline{SI}\,SII_8\,\overline{SII}\,\overline{SIII}$				1	1	1

Data Format

The Pioneer spacecraft data formats for format A and format B are shown in Figs. D1 and D2.

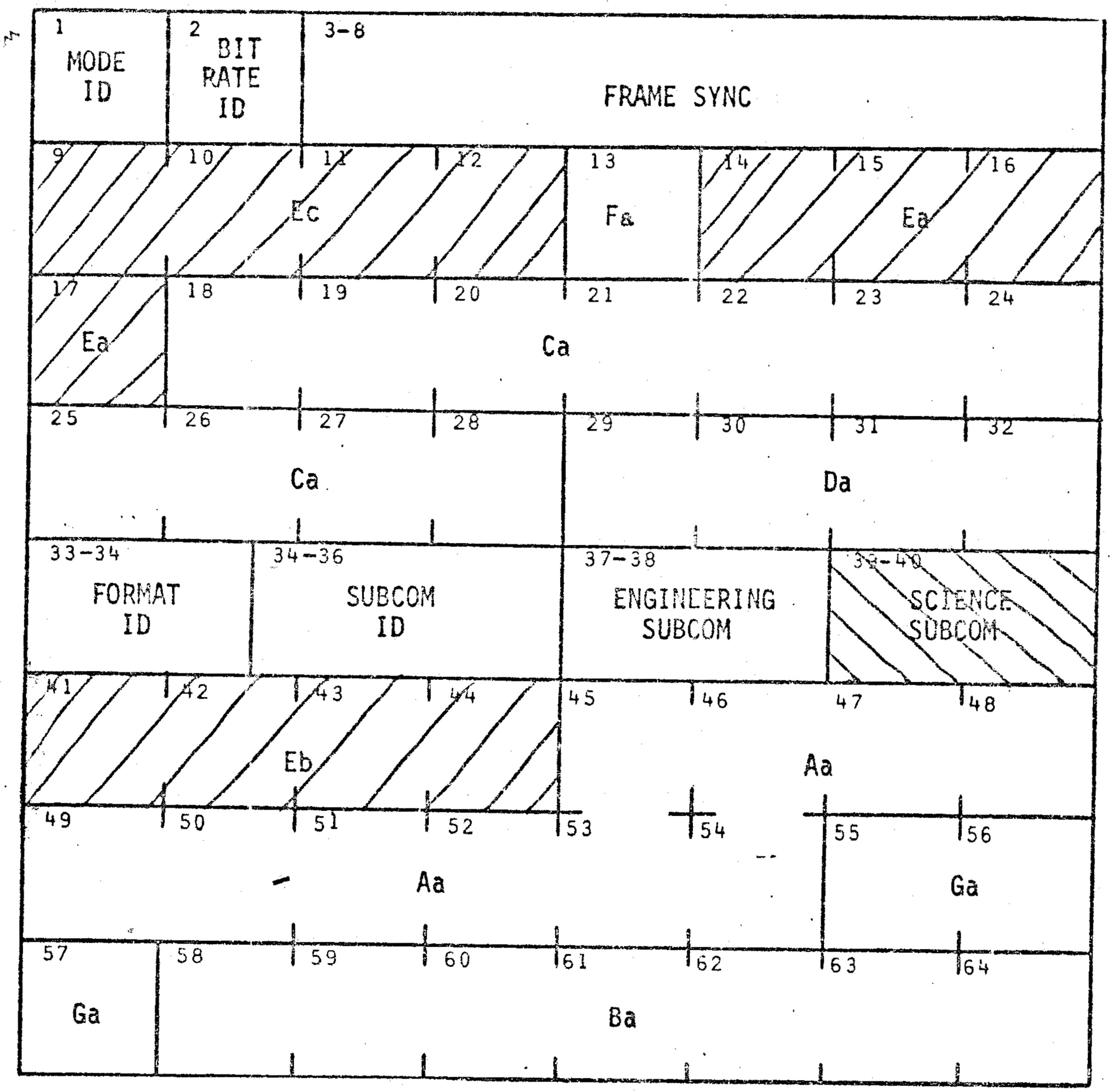
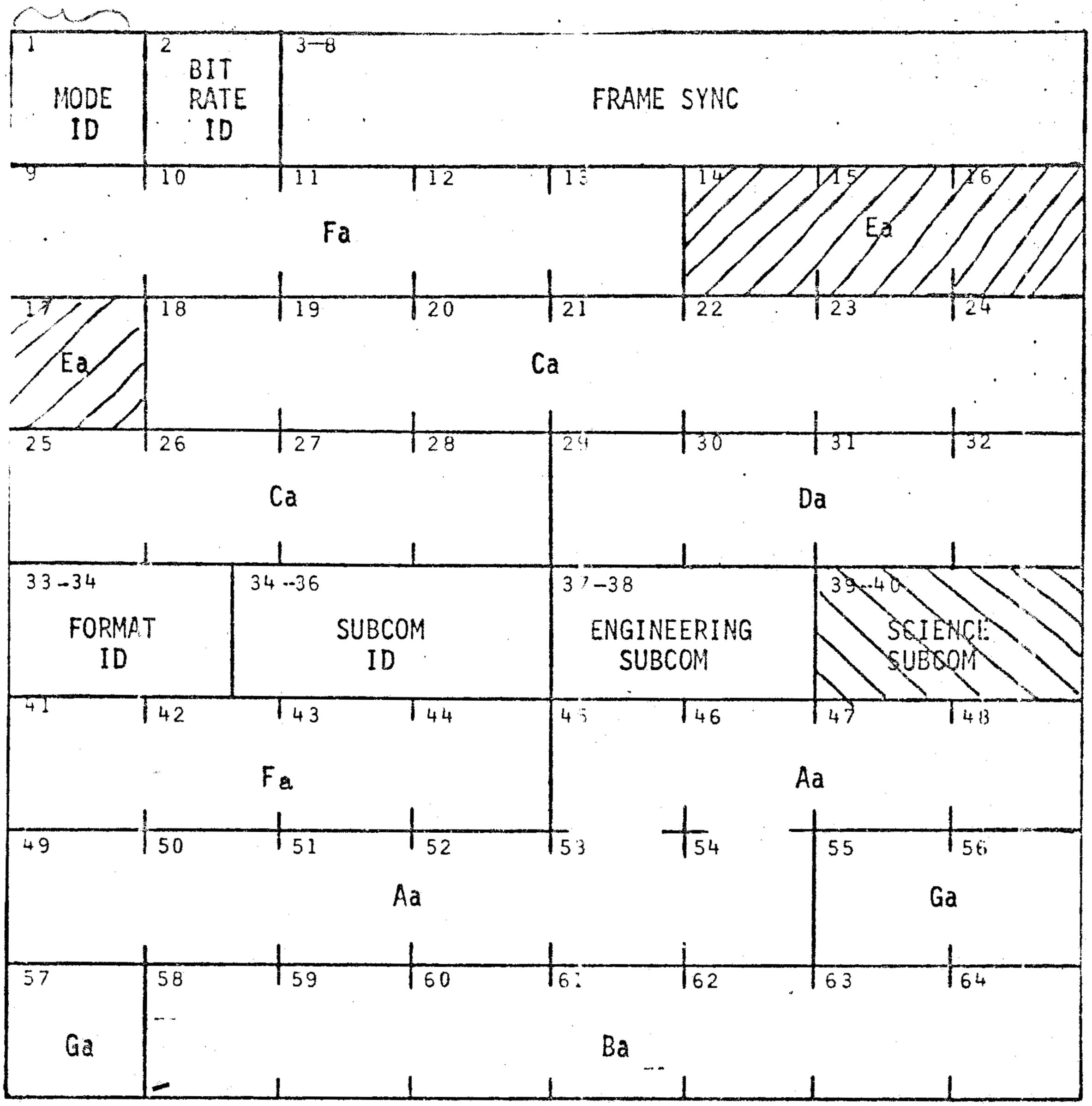


Fig. D1 S/C Mainframe format A



Formats A and B are only operating modes in which experiment data is outputed to the spacecraft. The words shown crosshatched are allotted to the GSFC experiment. It is seen that the CRT receives three M/F 12 bit words in format A and one S/SC 6 bit word. In format B there is one 12 bit M/F word and one S/SC 6 bit word. the S/SC word is only present (to the CRT) in one of each 64 mainframes and will be used as a starting point and synchronization check in interpreting the output data.

the other 63 are assigned to other users.

CRT gets 1 twelve bit word + 6 bit S. subcom word in frame 16

How do you know when subcom word belongs to CRT? — ?

Format A

As shown in Figure D3 below the experiment is assigned three M/F data words Ec, Eg, and Eb. Further, Fig. D3 shows how the data is assigned to these words within the instrument.

S SEQ ID = SECTORED RATE SEQUENCE ID
R SEC ID = UNSECTORED RATE SEQUENCE ID

□ RATE WORDS ARE 24 BIT LOG COMPRESSED TO 12 BITS.
* SEE FIGURE 3.1.1-2

URSeq	S/C WORDS	MF, 9-12	MF, 14-17	MF, 41-44	E-1, 30	
	WEIGHTING	$2^{11}\,2^{10}-2^{1}\,2^{0}$	$2^{11}\,2^{10}-2^{1}\,2^{0}$	□	$2^{2}\,2^{1}\,2^{0}$	$2^{2}\,2^{1}\,2^{0}$
	TYPE DATA	PHA	PHA	RATE	RSEQ ID	S SEQ ID
8	n	LET-B	LET-C	R16	0 0 0	X X X
1	n+1	*HET-TAG	HET-A	S1		
	n+2	HET-B	HET-C	S1		
	n+3	*LET-TAG	LET-A	S1		
	n+4	LET-B	LET-C	S1		
	n+5	*HET-TAG	HET-A	S1		
	n+8	LET-B	LET-C	S1		
	n+9	*HET-TAG	HET-A	S2		
	n+10	HET-B	HET-C	S2		
	n+15	*LET-TAG	LET-A	S2		
	n+16	LET-B	LET-C	S2		
	n+17	*HET-TAG	HET-A	R1		
	n+31	*LET-TAG	LET-A	R15		
	n+32	LET-B	LET-C	R16		
2	n+33	*HET-TAG	HET-A	S1		
	n+64	LET-B	LET-C	R16	0 1 0	X X X
	n+65	*HET-TAG	HET-A	S 1		
4	n+120	LET-B	HET-C	R16	1 0 0	X X X

FRAME NUMBER

Figure D3-Data to Word Assignments GSFC/CRT

If frame number N is arbitrarily assigned to the one frame in 64 which the CRT is assigned the SSC Wd (Wd 30 FMT E-1), we shall let the data frame begin with the next frame. i.e., N+1 in Fig. D3.

In Frame N+1, Fig. D3 shows that word Ec contains HET tag data, word Ea contains HET-A (A=DetA of Det CIII. See HET PHA section.) PHA data and word Eb contains sectored rate 1-sector 1 (SR1-1) data. In frame N+2 word Ec contains HET -B (Det B), word Ea contains HET-C (ΣDETCI+DETCII), and Eb contains SR1-2.

In frame N+3 LET-1 PHA tag data is read out in word Ec. Word Ea contains LET-A (Det DI), while word Eb continues the rate data: SR1-3. In frame N+4 LET-1 PHA data is continued in word Ec, LET-B (Det DII), and word Ea, LET-C (Det E), while word Eb has SR1-4.

In frame N+5 words Ec and Ea return to HET tags and HET-A and the frame sequence continues in the manner modulo four. Word Eb, however, continues to sequence through SR1 (-5, 6, 7, and 8), SR 2 (-1, 2, 3, 4, 5, 6, 7, 8) and unsectored rates 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16. (See sections on HET and LET rates for the rate equation of these rates in terms of detector outputs). At frame N+33 word Eb reads out SR1-1 again and the rate data has come full cycle in 32 frames. At this time the A/B bit is changed and the unsectored rate accumulators step to count on the next, in its particular rate equation sequence. The cycle continues, this way for 31 more frames at which time (N+64) the S SC Wd is again applied to the CRT experiment and the complete data cycle is begun anew with the next (N+65) frame. In this new cycle (64 frames) the PHS priorities have been changed (See HET and LET PHA sections) and the rate accumulators are once again advanced to the next rate equation.

The experiment continues in this manner as long as the spacecraft is in format A.

A description of how to extract the exact rate equation for each word Eb readout and how to establish the exact source of the PHA readouts will be given following the Format B section.

Format B

Since the CRT experiment now receives only one M/F word and it was not desired to sacrifice one type of data for another it was necessary to readout both types of data in word Ea. This was accomplished by alternating the 32 rate readouts with 8 PHA event readouts. NOTE: 1 PHA event is readout in 4 words therefore 8 events take 32 frames.

Figure D4 shows the word assignments in Format B.

UR Seq	S/C WORDS	MF, 14	MF, 15	MF, 16	MF, 17	E-1, 30					
	BIT	1 2 3	1 2 3	1 2 3	1 2 3	1	2	3	4	5	6
	WEIGHTING	2^{11} 2^{10} -(PHA Data)- 2^4 2^3 2^2 2^1 2^0				2^2	2^1	2^0	2^2	2^1	2^0
	WEIGHTING	24 bits log compressed to 12 bits									
	TYPE DATA	RATE OR PHA (as shown)				R seq ID			S seq ID		
8	n	LET - B				0	0	0	X	X	X
1	n + 1	LET - C									
	n + 2	S1 - 1									
	n + 9	S1 - 8									
	n + 10	S2 - 1									
FRAME NUMBER	n + 33	R16									
	n + 34	*HET-TAG									
	n + 35	HET-A									
	n + 42	*HET-TAG									
	n + 43	HET-A									
	n + 64	LET-C				0	0	1	X	X	X

Figure D4 Data to Word Assignments Format B GSFC/CRT

The sequence of rate data readouts is chronologically the same as in format A, however, it should be noted that cycle begins one frame late with respect to the SSC Wd, i.e., SR1-1 now is read out in the second frame following the SSC Wd. (frame W+2). Following the rate data come 32 frames of PHA data, N+34 to N+65 and the SSC Wd is once again received from the S/C and the experiment begins into cycle once again with SR1-1.

Form A/D B/D:

<u>Data Synchronization</u>

As was seen in the HET and LET descriptions the bits which control rate equation a given rate readout was accumulated under is controlled by the bits A/B, S1, and S2 for unsectored rates and SS1, SS2, and SS3 for sectored rates. These bits are readout once each 64 frames by the SSC Wd (Wd 30, E-2) in the format shown below:

<u>S2-S1-A/B</u>-SS3-SS2-SS1

The unsectored rate counter is advanced each 32 frames on Format A and each 64 frames in format B. In addition, in format A the unsectored rate counter LSB is reset by the SSC Wd and will therefore be equal to zero at readout time. The number readout in bits (S2, S1, A/B) will always advance by two and be an even number (i.e., A/B≠1). In format B this flip-flop is not reset and will, therefore, advance by one each SSC Wd readout.

The bits SS1, SS2, and SS3, of the sectored rate counter are dependent upon the S/C spin rate and therefore may change asychronously with the S2, S1, A/B bits. Therefore in order to give a closer indication of when the counter was advanced the SS1 bit ot the counter is readout as bit #7 (LSB+S) of the HET-tag word (See Figure D5). The criteria applied to determine which rate equation a read out sectored rate was accumulated under is dependent on whether or not the experiment has its sector synchronizer on or off. The status of the s.s. is found by examining bit 8 (LSB+4) of the HET-tag word.

<u>Sector Sync Inhibited</u>

The sectored rate data should be treated in the same manner as the unsectored rate data, i.e. the S seg ID readout in Wd 30 (SSC Wd) indicates the rate equation under which the following 16 sectored rate readouts were accumulated. E.G. If the S seg ID in Wd 30 were 3 this would indicate that the following sectored rate data were accumulated as follows:

Sectored Rate 1 = SID = DIDIIE $\overline{F}$

Sectored Rate 2 = S2D= $\overline{SI_3}\ \overline{\overline{SII}}\ \overline{SIIa}\ \overline{SIII}$?

The sectored SEQ counter is advanced every 32 frames, therefore, the next sectored rate data readout were accumulated under S SEQ ID-4. It is NOT possible to have redundant readouts with sector sync inhibited.

Sector Sync Not Inhibited

In this mode the internal sectored SEQ counter can only be updated at the time in the telemetry frame when unsectored rates are being readout and a prescribed number of S/C rolls have been completed.

To obtain sync with the sectored rate data one proceeds as follows: Note the reading of the SSEQ ID previously noted in Wd 30 (SSC Wd). if bit 7 does not change state the data in the following sectored rate readouts is redundant and should be discarded). Bit 7 of HET-tag Wd should be continuously monitored for state changes and S SEQ ID mentally increased by one for each change noted. A check may be had at each Wd 30 by comparing S SEQ's ID.

As an example suppose the S SEQ ID in Wd 30 were found to be 6 and during the next 32 frames examination of bit 7 of HET-tag Wd showed no state changes. The following data in the sectored rate words whould be rejected as redundant SEQ. ID 5 Data. If in the next 32 frames bit 7 changes state, (change the mental S SEQ ID to 7) sectored rate data this following readout would be fresh data and it accumulated under S SEQ ID = 6. Sectored rate - 1= S1C=DIDIIF sectored rate 2 = S2G=SI SII3 SIIa SIII. At the following word 30 (SSC Wd) the S SEQ ID should be verified: It should read 7.

In order to know the type of event (See HET and LET PHA sections) readout in the PHA words the event is modified by its accompanying tag word. Figure D5 shows the format meaning of both the HET and LET tag words.

BIT	1	2	3	4	5	6	7	8	9	10	11	12
WEIGHTING	2^2	2^1	2^0	2^0	2^1	2^0	2^0	2^0	2^3	2^2	2^1	2^0
HET-TAGS	SEC. ID			R	* □		S	SS	Δ 0	0	0	0
WEIGHTING	2^2	2^1	2^0	2^0	2^0	2^0	2^0	2^0	2^0	2^0	2^0	2^0
LET-TAGS	SEC. ID			ΣD	1	1	1	1	1	1	1	1

NOTES:

A) * WHEN BIT = 0: HET-A = DETECTOR A
WHEN BIT = 1: HET-A = DETECTOR CIII

B) Δ HIGH/LOW POWER 1 1 1 1 = ~~LOW POWER~~ High Power
0 0 0 0 = ~~HIGH POWER~~ Low Power

C) □ ANALYSIS CONDITION

D) R = RANGE (0/1) = 0 = CII threshold not exceeded; 1 = CII threshold is exceeded

E) S = LEAST SIGNIFICANT BIT OF SECTORED RATE SEQUENCE ID.

F) SS = SECTOR SYNC 1 = INHIBITED
0 = NOT INHIBITED

G) ΣD = 1 if event contains ΣD

Fig. D5 HET & LET Tag Words

The sector in which the event was encountered is found in bits 1, 2, and 3 of the tag words. For a LET event the type of event (ΣD of $\bar{\Sigma}$D) is revealed in bit 4 (the rest of the LET tag word is filled with ones). For a HET event an indication of the contribution of the CII detector to the channel number readout in the HET-C (ΣCI+CII) is found in bit 4 of the HET tag word. If the CII threshold (MeV) is exceeded the bits is 1 if not, a zero.

The type of event that triggered the HET analysis is contained in bits 5 and 6 of the HET tag word. If bit 5=1 the HET A detector CIII is output. If a zero' HET-A is related to detector A's output. Bits 4 and 5 provide more information as to the coincidence conditions resulting in the analysis when modified by the S1 bit readout in SSC Wd (see HET PHA section for priority description).

Bits 7-8-9 of the HET-tag contain information on whether the sector sync is on or off (bit 8), when the bit SS1 toggles (bit 7) and whther the experiment is in the high power mode or not. (bit 9=1 for high power) Bits 10-12 of HET tag word are unused.

ANALOG DATA SYSTEMS

The analog outputs of the CRT experiment together with the experiment connector (0854-J1) pin number are shown in Fig. AD1 below.

Pin Number	SC WORD (FMT. E-1)	Data
24	Wd 25	Power Supply Mon (Temp)
26	Wd 28	DET Temp (ARC-Therm)
27	Wd 26	Power Supply Mon. (Voltage)
28	Wd 27	Calib on/off
29	Wd 29	+RV Mon
30	Bit Wd 24	CRT Status

These analog output on pin 27 is an eight level commutation of seven voltage outputs of the experiment power supply and a ground position. The voltages in order of commutation are:

1) OV
2) +12V
3) +7.75V
4) +6.25V
5) +4.6V
6) -2V
7) -6.25V
8) -12V

All voltages are converted to the range $0.0 \leq V \leq 3.0$ before they are sent to the spacecraft quantizer.

The out-put on pin 28 indicates whether the CRT is being stimulated by it's internal calibrator. (OV=NO; 3V=yes)

The output on pin 30 supplies confirmation of the format in which the CRT is operating and, of course, should agree with that of the S/C. Pin 30=OV for format A and +3V for format B.

The output on Pin 24 comes from a thermister mounted directly on the power supply-input regulator-series transistor and serves as an indication of the dissipation of that device.

The output on Pin 26 comes from the Project Office supplied thermister which is mounted directly to LET-1 telescope housing.

DATA SYSTEM

The data system of the CRT may be broken up into two major areas: The "COSMIC RAY INTEGRATED MOSFET PROCESSOR" (CRIMP) and the INTERFACE DATA SYSTEM (IDS)

Crimp

The Crimp system is a design using LSI MOS technology to produce a logical building block normally referred to as a "bug." Some of the "bugs" used in the Crimp are:

1. Universal 4 bit MOS commutator C-1074
2. 10 channels of switch C-1070
3. Tree Bug
4. Mars bug
5. ATX, most bug C-1276

The hearts of the Crimp system are the Mars bugs which each contain a 24 bit accumutator, a 24 bit to 12 bit logarithmic compressor, readout gates which with suitable control produce the 12 bit compressed word as 3 bytes of 4 bits each. The compressed word is generated on command by disconnecting the accumulator input, transferring the contents to a ~~25~~ 24 bit shift registers, shifting ~~right~~ left until a "1" is found in the MSB of the register or 31 shifts have been made; counting the number of shifts required in a 5 bit counter, reading out the counter as the first five bits (characteristic) and the 7 MSB's of the shift register (after discarding the "1" in the MSB) as the last seven bits (Mantissa). It is seen that if the numbers accumulated is greater than 255 there will be some uncertainty in the number due to truncation from the left. Appendix A contains a listing of all possible outputs of rate data together with the uncertainty in the number read out. Included are octal and decimal representations of the rate number read out - neglecting the fact that it is compressed.

The Crimp also contains 6 PHA data accumulators of 12 bits and associated with each accumulator are 12 bits of interim storage, 12 bits of read out storage and necessary gating to sequentially produce, on application of control signals, the 12 bit PHA word as 3 bytes of 4 bits each. The PHA data is straight binary number representing the number of pulses produced by the HET or LET pulse height analyzers. Each LET or HET event has also a "tag" word associated with it which is formed in the IDS and shifted into readout storage with the 3 PHA words it modifies.

The Crimp contains circuitry necessary to produce the data format of the CRT. In a 6 stage binary counter, which is reset to all "1's" the the SSCWd (Wd 30 E-1), the Crimp keeps track of which frame it is in and sets up linkage to; the proper words (format A), or word (fromat B) to be read out in that frame. In format A the CRT receives three 12 bit words per frame making it is necessary to know where in the frame you are. For this purpose the Crimp has a sub counter (3 bit-set to all "1's" by the SSC Wd) which modifies the coarse address generated by the 6 bit counter reading out the 8 words of PHA data. Sectored rate (SR1 and SR2) accumulators are selected on the basis of 3 binary weighted lines from IDS which are decoded to one of eight lines by a "tree" bug in the Crimp. These lines in conjunction with a low "go" signal from IDS enable the Crimp to sequentially select the eight available accumulators are frozen.

INTERFACE DATA SYSTEM

The functions of the IDS are fourfold:

1. Provide specified impedence matching at the S/C-Experiment interface.
2. Provide interface between the MOS of the Crimp and the T^2L of the IDS.
3. Generate all necessary timing and control signals for operation of the experiment in gathering data.
4. Generate necessary timing signals to output data to the spacecraft date system.

S/C Experiment Interface

The IDS meets the required interface specification through the use of discrete amplifier on the input signals and discrete passive components output signals.

Crimp-IDS Interface

The IDS makes the voltage level shifts necessary between the MOS logic levels of the Crimp and its own transistor-transistor logic through discrete component inverting amplifier on all lines crossing the interface.

Timing and Control Signals

The IDS provides signals to both the linear system for PHA, control and rate commutation, and to the Crimp for accessing and fetching data for readout to the S/C.

The PHA's, their respective counters and tag registers in Crimp and IDS, and the control signals operate as shown the simplified block diagrams and timing diagram, figures IDS 1 and IDS 2.

Energy loss data from each PHA, only one of which is shown, consists of number N of logical pulses, (denoted GPT) which are counted in the 12 bit MOS counter. One additional signal from each group of three PHA, designated HET BUSY or LET BUSY is a pulse whose width is at least as long as the N pulses and therefore brackets all pulses to be counted. This signal indicates when the analyzers are busy and is used to inhibit any other analysis from overlapping the one in process. The TE of BUSY also initiates the transfer and reset pulse which moves data from the counters to intermediate storage and prepares the counters and PHA's for future analysis. The identifying tag bits associated with each event are strobed into the tag bit register in IDS shortly after the LE of BUSY. Subsequent events may be analyzed and written into intermediate storage, erasing all previous data. This is controlled by the priority system discussed above.

Once each 4 frames in format A or each 8 frames in format B, immediately prior to a PHA event readout. The PHA's are inhibited so that no analysis can take place, and the STU 32 KHz colck (after being divided by 2 to produce 16 KHz) is used to serially shift all data for both HET and LET events into readout storage. This data is fetched by Crimp under control of IDS in exactly the same way as rate data, i.e. by addressing each register sequentially and causing its data to be gated onto the output data bus. This is discussed in more detail later.

IDS also contains two counters, each with a capacity of 3 bits, which control commutation or rate data within the linear system. This allows the 32 rate counters of Crimp to be used for counting many more discrete coincidence rates from the various detector systems. Since the rates are basically of two types, sectored rates and unsectored rates, these two counters are called the sectored rate sequence counter (SRS) and the unsectored rate sequence counter (URS). The commutatuion sequence of each has already been described above. Operation and timing of each is described here.

The unsectored rate sequence counter is advanced by one count at the end of each unsectored rate accumulation interval as defined by the telemetry format in use. In format A, this occurs once each 32 main frames on the LE of the first Main Frame Word 14-17 (Ea) following the occurance of the subcom word E1-30 (SSC Wd) and 32 frames thereafter. The advance pulse also initiates log conversion of all unsectored rate counters so that, on the TE of Ea, new rate data is converted and ready to be fetched for readout in MFWd 41-44 (Eb). The URS is always advanced every 32 frames in format A. In format B URS is advanced every 64 frames, also on the first main frame word Ea following the subcom word E1-30. The unsectored rate data is thus converted and ready to be fetched on the TE of Ea for readout. The rate data readout cannot commence on MFWd 41-44, as it did in format A, however, because Ea is the only word present. Thus, in format B readout of rate data commences on the second Ea after E1-30.

In contrast to the above, the sectored rate sequence counter (SRS) can advance on one of two signals, either synchronously with the URS as described above, or in accordance with the Roll Index Pulse (RIP). In the former case, advance of SRS is synchronize with telemetry and has been fully described above. In the latter case, advance is synchronized with the S/C spin. One of these two signals is specified by the sector synchronizer command flip-flop and is indicated in the HET-tag word.

When the sector synchronizer is enabled, the sectored counters are allowed to accumulate for an integral number of complete S/C revolutions. The number of rolls is dependent upon the bit rate in use and present into the roll counter at the beginning of each accumulate interval. The roll counter increments by one on each RIP until the specified number of rolls has been completed. On the last roll pulse of each accumulate interval, a flip flop is set which enables the next Main Frame Word Ea in frames 17 through 32 or 49 through 64 initiate sectored accumulator data transfer and log compression. The next accumulate interval begins on the first RIP following data transfer.

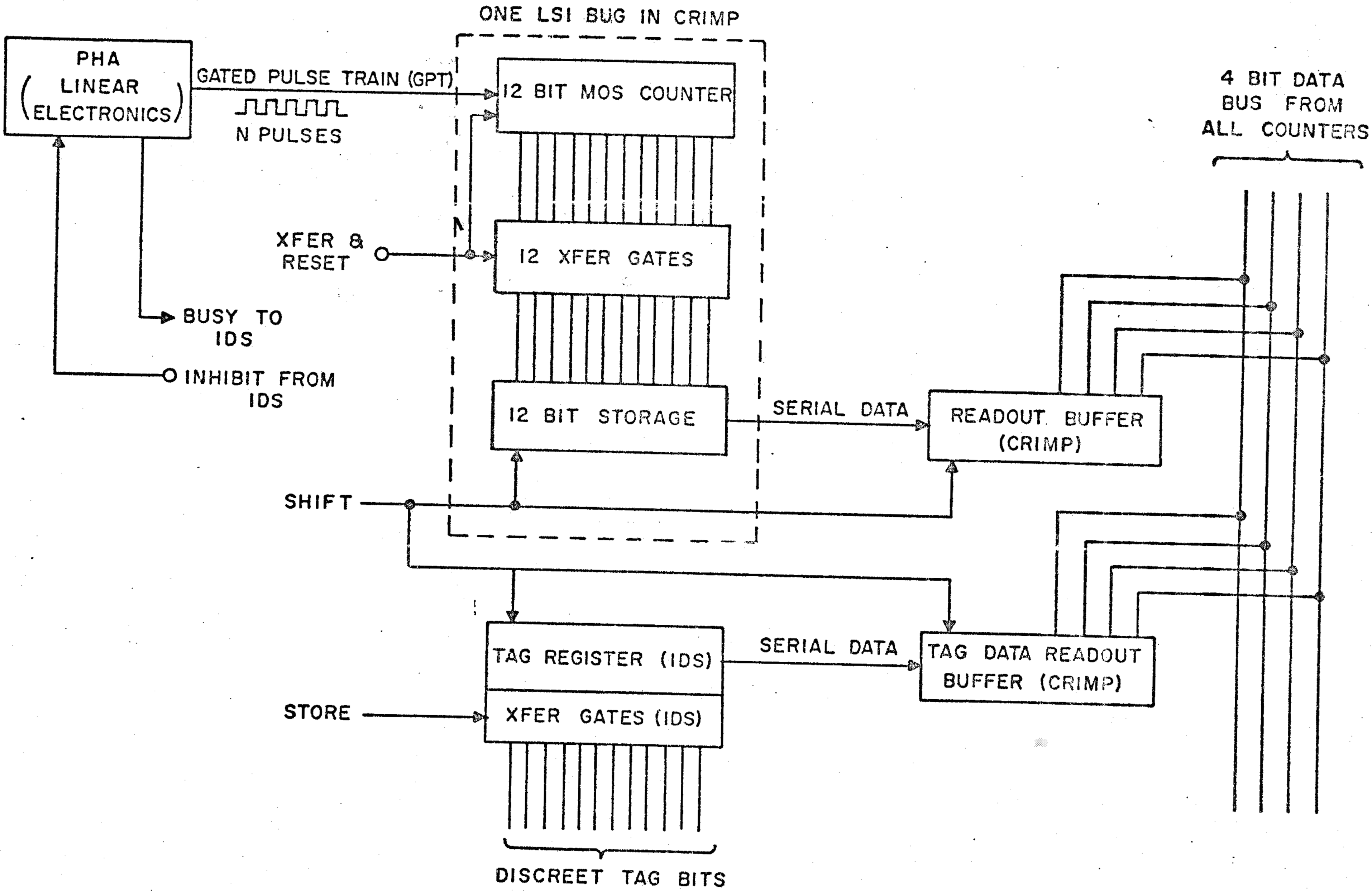
Data transfer is not allowed during frames 1-16 or 33-48 (Mode A) because sectored rate data in readout storage is being shifted out to the S/C. If transfer to readout storage was allowed during a sectored rate readout sequence. Two sources of error might arise. First, suppose the last RIP of an accumulate internal occured in frame 7. If transfer were allowed, the data transmitted to the ground in frames 1-7 would correspond to a different accumulate interval than that readout in frames 8-16. Recall that the sectored accumulators are commutated between several different rates, hence, adjacent accumulate intervals do not correspond to the same rate inputs. Allowing transfer as supposed above would intermaingle two intirely different coincidence rates in the data.

Secondly, if transfer were allowed during sectored rate readout, it is possible that a complete set of 16 readouts would be interrupted if the last RIP occured during the first readout of the sectored data. This can happen if the prescribed number of rolls for a high bit rate (size 1024 or 2048 bps, in which case m=31 is preset into the rolls counter, and the S/C is subsequently commanded into a lower bit rate in which the readout sequence is very long compared to one roll period.

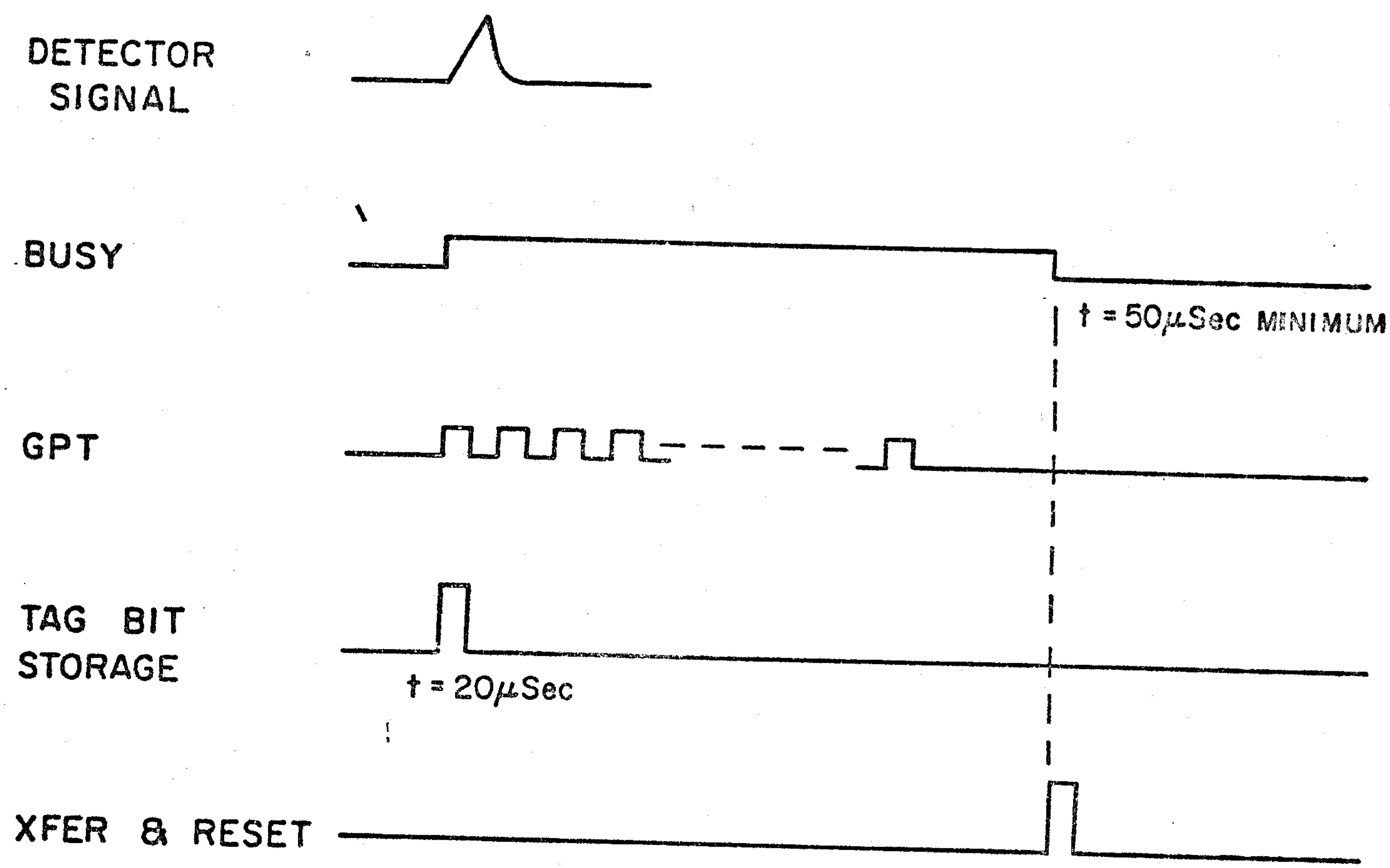
Format B, shows sectored data trnsfer is also inhibited during those frames in which rate data is being readout to telemetry. The frame numbers when transfer is inhibited are m to m+32, which is different than in format A.

One last feature should be noted. It is very likely, indeed it is desired, that the accumulate interval for sectored rate data will be longer than the readout interval, hence data for a given intervals will be repeated in the telemetry. This redundant data may be used for bit error checks in the processing system, but cannot be included in the rate averages. It is easy to identify which data is a repeat of old data and which is new data by use of the LSB of the sectored rate sequence counter (SRS) which is readout every four frames in HET-tag. This bit will change state every time SRS is incremented.

The contents of the two 3-bit counters, are readout fully in the subcom word E1-30. On the leading edge of E1-30, the state of each bit is strobed into a six bit shift register and immediately readout by the S/C. Advance of either counter must be at the time of Main F ame Word.Ea, hence, no error due to strobing during counter transition is possible. (See Data Format Section for information on how to obtain data synchronization.)


ONE LSI BUG IN CRIMP
PHA (LINEAR ELECTRONICS)
GATED PULSE TRAIN (GPT)
N PULSES
12 BIT MOS COUNTER
XFER & RESET
12 XFER GATES
BUSY TO IDS
INHIBIT FROM IDS
12 BIT STORAGE
SERIAL DATA
READOUT BUFFER (CRIMP)
4 BIT DATA BUS FROM ALL COUNTERS
SHIFT
TAG REGISTER (IDS)
SERIAL DATA
TAG DATA READOUT BUFFER (CRIMP)
STORE
XFER GATES (IDS)
DISCREET TAG BITS

IDS 1



DETECTOR
SIGNAL
BUSY
t = 50μSec MINIMUM
GPT
TAG BIT
STORAGE
t = 20μSec
XFER & RESET

IDS 2

Appendix A

TABLE OF CONVERSIONS

FOR

LOGARITHMIC ACCUMULATOR

GSFC COSMIC RAY TELESCOPE

Computer - Experiment Interface Section

Instrumentation Branch

Laboratory for High Energy
Astrophysics

Goddard Space Flight Center

Code 663.2

1. Insert counts in a 24 bit shift register

2. Subtract 1 from the register (0-1 = [illegible])

3. Shift bits until the MSB (24) of the shift register is 1 (or until 31 shifts have been made) count the number of shifts.

4. Store the shift count as the first five bits of the compressed word.

5. Store the MS-1 (23) to MS-8 (16) bits of the register as the last seven bits of the compressed word.

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
0	0	0177	127
1	0	7600	3968
2	0	5600	2944
3	0	5400	2816
4	0	5500	2880
5	0	5200	2688
6	0	5240	2720
7	0	5300	2752
8	0	5340	2784
9	0	5000	2560
10	0	5020	2576
11	0	5040	2592
12	0	5060	2608
13	0	5100	2624
14	0	5120	2640
15	0	5140	2656
16	0	5160	2672
17	0	4600	2432
18	0	4610	2440
19	0	4620	2448
20	0	4630	2456
21	0	4640	2464
22	0	4650	2472
23	0	4660	2480
24	0	4670	2488
25	0	4700	2496
26	0	4710	2504
27	0	4720	2512
28	0	4730	2520
29	0	4740	2528
30	0	4750	2536
31	0	4760	2544
32	0	4770	2552
33	0	4400	2304
34	0	4404	2308
35	0	4410	2312
36	0	4414	2316
37	0	4420	2320
38	0	4424	2324
39	0	4430	2328
40	0	4434	2332
41	0	4440	2336
42	0	4444	2340
43	0	4450	2344
44	0	4454	2348
45	0	4460	2352
46	0	4464	2356
47	0	4470	2360
48	0	4474	2364
49	0	4500	2368
50	0	4504	2372
51	0	4510	2376
52	0	4514	2380
53	0	4520	2384
54	0	4524	2388
55	0	4530	2392
56	0	4534	2396
57	0	4540	2400
58	0	4544	2404
59	0	4550	2408

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
60	0	4554	2412
61	0	4560	2416
62	0	4564	2420
63	0	4570	2424
64	0	4574	2428
65	0	4200	2176
66	0	4202	2178
67	0	4204	2180
68	0	4206	2182
69	0	4210	2184
70	0	4212	2186
71	0	4214	2188
72	0	4216	2190
73	0	4220	2192
74	0	4222	2194
75	0	4224	2196
76	0	4226	2198
77	0	4230	2200
78	0	4232	2202
79	0	4234	2204
80	0	4236	2206
81	0	4240	2208
82	0	4242	2210
83	0	4244	2212
84	0	4246	2214
85	0	4250	2216
86	0	4252	2218
87	0	4254	2220
88	0	4256	2222
89	0	4260	2224
90	0	4262	2226
91	0	4264	2228
92	0	4266	2230
93	0	4270	2232
94	0	4272	2234
95	0	4274	2236
96	0	4276	2238
97	0	4300	2240
98	0	4302	2242
99	0	4304	2244
100	0	4306	2246
101	0	4310	2248
102	0	4312	2250
103	0	4314	2252
104	0	4316	2254
105	0	4320	2256
106	0	4322	2258
107	0	4324	2260
108	0	4326	2262
109	0	4330	2264
110	0	4332	2266
111	0	4334	2268
112	0	4336	2270
113	0	4340	2272
114	0	4342	2274
115	0	4344	2276
116	0	4346	2278
117	0	4350	2280
118	0	4352	2282
119	0	4354	2284

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
120	0	4356	2286
121	0	4360	2288
122	0	4362	2290
123	0	4364	2292
124	0	4366	2294
125	0	4370	2296
126	0	4372	2298
127	0	4374	2300
128	0	4376	2302
129	0	4000	2048
130	0	4001	2049
131	0	4002	2050
132	0	4003	2051
133	0	4004	2052
134	0	4005	2053
135	0	4006	2054
136	0	4007	2055
137	0	4010	2056
138	0	4011	2057
139	0	4012	2058
140	0	4013	2059
141	0	4014	2060
142	0	4015	2061
143	0	4016	2062
144	0	4017	2063
145	0	4020	2064
146	0	4021	2065
147	0	4022	2066
148	0	4023	2067
149	0	4024	2068
150	0	4025	2069
151	0	4026	2070
152	0	4027	2071
153	0	4030	2072
154	0	4031	2073
155	0	4032	2074
156	0	4033	2075
157	0	4034	2076
158	0	4035	2077
159	0	4036	2078
160	0	4037	2079
161	0	4040	2080
162	0	4041	2081
163	0	4042	2082
164	0	4043	2083
165	0	4044	2084
166	0	4045	2085
167	0	4046	2086
168	0	4047	2087
169	0	4050	2088
170	0	4051	2089
171	0	4052	2090
172	0	4053	2091
173	0	4054	2092
174	0	4055	2093
175	0	4056	2094
176	0	4057	2095
177	0	4060	2096
178	0	4061	2097
179	0	4062	2098

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
180	0	4063	2099
181	0	4064	2100
182	0	4065	2101
183	0	4066	2102
184	0	4067	2103
185	0	4070	2104
186	0	4071	2105
187	0	4072	2106
188	0	4073	2107
189	0	4074	2108
190	0	4075	2109
191	0	4076	2110
192	0	4077	2111
193	0	4100	2112
194	0	4101	2113
195	0	4102	2114
196	0	4103	2115
197	0	4104	2116
198	0	4105	2117
199	0	4106	2118
200	0	4107	2119
201	0	4110	2120
202	0	4111	2121
203	0	4112	2122
204	0	4113	2123
205	0	4114	2124
206	0	4115	2125
207	0	4116	2126
208	0	4117	2127
209	0	4120	2128
210	0	4121	2129
211	0	4122	2130
212	0	4123	2131
213	0	4124	2132
214	0	4125	2133
215	0	4126	2134
216	0	4127	2135
217	0	4130	2136
218	0	4131	2137
219	0	4132	2138
220	0	4133	2139
221	0	4134	2140
222	0	4135	2141
223	0	4136	2142
224	0	4137	2143
225	0	4140	2144
226	0	4141	2145
227	0	4142	2146
228	0	4143	2147
229	0	4144	2148
230	0	4145	2149
231	0	4146	2150
232	0	4147	2151
233	0	4150	2152
234	0	4151	2153
235	0	4152	2154
236	0	4153	2155
237	0	4154	2156
238	0	4155	2157
239	0	4156	2158

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
240	0	4157	2159
241	0	4160	2160
242	0	4161	2161
243	0	4162	2162
244	0	4163	2163
245	0	4164	2164
246	0	4165	2165
247	0	4166	2166
248	0	4167	2167
249	0	4170	2168
250	0	4171	2169
251	0	4172	2170
252	0	4173	2171
253	0	4174	2172
254	0	4175	2173
255	0	4176	2174
256	0	4177	2175
257	1	3600	1920
259	1	3601	1921
261	1	3602	1922
263	1	3603	1923
265	1	3604	1924
267	1	3605	1925
269	1	3606	1926
271	1	3607	1927
273	1	3610	1928
275	1	3611	1929
277	1	3612	1930
279	1	3613	1931
281	1	3614	1932
283	1	3615	1933
285	1	3616	1934
287	1	3617	1935
289	1	3620	1936
291	1	3621	1937
293	1	3622	1938
295	1	3623	1939
297	1	3624	1940
299	1	3625	1941
301	1	3626	1942
303	1	3627	1943
305	1	3630	1944
307	1	3631	1945
309	1	3632	1946
311	1	3633	1947
313	1	3634	1948
315	1	3635	1949
317	1	3636	1950
319	1	3637	1951
321	1	3640	1952
323	1	3641	1953
325	1	3642	1954
327	1	3643	1955
329	1	3644	1956
331	1	3645	1957
333	1	3646	1958
335	1	3647	1959
337	1	3650	1960
339	1	3651	1961
341	1	3652	1962

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
343	1	3653	1963
345	1	3654	1964
347	1	3655	1965
349	1	3656	1966
351	1	3657	1967
353	1	3660	1968
355	1	3661	1969
357	1	3662	1970
359	1	3663	1971
361	1	3664	1972
363	1	3665	1973
365	1	3666	1974
367	1	3667	1975
369	1	3670	1976
371	1	3671	1977
373	1	3672	1978
375	1	3673	1979
377	1	3674	1980
379	1	3675	1981
381	1	3676	1982
383	1	3677	1983
385	1	3700	1984
387	1	3701	1985
389	1	3702	1986
391	1	3703	1987
393	1	3704	1988
395	1	3705	1989
397	1	3706	1990
399	1	3707	1991
401	1	3710	1992
403	1	3711	1993
405	1	3712	1994
407	1	3713	1995
409	1	3714	1996
411	1	3715	1997
413	1	3716	1998
415	1	3717	1999
417	1	3720	2000
419	1	3721	2001
421	1	3722	2002
423	1	3723	2003
425	1	3724	2004
427	1	3725	2005
429	1	3726	2006
431	1	3727	2007
433	1	3730	2008
435	1	3731	2009
437	1	3732	2010
439	1	3733	2011
441	1	3734	2012
443	1	3735	2013
445	1	3736	2014
447	1	3737	2015
449	1	3740	2016
451	1	3741	2017
453	1	3742	2018
455	1	3743	2019
457	1	3744	2020
459	1	3745	2021
461	1	3746	2022

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
463	1	3747	2023
465	1	3750	2024
467	1	3751	2025
469	1	3752	2026
471	1	3753	2027
473	1	3754	2028
475	1	3755	2029
477	1	3756	2030
479	1	3757	2031
481	1	3760	2032
483	1	3761	2033
485	1	3762	2034
487	1	3763	2035
489	1	3764	2036
491	1	3765	2037
493	1	3766	2038
495	1	3767	2039
497	1	3770	2040
499	1	3771	2041
501	1	3772	2042
503	1	3773	2043
505	1	3774	2044
507	1	3775	2045
509	1	3776	2046
511	1	3777	2047
513	3	3400	1792
517	3	3401	1793
521	3	3402	1794
525	3	3403	1795
529	3	3404	1796
533	3	3405	1797
537	3	3406	1798
541	3	3407	1799
545	3	3410	1800
549	3	3411	1801
553	3	3412	1802
557	3	3413	1803
561	3	3414	1804
565	3	3415	1805
569	3	3416	1806
573	3	3417	1807
577	3	3420	1808
581	3	3421	1809
585	3	3422	1810
589	3	3423	1811
593	3	3424	1812
597	3	3425	1813
601	3	3426	1814
605	3	3427	1815
609	3	3430	1816
613	3	3431	1817
617	3	3432	1818
621	3	3433	1819
625	3	3434	1820
629	3	3435	1821
633	3	3436	1822
637	3	3437	1823
641	3	3440	1824
645	3	3441	1825
649	3	3442	1826

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
653	3	3443	1827
657	3	3444	1828
661	3	3445	1829
665	3	3446	1830
669	3	3447	1831
673	3	3450	1832
677	3	3451	1833
681	3	3452	1834
685	3	3453	1835
689	3	3454	1836
693	3	3455	1837
697	3	3456	1838
701	3	3457	1839
705	3	3460	1840
709	3	3461	1841
713	3	3462	1842
717	3	3463	1843
721	3	3464	1844
725	3	3465	1845
729	3	3466	1846
733	3	3467	1847
737	3	3470	1848
741	3	3471	1849
745	3	3472	1850
749	3	3473	1851
753	3	3474	1852
757	3	3475	1853
761	3	3476	1854
765	3	3477	1855
769	3	3500	1856
773	3	3501	1857
777	3	3502	1858
781	3	3503	1859
785	3	3504	1860
789	3	3505	1861
793	3	3506	1862
797	3	3507	1863
801	3	3510	1864
805	3	3511	1865
809	3	3512	1866
813	3	3513	1867
817	3	3514	1868
821	3	3515	1869
825	3	3516	1870
829	3	3517	1871
833	3	3520	1872
837	3	3521	1873
841	3	3522	1874
845	3	3523	1875
849	3	3524	1876
853	3	3525	1877
857	3	3526	1878
861	3	3527	1879
865	3	3530	1880
869	3	3531	1881
873	3	3532	1882
877	3	3533	1883
881	3	3534	1884
885	3	3535	1885
889	3	3536	1886

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
893	3	3537	1887
897	3	3540	1888
901	3	3541	1889
905	3	3542	1890
909	3	3543	1891
913	3	3544	1892
917	3	3545	1893
921	3	3546	1894
925	3	3547	1895
929	3	3550	1896
933	3	3551	1897
937	3	3552	1898
941	3	3553	1899
945	3	3554	1900
949	3	3555	1901
953	3	3556	1902
957	3	3557	1903
961	3	3560	1904
965	3	3561	1905
969	3	3562	1906
973	3	3563	1907
977	3	3564	1908
981	3	3565	1909
985	3	3566	1910
989	3	3567	1911
993	3	3570	1912
997	3	3571	1913
1001	3	3572	1914
1005	3	3573	1915
1009	3	3574	1916
1013	3	3575	1917
1017	3	3576	1918
1021	3	3577	1919
1025	7	3200	1564
1033	7	3201	1565
1041	7	3202	1566
1049	7	3203	1567
1057	7	3204	1568
1065	7	3205	1569
1073	7	3206	1570
1081	7	3207	1571
1089	7	3210	1572
1097	7	3211	1573
1105	7	3212	1574
1113	7	3213	1575
1121	7	3214	1576
1129	7	3215	1577
1137	7	3216	1578
1145	7	3217	1579
1153	7	3220	1580
1161	7	3221	1581
1169	7	3222	1582
1177	7	3223	1583
1185	7	3224	1584
1193	7	3225	1585
1201	7	3226	1586
1209	7	3227	1587
1217	7	3230	1588
1225	7	3231	1589
1233	7	3232	1590

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
1241	7	3233	1591
1249	7	3234	1592
1257	7	3235	1593
1265	7	3236	1594
1273	7	3237	1595
1281	7	3240	1596
1289	7	3241	1597
1297	7	3242	1598
1305	7	3243	1599
1313	7	3244	1700
1321	7	3245	1701
1329	7	3246	1702
1337	7	3247	1703
1345	7	3250	1704
1353	7	3251	1705
1361	7	3252	1706
1369	7	3253	1707
1377	7	3254	1708
1385	7	3255	1709
1393	7	3256	1710
1401	7	3257	1711
1409	7	3260	1712
1417	7	3261	1713
1425	7	3262	1714
1433	7	3263	1715
1441	7	3264	1716
1449	7	3265	1717
1457	7	3266	1718
1465	7	3267	1719
1473	7	3270	1720
1481	7	3271	1721
1489	7	3272	1722
1497	7	3273	1723
1505	7	3274	1724
1513	7	3275	1725
1521	7	3276	1726
1529	7	3277	1727
1537	7	3300	1728
1545	7	3301	1729
1553	7	3302	1730
1561	7	3303	1731
1569	7	3304	1732
1577	7	3305	1733
1585	7	3306	1734
1593	7	3307	1735
1601	7	3310	1736
1609	7	3311	1737
1617	7	3312	1738
1625	7	3313	1739
1633	7	3314	1740
1641	7	3315	1741
1649	7	3316	1742
1657	7	3317	1743
1665	7	3320	1744
1673	7	3321	1745
1681	7	3322	1746
1689	7	3323	1747
1697	7	3324	1748
1705	7	3325	1749
1713	7	3326	1750

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
1721	7	3327	1751
1729	7	3330	1752
1737	7	3331	1753
1745	7	3332	1754
1753	7	3333	1755
1761	7	3334	1756
1769	7	3335	1757
1777	7	3336	1758
1785	7	3337	1759
1793	7	3340	1760
1801	7	3341	1761
1809	7	3342	1762
1817	7	3343	1763
1825	7	3344	1764
1833	7	3345	1765
1841	7	3346	1766
1849	7	3347	1767
1857	7	3350	1768
1865	7	3351	1769
1873	7	3352	1770
1881	7	3353	1771
1889	7	3354	1772
1897	7	3355	1773
1905	7	3356	1774
1913	7	3357	1775
1921	7	3360	1776
1929	7	3361	1777
1937	7	3362	1778
1945	7	3363	1779
1953	7	3364	1780
1961	7	3365	1781
1969	7	3366	1782
1977	7	3367	1783
1985	7	3370	1784
1993	7	3371	1785
2001	7	3372	1786
2009	7	3373	1787
2017	7	3374	1788
2025	7	3375	1789
2033	7	3376	1790
2041	7	3377	1791
2049	15	3000	1536
2065	15	3001	1537
2081	15	3002	1538
2097	15	3003	1539
2113	15	3004	1540
2129	15	3005	1541
2145	15	3006	1542
2161	15	3007	1543
2177	15	3010	1544
2193	15	3011	1545
2209	15	3012	1546
2225	15	3013	1547
2241	15	3014	1548
2257	15	3015	1549
2273	15	3016	1550
2289	15	3017	1551
2305	15	3020	1552
2321	15	3021	1553
2337	15	3022	1554

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
2353	15	3023	1555
2369	15	3024	1556
2385	15	3025	1557
2401	15	3026	1558
2417	15	3027	1559
2433	15	3030	1560
2449	15	3031	1561
2465	15	3032	1562
2481	15	3033	1563
2497	15	3034	1564
2513	15	3035	1565
2529	15	3036	1566
2545	15	3037	1567
2561	15	3040	1568
2577	15	3041	1569
2593	15	3042	1570
2609	15	3043	1571
2625	15	3044	1572
2641	15	3045	1573
2657	15	3046	1574
2673	15	3047	1575
2689	15	3050	1576
2705	15	3051	1577
2721	15	3052	1578
2737	15	3053	1579
2753	15	3054	1580
2769	15	3055	1581
2785	15	3055	1582
2801	15	3057	1583
2817	15	3060	1584
2833	15	3061	1585
2849	15	3062	1586
2865	15	3063	1587
2881	15	3064	1588
2897	15	3065	1589
2913	15	3066	1590
2929	15	3067	1591
2945	15	3070	1592
2961	15	3071	1593
2977	15	3072	1594
2993	15	3073	1595
3009	15	3074	1596
3025	15	3075	1597
3041	15	3075	1598
3057	15	3077	1599
3073	15	3100	1500
3089	15	3101	1501
3105	15	3102	1502
3121	15	3103	1503
3137	15	3104	1504
3153	15	3105	1505
3169	15	3106	1506
3185	15	3107	1507
3201	15	3110	1508
3217	15	3111	1509
3233	15	3112	1510
3249	15	3113	1511
3265	15	3114	1512
3281	15	3115	1513
3297	15	3116	1514

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
3313	15	3117	1515
3329	15	3120	1516
3345	15	3121	1517
3361	15	3122	1518
3377	15	3123	1519
3393	15	3124	1520
3409	15	3125	1521
3425	15	3126	1522
3441	15	3127	1523
3457	15	3130	1524
3473	15	3131	1525
3489	15	3132	1526
3505	15	3133	1527
3521	15	3134	1528
3537	15	3135	1529
3553	15	3136	1530
3569	15	3137	1531
3585	15	3140	1532
3601	15	3141	1533
3617	15	3142	1534
3633	15	3143	1535
3649	15	3144	1536
3665	15	3145	1537
3681	15	3146	1538
3697	15	3147	1539
3713	15	3150	1540
3729	15	3151	1541
3745	15	3152	1542
3761	15	3153	1543
3777	15	3154	1544
3793	15	3155	1545
3809	15	3156	1546
3825	15	3157	1547
3841	15	3160	1548
3857	15	3161	1549
3873	15	3162	1550
3889	15	3163	1551
3905	15	3164	1552
3921	15	3165	1553
3937	15	3166	1554
3953	15	3167	1555
3969	15	3170	1556
3985	15	3171	1557
4001	15	3172	1558
4017	15	3173	1559
4033	15	3174	1560
4049	15	3175	1561
4065	15	3176	1562
4081	15	3177	1563
4097	31	2600	1408
4129	31	2601	1409
4161	31	2602	1410
4193	31	2603	1411
4225	31	2604	1412
4257	31	2605	1413
4289	31	2606	1414
4321	31	2607	1415
4353	31	2610	1416
4385	31	2611	1417
4417	31	2612	1418

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
4449	31	2613	1419
4481	31	2614	1420
4513	31	2615	1421
4545	31	2616	1422
4577	31	2617	1423
4609	31	2620	1424
4641	31	2621	1425
4673	31	2622	1426
4705	31	2623	1427
4737	31	2624	1428
4769	31	2625	1429
4801	31	2626	1430
4833	31	2627	1431
4865	31	2630	1432
4897	31	2631	1433
4929	31	2632	1434
4961	31	2633	1435
4993	31	2634	1436
5025	31	2635	1437
5057	31	2636	1438
5089	31	2637	1439
5121	31	2640	1440
5153	31	2641	1441
5185	31	2642	1442
5217	31	2643	1443
5249	31	2644	1444
5281	31	2645	1445
5313	31	2646	1446
5345	31	2647	1447
5377	31	2650	1448
5409	31	2651	1449
5441	31	2652	1450
5473	31	2653	1451
5505	31	2654	1452
5537	31	2655	1453
5569	31	2656	1454
5601	31	2657	1455
5633	31	2660	1456
5665	31	2661	1457
5697	31	2662	1458
5729	31	2663	1459
5761	31	2664	1460
5793	31	2665	1461
5825	31	2666	1462
5857	31	2667	1463
5889	31	2670	1464
5921	31	2671	1465
5953	31	2672	1466
5985	31	2673	1467
6017	31	2674	1468
6049	31	2675	1469
6081	31	2676	1470
6113	31	2677	1471
6145	31	2700	1472
6177	31	2701	1473
6209	31	2702	1474
6241	31	2703	1475
6273	31	2704	1476
6305	31	2705	1477
6337	31	2706	1478

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
6369	31	2707	1479
6401	31	2710	1480
6433	31	2711	1481
6465	31	2712	1482
6497	31	2713	1483
6529	31	2714	1484
6561	31	2715	1485
6593	31	2716	1486
6625	31	2717	1487
6657	31	2720	1488
6689	31	2721	1489
6721	31	2722	1490
6753	31	2723	1491
6785	31	2724	1492
6817	31	2725	1493
6849	31	2726	1494
6881	31	2727	1495
6913	31	2730	1496
6945	31	2731	1497
6977	31	2732	1498
7009	31	2733	1499
7041	31	2734	1500
7073	31	2735	1501
7105	31	2736	1502
7137	31	2737	1503
7169	31	2740	1504
7201	31	2741	1505
7233	31	2742	1506
7265	31	2743	1507
7297	31	2744	1508
7329	31	2745	1509
7361	31	2746	1510
7393	31	2747	1511
7425	31	2750	1512
7457	31	2751	1513
7489	31	2752	1514
7521	31	2753	1515
7553	31	2754	1516
7585	31	2755	1517
7617	31	2756	1518
7649	31	2757	1519
7681	31	2760	1520
7713	31	2761	1521
7745	31	2762	1522
7777	31	2763	1523
7809	31	2764	1524
7841	31	2765	1525
7873	31	2766	1526
7905	31	2767	1527
7937	31	2770	1528
7969	31	2771	1529
8001	31	2772	1530
8033	31	2773	1531
8065	31	2774	1532
8097	31	2775	1533
8129	31	2776	1534
8161	31	2777	1535
8193	63	2400	1280
8257	63	2401	1281
8321	63	2402	1282

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
8385	63	2403	1283
8449	63	2404	1284
8513	63	2405	1285
8577	63	2406	1286
8641	63	2407	1287
8705	63	2410	1288
8769	63	2411	1289
8833	63	2412	1290
8897	63	2413	1291
8961	63	2414	1292
9025	63	2415	1293
9089	63	2416	1294
9153	63	2417	1295
9217	63	2420	1296
9281	63	2421	1297
9345	63	2422	1298
9409	63	2423	1299
9473	63	2424	1300
9537	63	2425	1301
9601	63	2426	1302
9665	63	2427	1303
9729	63	2430	1304
9793	63	2431	1305
9857	63	2432	1306
9921	63	2433	1307
9985	63	2434	1308
10049	63	2435	1309
10113	63	2436	1310
10177	63	2437	1311
10241	63	2440	1312
10305	63	2441	1313
10369	63	2442	1314
10433	63	2443	1315
10497	63	2444	1316
10561	63	2445	1317
10625	63	2446	1318
10689	63	2447	1319
10753	63	2450	1320
10817	63	2451	1321
10881	63	2452	1322
10945	63	2453	1323
11009	63	2454	1324
11073	63	2455	1325
11137	63	2456	1326
11201	63	2457	1327
11265	63	2460	1328
11329	63	2461	1329
11393	63	2462	1330
11457	63	2463	1331
11521	63	2464	1332
11585	63	2465	1333
11649	63	2466	1334
11713	63	2467	1335
11777	63	2470	1336
11841	63	2471	1337
11905	63	2472	1338
11969	63	2473	1339
12033	63	2474	1340
12097	63	2475	1341
12161	63	2476	1342

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
12225	63	2477	1343
12289	63	2500	1344
12353	63	2501	1345
12417	63	2502	1346
12481	63	2503	1347
12545	63	2504	1348
12609	63	2505	1349
12673	63	2506	1350
12737	63	2507	1351
12801	63	2510	1352
12865	63	2511	1353
12929	63	2512	1354
12993	63	2513	1355
13057	63	2514	1356
13121	63	2515	1357
13185	63	2516	1358
13249	63	2517	1359
13313	63	2520	1360
13377	63	2521	1361
13441	63	2522	1362
13505	63	2523	1363
13569	63	2524	1364
13633	63	2525	1365
13697	63	2526	1366
13761	63	2527	1367
13825	63	2530	1368
13889	63	2531	1369
13953	63	2532	1370
14017	63	2533	1371
14081	63	2534	1372
14145	63	2535	1373
14209	63	2536	1374
14273	63	2537	1375
14337	63	2540	1376
14401	63	2541	1377
14465	63	2542	1378
14529	63	2543	1379
14593	63	2544	1380
14657	63	2545	1381
14721	63	2546	1382
14785	63	2547	1383
14849	63	2550	1384
14913	63	2551	1385
14977	63	2552	1386
15041	63	2553	1387
15105	63	2554	1388
15169	63	2555	1389
15233	63	2556	1390
15297	63	2557	1391
15361	63	2560	1392
15425	63	2561	1393
15489	63	2562	1394
15553	63	2563	1395
15617	63	2564	1396
15681	63	2565	1397
15745	63	2566	1398
15809	63	2567	1399
15873	63	2570	1400
15937	63	2571	1401
16001	63	2572	1402

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
16065	63	2573	1403
16129	63	2574	1404
16193	63	2575	1405
16257	63	2576	1406
16321	63	2577	1407
16385	127	2200	1152
16513	127	2201	1153
16641	127	2202	1154
16769	127	2203	1155
16897	127	2204	1156
17025	127	2205	1157
17153	127	2206	1158
17281	127	2207	1159
17409	127	2210	1160
17537	127	2211	1161
17665	127	2212	1162
17793	127	2213	1163
17921	127	2214	1164
18049	127	2215	1165
18177	127	2216	1166
18305	127	2217	1167
18433	127	2220	1168
18561	127	2221	1169
18689	127	2222	1170
18817	127	2223	1171
18945	127	2224	1172
19073	127	2225	1173
19201	127	2226	1174
19329	127	2227	1175
19457	127	2230	1176
19585	127	2231	1177
19713	127	2232	1178
19841	127	2233	1179
19969	127	2234	1180
20097	127	2235	1181
20225	127	2236	1182
20353	127	2237	1183
20481	127	2240	1184
20609	127	2241	1185
20737	127	2242	1186
20865	127	2243	1187
20993	127	2244	1188
21121	127	2245	1189
21249	127	2246	1190
21377	127	2247	1191
21505	127	2250	1192
21633	127	2251	1193
21761	127	2252	1194
21889	127	2253	1195
22017	127	2254	1196
22145	127	2255	1197
22273	127	2256	1198
22401	127	2257	1199
22529	127	2260	1200
22657	127	2261	1201
22785	127	2262	1202
22913	127	2263	1203
23041	127	2264	1204
23169	127	2265	1205
23297	127	2266	1206

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
23425	127	2267	1207
23553	127	2270	1208
23681	127	2271	1209
23809	127	2272	1210
23937	127	2273	1211
24065	127	2274	1212
24193	127	2275	1213
24321	127	2276	1214
24449	127	2277	1215
24577	127	2300	1216
24705	127	2301	1217
24833	127	2302	1218
24961	127	2303	1219
25089	127	2304	1220
25217	127	2305	1221
25345	127	2306	1222
25473	127	2307	1223
25601	127	2310	1224
25729	127	2311	1225
25857	127	2312	1226
25985	127	2313	1227
26113	127	2314	1228
26241	127	2315	1229
26369	127	2316	1230
26497	127	2317	1231
26625	127	2320	1232
26753	127	2321	1233
26881	127	2322	1234
27009	127	2323	1235
27137	127	2324	1236
27265	127	2325	1237
27393	127	2326	1238
27521	127	2327	1239
27649	127	2330	1240
27777	127	2331	1241
27905	127	2332	1242
28033	127	2333	1243
28161	127	2334	1244
28289	127	2335	1245
28417	127	2336	1246
28545	127	2337	1247
28673	127	2340	1248
28801	127	2341	1249
28929	127	2342	1250
29057	127	2343	1251
29185	127	2344	1252
29313	127	2345	1253
29441	127	2346	1254
29569	127	2347	1255
29697	127	2350	1256
29825	127	2351	1257
29953	127	2352	1258
30081	127	2353	1259
30209	127	2354	1260
30337	127	2355	1261
30465	127	2356	1262
30593	127	2357	1263
30721	127	2360	1264
30849	127	2361	1265
30977	127	2362	1266

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
31105	127	2363	1267
31233	127	2364	1268
31361	127	2365	1269
31489	127	2366	1270
31617	127	2367	1271
31745	127	2370	1272
31873	127	2371	1273
32001	127	2372	1274
32129	127	2373	1275
32257	127	2374	1276
32385	127	2375	1277
32513	127	2376	1278
32641	127	2377	1279
32769	255	2000	1024
33025	255	2001	1025
33281	255	2002	1026
33537	255	2003	1027
33793	255	2004	1028
34049	255	2005	1029
34305	255	2006	1030
34561	255	2007	1031
34817	255	2010	1032
35073	255	2011	1033
35329	255	2012	1034
35585	255	2013	1035
35841	255	2014	1036
36097	255	2015	1037
36353	255	2016	1038
36609	255	2017	1039
36865	255	2020	1040
37121	255	2021	1041
37377	255	2022	1042
37633	255	2023	1043
37889	255	2024	1044
38145	255	2025	1045
38401	255	2026	1046
38657	255	2027	1047
38913	255	2030	1048
39169	255	2031	1049
39425	255	2032	1050
39681	255	2033	1051
39937	255	2034	1052
40193	255	2035	1053
40449	255	2036	1054
40705	255	2037	1055
40961	255	2040	1056
41217	255	2041	1057
41473	255	2042	1058
41729	255	2043	1059
41985	255	2044	1060
42241	255	2045	1061
42497	255	2046	1062
42753	255	2047	1063
43009	255	2050	1064
43265	255	2051	1065
43521	255	2052	1066
43777	255	2053	1067
44033	255	2054	1068
44289	255	2055	1069
44545	255	2056	1070

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
44801	255	2057	1071
45057	255	2060	1072
45313	255	2061	1073
45569	255	2062	1074
45825	255	2063	1075
46081	255	2064	1076
46337	255	2065	1077
46593	255	2066	1078
46849	255	2067	1079
47105	255	2070	1080
47361	255	2071	1081
47617	255	2072	1082
47873	255	2073	1083
48129	255	2074	1084
48385	255	2075	1085
48641	255	2076	1086
48897	255	2077	1087
49153	255	2100	1088
49409	255	2101	1089
49665	255	2102	1090
49921	255	2103	1091
50177	255	2104	1092
50433	255	2105	1093
50689	255	2106	1094
50945	255	2107	1095
51201	255	2110	1096
51457	255	2111	1097
51713	255	2112	1098
51969	255	2113	1099
52225	255	2114	1100
52481	255	2115	1101
52737	255	2116	1102
52993	255	2117	1103
53249	255	2120	1104
53505	255	2121	1105
53761	255	2122	1106
54017	255	2123	1107
54273	255	2124	1108
54529	255	2125	1109
54785	255	2126	1110
55041	255	2127	1111
55297	255	2130	1112
55553	255	2131	1113
55809	255	2132	1114
56065	255	2133	1115
56321	255	2134	1116
56577	255	2135	1117
56833	255	2136	1118
57089	255	2137	1119
57345	255	2140	1120
57601	255	2141	1121
57857	255	2142	1122
58113	255	2143	1123
58369	255	2144	1124
58625	255	2145	1125
58881	255	2146	1126
59137	255	2147	1127
59393	255	2150	1128
59649	255	2151	1129
59905	255	2152	1130

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
60161	255	2153	1131
60417	255	2154	1132
60673	255	2155	1133
60929	255	2156	1134
61185	255	2157	1135
61441	255	2160	1136
61697	255	2161	1137
61953	255	2162	1138
62209	255	2163	1139
62465	255	2164	1140
62721	255	2165	1141
62977	255	2166	1142
63233	255	2167	1143
63489	255	2170	1144
63745	255	2171	1145
64001	255	2172	1146
64257	255	2173	1147
64513	255	2174	1148
64769	255	2175	1149
65025	255	2176	1150
65281	255	2177	1151
65537	511	1600	896
66049	511	1601	897
66561	511	1602	898
67073	511	1603	899
67585	511	1604	900
68097	511	1605	901
68609	511	1606	902
69121	511	1607	903
69633	511	1610	904
70145	511	1611	905
70657	511	1612	906
71169	511	1613	907
71681	511	1614	908
72193	511	1615	909
72705	511	1616	910
73217	511	1617	911
73729	511	1620	912
74241	511	1621	913
74753	511	1622	914
75265	511	1623	915
75777	511	1624	916
76289	511	1625	917
76801	511	1626	918
77313	511	1627	919
77825	511	1630	920
78337	511	1631	921
78849	511	1632	922
79361	511	1633	923
79873	511	1634	924
80385	511	1635	925
80897	511	1636	926
81409	511	1637	927
81921	511	1640	928
82433	511	1641	929
82945	511	1642	930
83457	511	1643	931
83969	511	1644	932
84481	511	1645	933
84993	511	1646	934

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
85505	511	1647	935
86017	511	1650	936
86529	511	1651	937
87041	511	1652	938
87553	511	1653	939
88065	511	1654	940
88577	511	1655	941
89089	511	1656	942
89601	511	1657	943
90113	511	1660	944
90625	511	1661	945
91137	511	1662	946
91649	511	1663	947
92161	511	1664	948
92673	511	1665	949
93185	511	1666	950
93697	511	1667	951
94209	511	1670	952
94721	511	1671	953
95233	511	1672	954
95745	511	1673	955
96257	511	1674	956
96769	511	1675	957
97281	511	1676	958
97793	511	1677	959
98305	511	1700	960
98817	511	1701	961
99329	511	1702	962
99841	511	1703	963
100353	511	1704	964
100865	511	1705	965
101377	511	1706	966
101889	511	1707	967
102401	511	1710	968
102913	511	1711	969
103425	511	1712	970
103937	511	1713	971
104449	511	1714	972
104961	511	1715	973
105473	511	1716	974
105985	511	1717	975
106497	511	1720	976
107009	511	1721	977
107521	511	1722	978
108033	511	1723	979
108545	511	1724	980
109057	511	1725	981
109569	511	1726	982
110081	511	1727	983
110593	511	1730	984
111105	511	1731	985
111617	511	1732	986
112129	511	1733	987
112641	511	1734	988
113153	511	1735	989
113665	511	1736	990
114177	511	1737	991
114689	511	1740	992
115201	511	1741	993
115713	511	1742	994

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
116225	511	1743	995
116737	511	1744	996
117249	511	1745	997
117761	511	1746	998
118273	511	1747	999
118785	511	1750	1000
119297	511	1751	1001
119809	511	1752	1002
120321	511	1753	1003
120833	511	1754	1004
121345	511	1755	1005
121857	511	1756	1006
122369	511	1757	1007
122881	511	1760	1008
123393	511	1761	1009
123905	511	1762	1010
124417	511	1763	1011
124929	511	1764	1012
125441	511	1765	1013
125953	511	1766	1014
126465	511	1767	1015
126977	511	1770	1016
127489	511	1771	1017
128001	511	1772	1018
128513	511	1773	1019
129025	511	1774	1020
129537	511	1775	1021
130049	511	1776	1022
130561	511	1777	1023
131073	1023	1400	768
132097	1023	1401	769
133121	1023	1402	770
134145	1023	1403	771
135169	1023	1404	772
136193	1023	1405	773
137217	1023	1406	774
138241	1023	1407	775
139265	1023	1410	776
140289	1023	1411	777
141313	1023	1412	778
142337	1023	1413	779
143361	1023	1414	780
144385	1023	1415	781
145409	1023	1416	782
146433	1023	1417	783
147457	1023	1420	784
148481	1023	1421	785
149505	1023	1422	786
150529	1023	1423	787
151553	1023	1424	788
152577	1023	1425	789
153601	1023	1426	790
154625	1023	1427	791
155649	1023	1430	792
156673	1023	1431	793
157697	1023	1432	794
158721	1023	1433	795
159745	1023	1434	796
160769	1023	1435	797
161793	1023	1436	798

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
162817	1023	1437	799
163841	1023	1440	800
164865	1023	1441	801
165889	1023	1442	802
166913	1023	1443	803
167937	1023	1444	804
168961	1023	1445	805
169985	1023	1446	806
171009	1023	1447	807
172033	1023	1450	808
173057	1023	1451	809
174081	1023	1452	810
175105	1023	1453	811
176129	1023	1454	812
177153	1023	1455	813
178177	1023	1456	814
179201	1023	1457	815
180225	1023	1460	816
181249	1023	1461	817
182273	1023	1462	818
183297	1023	1463	819
184321	1023	1464	820
185345	1023	1465	821
186369	1023	1466	822
187393	1023	1467	823
188417	1023	1470	824
189441	1023	1471	825
190465	1023	1472	826
191489	1023	1473	827
192513	1023	1474	828
193537	1023	1475	829
194561	1023	1476	830
195585	1023	1477	831
196609	1023	1500	832
197633	1023	1501	833
198657	1023	1502	834
199681	1023	1503	835
200705	1023	1504	836
201729	1023	1505	837
202753	1023	1506	838
203777	1023	1507	839
204801	1023	1510	840
205825	1023	1511	841
206849	1023	1512	842
207873	1023	1513	843
208897	1023	1514	844
209921	1023	1515	845
210945	1023	1516	846
211969	1023	1517	847
212993	1023	1520	848
214017	1023	1521	849
215041	1023	1522	850
216065	1023	1523	851
217089	1023	1524	852
218113	1023	1525	853
219137	1023	1526	854
220161	1023	1527	855
221185	1023	1530	856
222209	1023	1531	857
223233	1023	1532	858

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
224257	1023	1533	859
225281	1023	1534	860
226305	1023	1535	861
227329	1023	1536	862
228353	1023	1537	863
229377	1023	1540	864
230401	1023	1541	865
231425	1023	1542	866
232449	1023	1543	867
233473	1023	1544	868
234497	1023	1545	869
235521	1023	1546	870
236545	1023	1547	871
237569	1023	1550	872
238593	1023	1551	873
239617	1023	1552	874
240641	1023	1553	875
241665	1023	1554	876
242689	1023	1555	877
243713	1023	1556	878
244737	1023	1557	879
245761	1023	1560	880
246785	1023	1561	881
247809	1023	1562	882
248833	1023	1563	883
249857	1023	1564	884
250881	1023	1565	885
251905	1023	1566	886
252929	1023	1567	887
253953	1023	1570	888
254977	1023	1571	889
256001	1023	1572	890
257025	1023	1573	891
258049	1023	1574	892
259073	1023	1575	893
260097	1023	1576	894
261121	1023	1577	895
262145	2047	1200	540
264193	2047	1201	541
266241	2047	1202	542
268289	2047	1203	543
270337	2047	1204	544
272385	2047	1205	545
274433	2047	1206	546
276481	2047	1207	547
278529	2047	1210	548
280577	2047	1211	549
282625	2047	1212	550
284673	2047	1213	551
286721	2047	1214	552
288769	2047	1215	553
290817	2047	1216	554
292865	2047	1217	555
294913	2047	1220	556
296961	2047	1221	557
299009	2047	1222	558
301057	2047	1223	559
303105	2047	1224	560
305153	2047	1225	561
307201	2047	1226	562

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
309249	2047	1227	563
311297	2047	1230	564
313345	2047	1231	565
315393	2047	1232	566
317441	2047	1233	567
319489	2047	1234	568
321537	2047	1235	569
323585	2047	1236	570
325633	2047	1237	571
327681	2047	1240	572
329729	2047	1241	573
331777	2047	1242	574
333825	2047	1243	575
335873	2047	1244	576
337921	2047	1245	577
339969	2047	1246	578
342017	2047	1247	579
344065	2047	1250	580
346113	2047	1251	581
348161	2047	1252	582
350209	2047	1253	583
352257	2047	1254	584
354305	2047	1255	585
356353	2047	1256	586
358401	2047	1257	587
360449	2047	1260	588
362497	2047	1261	589
364545	2047	1262	590
366593	2047	1263	591
368641	2047	1264	592
370689	2047	1265	593
372737	2047	1266	594
374785	2047	1267	595
376833	2047	1270	596
378881	2047	1271	597
380929	2047	1272	598
382977	2047	1273	599
385025	2047	1274	700
387073	2047	1275	701
389121	2047	1276	702
391169	2047	1277	703
393217	2047	1300	704
395265	2047	1301	705
397313	2047	1302	706
399361	2047	1303	707
401409	2047	1304	708
403457	2047	1305	709
405505	2047	1306	710
407553	2047	1307	711
409601	2047	1310	712
411649	2047	1311	713
413697	2047	1312	714
415745	2047	1313	715
417793	2047	1314	716
419841	2047	1315	717
421889	2047	1316	718
423937	2047	1317	719
425985	2047	1320	720
428033	2047	1321	721
430081	2047	1322	722

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
432129	2047	1323	723
434177	2047	1324	724
436225	2047	1325	725
438273	2047	1326	726
440321	2047	1327	727
442369	2047	1330	728
444417	2047	1331	729
446465	2047	1332	730
448513	2047	1333	731
450561	2047	1334	732
452609	2047	1335	733
454657	2047	1336	734
456705	2047	1337	735
458753	2047	1340	736
460801	2047	1341	737
462849	2047	1342	738
464897	2047	1343	739
466945	2047	1344	740
468993	2047	1345	741
471041	2047	1346	742
473089	2047	1347	743
475137	2047	1350	744
477185	2047	1351	745
479233	2047	1352	746
481281	2047	1353	747
483329	2047	1354	748
485377	2047	1355	749
487425	2047	1356	750
489473	2047	1357	751
491521	2047	1360	752
493569	2047	1361	753
495617	2047	1362	754
497665	2047	1363	755
499713	2047	1364	756
501761	2047	1365	757
503809	2047	1366	758
505857	2047	1367	759
507905	2047	1370	760
509953	2047	1371	761
512001	2047	1372	762
514049	2047	1373	763
516097	2047	1374	764
518145	2047	1375	765
520193	2047	1376	766
522241	2047	1377	767
524289	4095	1000	512
528385	4095	1001	513
532481	4095	1002	514
536577	4095	1003	515
540673	4095	1004	516
544769	4095	1005	517
548865	4095	1006	518
552961	4095	1007	519
557057	4095	1010	520
561153	4095	1011	521
565249	4095	1012	522
569345	4095	1013	523
573441	4095	1014	524
577537	4095	1015	525
581633	4095	1016	526

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
585729	4095	1017	527
589825	4095	1020	528
593921	4095	1021	529
598017	4095	1022	530
602113	4095	1023	531
606209	4095	1024	532
610305	4095	1025	533
614401	4095	1026	534
618497	4095	1027	535
622593	4095	1030	536
626689	4095	1031	537
630785	4095	1032	538
634881	4095	1033	539
638977	4095	1034	540
643073	4095	1035	541
647169	4095	1036	542
651265	4095	1037	543
655361	4095	1040	544
659457	4095	1041	545
663553	4095	1042	546
667649	4095	1043	547
671745	4095	1044	548
675841	4095	1045	549
679937	4095	1046	550
684033	4095	1047	551
688129	4095	1050	552
692225	4095	1051	553
696321	4095	1052	554
700417	4095	1053	555
704513	4095	1054	556
708609	4095	1055	557
712705	4095	1056	558
716801	4095	1057	559
720897	4095	1060	560
724993	4095	1061	561
729089	4095	1062	562
733185	4095	1063	563
737281	4095	1064	564
741377	4095	1065	565
745473	4095	1066	566
749569	4095	1067	567
753665	4095	1070	568
757761	4095	1071	569
761857	4095	1072	570
765953	4095	1073	571
770049	4095	1074	572
774145	4095	1075	573
778241	4095	1076	574
782337	4095	1077	575
786433	4095	1100	576
790529	4095	1101	577
794625	4095	1102	578
798721	4095	1103	579
802817	4095	1104	580
806913	4095	1105	581
811009	4095	1106	582
815105	4095	1107	583
819201	4095	1110	584
823297	4095	1111	585
827393	4095	1112	586

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
831489	4095	1113	587
835585	4095	1114	588
839681	4095	1115	589
843777	4095	1116	590
847873	4095	1117	591
851969	4095	1120	592
856065	4095	1121	593
860161	4095	1122	594
864257	4095	1123	595
868353	4095	1124	596
872449	4095	1125	597
876545	4095	1126	598
880641	4095	1127	599
884737	4095	1130	500
888833	4095	1131	501
892929	4095	1132	502
897025	4095	1133	503
901121	4095	1134	504
905217	4095	1135	505
909313	4095	1136	506
913409	4095	1137	507
917505	4095	1140	508
921601	4095	1141	509
925697	4095	1142	510
929793	4095	1143	511
933889	4095	1144	512
937985	4095	1145	513
942081	4095	1146	514
946177	4095	1147	515
950273	4095	1150	516
954369	4095	1151	517
958465	4095	1152	518
962561	4095	1153	519
966657	4095	1154	520
970753	4095	1155	521
974849	4095	1156	522
978945	4095	1157	523
983041	4095	1160	524
987137	4095	1161	525
991233	4095	1162	526
995329	4095	1163	527
999425	4095	1164	528
1003521	4095	1165	529
1007617	4095	1166	530
1011713	4095	1167	531
1015809	4095	1170	532
1019905	4095	1171	533
1024001	4095	1172	534
1028097	4095	1173	535
1032193	4095	1174	536
1036289	4095	1175	537
1040385	4095	1176	538
1044481	4095	1177	539
1048577	8191	0600	384
1056769	8191	0601	385
1064961	8191	0602	386
1073153	8191	0603	387
1081345	8191	0604	388
1089537	8191	0605	389
1097729	8191	0606	390

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
1105921	8191	0607	391
1114113	8191	0610	392
1122305	8191	0611	393
1130497	8191	0612	394
1138689	8191	0613	395
1146881	8191	0614	396
1155073	8191	0615	397
1163265	8191	0616	398
1171457	8191	0617	399
1179649	8191	0620	400
1187841	8191	0621	401
1196033	8191	0622	402
1204225	8191	0623	403
1212417	8191	0624	404
1220609	8191	0625	405
1228801	8191	0626	406
1236993	8191	0627	407
1245185	8191	0630	408
1253377	8191	0631	409
1261569	8191	0632	410
1269761	8191	0633	411
1277953	8191	0634	412
1286145	8191	0635	413
1294337	8191	0636	414
1302529	8191	0637	415
1310721	8191	0640	416
1318913	8191	0641	417
1327105	8191	0642	418
1335297	8191	0643	419
1343489	8191	0644	420
1351681	8191	0645	421
1359873	8191	0646	422
1368065	8191	0647	423
1376257	8191	0650	424
1384449	8191	0651	425
1392641	8191	0652	426
1400833	8191	0653	427
1409025	8191	0654	428
1417217	8191	0655	429
1425409	8191	0656	430
1433601	8191	0657	431
1441793	8191	0660	432
1449985	8191	0661	433
1458177	8191	0662	434
1466369	8191	0663	435
1474561	8191	0664	436
1482753	8191	0665	437
1490945	8191	0666	438
1499137	8191	0667	439
1507329	8191	0670	440
1515521	8191	0671	441
1523713	8191	0672	442
1531905	8191	0673	443
1540097	8191	0674	444
1548289	8191	0675	445
1556481	8191	0676	446
1564673	8191	0677	447
1572865	8191	0700	448
1581057	8191	0701	449
1589249	8191	0702	450

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
1597441	8191	0703	451
1605633	8191	0704	452
1613825	8191	0705	453
1622017	8191	0706	454
1630209	8191	0707	455
1638401	8191	0710	456
1646593	8191	0711	457
1654785	8191	0712	458
1662977	8191	0713	459
1671169	8191	0714	460
1679361	8191	0715	461
1687553	8191	0716	462
1695745	8191	0717	463
1703937	8191	0720	464
1712129	8191	0721	465
1720321	8191	0722	466
1728513	8191	0723	467
1736705	8191	0724	468
1744897	8191	0725	469
1753089	8191	0726	470
1761281	8191	0727	471
1769473	8191	0730	472
1777665	8191	0731	473
1785857	8191	0732	474
1794049	8191	0733	475
1802241	8191	0734	476
1810433	8191	0735	477
1818625	8191	0736	478
1826817	8191	0737	479
1835009	8191	0740	480
1843201	8191	0741	481
1851393	8191	0742	482
1859585	8191	0743	483
1867777	8191	0744	484
1875969	8191	0745	485
1884161	8191	0746	486
1892353	8191	0747	487
1900545	8191	0750	488
1908737	8191	0751	489
1916929	8191	0752	490
1925121	8191	0753	491
1933313	8191	0754	492
1941505	8191	0755	493
1949697	8191	0756	494
1957889	8191	0757	495
1966081	8191	0760	496
1974273	8191	0761	497
1982465	8191	0762	498
1990657	8191	0763	499
1998849	8191	0764	500
2007041	8191	0765	501
2015233	8191	0765	502
2023425	8191	0767	503
2031617	8191	0770	504
2039809	8191	0771	505
2048001	8191	0772	506
2056193	8191	0773	507
2064385	8191	0774	508
2072577	8191	0775	509
2080769	8191	0775	510

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
2088961	8191	0777	511
2097153	16383	0400	256
2113537	16383	0401	257
2129921	16383	0402	258
2146305	16383	0403	259
2162689	16383	0404	260
2179073	16383	0405	261
2195457	16383	0406	262
2211841	16383	0407	263
2228225	16383	0410	264
2244609	16383	0411	265
2260993	16383	0412	266
2277377	16383	0413	267
2293761	16383	0414	268
2310145	16383	0415	269
2326529	16383	0416	270
2342913	16383	0417	271
2359297	16383	0420	272
2375681	16383	0421	273
2392065	16383	0422	274
2408449	16383	0423	275
2424833	16383	0424	276
2441217	16383	0425	277
2457601	16383	0426	278
2473985	16383	0427	279
2490369	16383	0430	280
2506753	16383	0431	281
2523137	16383	0432	282
2539521	16383	0433	283
2555905	16383	0434	284
2572289	16383	0435	285
2588673	16383	0436	286
2605057	16383	0437	287
2621441	16383	0440	288
2637825	16383	0441	289
2654209	16383	0442	290
2670593	16383	0443	291
2686977	16383	0444	292
2703361	16383	0445	293
2719745	16383	0446	294
2736129	16383	0447	295
2752513	16383	0450	296
2768897	16383	0451	297
2785281	16383	0452	298
2801665	16383	0453	299
2818049	16383	0454	300
2834433	16383	0455	301
2850817	16383	0456	302
2867201	16383	0457	303
2883585	16383	0460	304
2899969	16383	0461	305
2916353	16383	0462	306
2932737	16383	0463	307
2949121	16383	0464	308
2965505	16383	0465	309
2981889	16383	0466	310
2998273	16383	0467	311
3014657	16383	0470	312
3031041	16383	0471	313
3047425	16383	0472	314

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
3063809	16383	0473	315
3080193	16383	0474	316
3096577	16383	0475	317
3112961	16383	0476	318
3129345	16383	0477	319
3145729	16383	0500	320
3162113	16383	0501	321
3178497	16383	0502	322
3194881	16383	0503	323
3211265	16383	0504	324
3227649	16383	0505	325
3244033	16383	0506	326
3260417	16383	0507	327
3276801	16383	0510	328
3293185	16383	0511	329
3309569	16383	0512	330
3325953	16383	0513	331
3342337	16383	0514	332
3358721	16383	0515	333
3375105	16383	0516	334
3391489	16383	0517	335
3407873	16383	0520	336
3424257	16383	0521	337
3440641	16383	0522	338
3457025	16383	0523	339
3473409	16383	0524	340
3489793	16383	0525	341
3506177	16383	0526	342
3522561	16383	0527	343
3538945	16383	0530	344
3555329	16383	0531	345
3571713	16383	0532	346
3588097	16383	0533	347
3604481	16383	0534	348
3620865	16383	0535	349
3637249	16383	0536	350
3653633	16383	0537	351
3670017	16383	0540	352
3686401	16383	0541	353
3702785	16383	0542	354
3719169	16383	0543	355
3735553	16383	0544	356
3751937	16383	0545	357
3768321	16383	0546	358
3784705	16383	0547	359
3801089	16383	0550	360
3817473	16383	0551	361
3833857	16383	0552	362
3850241	16383	0553	363
3866625	16383	0554	364
3883009	16383	0555	365
3899393	16383	0556	366
3915777	16383	0557	367
3932161	16383	0560	368
3948545	16383	0561	369
3964929	16383	0562	370
3981313	16383	0563	371
3997697	16383	0564	372
4014081	16383	0565	373
4030465	16383	0566	374

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
4046849	16383	0567	375
4063233	16383	0570	376
4079617	16383	0571	377
4096001	16383	0572	378
4112385	16383	0573	379
4128769	16383	0574	380
4145153	16383	0575	381
4161537	16383	0576	382
4177921	16383	0577	383
4194305	32767	0200	128
4227073	32767	0201	129
4259841	32767	0202	130
4292609	32767	0203	131
4325377	32767	0204	132
4358145	32767	0205	133
4390913	32767	0206	134
4423681	32767	0207	135
4456449	32767	0210	136
4489217	32767	0211	137
4521985	32767	0212	138
4554753	32767	0213	139
4587521	32767	0214	140
4620289	32767	0215	141
4653057	32767	0216	142
4685825	32767	0217	143
4718593	32767	0220	144
4751361	32767	0221	145
4784129	32767	0222	146
4816897	32767	0223	147
4849665	32767	0224	148
4882433	32767	0225	149
4915201	32767	0226	150
4947969	32767	0227	151
4980737	32767	0230	152
5013505	32767	0231	153
5046273	32767	0232	154
5079041	32767	0233	155
5111809	32767	0234	156
5144577	32767	0235	157
5177345	32767	0236	158
5210113	32767	0237	159
5242881	32767	0240	160
5275649	32767	0241	161
5308417	32767	0242	162
5341185	32767	0243	163
5373953	32767	0244	164
5406721	32767	0245	165
5439489	32767	0246	166
5472257	32767	0247	167
5505025	32767	0250	168
5537793	32767	0251	169
5570561	32767	0252	170
5603329	32767	0253	171
5636097	32767	0254	172
5668865	32767	0255	173
5701633	32767	0256	174
5734401	32767	0257	175
5767169	32767	0260	176
5799937	32767	0261	177
5832705	32767	0262	178

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
5865473	32767	0263	179
5898241	32767	0264	180
5931009	32767	0265	181
5963777	32767	0266	182
5996545	32767	0267	183
6029313	32767	0270	184
6062081	32767	0271	185
6094849	32767	0272	186
6127617	32767	0273	187
6160385	32767	0274	188
6193153	32767	0275	189
6225921	32767	0276	190
6258689	32767	0277	191
6291457	32767	0300	192
6324225	32767	0301	193
6356993	32767	0302	194
6389761	32767	0303	195
6422529	32767	0304	196
6455297	32767	0305	197
6488065	32767	0306	198
6520833	32767	0307	199
6553601	32767	0310	200
6586369	32767	0311	201
6619137	32767	0312	202
6651905	32767	0313	203
6684673	32767	0314	204
6717441	32767	0315	205
6750209	32767	0316	206
6782977	32767	0317	207
6815745	32767	0320	208
6848513	32767	0321	209
6881281	32767	0322	210
6914049	32767	0323	211
6946817	32767	0324	212
6979585	32767	0325	213
7012353	32767	0326	214
7045121	32767	0327	215
7077889	32767	0330	216
7110657	32767	0331	217
7143425	32767	0332	218
7176193	32767	0333	219
7208961	32767	0334	220
7241729	32767	0335	221
7274497	32767	0336	222
7307265	32767	0337	223
7340033	32767	0340	224
7372801	32767	0341	225
7405569	32767	0342	226
7438337	32767	0343	227
7471105	32767	0344	228
7503873	32767	0345	229
7536641	32767	0346	230
7569409	32767	0347	231
7602177	32767	0350	232
7634945	32767	0351	233
7667713	32767	0352	234
7700481	32767	0353	235
7733249	32767	0354	236
7766017	32767	0355	237
7798785	32767	0356	238

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
7831553	32767	0357	239
7864321	32767	0360	240
7897089	32767	0361	241
7929857	32767	0362	242
7962625	32767	0363	243
7995393	32767	0364	244
8028161	32767	0365	245
8060929	32767	0366	246
8093697	32767	0367	247
8126465	32767	0370	248
8159233	32767	0371	249
8192001	32767	0372	250
8224769	32767	0373	251
8257537	32767	0374	252
8290305	32767	0375	253
8323073	32767	0376	254
8355841	32767	0377	255
8388609	65535	0000	0
8454145	65535	0001	1
8519681	65535	0002	2
8585217	65535	0003	3
8650753	65535	0004	4
8716289	65535	0005	5
8781825	65535	0006	6
8847361	65535	0007	7
8912897	65535	0010	8
8978433	65535	0011	9
9043969	65535	0012	10
9109505	65535	0013	11
9175041	65535	0014	12
9240577	65535	0015	13
9306113	65535	0016	14
9371649	65535	0017	15
9437185	65535	0020	16
9502721	65535	0021	17
9568257	65535	0022	18
9633793	65535	0023	19
9699329	65535	0024	20
9764865	65535	0025	21
9830401	65535	0026	22
9895937	65535	0027	23
9961473	65535	0030	24
10027009	65535	0031	25
10092545	65535	0032	26
10158081	65535	0033	27
10223617	65535	0034	28
10289153	65535	0035	29
10354689	65535	0036	30
10420225	65535	0037	31
10485761	65535	0040	32
10551297	65535	0041	33
10616833	65535	0042	34
10682369	65535	0043	35
10747905	65535	0044	36
10813441	65535	0045	37
10878977	65535	0046	38
10944513	65535	0047	39
11010049	65535	0050	40
11075585	65535	0051	41
11141121	65535	0052	42

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
11206657	65535	0053	43
11272193	65535	0054	44
11337729	65535	0055	45
11403265	65535	0056	46
11468801	65535	0057	47
11534337	65535	0060	48
11599873	65535	0061	49
11665409	65535	0062	50
11730945	65535	0063	51
11796481	65535	0064	52
11862017	65535	0065	53
11927553	65535	0066	54
11993089	65535	0067	55
12058625	65535	0070	56
12124161	65535	0071	57
12189697	65535	0072	58
12255233	65535	0073	59
12320769	65535	0074	60
12386305	65535	0075	61
12451841	65535	0076	62
12517377	65535	0077	63
12582913	65535	0100	64
12648449	65535	0101	65
12713985	65535	0102	66
12779521	65535	0103	67
12845057	65535	0104	68
12910593	65535	0105	69
12976129	65535	0106	70
13041665	65535	0107	71
13107201	65535	0110	72
13172737	65535	0111	73
13238273	65535	0112	74
13303809	65535	0113	75
13369345	65535	0114	76
13434881	65535	0115	77
13500417	65535	0116	78
13565953	65535	0117	79
13631489	65535	0120	80
13697025	65535	0121	81
13762561	65535	0122	82
13828097	65535	0123	83
13893633	65535	0124	84
13959169	65535	0125	85
14024705	65535	0126	86
14090241	65535	0127	87
14155777	65535	0130	88
14221313	65535	0131	89
14286849	65535	0132	90
14352385	65535	0133	91
14417921	65535	0134	92
14483457	65535	0135	93
14548993	65535	0136	94
14614529	65535	0137	95
14680065	65535	0140	96
14745601	65535	0141	97
14811137	65535	0142	98
14876673	65535	0143	99
14942209	65535	0144	100
15007745	65535	0145	101
15073281	65535	0146	102

COUNTS	UNCERTAINTY	COMPRESSED OUTPUT (OCTAL)	(DECIMAL)
15138817	65535	0147	103
15204353	65535	0150	104
15269889	65535	0151	105
15335425	65535	0152	106
15400961	65535	0153	107
15466497	65535	0154	108
15532033	65535	0155	109
15597569	65535	0156	110
15663105	65535	0157	111
15728641	65535	0160	112
15794177	65535	0161	113
15859713	65535	0162	114
15925249	65535	0163	115
15990785	65535	0164	116
16056321	65535	0165	117
16121857	65535	0166	118
16187393	65535	0167	119
16252929	65535	0170	120
16318465	65535	0171	121
16384001	65535	0172	122
16449537	65535	0173	123
16515073	65535	0174	124
16580609	65535	0175	125
16646145	65535	0176	126
16711681	65535	0177	127

11/30/71 (?)

PIONEER DATA PROCESSING SYSTEM

Name	Purpose
1. PIODPP	This program reads the Pioneer EDR tapes and produces PHA, RATES and Catalog tapes and printed daily summaries of pertinent information.
2. EDRLST	This program reads the Pioneer EDR tapes and prints data by record number or time period.
3. PHALST	This program reads the Pioneer PHA tape and prints data by record number or time period.
4. RATLST	This program reads the Pioneer RATES tape and prints data by record number and time period.
5. CATLST	This program reads the Pioneer Catalog tapes containing the I.D., Command and Attitude information and prints data by absolute file number or time period.
6. DUPPRT	This program generates the backup tapes for the PHA and RATES tapes.
7. CATINT	This program initializes the tape catalog pointer and the four tape catalogs for the Pioneer Data Processing Program (PIODPP).
8. CATUPD	This program performs various maintenance functions (add blank tapes etc.) on the four tape catalogs.

MILESTONE CHART

TASK NUMBER: ______________

NAME Pioneer Data Processing System

CALENDAR MONTH

	MILESTONES	J	F	M	A	M	J	J	A	S	O	N	D	J
JAN	PIODRS	O											V	
	PHA Tape				V									
TPS	PHA Summarizer	O					V							
	Summary Tape					V								
TKB	Plot Program	O				V								
TKB	Merge Program		O			V								
TKB	Intermediate Flux				O								V	
JSW	Rates Display (Assuming no intermed. proc.)							O	V					
JSW	Flux Display									O	V			
TPS	ANALEER							O					V	

12/20/71

PIONEER DATA REDUCTION SYSTEM

Purpose

The Pioneer Data Reduction System consists of a set of programs which read, interpret and verify the Pioneer EDR and Trajectory tapes. These programs generate various data sets containing the Pioneer GSFC/CRT experiment data (PHA and RATES), related spacecraft information (Logistics, Command and Attitude) and the trajectory information and provide the capability to access these data sets.

Programs in order of Implementation Priority

Name	Purpose
1. PIODRP	This program reads the Pioneer EDR tapes and produces PHA, RATES and Catalog tapes and printed daily summaries of pertinent information.
2. CATINT	This program initializes the tape catalog pointer and the four tape catalogs for the Pioneer Data Reduction Program (PIODRP).
3. CATUPD	This program performs various maintenance functions (add blank tapes etc.) on the four tape catalogs
4. EDRLST	This program reads the Pioneer EDR tapes and prints data by record number or time period.
5. PHALST	This program reads the Pioneer PHA tape and prints data by record number or time period.
6. RATLST	This program reads the Pioneer RATES tape and prints data by record number and time period.
7. CATLST	This program reads the Pioneer Catalog tapes containing the I.D., Command and Attitude information and prints data by absolute file number or time period.

Name	Purpose
8. TRJLST	This program lists the Trajectory Tape by time period or record number.
9. DUPPRT	This program generates the backup tapes for the PHA and RATES tapes.

PIONEER DATA ANALYSIS PROGRAM

These programs will be implemented according to the following priorities:

1. PHA Data Summarizer

This program creates a data base of sorted PHA readings for the entire range of data from both experiment packages. Each data set within the data base will consist of sorted PHA data for an input time period, not smaller than one hour. The sort is based on event type, PHA values, sector designator, and priority mode.

2. PHA Data Plot Program

This program creates two dimensional plots of summarized PHA data for either single or merged time periods, according to event type. It will produce as many of the requested plots as is possible with a single pass through the data set. It will produce plots for requested multiple time periods to the extent of the available summarized PHA data.

3. PHA Time Period Merge Program

This program creates a data set by merging the sorted data from two or more PHA summary data sets. This merge will be performed without the application of gain factors to the data.

4. Intermediate Flux Program

This program generates a data tape consisting of counts of PHA event occurrence within pre-defined areas of the range of the data from both experiment packages on a time interval basis.

5. Flux Display Program

This program creates displays of the data contained on the tape generated by the Intermediate Flux Program.

6. Rates Display Program

This program creates displays of the data contained on the RATES tape generated by the Data Reduction System.

7. PHA Data Analysis Program

This program produces two dimensional plots of the PHA data as contained in the PHA Summary data base, for one time period or combinations of time periods (using the merged data sets where possible). A histogram showing the distribution of actual data values around a pre-defined standard curve is also created.

PFG.290.300

Bufop tape format

USER MANUAL

Pioneer F/G Integration and Test Software

Signal Processing Department

Approved by:

1/27/72

A. W. Jones, Head
Pioneer F/G Software Section

R. A. DeKimpe, Manager
Signal Processing Department

R. A. Beach, Manager
Real Time Software Laboratory

W. F. Sheehan, APM
Spacecraft Assembly, Test, and Launch

B. J. O'Brien, Manager
Pioneer F/G Spacecraft Project

TRW SYSTEMS GROUP

TRW SYSTEMS GROUP OF TRW, INC., Redondo Beach, California

February 15, 1971

Revised September 1971

E. MAGNETIC TAPE OUTPUT

If telemetry and command data are to be recorded on magnetic tape, the tape is mounted on the tape control unit with a logical unit address of 3. The tape unit should be in a ready state prior to requesting the actual recording of data.

Data recording on the magnetic tape is controlled by breakpoint switch 9.

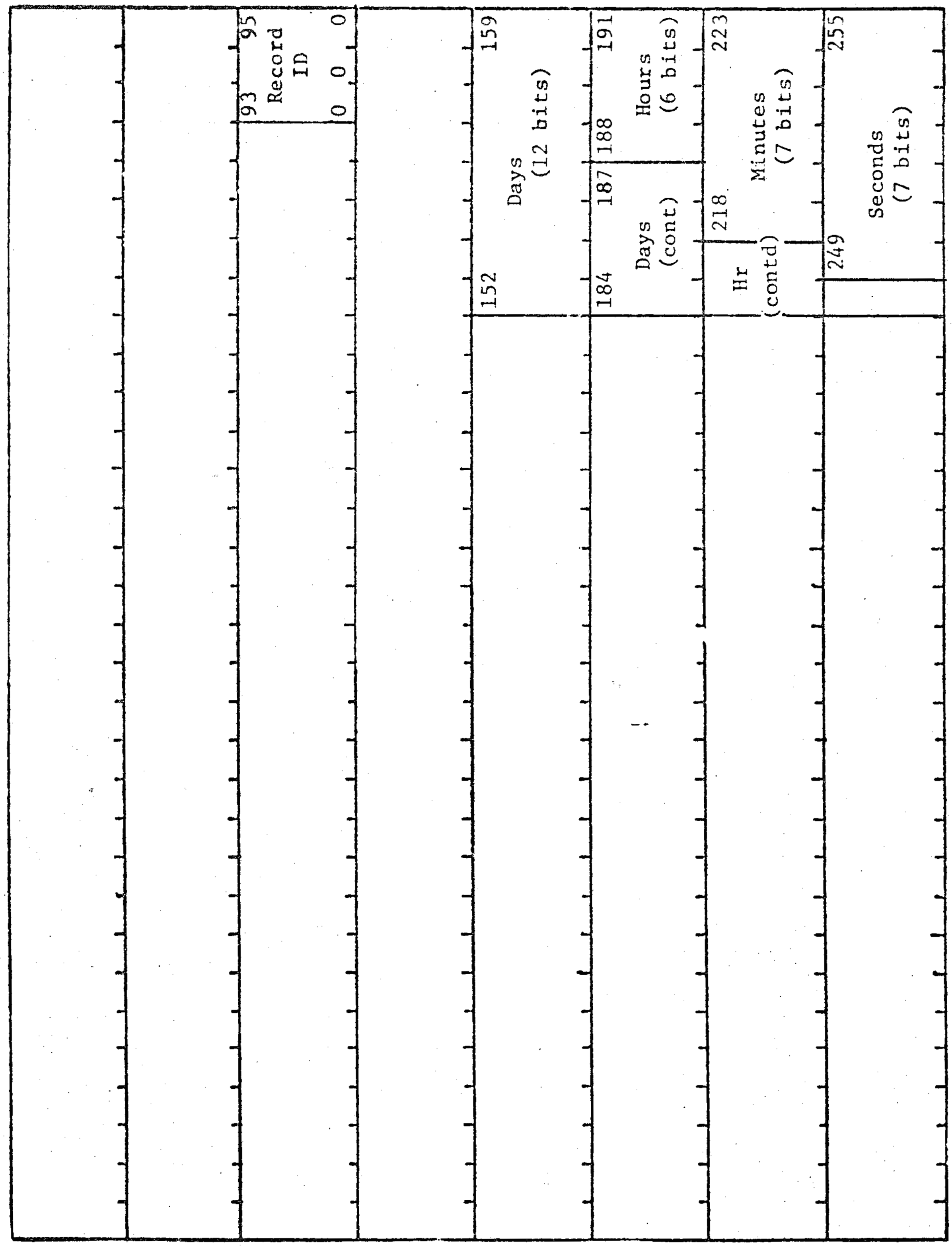
Each logical record is 32 bytes; 12 logical records are blocked to form a physical tape record. A record count is maintained by the program.

The count is maintained to provide means of copying a 9-track tape onto a 7-track tape without the use of multiple reels. One reel of 7-track tape can hold about three fourths of a reel of 9-track information. Therefore, if the above mentioned recording scheme is used, the maximum number of records is about 1700. To allow for contingencies, the count is set at 1200. A MAG TAPE FULL message is output to the teletype to inform the operator when this number of records is reached.

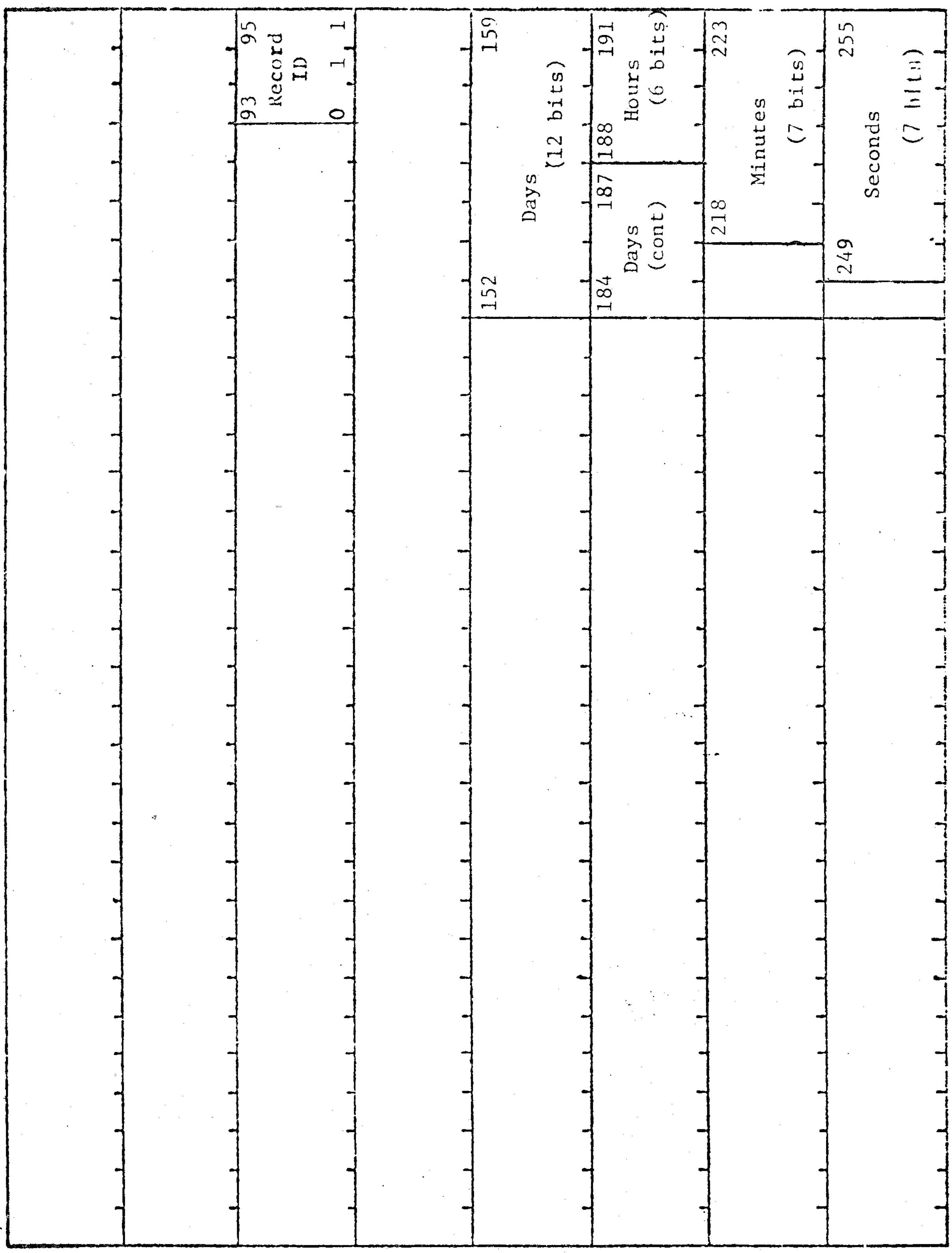
Layouts of data records on tape are shown on the following pages. In addition to the information shown, an end-of-file is written each time BPS 9 is turned off, and an additional end-of-file is written at the end of the data on the tape.

1. MAGNETIC TAPE HEADER

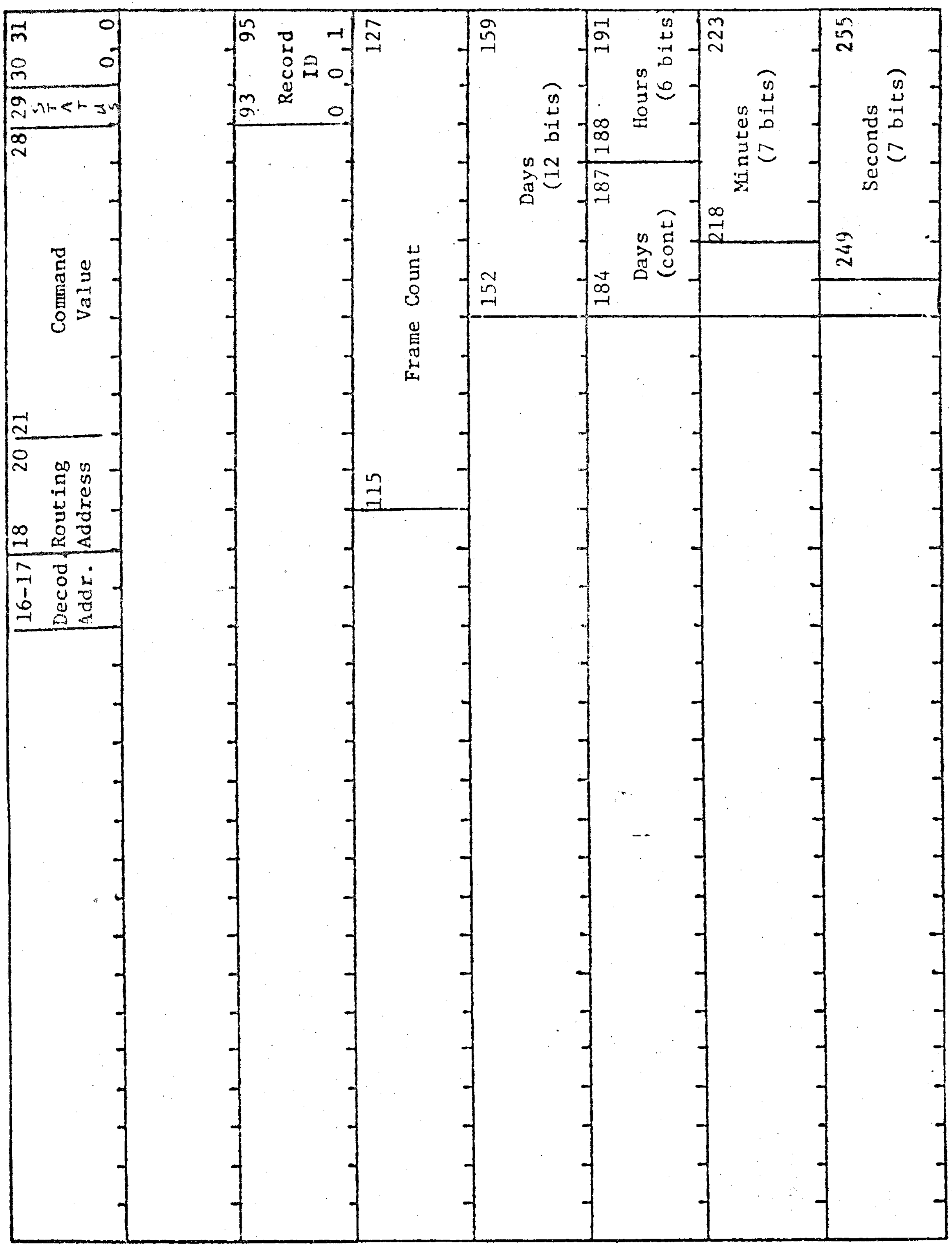
The header record is output when the magnetic tape output breakpoint switch goes from an <u>off</u> state to an <u>on</u> state.



2. MAGNETIC TAPE TELEMETRY LOSS-OF-SYNC RECORD

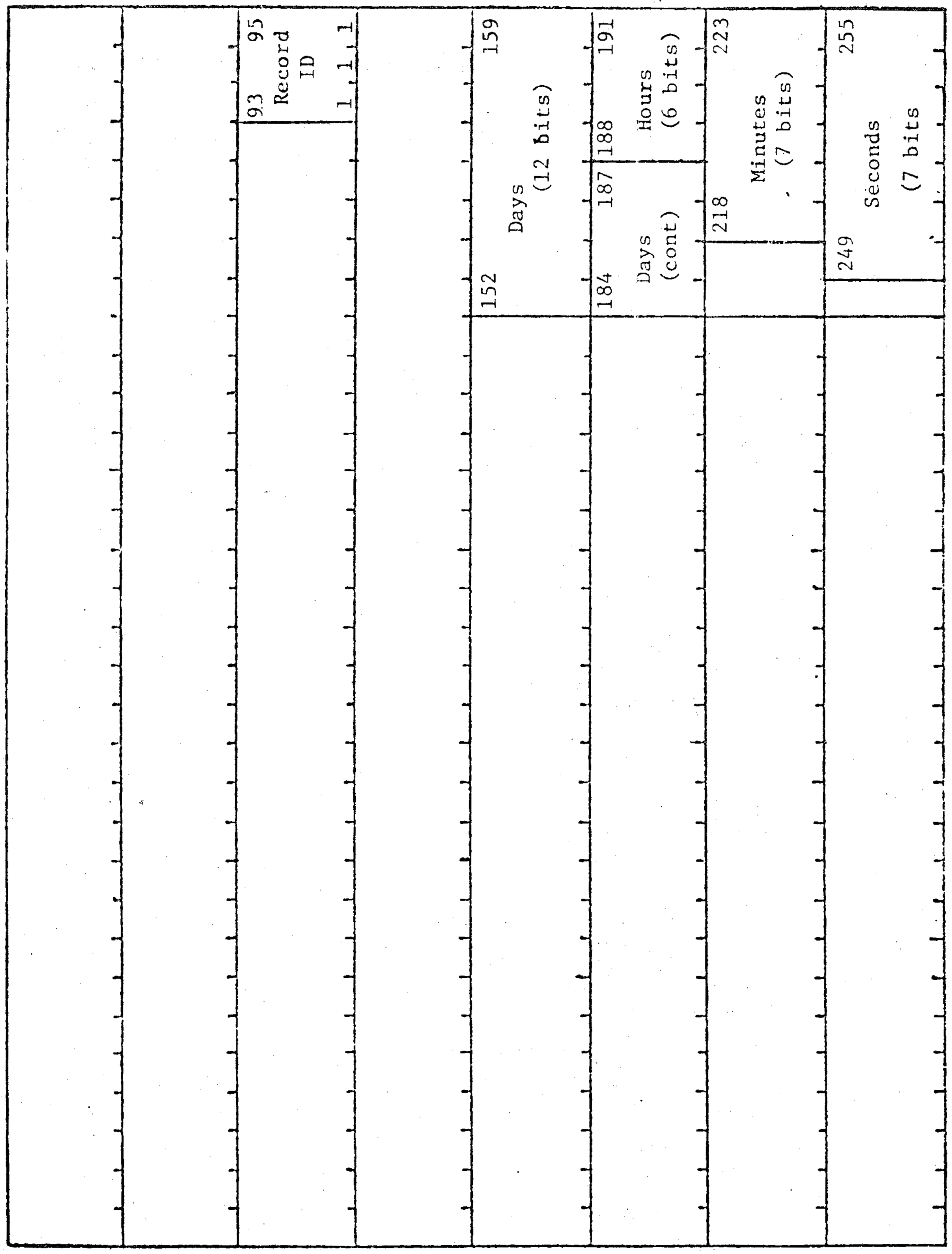


3. MAGNETIC TAPE COMMAND RECORD



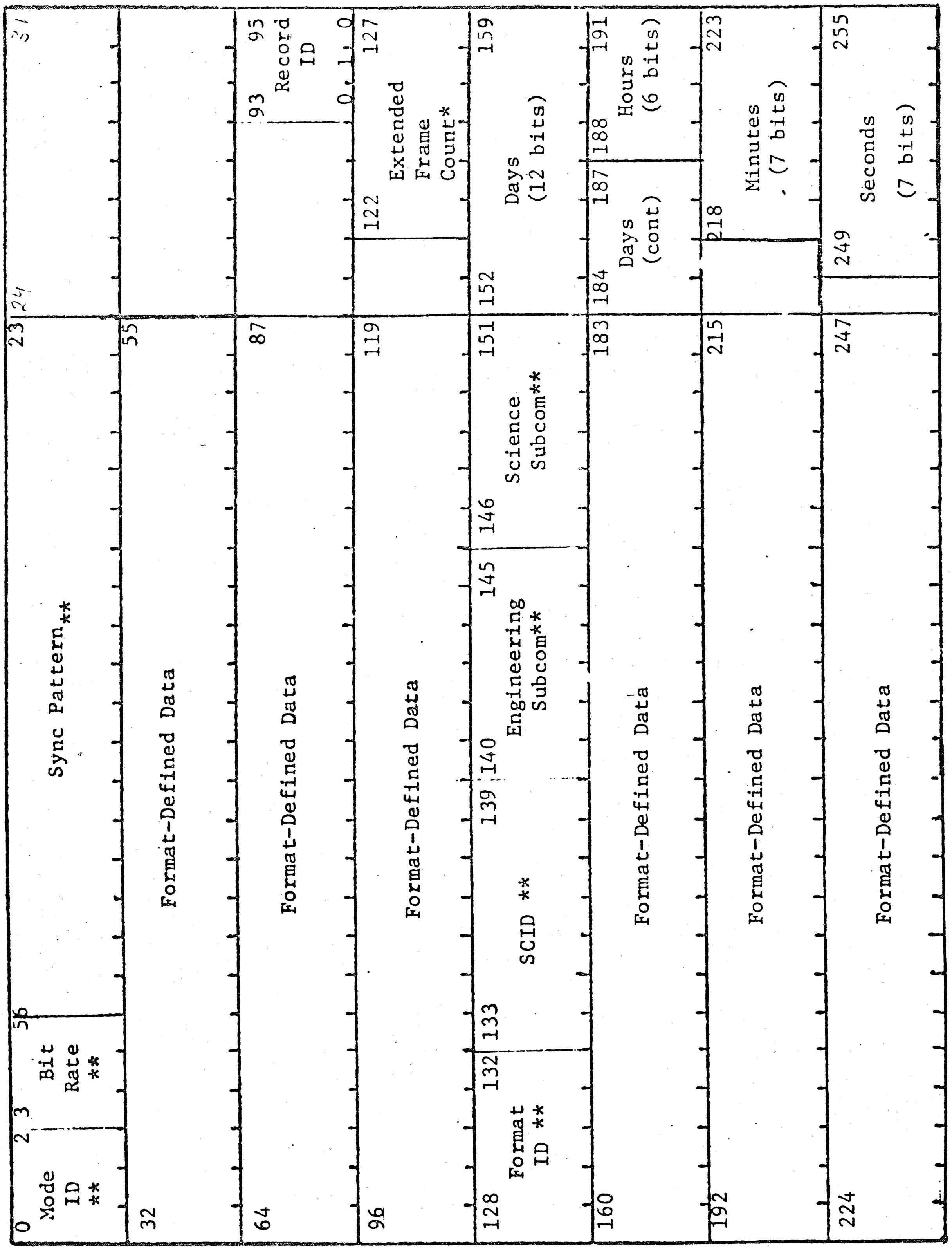
4. MAGNETIC TAPE END-OF-DATA RECORD

The following output occurs when the magnetic tape breakpoint switch goes from an <u>on</u> to an <u>off</u> state.



5. MAGNETIC TAPE TELEMETRY DATA RECORD

In the diagram, the fields marked with ** are replaced by format-defined data in a D mainframe. The fields marked with * are not available in a D mainframe.



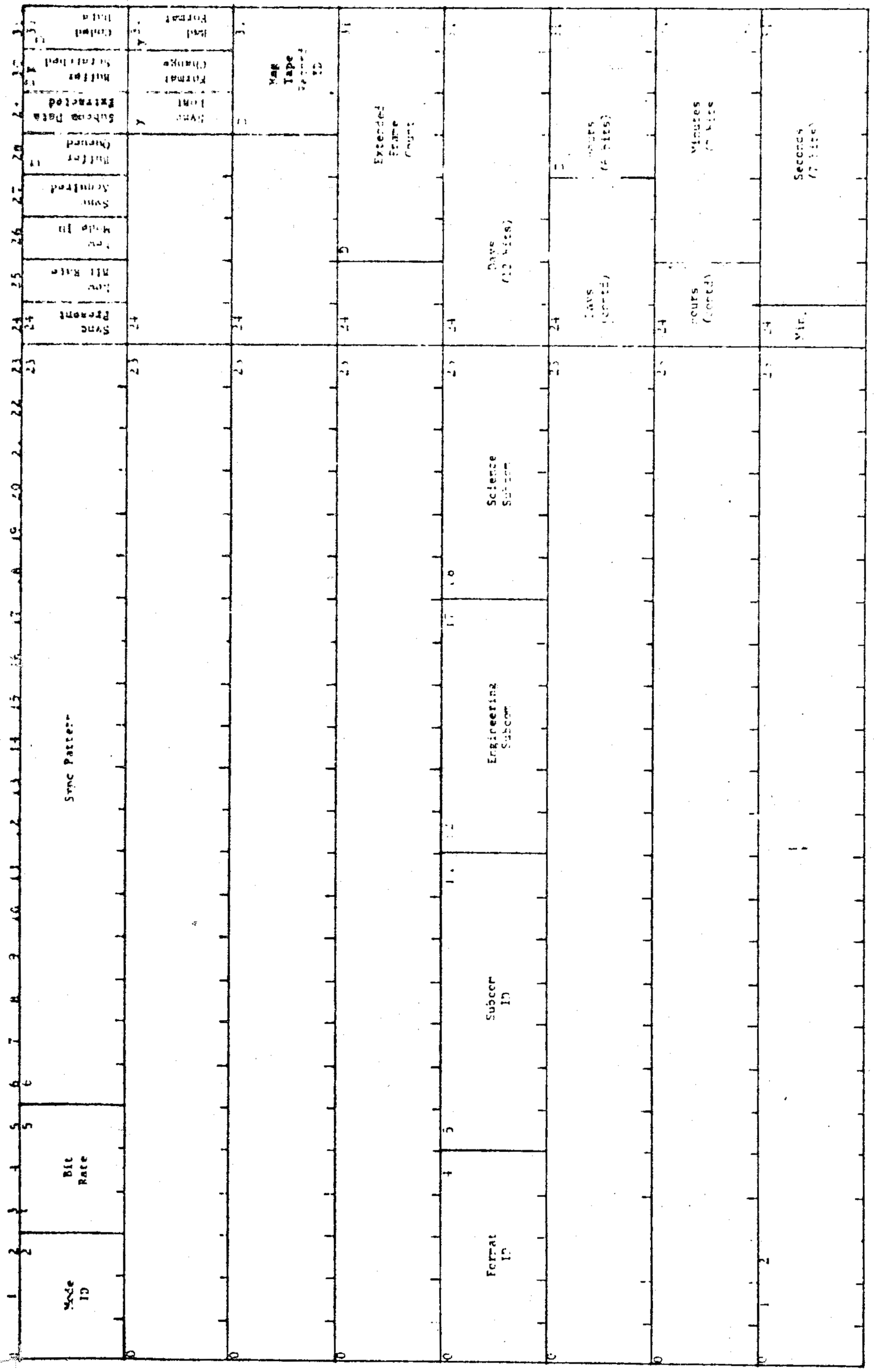


Figure II-20. Mainframe Contents