PIONEER 6 & 7 COSMIC RAY TELESCOPE
EXPERIMENT DESCRIPTION
(65-105A-03, 66-075A-06)

University of Chicago
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Preliminary Document

I. PIONEER 6 AND 7 SPACECRAFT OPERATION

Pioneer 6 and 7 were launched into heliocentric orbits December 16, 1965 and August 17, 1966, respectively. Aphelion and perihelion for Pioneer 6 are .984 A.U. and .814 A.U. respectively, while for Pioneer 7 they are 1.13 A.U. and 1.01 A.U. The spacecraft are spin stabilized with spin period ~60 RPM. Figure 1 shows the trajectory of both spacecraft in a heliocentric coordinate system in which the earth always lies along the Y axis. A detailed description of spacecraft operations may be found in Pioneer VI Mission Report prepared by Pioneer Project Office, Ames Research Center, Moffett Field, California, May 22, 1967.

A. Telemetry

Data is telemetered to earth from both spacecraft in regular cycles called "frames." Each frame of data consists of 32 digital words of 6 data bits plus 1 parity bit (parity is odd, computed on data bits 1, 3 and 5). The allocation of information in a frame is determined by the "format." Four formats are available on Pioneers 6 and 7, and may be switched by ground command. The bulk of University of Chicago data appears on formats A and B. Word 3 of either format A or B is used to display science subformat E. This format is 16 words and is subcommutated, one word per frame onto word 3 of the format A or B main frame; hence it takes 16 main frames to transmit all words of format E, the "science subcom," sequentially. Similarly, word 19 of either format A or B contains sequential words of format C, called the "engineering subcom." This format is 64 words long, and the set of 64 frames required to transmit all words of format C is called an "engineering subcom sequence."

The five transmission rates which can be chosen by ground command are 512, 256, 64, 16 and 8 bits/second. Each frame of data involves the transmission of 32 words x (6 data bits +1 parity bit per word) = 224 bits. Hence for each of the above bit rates the transmission of one frame of data requires .4375, .875, 3.5, 14 or 28 seconds, respectively.

B. Spacecraft data storage

Data Transmission normally occurs on a real time basis. However, both spacecraft can be requested to store data and later transmit the contents of the storage unit. Data storage may proceed in one of two modes, called "telemetry storage Mode" (TLS) and "duty cycle storage mode" (DCS). Both forms of storage use the spacecraft storage unit, which is capable of holding 68 complete telemetry frames.

When telemetry storage mode is commanded the data is placed in the storage unit at the same rate and in the same form it is being transmitted to earth. This form of storage is useful for the collection of data at high rates when real time data must be transmitted at a low telemetry bit rate in order to maintain low error rates. In this case the spacecraft can be switched to a high transmission rate and then into telemetry storage mode. The stored data can be read out later at the lower transmission rate, producing counting rate information with characteristics of the higher transmission rate.

Duty cycle storage mode allows one data frame to be placed in the storage unit every 128, 256, 512 or 1024 seconds, depending on whether the spacecraft was transmitting at 512 or 256, 64, 16, or 8 bits/second when the spacecraft was switched into this mode. Each frame is placed in the storage unit at the rate of 512 bits per second; thus the storage of any frame takes .4375 second. The time required to fill the data storage unit ranges from 2.4 to 19.3 hours. This form of storage is used to record data for some periods not covered by real time tracking. The mode of transmission (realtime, TLS or DCS) is indicated in the data stream. DCS data is submitted to NSSDC only in the form of listings.

C. Data Acquisition

Data is collected by stations of the Deep Space Network (DSN) at the highest feasible bit rate. Figure 2 shows coverage of each spacecraft through 1968. Note that during that portion of the missions when only a single station was tracking Pioneer 6 and 7 the coverage consisted of short tracking periods and long gaps. Appendix III contains detailed coverage charts for both spacecraft.

II. UNIVERSITY OF CHICAGO EXPERIMENT OPERATION

The University of Chicago Experiments aboard Pioneer 6 and 7 were designed to obtain information about protons and helium in the energy interval ~1 to ~100 MEV/nucleon. The information includes spectra, arrival direction, and counting rates for selected energy interval. The instruments are nearly identical, charged particle telescopes which consist of a stack of three lithium drifted, silicon, solid state detectors (D1, D2 and D3) separated by absorbers and surrounded by a cylindrical plastic scintillator (D4). Figure 3 shows a cross section of the telescope. Information telemetered to earth includes counting rates for $D1\overline{D2}\,\overline{D4}$, $D1D2\overline{D3}\,\overline{D4}$, $D1D2D3\overline{D4}$ and $\overline{D1}D2D3\overline{D4}$ coincidences.[1]

[1] $D1\overline{D2}\,\overline{D4}$ requires the presence of a D1 pulse and the absence of D2 and D4 pulses. The detector not mentioned (i.e. D3) is not considered and may or may not produce pulses.

A total counting rate is generated for D4 via frequency to analog to digital conversion ("analog rate meter"). In addition, 128 channel pulse height information for D1, 32 channel pulse height information for D3, and angular information (giving the relationship of the particle's arrival direction to the direction of the sun) is transmitted for some $D1D2\overline{D4}$ events.

The University of Chicago experiments may be commanded into two modes of operation: "normal mode" and "calibrate mode." Calibrate mode operation modifies coincidence requirements on rates and pulse height analysis to produce single detector counting rates and pulse height information. Instrument operating mode is indicated in the data.

Table 1 describes each element of the particle telescope for both Pioneer 6 and 7. Figure 4 shows the dimensions of the telescope. Table 2 shows energy ranges and geometrical factors for the various detector coincidence combinations.

A. Rate Data, Normal Mode

Whenever a particle passes through the telescope and produces one of the four coincidence events $D1\overline{D2}\,\overline{D4}$, $D1D2\overline{D3}\,\overline{D4}$, $D1D2D3\overline{D4}$ or $D1\overline{D2}D3\overline{D4}$ it is counted in the appropriate one of four binary accumulators. These four accumulators are never reset. Counting rate information telemetered to earth consists of selected bits from each accumulator. Table 3 shows these bits. A count rate is also generated for $D1D2\overline{D4}$ events according to telescope orientation. This is described in greater detail in the section on angular sectoring.

B. Rate Data, Calibrate Mode

A command issued from earth places the University of Chicago instruments into calibrate mode. In this mode of operation some of the coincidence requirements are relaxed and single detector counting rates are produced, which can be used to check instrument operation. Table 3 shows the relationship between normal mode and calibrate mode coincidence requirements.

C. Pulse Height Data, Normal Mode

Particle events causing a $D1D2\overline{D4}$ coincidence are subject to pulse height analysis in D1 with 128 channel resolution and in D3 with 32 channel resolution. Pioneer 6 transmits the last such event before readout on the current format A or B frame, while Pioneer 7 transmits the first such event following the preceding readout. If no new event takes place before the current readout, the previous event is transmitted again. When the event was $D1D2\overline{D3}\,\overline{D4}$ the D3 analyzer is reset to channel 32.

D. Pulse Height Data, Calibrate Mode

Calibrate mode pulse height analysis in Pioneer 7 differs from normal mode only in that the coincidence requirements for D1 analysis are relaxed from $D1D2\overline{D4}$ to $D1\overline{D4}$. In the Pioneer 6 instrument all logic requirements are entirely removed, so a D1 and/or D3 event will cause analysis to take place independent of any other detectors. In case the event is $\overline{D1}D3$ the D1 binaries are reset to channel 128, while a $D1\overline{D3}$ event causes the D3 binaries to be reset to channel 32.

E. Directional Information

In addition to pulse height information the direction in which the telescope was pointing when a particle was pulse-height analyzed is also transmitted, as follows: when the telescope is pointing roughly 119° east of the spacecraft-sun line (see Figure 5 for geometry) a pulse from a sun sensor resets a 5 bit accumulator which counts pulses from a 16 c.p.s. clock. When an event is pulse height analyzed the configuration of the four highest order bits is read into four storage binaries. The state of these storage binaries is transmitted along with the pulse height information and the binary value is called the "sector." An analysis of sector operation and use may be found in Appendix I.

All particles causing a $D1D2\overline{D4}$ coincidence are counted in a five bit "quadrant scaler" when the angular sector binaries are set to specified values. The values specified change, selecting successive quadrants, after each readout (every eight frames-see section F) of the quadrant scaler. The quadrants, in order 1 through 4, consist of sectors 1 and 2; 3 and 4; 5 and 6; 7, 8 and possibly 9 (see Figure 5). Quadrant data is useful only for transmission bit rates 64 bps and greater, and for total $D1D2\overline{D4}$ rates greater than ~2 c.p.s. Because of this limited range of utility the quadrant data was not included on the data tapes. Persons interested in this data should obtain more information from the experimenter.

Both spacecraft have spin rates of ~60 RPM. Due to a gas leak on Pioneer 6 its spin rate varies during the mission, as shown in Figure 6. The spin rate is determined from the number of sun pulses counted in a 64 second interval and is transmitted once each engineering subcom sequence.

F. Data Telemetry Formats

Table 4 shows the location of University of Chicago data in format A or B. Information contained in the engineering subcom (format C) is the spin rate counter (word 15), the D4 analog rate meter (word 35), the U. of C. instrument temperature (word 36) and the platform temperature (word 52). The science subcom (format E) contains the quadrant flag which identifies the quadrant (bit 1 of words 1 and 9) and the contents of the quadrant scaler (bits 2-6 of words 1 and 9).

III. DATA SUBMISSION TO NSSDC

A. Counting Rate Plot Submission

The data consists of microfilms of computer-generated plots of all counting rates available for both Pioneer 6 and 7 from the beginning of their missions through 3 January, 1969. Each plot for a particular rate covers one Bartels Solar rotation period. Time axis labels are in day of year. The averaging periods used were determined in such a way as to produce the greatest time resolution commensurate with a statistically significant sample. These periods are integers multiples of .01 days (14.4 minutes). This choice was made because the plotter's resolution is limited to .01 day.

Hand drawn additions to the computer-drawn real time data consist of manually-calculated rates from duty cycle storage data and annotations to the machine-drawn data where it is incorrect. Table 5 describes these additions.

B. Data Tape Submission

Data from both instruments from the beginning of their missions through 1968 is available on standard 7-track binary mode, IBM compatible digital magnetic recording tape. The information contains all telemetered information pertinent to the experiments with the exception of quadrant data (see description of angular sectoring). The data has been edited to the extent that doubtful information is flagged as such and unusable data is deleted.

The tapes contain physical records of 6000, 6-bit bytes in length. Each physical record consists of 500 logical records of 12 bytes each. Logical records are either header records or data records. A header logical record contains information on spacecraft operating format and mode as well as the engineering data from all or part of an engineering subcom sequence (64 spacecraft frames). A header logical record is followed by from 1 to 64 data records of the same engineering subcom sequence. During perfect data reception with no discernible data errors the header will precede the complete set of 64 data logical records for a given engineering subcom sequence. However, if there are errors in the data a header may appear more than once in a given engineering subcom sequence, and fewer than 64 data records will be presented for the engineering subcom sequence, the erroneous data being deleted. Each such header logical record will contain part or all of the engineering information it would contain if it were the single header associated with a perfectly received engineering subcom sequence. Therefore, in order to obtain all possible engineering information for a given engineering subcom sequence (which might not be the complete set available from a perfectly received sequence) all the headers associated with the sequence should be used. Usually a given header will contain only engineering data which is read out on frames appearing between it and the next header. The header format appears in Figure 7.

Each data logical record contains the U. of Chicago information from one frame of format A or B telemetry. Also included is the time of transmission of the first bit of that frame, corrected for transit time between the spacecraft and earth. The format of data logical records is shown in Figure 8.

Each tape terminates with the 'EOD' flag set in the last good data record. The rest of that physical record is filled to the standard length of 500 logical records. Following this physical record is a record 36 bytes in length consisting of 3 dummy header records, each with the 'ET' flag set. Following this are 3 file marks.

IV. DATA USAGE

A. Counting Rate Data

An average of a particular rate, R, may be found from the formula R = CN/T, where N = number of counts per state change of a bit and T = time required to produce C state changes in the selected bit. The bit selected is usually the lowest order bit which changes state in a time longer than the current readout (format A or B frame) period. The method breaks down when the highest order bit available is changing state approximately once each readout. When this bit changes state exactly once each readout the calculated rate will be a maximum. As the true rate increases above this value the highest order bit will change state more often than once each readout and the calculated rate will decrease, reaching zero when the highest order bit changes state exactly twice between readouts. When the true rate is greater than the calculated rate due to these unobserved state changes in the highest order bit the calculated rate is "saturated". Table 6 shows the maximum observable counting rate for each telemetry bit rate.

In calculating rate averages from U. of C. data one should determine the scale bit to use by checking for consistency between two successive scale bits. For example, if the 2^4 scale bit is changing state 20 times for each state change of the 2^9 scale bit, the 2^4 scale bit is clearly saturated; it should change state

32 times for every state change of the 2^9 bit. If the averaging period chosen is so short that the lowest order unsaturated scale bit changes state less than once per averaging period the calculated rate will be erroneous since only saturated data will be available for the average.

Note that the statistical fluctuations of a particular bit will obey the "s-fold" distribution:

where dP_t is the probability of s events taking between t and t + dt units of time, a is the average counting rate and $s=2^n$, the scale factor of the bit. Because of this the 2^0 bit should be avoided in computing rates since the most probable interval between events is zero and hence the probability of undetected state changes of this bit never goes to zero. (c.f. Evans, The Atomic Nucleus, pp. 794-802.)

B. Pulse Height Data

Figures 9 thru 13 show the response of the D1 analyzer on both instruments to protons and helium. Also indicated on these graphs are the thresholds for triggering the D2 and D3 detectors. Figures 14 and 15 show D1 analyzer response for both instruments for nuclei through ${}_8O^{16}$. Figure 16 is a matrix of about 450,000 selected pulse height events from Pioneer 6 chosen during periods of high bit rate, good coverage and when no solar flare activity was present. The time periods extends from launch through day 76, 1966. Superimposed on this matrix are lines which show where the preflight calibrations predict particle tracks. The tracks are calculated for particles incident at 16.5 degrees from the telescope centerline, which is the angle corresponding to the average pathlength, $\overline{l}$, given by

where l is pathlength of a particle in Dl and (dG/dl)dl is the fraction of an isotropic flux which is incident on Dl with pathlength between l and l + dl.

The spread of the data about these ideal tracks results from the 60 degree opening angle, random fluctuations of energy loss in the detectors and electronic noise. Events lying between tracks are due to a variety of effects including interactions within the telescope and undetected telemetry errors. See Appendix II for a more detailed description of pulse height data usage.

TABLE 1

Telescope Element	Description P-6	Description P-7
A1	Aluminized mylar window, 15 gauge Thickness: 0.000531 gm/cm^2	0.000530 gm/cm^2
D1	Lithium drifted silicon detector p=0.0μ w=416μ(=0.0969 gm/cm^2) Li=110μ(=0.0256 gm/cm^2) Radius=1.17 cm	 390μ(=0.0909 gm/cm^2) 60μ(=0.0140 gm/cm^2)
A2	Aluminum absorber Thickness=508μ(=0.137 gm/cm^2)	 534μ(=0.144 gm/cm^2)
D2	Lithium drifted silicon detector p=92μ(=0.0214 gm/cm^2) w=750μ(=0.175 gm/cm^2) Li=150μ(=0.0349 gm/cm^2) Radius=1.17 cm	 0.0μ(=0.0 gm/cm^2) 820μ(=0.191 gm/cm^2) 120μ(=0.0280 gm/cm^2)
A3	Platinum + 5% Iridium absorber Thickness=3937μ(=8.445 gm/cm^2) (ρ=21.45)	
D3	Lithium drifted silicon detector p=0.0μ w=842μ(=0.196 gm/cm^2) Li=108μ(=0.0252 gm/cm^2) Radius=1.328 cm	 879μ(=0.205 gm/cm^2) 744μ(=0.172 gm/cm^2)
D4	Plastic scintillator anticoincidence detector	

TABLE 2

TELESCOPE CHARACTERISTICS

Coincidence Requirements	Kinetic Energy, MEV Protons		Kinetic Energy, MEV Helium		Geometrical Factor, M^2 - Ster	
	P-6	P-7	P-6	P-7	P-6	P-7
$D1D2\overline{D4}$	.6-13.9	.6-12.7	2.4-55.6	2.4-50.8	5.8×10^{-4}	5.8×10^{-4}
$D1D2\overline{D3}\,\overline{D4}$	13.9-73.2	12.7-73.0	55.6-293	50.8-292	1.15×10^{-4}	1.15×10^{-4}
$D1D2D3\overline{D4}$	73.2-175	73.0-165	>293	>292	1.15×10^{-4}	1.15×10^{-4}
$\overline{D1}D2D3\overline{D4}$	>175	>165	None	None	1.74×10^{-4}	1.74×10^{-4}
*$D1D2\overline{D3}\,\overline{D4}$ or $D1D2D3\overline{D4}$	13.9-175	12.7-165	55.6-293	50.8-292	1.15×10^{-4}	1.15×10^{-4}

* This rate is the calculated sum of the second and third rates. It is not transmitted.

TABLE 3

COUNTING RATE COINCIDENCE REQUIREMENTS AND BITS TRANSMITTED

Coincidence Requirements			Bits Transmitted	
Normal Mode	Calibrate Mode P-6	Calibrate Mode P-7	P-6	P-7
$D1D2\overline{D4}$	D1	D1 or D3	$2^0, 2^4, 2^9, 2^{13}$	$2^2, 2^6, 2^9, 2^{13}$
$D1D2\overline{D3}\,\overline{D4}$	D2	D2	$2^0, 2^4, 2^9$	$2^0, 2^4, 2^9$
$D1D2D3\overline{D4}$	D3	$D1D2D3\overline{D4}$	$2^0, 2^4, 2^9$	$2^0, 2^4, 2^9$
$\overline{D1}D2D3\overline{D4}$	$\overline{D1}D2D3\overline{D4}$	$\overline{D1}D2D3\overline{D4}$	$2^0, 2^4, 2^9$	$2^0, 2^4, 2^9$

TABLE 4

Word No.	Bit No.*	Significance
4	1 (P-6)	$D1\overline{D2}\overline{D4}$ rate 2^0 scale bit,
	1 (P-7)	$D1\overline{D2}\overline{D4}$ rate 2^2 scale bit,
	2 (P-6)	$D1\overline{D2}\overline{D4}$ rate 2^4 scale bit,
	2 (P-7)	$D1\overline{D2}\overline{D4}$ rate 2^6 scale bit,
	3	$D1\overline{D2}\overline{D4}$ rate 2^9 scale bit
	4	$D1D2\overline{D3}\overline{D4}$ rate 2^0 scale bit
	5	$D1D2\overline{D3}\overline{D4}$ rate 2^4 scale bit
	6	$D1D2\overline{D3}\overline{D4}$ rate 2^9 scale bit
9	1-6	low order 6 bits of D1 pulse height (bit 1 is least significant)
10	1	highest order bit of D1 PHA
	2-6	D3 PHA (bit 2 least significant)
11	1-4	angular sectoring indicator ($\text{sector}_{10} = 14_{10} - \text{contents}_{10}$)
	5	$D1\overline{D2}\overline{D4}$ rate 2^{13} scale bit
	6	0 for normal mode, 1 for calibrate mode
20	1	$D1D2D3\overline{D4}$ rate 2^0 scale bit
	2	$D1D2D3\overline{D4}$ rate 2^4 scale bit
	3	$D1D2D3\overline{D4}$ rate 2^9 scale bit
	4	$D1D2D3\overline{D4}$ rate 2^0 scale bit
	5	$\overline{D1}D2D3\overline{D4}$ rate 2^4 scale bit
	6	$\overline{D1}D2D3\overline{D4}$ rate 2^9 scale bit

*Bit 1 of a given word is the first bit telemetered.

TABLE 5

ANNOTATIONS TO THE PLOTS

Symbol	Meaning
1. 	This is a data point calculated from duty cycle storage data. The vertical error bar indicates the 1σ error in the counting rate whereas the horizontal bar represents the period on which the average was performed. (Example: P-6 D1$\overline{D2}$D4, day 15, 1966; P-7 D1$\overline{D2}$D4, day 256, 1966)
2. +	Large hand drawn crosses which appear during periods not covered by real time machine drawn data are points derived from saturated duty cycle storage data. The rates calculated are reliable. However, the time has an uncertainty of $\sim\pm2$ hours. (Example: P-6 D1$\overline{D2}$D4, day 235, 1966; P-7 D1$\overline{D2}$D4, day 256, 1966)
3. C or C	This is calibrate mode data and should not be mistaken for a sudden change in the normal mode rate. (Example: P-6 D1$\overline{D2}$D4, day 355, 1965; P-7 D1$\overline{D2}$D4, days 229, 230, 1966)
4. S or S	This data is saturated (true rate is higher than indicated) and must not be trusted. (Example: P-6 D1$\overline{D2}$D4, day 82, 1966; P-7 D1$\overline{D2}$D4, days 241, 242, 1966)
5. x	This symbol is produced by the computer whenever the data quality is such as to produce a questionable rate. This symbol always appears directly on the questionable point. (Example: P-6 D1$\overline{D2}$D4, days 92, 93, 94, 1966; P-7 D1$\overline{D2}$D4, day 272, 1966)
6. ? or ?	Data may be saturated or otherwise untrustworthy and should not be considered accurate. (Example: P-6 D1$\overline{D2}$D4, day 83, 1966; P-7 D1$\overline{D2}$D4, day 20, 1967)
7. +	Small machine drawn crosses appearing in the middle of real time machine plotted data are telemetry storage data. The size of the cross does not indicate

Symbol	Meaning
9. (cont'd)	either error bounds on the rate or the duration of the period. The rate calculated is true to about two percent. (Example: P-6 D1$\overline{\text{D2D4}}$, days 117, 118, 1966; P-7 D1$\overline{\text{D2D4}}$, days 347, 348, 1966)
8. ⊕	This telemetry storage point is to be trusted whereas the surrounding data should not be. (Example: P-6 D1$\overline{\text{D2D4}}$, day 249, 1966; P-7 none.)
9. Ⓣ	This symbol appears directly above a telemetry storage point which should be treated as in 8 above. (Example: P-6 none; P-7 D1$\overline{\text{D2D4}}$, days 347, 348, 1966)
10.	This is a lower bound on the actual rate for the time covered by the horizontal bar. (Example: P-6 none; P-7 D1$\overline{\text{D2D4}}$, day 12, 1967)

TABLE 6

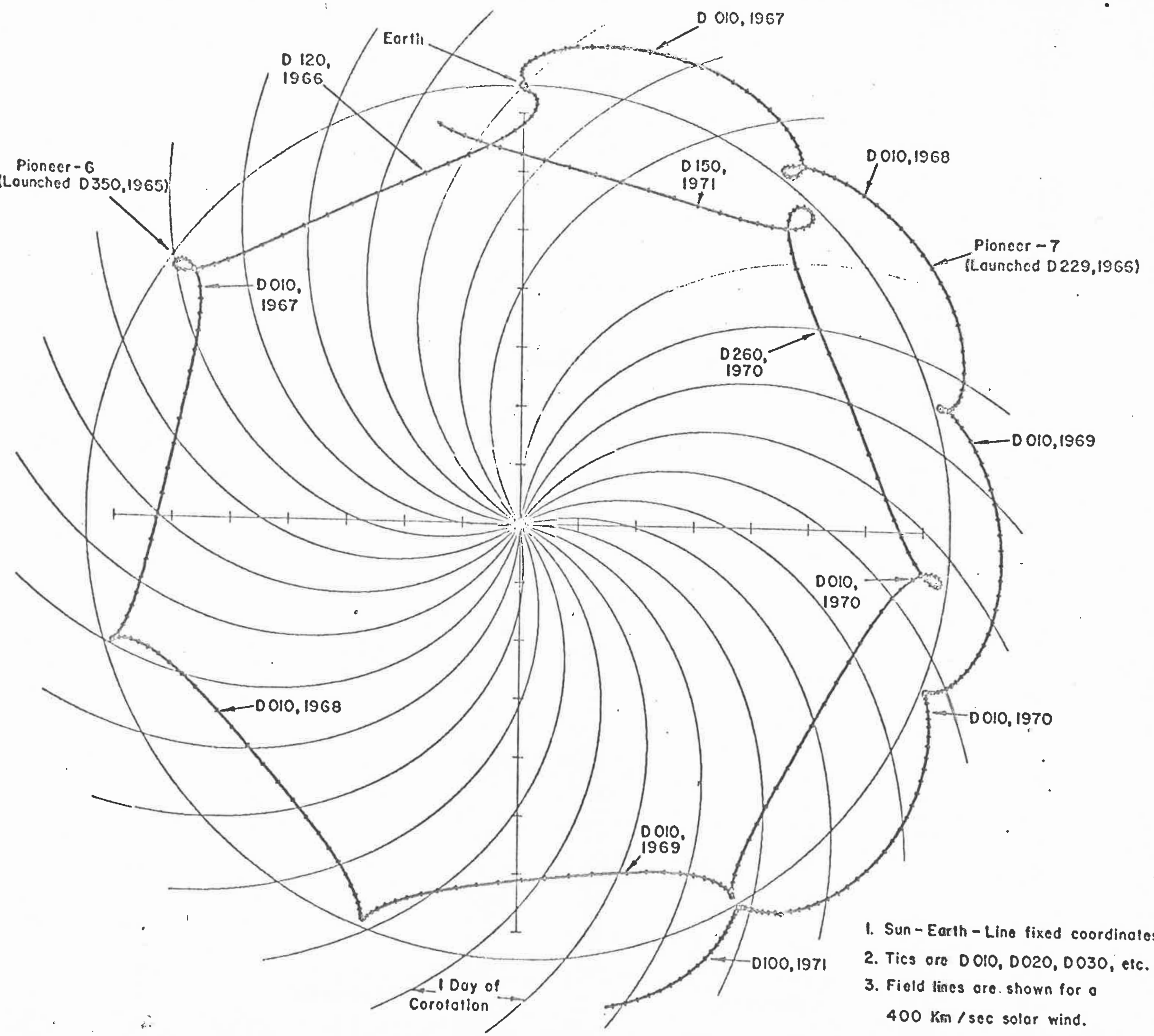
MAXIMUM OBSERVABLE COUNTING RATES IN COUNTS/SEC.

Coincidence Rate	Highest Order Bit	Transmission Rate in Bits/Sec.				
		512	256	64	16	8
$D1\overline{D2}\,\overline{D4}$	2^{13}	~8000*	~8000*	2341	585	293
$D1D2\overline{D3}\,\overline{D4}$	2^{9}	1170	585	146	36.6	18.3
$D1D2D3\overline{D4}$	2^{9}	1170	585	146	36.6	18.3
$\overline{D1}D2D3\overline{D4}$	2^{9}	1170	585	146	36.6	18.3

* This maximum is due to dead time effects and not to saturation.

FIGURE CAPTIONS

Figure 1.	Pioneer 6 and 7 trajectories in a heliocentric coordinate system in which the earth remains fixed on the Y axis.
Figure 2.	Plot of Pioneer 6 telemetry bit rate v. s. time on a scale of 10 days per inch. Data gaps shorter than .01 inch on this scale are not indicated. The vertical scale markings at the left of each line represent the heights at which the 5 possible bit rates appear; in ascending order they are 8, 16, 64, 256 and 512 bits per second. Pioneer 7 to be supplied.
Figure 3.	Labeled cross section of the Pioneer 6/7 telescopes.
Figure 4.	Dimensioned cross section of the two telescopes. Note that the dimension 1.750 inches refers to the inside of the inner retaining cup (not shown) which defines the aperture for low energy particles, whereas 1.828 inches is the inner diameter of the D4 detector itself. Similarly the dimension 3.395 inches is the height of the low energy defining aperture (not shown) whereas 3.330 inches is the height of the D4 detector itself.
Figure 5.	Figure 5 (a) shows the orientation of the spin axis of the two spacecraft, the direction of spin and the angle at which the sum pulse is generated. Figure 5 (b) shows the sector and quadrant timing. Figure 5 (c) shows the probabilities Pi(t) of finding a particle in sector i after time t from the sun pulse. This distribution is discussed in Appendix III.
Figure 6.	This figure shows the Pioneer 6 spin rate for the early portion of the mission when it was changing rapidly.
Figure 7.	Format of header records of our data tapes submitted to NSSDC.
Figure 8.	Format of data records on data tapes submitted to NSSDC.
Figure 9 - 14	To be supplied



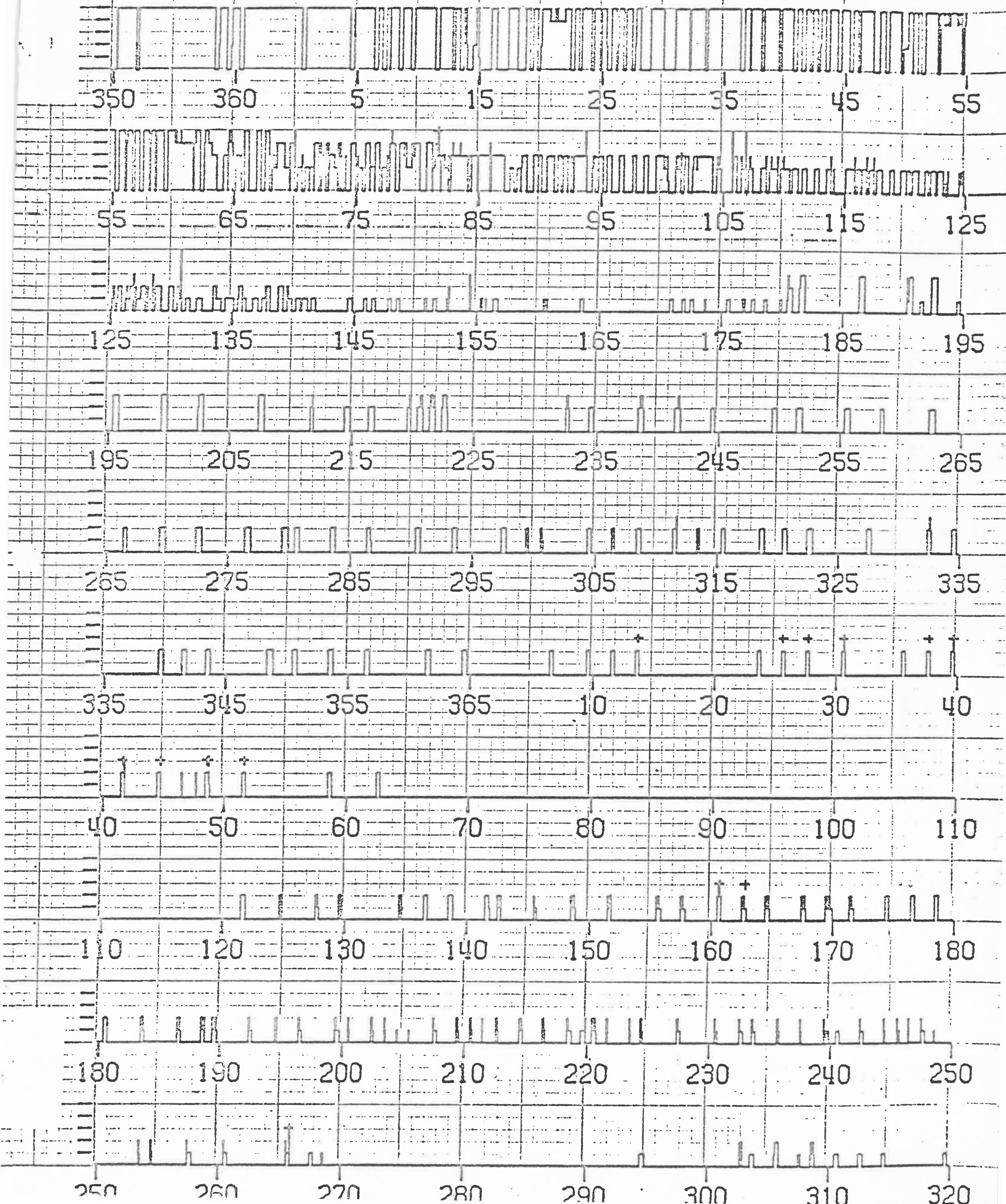
Pioneer 6 and 7 Trajectory

1. Sun – Earth – Line fixed coordinates.
2. Tics are D010, D020, D030, etc.
3. Field lines are shown for a 400 Km / sec solar wind.
4. 1 scale division = 2×10^7 Km.

Figure 1

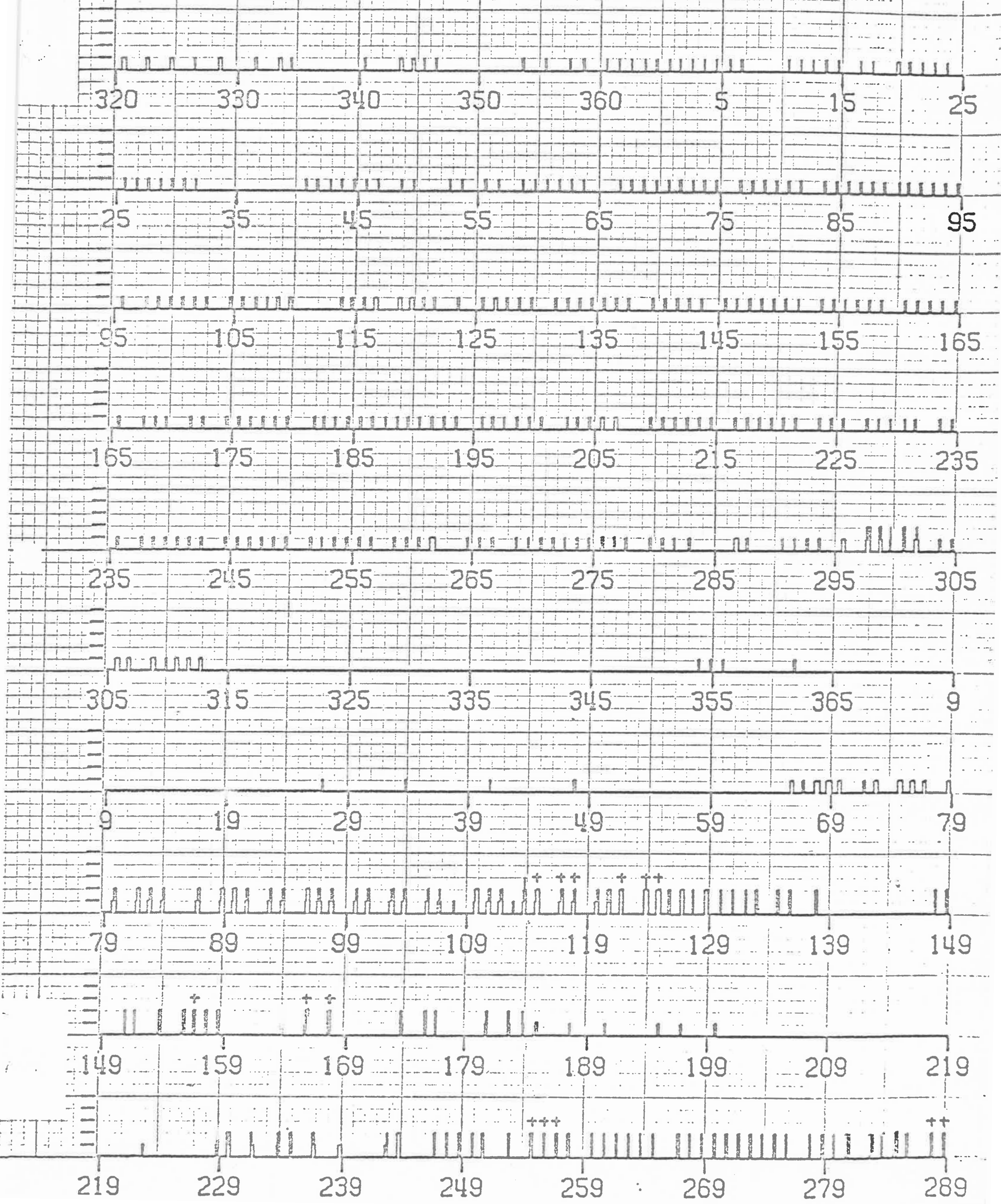
PIØNEER-6 TELEMETRY CØVERAGE 1965/66/67

Figure 2, page 1



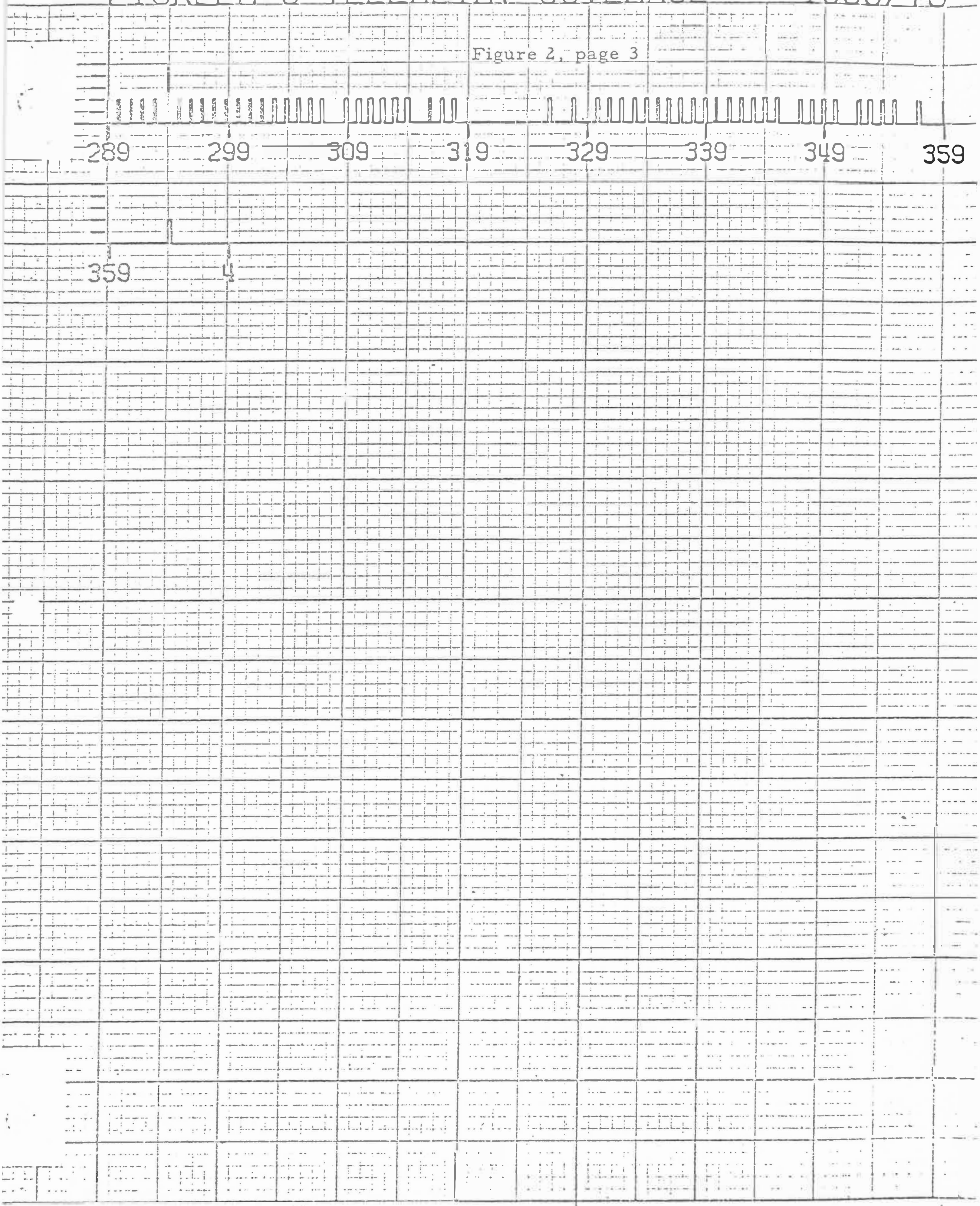
PIØNEER-6 TELEMETRY CØVERAGE 1967/68/69

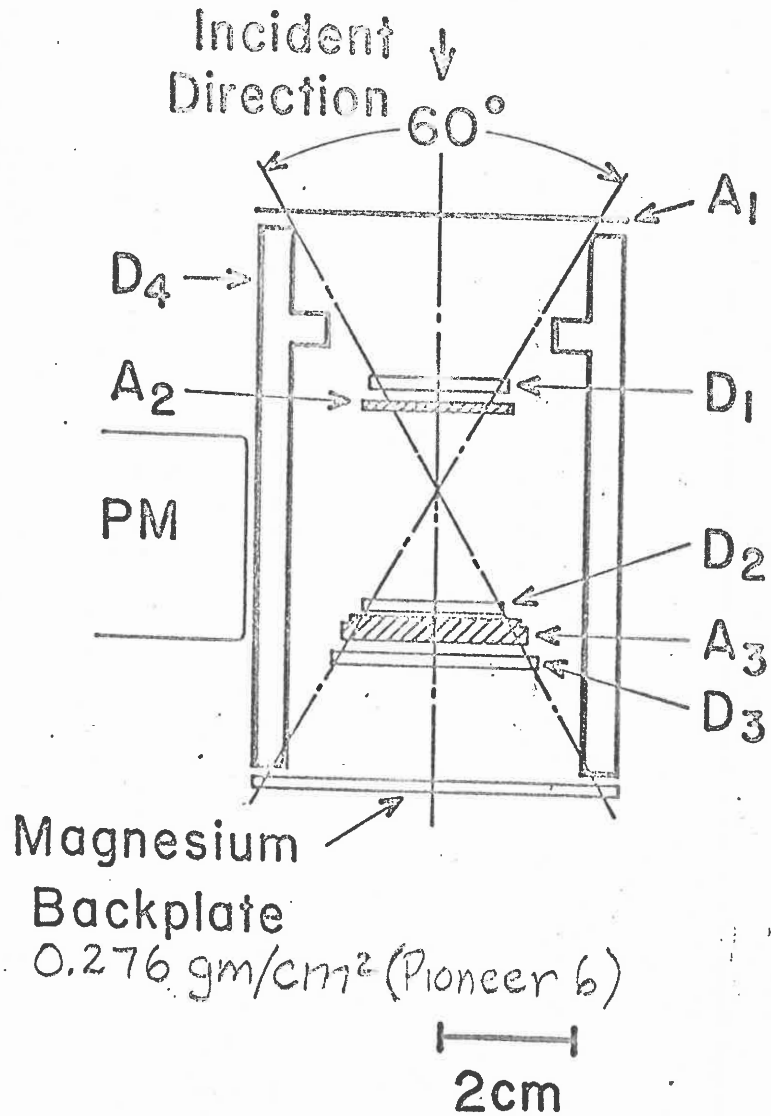
Figure 2, page 2



PIONEER-6 TELEMETRY COVERAGE 1969/70

Figure 2, page 3





A_1 Aluminized Mylar Window

D_1 Lithium Drift Silicon Detector

A_2 Aluminum Absorber

D_2 Lithium Drift Silicon Detector

A_3 Platinum Absorber

D_3 Lithium Drift Silicon Detector

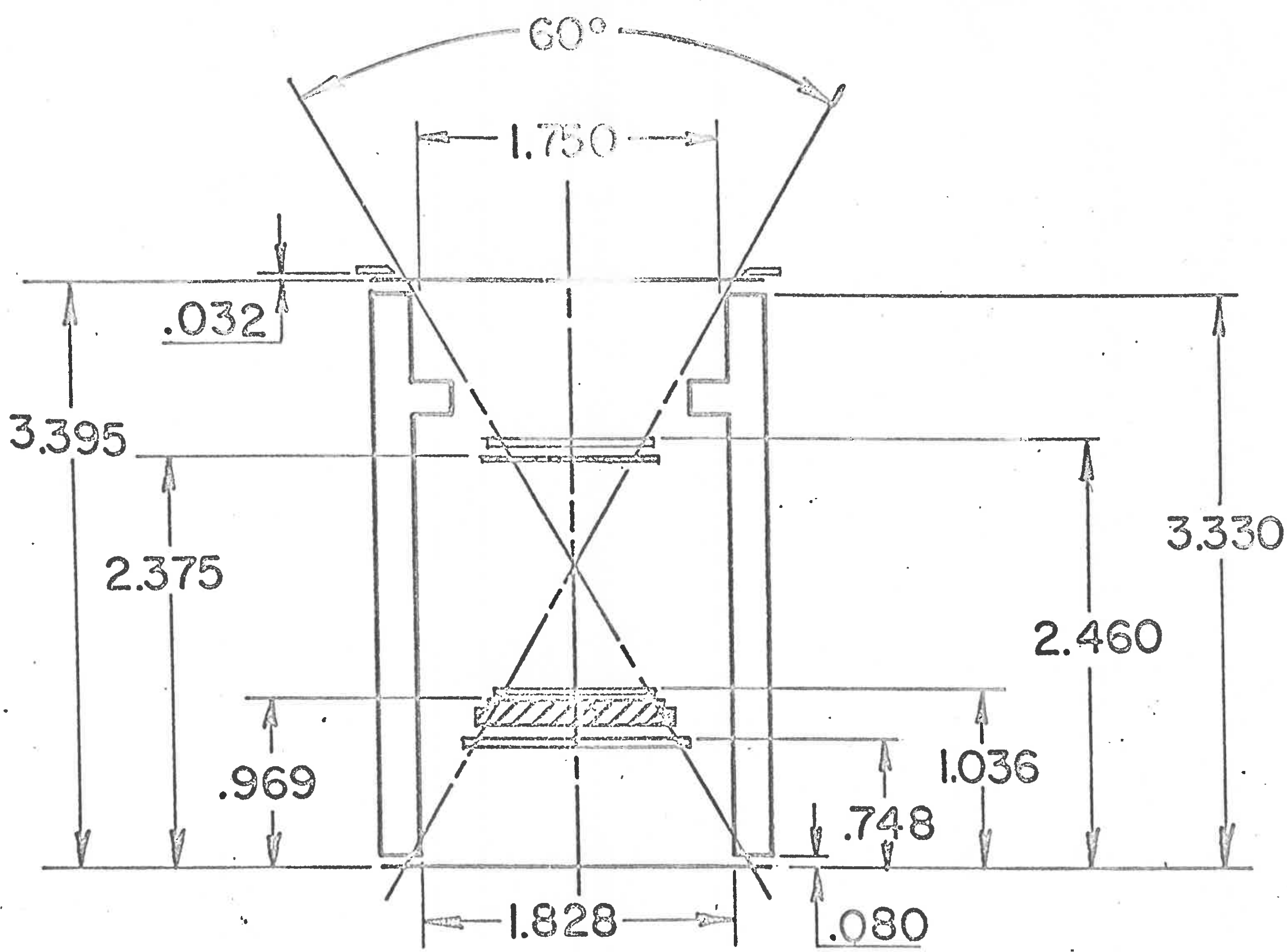
D_4 Plastic Scintillator

PM Photo Multiplier Tube

Pioneer-6/7 Cosmic Ray Telescope
The University of Chicago

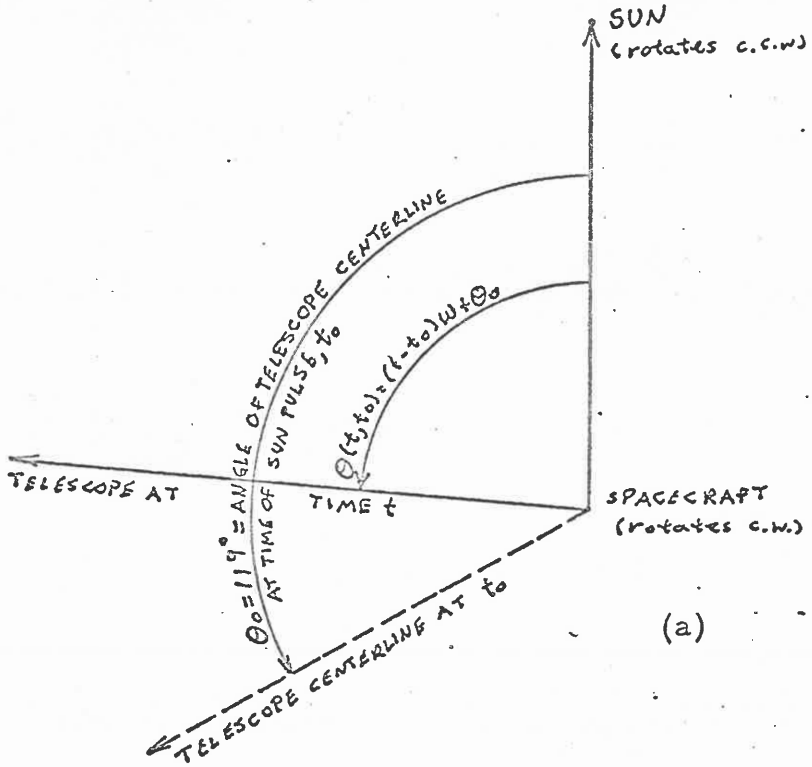
Figure 3

Figure 4



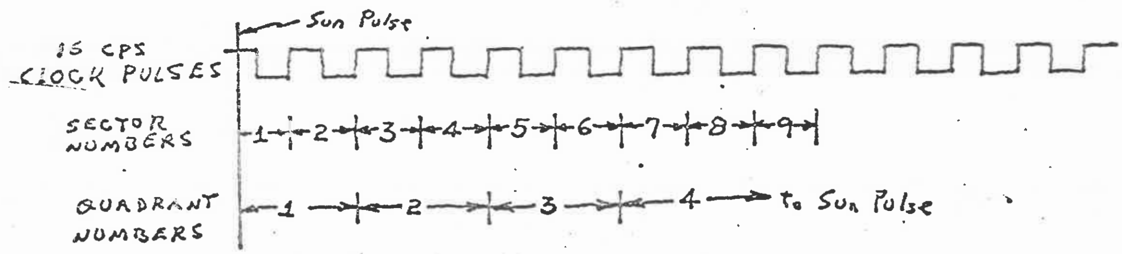
Pioneer 6 & 7 _ Cosmic Ray Telescope
The University of Chicago

Figure 5



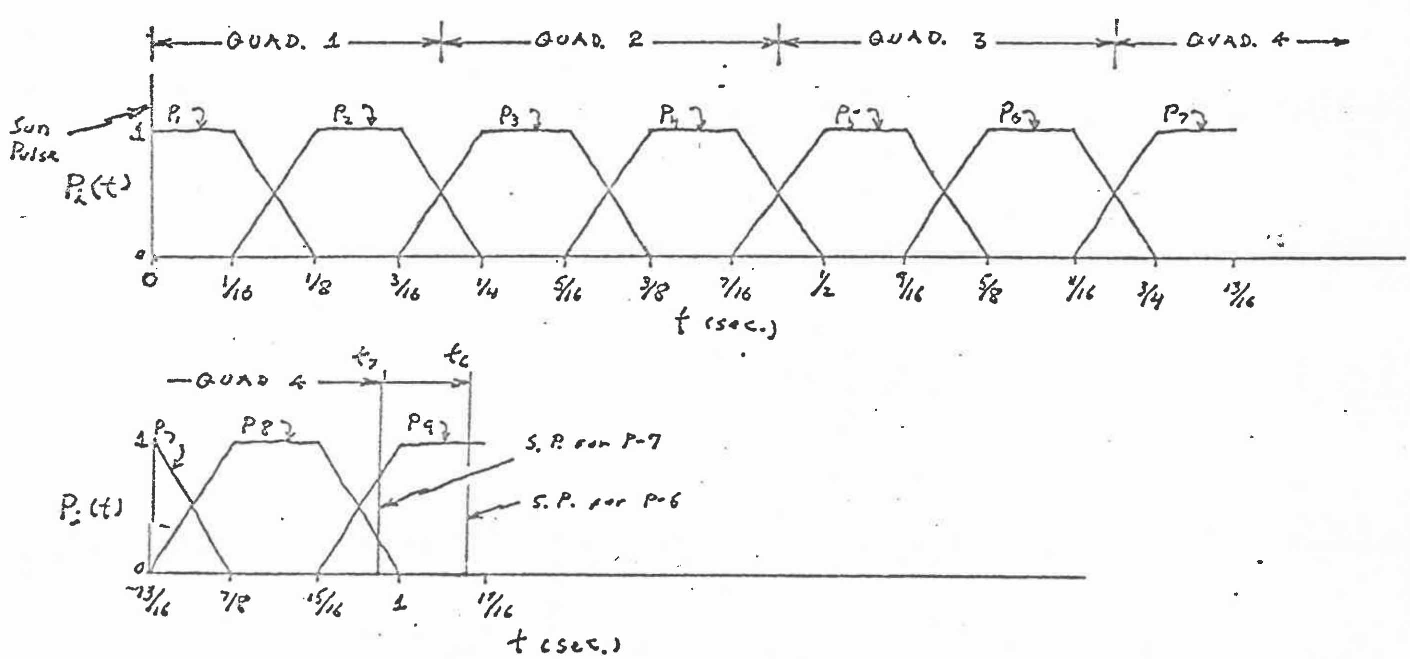
SUN (rotates c.c.w.)
$\Theta_0 = 119° =$ ANGLE OF TELESCOPE CENTERLINE AT TIME OF SUN PULSE, t_0
$\Theta(t, t_0) = (t - t_0)\omega + \Theta_0$
TELESCOPE AT TIME t
SPACECRAFT (rotates c.w.)
TELESCOPE CENTERLINE AT t_0

(a)



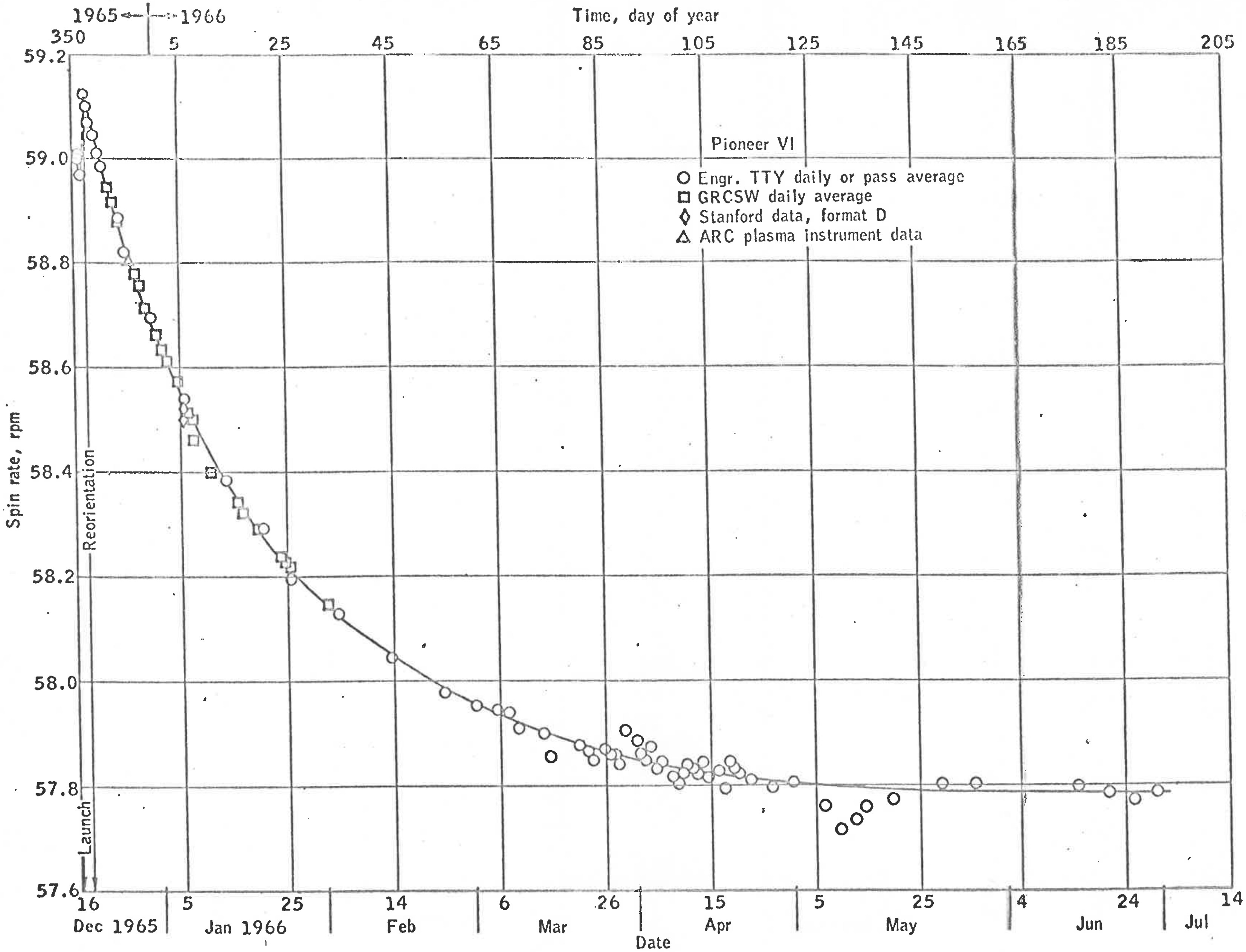
Sun Pulse
15 CPS CLOCK PULSES
SECTOR NUMBERS
1 2 3 4 5 6 7 8 9
QUADRANT NUMBERS
1 2 3 4 to Sun Pulse

(b)



QUAD. 1
QUAD. 2
QUAD. 3
QUAD. 4
Sun Pulse
P_1 P_2 P_3 P_4 P_5 P_6 P_7
$P_i(t)$
1
0
0 1/16 1/8 3/16 1/4 5/16 3/8 7/16 1/2 9/16 5/8 11/16 3/4 13/16
t (sec.)
QUAD 4
t_7
t_6
P_7 P_8 P_9
S.P. for P-7
S.P. for P-6
$P_i(t)$
13/16 7/8 15/16 1 17/16
t (sec.)

(c)



Variation of Pioneer VI spin rate with time.

Figure 6

Header Logical Record Format

Bit No.	1 – 12	13 – 29	30 – 36	37 – 43	44 – 50	51 – 55	56 – 61	62 – 65	66	69	70	71	72
	Year	Analog Rate Meter	Platform Temperature	Telescope Temperature	Spin Rate	Extended Frame Counter	Bit Rate	S/C Mode		ERR	BA	ET	1
Note No.	(1)	(2)	(3)	(4)	(5)		(6)	(7)		(8)	(9)	(10)	(11)

Notes:
1. Binary integer year in which data was acquired + 256 x spacecraft number (6 or 7).
2. Analog rate meter is in counts per second (integer).
3. Platform temperature is in integer degrees Fahrenheit.
4. Telescope temperature is in integer degrees Fahrenheit.
5. Spin Rate is in counts per 64 seconds.
6. Bit Rate is an integer:
   value 0 = error in source record.
   " 1 = 8 Bits per second transmission rate
   " 2 = 16 bps
   " 4 = 64 bps
   " 10_{10} = 256 bps
   " 20_{20} = 512 bps
7. Spacecraft mode is an integer:
   value 0 = error in source record.
   " 2 = telemetry storage mode
   " 4 = memory readout
   " 10_{10} = Real time
   Note that the combination 2 + 4 = 6 is the only valid combination other than 10_{10}.
8. ERR=1 if data in this header and following data records were taken from a suspect input record.
9. BA=1 signifies that this header record was the first of a new telemetry acquisition, otherwise it is zero.
10. ET=1 signifies that the header is a dummy logical record signalling the end of the data tape.
11. Bit No. 72 is always 1 for a header logical record.
12. The default value for any parameters out of range or otherwise in error is zero.

Figure 7

Data Logical Records

Bit No.	1–30	31–36	37–43	44–48	49–52	53–55	56–58	59–61	62–65	66–69	70	71	72
	Time	Sequence Count	D1 PHA	D3 PHA	$D1\overline{D2}$ Rate	$D1D2\overline{D3}$ Rate	$D123\overline{4}$ Rate	D23 Rate	Sector	Flag	C/N	EOD	0
Note No.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)

Note: 1. Time is integer deciseconds of year (seconds of year x 10).

2. Sequence is an integer, 0-63, corresponding to data frame number within an engineering subcom sequence.
3. D1 PHA is channel, uncorrected (0-127). Channel No. = 1 + D1 PHA.
4. D3 PHA is channel, uncorrected (0-31). Channel No. = 1 + D3 PHA.
5. $D1\overline{D2}$ are the 4, one-bit scales 2^{13}, 2^9, 2^4, 2^0 for P-6; 2^{13}, 2^9, 2^6, 2^2, for P-7 of $D1\overline{D2}\overline{D4}$ rate scaler.
6. $D1D2\overline{D3}$ are the 3 scales (2^9, 2^4, 2^0) of $D1D2\overline{D3}\overline{D4}$ rate scaler.
7. $D123\overline{4}$ are the 3 scales (2^9, 2^4, 2^0) of $D1D2D3\overline{D4}$ rate scaler.
8. D23 are the 3 scales (2^9, 2^4, 2^0) of $\overline{D1}D2D3\overline{D4}$ rate scaler.
9. Sector is the value of the sector scaler (0-16).
10. Flags: The flag is made up of four independent bits having the values in order:

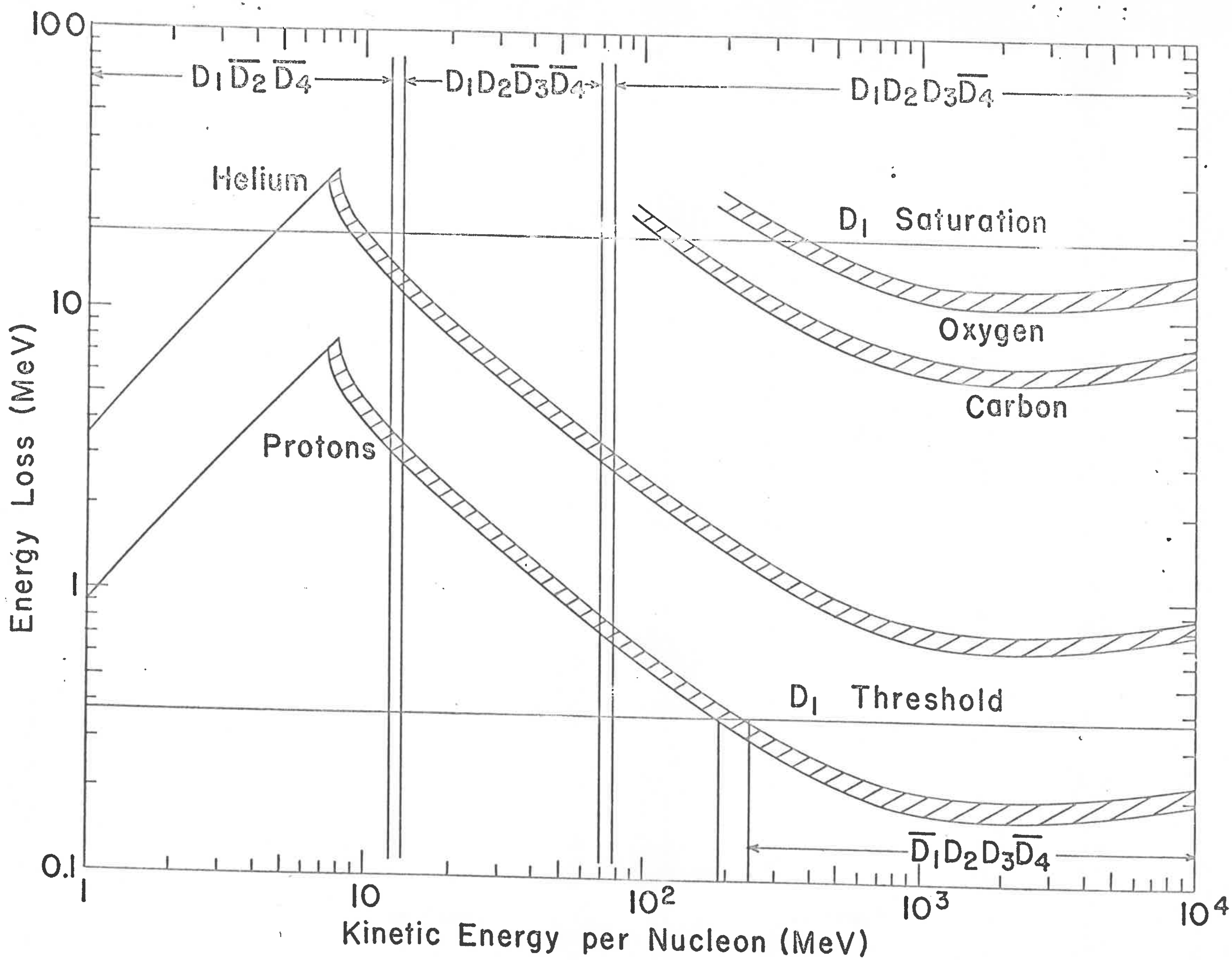
    value = 8 → parity error in Spacecraft (S/C) word 4.
    " = 4 → parity error in S/C word 20.
    " = 2 → parity error in S/C word 9 or 10.
    " = 1 → parity error in S/C word 11.

    Not that any combination is possible (e.g. 1 + 8 = 9.)

If any flag set, the subject parameter will be suspect.

11. C/N = 1 when experiment is in calibrate mode, else zero.
12. EOD = 1 for last data logical record in last physical record on a tape, else zero. All logical records following such an EOD logical record are invalid. Only occurs for last physical data record on a tape.
13. Bit 72 = 0 for data logical records.
14. Any parameter which was filled in the source will be set to zero. Thus a D1 PHA of zero with the Flag = 2 could mean either that the source D1 value was zero with a parity error or that the source D1 value was fill.

Figure 8



D_1 Detector Energy Loss vs. Particle Energy

Pioneer 6 Cosmic Ray Telescope

The University of Chicago

65-105A-03 and 66-075A-06

Pioneer 6 & 7 Cosmic Ray Telescope Experiment, Simpson

Obtained from Gordon Lentz by Leo Davis on trip to Univ. of Chicago 23 Oct. 1968.

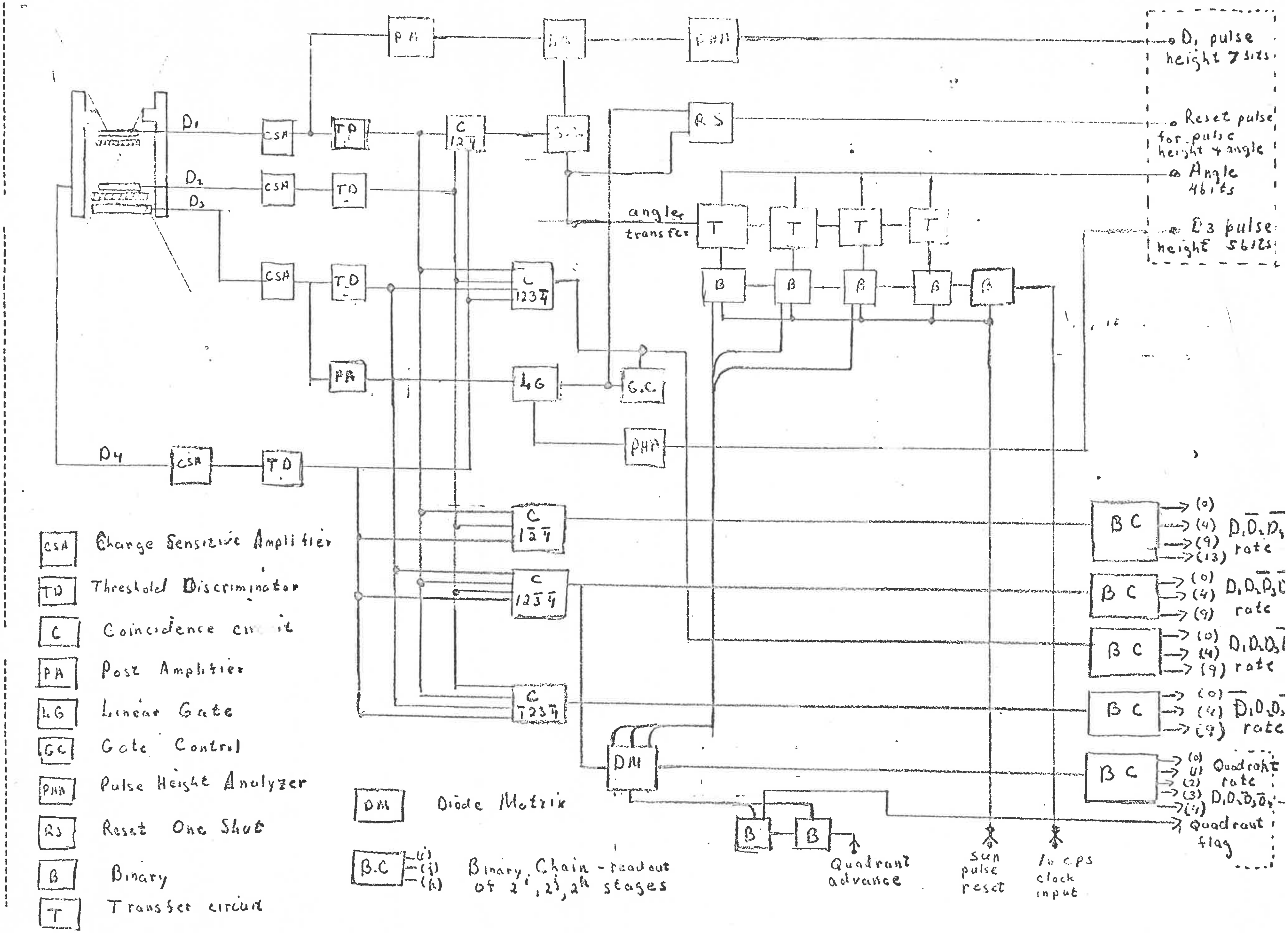
SHEET NO. OF

JOB NO.

SUBJECT Final drawing

BY DATE

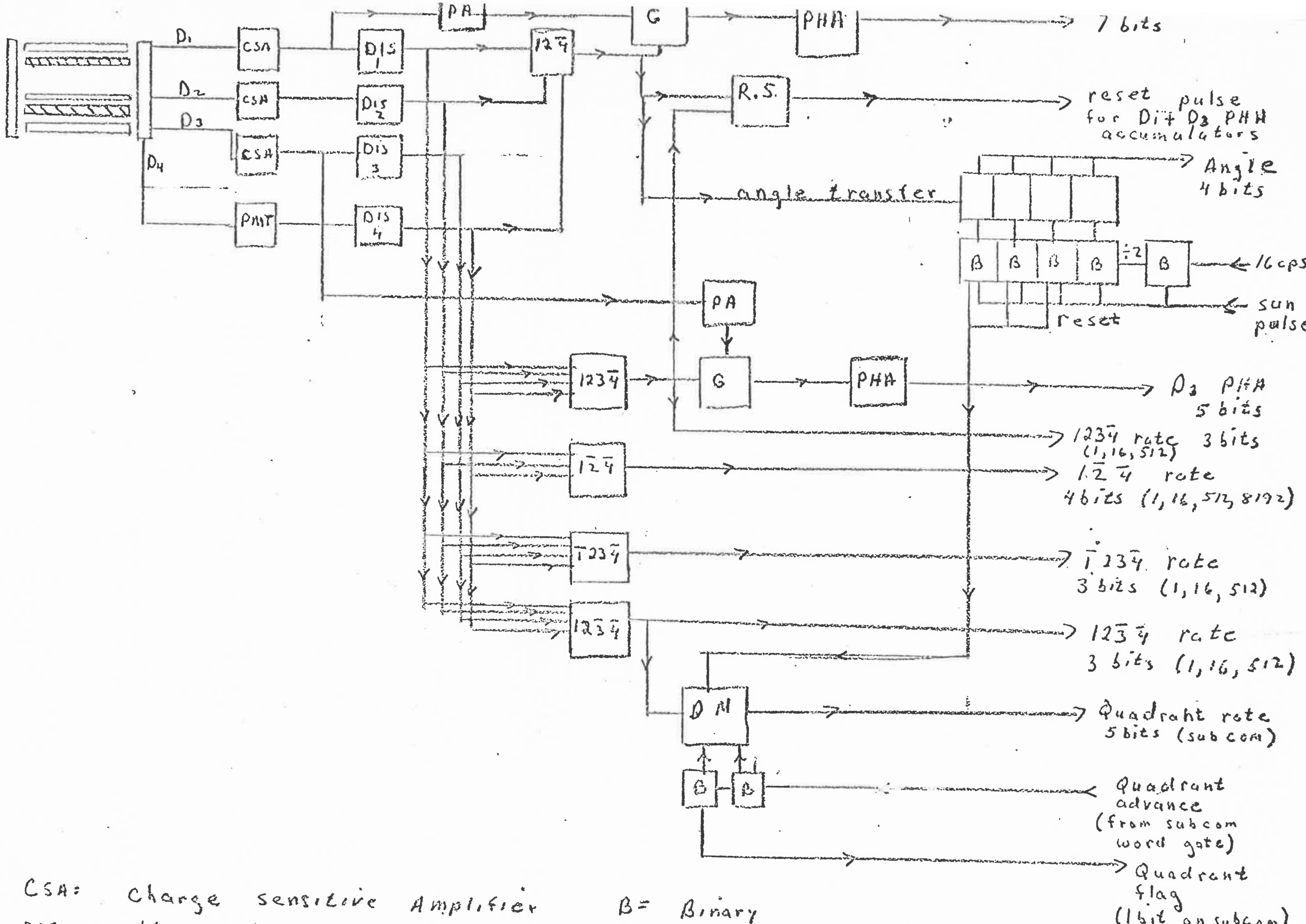
CHKD. BY DATE



65-105A-03 and 66-075A-06

Pioneer 6&7 Cosmic Ray Telescope Final Drawings
Univ. of Chicago

Obtained from Gordon Lentz by Leo Davis on trip to U. of C.
23 Oct. 1968.



CSA: Charge sensitive Amplifier

DIS = threshold discriminator

G = linear Gate.

PA = delay line and low gain post amplifier

B = Binary

DM = diode matrix

SHEET NO. ______ OF ______

JOB NO. ______

SUBJECT Pioneer VI Front end block diagram

BY DRS DATE 3-1-66

CHKD. BY ______ DATE ______

65 - 105A - 03 and 66 - 075A - 06

Preliminary Drawings (see final drawings)

Obtained from Gordon Lentz by Leo Davis on trip to Univ. of Chicago 23 Oct. 1968.

Appendices I, II, III will be supplied

NSSDC ID NUMBER 69-015A-06G
PIONEER 7

NSSDC AIM FILE CODING - RECORD SHEET
DATA SET ENTRY

ok

RECEIVED KR DATE 10/5/7
SUBMITTED JJB DATE 9/8/70
REVIEWED ______ DATE ______
PUNCHED ______ DATE ______
VERIFIED ______ DATE ______

TYPE OF ENTRY

NEW ☑ ADD ☐ DELETE ☐ CORRECT ☐ NOTE DISCREPANCY ☐

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 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

NAME OF DATA SET (33 CHARACTERS) / CONTACT — DD1
SGD PBLSHD ~~PROTON CO~~ COUNT RATES SIMPSON
CR PROTON

GROUP-AGENT-RANK / FORM + SIZE — DD2
BJJBB BT 16

ACCESSION UNITS — D91
BT00065-BT00075, BT00077-BT00081

PERIOD COVERED BY DATA SET (MMYY – MMYY) — D81
040169-083170

PROGRAMS AVAILABLE FOR PROCESSING DATA SET — D71

DATA AVAILABILITY*
ALL DATA RECEIVED — D41
7 M M D D Y Y
B

OTHER SUPPORTING INFORMATION — D42

DATA SET CHECK LIST
DATA REPOSITORY ☐ ACQUISITION AGENT ☑ PROGRAMMING SERVICES ☐ PUBLICATIONS ☐ SYSTEMS IMPLEMENTATION ☐ ACQUISITIONS FILE ☐

*P-PROPRIETARY
X-DATA EXCHANGE
O-OPEN

601-18 (4/69)

NSSDC ID NUMBER 66-075A-06E

PIONEER 7

JJB

NSSDC AIM FILE CODING - RECORD SHEET
DATA SET ENTRY

RECEIVED	PdR	DATE	10/15/70
SUBMITTED		DATE	
REVIEWED		DATE	
PUNCHED		DATE	
VERIFIED		DATE	

TYPE OF ENTRY

NEW [✓] ADD [ ] DELETE [ ] CORRECT [ ] NOTE DISCREPANCY [ ]

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 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

NAME OF DATA SET (33 CHARACTERS) — CONTACT — D D 1

GROUP-AGENT-RANK — FORM + SIZE (add ①): BT 18 — D D 2

ACCESSION UNITS: ~~BT00065-BT00082~~ BT00426-BT00443 — D 9 1

PERIOD COVERED BY DATA SET (MMYY – MMYY): 040169-083170 — D 8 1

PROGRAMS AVAILABLE FOR PROCESSING DATA SET — D 7 1

DATA AVAILABILITY* / ALL DATA RECEIVED (7 M M D D Y Y) — D 4 1

OTHER SUPPORTING INFORMATION — D B 1 / D B 2

DATA SET CHECK LIST

DATA REPOSITORY [✓] ACQUISITION AGENT [ ] PROGRAMMING SERVICES [ ] PUBLICATIONS [ ] SYSTEMS IMPLEMENTATION [ ] ACQUISITIONS FILE [ ]

*P-PROPRIETARY
X-DATA EXCHANGE
O-OPEN

Data contained in Solar Geophysical Data.

601-18 (4/69)