NOAA Technical Memorandum ERL SEL-71

TIROS/NOAA SATELLITES SPACE ENVIRONMENT MONITOR ARCHIVE TAPE DOCUMENTATION

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Space Environment Laboratory
Boulder, Colorado
January 1985

noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION / Environmental Research Laboratories

National Oceanic and Atmospheric Administration
TIROS Satellites and Satellite Meteorology

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UNITED STATES
DEPARTMENT OF COMMERCE

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Secretary

NATIONAL OCEANIC AND
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Environmental Research
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Vernon E. Derr
Director

NOTICE

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TIROS/NOAA Satellites Space Environment Monitor Archive Tape Documentation

V. J. HILL, D. S. EVANS, H. H. SAUER

ABSTRACT. TIROS/NOAA satellite archive tapes containing data obtained with the Medium Energy Proton and Electron Detector (MEPED), High Energy Proton and Alpha Particle Detector (HEPAD), and Total Energy Detector (TED) are described. Descriptions of the data include orbital and housekeeping details and the information needed to decode and understand the data. Specifications of the data channels are supplied, with the timing information needed to convert the data to usable information. Description of the archive tape format gives the information needed to read the tape and unpack the data. Appendices supply the retrieval routines used by the Space Environment Services Center in Boulder.

1.0 INTRODUCTION

The TIROS/NOAA (Television and Infrared Observation Satellite / National Oceanic and Atmospheric Administration) satellites carry a set of instruments to detect and monitor the influx of ions and electrons into the upper atmosphere as a result of solar and magnetospheric activity. The set instruments is called the Space Environment Monitor (SEM). SEM data are received in near-real time at the Space Environment Services Center (SESC) of the Space Environment Laboratory in Boulder, Colorado. The data are used operationally by SESC and are also archived on magnetic tape. Tape copies can be obtained from the Laboratory:

National Oceanic & Atmospheric Administration
Space Environment Laboratory R/E/SE
325 Broadway
Boulder, CO 80303 U.S.A.

The TIROS/NOAA archive tapes contain orbital and housekeeping information, and data from the three SEM instruments:

(1) The MEPED - Medium Energy Proton and Electron Detector

(2) The HEPAD - High Energy Proton and Alpha Particle Detector

(3) The TED - Total Energy Detector

Four TIROS/NOAA satellites have been launched, and three more spacecraft are scheduled in the series. The lifetime of each satellite is about 2 years; at most, two satellites are operational at any time. Figure 1.1 shows the location of the SEM instruments on the spacecraft.

Archive tapes are available for the following periods:

TIROS-N	2 November 1978	through	27 February 1980
NOAA-6	28 June 1979	through	10 May 1983
and	01 July 1984	through	Current
NOAA-7	11 July 1981	through	Current
	(MEPED and HEPAD turned off 1 April 1982)		
NOAA-8	1 May 1983	through	12 June 1984
	(No HEPAD instrument on NOAA-8)		

Archive tapes are created within two weeks of real-time. The launch of NOAA-9 is scheduled in 1985 to replace NOAA-6, which was reactivated after NOAA-8 failed in June of 1984.

This document is designed to assist the user in reading and decoding the archive tapes and also in understanding the information contained in the SEM data. It includes descriptions of the instruments and detailed specifications of the data channels, with timing information. These specifications are necessary to convert the data to usable information. The descriptions of the SEM instruments were written by the primary investigators. For more information about the instruments, data, current uses, and published papers contact Dr. D. S. Evans (about the TED) or Dr. H. H. Sauer (about the MEPED and HEPAD) at this address: National Oceanic & Atmospheric Administration, Space Environment Laboratory R/E/SE, 325 Broadway, Boulder CO 80303.

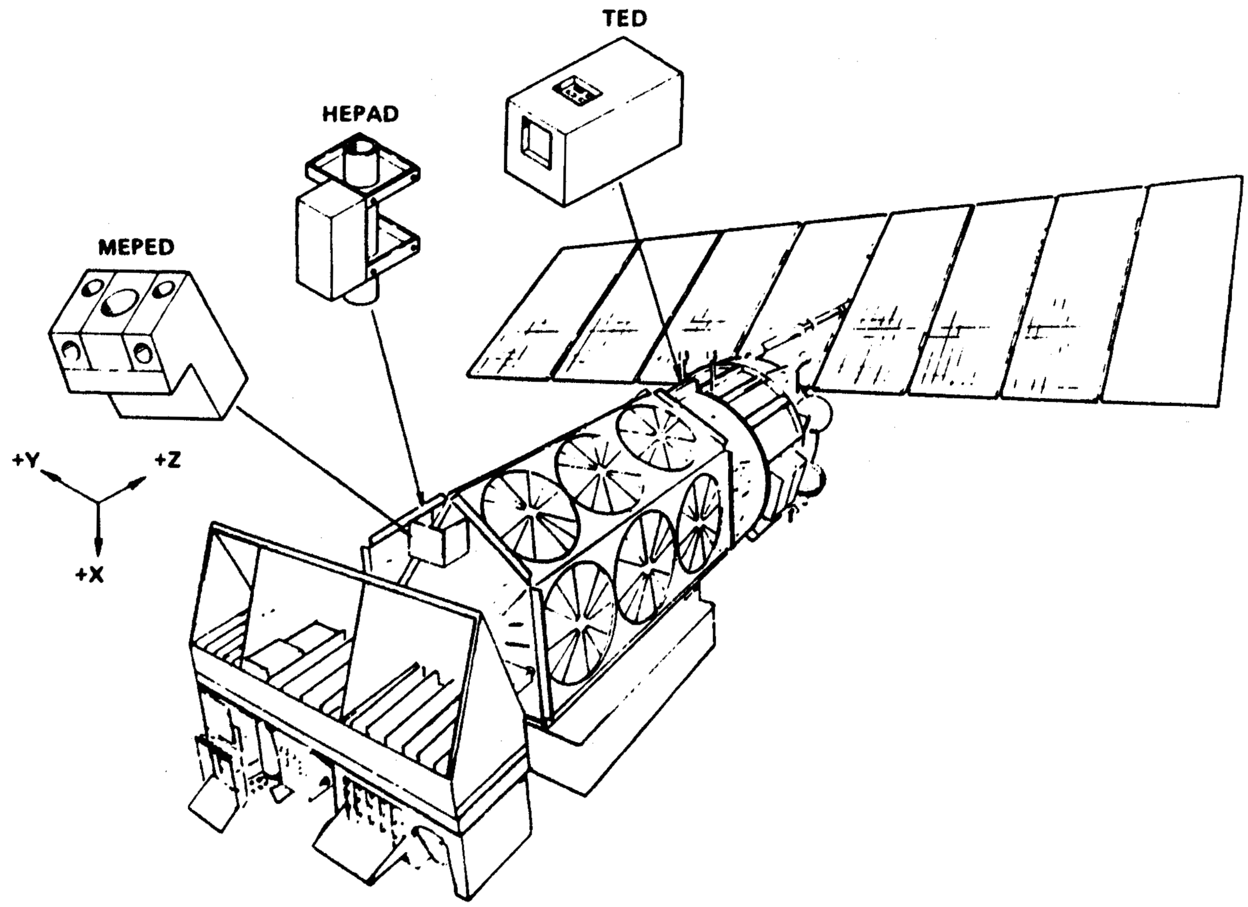


Figure 1.1 SEM Instruments on TIROS/NOAA Spacecraft

2.0 DESCRIPTION OF THE MEPED INSTRUMENT

The MEPED (Medium Energy Proton and Electron Detector) is that portion of the SEM designed to measure the flux of protons (ions) and electrons mirroring above, and precipitating into, the high latitude ionosphere. Each MEPED consists of two sensor subassemblies, the directional particle detectors and the omnidirectional proton detectors.

The directional particle detectors are mounted in two pairs, one of each pair detecting electrons, the other detecting protons (and heavier ions having energies greater than 6 MeV). One pair of detectors is mounted to view outward along the Earth-satellite radial vector. At geomagnetic latitudes greater than 30 deg these detectors view charged particles that are in the atmospheric loss cone and will enter the atmosphere. The other detector pair is mounted to view at about 80 deg to the first and, for magnetic latitudes greater than 30 deg, will measure particles that have pitch angles near 90 deg, i.e., particles that are outside the loss cone and are trapped. The estimated local pitch angles of the particles observed by these two pairs of directional detectors at any point in the orbit are calculated using a model magnetic field and are inserted into the archive tape header record.

The electron detector within each directional pair is a thin (1700 μm) 25 mm^2 solid state detector covered by a 50-μm-thick nickel foil (60 μm in the case of TIROS-N), which suppresses detector response to photons and reduces pulse pile-up caused by incident low energy electrons or protons. Electronic pulse height discrimination is used to select pulses due to incident electrons of nominal energies greater than 30 keV, 100 keV, and 300 keV (taking into account a nominal 5-keV energy loss as the electron passes through the foil). An electronic anticoincidence for detector pulses corresponding to energy losses of more than 1 MeV in the detector serves to eliminate any contamination of the detector response due to energetic protons. The electron detectors are sensitive to protons between about 135 keV and 1 MeV. Data from the directional proton detectors may be used to correct for this effect.

The proton detector within each directional detector pair is a two-element solid state detector telescope. The front element has an effective area of 25 mm^2 and thickness of 200 μm; the back element has an effective area of 50 mm^2 and a thickness of 200 μm also. A 2500-gauss magnet is mounted across the input aperture of this detector assembly to prevent any electrons of energies less than 1.5 MeV from reaching the detectors. The front face of the front detector of the telescope is coated with an aluminum layer 18 $\mu g\ cm^{-2}$ thick, which serves both as one electrical contact and to suppress the detector's sensitivity to photons.

Electronic pulse height discrimination, together with coincidence logic on the pulses from the two detectors in the telescope, is used to select protons in four energy passbands (nominally 30-80 keV, 80-250 keV, 250-800 keV, and 800-2500 keV) and an integral channel for energies greater than 2.5 MeV. A second set of pulse logic isolates events due to ions (Z>2) of energies between 6 MeV and 55 MeV.

The geometric factor for both the electron and proton directional detector systems is $9.5 \times 10^{-3}\ cm^{-2}\ ster^{-1}$. Table 2.1 lists the nominal energy ranges for the MEPED Detectors.

Table 2.1 MEPED detector energy ranges

Data channel	Energy Range 90-deg detector			0-deg detector		
Proton Telescope Passbands						
I	6 -	55	MeV	6 -	55	Mev
P1	30 -	80	keV	30 -	80	keV
P2	80 -	250	keV	80 -	250	keV
P3	250 -	800	keV	250 -	800	keV
P4	800 -	2,500	keV	800 -	2,500	keV
P5		> 2,500	keV		> 2,500	keV
Electron Detector Passbands						
E1		> 30	keV		> 30	keV
E2		> 100	keV		> 100	keV
E3		> 300	keV		> 300	keV

The omnidirectional sensors comprise three nominally identical Kevex Si(Li) solid state detectors of 0.50 cm^2 area by 3 mm thickness, independently mounted under spherical shell moderators. Each detector has a full-opening viewing angle of 120 deg in the zenithal direction. The omnidirectional flux is defined as the flux through a unit cross section sphere: Flux = Counts/omnidirectional geometric factor.

Table 2.2 MEPED omnidirectional sensors

Data channel	Energy response	Approx area cm^2 solid ang ster		Omnidirectional geometric factor	Moderator Material	Thickness
P6	16 - 80 MeV	0.5	(2π)	.09375 cm^2	Aluminum	.050 in
	80 - 215 MeV	0.43	(4π)	.215 cm^2		
P7	36 - 80 MeV	0.5	(2π)	.09375 cm^2	Copper	.230 in
	80 - 215 MeV	0.43	(4π)	.215 cm^2		
P8	80 - 215 MeV	0.43	(4π)	.215 cm^2	Mallory	.086 in

The equality of the secondary energy responses of channels P6 and P7 is a reflection of the design decision to have the out-of-aperture response of the three omnidirectional sensors equal. This allows correction through subtraction of the P8 channel output from the primary channel response from P6 and P7.

3.0 DESCRIPTION OF THE HEPAD INSTRUMENT

The HEPAD (High Energy Proton and Alpha Detector) senses the intensity in the local zenith direction of ambient solar protons above 370 MeV in four energy bands and of ambient solar alpha particles above 640 MeV/nucleon in two energy bands. Three detectors are employed in a telescope configuration--two solid state detectors defining the telescope acceptance aperture, and a Cerenkow radiator/PMT performing the energy analysis for events producing a triple coincidence in the three detectors.

In-flight calibrations permit the energy band boundaries to be established to better than ±20%:

(1) Large characteristic spectrum

$$J(>P) = 2 \times 10^4 \sqrt{e^{-P/200}}$$

where: $P = (E^2 + 1876E)^{1/2}$

(2) Electron background

$$dJ/dE = 4 \times 10^3 \sqrt{E^{-3.3}} \quad \text{electrons cm}^{-2}\ \text{s}^{-1}\ \text{ster}^{-1}\ \text{MeV}^{-1}$$

where: E represents particle energy in MeV.

The geometric factor of the telescope acceptance aperture is about 0.9 cm^2 $ster^{-1}$ with a half-angle field of view of about 24 deg. Spectral intensity data are supplied at a rate of one sample every 4 seconds. The electronic circuit logic establishes the detector response as given in Table 3.1.

Table 3.1 HEPAD detector outputs

Data Channel	Nominal output			Count accumulation interval	Nominal max. random rates (pps)
P1	Protons	370-490	MeV	4 s	620
P2	Protons	490-620	Mev	4 s	420
P3	Protons	620-850	MeV	4 s	260
P4	Protons	>850	MeV	4 s	260
alpha 1	Alphas	600-875	MeV/nucleon	4 s	80
alpha 2	Alphas	>875	MeV/nucleon	4 s	85
S1	1SSD	#1 Singles LS #9		94 ms	1.8×10^5
S2	1SSD	#2 Singles LS #7		94 ms	1.6×10^5
S3	1PMT	Singles LS #1		94 ms	5.6×10^4
S4	1PMT	Gain monitor LS #4		2.5 s	2.0×10^3
S5	1SSD	#1,#2 Double coincidence		1.2 s	2.0×10^4

Data channels S1-S3 identify events exceeding the most sensitive pulse height discriminator (LS) thresholds associated with the two SSDs and the PMT; channel S5 identifies time coincident events in the two SSDs that exceed these thresholds. Channel S4 identifies PMT events produced by the IFC radioactive source that exceed the fourth PMT LS threshold.

Figure 3.1 shows a plan view of the telescope assembly. Two surface barrier silicon detectors D1 and D2 (area 3 cm^2, thickness 500 μm, totally depleted) define an acceptance aperture of about 24 deg half-angle or geometric factor about 0.9 cm^2 $ster^{-1}$. All linear trajectories passing through these detectors also pass through the conical fused silica radiator (special PMT faceplate), which has an average thickness of about 17 mm. For an isotropic environment, the probability distribution of pathlengths in the conical radiator has a mean value 1.05 times the axial thickness of 14 mm, so that the average Cerenkov radiation amplitude should correspond to traversal of about 18 mm of silica. Silica is employed as the radiator to provide the desired proton energy threshold (about 320 MeV) and to allow efficient transmission of the shorter wavelengths of the Cerenkov light (cutoff about 1900 Å). Most of the area of the radiator's conical surface is bare to allow total internal reflection of incident Cerenkov light from all trajectories within the acceptance cone. Assuming an average quantum efficiency of 18% and full light collection efficiency within the 2000-4500 Å interval, 225 photoelectrons should be produced by axial protons of β=1.

Mallory metal (high-Z) is employed to shield the detectors against bremsstrahlung generated by ambient electrons (thickness is one absorption length for E<350 keV). Similarly, an aluminum moderator (low-Z) is employed to shield these detectors against ambient electrons and protons and to suppress the bremsstrahlung radiated by the stopping electrons. Within the out-of-aperture solid angle, the moderator will stop protons of <80 MeV and electrons of <7 MeV. For in-aperture directions, the shielding is effective against protons of <65 MeV and electrons of <4 MeV and will absorb about 15 MeV from a 370-MeV proton. Shielding of the detectors from "upward"-entering protons of E<90 MeV is supplied by the silica radiator and the magnetic shield, lead shield, and aluminum shell surrounding the PMT.

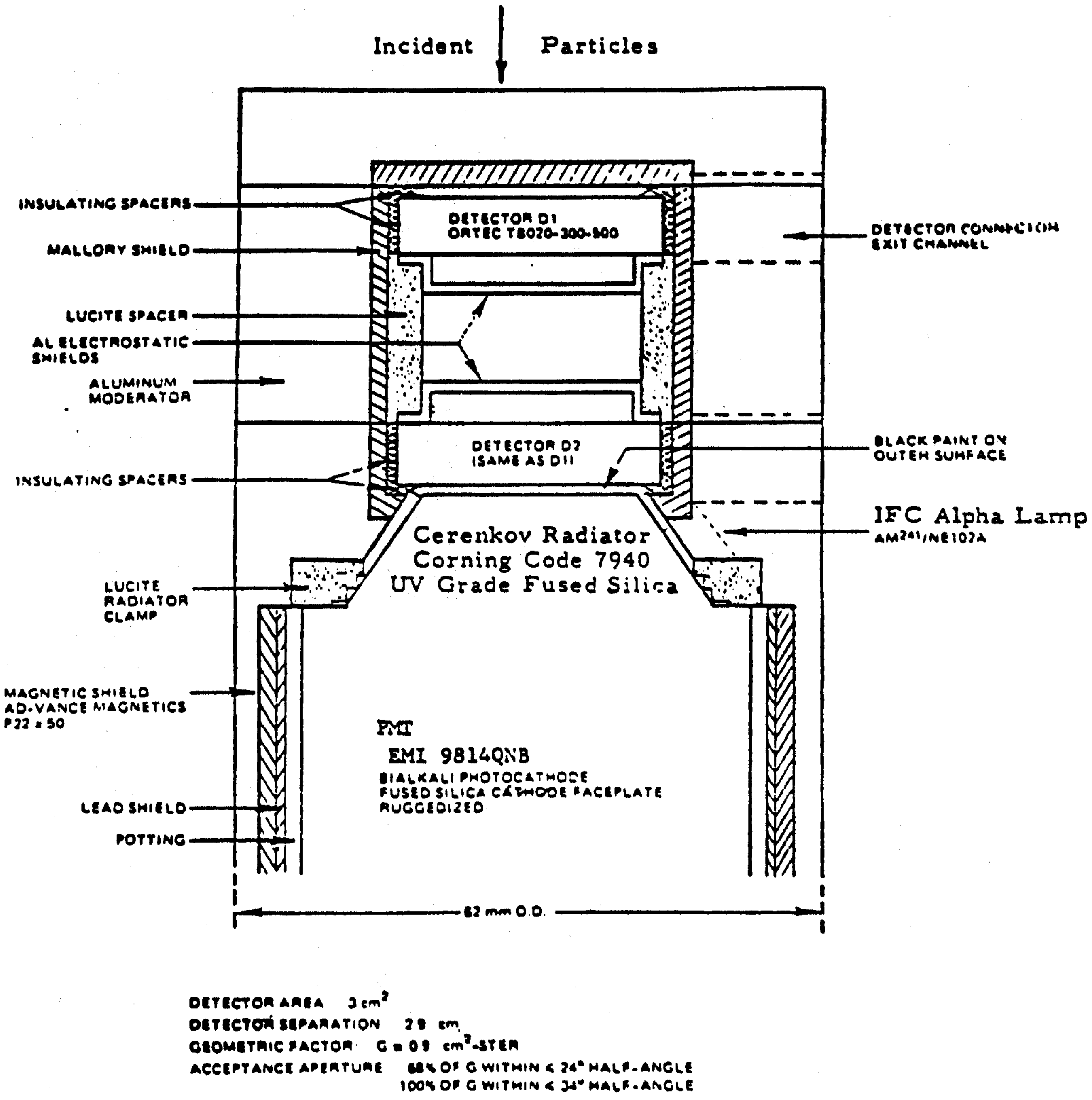


Figure 3.1 HEPAD telescope assembly.

4.0 DESCRIPTION OF THE TED INSTRUMENT

The TED (Total Energy Detector) measures the total energy flux carried into the atmosphere by charged particles of auroral energies.

Two separate electrostatic-analyzer charged-particle detector systems were included on TIROS/NOAA. The two systems view charged particles coming from different directions so that observations can be made of the directional energy flux at two different angles to the local geomagnetic field direction. One of these detectors views outward, parallel to the Earth center radial vector, so that it measures charged particles whose velocities are toward the Earth along this radial vector. The other detector views at an angle of 30 deg to the first. In this documentation, data from the first detector are tagged with the prefix 0 and data from the second with the prefix 30. It is stressed that these two angles are defined with respect to the Earth center-satellite vector and have nothing to do with the pitch angle α associated with the charged particles being measured.

Each of the two particle detector systems alternates between measuring electrons and measuring protons. The time taken for a full cycle is 2 seconds. During the first half cycle (1 s) both instruments are devoted to measuring electrons. The 1-s period is divided into 13 equal segments. During the first 1/13-s a background measurement is taken; during the final 1/13 second the instrument undergoes a reset sequence during which no data are taken. During the center 11/13 seconds the analyzers are swept, effectively linearly with time, from an energy of 300 eV to an energy of 20,000 eV. The total number of counts accumulated by the detector during this sweep is telemetreed to the ground as a measure of the integrated (from 300 eV to 20,000 eV) directional energy flux carried by the electrons observed by that particular detector. During the second half of the cycle the process is repeated for protons.

4.1 Terminology

0 E-FD and 30 E-FD - The total number of counts accumulated during an electron sweep on the 0- and 30-deg detectors. These numbers are linearly related to the directional energy flux carried by electrons between 300 eV and 20,000 eV.

0 P-FD and 30 P-FD - The corresponding total accumulated counts for the 0- and 30-deg detectors during the proton phase of the sweep.

The four data points (0 E-FD, 30 E-FD, 0 P-FD, and 30 P-FD) are regarded as the prime data from the TED instrument and are transmitted continuously every 2 seconds (about 15 km of spacecraft travel).

The TIROS/NOAA instrument also telemeters data points that are related to the directional energy fluxes associated with electrons or ions having energies within selected, narrow energy bands. Thus, an estimate can be made of what energy particles are carrying the bulk of the energy flow and at what altitude in the atmosphere this energy will ultimately be deposited.

The maximum number of counts accumulated in a single 1/13-s subinterval during a given sweep of a given detector system and the corresponding energy band number are transmitted every 2 seconds from both detectors for both particle species. These data represent both the energy band containing the most energy flux and the value of that directional energy flux:

Ø DE-M, 3Ø DE-M, Ø DP-M, 3Ø DP-M - The maximum number of counts

Ø E-M, 3Ø E-M, Ø P-M, 3Ø P-M - The corresponding interval number.

During the full energy sweep from 3ØØ eV to 2Ø,ØØØ eV, which takes 11/13 second, the number of detector counts are accumulated during each successive 1/13-s interval, giving 11 data points from each detector during an energy sweep. Because there are two detector systems, each studying two particle species, four data channel sets are generated every 2 seconds. However, only six values are telemetered for each full energy sweep from a single data channel; and each channel is sampled once every fourth sweep. The first four values are the number of counts accumulated during the first, third, fifth, and seventh accumulation intervals. The fifth is the number of counts accumulated during the greatest interval, and the sixth is the interval in which the maximum counts were accumulated. Data channel terminology refers to the detector (Ø or 3Ø), the particle species (E or P), the energy band number (1, 3, 5, or 7), and the maximum energy band (M = 1 to 11).

<u>Transmission</u>	<u>sequence:</u>
first 2 s	Ø DE-1, Ø DE-3, Ø DE-5, Ø DE-7, Ø DE-M and Ø E-M
next 2 s	3Ø DE-1, 3Ø DE-3, 3Ø DE-5, 3Ø DE-7, 3Ø DE-M and 3Ø E-M
next 2 s	Ø DP-1, Ø DP-3, Ø DP-5, Ø DP-7, Ø DP-M and Ø P-M
last 2 s	3Ø DP-1, 3Ø DP-3, 3Ø DP-5, 3Ø DP-7, 3Ø DP-M and 3Ø P-M

Background data are also included as a quality check on the operation of the instrument. The counts registered by the detectors during the first 1/13 second (background phase) of each sweep are accumulated for 16 sweeps - a total of 1.23 s. The accumulated counts are transmitted once each 32 seconds in place of the normal transmission of Ø DE-1, Ø DE-3, Ø DE-5, Ø DE-7. These numbers are generally less than 5Ø and, should they exceed 2ØØ, possible detector malfunctions ought to be considered.

4.2 Conversion

There are two physical interpretations of the counts accumulated during a single subinterval of the energy sweep. The first relates this number to the directional energy flux within the limited energy range swept by the detector in the 1/13-s subinterval. By dividing the directional energy flux by the width of the energy band sampled, the directional differential energy flux at the center energy of the band may be obtained.

Following is the conversion between the telemetered values and the corresponding directional energy flux in physical units. The difference between electron and proton conversion reflects a difference between detection efficiencies of the two particle species:

Directional energy flux (ergs cm^{-2} s^{-1} $ster^{-1}$) =
For electrons: $1.9Ø5 \times 1Ø^{-3}$ x (Ø E-FD or 3Ø E-FD)
For protons: $1.5Ø \times 1Ø^{-3}$ x (Ø P-FD or 3Ø P-FD)

A data point can be multiplied by the following conversion factors to convert from counts to differential directional energy flux:

Differential directional energy flux (ergs cm^{-2} s^{-1} $ster^{-1}$ eV^{-1}) at the center energy =

For Electrons 3.78×10^{-7} (for all energy bands)
For Protons 2.97×10^{-7} (for all energy bands)

Table 4.1 lists the details of each of the energy bands and gives the multiplying constants required to convert the raw data point to a physical quantity. Table 4.2 lists the altitudes in the atmosphere where electrons within each band will deposit their energy.

Table 4.1 TED energy bands

Energy band number	Edges of band (eV)	Center energy (eV)	Conversion from counts to directional energy flux (ergs cm^{-2} s^{-1} $ster^{-1}$)	
			Electrons	Protons
1	300 - 458	379	5.97×10^{-5}	4.69×10^{-5}
2	458 - 773	616	1.19×10^{-4}	9.38×10^{-5}
3	773 - 1088	931	1.19×10^{-4}	9.38×10^{-5}
4	1088 - 1718	1403	2.38×10^{-4}	1.88×10^{-4}
5	1718 - 2349	2033	2.38×10^{-4}	1.88×10^{-4}
6	2349 - 3610	2979	4.76×10^{-4}	3.75×10^{-4}
7	3610 - 4870	4250	4.76×10^{-4}	3.75×10^{-4}
8	4870 - 7392	6131	9.52×10^{-4}	7.50×10^{-4}
9	7392 - 9914	8653	9.52×10^{-4}	7.50×10^{-4}
10	9914 - 14957	12436	1.90×10^{-3}	1.50×10^{-3}
11	14957 - 20000	17479	1.90×10^{-3}	1.50×10^{-3}

Table 4.2 TED - altitudes of energy deposition

Energy band number	Edges of band (eV)	Altitude at which energy will be deposited (km)
1	300 - 458	>300
2	458 - 773	215
3	773 - 1088	190
4	1088 - 1718	165
5	1718 - 2349	145
6	2349 - 3610	130
7	3610 - 4870	120
8	4870 - 7392	115
9	7392 - 9914	108
10	9914 - 14957	105
11	14957 - 20000	104

The physical parameters listed in Tables 4.1 and 4.2 are measured at the satellite at 850 km altitude. These measured values must be manipulated, together with a geomagnetic field model, to obtain the truly relevant parameter: the magnitude of the energy flow into the atmosphere and the location at which this energy input is occurring.

Figure 4.1 illustrates this situation. The charged particles measured at the satellite are guided along the magnetic field lines. Because these magnetic lines of force are not radially outward, the point at which the field line that passses through the satellite actually intersects the atmosphere may be displaced considerably from the subsatellite point. In the TIROS/NOAA data processing, a magnetic field model is used to trace the field line passing through the satellite to the point where the field line intersects the atmosphere at 120 km (Foot Of the Field Line, FOFL). The coordinates of this point, both geographic and geomagnetic, together with the solar time and magnetic time, are calculated and given in the archive tape header records. By convention, if TIROS/NOAA is north of the geomagnetic equator, the FOFL is taken to be in the Northern Hemisphere. Otherwise the foot of the field line is in the Southern Hemisphere.

The angles between the geomagnetic field direction and the look direction of the two detector systems are also computed using the same geomagnetic field model. These two angles are the local pitch angles of the charged particles being studied by the two detectors. However, because of the "magnetic mirror effect" on the motion of charged particles, the pitch angles these particles have at the location of the satellite are not the same pitch angles the particles would have at the top of the atmosphere. The relation between the two pitch angles is

$$\sin \alpha_{120} = \sqrt{\frac{B_{120}}{B_{850}}} \sin \alpha_{850}$$

where

α_{850} = particle's pitch angle at the TIROS/NOAA spacecraft

α_{120} = particle's pitch angle at the FOFL

B_{850} = geomagnetic field strength at the TIROS/NOAA spacecraft

B_{120} = geomagnetic field strength at the FOFL

Figure 4.2 illustrates how the pitch angle of a charged particle varies as it moves along the geomagnetic field line between TIROS/NOAA and the atmosphere. Note that convention defines a particle's velocity vector and the direction of the magnetic field. This means that in the Northern Hemisphere charged particles moving downward toward the atmosphere have pitch angles between 0 and 90 deg. In the Southern Hemisphere charged particles moving toward the atmosphere have pitch angles between 90 and 180 deg.

Note also that it is possible for the $\sin \alpha_{120}$ to exceed 1.0. Physically, this occurs when the charged particles measured going downward toward the atmosphere at TIROS/NOAA in fact magnetically mirror before reaching the atmosphere and return back up the magnetic field line. Such particles cannot be counted as contributing to the energy influx into the Earth's atmosphere.

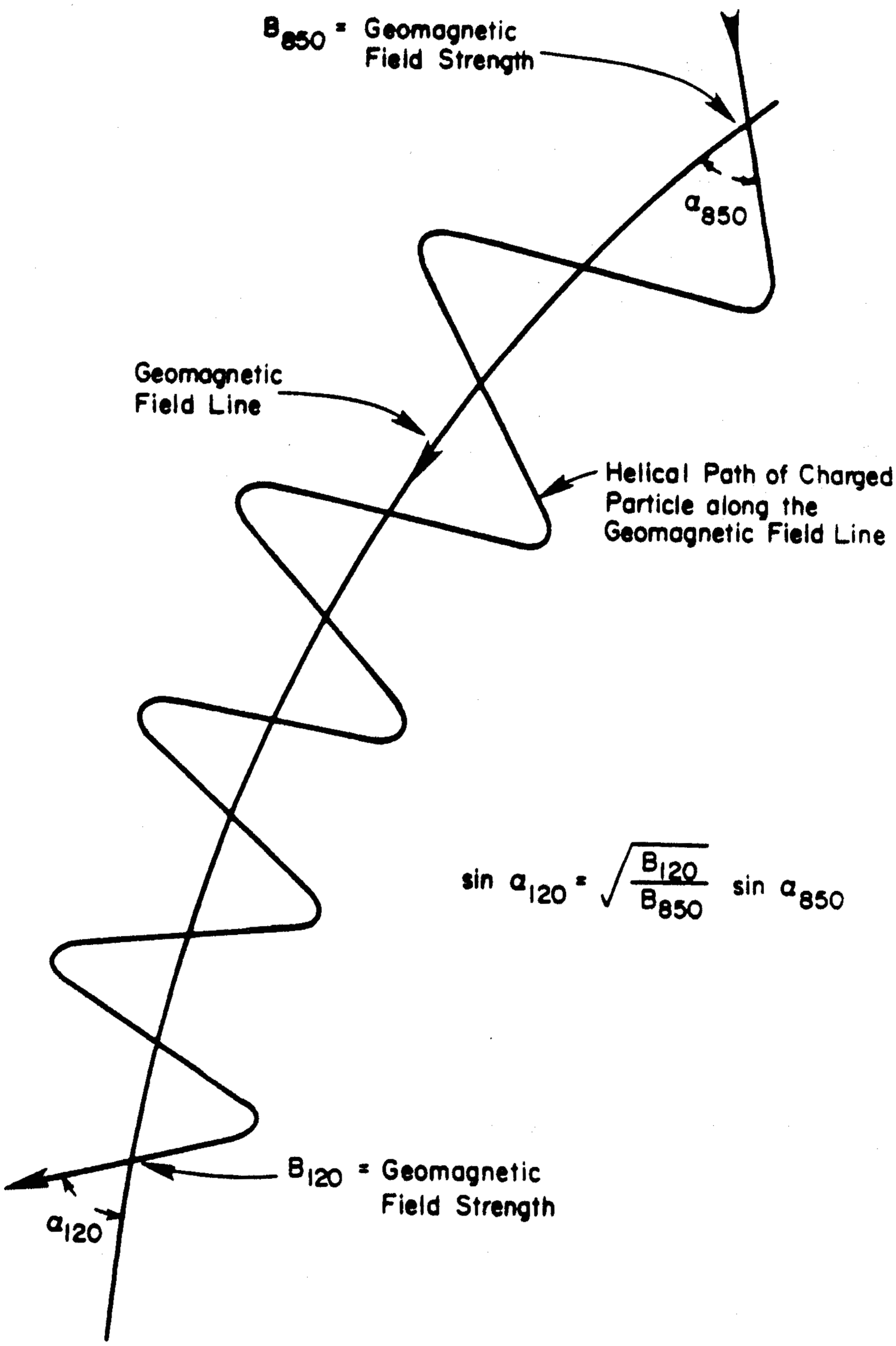
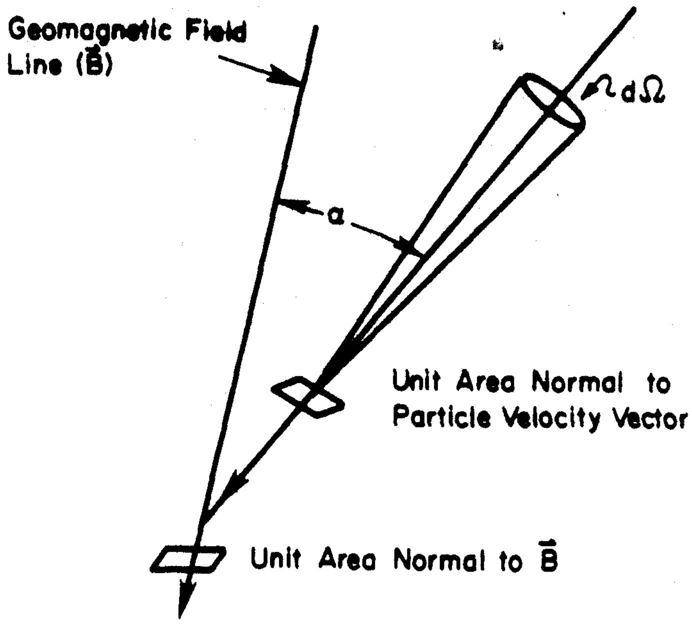


Figure 4.1 Path of charged particles along the geomagnetic field line.



$j(E,\alpha)$ = Particle Differential Directional Number Flux

$E(E,\alpha) = j(E,\alpha)E$ = Particle Differential Direction Energy Flux

$E_D(\alpha) = \int_0^\infty j(E,\alpha)\,EdE$ = Particle Directional Energy Flux

$E_T = 2\pi \int_0^{\pi/2} E_D(\alpha) \sin\alpha \cos\alpha\, d\alpha$ = Particle Total Energy Flux (Evaluated at top of atmosphere)

Figure 4.2 Evaluation of particle Total Energy Flux.

In the course of data processing, all parameters concerning the geomagnetic field are computed once each 8 seconds and given in the header format. These parameters are included:

(1) The three vector components of the geomagnetic field at TIROS/NOAA together with the scalar magnitude of the field.

(2) The geographic location where the geomagnetic flux tube that threads TIROS/NOAA intersects the top of the atmosphere at 120 km.

(3) The geomagnetic coordinates of the FOFL and the local solar and geomagnetic times of the FOFL.

(4) The three-vector components of the geomagnetic field at the FOFL together with the scalar magnitude of the field.

(5) The pitch angles of those charged particles being observed by the two TED detector systems as transformed to the FOFL.

By using the measurements of 0 E-FD, 30 E-FD, 0 P-FD, and 30 P-FD, together with the pitch angles at which the measurements were made (as transformed to 120 km), the quantity

$$E_T = 2\pi \int_0^{\pi/2} E_D(\alpha) \sin\alpha \cos\alpha \, d\alpha$$

may be evaluated independently for both electrons and ions. The sum of these two is converted to physical units (milli-ergs cm^{-2} s^{-1}) and becomes the "Total Energy" value given in the TED format.

If neither of the two detectors is viewing charged particles that reach the Earth's atmosphere, then the value of the Total Energy is set to 0. However, the actual values of 0 E-FD, 30 E-FD, 0 P-FD, and 30 P-FD remain available in the output record. The situation in which neither detector views charged particles that can reach the atmosphere is confined to measurements made at rather low geographic latitudes where any energy flow into the atmosphere is expected to be small in any case.

The TED detector system was originally designed to be operated in any one of three different modes in order to compensate for possible detector failures. However, the instrument has thus far proved reliable so there is a policy that the TED instrument is operated only in its normal mode.

Finally, when these data are being analyzed, care should be taken in treating total energy flux values that exceed 100 ergs cm^{-2} s^{-1}. Experience has shown that a high percentage (about 50%) of such data points are in fact associated with telemetry noise and do not represent valid observations.

5.Ø DATA DESCRIPTIONS

This section specifies the data contained on the archive tapes and gives the timing information necessary to convert the data to usable units. In general the data can be divided into five types of information: Orbital information, Housekeeping information, MEPED data, HEPAD data, and TED data.

Orbital information contains the time of the data record and defines the location and orientation of the spacecraft at that time.

Housekeeping information specifies the status of each individual instrument (ON or OFF) and whether an In-Flight Calibration is in progress. Weekly calibrations of the SEM instruments appear on the archive tapes, and it is the user's responsibility to recognize and discard calibration data.

The MEPED, HEPAD, and TED data descriptions identify the Data Channels, Detectors, Particle Types, and Energy Ranges on each instrument. The descriptions also include the channel name abbreviations used throughout this document and the Record Timing Tables.

The archive tapes consist of short records, each containing 8 seconds of data. The begin time, called TØ, is included on every record. TØ is the time of the orbital and housekeeping information on that record. However, TØ is not the time the MEPED, HEPAD, and TED data channels were sampled. The Record Timing tables (in sections 5.3, 5.4, and 5.6) show the time each data channel began accumulation, relative to TØ. The length of the accumulation period is also included for converting counts per accumulation period into counts per second. An example of the Record Timing Table for the MEPED data is shown below. In this example the MEPED data channels ØE1 to ØE3 are accumulated for 1 second each. The first readings of each of these data channels (MEPED words 8, 9 and 1Ø) began accumulation at time TØ-1 second. The second readings of each data channel (MEPED words 27, 28 and 29) began accumulation at TØ+1 second. The user can determine the exact time a data channel was sampled and convert the value to "counts per second" by referring to the Record Timing Tables.

Table 5.1 Sample record timing table

Word	Data channel	Accumulation period (s)	Accumulation begin time relative to TØ (s)
.	.	.	.
.	.	.	.
8-1Ø	ØE1 to ØE3	1	-1
.	.	.	.
.	.	.	.
27-29	ØE1 to ØE3	1	+1

5.1 Orbital Information

The Orbital Information in each data record gives the time of the record, the location and orientation of the spacecraft, and other values useful in evaluating the instrument data. All Orbital Information is valid for TØ, the begin time of the record. All latitudes, longitudes, pitch angles, local times, and magnetic times are given in degrees. The units of the magnetic field parameters are gammas. Orbital Information includes values from the original raw data and calculated values.

The calculated values, helpful in evaluating the instrument data, are derived by the following method. Magnetic field and FOFL parameters necessary to interpret the charged particle data are calculated from the satellite location using a magnetic field model. The model uses a table look-up and interpolation scheme. The look-up table is a 4-deg-latitude by 4-deg-longitude grid of subsatellite locations. The computation of magnetic parameters for this table was done at the University of Bergen (Aarnes and Lundblad) using the model magnetic field and field line tracing routines developed at the National Space Science Data Center (Stassinopoulos and Mead, 1972). The table was contructed for a single satellite altitude of 87Ø km and, strictly speaking, the table and interpolations are appropriate only for a satellite at that altitude. The TIROS/NOAA satellite are at altitudes ranging from 815 to 85Ø km so that errors are introduced by the procedure. However, at high latitudes, where the charged particle observations are most useful, these errors are not large.

5.1.1 RAW DATA

<u>Satellite ID</u>

Satellite identification:
Ø = zero fill record
1 = TIROS-N
2 = NOAA-6
4 = NOAA-7
6 = NOAA-8

Zero fill records, used to fill out the physical record at the end of the tape, can be uniquely identified when the spacecraft ID is zero.

<u>TØ, begin time of the record</u>

The begin time of the record is defined by the year, day of the year, and milliseconds of the day in Universal Time. Records contain 8 seconds of data, they are ordered by time, there are no duplicate records, and the time difference between records is always a multiple of 8 seconds. All orbital and housekeeping information is valid at TØ.

Receiving station

This is the tracking station that recorded the original raw data as telemetered from the spacecraft. It does not affect or change the archive data in any way.

Station Codes:
0 = unknown
1 = Wallops Island, Virginia
2 = Gillmore Creek, Alaska
3 = Western European Satellites, Spain

Altitude of the satellite

TIROS/NOAA satellites are in near-circular orbits of about 850 km. In calculations for the archive tape involving altitude, 870 km is used for all spacecraft. An accurate altitude for each spacecraft at any time is not recorded, but the nominal altitude for each spacecraft is included on the archive tapes for the user's information.

TIROS-N = 853.5 km
NOAA-6 = 815.5 km
NOAA-7 = 849.2 km
NOAA-8 = 815.5 km

Inclination of the satellite

Like the altitude, the satellite inclination is assumed to be constant. The nominal inclinations are written on the archive tapes for each spacecraft:

TIROS-N = 98.9 deg
NOAA-6 = 98.7 deg
NOAA-7 = 98.9 deg
NOAA-8 = 98.9 deg

Orbit number

The orbit number is a count of the number of times the satellite has orbited the Earth. The orbit number, or revolution number, is incremented when the satellite crosses the Equator from the Southern to the Northern Hemisphere. The period of all spacecraft is approximately 102 minutes. Orbit numbers are based on time and estimated orbital period. They are assigned in Record Type 1.

Record types

On the original raw data tapes each logical record contains 32 seconds of data. To simplify the Archive data records these 32-s records are divided into four 8-s records. The four archive records all contain the same information except for slight differences in MEPED and TED data. These differences are described in Sections 6.3.4 and 6.3.6. In order to check for these difference each archive record contains a "Record Type", a number from 1 to 4 that denotes the records location in the original raw data record.

5.1.2 CALCULATED DATA AT THE SATELLITE

<u>Geographic latitude at the satellite</u>
<u>Geographic east longitude at the satellite</u>

This is the subsatellite geographic latitude and east longitude for time TØ. The subsatellite location is used to calculate all the following information at the satellite and at the FOFL.

<u>BR the radius vector at the satellite, where positive is up</u>
<u>BT the north-south vector at the satellite, where positive is south</u>
<u>BP the east-west vector at the satellite, where positive is east</u>
<u>BB the total field at the satellite</u>

5.1.3 CALCULATED DATA AT THE FOOT OF THE FIELD LINE

The Foot Of the Field Line (FOFL) is the point where the magnetic field line through the satellite crosses 12Ø km altitude. The model used to calculate the magnetic field vector at a given location is also used to trace the magnetic field line through the satellite to an altitude of 12Ø km in the local hemisphere.

<u>Geographic latitude at the FOFL</u>
<u>Geographic east longitude at the FOFL</u>

<u>BR12Ø the radius vector at the FOFL, where positive is up</u>
<u>BT12Ø the north-south vector at the FOFL, where positive is south</u>
<u>BP12Ø the east-west vector at the FOFL, where positive east</u>
<u>BB12Ø the total field at the FOFL</u>

<u>Geomagnetic latitude at the FOFL</u>
<u>Geomagnetic east longitude at the FOFL</u>

The geographic latitude and longitude of the FOFL point is used as the input to a simple transformation to obtain the <u>uncorrected</u> dipole geomagnetic coordinates.

<u>L-value at the FOFL</u>

The L value is also computed, in the model, at the FOFL. If the L value is computed to be $\geq$ 15.ØØ it is considered to be undefined and the value set to Ø.ØØ. This causes no ambiguity because even at the magnetic equator the L value sampled by the satellite is never less than 1.1Ø.

5.1.4 CALCULATED PITCH ANGLES

The pitch angles, with respect to the geomagnetic field, of the particles being sensed by the TED and MEPED detectors are calculated to help the users interpret the data. The pitch angle of the charged particles being sampled by a detector is the angle between the particle's velocity vector and the magnetic field. It is defined with the convention that 0 deg is a particle moving parallel to the magnetic field and 180 deg is a particle moving antiparallel to the magnetic field. The look direction of the detectors, and three components of the magnetic field, together with the location of the satellite, are used to compute the pitch angles of the particles being measured at the satellite.

The calculations for the TED and MEPED detector systems are performed as follows:

TED0 - The pitch angle for the TED 0 deg detector at the FOFL
TED30 - The pitch angle for the TED 30 deg detector at the FOFL

These pitch angles have been transformed to the FOFL. If the particle mirrors above 120 km altitude, the pitch angle is given as 90 deg. The pitch angles assigned to the TED detectors (which view along the Earth-center radial vector and at 30 deg to that direction) are the pitch angles proccessed by the particles and have been transformed from the satellite location to the FOFL to ease the integration over angle required to complete the energy flux into the atmosphere. The magnetic field intensity of the satellite and the magnetic field intensity at 120 km are used to transform the TED particle pitch angles from what they were at the satellite to what they would be at 120 km altitude at the FOFL. This transformation in pitch angles is necessary in order to perform a proper angular integral of the directional energy fluxes measured at the satellite to obtain the energy flux into the atmosphere.

MEPED81 - MEPED 90 deg proton detector pitch angle at the satellite
MEPED83 - MEPED 90 deg electron detector pitch angle at the satellite
MEPED0 - MEPED 0 deg proton and electron detector pitch angle at the satellite

NOTE: MEPED81 and MEPED83 are incorrect when the satellite is NORTHBOUND.

For the MEPED detectors, pitch angles are calculated at the satellite position and are the angle between the detector look direction and the local magnetic field direction, not the angle between the particle velocity direction and the magnetic field. For example, in the Northern Hemisphere the MEPED0 pitch angle is between 90 and 180 deg while the particle's pitch angle is the supplement of this angle. The MEPED 90-deg electron and proton detectors are actually viewing at 83 and 81 deg to the Earth-center radial. The detectors will continue to be designated as the 90-deg detectors. The pitch angle calculations for the 90-deg electron and proton detectors have been performed incorrectly when the satellite is moving NORTHBOUND geographically. The calculations when the satellite is southbound are correct. Although this error is minimum at high geographic latitudes, the error approaches 30 deg at some middle and low latitude locations. Care must be exercised in interpeting these pitch angles when the satellite is NORTHBOUND.

5.1.5 OTHER CALCULATED VALUES

Local time at the satellite
Magnetic local time at the satellite
Program version
Zero fill

The approximate local time at the subsatellite point is computed directly from the universal time TØ and the geographic longitude. Similarily, the eccentric dipole magnetic local time AT THE SUBSATELLITE LOCATION is computed from the subsatellite location, day, and universal time.

The local and magnetic local times are in degrees and can be converted to hours by dividing by 15. The local time at the FOFL can be calculated as follows:

MIN = milliseconds of the day / 3,6ØØ,ØØØ
TIME = MIN + (FOFL geographic longitude in degrees / 15)
If TIME > 24 then TIME = TIME - 24

where TIME is the local time in hours, and TIME multiplied by 15 is the local time in degrees.

The Program Version number will be incremented whenever a change is made in the Archive Tape data or format. It is currently 1.

Three bytes of zero are left for later additions to the orbital information.

5.2 Housekeeping Information

The Housekeeping Information of the archive tapes includes Instrument On/Off flags, In-Flight Calibration (IFC) flags, TED flags, and Detector Housekeeping values. All the flags and values are valid at TØ, the begin time of the record.

Instrument flags

The instrument on/off flags are normally in the "on" state but should always be checked. On occasion, an instrument has been unexplainably commanded "off" and remained so for up to two weeks.

IFC flags

In-Flight Calibrations (IFC) are conducted approximately once per week and they appear on the tapes in the same format as the other data. If the IFC flag is equal to 1 (yes) an IFC is in progress. The IFC flags should be checked on every record and the data discarded when an IFC is in progress. The calibration sequence begins for all instruments at the same time but the MEPED IFC lasts for 576 seconds and the TED/HEPAD for 768 seconds. Sometimes, however, only partial calibrations are on the tape. This happens when the flags are set accidentally by telemetry noise and when data are missing from the archive tape because of telemetry problems.

TED flags

The TED MODE and TELEMETRY FORMAT together show what data are being sampled in the TED experiment. The following configurations are possible, but only the first setting (MODE Ø or 2, FORMAT 1) has been, or is expected to be used.

TED MODE AND TELEMETRY FORMAT DESCRIPTIONS

MODE Ø or 2, FORMAT 1 - normal electrons and protons
MODE 1, FORMAT 1 - electron dwell, no protons
MODE 3, FORMAT 1 - proton dwell, no electrons

For 1Ø4 minutes after an IFC the TED channeltron gain is verified and the gain signal is changed. This does not affect the data but the user can check for this condition in the TED PHD flags. The normal value of the PHD flags is all zeros, any other value means the TED channeltron gain is being verified.

Detector Housekeeping Values

No explanation of the Detector Housekeeping values is included here because they are for SEL's use in evaluating the performance of the instruments. Table 5.2 is a list of the Detector Housekeeping word abbreviations and their meaning.

Table 5.2 Detector Housekeeping word descriptions

Detector word	Description		
1	MPTT	MEPED	proton telescope temperature
2	METT	MEPED	electron telescope temperature
3	MELT	MEPED	electronics temperature
4	OMNI	MEPED	OMNI temperature
5	AMSS	MEPED	detector bias voltage
6	HELT	HEPAD	electronics temperature
7	PMT	HEPAD	photo multiplier tube temperature
8	PMHV	HEPAD	high voltage power supply monitor
9	HSSD	HEPAD	solid state detector bias monitor
10	LVL	HEPAD	level calculated from PMHV and HELT
11	TEPS	TED	electron channeltron power supply monitor
12	TPPS	TED	proton channeltron power supply monitor
13	LVR	TED	low voltage ramp monitor
14	CEA	TED	cylindrical electrostatic analyser power supply monitor
15	TEDT	TED	temperature monitor

5.3 MEPED Data Description

MEPED data channels are directional measurements, at 0 and 90 deg (with respect to the local zenith) of protons, electrons and nominally omnidirectional measurements of protons. Channels I(positive Z $\geq$ 2 ions), E1 to E3, and P1 to P5 are read at 0 and 90 deg; P6, P7, and P8 are omnidirectional.

Table 5.3 MEPED data channels

MEPED word	data channel	Detector	Particle type	Nominal energy range KeV
1	0I	0 deg Ions	Pos. (Z≥2) Ions	6,000 - 55,000
2	90I	90 deg Ions	Pos. (Z≥2) Ions	6,000 - 55,000
3	0P1	0 deg Proton	Protons	30 - 80
4	0P2	0 deg Proton	Protons	80 - 250
5	0P3	0 deg Proton	Protons	250 - 800
6	0P4	0 deg Proton	Protons	800 - 2,500
7	0P5	0 deg Proton	Protons	>2,500
8	0E1	0 deg Electron	Electrons	>30
9	0E2	0 deg Electron	Electrons	>100
10	0E3	0 deg Electron	Electrons	>300
11	90P1	90 deg Proton	Protons	30 - 80
12	90P2	90 deg Proton	Protons	80 - 250
13	90P3	90 deg Proton	Protons	250 - 800
14	90P4	90 deg Proton	Protons	800 - 2,500
15	90P5	90 deg Proton	Protons	>2,500
16	90E1	90 deg Electron	Electrons	>30
17	90E2	90 deg Electron	Electrons	>100
18	90E3	90 deg Electron	Electrons	>300
19	P6	Omnidirectional Proton	Protons	16 - 80 MeV 80 - 215 MeV
20	P7	Omnidirectional Proton	Protons	36 - 80 MeV 80 - 215 MeV
21	P8	Omnidirectioanl Proton	Protons	80 - 215 MeV

The MEPED consists of four sensor systems, two of which view at 0 deg and two of which view at 90 deg, with respect to the local zenith. Each pair of sensors consists of a proton telescope and a thin solid state electron detector. Each proton telescope measures ions in channels P1 through P5 over the range 30 keV to >2,500 keV. Channel I is sensitive to Z $\geq$ 2 ions in the range 6 MeV through 55 MeV. The proton telescope also measures nominally omnidirectional protons. The geometric factor for both the proton telescope and electron detector is 9.5×10^{-3} cm^2 ster.

On the MEPED each data channel is sampled four times every 8 seconds, except for the 0 I and 90 I channels which are sampled only once every 16 seconds. The record timing information for the MEPED is shown in table 5.4.

Table 5.4 MEPED data - record timing

MEPED word	Data channel	Accumulation period (s)	Accumulation begin time relative to T0 (s)
1	0 I	16	-16
2	90 I	16	-16
3- 7	0P1 to 0P5	1	-1
8-10	0E1 to 0E3	1	-1
11-15	90P1 to 90P5	1	+0
16-18	90E1 to 90E3	1	+0
19-21	P6 to P8	2	-2
22-26	0P1 to 0P5	1	+1
27-29	0E1 to 0E3	1	+1
30-34	90P1 to 90P5	1	+2
35-37	90E1 to 90E3	1	+3
38-40	P6 to P8	2	+0
41-45	0P1 to 0P5	1	+3
46-48	0E1 to 0E3	1	+3
49-53	90P1 to 90P5	1	+4
54-56	90E1 to 90E3	1	+5
57-59	P6 to P8	2	+2
60-64	0P1 to 0P5	1	+5
65-67	0E1 to 0E3	1	+5
68-72	90P1 to 90P5	1	+6
73-75	90E1 to 90E3	1	+6
76-78	P6 to P8	2	+4

5.4 HEPED data description

The HEPAD data channels are shown in table 5.5. For a description of the instrument see Section 3.

Table 5.5 HEPAD data channels

HEPAD word	Data channel	Detector	Particle type	Energy range
1	P1	Proton	Protons	370 - 480 MeV
2	P2	Proton	Protons	480 - 640 MeV
3	P3	Proton	Protons	640 - 850 MeV
4	P4	Proton	Protons	>850 MeV
5	alpha 1		Alphas	640 - 850 MeV/Nucleon
6	alpha 2		Alphas	>850 MeV/Nucleon
7	S5			SSD D1-D2 Double Coincidences
8	S4			PMT Gain Montior
9	S1			SSD D1 Singles
10	S2			SSD D2 Singles
11	S3			LSI (PMT Anode) Singles

The HEPAD data channels are read out every 4 seconds therefore, there are two values for each channel in every 8-s data record.

Table 5.6 HEPAD data - record timing

HEPAD word	Data channel	Accumulation period (s)	Accumulation begin time relative to TØ (s)
1	P1	4.Ø	-4.Ø
2	P2	4.Ø	-4.Ø
3	P3	4.Ø	-4.Ø
4	P4	4.Ø	-4.Ø
5	alpha 1	4.Ø	-4.Ø
6	alpha 2	4.Ø	-4.Ø
7	S5	1.2	-1.2
8	S4	2.5	+Ø.Ø
9	S1	Ø.1	+2.5
1Ø	S2	Ø.1	+2.6
11	S3	Ø.1	+2.7
12	P1	4.Ø	+Ø.Ø
13	P2	4.Ø	+Ø.Ø
14	P3	4.Ø	+Ø.Ø
15	P4	4.Ø	+Ø.Ø
16	alpha 1	4.Ø	+Ø.Ø
17	alpha 2	4.Ø	+Ø.Ø
18	S5	1.2	+3.2
19	S4	2.5	+4.Ø
2Ø	S1	Ø.1	+6.5
21	S2	Ø.1	+6.6
22	S3	Ø.1	+6.7

5.5 TED Data Description

The TED instrument and it's data channels are described in Section 4. The TED data in each 8-s data record contains values from four different detectors, each sampled once every 2 seconds. Table 5.7 decribes the data channels for each detector. Table 5.8 shows the sequencing of the data values, as they appear on the archive tape, and the record timing information.

Table 5.7 TED data channels

Data channel	Detector	Energy flux	Energy interval during which counts accumulated
ØDE-1	Ø deg electron	differential directional energy flux	1st interval
ØDE-3	Ø deg electron	"	3rd interval
ØDE-5	Ø deg electron	"	5th interval
ØDE-7	Ø deg electron	"	7th interval
ØDE-M	Ø deg electron	"	maximum interval
ØE-M		interval maximum counts were accumulated	
ØEF-D	Ø deg electron	directional energy flux	all intervals
3ØDE-1	3Ø deg electron	differential directional energy flux	1st interval
3ØDE-3	3Ø deg electron	"	3rd interval
3ØDE-5	3Ø deg electron	"	5th interval
3ØDE-7	3Ø deg electron	"	7th interval
3ØDE-M	3Ø deg electron	"	maximum interval
3ØE-M		interval maximum counts were accumulated	
3ØEF-D	3Ø deg electron	directional energy flux	all intervals
ØDP-1	Ø deg proton	differential directional energy flux	1st interval
ØDP-3	Ø deg proton	"	3rd interval
ØDP-5	Ø deg proton	"	5th interval
ØDP-7	Ø deg proton	"	7th interval
ØDP-M	Ø deg proton	"	maximum interval
ØP- M		interval maximum counts were accumulated	
ØPF-D	Ø deg proton	directional energy flux	all intervals
3ØDP-1	3Ø deg proton	differential directional energy flux	1st interval
3ØDP-3	3Ø deg proton	"	3rd interval
3ØDP-5	3Ø deg proton	"	5th interval
3ØDP-7	3Ø deg proton	"	7th interval
3ØDP-M	3Ø deg proton	"	maximum interval
3ØP M		interval maximum counts were accumulated	
3ØPF-D	3Ø deg proton	directional energy flux	all intervals
Total Energy	all detectors	total energy flux	all intervals

Table 5.8 shows the TED RECORD TIMING information for the TED in Normal Mode, Telemetry Format 1 - the only configuation in which the TED has been operated. The accumulation period, written as 11/13, means eleven-thirteenths of a second. Note that the TED record contains 4 groups of data. The first 6 words of each group are from a different detector, but the remaining 14 words are the same detectors read every 2 seconds.

Table 5.8 TED data - record timing, for record types 1, 2 & 3

TED word	Data channel	Accumulation period (s)	Accumulation begin time relative to TØ (s)
1-4	ØDE-1, ØDE-3, ØDE-5, ØDE-7	11/13	-2
5	ØDE-M	11/13	-2
6	ØE-M	-	-
7-8	ØEF-D, ØDE-M	11/13	-2
9	ØE-M	-	-
1Ø-11	3ØEF-D,3ØDE-M	11/13	-2
12	3ØE-M	-	-
13-14	ØPF-D, ØDP-M	11/13	-1
15	ØP-M	-	-
16-17	3ØPF-D,3ØDP-M	11/13	-1
18	3ØP-M	-	-
19	Total Energy	-	-
2Ø-23	3ØDE-1, 3ØDE-3, 3ØDE-5, 3ØDE-7	11/13	+Ø
24	3ØDE-M	11/13	+Ø
25	3ØE-M	-	-
26-27	ØEF-D, ØDE-M	11/13	+Ø
28	ØE-M	-	-
29-3Ø	3ØEF-D,3ØDE-M	11/13	+Ø
31	3ØE-M	-	-
32-33	ØPF-D, ØDP-M	11/13	+1
34	ØP-M	-	-
35-36	3ØPF-D,3ØDP-M	11/13	+1
37	3ØP-M	-	-
38	Total Energy	-	-
39-42	ØDP-1, ØDP-3, ØDP-5, ØDP-7	11/13	+3
43	ØDP-M	11/13	+3
44	ØP-M	-	-
45-46	ØEF-D, ØDE-M	11/13	+2
47	ØE-M	-	-
48-49	3ØEF-D,3ØDE-M	11/13	+2
5Ø	3ØE-M	-	-
51-52	ØPF-D, ØDP-M	11/13	+3
53	ØP-M	-	-
54-55	3ØPF-D,3ØDP-M	11/13	+3
56	3ØP-M	-	-
57	Total Energy	-	-

58-61	30DP-1, 30DP-3, 30DP-5, 30DP-7	11/13	+5
62	30DP-M	11/13	+5
63	30P-M	-	-
64-65	0EF-D, 0DE-M	11/13	+4
66	0E-M	-	-
67-68	30EF-D,30DE-M	11/13	+4
69	30E-M	-	-
70-71	0PF-D, 0DP-M	11/13	+4
72	0P-M	-	-
73-74	30PF-D,30DP-M	11/13	+4
75	30P-M	-	-
76	Total Energy	-	-

TED Background values, 0 E-BK, 30 E-BK, 0 P-BK, and 30 E-BK, are listed in place of the energy flux values for the sweep intervals 1, 3, 5, and 7 in Record Type 4. Table 5.9 shows where the background data appear in the record. (Note that background data are given only in Record Type 4.)

Table 5.9 TED background data channels - record type 4

TED word	Detector
1- 4	OE BK, 30E BK, 0P BK, 30P BK
5-19	same as RECORD TYPES 1, 2, & 3
20-23	zeros
24-38	same as RECORD TYPES 1, 2, & 3
39-42	zeros
43-57	same as RECORD TYPES 1, 2, & 3
58-61	zeros
62-76	same as RECORD TYPES 1, 2, & 3

TED Background data are acquired by the instrument in the following manner. The total number of counts accumulated during the first 1/13 second (background interval) of each of the 16 energy sweeps for each of the detectors is summed and read out once every 32 seconds.

6. ARCHIVE TAPE FORMAT

The physical format details of the Archive Tapes and the logical data records must be known, to read the tape and unpack the data. Figure 6.1 is a printout of one logical data record. The archive tape format and contents are the same for all spacecraft.

An Archive tape contains data from one satellite for 1Ø or 11 days; thus, one calender month requires three tapes. The first day of the month always starts a new tape. Raw input records with missing, bad, or ambiguous data have been discarded so that only good data records are on the Archive tapes. All records are complete, however, there can be gaps between records where data where bad or missing. The percentage of good data from the TIROS/NOAA satellites is greater than 9Ø% for most days. Zeros are sometimes used to fill out the last physical record on a tape. These zero records can be recognized by a Satellite ID of zero.

For users with access to the ERL computer system, there is a Library of routines that read, unpack an Archive tape, and pass the converted data to the user via a COMMON BLOCK. See Appendix A for a description of these routines.

6.1 Physical Tape Format

6.1.1 Tape Format

Packed Binary
9 Track
16ØØ BPI Density
456 6Ø-bit words/physical record
 or 342Ø bytes/physical record
12 logical records/physical record
285 bytes/logical record
8 bits/byte

3 tapes/month
1Ø or 11 days/tape
99ØØ maximum physical records/tape
1 file/tape followed by an End of Information

The tapes are written on a Control Data Corporation CYBER 17Ø/75Ø machine with the NOS operating system. They are in CDC internal format with standard ANSI labels. If they are read on a non-CDC machine, the physical records will contain 3426 bytes; the last 6 bytes are internal CDC counters which can be ignored. The tape labels have a file identification in the form FI=TIROSN (or NOAA6, NOAA7, NOAA8), the satellite name.

6.1.2 Tape Summary

Two 8Ø-byte tape label records (ANSI standard)
End of File
One "Tables Record" (342Ø bytes)
Up to 99ØØ 342Ø-byte physical "Data Records" (3426 bytes on non-CDC machin
End of Information - indicated by EOF, 8Ø-byte trailer record, EOF, EOF

```
                TIROS/NOAA ARCHIVE RECORD FOR  YEAR 83   DAY 254   HR  0   MIN  1   MSEC 30983
      S/C ID 6   YEAR 83   DAY 254   MS     90983   REC STA   1   ALT 8155   INCL 989   ORBIT  2364   REC TYPE 2
 SAT PAR  GEOG LAT -40.41   LONG  300.62   BR  12958.   BT -15146.   BP    330.   BB  19942.
FOFL PAR  GEOG LAT -47.20   LONG  300.09   BR  19901.   BT -20328.   BP   1956.   3B  26515.
          GEOM LAT -36.04   LONG     8.81   L VALUE  1.49   TED0 114.71   TED30 114.46
          MEP81  74.32   MEP83  75.60   MEPO  49.44   L TIME 301.00   ML TIME 300.54   VERS 1.
      ON/OFF    MEPED 1   HEPAD 0   TED 1    IFC   MEPED 0   TED/HEPAD 0   TED MODE 0   FORMAT 1   TED PHD  0
                 MPTT   METT   MELT   OMNI   AMSS   HELT   PMT   PMHV   HSSD   LVL   TEPS   TPSS   LVR   CEA   TEDT
HOUSEKEEPING    -11.8  -11.2  -10.7  -28.8   82.8  -67.0  -67.0   0.0    0.0   0.0    3.0    2.0   3.0  653.6  -11.5
      HEPAD DATA IN COUNTS
   BLOCK     P1     P2     P3     P4     A1     A2     S5     S4     S1     S2     S3
     1        0      0      0      0      0      0      0      0      0      0      0
     2        0      0      0      0      0      0      0      0      0      0      0
      MEPED DATA      IONS   0I    -1    90I    -1
SUB  0P1   0P2   0P3   0P4   0P5   0E1   0E2   0E3  90P1  90P2  90P3  90P4  90P5  90E1   90E2   90E3   P6   P7   P8
 5   197   561   165    20    46   589   441   149    87   133    52    16    71  29185  18945  3009 1889 1121  913
 6   197   551   157    22    56   689   441   123    79   123    49    13    79  29185  18945  3009 1889 1121  913
 7   189   593   173    14    60   753   473   133    83   165    58    15    75  30209  19959  3265 1953 1185  977
 8   213   593   165    20    52   721   441   141    75   127    56    15    75  30209  19959  3137 2017 1249  977
     0DE1   0DE3   0DE5   0DE7   0DE    0EM        FLUX      300E1  300E3  300E5  300E7  300EM  30EM        FLUX
       5.     4.     4.     2.     9.    11.       .192        3.     2.     2.     4.     6.    2.         .177
     0DP1   0DP3   0DP5   0DP7   0DP    0PM        FLUX      300P1  300P3  300P5  300P7  300P   30PM        FLUX
       0.     2.     2.     1.     4.    10.       .186        1.     3.     3.     5.     5.    7.         .218
   0EFD   0DEM   0EM   30EFD  300EM  30EM   0PFD   0DPM   0PM   30PFD  300PM  30PM
   20.0     9.   11.    21.0     7.   11.    7.8     5.    2.    12.5     4.    9.
   17.0     5.    2.    21.0     6.    2.   13.5     6.    1.     8.5     3.    5.
   22.0     7.    5.    21.0     7.    4.   13.5     4.   10.     9.5     4.    3.
   18.0     6.    6.    27.0     8.   10.    7.3     4.    1.    11.5     5.    7.
```

Figure 6.1 A sample 8-s data record

6.1.3 Data

The data are packed binary, 2's complement, signed integers. An S follows the number of bytes in a word if the word can be negative. If all values are unpacked as unsigned integers then the signed values can be converted as follows

1S:	If the word is greater than 127,	subtract	256
2S:	If the word is greater than 32,767,	subtract	65,536
3S:	If the word is greater than 8,388,6Ø7,	subtract	16,777,216

6.2 Tables Record Format

Each Archive tape starts with a "Tables Record" which is followed by up to 99ØØ "Data Records". The Tables Record contains the conversion tables used to convert the telemetry word to the detector response in counts per accumulation period. Data Records are physical records of 342Ø bytes, which contain 12 logical records of 285 bytes. The Tables Record is the same for all spacecraft and on all archive tapes. On the archive tape, data values have not been converted to counts. There are two ways to convert the data: by using the Conversion Tables in the Tables Record (described in Section 6.2.1), or by using the algorithms described in Section 6.2.2.

6.2.1 Conversion Tables

The Conversion Tables in the Tables Record are in two arrays called CC1 and CC2. The arrays are used as look-up tables to convert a telemetry data word into counts per accumulation period. The CC1 and CC2 arrays each contain 256 24-bit words (see table 6.1). Telemetry data words are always one byte (8 bits) in the range Ø - 255. To convert a telemetry word to counts, use the value of the telemetry word plus 1 (telemetry word + 1 range 1 - 256) as an index to the CC1 or CC2 array. The number indexed from the array will give counts per accumulation period. To convert counts per accumulation period to counts per second, see the Record Timing description and tables in section 5.

The CC1 array is used for all telemetry data words except the TED Total Flux Channels (ØEFD, 3ØEFD, ØPFD and 3ØPFD). This conversion is used only for data values that measure counts (TED Interval and Total Energy Flux values are not counts).

Note that the CC2 array is the same as CC1 except for CC2(1Ø5) through CC2(16Ø), so it is not necessary to hold both arrays. Values CC2(145) through CC2(152) are not possible from valid telemetry data and so are shown as -1 in the array.

Table 6.1 Tables Record

Array	Range	Units	Conversion factor	Number of words	Byte count	Bytes per word
CC1	Ø-499713	Counts	1	256	1 - 768	3
CC2	Ø.1-192512	Counts	Ø.1	256	769 - 1536	3

6.2.2 Conversion Algorithms

Telemetry words can be converted to counts per accumulation period by using algorithms instead of the CC1 and CC2 conversion tables. In the algorithms variables are used:

CTS = counts per accumulation period
Y = the four most significant bits of the telemetry word
X = the four least significant bits of the telemetry word
Note: Use the integer portion of CTS only.

CC1: Normal Conversion

If Y = Ø through 8 and X = Ø through 15,	CTS = $[(X + 16.5) * 2^{(Y+6)}] + 1$
except if Y = 8 and X = 15,	CTS = Ø.Ø
If Y = 9 and X = Ø through 15,	CTS = X + 1.5
If Y = 1Ø and X = Ø through 15,	CTS = X + 17.5
If Y = 11 through 15 and X = Ø through 15,	CTS = $[(X + 16.5) * 2^{(Y-1Ø)}] + 1$

CC1 Alternate conversion

Add 113 (Ø111ØØØ1 binary) to the word

If Y = Ø,	CTS = X
If Y = 1 through 15,	CTS = $[(X + 15.5) * 2^{(Y-1)}] + 1$

Note: If Y > 2 and X = Ø, add $2^{(Y-3)}$
If Y = 2 and X = Ø, add 1

CC2 converion:

For the TED Total Flux Channels only (ØEF D, ØPF D, 3ØEF D, 3ØPF D). Use the CC1 conversion, with these exceptions:

If Y = 9 and X = Ø through 7,	ERROR; this configuration cannot occur
If Y = 9 and X = 8 through 15,	CTS = X + .5
If Y = 8 and X = Ø through 15,	CTS = .125X + .Ø625
If Y = 7 and X = Ø through 7,	use CC1 except subtract 1
If Y = 7 and X = 8 through 15,	CTS = .25X + .125
If Y = 6 and X = Ø through 7,	use CC1 except subtract 1
If Y = 6 and X = 8 through 15,	CTS = .5X + .25

For TED ØDE M, ØDP M, 3ØDE M and 3ØDP M Channels use CC1 conversion, with these exceptions:

If Y = Ø and X = Ø, check corresponding F_D channel
if counts are present in the F_D channel, CTS = 1Ø57.
if counts are not present in the F_D channel, CTS = Ø.Ø.

6.3 Logical Record Formats

Logical data records contain 8 seconds of instrument data plus the related orbital and housekeeping information.

The records are ordered by time, and the time, T0, associated with every record is in milliseconds of the day. Orbital and housekeeping information is valid at T0, but other data are not (see the discussion on record timing, Section 5). Table 6.2 shows the general format of every logical record.

Table 6.2 Logical Record Format

Description	Number of bytes	Byte count
Orbital Information	72	1 - 72
Housekeeping Information	29	73 - 101
MEPED	78	102 - 179
HEPAD	22	180 - 201
TED	84	203 - 285
Total Bytes	285	

The format of all records is the same, but the values contained in certain fields of the MEPED and TED instrument data are not the same in all records. The original raw data tapes contain data "frames" of 32 seconds each. These frames are divided into four 8-s records on the archive tape. To identify which part of the original frame a record comes from, a number from 1 to 4 is included on each archive record to indicate "Record Type". Sections 6.3.3 and 6.3.5 describe the differences between the Record Types for the MEPED and TED data. Because the four record types were originally a single frame on the raw data tape they will always be in consecutive order and time gaps are possible only between Record Type 4 and 1.

In tables 6.3 - 6.9 the headings mean the following:

Word - The position of the data within the COMMON BLOCK arrays described in Appendix A table A.2.
Description - The term used to identify the data.
Data Channel- The term used to identify the data.
Range - The maximum and minimum values of the data, after conversion.
Units - The units of the data, after conversion.
Conversion Factor - The number by which a data value must be multiplied to convert it to useable units. Note for data being converted to counts this is the conversion table name, CC1 or CC2 (see section 6.2).
Number of Bytes - The number of bytes required for these data.
Byte Count - The position of the data within the whole 285-byte record.

6.3.1 Orbital Information Format

Table 6.3 shows the orbital information in every 8-s data record.

Table 6.3 Orbital Information

Word	Description	Range	Units	Conversion factor	Number of bytes	Byte count
1	Spacecraft ID	0 to 9			1	1
T0	Begin time of the record					
2	Year	78 to 99			1	2
3	Day of the year	1 to 366			2	3- 4
4	Milliseconds of the day	0 to 86400000			4	5- 8
5	Receiving station	0 to 6			2	9-10
6	Altitude	about 850.0	km	0.1	2	11-12
7	Inclination	about 99.0	deg	0.1	2	13-14
8	Orbit number (>12 years)	1 to 65535			2	15-16
9	Record type	1 to 4			2	17-18
	Data at the satellite					
1	Geographic latitude	-90.00 to 90.00	deg	0.01	2S	19-20
2	Geographic east longitude	0.00 to 360.00	deg	0.01	2	21-22
3	BR	-41000 to 43000	gammas		3S	23-25
4	BT	-27000 to 10000	gammas		3S	26-28
5	BP	-10000 to 10000	gammas		3S	29-31
6	BB	20000 to 45000	gammas		2	32-33
	Data at the Foot Of the Field Line (FOFL)					
7	Geographic latitude	-90.00 to 90.00	deg	0.01	2S	34-35
8	Geographic east longitude	0.00 to 360.00	deg	0.01	2	36-37
9	BR120	-58000 to 65000	gammas		3S	38-40
10	BT120	-36000 to 15000	gammas		3S	41-43
11	BP120	-15000 to 15000	gammas		3S	44-46
12	BB120	20000 to 45000	gammas		2	47-48
13	Geomagnetic latitude	-90.00 to 90.00	deg	0.01	2S	49-50
14	Geomagnetic east longitude	0.00 to 360.00	deg	0.01	2	51-52
15	L-value (set to 0.0 if greater than 14.99)	0.93 to 14.99		0.01	2	53-54
	Pitch Angles					
16	TED 0 deg detector*	0.00 to 180.00	deg	0.01	2	55-56
17	TED 30 deg detector*	0.00 to 180.00	deg	0.01	2	57-58
18	MEPED 81 deg Electron detector**	0.00 to 180.00	deg	0.01	2	59-60
19	MEPED 83 deg Electron detector**	0.00 to 180.00	deg	0.01	2	61-62
20	MEPED 0 deg Electron detector**	0.00 to 180.00	deg	0.01	2	63-64

Miscellaneous information

21	Local time**	0.00 to 360.00	deg	0.01	2	65-66
22	Magnetic local time**	0.00 to 360.00	deg	0.01	2	67-68
23	Program version	1 to 99			1	69
	Zero fill	0			3	70-72
			Total Bytes		72	

* at the Foot Of the Field Line, 120 km
** at the satellite
Pitch angle detector sensor angle descriptions are with respect to the zenith (local Earth vertical).

6.3.2 Housekeeping Information Format

Tables 6.4 and 6.5 show the status and housekeeping information in every 8-s data record.

Table 6.4 Status Information

Status Word	Description	Status	Position	Bits	Number of bytes	Byte count
1	MEPED on/off	1 = on, Ø = off	MSB**	1		
2	HEPAD on/off	1 = on, Ø = off		1		
3	TED on/off	1 = on, Ø = off		1		
4	MEPED IFC*	1 = yes, 2 = no		1	1	73
5	TED/HEPAD IFC*	1 = yes, 2 = no		1		
6	TED MODE	Ø to 3		2		
7	TELEMETRY FORMAT	1 = 1, Ø = 2	LSB**	1		
8	TED PHD flags	Ø to 15		4-4	1	74
			Total Bytes		2	

* IFC = In Flight Calibration
** MSB = the most significant bit of the word; LSB = the least significant bit.

Table 6.5 Housekeeping Information

Housekeeping Word	Description	Range	Units	Conversion factor	Number of bytes	Byte count
1	MPTT	-67.Ø to 4Ø.6	deg C	Ø.1	2S	75- 76
2	METT	-67.Ø to 4Ø.6	deg C	Ø.1	2S	77- 78
3	MELT	-67.Ø to 4Ø.6	deg C	Ø.1	2S	79- 8Ø
4	OMNI	-81.Ø to 4.9	deg C	Ø.1	2S	81- 82
5	AMSS	-Ø.ØØ to 464Ø.3Ø	volts	Ø.Ø1	2	83- 84
6	HELT	-67.Ø to 4Ø.6	deg C	Ø.1	2S	85- 86
7	PMTT	-67.Ø to 4Ø.6	deg C	Ø.1	2S	87- 88
8	PMHV	Ø.ØØ to 5.1Ø	volts	Ø.Ø1	2	89- 9Ø
9	HSSD	Ø.Ø to 5478.4	volts	Ø.1	2	91- 92
1Ø	LVL	Ø to 128	level	1	1	93
11	TEPS	Ø to 8	level	1	1	94
12	TPPS	Ø to 8	level	1	1	95
13	LVR	Ø.ØØ to 5.1Ø	volts	Ø.Ø1	2	96- 97
14	CEA	Ø.Ø to 791.5	volts	Ø.1	2	98- 99
15	TEDT	-67.Ø to 4Ø.6	deg C	Ø.1	2S	1ØØ-1Ø1
				Total Bytes	27	

6.3.3 MEPED Data Format

Table 6.6 shows the MEPED data in one 8-s data record. The Ø and 9Ø deg Z ≥ 2 Ions (MEPED words 1 and 2) are read out only once every 16 seconds and are therefore present only in Record Types 1 and 3. Words 1 and 2 of Record Types 2 and 4 contain -1. The Record Type is in Orbital Information in every data record. All other channels are read every 2 seconds and are in four groups within the 8-s record. Remember, "Counts" in the data record are Counts per Accumulation Period.

Table 6.6 MEPED Data Format

MEPED word	Data channel	Units	Conversion factor	Number of bytes	Byte count
	Ions				
1	ØI (Record Type 1 & 3 only)	Counts	CC1	1	1Ø2
2	9ØI (Record Type 1 & 3 only)	"	"	1	1Ø3
	Protons and Electrons				
3 to 7	ØP1 to ØP5	"	"	5 X 1	1Ø4-1Ø8
8 to 1Ø	ØE1 to ØE3	"	"	3 X 1	1Ø9-111
11 to 15	9ØP1 to 9ØP5	"	"	5 X 1	112-116
16 to 18	9ØE1 to 9ØE3	"	"	3 X 1	117-119
19 to 21	P6 to P8	"	"	3 X 1	12Ø-122
repeat words 3 to 21 (ØP1 to P8)		"	"	19 X 1	123-141
repead words 3 to 21 (ØP1 to P8)		"	"	19 X 1	142-16Ø
repeat words 3 to 21 (ØP1 to P8)		"	"	19 X 1	161-179
		Total Bytes		78	

6.3.4 HEPAD Data Format

Table 6.7 shows the HEPAD data in one 8-s data record. Each data channel is read every 2 seconds, and the data are in four groups within the 8-s record. Remember, "Counts" in the data record are Counts per Accumulation Period.

Table 6.7 HEPAD Data Format

HEPAD word	Data channel	Units	Conversion factor	Number of bytes	Byte count
Protons and Alpha particles					
1	P1	Counts	CC1	1	180
2	P2	"	"	1	181
3	P3	"	"	1	182
4	P4	"	"	1	183
5	alpha 1	"	"	1	184
6	alpha 2	"	"	1	185
7	S5	"	"	1	186
8	S4	"	"	1	187
9	S1	"	"	1	188
10	S2	"	"	1	189
11	S3	"	"	1	190
repeat	P1 to S3	"	"	11 X 1	191-201
			Total Bytes	22	

6.3.5 TED Data Format

The TED data set is much larger and more complex than the other instrument data sets. It contains data from four different detectors, and each detector is sampled four times in every 8-s data record. However, although some values are read out four times per record, others are included only once. Table 6.8 shows the TED Record Format in Record Types 1, 2, and 3. Table 6.9 shows Record Type 4, which contains background information as well as the repeated detector data. Note that these and the other TED Tables are for PHD settings - Mode Ø Format 1; this is the only configuration the TED has operated in.

Each data record contains TED data from four detectors - the Ø-deg Electron detector, the 3Ø-deg Electron detector, the Ø-deg Proton detector and the 3Ø-deg Proton detector. In Record Types 1, 2, and 3, the TED data contain four groups of 19 data words. The first six words of each group are different energy interval readings from one detector; each of the four detectors is used in one of the four groups. Words 7-18 are the same in each of the four groups, but contain only the maximum energy interval reading from each detector. Word 19 is the Total Energy Flux, calculated from the ØEF-D, ØPF-D, 3ØEF-D, and 3ØPF-D maximum energy interval data in that group. In Record Type 1 the first 19 words contain all zeros at the beginning of the tape, after a time gap, and if the preceding record is missing.

In Record Type 4, words 1-4 of the first group contain background data. The first four words of the following groups contain zeros. Words 5-19 of all groups are the same as in Record Types 1, 2, and 3 (see table 6.9).

TED data are converted to counts using the CC1 or CC2 tables (except of course the Total Energy Flux values and ØE-M, 3ØE-M, ØP-M, and 3ØP-M, which need no conversion).

When the received signal is noisy and the data processing equipment loses synchronization, the value 1Ø57 is put into the data word. Unfortunately, the value 1Ø57 can represent a valid data point, and often does. The only way this ambiguity can be resolved is to examine all data channels for that time and to look for other anomalous data values (particularly in the housekeeping data) which indicate noisy data. Such a subjective examination was not done on the Archive Tapes.

The Total Energy Flux calculation always treats the value 1Ø57 in the ØEF-D, 3ØEF-D, ØPF-D, or 3ØPF-D channels as noise. In such instances the corresponding value for the Total Energy Flux is set to Ø.ØØ. If the value 1Ø57 was, in fact, a valid data point and not telemetry noise, the corresponding Total Energy Flux value would be about 8 ergs cm^{-2} s^{-1}.

Table 6.8 TED Data Format - Record Types 1, 2, 3

TED word	Data channel	Range	Units	Conversion factor	Number of bytes	Byte count
1	0DE-1		Counts	CC1	1	202
2	0DE-3		"	"	1	203
3	0DE-5		"	"	1	204
4	0DE-7		"	"	1	205
5	0DE-M		"	"	1	206
6	0E-M	1-11			1	207
7	0EF-D		"	CC2	1	208
8	0DE-M		"	CC1	1	209
9	0E-M	1-11			1	210
10	30EF-D		"	CC2	1	211
11	30DE-M		"	CC1	1	212
12	30E-M	1-11			1	213
13	0PE-D		"	CC2	1	214
14	0DP-M		"	CC1	1	215
15	0P-M	1-11			1	216
16	30PF-D		"	CC2	1	217
17	30DP-M		"	CC1	1	218
18	30P-M	1-11			1	219
19	Total Energy Flux	0.001 to 1000	ergs cm^{-2} s^{-1}	0.001	3	220-222
			(total bytes in this group		21)	
	30DE-1, 3, 5, 7		Counts	CC1	4	223-226
	30DE-M		"	CC1	1	227
	30E-M	1-11			1	228
repeat 0EF-D to Total Energy Flux (words 7-19)					15	229-243
			(total bytes in this group		21)	
	0DP-1, 3, 5, 7		Counts	CC1	4	244-247
	0DP-M		"	CC1	1	248
	0P-M	1-11			1	249
repeat 0EF-D to Total Energy Flux (words 7-19)					15	250-264
			(total bytes in this group		21)	
	30DP-1, 3, 5, 7		Counts	CC1	4	265-268
	30DP-M		"	CC1	1	269
	30P-M	1-11			1	270
repeat 0EF-D to Total Energy Flux (words 7-19)					15	271-285
			(total bytes in this group		21)	
			Total Bytes		84	

Table 6.9 TED Background Data Format - Record Type 4

TED word	Data channel	Range	Units	Conversion factor	Number of bytes	Byte count
1	ØE-BK		Counts	CCl	1	2Ø2
2	3ØE-BK		"	"	1	2Ø3
3	ØP-BK		"	"	1	2Ø4
4	3ØP-BK		"	"	1	2Ø5
5-19	same as Record Types 1, 2 & 3					2Ø6-222
			(total bytes in this group		21)	
	zeros					223-226
	same as Record Types 1, 2 & 3					227-243
			(total bytes in this group		21)	
	zeros					244-247
	same as Record Types 1, 2 & 3					248-264
			(total bytes in this group		21)	
	zeros					265-268
	same as Record Types 1, 2 & 3					269-285
			(total bytes in this group		21)	
			Total Bytes		84	

APPENDIX A: Retrieval Routines on the ERL Computer

The Archive tapes can be read and unpacked with routines from two libraries on the ERL CYBER 750 computer in Boulder. The routines run under CDC Fortran 5. Users who do not have access to the ERL computer can get listings of the libraries from Viola Hill or Judy Stephenson at NOAA/SEL, RE/E/SE2, 325 Broadway, Boulder, CO 80303.

To use the libraries the following control cards are needed. The volume serial numbers (VSN) for archive tapes are available from Judy Stephenson.

```
ATTACH(TLIB5/UN=TIROS)
ATTACH(ULIB5/UN=SELLIB)
LIBRARY(TLIB5/ULIB5)
```

The Archive tape is assigned to TAPE1 as follows:

```
LABEL(TAPE1,NT,D=1600,PO=R,F=I,LB=KL,FA=E,VSN=TXXXXX=NXXXXX)
```

The user must call two subroutines:
1) READIN - to set-up the range of data to retrieve
2) CONTROL - to read the next logical data record into COMMON /REC/.

These subroutines are described following a sample program that shows how to read an Archive tape and print out 10 records using the library routines. Subroutine PRINTER, also in the library, prints out the data in COMMON /REC/ in the format shown in Section 6.1 (figure 6.1).

```
      PROGRAM PRINT (INPUT,OUTPUT,TAPE1)
C          PRINT RECORDS FROM A TIROS/NOAA ARCHIVE TIME
C
      COMMON/REC/ IHD(9), HEAD(23), ISTAT(8), HOUS(15), MEPI(2), MEP(19,4),
                  IHEP(11,2), TED(18,4), TEDFX(4)
C
C         READ INPUT, SET LIMITS AND READ TABLES RECORD, ONLY CALLED ONCE
      CALL READIN
C
C         READ AND PRINT DATA RECORDS UNTIL LIMITS REACHED
10    CALL CONTROL (IQT)
      IF (IQT .EQ. 1) GO TO 90
      CALL PRINTER
      GO TO 10
C
C         END FOUND
90    PRINT 9000
9000  FORMAT (*0END OF TAPE*)
      STOP
      END
```

<u>INPUT</u>

```
READ 10 RECORDS STARTING 1983, FEB 12, 1230UT.   THIS IS THE COMMENT CARD
'START',83,33,12,30,0/
'RECORDS'1,10/
```

(1) Subroutine READIN - in the form CALL READIN

Every program must begin with one call to subroutine READIN, which reads INPUT for the range of data to retrieve. The INPUT cards are described in Table A.1. At least one card, the Comment Card, must be in INPUT or the program will stop; it may be followed by as many Option Cards as needed. The Comment Card is one line describing the job. The Option Cards have the general format

'keyword',P1,P2,P3,P4,P5/

where the keyword is enclosed in single quotes and followed by up-to-5-integer parameters separated by commas and terminated with a slash. The current keywords are: START, END, ORBIT (or ORBITS), and RECORD (or RECORDS).

The Comment Card, the current date/time, and the Option Cards are printed on the top of the first page of output.

Table A.1 INPUT cards for subroutine READIN

INPUT card format	Description
NECESSARY CARD	
COMMENT CARD	up to 8Ø characters of general information which are printed on the output
OPTION CARDS	
'START',YR,DOY,HR,MIN,MSEC/	date/time to begin
'END',YR,DOY,HR,MIN,MSEC/	date/time to end
'ORBIT',n/	orbit number to begin processing
'ORBITS',n,m/	range of orbit numbers to process
'RECORD',n/	begin with nth data record on the tape after START and ORBIT are satisfied.
'RECORDS',n,m/	begin with the nth record on the tape after START and ORBIT are satisfied. Process through the mth record.

PARAMETERS

YR	year, 2 digits only - example 82
DOY	day of the year - 1 to 366
HR	Hour of the day - any integer
MIN	Minute of the hour - any integer
MSEC	Millisecond of the minute - any integer
n,m	any integers

The parameters must be in the correct order, but it is not necessary to use all of them. For example 1983 FEB 12 ØØ:ØØ:ØØ can be entered as

'START',83,33,Ø,Ø,Ø/ or 'START',83,33/

'RECORDS',5,1Ø/ will return the 5th, 6th, 7th, 8th, 9th, and 1Øth record after the ORBIT number and START time are satisfied, if they are present.

Option cards can be used in any combination. When an ORBIT number is included the tape is read until the beginning ORBIT number is found; then the tape is read until the START time is reached. Finally the RECORD count begins, and the nth record from this point is the first record returned. Processing stops on the record after any limit is satisfied, e.g., after the END time is reached, the last ORBIT number is found, or the mth record is read. No checks are made on the date/times or other numbers to be sure they are valid or reasonable.

(2) Subroutine CONTROL in the form CALL CONTROL (IQT) with common block /REC/

CONTROL unpacks the next logical data record into COMMON /REC/. Table A.2 show the contents of this COMMON block. After every CALL CONTROL the next 8-s data record is read, unpacked, converted to the units defined in Section 6, and put into COMMON /REC/ in this format:

```
COMMON/REC/ IHD(9), HEAD(23), ISTAT(8), HOUS(15), MEPI(2), MEP(19,4),
            IHEP(11,2), TED(18,4), TEDFX(4)
```

The variable IQT in the subroutine CONTROL calling sequence is a flag to signal a good read or to stop.

If IQT = Ø, the read was good and a new record is in /REC/.
If IQT = 1, a new record was not read. Processing has stopped because the end of the tape was reached or the end of the range was reached.

The libraries use the following names for subroutines and common blocks, so the user's programs should not contain routines with these names:

/CON/	READCW	UNPACK
CONTROL	READER	UNPACKH
INITCW	READIN	UNPACKM
/INPUT/	/REC/	UNPACKT
/IPR/	SKIPCW	UNPACK24
I2TT	UCTAB	UNPACK8
PRINTER		

Table A.2 Contents of COMMON /REC/

Variable	Type	Description
ORBITAL INFORMATION		
IHD(1)	Integer	Spacecraft ID
IHD(2)	"	Year
IHD(3)	"	Day of the year
IHD(4)	"	Millisecond of the day
IHD(5)	"	Receiving station
IHD(6)	"	Altitude
IHD(7)	"	Inclination
IHD(8)	"	Orbit number
IHD(9)	"	Record type
HEAD(1)	Floating point	Geographic latitude at the satellite
HEAD(2)	"	Geographic east longitude at the satellite
HEAD(3)	"	BR at the satellite
HEAD(4)	"	BT at the satellite
HEAD(5)	"	BP at the satellite
HEAD(6)	"	BB at the satellite
HEAD(7)	"	Geographic latitude at the FOFL
HEAD(8)	"	Geographic east longitude at the FOFL
HEAD(9)	"	BR120 at the FOFL
HEAD(10)	"	BT120 at the FOFL
HEAD(11)	"	BP120 at the FOFL
HEAD(12)	"	BB120 at the FOFL
HEAD(13)	"	Geomagnetic latitude at the FOFL
HEAD(14)	"	Geomagnetic east longitude at the FOFL
HEAD(15)	"	L-value
HEAD(16)	"	TED0 Pitch Angle
HEAD(17)	"	TED30 Pitch Angle
HEAD(18)	"	MEPED81 Pitch Angle
HEAD(19)	"	MEPED83 Pitch Angle
HEAD(20)	"	MEPED0 Pitch Angle
HEAD(21)	"	Local time at the satellite
HEAD(22)	"	Magnetic Local time at the satellite
HEAD(23)	"	Program version
HOUSEKEEPING INFORMATION		
ISTAT(1)	Integer	MEPED on/off
ISTAT(2)	"	HEPAD on/off
ISTAT(3)	"	TED on/off
ISTAT(4)	"	MEPED IFC
ISTAT(5)	"	TED/HEPAD IFC
ISTAT(6)	"	TED MODE
ISTAT(7)	"	TELEMETRY FORMAT
ISTAT(8)	"	TED PHD flags
HOUS(1) - HOUS(15)	Floating point	Instrument housekeeping words

MEPED DATA

MEPI(1), MEPI(2)	Integer	ØI, 9ØI
MEP(1,n) - MEP(5,n)	"	ØP1 to ØP5
MEP(6,n) - MEP(8,n)	"	ØE1 to ØE3
MEP(9,n) - MEP(13,n)	"	9ØP1 to 9ØP5
MEP(14,n) - MEP(16,n)	"	9ØE1 to 9ØE3
MEP(17,n) - MEP(19,n)	"	P6 to P8

where n = 1 to 4

HEPAD DATA

IHEP(1,n) - IHEP(4,n)	Integer	P1 to P4
IHEP(5,n)	"	alpha 1
IHEP(6,n)	"	alpha 2
IHEP(7,n)	"	S5
IHEP(8,n)	"	S4
IHEP(9,n)	"	S1
IHEP(1Ø,n)	"	S2
IHEP(11,n)	"	S3

where n = 1 to 2

TED DATA

TED(1,n)	Integer	ØDE 1 *
TED(2,n)	"	ØDE 3 *
TED(3,n)	"	ØDE 5 *
TED(4,n)	"	ØDE 7 *
TED(5,n)	"	ØDE M *
TED(6,n)	"	ØE M *
TED(7,n) - TED(9,n)	"	ØEF D, ØDE M, ØE M
TED(1Ø,n) - TED(12,n)	"	3ØEF D, 3ØDE M, 3ØE M
TED(13,n) - TED(15,n)	"	ØPF D, ØDP M, ØP M
TED(16,n) - TED(18,n)	"	3ØPF D, 3ØDP M, 9ØP M

where n = 1 to 4

TEDFX(1) - TEDFX(4)	Floating point	The four Total Energy values

* where n = 1 for the Ø-deg electron detector,
n = 2 for the 3Ø-deg electron detector,
n = 3 for the Ø-deg proton detector,
n = 4 for the 3Ø-deg proton detector.

In RECORD TYPE 1, TED (1,1) through TED (18,1) contain zeros if the previous record was missing (i.e., if this is the first record on the tape or the first record after a time gap).

In RECORD TYPE 4, TED(1,1) through TED(4,1) contain background counts and TED(1,n) through TED(4,n), for n = 2, 3, 4 contain zeros.

APPENDIX B: Problems and Errors on the TIROS/NOAA Archive Data Tapes

Some problems have been found in the SEM data and the Archive tapes since processing began in late 1978. The TED instrument data are analyzed carefully when the Archive tapes are produced and all known problems with the data are noted below. The MEPED and HEPAD data have not been looked at consistently, and little is known about minor instrument problems. All known problems are described briefly in this section.

When the received signal is noisy and the data processing equipment loses synchronization the value 1057 is put into the data word. As noted, the value 1057 can represent a valid data point, and often does. The only way this ambiguity can be resolved is to examine all data channels for that time and to look for other anomalous data values (particularly in the housekeeping data) that indicate noisy data. Such a subjective examination was not done on the archive tapes.

The Total Energy Flux data in the TED instrument (the only calculated data value on the archive tape) always treats the value 1057 in the 0EF D, 30EF D, 0PF D, or 30PF D channels as noise. In such instances the corresponding value for the Total Energy Flux is set to 0.00. If the value 1057 was, in fact, a valid data point and not telemetry noise the corresponding Total Energy Flux value would be the order of 8 ergs cm^{-2} s^{-1}.

The orbit number in the header information should increment as the satellite crosses from the southern hemisphere to the northern hemisphere in each orbit. Because of a problem in the algorithm used, some orbit numbers in the 1979 and 1980 data on both TIROS-N and NOAA-6 do not increment when the satellite is near the equator but change as far north as 20 deg. The orbit numbers in data from Jan. 1, 1981, onward increment when the satellite is between 0 and 4 deg north of the equator.

The NOAA-7 TED 30-deg detector "sees" sunlight, which introduces a background response. This response occurs when the satellite is on the day side of the Earth and is most apparent in the Northern Hemisphere during the Northern Hemisphere summer and in the Southern Hemisphere during the Southern Hemisphere summer. The magnitude of the undesirable detector response maximizes at the sub-solar location but is still observed to be present well into the auroral regions. The 0-deg detector is unaffected. When the contaminated 30-deg detector response is combined with the normal 0-deg response to obtain the Total Energy Flux at locations below the auroral zones (where the contamination is largest) an anomalous energy flux of about 0.1 erg cm^{-2} s^{-1} is obtained. Those instances when the 30-deg detector contamination gives rise to totally incorrect total energy fluxes may be reliably indentified with the following criterion. If the satellite is on the day side of the Earth and the 30-deg detector response exceeds the 0-deg detector response by more than a factor of 3, then the 30-deg detector response should be neglected.

NOAA-7 in 1982 sustained a loss of TED data from day 068, 1145 UT, through day 082, 1403 UT. During this time the TED instrument was turned off in the course of testing for the source of interference with the NOAA-7 command receiver and then turned on again in the wrong mode.

In 1982 there was another loss of TED data on NOAA-7 from day 328, 0100 UT, through day 394, 1625 UT. The TED was again turned off in order to check the source of contamination that was being sensed by a "contamination" detector on the spacecraft. After the instrument was turned back on again, there was evidence of an electrical interference source or corona, which affected the 30-deg proton detector in a spasmodic fashion for many days. This problem eventually went away, but while it was present it caused large count rates to appear in the 30-deg proton channel, which in turn resulted in large and incorrect Total Energy Fluxes.

When NOAA-8 came on line the "sunlight" problem was more severe than on NOAA-7. A modification was made to the archive program that removes this contamination.

Table B.1 shows the dates and times of minor data problems.

Table B.1 Problems in the SEM data

Spacecraft	Year	Begin DOY/time	End DOY/time	Problem
TIROS-N	1979	188/0000 UT	218/2359 UT	Bad orbital data
TIROS-N	1979	188/2025 UT	218/1324 UT	TED data bad
TIROS-N	1980	067/0130 UT	068/0130 UT	All SEM data bad
TIROS-N	1980	268/1900 UT	269/0730 UT	Bad orbital data
NOAA-6	1980	062/0430 UT	064/0000 UT	Bad orbital data
NOAA-6	1980	329/0615 UT	329/2300 UT	Bad orbital data
NOAA-6	1981	250/1545 UT	265/1443 UT	No TED data

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Aarnes and Lundblad, (University of Bergen, Norway) 1979: Geomagnetic Field parameters look-up table. (personal communication).