NSSDC
72-11

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NOVEMBER 1972

(NASA-TM-X-69988) THE USE OF THE INNER ZONE ELECTRON MODEL AE-5 AND ASSOCIATED COMPUTER PROGRAMS (NASA) ~~75~~ 67 p HC $6.75 CSCL 09B
N74-19836
Unclas
G3/08 33922

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NSSDC 72-11

The Use of the Inner Zone Electron Model AE-5 and Associated Computer Programs

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November 1972

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1. INTRODUCTION

This report is intended as a guide to the users of the inner radiation zone electron model AE-5. Section 2 includes a description of the model, the forms in which it is available, directions on how to use the model, and a discussion of its limitations. Computer programs MODEL and ORP are described in Sections 3 and 4, respectively. These are major programs needed to use the electron models AE-4 and AE-5 and the smoothed proton models.

This document is a companion to one published previously by Teague and Vette ("The Inner Zone Electron Model AE-5," NSSDC 72-10, 1972), and the reader is referred to that document for a complete description of the development of the model. Work is currently in progress to improve the high-energy part of model AE-5. In addition, a new proton model is being developed. When both of these models are completed, they will be compatible with the computer programs described in this document.

2. DESCRIPTION, USE, AND LIMITATIONS OF MODEL AE-5

A. Description of the Model

Model AE-5 describes the inner radiation zone electron environment and is based on data from five satellites spanning the period December 1964 to December 1967. The model provides omnidirectional integral flux for energy thresholds E_T in the range $4.0 > E_T/(\mathrm{MeV}) > 0.04$ and for L values in the range $2.8 \geq L/(R_e) \geq 1.2$ for an epoch of October 1967. Confidence codes for certain regions of B-L space and certain energies are given based on data coverage and the assumptions made in the analysis.

Data from satellites OGO 1, OGO 3, 1963-38C, OV3-3, and Explorer 26 were used. The University of Minnesota electron spectrometers were carried on board OGOs 1 and 3 and produced data used for model AE-5 (NSSDC data sets 64-054A-21A and 66-049A-22A supplied to the Data Center by Prof. John Winckler and Dr. Karl Pfitzer). These measurements extended over the period September 1964 to December 1967. The 1963-38C satellite was launched in September 1963 and provided data through 1967. This spacecraft carried an integral electron spectrometer from the Applied Physics Laboratory (Beall, 1969). Data obtained from mid-1966 to late 1967 were used in developing model AE-5. Explorer 26 data from detectors designed by McIlwain were used for the time interval January to June 1965. OV3-3 data from the Aerospace Corporation differential nine-channel electron spectrometer, supplied by Vampola late in the development of the model, were also incorporated in model AE-5.

The model forms available to a user include a graphical presentation and a variety of computer programs. This section describes the types of graphs and includes examples of each type. Computer programs are discussed in Sections 3 and 4.

In previous documentation on trapped particle models, the major display has been in the form of omnidirectional integral flux tables. Model AE-5, however, is presented in the form of two-dimensional carpet plots $J = J(B,L)$ for given energy thresholds. In addition, carpet plots are used for the graphical presentation of the solar cycle variation expressed as a ratio. While the omnidirectional flux data have been presented tabularly in previous model documentation with greater resolution than can be obtained from carpet plots, the error associated with determining a number from the carpet plots is considered insignificant in comparison to the inherent error associated with the model.

Omnidirectional flux plots are presented in Figures 1 through 7 for threshold energies E_T = 40, 100, 250, and 500 keV and 1, 2, and 4 MeV. Fluxes at nongrid B, L, and E points may be obtained simply by interpolation as described in Appendix A of Teague and Vette (1972). B-L and R-λ flux maps are presented in Figures 8 through 13 for threshold energies E_T = 40 keV, 500 keV, and 1 MeV. In addition, a physical impression of the model at these energies may be obtained from the three-dimensional plots given in Figures 14 through 16. While the basic epoch of model AE-5 is October 1967 corresponding approximately to solar maximum, AE-5 contains approximate values of the solar cycle parameter for time T

$$R_T\ (E_T,L,T) = \frac{J(E_T,L,T = \text{October } 1967)}{J(E_T,L,T)}$$

Plots of $R_T(L,T)$ are presented in Figures 17 through 20 for energy thresholds E_T = 40, 100, 250, and 500 keV. In these plots, the time parameter T has units of months from solar minimum taken as September 1964. Values of R_T are not presented for higher energies because of magnetic storm effects (Teague and Vette, 1972). While the values of R_T presented in Figures 17 through 20 have been determined from data over the period 1964 to 1967, they may be used to obtain very approximate estimates of the solar cycle effects for epochs later than October 1967. Using as a basis the Zurich Sunspot Number, it may be assumed that the flux is constant until T = 69 approximately (June 1970) and thereafter decreases approximately as described by Figures 17 through 20, reaching a minimum at approximately T = 100 (January 1973). It should be appreciated that extrapolating the model solar cycle dependence in this manner is likely to provide very approximate flux estimates only (Section 2B).

B. Limitations of the Model

It should be remembered that model AE-5 is presented for an epoch of October 1967, and temporal variations may result in significant flux changes in certain regions of B-L-E space. These temporal variations include magnetic storm effects, solar cycle effects, and the decay of residual Starfish electrons. These effects are discussed in detail in the paper by Teague and Vette (1972). With the exception of magnetic storm effects, these temporal variations, however, cause the flux to decrease from that given by AE-5 at epoch October 1967, and thus the model provides a conservative estimate of the influence of trapped inner zone electrons on orbital vehicles.

To enable the user to assess the reliability of model AE-5, a system of confidence codes is presented. In developing these codes a number of criteria were used: number of data sets used, data coverage, the degree of data agreement, errors introduced by modeling technique, and uncertainties introduced by temporal variations. A scale of 1 to 10 is used, where 10 corresponds to the highest reliability with an expected error of 2 or less and 1 corresponds to the least reliability with an expected error in excess of a factor of 10. In general, however, efforts have been made to provide pessimistic flux estimates where low confidence codes are given so that it is more probable that the flux is lower than the quoted value than higher. Two sets of codes are given -- one for the omnidirectional flux at an epoch of October 1967 (Table 1) and one for the solar cycle parameters (Table 2). In each case, a brief explanation for the confidence code and a section reference to the paper by Teague and Vette (1972) are given.

For example, in Table 1, where the B range is $>B_0$, the L range is 1.2 to 1.4 R_e, and the E_T range is >3 MeV, the confidence code is 1. This code indicates that in these ranges the omnidirectional flux indicated by model AE-5 has low reliability, with an expected error of more than a factor of 10. The comment column indicates that this error results from extrapolation on both B dependence and spectrum and from a lack of data.

Three temporal variations have been noted in the inner radiation zone: the decay of Starfish electrons, solar cycle effect, and magnetic storm effects. AE-5 attempts to model all three of these, and the reader is referred to Teague and Vette (1972) for a complete description of the modeling techniques used.

Model AE-5 contains a small Starfish residual flux in the energy range 500 keV $\leq E_T \leq$ 3 MeV and the L range $1.2 < L/(R_e) < 1.5$. Because of the lack of Starfish-free data, natural flux levels could not be obtained in these intervals, and corresponding low confidence limits are quoted in Table 1. Estimates have been made of the times at which the Starfish flux component has decayed to the level of the natural flux component, and these are presented in Table 3. For the L and E_T region of AE-5 that is influenced by Starfish electrons, it is estimated that a maximum reduction of a factor of 5 will result from the decay of this component.

Some discussion of the solar cycle effect has been given in the previous section. The confidence limits presented in Table 1 are applicable to the model at epoch October 1967. At other epochs the confidence codes are smaller because of the solar cycle effect. If Figures 17 through 20 are used to estimate this solar cycle effect, however, only the higher confidence codes should be reduced. That is, where the model is already associated with a factor of 5 or 6 error, no further error is introduced, whereas errors of a factor of 2 will be increased to 3 or 4 dependent upon the value of R_T.

The third temporal variation included in model AE-5 is the effect of magnetic storms. This effect is most noticeable at L = 1.9 to 2.4 R_e, and E_T = 0.4 to 2 MeV. Three variables are considered in determining the magnetic storm effect: the frequency of the storm, the intensity in relation to the undisturbed (quiet day) background, and the duration. Assessment of the importance of magnetic storms can be performed in practice with consideration of the first two variables alone because these exhibit much greater variation with E and L than does the third variable.

The frequency of magnetic storms in the inner belt is too low for a statistical approach. However, although the storms are infrequent, their relative intensity is high. In these circumstances the flux varies considerably from quiet to storm conditions in such a way that the changes from one condition to another are unpredictable and cannot easily be modeled.

A crude method has been adopted in model AE-5 for including magnetic storm effects. Average fluxes including magnetically disturbed and quiet periods were determined for the period June 1966 to December 1967. Magnetic storm effects were found to influence this average in the region $L \geq 1.8$ and $0.4 \leq E_T/(\mathrm{MeV}) \leq 2.0$. The maximum ratio of average to quiet period flux was found to be 40 approximately at E_T = 1 MeV at L = 2.4 R_e. At L = 1.9 R_e, this ratio had reduced to 3. It should be appreciated that the average storm flux included in AE-5 provides inaccurate estimates of the instantaneous fluxes and an inaccurate basis for orbit flux integrations because of the low frequency and high intensity of magnetic storm effects. These inaccuracies are incorporated in the confidence limits presented in Table 1. A model is currently being developed to describe the magnetic storm effects in the inner zone with greater accuracy than presently given by AE-5.

3. PROGRAM MODEL

Program MODEL is a Fortran program that enables the user to access any of the current trapped radiation models available through the National Space Science Data Center (NSSDC). These models include the Inner Zone Electron Model AE-5 for epoch October 1967 described in brief in Section 2 of this document and described in detail by Teague and Vette (1972), the Outer Zone Electron Model AE-4 for epoch 1967 given by Singley and Vette (1972), and a smoothed version of the proton models AP1, AP5, AP6, and AP7 (originally presented by Vette et al. 1966-1970) described by Kluge and Lenhart (1971). A matrix storage technique originally developed at ESRO (Kluge and Lenhart, 1971) is adopted for the containment of these models. A new interpolation scheme has been developed at NSSDC and is described in the following sections.

The matrix storage scheme and interpolation routines are completely general, and, as new models become available, these can be easily incorporated into Program MODEL. Work is currently in progress on developing new proton and inner zone high-energy electron models.

A. Program Logic and Restrictions

Flux versus B/B_0 curves are stored in Program MODEL at discrete energies and L values using the scheme indicated in Figure 21. Using the decadic logarithm of the omnidirectional integral flux, equal increments in the ordinate are chosen and the B/B_0 intervals $\delta(B/B_0)i$ are determined. Each flux versus B/B_0 curve is represented in the stored matrix by the variable F_0, equal to the logarithm of the flux at the equator, and the B/B_0 intervals $\delta(B/B_0)_i$. Using equal increments in the ordinate as opposed to the abscissa has the advantage that a fixed accuracy is maintained for the flux versus B/B_0 curve even in the region of the atmospheric cutoff, where the slope of the curve becomes very large. Linear interpolation on the logarithm is used between the grid points defined by $\delta(B/B_0)_i$, and the accuracy of the interpolated flux is essentially determined by the ordinate increment. Four points per decadic cycle are stored in the present matrix for the electron models and two per cycle for the proton model. Flux versus B/B_0 curves are stored in this manner at a variety of energies and L values. Linear interpolation on the logarithm is performed to obtain fluxes at intermediate energies and L values. Sufficient energies and L values are stored such that an exponential assumption between grid points provides sufficient accuracy. This is determined by the radial profiles and spectra of the models and is therefore model dependent. The energy and L value grid points used for the three models are shown in Figure 22. Linear logarithmic interpolation between these grid points introduces less than 10% error in the flux, i.e., considerably less error than is presently associated with the models.

Program MODEL performs the interpolation between grid points in the following order: (1) B/B_0 interpolation, (2) L interpolation, and (3) energy interpolation. The interpolation scheme adopted for B/B_0 and L is presented in Figure 23. In this figure, the flux is required at some nongrid point $P(B/B_0, L)$ for which the nearest surrounding grid L values are L_1 and L_2. A number of rays are drawn from the origin 0, taken as $B/B_0 = 1$, $\log_{10}(\text{flux}) = 0$, to the four grid points surrounding P, A_1, A_2 for $L = L_1$ and B_1, B_2 for $L = L_2$. The intermediate points B' and A' are determined by linear interpolation on the $\log_{10}(\text{flux})$ and B/B_0 between points B_1 and B_2 and A_1 and A_2, respectively. Further linear interpolation is performed to obtain C_1 and C_2 at the required L value. A final interpolation between C_1 and C_2 is performed to obtain the correct B/B_0 value at point P. In the event that the grid L flux-B/B_0 distributions cross (as occurs, for instance, in AE-5 at low L values and intermediate energies), a number of additional rays are drawn. For nongrid energies, the interpolation scheme described above and shown in Figure 23 is used at the two surrounding grid energies, and linear interpolation on $\log_{10}$(flux) and E is performed to obtain the flux at the correct energy.

The Kluge and Lenhart (1971) scheme stores the flux using B as grid points and interpolates between grid L and E values at constant B. The present storage and interpolation scheme has a number of advantages over the Kluge and Lenhart method. For $L_2 > L_1$ in Figure 23 at the equator $B_0(L_2)$ is less than $B_0(L_1)$ and, at atmospheric cutoff, $B_c(L_2)$ is greater than $B_c(L_1)$. Thus there are two regions for $B < B_0(L_1)$ and $B > B_c(L_1)$ for which flux values can be determined for $L = L_2$ only. Interpolation at constant B/B_0 removes the region $B < B_0(L_1)$, but the problem remains at the cutoff. With the technique described in the previous paragraph, however, the interpolation is performed in a completely general fashion without restriction on B/B_0 or B. In addition, the Kluge and Lenhart scheme is inaccurate for low L values where the equatorial B value is quite different from one L grid point to the next.

In the following paragraphs, a brief description of the main program and subroutines of Program MODEL and their restrictions is given in the order in which they are called.

MAIN

MAIN performs the I/O function of Program MODEL and offers a variety of options to the user for inputting B, L, and E. These options are described fully in Section 3B. The variable retrieved by the interpolation subroutines is omnidirectional integral flux with units particles/cm^2-sec.

The radial profile and spectra for each model have been smoothed at grid points, and each model provides fluxes down to 1 particle/cm^2-sec. Smaller fluxes are defined as zero. MAIN is able to determine average differential flux in particles/cm^2-sec-MeV for limited energy ranges. An infinite number of grid energies would be required to determine smooth point differential fluxes, and practical limits on the energy bandwidth result from the finite number of grid energies stored (Figure 22). These practical limits are determined by imposing the restrictions that the resulting differential spectra and radial profiles must remain smooth. They are determined to be:

Protons:	$E < 1$ MeV	$\Delta E \geq 250$ keV
	$1 \leq E/(\text{MeV}) \leq 20$	$\Delta E \geq 1$ MeV
	$20 < E/(\text{MeV}) \leq 50$	$\Delta E \geq 5$ MeV
	$E > 50$ MeV	$\Delta E \geq 10$ MeV

Inner Zone Electrons:	$E < 100$ keV	$\Delta E \geq 50$ keV
	$100 \leq E/(\text{keV}) \leq 250$	$\Delta E \geq 100$ keV
	$E > 250$ keV	$\Delta E \geq 200$ keV

Outer Zone Electrons: same as inner zone electrons except

$E > 4$ MeV $\quad \Delta E \geq 100$ keV

An additional restriction is given for AE-5 as $L \geq 1.2\ R_e$. MAIN tests that these conditions are satisfied and disallows smaller energy intervals than those shown above.

Program MAIN supplies the interpolation routines with the particle type, a single B and L value, and an array of energies. Multiple B and L values are obtained by looping within MAIN.

Subroutine TYPE

Subroutine TYPE is primarily a buffer routine between MAIN and the interpolation subroutines that facilitates the incorporation of program MODEL into existing programs (Section 3B). In addition, TYPE determines the model to be accessed and converts from logarithm of the flux to flux.

Subroutine TRARA1

Subroutine TRARA1 determines the grid energies to be retrieved and performs the energy interpolation.

Subroutine TRARA2

Subroutine TRARA2 determines the grid L values to be retrieved and performs the B/B_0-L interpolation shown in Figure 23.

BLOCK DATA Statements

The BLOCK DATA statements contain the grid B/B_0, L, and E points stored for each model and shown in Figure 22. Three BLOCK DATA statements are included, one for each model (see Section 3B for removal of unneeded models). The format of the BLOCK DATA statements is shown in Figure 21 for an arbitrary grid energy E. The format is repeated for each grid energy. The variables E, L, F_0, and $\delta(B/B_0)$ are scaled such that they can be stored in the BLOCK DATA statements with an I6 format. The first number N of each grid energy E_i is the total number of points in the BLOCK DATA statement corresponding to that energy. A general flux versus B/B_0 curve, J_j versus $(B/B_0)_j$, corresponding to $L = L_j$ is represented by the number of elements N_j at L_j, the L value L_j, the decadic logarithm of the equatorial flux, F_0, and n_j B/B_0 increments where $N_j = n_j + 3$. This format is repeated for each grid L value. The first two and the last L values stored are end points having $F_0 = 0$.

Subroutine DIFF

Subroutine DIFF accumulates the average differential flux for writing out by MAIN.

B. Use of Program MODEL

Versions of the Fortran program MODEL that are suitable for operation on IBM 360 series or UNIVAC 1108 computers can be supplied to a user. Source deck setups for operation on these machines are shown in Figure 24. For operation with source decks, approximate CPU times are 6 minutes (IBM 360/75) and (UNIVAC 1108) for 2.5 x 10^4 points in B-L-E space. Reductions in CPU compile time are obtained if Program MODEL is executed with object BLOCK DATA statements. Because of variations in compiler speed, the actual savings are machine dependent. For the Fortran G compiler on the IBM 360/75 at the Goddard Space Flight Center, a reduction of a factor of 7 in CPU compile time is obtained for 2.5 x 10^4 B-L-E points. In general, however, a factor of 2 reduction may be more typical. Combined object and source deck setups are shown in Figure 24.

Program MODEL offers the user a number of options determined by the data cards described in the following paragraphs.

Card Number	Variable Name	Columns	Format	Function
a		1-18	6I3	
	NE	1-3	I3	Number of energies. Maximum NE = 9 for line printer output (IPUN = 0) and NE = 5 for card output (IPUN = 1). Program terminates for NE = 0.
	NL	4-6	I3	Number of L values. Maximum NL = 100 limited by DIMENSION statements only.

Card Number	Variable Name	Columns	Format	Function
	MTYPE	7-9	I3	Particle type. MTYPE = 2 for electrons. MTYPE = 1 for protons.
	IDIFF	9-12	I3	Determines type of tabular output. IDIFF = 0 for integral flux output, IDIFF = 1 for average differential flux, and IDIFF = 2 for both. For IDIFF = 1 or 2, NDELB (card e) is restricted to 50 by DIMENSION statements.
	IDEF	13-15	I3	Determines type of B/B_0 range used. For IDEF = 0, program defaults to 25 to 30 linear B/B_0 increments over the range B_0 to atmospheric cutoff. IDEF = 1 for user input (card e).
	IPUN	15-18	I3	Determines type of output. IPUN = 0 for line printer; IPUN = 1 for card output (see also variable NE). For IPUN = 1, output variables are L, B, B/B_0, and integral flux for each input energy with format (F6.2, F8.4, F8.3, 5(1PE10.3).
b		1-63	9F7.3	
	E		F7.3	Energy (MeV) array of length NE (card a). Energies can be input in any order (see final paragraph, Section 3B). If average differential flux is required (IDIFF = 1 or 2, card a), this is determined in the interval E(I1) to E(I + 1) after the E array has been sorted into ascending order.

Card Number	Variable Name	Columns	Format	Function
c to d		1-77	11F7.3	Number of cards determined by NL (card a).
	XL	1-7 8-14 etc.	F7.3	L value array of length NL (card a). L values can be input in any order.
e to f		1-23	2E10.3,I3	These cards are omitted for IDEF = 0 (card a). For IDEF = 1, one card is required for each L value.
	B01	1-10	E10.3	Lower limit of B/B_0 required.
	B02	11-20	E10.3	Upper limit of B/B_0 required for NDELB $\neq$ 1. For NDELB = 1, B02 is the required B/B_0 increment, and the upper limit of B/B_0 corresponds approximately to atmospheric cutoff.
	NDELB	21-23	I3	Number of B/B_0 intervals required between B01 and B02 for NDELB $\neq$ 1. For NDELB = 0, program defaults to NDELB = 20.
g		1-18	6I3	As card a. Program terminates for NE = 0.

A summary of the data setup is shown in Figure 25.

Sample integral and differential flux tables are shown in Figure 26 obtained with the variables NE = 9, NL = 1, MTYPE = 2, IDIFF = 2, IDEF = 0, E = 0.05, 0.1, 0.25, 0.5, 1.00, 1.25, 1.5, 1.75, 2.0, and XL = 1.7. In addition to the output shown, a number of messages may be printed in association with the model restrictions described in Section 3A. If at a given L value no flux is found greater than 1 particle/cm^2-sec or cm^2-sec-MeV, a message is written to that effect.

In addition, messages are given if the average differential flux cannot be accurately determined because the L value is less than 1.2 or because the energy interval input is too small.

If all BLOCK DATA statements are not required for regular usage of Program MODEL, the unneeded models can be removed by removal of (a) the appropriate BLOCK DATA statement in which the model is identified by the variable NAME, (b) the associated COMMON blocks from MAIN, and (c) the associated calls to subroutine TRARA1 made from subroutine TYPE and identified by comment cards. The operation of Program MODEL remains as described above.

Program MODEL is designed to be easily incorporated into existing programs. A single call to subroutine TYPE is required in the existing program:

```
CALL TYPE(MTYPE, B, FL, NE, E, FLUX)
```

where E, the energy array in MeV, and FLUX, the integral omnidirectional flux array returned by TYPE for these energies, must be dimensioned to NE in the existing program. In the calling argument for TYPE, MTYPE is the particle type as described in card a, and B and FL are, respectively, the required magnetic field strength in gauss and the L value in earth radii. The variable FLUX has units of particles/cm^2-sec and has been equated to zero for fluxes of less than 1 particle/cm^2-sec. A single additional restriction is imposed upon the user as a consequence of the interpolation algorithm used in subroutine TRARA. The energy E must be supplied to subroutine TYPE as an ascending array.

4. PROGRAM ORP

The Orbital Radiation Program (ORP) is a Fortran program designed to calculate the average geomagnetically trapped radiation accumulated by an orbiting vehicle. ORP is a substitute for Program TRECO, previously issued by NSSDC (Lucero, 1968), and differs from that program in three respects. First, ORP requires B and L coordinates for the satellite orbit. Programs for the calculation of the B and L coordinates from latitude, longitude, and altitude can be supplied by NSSDC (King, 1971). Secondly, ORP uses Program MODEL, described in Section 3, for determining the particle omnidirectional integral flux along the orbit. As noted in Section 3, Program MODEL is general and will be able to contain new particle models, as they become available, with only minor modification. Finally, ORP does include an orbit generation facility.

ORP is able to generate the following tabular output.

Table 1	Intermediate Printout - a point by point printout of the omnidirectional integral flux at each point of the orbit for a given threshold energy.
Table 2	L-Band Summary - a summary of the omnidirectional particle flux (particles/cm^2-day) accumulated in arbitrary energy and L bands.
Table 3	Integrated Flux - a summary of the integrated flux accumulated in arbitrary energy bands.
Table 4	Intensity Summary - a summary of the omnidirectional particle flux accumulated in arbitrary energy and intensity bands.
Table 5	Peak Flux per Orbit - a table of peak omnidirectional integral flux encountered for each revolution for a given energy threshold.
Table 6	Standard Circular Orbits - a summary of omnidirectional fluxes (particles/cm^2-day) to be used only for standard circular orbits for four inclinations at a given altitude. This information may also be written on tape.

Any combination of the above tables may be obtained for a given program run with the restriction that the arbitrary energy bands are fixed for a given run. Examples of these tables are shown in Figure 27.

A. Program Logic

MAIN

ORP uses inputted logical controls to determine the types of tabular output to be presented. A search on the input tape (Section 4B) is initiated to locate the first of the orbits needed. ORP loops to determine the flux for each point along this orbit. The Intermediate Printout table is written out in this loop. At the end of each orbit, the summary tables described in Section 4 are written out and the program proceeds to the next orbit or terminates. Each new orbit data set must follow the previous set on the tape. For the special case of standard circular orbits at 0°, 30°, 60°, and 90° inclination, MAIN writes the Standard Circular Orbits table at the end of each fourth orbit. This last output table is primarily used for presenting exposures along standard orbits for inclusion in model documentation. Examples of this table are presented by Singley and Vette (1972) in the documentation for the outer zone electron environment AE-4.

Subroutines TYPE, TRARA1, TRARA2, and BLOCK DATA Statements

These subroutines are identical to the ones previously described in Section 3A and are the interpolation subroutines and model matrices providing omnidirectional integral flux at the B-L-E points supplied to TYPE by MAIN.

Subroutine STORE

Subroutine STORE accumulates integral fluxes in L bins for the L-Band Summary table. The L-bins are specified by the IF statements in subroutine STORE.

Subroutine FLITAB

Subroutine FLITAB accumulates integral fluxes in intensity ranges for the Intensity Summary table. The intensity ranges are specified by DATA statement FLXBIN in subroutine FLITAB.

Subroutine DECACC

Subroutine DECACC determines the peak integral omnidirectional flux in each revolution for a given threshold energy. This energy is user input and is the same energy as used for the Intermediate Printout table. For nonequatorial orbits, the south-north crossing of the equatorial plane is used to denote the start of each orbit. For equatorial orbits, a local time of zero is used. Subroutine DECACC is not accessed if altitude is zero.

Subroutine DEPRNT

Subroutine DEPRNT computes the flux accumulated per day in the user input energy bands for the L-Band Summary, Integrated Flux, and Intensity Summary tables. DEPRNT writes these tables and the Peak Flux per Orbit table.

Subroutine STAND

Subroutine STAND accumulates the omnidirectional flux per day in energy bands for the Standard Circular Orbits table and writes this table on the line printer and on tape.

B. Use of Program ORP

When Program ORP is run on an IBM 360/75 computer under MVT with the Fortran IV H, opt=2 compiler, the run time for four standard (0°, 30°, 60°, and 90° inclination) orbits of 1440 data points each is approximately 2 minutes CPU and 0.5 minutes I/O time using object BLOCK

DATA statements. As noted in Section 3B, significant savings in CPU time are obtained by using object rather than source decks on a 360/75. The execution step used approximately 150K bytes of storage with the two electron models included. A sample deck setup is shown in Figure 28 for combined object and source decks.

The orbit information is input to Program ORP using tape input with data set reference unit number 10 (see Figure 28). Each orbit is preceded by an alphanumeric header record of up to 76 characters in length that describes the orbit and is written out in Tables 1 through 5 (Section 4A). The header record is followed by data records giving standard geocentric and B and L coordinates for each time. Each record contains the following data in E format: longitude, latitude, altitude, B, L, and time in hours since start of orbit. An altitude of -100 denotes the end of an orbit. The B and L coordinates are mandatory, but the latitude, longitude, and altitude information is optional unless the Peak Flux per Orbit table is required. These variables should be set to zero or left blank if actual values are not to be supplied. The input tape format is as follows:

Header Record (one per orbit)

Variable Name	Format	Function
HEAD	19A4	Alphanumeric Orbit Description

Data Record (one per point on orbit)

Variable Name	Format	Function
ORBVAL (1)	E18.8	Longitude (degrees)
ORBVAL (2)	E18.8	Latitude (degrees)
ORBVAL (3)	E18.8	Latitude (km)
ORBVAL (4)	E18.8	B (gauss)
ORBVAL (5)	E18.8	L (earth radii)
ORBVAL (6)	E18.8	Time (hours from start of orbit)

Trailer Record

Variable Name	Format	Function
ORBVAL (3)	E18.8	Set equal to -100 to signal end of orbit. Other ORBVAL variables are not important for this final record.

The various options of Program ORP may be obtained by use of the data deck setup described in the following paragraphs.

Card Number	Variable Name	Columns	Format	Function
a		1-70	10L1,10A4, I3,F6.2, 10X,I1	
	TABCON(1)	1	L1	TABCON(1) = T for Intermediate Printout table, F for no table.
	TABCON(2)	2	L1	TABCON(2) = T for L-Band Summary table, F for no table.
	TABCON(3)	3	L1	TABCON(3) = T for Integrated Flux table, F for no table.
	TABCON(4)	4	L1	TABCON(4) = T for Intensity Summary table, F for no table.
	TABCON(5)	5	L1	TABCON(5) = T for Peak Flux per Orbit table, F for no table.
	TABCON(6)	6	L1	TABCON(6) = T for Standard Circular Orbit table, F for no table.
	TABCON(7)	7	L1	TABCON(7) = T for tape output of Standard Circular Orbit table, F for no table.
	TITLE	11-50	10A4	Alphanumeric array for writing at top of first page.

Card Number	Variable Name	Columns	Format	Function
	NE	51-33	I3	The number of integral energy values input. Maximum NE = 30.
	ET	54-59	F6.2	The threshold energy (MeV) used for the Intermediate Printout and Peak Flux per Orbit tables. ET may be omitted if these tables are not required.
	MODEL	70	I1	Particle Type. MODEL = 2 for electrons, 1 for protons. Appropriate BLOCK DATA statements must be included (Section 3).
b to c		1-80	10(F6.2,2X)	Number of cards determined by NE. Ten values per card.
e		1-6	F6.2	Energy threshold array of length NE.
		9-14, etc.		Must be in ascending order. For tabular output Tables 2, 3, 4, and 6 (Section 4A) the energy intervals E(I+1) to E(I) are subject to the restrictions given in Section 3A under MAIN. This function is not performed automatically by ORP.
d		1-4	2I2	
	IORB(1)	1-2		Index number for the first orbit required on the input tape. The first orbit is IORB(1) = 1.

Card Number	Variable Name	Columns	Format	Function
d (cont'd)	IORB(2)	3-4	I2	Index number for last orbit required on the input tape. If this tape contains a single orbit, IORB(2) may be left blank.

A summary of the data setup is given in Figure 29.

ACKNOWLEDGMENTS

Our thanks are due to Professor Winckler and Dr. Pfitzer for providing data from the OGO 1 and OGO 3 satellites, to Dr. Bostrom for the 1963-38C data, to Dr. Vampola for the OV3-3 data, and to Professor McIlwain for the Explorer 26 data. In addition, we express our appreciation to Dr. Vampola and Dr. Pfitzer, who provided valuable assistance in incorporating their data into AE-5 and who reviewed this document and recommended several improvements. Our thanks are also due to Mrs. Susan Smith, who acted as Technical Writer for the first section of this document and Editor for the remaining sections.

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3. Kluge, G., and K. G. Lenhart, "A Unified Computing Procedure for Trapped Radiation Models," ESOC Internal Note. 78, March 1971.

4. Lucero, A. B., "TRECO, An Orbital Integration Computer Program for Trapped Radiation," Data Users' Note, NSSDC 68-02, 1968.

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Table 1. Omnidirectional Flux Confidence Limits

Code	B Range	L Range	E_- Range	Section	Comment
1	$>B_o$	1.2-1.4	>3 MeV	4	Extrapolation on both B dependence and spectrum, no data
2	$\sim B_o$	1.2-1.4	>3 MeV	4	Extrapolation on spectrum, no data
4	$\geq B_o$	1.2-1.7	>250 keV	6B	Possible presence of Starfish electrons
5	$\geq B_o$	1.9-1.4	4-2 MeV	4	Magnetic storm effects, single data set, B extrapolation
6	$>B_o$	1.7-1.9	>500 keV	4	Single data set, B extrapolation
6	$\geq B_o$	< 1.25	all energies	5	L extrapolation
6	$\sim B_o$	>1.5	all energies	3	Poor data
7	$\geq B_o$	1.3	all energies	3	Poor OGO data
8	$>>B_o$	>2	all energies	3	Poor pitch angle coverage
10	$\geq B_o$	1.4-1.9	< 250 keV	3	Agreement between three data sets

Table 2. Solar Cycle Parameter Confidence Limits

Code	L Range	E_T	T Range	Section	Comment
3	<1.8	250,500	>22	6B	Significant Starfish flux at T=22 resulting in iteration
4	>1.9	all	all	3	Poor OGO data at high L values
4	all	40	all	6A	Small R_T values; data standard deviation becomes significant.
5	<1.4	250,500	all	6B	Hardening of spectrum; assumed constancy of j(>690) term in equation 16
5	>1.8	500	all	6A	Storm effects term in equation 17 becomes significant
7	1.6-2.0	250,500	all	6A	Two data sets available (i.e., OGO and 1963-38C)

Note that these confidence codes are low because integral flux values of R_T are determined from the OGO data using an approximate expression, and B independence has been assumed. Further, if R_T is used to extrapolate beyond the epoch of October 1967, as described in Section 7, the above confidence codes will be reduced because of asymmetries in the solar cycle.

Table 3. Cutoff Times for Starfish Electrons

L	p = 0.5				p = 0.25			
	Ch 2	Ch 3	Ch 4	Ch 5	Ch 2	Ch 3	Ch 4	Ch 5
1.4	2/65 (31) ±3	7/66 (48) ±6	3/68 (68) ±8	1/68 (66) ±7	8/65 (37)	11/66 (52)	7/69 (84)	12/68 (77)
1.5	3/65 (32) ±3	7/66 (48) ±6	9/67 (62) ±7	4/67 (57) ±6	9/65 (38)	11/66 (52)	10/68 (75)	3/68 (68)
1.6	3/65 (32) ±2	7/66 (48) ±4	9/66 (50) ±2	3/66 (44) ±2	10/65 (39)	11/66 (52)	8/67 (61)	2/67 (55)
1.7	4/65 (33) ±2	2/66 (43) ±3	2/66 (43) ±2	~10/65 (39) ±2	12/65 (41)	8/66 (49)	8/66 (49)	~4/66 (45)
1.8	3/65 (32) ±2	2/66 (43) ±3	ND	< 12/64 (< 29)	10/65 (39)	6/66 (47)	ND	< 12/64 (< 29)
1.9	1/65 (30) ±2	11/65 (40) ±3	ND	< 12/64 (< 29)	9/65 (38)	4/66 (45)	ND	< 12/64 (< 29)
2.0	1/65 (30) ±2	ND	ND	< 12/64 (< 29)	7/65 (36)	ND	ND	< 12/64 (< 29)
2.2	10/64 (27) ±2	ND	ND	< 12/64 (< 29)	2/65 (31)	ND	ND	< 12/64 (< 29)

$p = j_{st}/j$

ND denotes no data because of magnetic storm effects or no measurements.

Figures in parentheses represent months from Starfish injection.

Channel	Energy Range (keV)
2	133-292
3	292-690
4	690-1970
5	1970-4740

Figures 1-7. These computer-generated plots present carpet plots of the AE-5 omnidirectional flux as functions of B and L for threshold energies E_T = 0.04, 0.1, 0.25, 0.5, 1.0, 2.0, and 4.0 MeV. A description of the use of these carpet plots is given in Appendix A of NSSDC 72-10 (Teague and Vette, 1972). In general, lines of constant B are presented in 0.02-gauss increments from the equator to 0.28 gauss, and lines of constant L are presented in increments of 0.05 earth radii for $1.2 \leq L \leq 1.6$ and increments of 0.1 earth radii for $1.6 < L \leq 2.4$. In some cases, lines are omitted for clarity. For the energies 1.0, 2.0, and 4.0 MeV, the plots are subdivided into two L ranges because of steep gradients in the radial profiles at these energies. In each figure the ordinate scale increments are shown as error bars on the left-hand side of the plot and the abscissa scale is shown as powers of ten.

FIGURE 1

AE5 OMNIDIRECTIONAL INTEGRAL FLUX, ET=40 KEV

EPOCH OCTOBER 1967

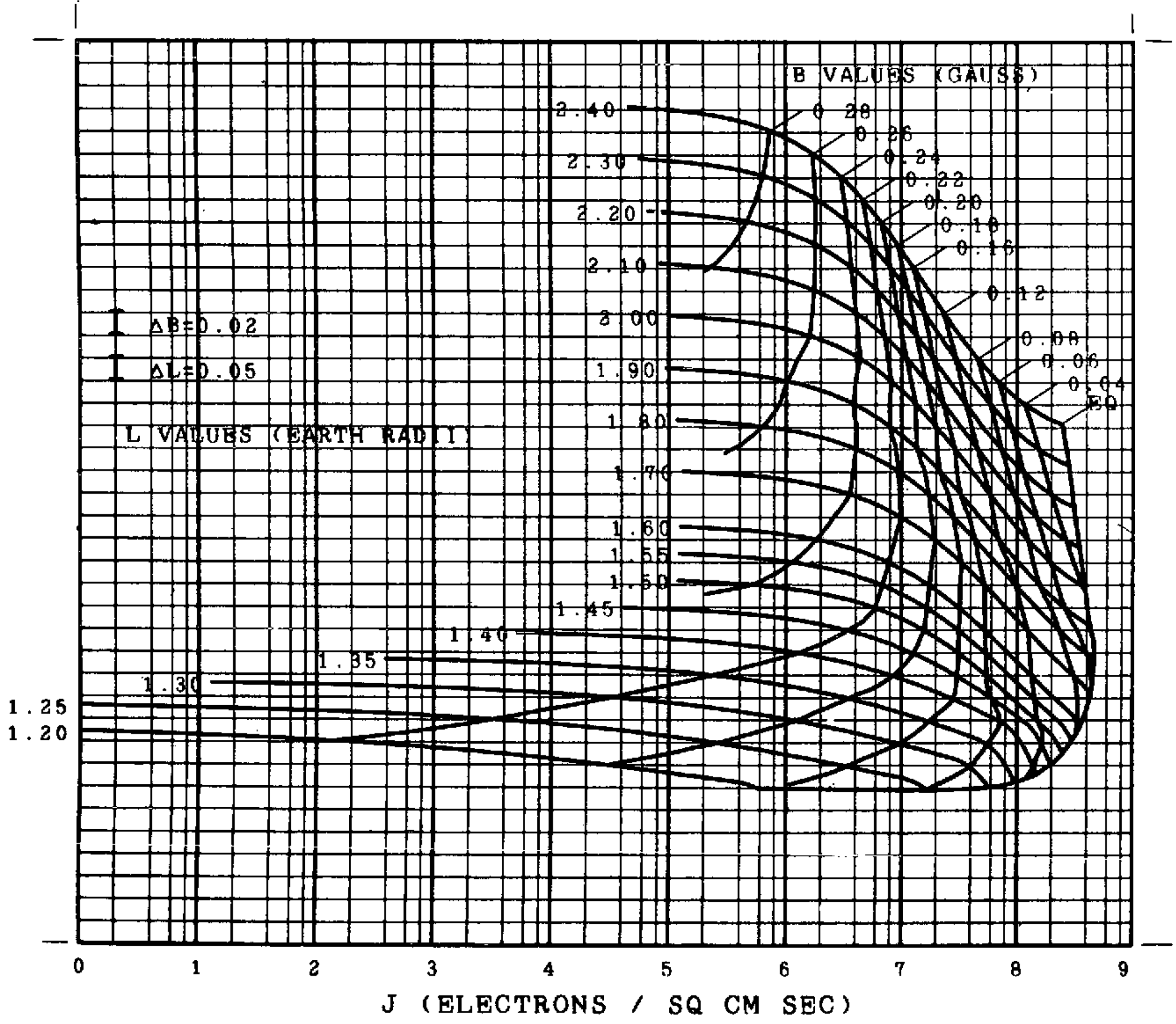


FIGURE 2

AE5 OMNIDIRECTIONAL INTEGRAL FLUX, ET=100 KEV

EPOCH OCTOBER 1967

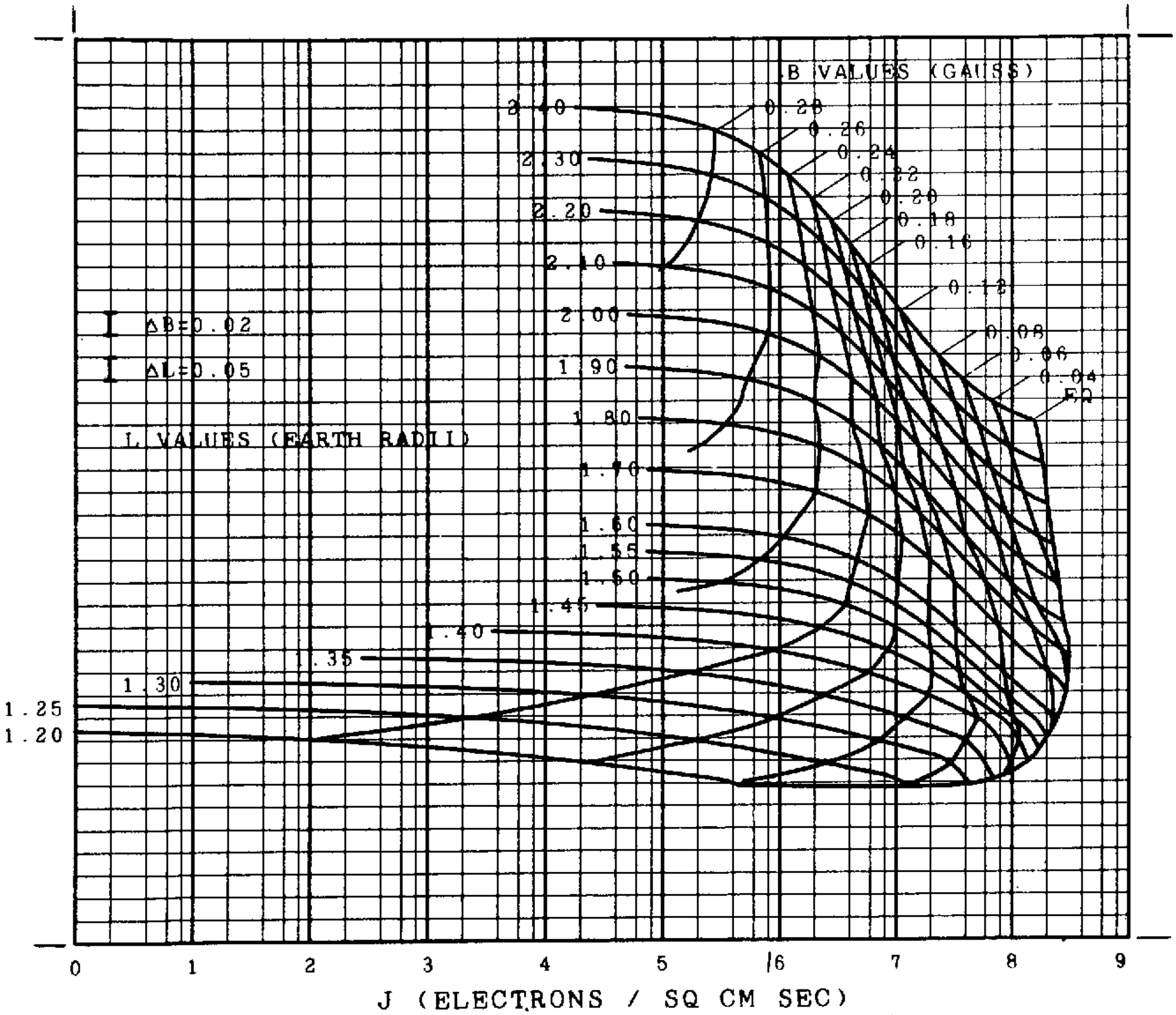


FIGURE 3

AE5 OMNIDIRECTIONAL INTEGRAL FLUX, ET=250 KEV

EPOCH OCTOBER 1967

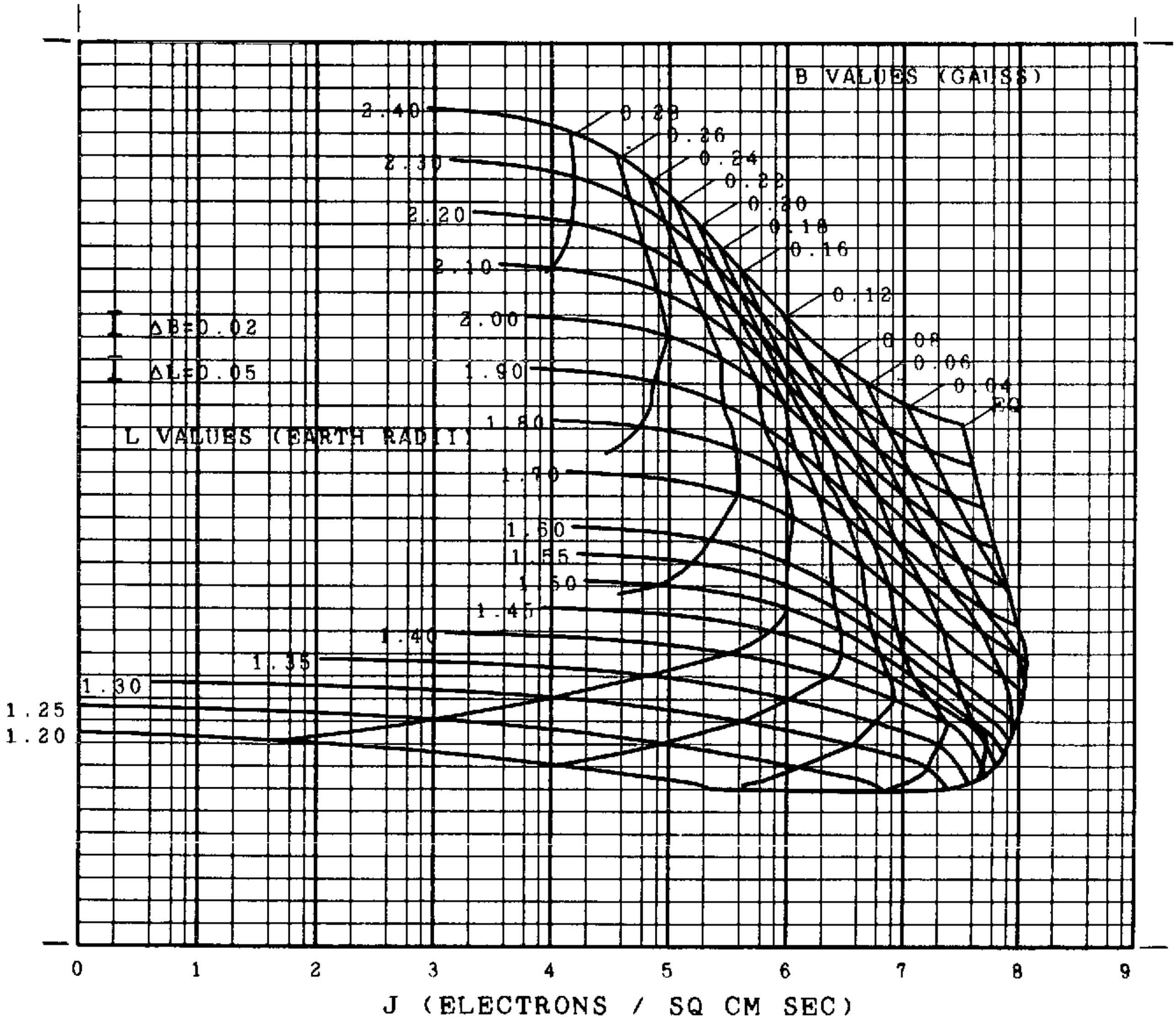


FIGURE 4

AE5 OMNIDIRECTIONAL INTEGRAL FLUX, ET=500 KEV

EPOCH OCTOBER 1967

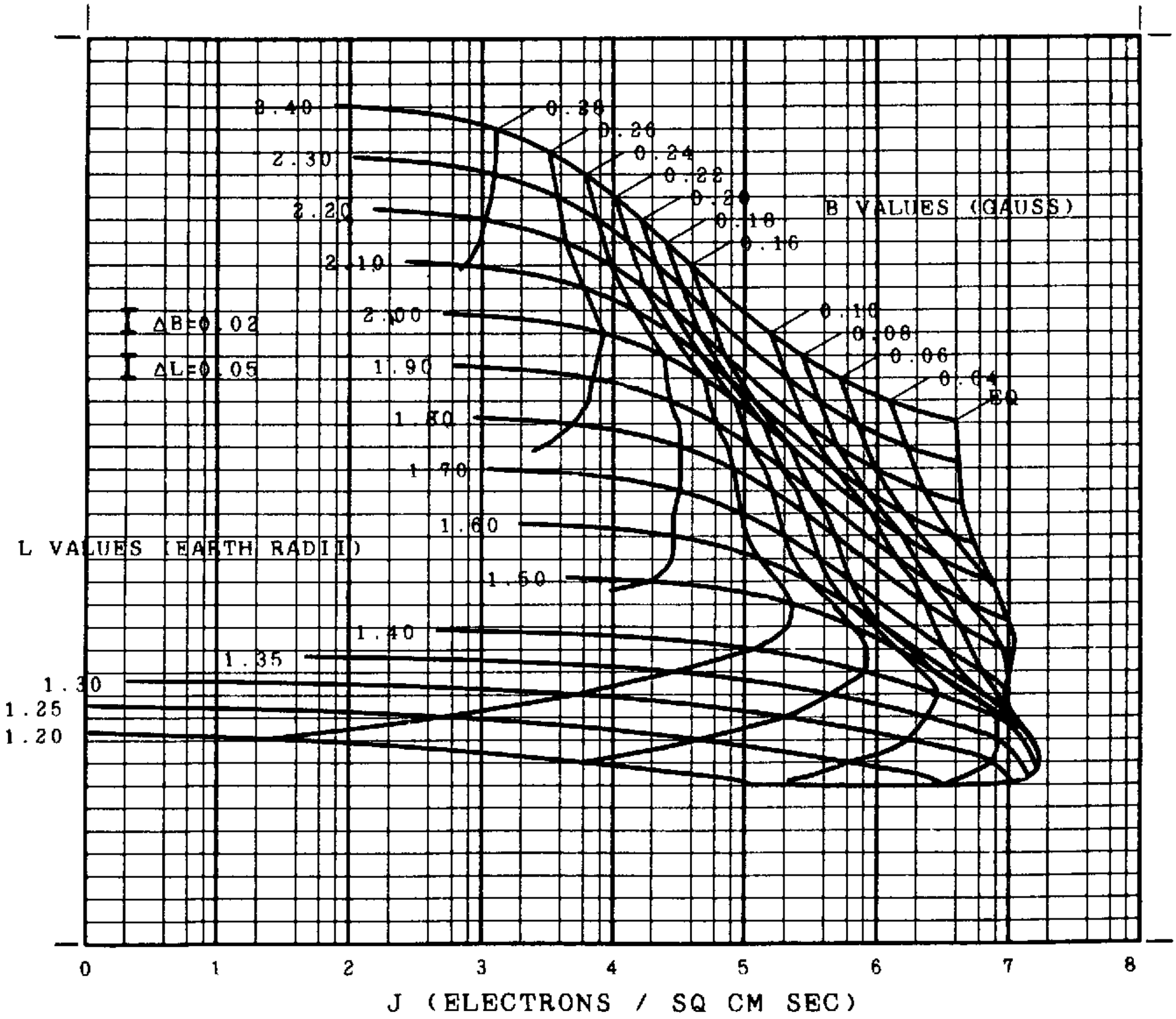


FIGURE 5

AE5 OMNIDIRECTIONAL INTEGRAL FLUX, ET=1 MEV

EPOCH OCTOBER 1967

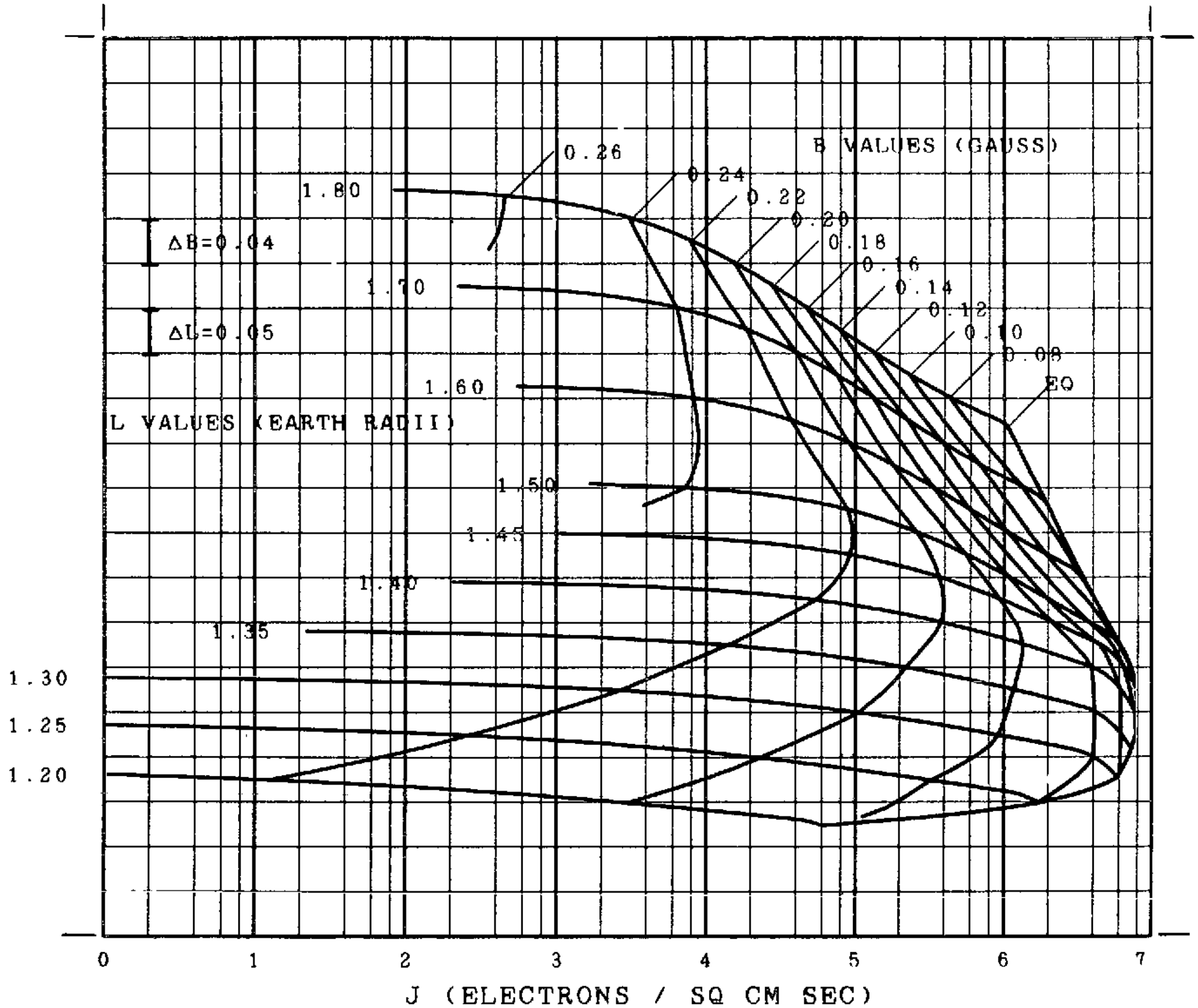


FIGURE 5 CONT

AE5 OMNIDIRECTIONAL INTEGRAL FLUX, ET=1 MEV

EPOCH OCTOBER 1967

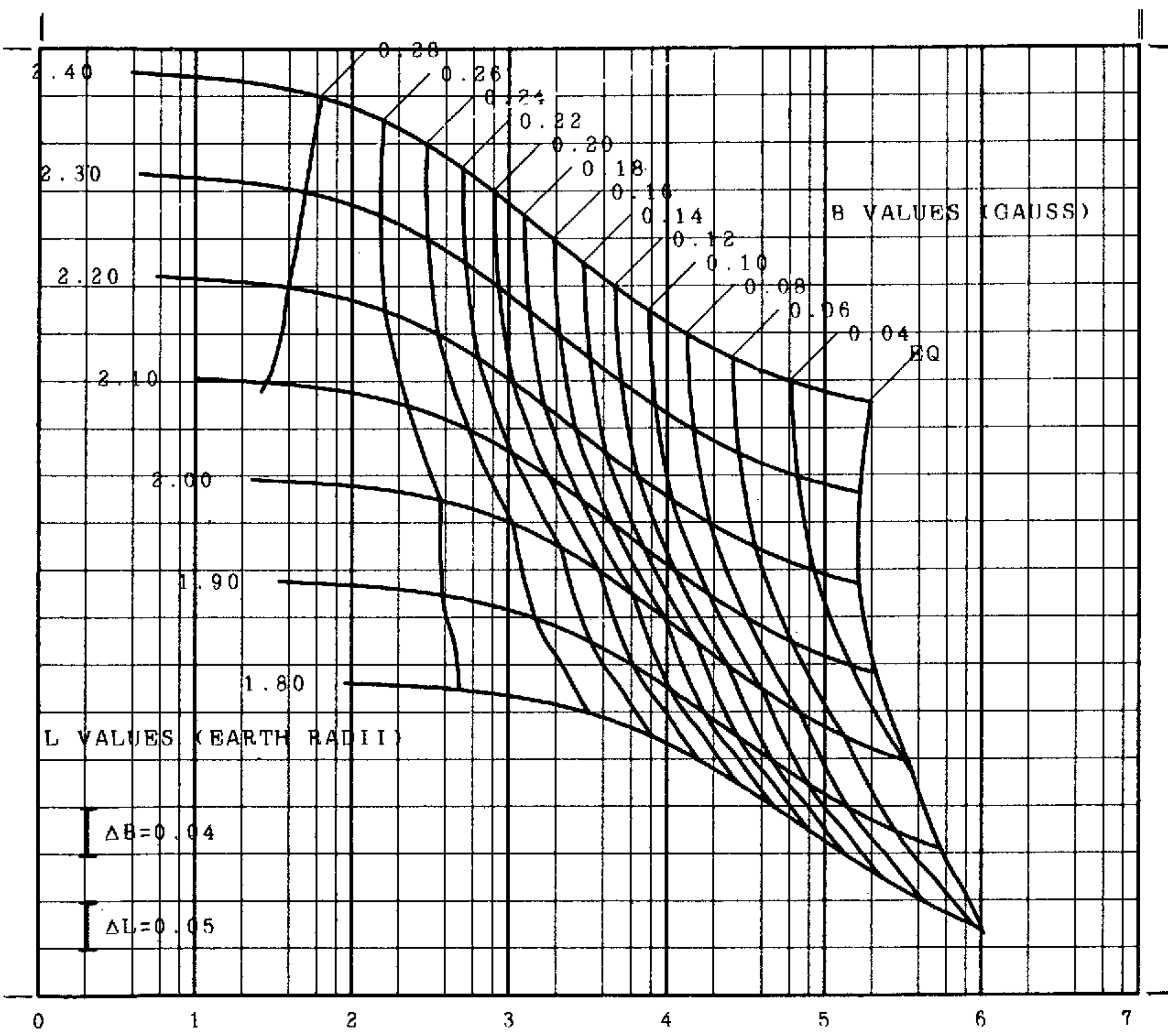


FIGURE 6

AE5 OMNIDIRECTIONAL INTEGRAL FLUX, ET=2 MEV

EPOCH OCTOBER 1967

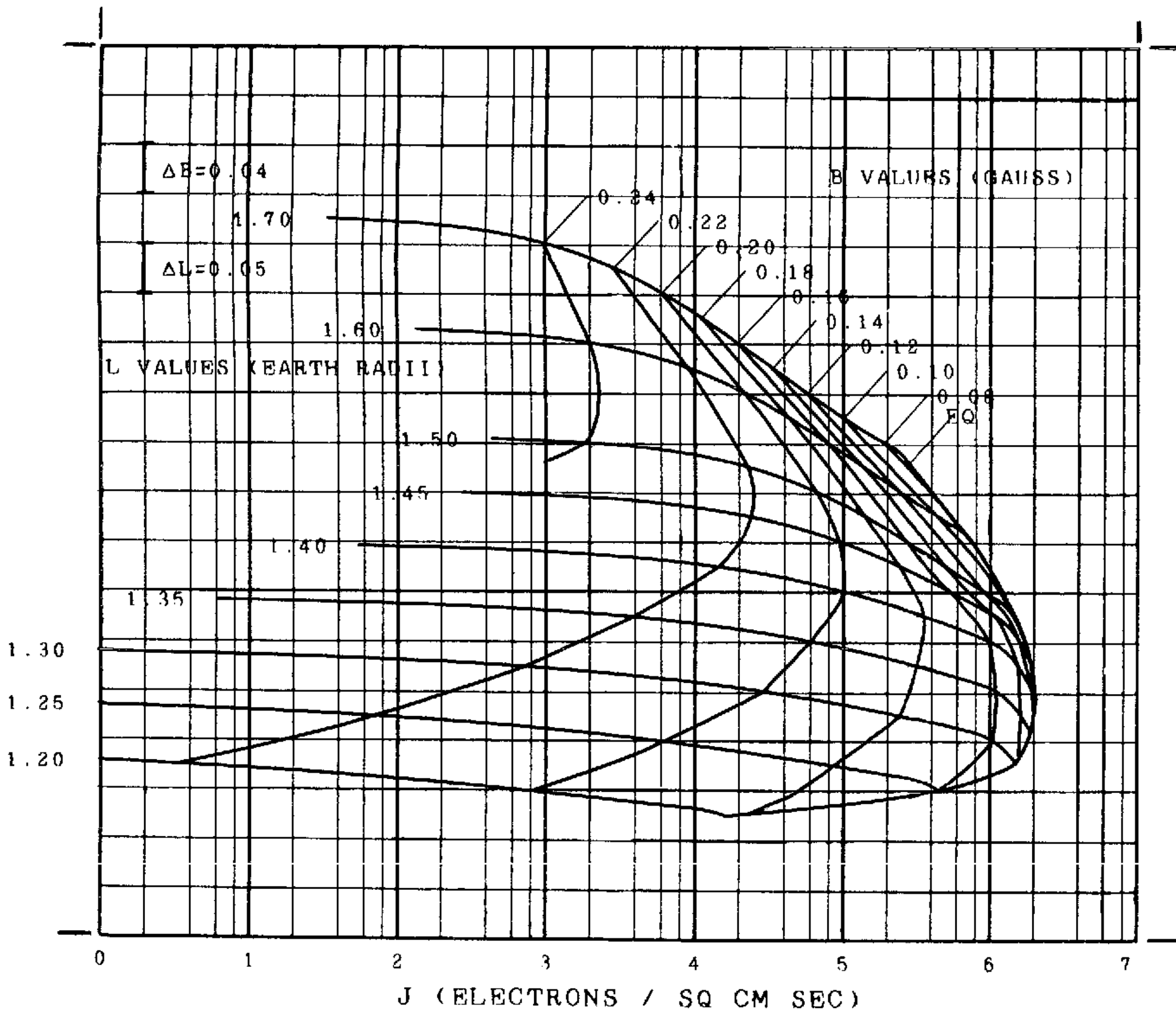


FIGURE 6 CONT

AE5 OMNIDIRECTIONAL INTEGRAL FLUX, ET=2 MEV

EPOCH OCTOBER 1967

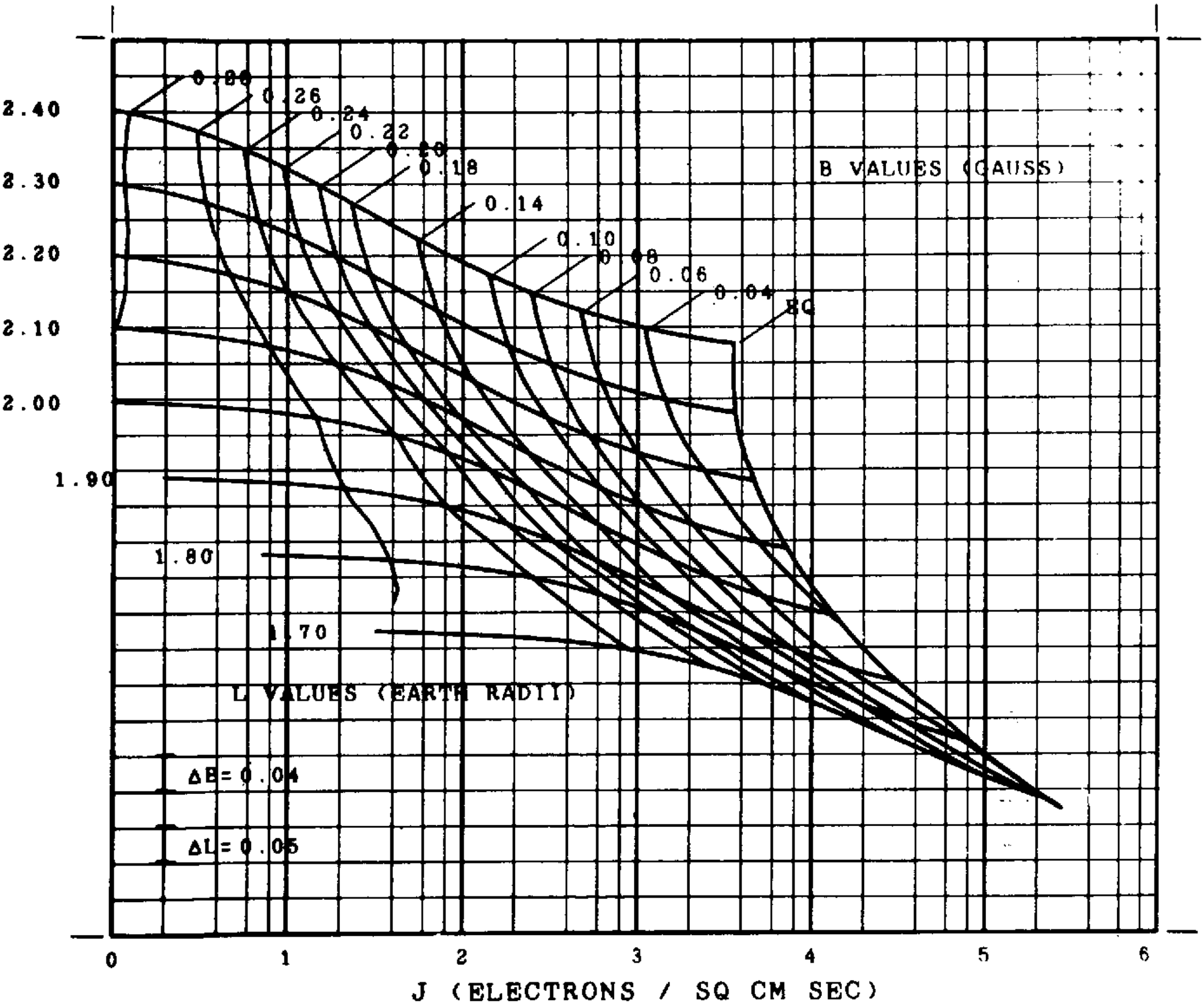


FIGURE 7

AE5 OMNIDIRECTIONAL INTEGRAL FLUX, ET=4 MEV

EPOCH OCTOBER 1967

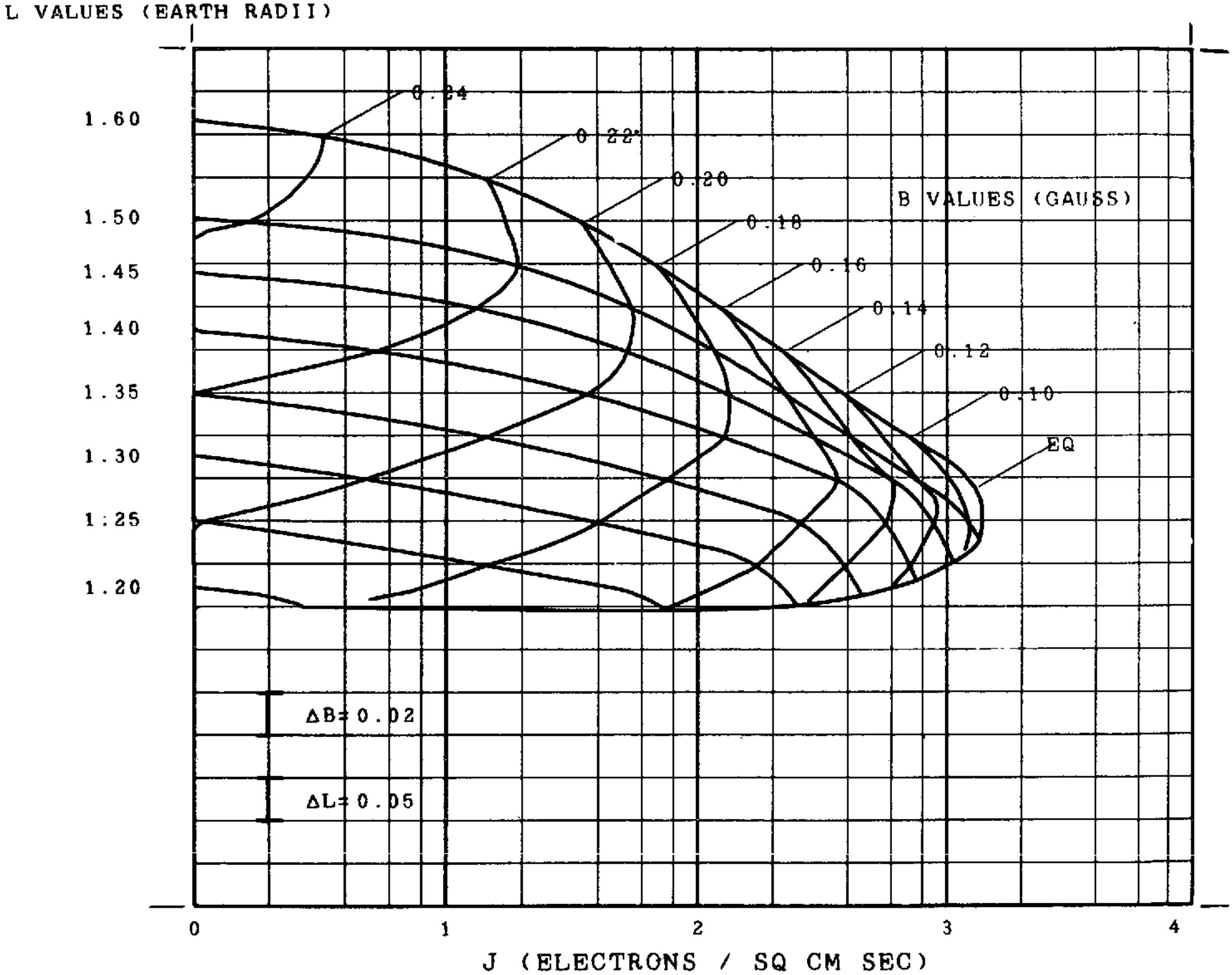
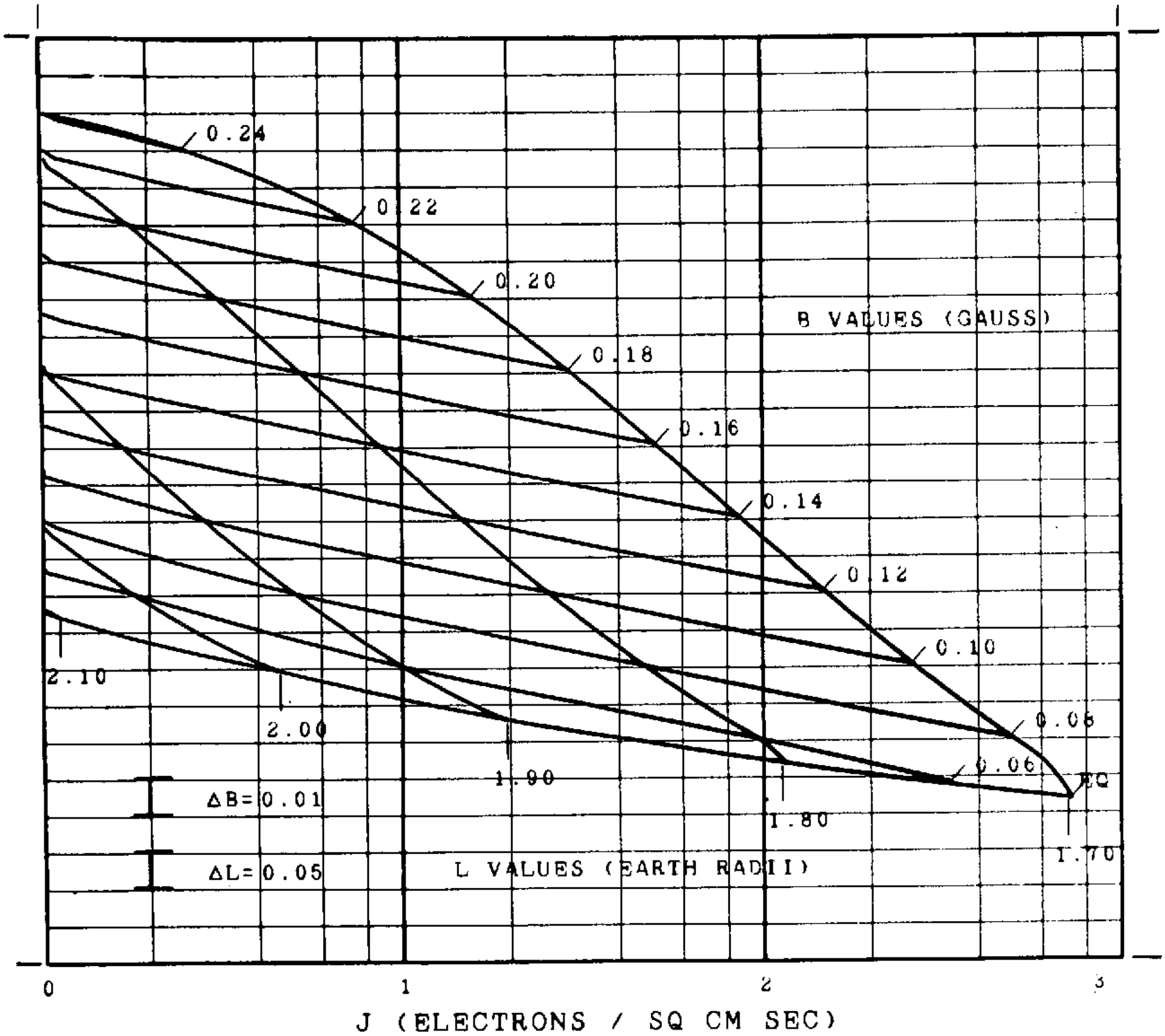


FIGURE 7 CONT

AE5 OMNIDIRECTIONAL INTEGRAL FLUX, ET=4 MEV

EPOCH OCTOBER 1967



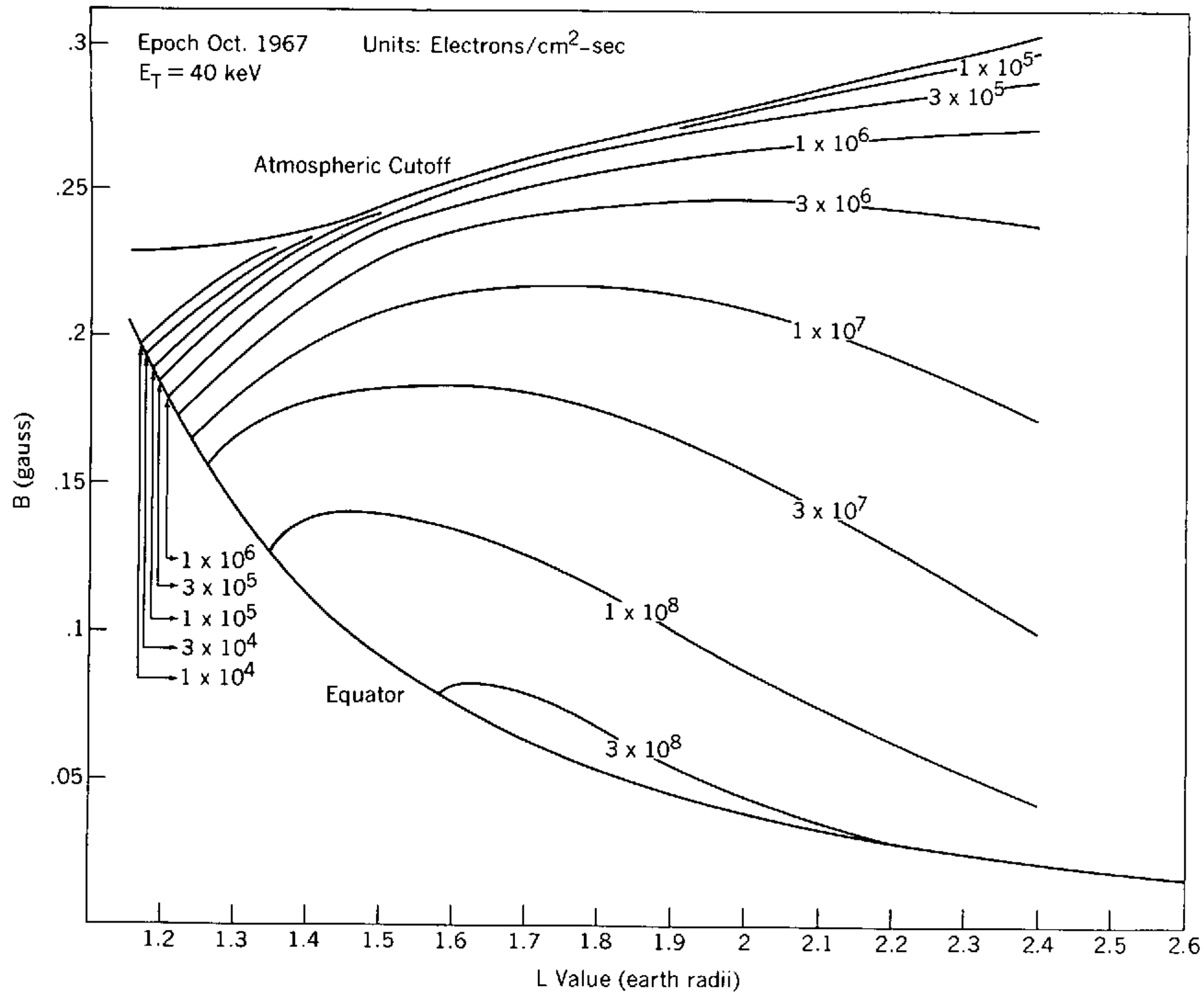


Figure 8. AE-5 B-L Flux Map

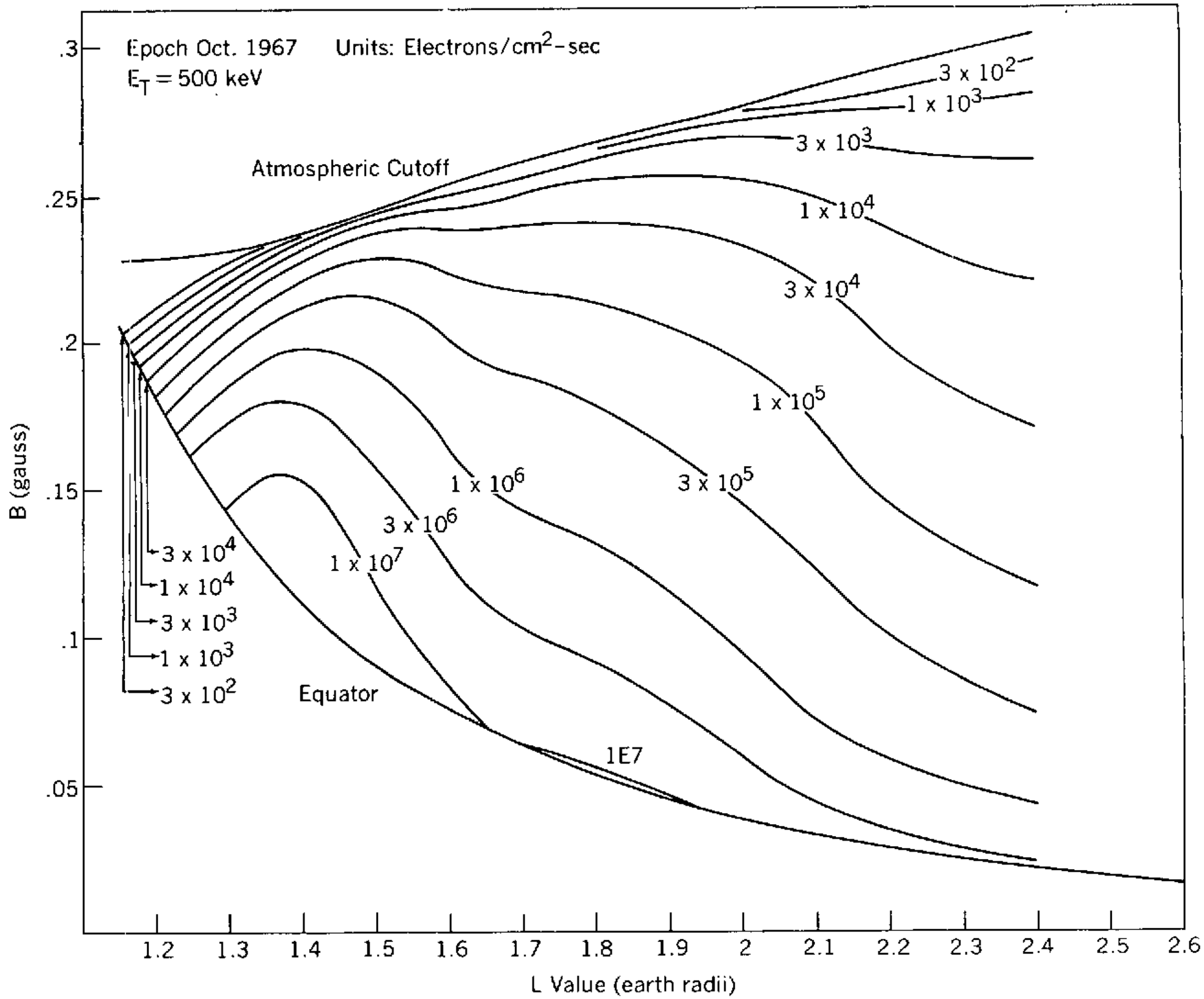


Figure 9. AE-5 B-L Flux Map

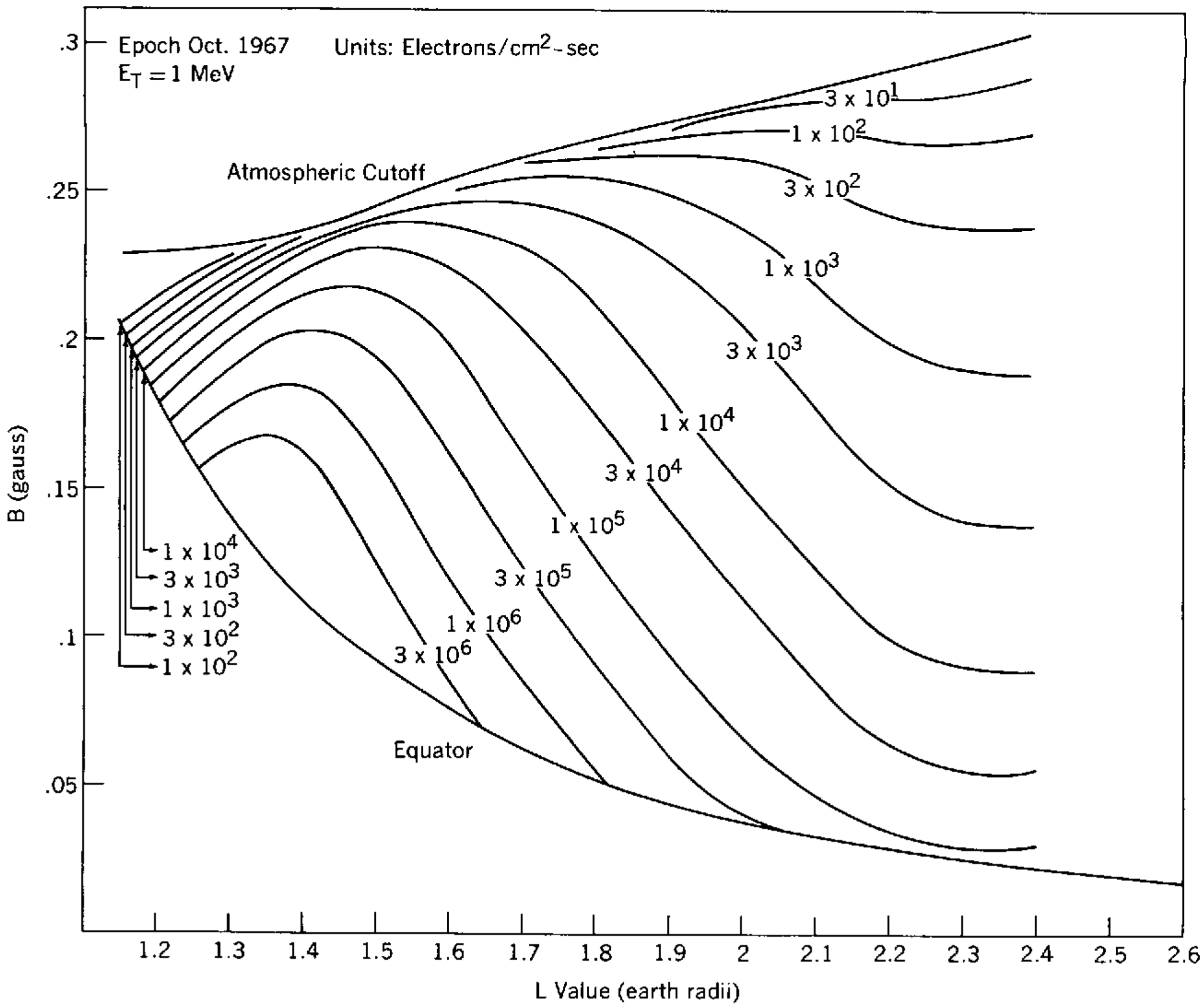


Figure 10. AE-5 B-L Flux Map

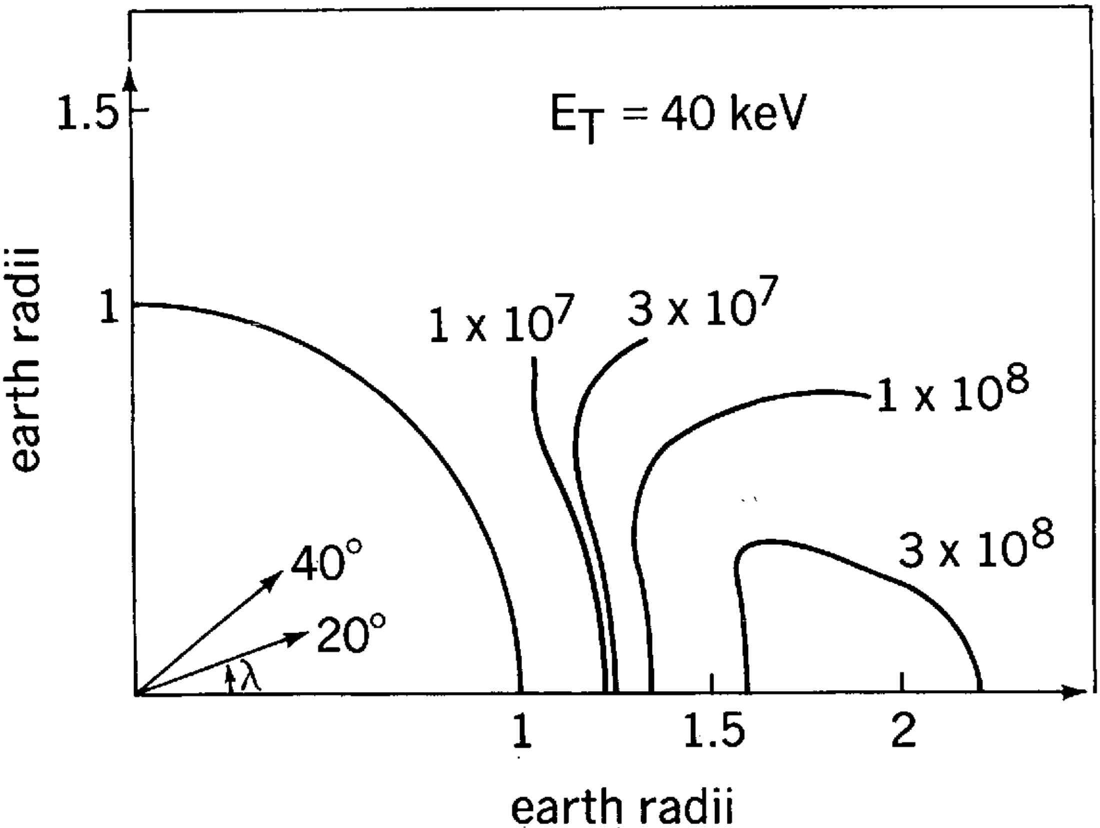


Figure 11. AE-5 R-λ Flux Map (electrons/cm²-sec)

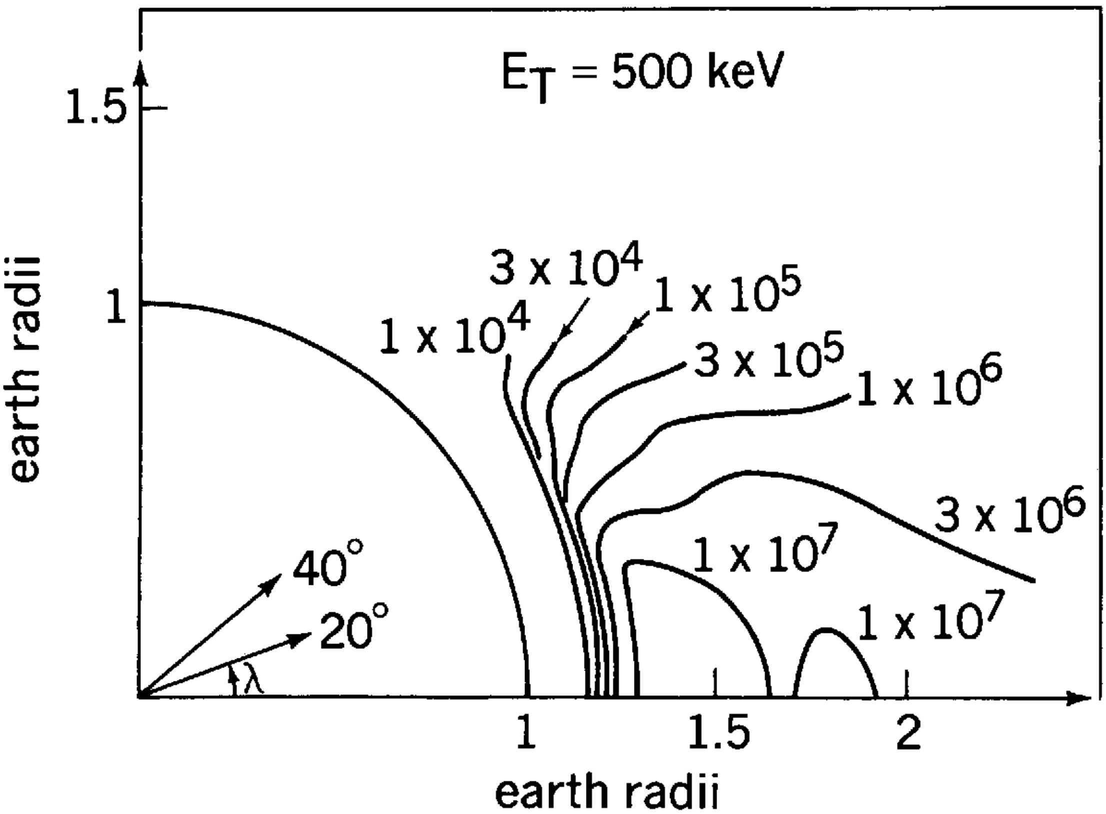


Figure 12. AE-5 R-λ Flux Map (electrons/cm^2-sec)

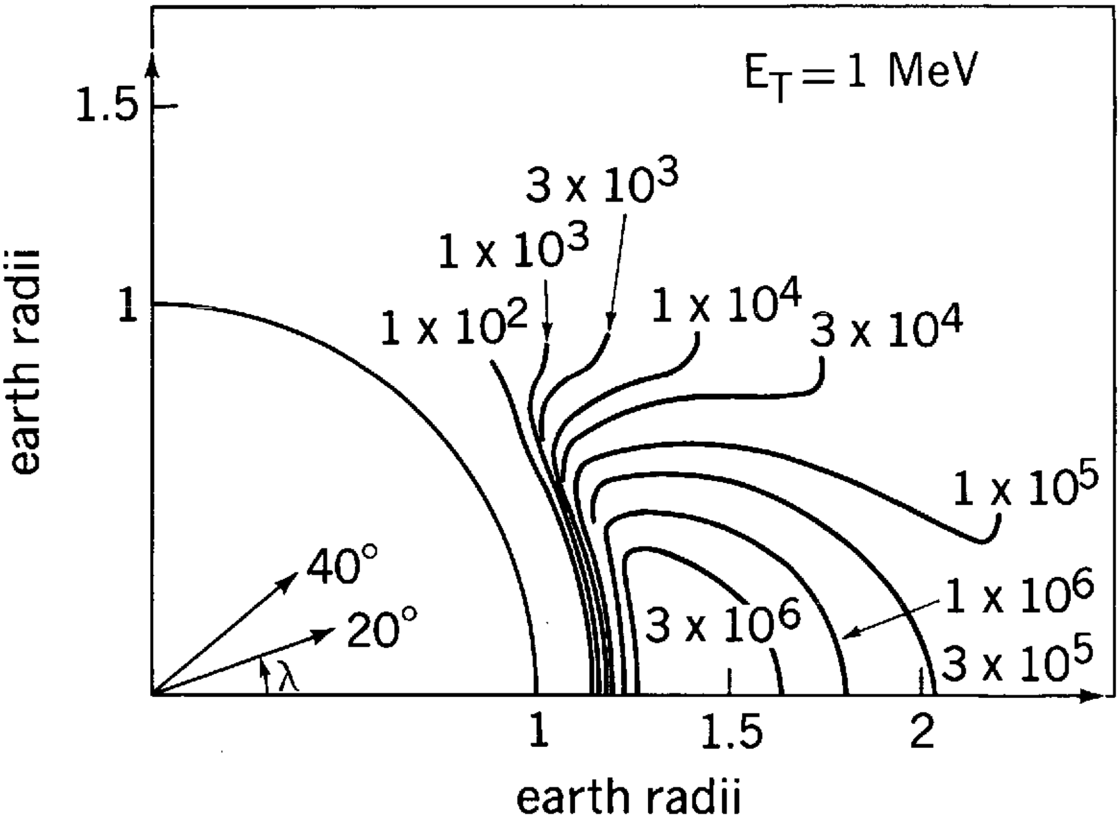


Figure 13. AE-5 R-λ Flux Map (electrons/cm²-sec)

FIGURE 14
AE5 OMNI-DIRECTIONAL INTEGRAL FLUX
GREATER THAN 40 KEV
EPOCH OCTOBER 1967

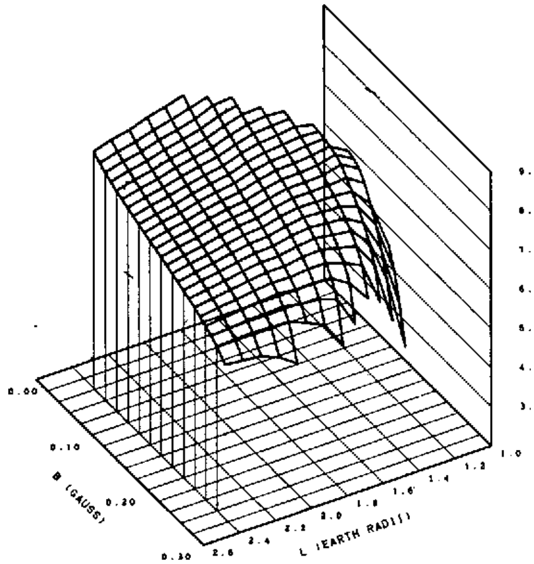
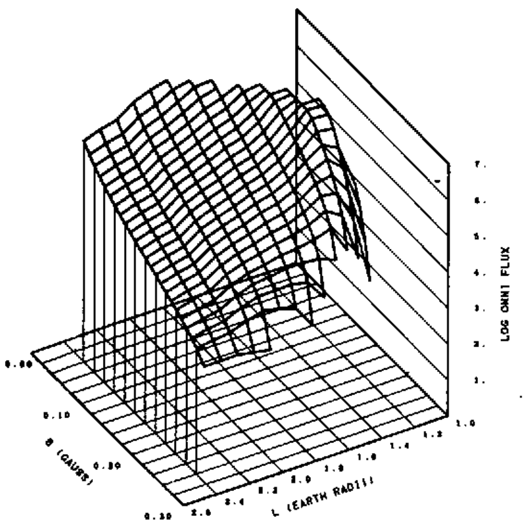
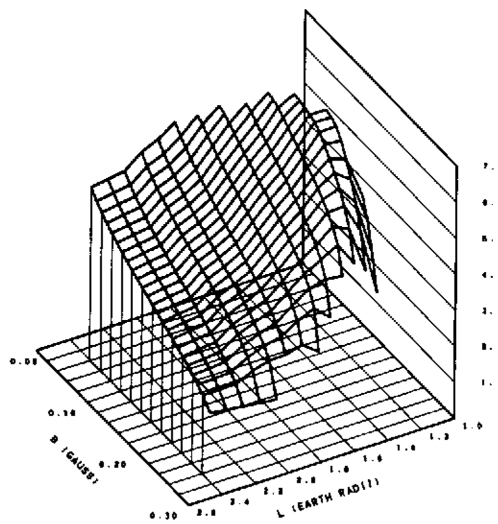


FIGURE 15
AE5 OMNI-DIRECTIONAL INTEGRAL FLUX
GREATER THAN 500 KEV
EPOCH OCTOBER 1967



FLUX UNITS - ELECTRONS/SQ CM SEC

FIGURE 16
AE5 OMNI-DIRECTIONAL INTEGRAL FLUX
GREATER THAN 1 MEV
EPOCH OCTOBER 1967



FLUX UNITS - ELECTRONS/SQ CM SEC

Figures 14-16. Three-Dimensional Flux Maps

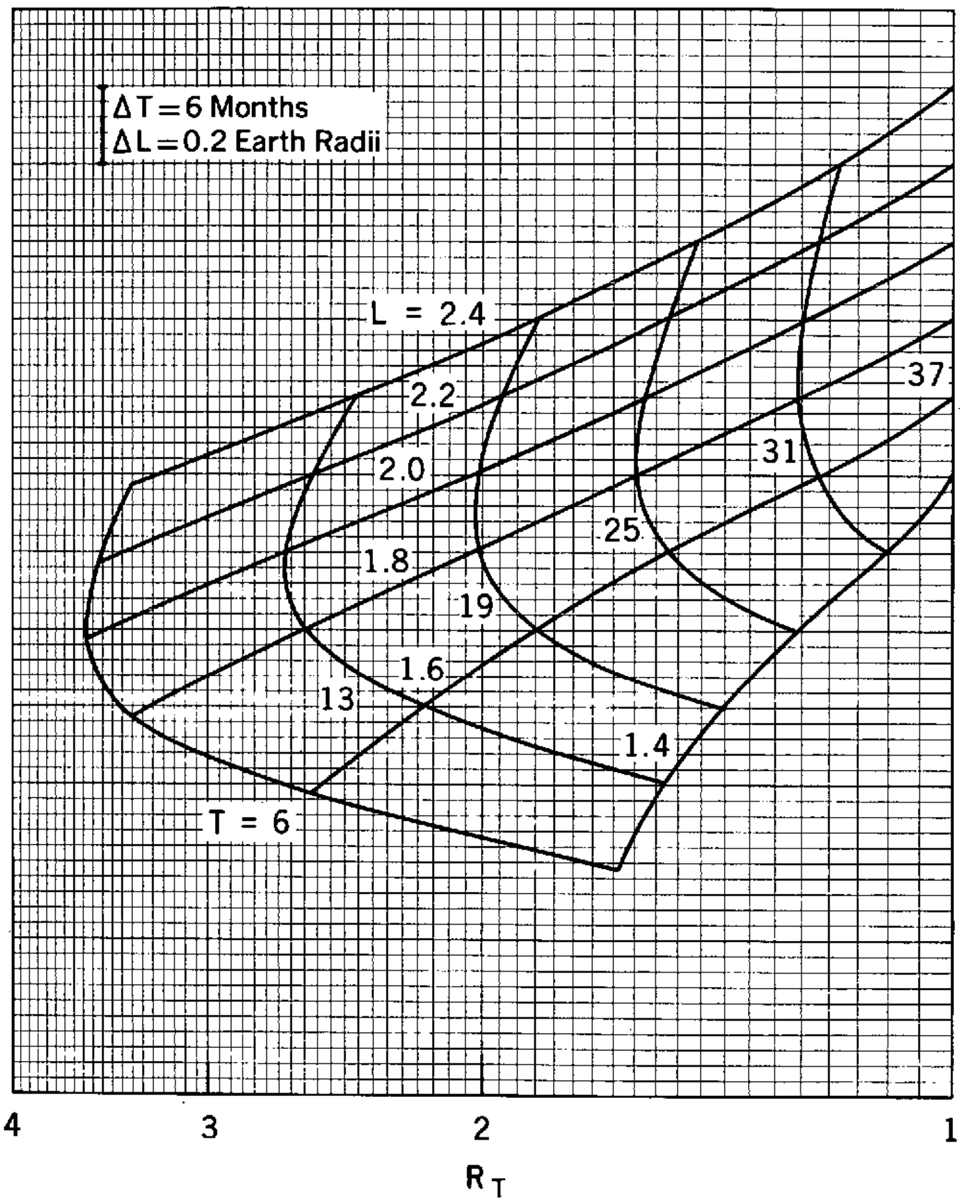


Figure 17. Integral Flux Solar Cycle Ratios R_T, E > 40 keV

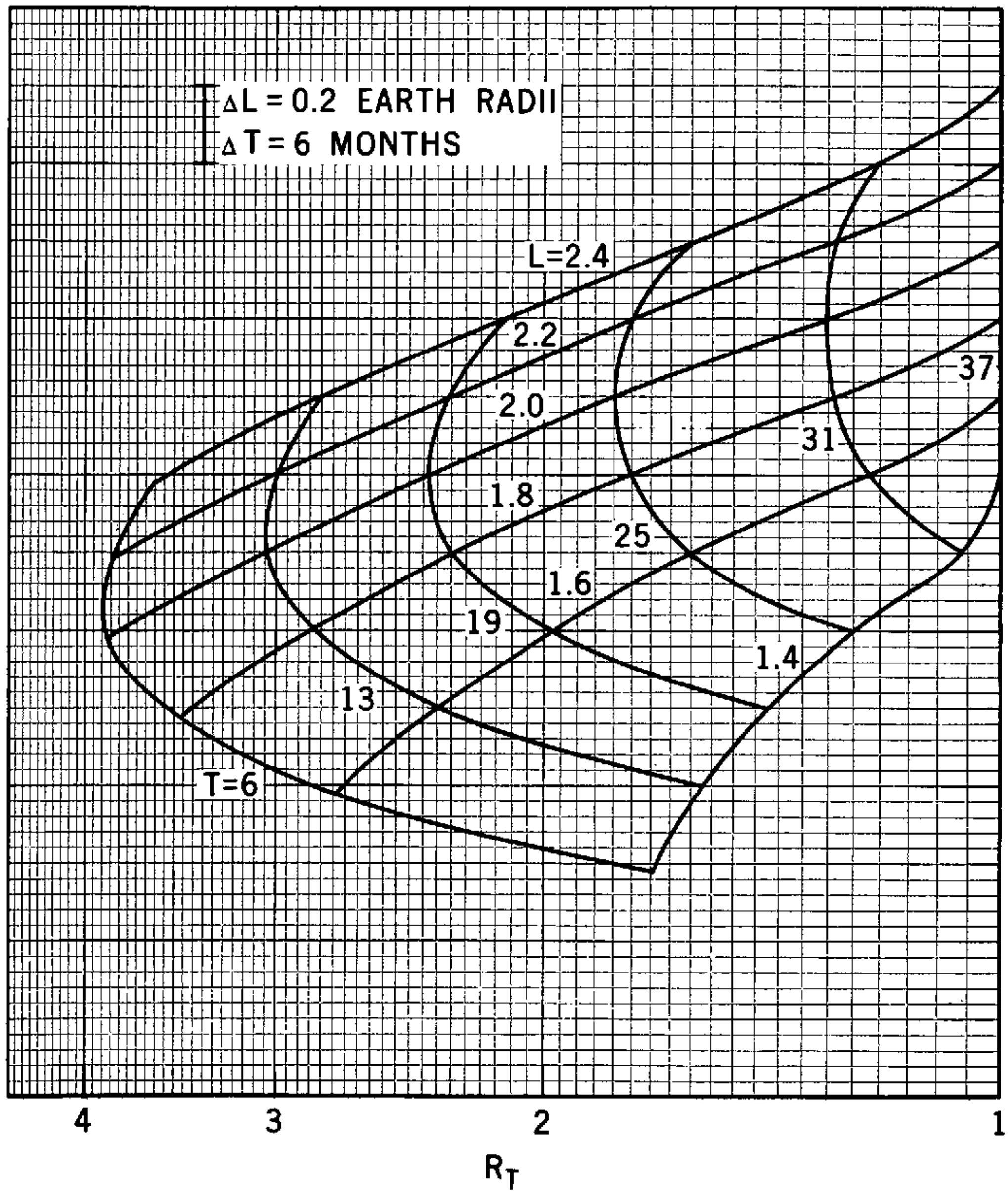


Figure 18. Integral Flux Solar Cycle Ratios R_T, E > 100 keV

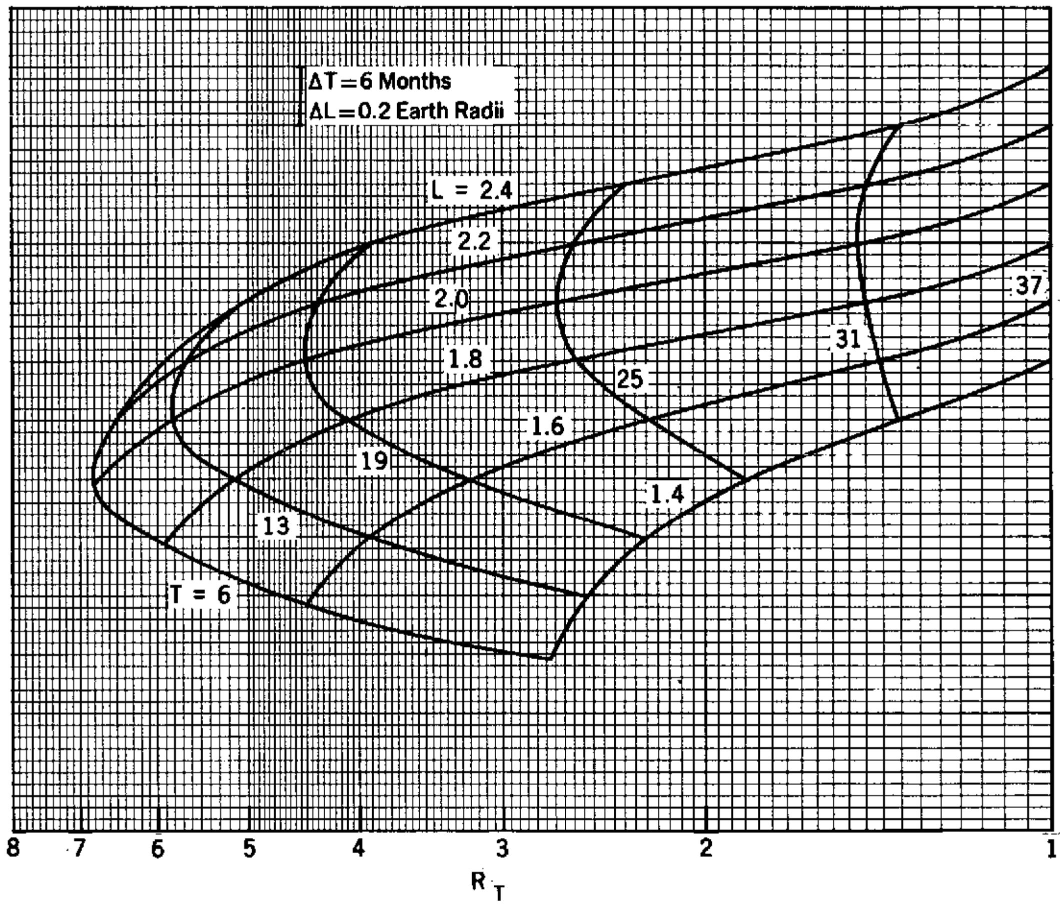


Figure 19. Integral Flux Solar Cycle Ratios R_T, E > 250 keV

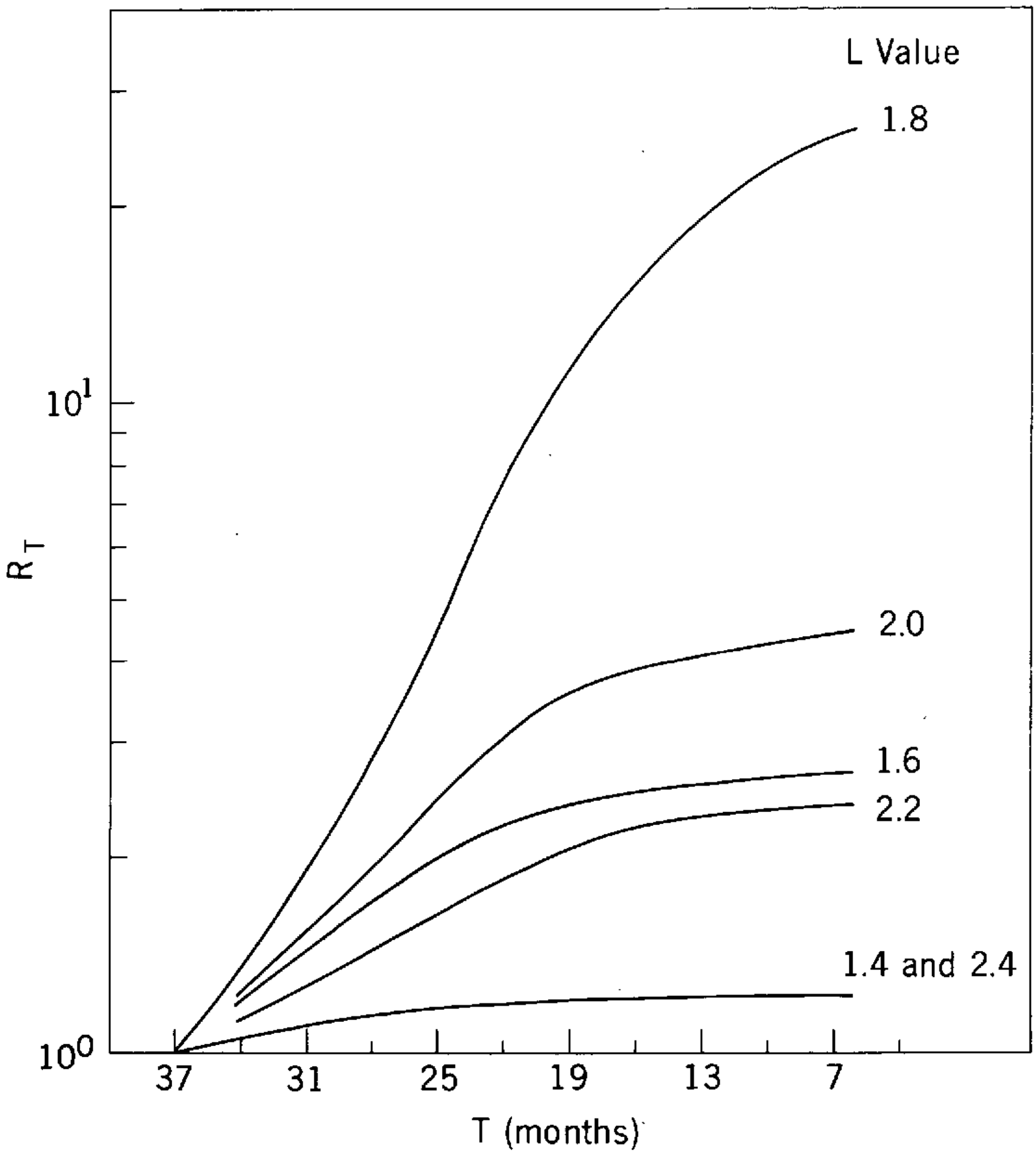


Figure 20. Integral Flux Solar Cycle Ratios R_T, E > 500 keV

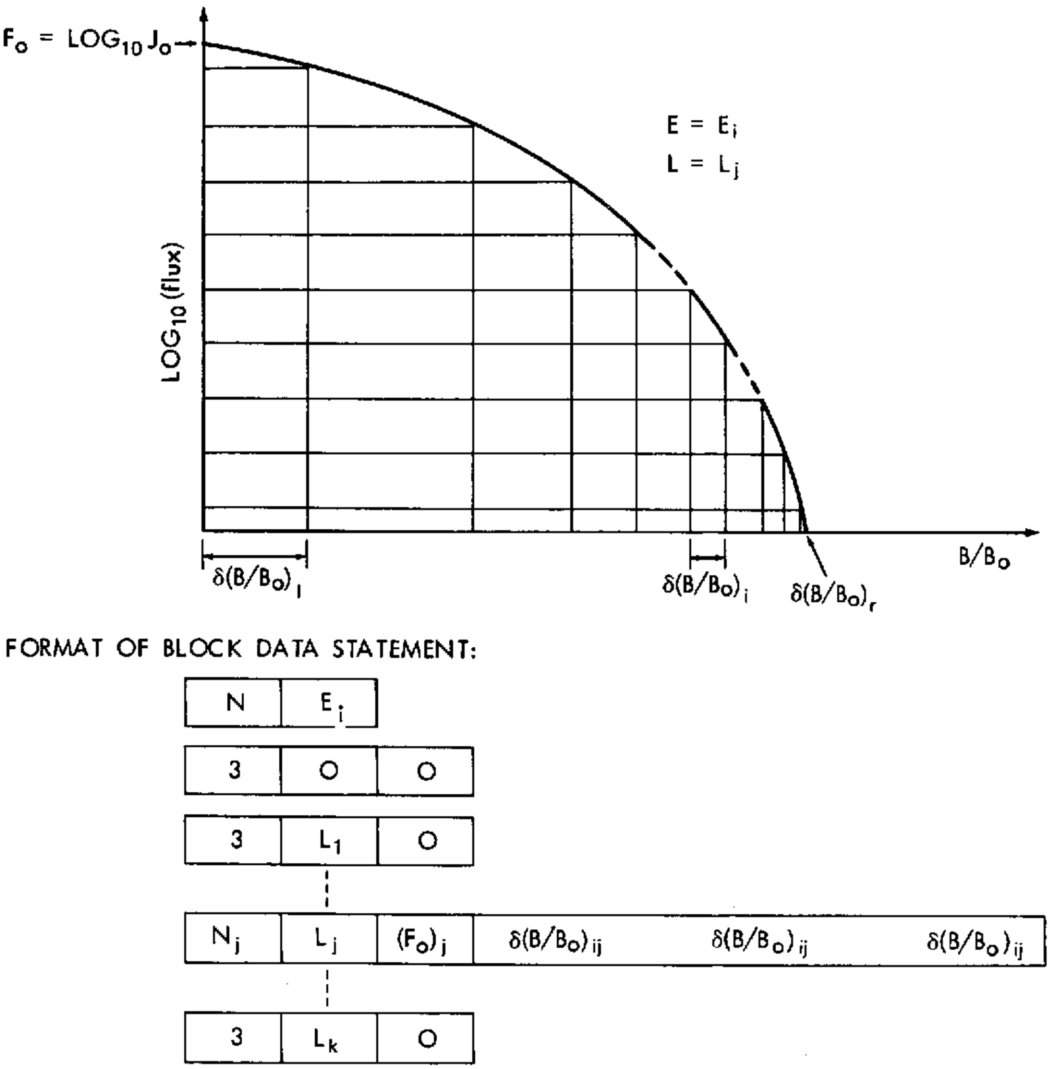


Figure 21. Storage of Flux-B Curves

Protons

Energies: 0.375, 0.78, 4.1, 8.0, 16.0, 50.0, 100.0 MeV

L values: 1.2 by 0.1 increments to 6.6

Inner Zone Electrons

Energies: 0.04, 0.1, 0.25 by 0.25 increments to 2.0,
2.0 by 0.5 increments to 4.5 MeV

L values: 1.2 by 0.05 increments to 1.5, 1.5 by 0.1
increments to 2.0, 2.0 by 0.2 increments to 2.8

Outer Zone Electrons

Energies: 0.04, 0.1, 0.3, 0.5, 1.0, 2.0, 2.5, 3.0, 3.5,
4.0, 4.1, 4.25, 4.35, 4.5, 4.65, 4.85 MeV

L values: 2.8 by 0.2 increments to 4.0, 4.0 by 0.5 increments
to 6.0, 6.6, 7.0 by 1.0 increments to 11.0

Figure 22. Model Grid Points

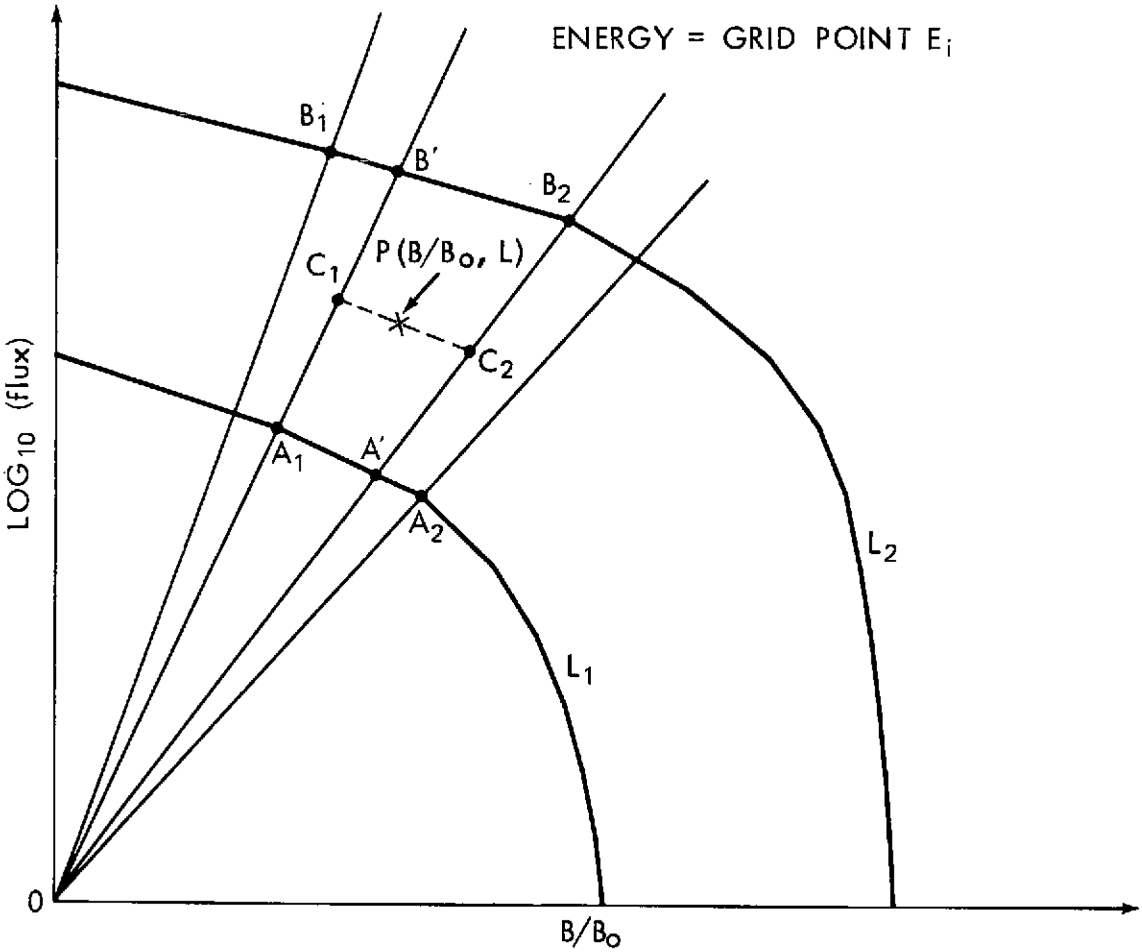


Figure 23. B/B_0 and L Interpolation

IBM 360 Series

```
Job Card

// EXEC FORTRANG,PARM='ID,MAP,
   XREF',REGION=250K+

//SOURCE.SYSIN DD *

Source Deck

/*

//STEPG EXEC LINKGO,REGION=160K

//LINK.OBJECT DD *

Object Deck if used

/* if Object Deck used

//GO.SYSUDUMP DD SYSOUT=A

//GO.GSFCDUMP DD SYSOUT=A
  (GSFC only)

//GO.DATA5 DD *

Data Deck (Figure 25)

/*

//
```

Univac 1108

```
Job Card

@ FOR,SIA .MAIN,.MAIN/R
  Main Program

@ FOR,SIA .SUB1,.SUB1/R
  Subroutine Type

@ FOR,SIA .SUB2,.SUB2/R
  Subroutine DIFF

@ FOR,SIA .SUB3,.SUB3/R
  Subroutine TRARA1

@ FOR,SIA .SUB4,.SUB4/R
  Function TRARA2

@ FOR,SIA .SUB8,.SUB8/R
  AE5 Block Data

@ FOR,SIA .SUB9,.SUB9/R
  AE4 Block Data

@ FOR,SIA .S010,.S010/R

@ MAP,I .MAIN/R, .MJTP/A

@ XQT .MJTP/A
  Data Deck

@ FIN
```

+Source block data statements only.

Figure 24. MODEL Deck Setup

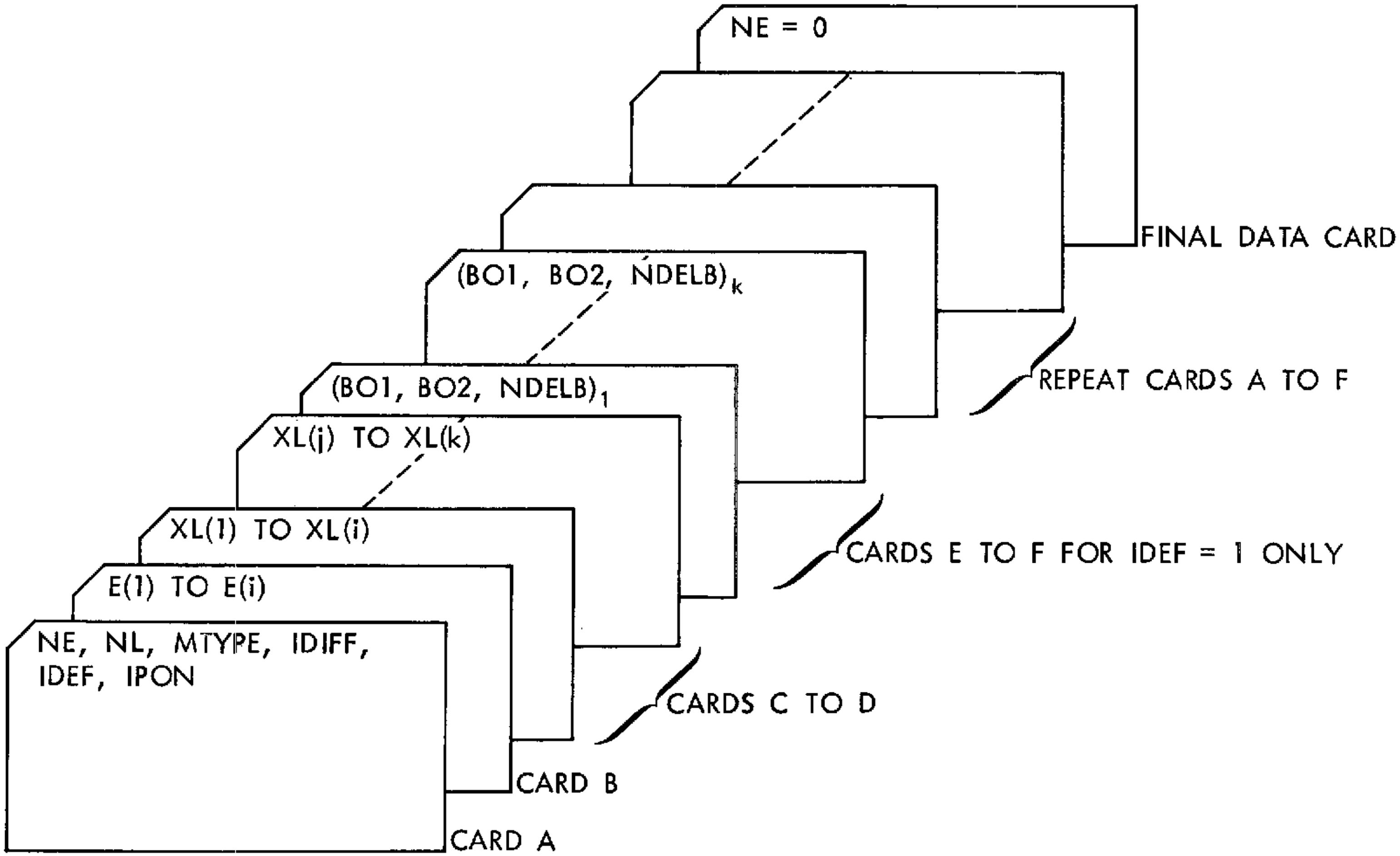


Figure 25. MODEL Data Deck Setup

INNER ZONE ELECTRON MODEL AE5 EPOCH OCTOBER 1967.

INTEGRAL FLUX UNITS- ELECTRONS/SQCM.SEC

L VALUE = 1.70 EQ B = 0.0634 GAUSS

ENERGIES(MEV).

B	B/B0	0.050	0.100	0.250	0.500	1.000	1.250	1.500	1.750	2.000
0.0634	1.000	3.913E 08	2.910E 08	9.933E 07	9.306E 06	1.868E 06	1.129E 06	6.994E 05	4.352E 05	2.738E 05
0.0704	1.110	3.295E 08	2.495E 08	8.329E 07	7.756E 06	1.557E 06	9.411E 05	5.829E 05	3.627E 05	2.282E 05
0.0774	1.220	2.843E 08	2.139E 08	6.994E 07	6.465E 06	1.258E 06	7.844E 05	4.859E 05	3.023E 05	1.902E 05
0.0944	1.330	2.453E 08	1.834E 08	5.856E 07	5.338E 06	1.082E 06	6.538E 05	4.050E 05	2.520E 05	1.586E 05
0.0913	1.440	2.115E 08	1.568E 08	4.818E 07	4.375E 06	8.785E 05	5.308E 05	3.288E 05	2.046E 05	1.287E 05
0.0983	1.550	1.910E 08	1.329E 08	3.936E 07	3.535E 06	7.097E 05	4.289E 05	2.657E 05	1.653E 05	1.040E 05
0.1053	1.660	1.549E 08	1.127E 08	3.215E 07	2.863E 06	5.750E 05	3.474E 05	2.152E 05	1.339E 05	8.426E 04
0.1123	1.770	1.326E 08	9.553E 07	2.668E 07	2.358E 06	4.735E 05	2.861E 05	1.772E 05	1.103E 05	6.939E 04
0.1193	1.880	1.133E 08	8.167E 07	2.218E 07	1.942E 06	3.899E 05	2.356E 05	1.460E 05	9.082E 04	5.715E 04
0.1262	1.990	9.925E 07	6.999E 07	1.845E 07	1.602E 06	3.216E 05	1.943E 05	1.204E 05	7.490E 04	4.713E 04
0.1332	2.100	8.490E 07	5.999E 07	1.541E 07	1.330E 06	2.671E 05	1.614E 05	9.996E 04	6.220E 04	3.914E 04
0.1402	2.210	7.319E 07	5.140E 07	1.290E 07	1.104E 06	2.218E 05	1.340E 05	8.301E 04	5.165E 04	3.250E 04
0.1472	2.320	6.301E 07	4.393E 07	1.079E 07	9.171E 05	1.841E 05	1.113E 05	6.892E 04	4.289E 04	2.699E 04
0.1541	2.430	5.433E 07	3.755E 07	9.009E 06	7.605E 05	1.527E 05	9.228E 04	5.716E 04	3.557E 04	2.238E 04
0.1611	2.540	4.641E 07	3.209E 07	7.507E 06	6.307E 05	1.266E 05	7.653E 04	4.740E 04	2.950E 04	1.856E 04
0.1681	2.650	3.979E 07	2.726E 07	6.255E 06	5.230E 05	1.050E 05	6.346E 04	3.931E 04	2.446E 04	1.539E 04
0.1751	2.760	3.370E 07	2.292E 07	5.190E 06	4.293E 05	8.600E 04	5.197E 04	3.219E 04	2.003E 04	1.260E 04
0.1821	2.870	2.834E 07	1.928E 07	4.247E 06	3.508E 05	7.043E 04	4.256E 04	2.636E 04	1.640E 04	1.032E 04
0.1890	2.980	2.393E 07	1.618E 07	3.482E 06	2.864E 05	5.750E 04	3.475E 04	2.152E 04	1.339E 04	8.427E 03
0.1960	3.090	1.976E 07	1.317E 07	2.812E 06	2.285E 05	4.587E 04	2.772E 04	1.717E 04	1.068E 04	6.723E 03
0.2030	3.200	1.599E 07	1.072E 07	2.234E 06	1.823E 05	3.660E 04	2.212E 04	1.370E 04	8.524E 03	5.364E 03
0.2100	3.310	1.291E 07	8.611E 06	1.776E 06	1.417E 05	2.845E 04	1.719E 04	1.065E 04	6.627E 03	4.170E 03
0.2169	3.420	1.006E 07	6.638E 06	1.340E 06	1.081E 05	2.170E 04	1.311E 04	8.123E 03	5.054E 03	3.180E 03
0.2239	3.530	7.647E 06	5.099E 06	1.011E 06	7.982E 04	1.603E 04	9.685E 03	5.999E 03	3.733E 03	2.349E 03
0.2309	3.640	5.514E 06	3.608E 06	7.049E 05	5.667E 04	1.138E 04	6.876E 03	4.259E 03	2.650E 03	1.668E 03
0.2379	3.750	3.774E 06	2.430E 06	4.674E 05	3.693E 04	7.414E 03	4.481E 03	2.775E 03	1.727E 03	1.087E 03
0.2449	3.860	2.240E 06	1.456E 06	2.754E 05	2.150E 04	4.317E 03	2.609E 03	1.616E 03	1.006E 03	6.327E 02
0.2519	3.970	1.038E 06	6.660E 05	1.245E 05	9.919E 03	1.992E 03	1.203E 03	7.455E 02	4.638E 02	2.919E 02
0.2588	4.080	2.092E 05	1.393E 05	2.394E 04	1.917E 03	3.848E 02	2.326E 02	1.441E 02	8.964E 01	5.640E 01

Figure 26. Sample MODEL Output

INNER ZONE ELECTRON MODEL AE5 EPOCH OCTOBER 1967.

DIFFERENTIAL FLUX UNITS- ELECTRONS/SQCM.SEC.MEV

L VALUE = 1.70 EQ B = 0.0634 GAUSS

ENERGIES(MEV).

B	B/B0	0.050 TO 0.100	0.100 TO 0.250	0.250 TO 0.500	0.500 TO 1.000	1.000 TO 1.250	1.250 TO 1.500	1.500 TO 1.750	1.750 TO 2.000
0.0634	1.000	1.317E 09	1.278E 09	3.601E 08	1.487E 07	2.957E 06	1.719E 06	1.057E 06	6.454E 05
0.0704	1.110	1.630E 09	1.108E 09	3.021E 08	1.240E 07	2.465E 06	1.433E 06	8.809E 05	5.379E 05
0.0774	1.220	1.409E 09	9.605E 08	2.535E 08	1.033E 07	2.055E 06	1.194E 06	7.342E 05	4.483E 05
0.0844	1.330	1.239E 09	9.323E 08	2.127E 08	8.613E 06	1.712E 06	9.952E 05	6.123E 05	3.737E 05
0.0913	1.440	1.095E 09	7.241E 08	1.752E 08	6.993E 06	1.390E 06	8.081E 05	4.969E 05	3.034E 05
0.0983	1.550	9.618E 08	6.239E 08	1.433E 08	5.650E 06	1.123E 06	6.529E 05	4.014E 05	2.451E 05
0.1053	1.660	8.443E 08	5.369E 08	1.171E 08	4.577E 06	9.100E 05	5.289E 05	3.252E 05	1.986E 05
0.1123	1.770	7.435E 08	4.590E 08	9.728E 07	3.769E 06	7.495E 05	4.356E 05	2.679E 05	1.635E 05
0.1193	1.880	6.434E 08	3.966E 08	8.097E 07	3.104E 06	6.172E 05	3.587E 05	2.206E 05	1.347E 05
0.1262	1.990	5.652E 08	3.437E 08	6.738E 07	2.560E 06	5.090E 05	2.958E 05	1.819E 05	1.111E 05
0.1332	2.100	4.963E 08	2.972E 08	5.633E 07	2.126E 06	4.227E 05	2.457E 05	1.511E 05	9.224E 04
0.1402	2.210	4.357E 08	2.567E 08	4.716E 07	1.765E 06	3.510E 05	2.040E 05	1.254E 05	7.660E 04
0.1472	2.320	3.916E 08	2.209E 08	3.949E 07	1.466E 06	2.914E 05	1.694E 05	1.042E 05	6.369E 04
0.1541	2.430	3.306E 08	1.903E 08	3.299E 07	1.216E 06	2.417E 05	1.405E 05	8.637E 04	5.274E 04
0.1611	2.540	2.853E 08	1.639E 08	2.750E 07	1.008E 06	2.004E 05	1.165E 05	7.163E 04	4.374E 04
0.1681	2.650	2.595E 08	1.400E 08	2.293E 07	8.360E 05	1.662E 05	9.661E 04	5.940E 04	3.627E 04
0.1751	2.760	2.155E 08	1.183E 08	1.901E 07	6.847E 05	1.361E 05	7.912E 04	4.865E 04	2.971E 04
0.1821	2.870	1.313E 09	1.002E 08	1.558E 07	5.607E 05	1.115E 05	6.479E 04	3.984E 04	2.433E 04
0.1890	2.980	1.529E 08	8.465E 07	1.278E 07	4.577E 05	9.101E 04	5.289E 04	3.252E 04	1.986E 04
0.1960	3.090	1.317E 08	6.907E 07	1.033E 07	3.652E 05	7.261E 04	4.220E 04	2.595E 04	1.584E 04
0.2030	3.200	1.053E 08	5.660E 07	8.209E 06	2.913E 05	5.793E 04	3.367E 04	2.070E 04	1.264E 04
0.2100	3.310	8.697E 07	4.557E 07	6.536E 06	2.265E 05	4.504E 04	2.618E 04	1.609E 04	9.828E 03
0.2160	3.420	6.939E 07	3.532E 07	4.930E 06	1.727E 05	3.435E 04	1.996E 04	1.227E 04	7.495E 03
0.2239	3.530	5.096E 07	2.726E 07	3.724E 06	1.276E 05	2.537E 04	1.474E 04	9.065E 03	5.536E 03
0.2309	3.640	3.912E 07	1.936E 07	2.593E 06	9.058E 04	1.801E 04	1.047E 04	6.436E 03	3.930E 03
0.2379	3.750	2.698E 07	1.309E 07	1.722E 06	5.902E 04	1.174E 04	6.821E 03	4.194E 03	2.561E 03
0.2449	3.860	1.567E 07	7.873E 06	1.016E 06	3.437E 04	6.833E 03	3.971E 03	2.442E 03	1.491E 03
0.2518	3.970	7.437E 06	3.610E 06	4.585E 05	1.585E 04	3.152E 03	1.932E 03	1.126E 03	6.879E 02
0.2590	4.080	1.556E 06	7.053E 05	8.809E 04	3.064E 03	6.091E 02	3.540E 02	2.177E 02	1.329E 02

Figure 26 (continued)

L BAND SUMMARY

AVERAGE INTEGRAL FLUX WITHIN ENERGY BANDS

(PARTICLES / (CM**2 - DAY))

CIRCULAR ORBIT, PER & AP = 300 NM, FIELD MOD = H&C-120, INCL =30 DEG

MODELS USED = AE4, AE5

ENERGY RANGES (MEV)	L VALUES 1.00 TO 1.22	1.22 TO 1.27	1.27 TO 1.32	1.32 TO 1.37	1.37 TO 1.45	1.45 TO 1.55	1.55 TO 1.65	1.65 TO 1.75	1.75 TO 1.85	1.85 TO 1.95	1.95 TO 2.05	2.05 TO 2.15
0.05- 0.25	2.57E 07	1.76E 08	4.67E 08	7.46E 08	1.34E 09	2.28E 09	1.59E 09	1.12E 09	5.36E 08	0.0	0.0	0.0
0.25- 0.50	9.27E 06	5.65E 07	1.43E 08	2.11E 08	3.35E 08	4.41E 08	2.63E 08	1.52E 08	6.33E 07	0.0	0.0	0.0
0.50- 0.75	3.25E 06	1.86E 07	4.55E 07	5.72E 07	6.65E 07	6.39E 07	2.01E 07	9.27E 06	4.44E 06	0.0	0.0	0.0
0.75- 1.00	1.24E 06	6.87E 06	1.72E 07	2.09E 07	2.03E 07	1.60E 07	6.11E 06	2.46E 06	8.05E 05	0.0	0.0	0.0
1.00- 1.25	9.36E 05	5.02E 06	1.21E 07	1.37E 07	1.37E 07	1.07E 07	2.89E 06	1.09E 06	3.11E 05	0.0	0.0	0.0
1.25- 1.50	8.43E 05	4.52E 06	1.08E 07	1.23E 07	1.25E 07	9.51E 06	2.08E 06	6.42E 05	1.63E 05	0.0	0.0	0.0
1.50- 1.75	8.43E 05	4.47E 06	1.08E 07	1.22E 07	1.21E 07	8.79E 06	1.63E 06	4.00E 05	8.84E 04	0.0	0.0	0.0
1.75- 2.00	8.43E 05	4.35E 06	1.04E 07	1.14E 07	1.05E 07	7.42E 06	1.25E 06	2.46E 05	4.73E 04	0.0	0.0	0.0
2.00- 2.25	7.14E 05	3.17E 06	8.03E 06	9.14E 06	8.20E 06	5.66E 06	9.67E 05	1.67E 05	2.84E 04	0.0	0.0	0.0
2.25- 2.50	4.16E 05	1.80E 06	4.38E 06	4.96E 06	4.52E 06	3.18E 06	5.68E 05	1.01E 05	1.62E 04	0.0	0.0	0.0
2.50- 2.75	2.68E 05	1.26E 06	2.71E 06	2.99E 06	2.77E 06	2.01E 06	3.73E 05	6.70E 04	9.97E 03	0.0	0.0	0.0
2.75- 3.00	1.47E 05	5.91E 05	1.31E 06	1.47E 06	1.38E 06	1.02E 06	2.01E 05	3.78E 04	5.39E 03	0.0	0.0	0.0
3.00- 3.25	1.26E 05	3.96E 05	9.50E 05	1.06E 06	9.87E 05	7.22E 05	1.48E 05	2.95E 04	3.13E 03	0.0	0.0	0.0
3.25- 3.50	4.40E 04	9.58E 04	2.20E 05	2.67E 05	2.79E 05	2.32E 05	5.55E 04	1.17E 04	1.56E 03	0.0	0.0	0.0
3.50- 3.75	1.62E 04	2.34E 04	5.12E 04	6.72E 04	7.90E 04	7.45E 04	2.09E 04	4.77E 03	7.05E 02	0.0	0.0	0.0
3.75- 4.00	8.43E 03	6.62E 03	1.19E 04	1.70E 04	2.24E 04	2.41E 04	7.96E 03	2.26E 03	0.0	0.0	0.0	0.0
4.00- 4.25	0.0	0.0	2.80E 03	4.30E 03	7.06E 03	8.62E 03	3.11E 03	6.71E 02	0.0	0.0	0.0	0.0
4.25- 4.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL =	4.46E 07	2.84E 08	7.35E 08	1.10E 09	1.83E 09	2.85E 09	1.39E 09	1.29E 09	6.05E 08	0.0	0.0	0.0

Figure 27. Sample ORP Output

INTEGRATED FLUX TABLE

CIRCULAR ORBIT, PER & AP = 300 NM. FIELD MCD = H&C-120, INC =30 DEG

MODELS USED = AE4, AE5

ENERGY RANGES (MEV) E1 - E2		AVERAGED FLUX ABOVE E1 (PER DAY)	AVERAGED INTEGRAL FLUX IN ENERGY BAND E1 - E2 (PER DAY)	PER CENT
0.05-	0.25	1.07E 10	8.38E 09	78.12
0.25-	0.50	2.35E 09	1.68E 09	15.61
0.50-	0.75	6.73E 08	2.89E 08	2.69
0.75-	1.00	3.84E 08	9.18E 07	0.86
1.00-	1.25	2.92E 08	6.05E 07	0.56
1.25-	1.50	2.32E 08	5.34E 07	0.50
1.50-	1.75	1.79E 08	5.13E 07	0.48
1.75-	2.00	1.27E 08	4.65E 07	0.43
2.00-	2.25	8.08E 07	3.61E 07	0.34
2.25-	2.50	4.47E 07	1.99E 07	0.19
2.50-	2.75	2.47E 07	1.25E 07	0.12
2.75-	3.00	1.23E 07	6.17E 06	0.06
3.00-	3.25	6.11E 06	4.43E 06	0.04
3.25-	3.50	1.69E 06	1.21E 06	0.01
3.50-	3.75	4.79E 05	3.38E 05	0.00
3.75-	4.00	1.41E 05	1.01E 05	0.00
4.00-	4.25	3.54E 04	3.11E 04	0.00
4.25-	4.50	8.26E 03	8.26E 03	0.00
4.50		0.0		0.0

Figure 27 (continued)

INTENSITY SUMMARY

AVERAGE INTEGRAL FLUX WITHIN ENERGY BANDS

(PARTICLES / (CM**2 - DAY))

CIRCULAR ORBIT, PER & AP = 300 NM, FIELD MOD = HGC-120, INCL =30 DEG

MODELS USED = AE4, AE5

ENERGY RANGES	INTENSITY RANGES 1.E2 OR LESS	1.E2 TO 1.E3	1.E3 TO 1.E4	1.E4 TO 1.E5	1.E5 TO 1.E6	1.E6 TO 1.E7	1.E7 TO 1.E8	1.E8 & OVER
0.05 - 0.25	6.20E 04	5.04E 05	5.26E 06	7.12E 07	1.16E 09	7.15E 09	0.0	0.0
0.25 - 0.50	7.83E 04	4.89E 05	6.71E 06	9.09E 07	1.45E 09	1.27E 08	0.0	0.0
0.50 - 0.75	5.85E 04	9.20E 05	1.06E 07	1.38E 08	1.39E 08	0.0	0.0	0.0
0.75 - 1.00	7.30E 04	8.81E 05	1.28E 07	7.81E 07	0.0	0.0	0.0	0.0
1.00 - 1.25	7.70E 04	1.00E 06	1.28E 07	4.66E 07	0.0	0.0	0.0	0.0
1.25 - 1.50	7.34E 04	1.05E 06	1.04E 07	4.19E 07	0.0	0.0	0.0	0.0
1.50 - 1.75	7.71E 04	1.07E 06	1.06E 07	3.96E 07	0.0	0.0	0.0	0.0
1.75 - 2.00	1.18E 05	1.01E 06	9.40E 06	3.60E 07	0.0	0.0	0.0	0.0
2.00 - 2.25	1.19E 05	1.07E 06	1.04E 07	2.45E 07	0.0	0.0	0.0	0.0
2.25 - 2.50	1.36E 05	1.07E 06	1.28E 07	5.91E 06	0.0	0.0	0.0	0.0
2.50 - 2.75	1.17E 05	1.22E 06	1.11E 07	0.0	0.0	0.0	0.0	0.0
2.75 - 3.00	1.33E 05	1.09E 06	4.95E 06	0.0	0.0	0.0	0.0	0.0
3.00 - 3.25	1.37E 05	1.05E 06	3.24E 06	0.0	0.0	0.0	0.0	0.0
3.25 - 3.50	1.45E 05	1.06E 06	0.0	0.0	0.0	0.0	0.0	0.0
3.50 - 3.75	1.49E 05	1.88E 05	0.0	0.0	0.0	0.0	0.0	0.0
3.75 - 4.00	9.17E 04	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.00 - 4.25	2.50E 04	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.25 - 4.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Figure 27 (continued)

PEAK FLUX PER ORBIT TABLE

CIRCULAR ORBIT, PER & AP = 300 NM, FIELD MOD = HSC-120, INCL =30 DEG

MODELS USED = AE4, AE5

ORBIT NO.	PEAK FLUX ENCOUNTERED	LONGITUDE	LATITUDE	ALTITUDE	TIME (HRS)	FIELD(B) (GAUSS)	LINE(L) (E.R.)	TOTAL FLUX/ORBIT (PARTICLES/CM**2)	S-N EQUATORIAL CROSSING (DEG)
1	2.731E 03	298.81	-20.41	555.6	1.40000	0.19782	1.171	1.158E 06	0.0
2	1.356E 02	295.17	-10.23	555.6	3.10000	0.21322	1.154	4.733E 04	336.70
3	2.372E 00	271.88	-9.81	555.6	4.70000	0.23016	1.109	4.620E 02	313.39
4	0.0	266.78	1.76	555.6	6.40000	0.25958	1.140	0.0	290.09
5	0.0	240.47	0.32	555.6	7.98333	0.25276	1.089	0.0	266.78
6	0.0	217.17	0.76	555.6	9.58333	0.0	0.0	0.0	240.47
7	0.0	193.86	1.20	555.6	11.18333	0.0	0.0	0.0	217.17
8	2.373E 00	356.20	2.34	555.6	11.95000	0.23064	1.111	4.610E 02	193.86
9	4.130E 03	24.63	-24.59	555.6	13.81667	0.24900	1.592	1.116E 06	170.56
10	9.011E 04	357.82	-23.69	555.6	15.40000	0.22745	1.471	3.312E 07	144.25
11	2.830E 05	342.10	-26.16	555.6	17.03331	0.21194	1.412	1.017E 08	120.95
12	4.440E 05	334.69	-29.25	555.6	18.70000	0.20692	1.407	1.717E 08	97.64
13	4.615E 05	332.00	-29.72	555.6	20.38332	0.20514	1.394	2.306E 08	74.34
14	2.575E 05	320.95	-28.10	555.6	22.03331	0.19706	1.297	1.191E 08	48.03
15	3.343E 04	313.03	-24.01	555.6	23.70000	0.19300	1.221	1.439E 07	24.72
16	0.0	10.48	6.55	555.6	24.00000	0.24553	1.083	0.0	0.0

Figure 27 (continued)

FOUR ORBIT INTEGRATED FLUX SUMMARY MODEL USED=AE4, AE5

ORBIT ALTITUDE.. 300 N MI TOTAL TIME.. 24. HOURS TIME INTERVAL.. 60. SECONDS

ENERGY MEV		ORBITAL FLUX 0 DEG		ORBITAL FLUX 30 DEG		ORBITAL FLUX 60 DEG		ORBITAL FLUX 90 DEG	
E1	E2	*E1	E1-E2	*E1	E1-E2	*E1	E1-E2	*E1	E1-E2
0.05	0.25	0.416E 06	0.128E 06	0.107E 11	0.838E 10	0.232E 11	0.181E 11	0.194E 11	0.149E 11
0.25	0.50	0.288E 06	0.702E 05	0.235E 10	0.168E 10	0.510E 10	0.338E 10	0.457E 10	0.295E 10
0.50	0.75	0.218E 06	0.335E 05	0.673E 09	0.289E 09	0.172E 10	0.728E 09	0.162E 10	0.690E 09
0.75	1.00	0.184E 06	0.154E 05	0.384E 09	0.918E 08	0.992E 09	0.364E 09	0.932E 09	0.351E 09
1.00	1.25	0.169E 06	0.132E 05	0.292E 09	0.605E 08	0.628E 09	0.193E 09	0.581E 09	0.186E 09
1.25	1.50	0.156E 06	0.132E 05	0.232E 09	0.534E 08	0.435E 09	0.133E 09	0.394E 09	0.125E 09
1.50	1.75	0.142E 06	0.132E 05	0.179E 09	0.513E 08	0.302E 09	0.965E 08	0.269E 09	0.883E 08
1.75	2.00	0.127E 06	0.132E 05	0.127E 09	0.465E 08	0.205E 09	0.704E 08	0.181E 09	0.630E 08
2.00	2.25	0.108E 06	0.132E 05	0.808E 08	0.361E 08	0.135E 09	0.505E 08	0.118E 09	0.441E 08
2.25	2.50	0.867E 05	0.132E 05	0.447E 08	0.199E 08	0.843E 08	0.310E 08	0.736E 08	0.271E 08
2.50	2.75	0.696E 05	0.132E 05	0.247E 08	0.125E 08	0.532E 08	0.217E 08	0.465E 08	0.189E 08
2.75	3.00	0.551E 05	0.115E 05	0.123E 08	0.617E 07	0.315E 08	0.126E 08	0.276E 08	0.110E 08
3.00	3.25	0.436E 05	0.115E 05	0.611E 07	0.443E 07	0.189E 08	0.990E 07	0.166E 08	0.861E 07
3.25	3.50	0.290E 05	0.979E 04	0.169E 07	0.121E 07	0.903E 07	0.455E 07	0.797E 07	0.400E 07
3.50	3.75	0.193E 05	0.663E 04	0.479E 06	0.338E 06	0.448E 07	0.300E 07	0.397E 07	0.266E 07
3.75	4.00	0.126E 05	0.663E 04	0.141E 06	0.101E 06	0.148E 07	0.992E 06	0.131E 07	0.880E 06
4.00	4.25	0.454E 04	0.0	0.394E 05	0.311E 05	0.489E 06	0.394E 06	0.432E 06	0.250E 06
4.25	4.50	0.0	0.0	0.826E 04	0.0	0.946E 05	0.853E 05	0.829E 05	0.742E 05
4.50		0.0	0.0	0.0	0.0	0.925E 04	0.925E 04	0.867E 04	0.867E 04

Figure 27 (continued)

```
Job Card
// EXEC FORTRANH,PARM='OPT=2,ID,MAP,XREF',REGION=450K+ or 375KX
//SOURCE.SYSIN DD *
Source Deck
/*
// EXEC LINKGO,REGION.GO = 160K
//LINK.OBJECT DD *
Object Deck
/*
//GO.FT10F001 DD (input tape information)
//GO.FT13F001 DD (output tape information)
//GO.SYSUDUMP DD SYSOUT=A
//GO.GSFCDUMP DD SYSOUT=A (GSFC only)
//GO.DATA5 DD *
Data Deck (Figure 29)
/*
//
```

+Source block data statements.

XObject block data statements.

Figure 28. ORP Deck Setup

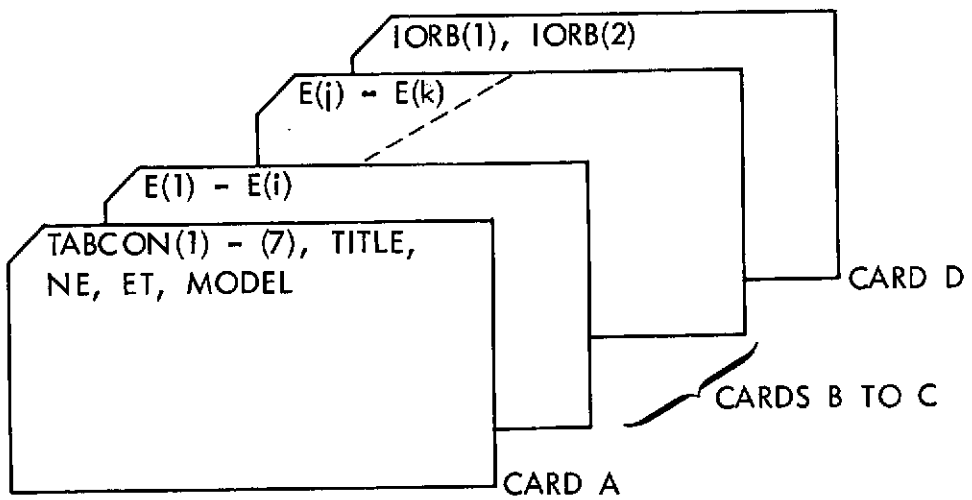


Figure 29. ORP Data Deck Setup

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