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RADIATION RESEARCH ASSOCIATES, INC.
Fort Worth, Texas

COHORT

A MONTE CARLO PROGRAM FOR CALCULATION OF RADIATION HEATING AND TRANSPORT

Volume II: Utilization Instructions for SO1, SO2, and CO1 Routines

D. G. COLLINS and M. B. WELLS

Prepared Under Contract NAS8-20195 for

THE GEORGE C. MARSHALL SPACE FLIGHT CENTER,
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION,
Huntsville, Alabama

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COHORT
A Monte Carlo Program for Calculation of Radiation Heating and Transport

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ABSTRACT

The family of routines designated as COHORT was recoded in FORTRAN-IV language and several improvements were made in the routines in order to increase their efficiency and to widen their range of application to radiation heating and transport problems. Every effort was made to discover and correct all coding errors in the updated version of COHORT and the accuracy of the calculational methods used in the code was checked out through comparisons of results from test problems with data from other calculational methods.

A discussion of the modifications made to COHORT and comparison of results from the FORTRAN-IV version of the code with data from other calculational methods are given in Volume I of this report. Utilization instructions for the FORTRAN-IV version of the primary source generator routine, S01, the secondary source generator routine, S02, and the tape read routine, C01, are contained in Volume II. Utilization instructions for the history generator routine, H01, and the tape sort routine, J01, are contained in Volume III. Utilization instructions for the two analysis routines, A01 and A02, are contained in Volume IV.

FOREWORD

The authors wish to acknowledge the work of all those who have participated in the development of the COHORT code, especially D. M. Braddock, L. M. Bostick, C. F. Malone and T. W. DeVries who shared in the coding of the original version of COHORT. They wish to express their appreciation to Mr. Len Soffer and Mr. I. Karp for their work in translating COHORT to FORTRAN-IV and their suggestions for improvements to the code. They also wish to express their appreciation to Mr. James Price and Mrs. Linda Causey for their help in debugging the current version of COHORT. The authors are appreciative of the guidance provided by Mr. Henry Stern, the technical monitor of both the previous and current studies for the development improvement of COHORT.

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I INTRODUCTION

This document contains the utilization instructions for the primary source routine, the secondary gamma-ray source routine, and the tape-read routine which are three of the family of seven routines designated as the COHORT (Calculation of Heating or Radiation Transport) code (Ref. 1 & 2). This document furnishes the information necessary for the preparation of input data, provides operational instructions, and identifies the values printed in the problem output data.

Brief descriptions of the methods used in the primary source generation routine, S01, and in the secondary gamma-ray source routine, S02, are given to help define the input variables.

The primary output from the S01 and S02 routines is a tape containing values of the source particle parameters for however many source particles that are being considered. The S02 routine and the C01 routine also require a tape as a portion of the input. In addition to the input and output tapes the S02 routine uses several scratch tapes. Since tape assignments are different at the various computing facilities where the COHORT code is in operation, it is impossible to identify the units that are used at any given facility. In this document the logical tape numbers used in the body of the FORTRAN statements will be given in any discussion of tape usage and any changes in tape assignments will be understood to modify the discussion accordingly.

II PRIMARY SOURCE GENERATOR CODE S01

The Primary Source Generator Code, S01, is a procedure for generating the nine parameters required to define each source particle. These parameters are the spatial coordinates X, Y and Z; the direction cosines α, β, and γ, the initial energy E; the initial weight W; and the number of the source region, NR. The output obtained from running a problem on S01 is a tape containing 14 sets of source parameters per tape record. The maximum number of primary source particles that can be generated in a single problem is limited to 32768, the largest fixed point number acceptable to the IBM-7090.

2.1 Method

The basic assumption in the Primary Source Particle Code is that the distribution defining the source can be separated into independent distributions which define the spatial, direction and energy parameters. Each probability distribution table used in S01 consists of a set of values of the probabilities and their corresponding random variables. If f(x) is the density function for x, then

$$\int_{x_{i-1}}^{x_i} f(x)dx = p_i$$

represents the probability that x lies between x_{i-1} and x_i. Random values of x_i can be chosen from the cumulative probability distribution defined by determining the smallest value of i for which

$$\sum_{j=1}^{i} p_j > R_1 ,$$

where R_1 (and R_2 in the expression below) is a number selected at random from a uniform distribution between zero and one. A random x is then

computed as

$$x = x_{i-1} + R_2(x_i - x_{i-1}) \ .$$

The number of probability distribution tables required for input in S01 depends on the options used in selecting the source parameters.

2.1.1 Spatial Coordinate Selection

The generation of all source particle coordinates is based on the assumption that the center of the source region lies at the origin of the coordinate axes. Translation of the origin of the source coordinate system to the one used in describing a problem for the history generation code, H01, is accomplished by use of the transformation parameters X_o, Y_o and Z_o, which are part of the input data for H01.

In S01 the control number IC is input to specify the method of selecting the particle spatial coordinates. These methods are described below.

IC = 0 Point Source. The source is located at the origin of the coordinate system.

IC = 1 Rectangular Volume Source. It is assumed that the source density is known and that the source can be divided into many smaller rectangular subvolumes, so that p_i represents the fraction of the total source density to be assigned to the ith subvolume with sides defined by $X_{i,min}$ $X_{i,max}$; $Y_{i,min}$, $Y_{i,max}$; and $Z_{i,min}$, $Z_{i,max}$. The subvolume in which the particle is to be started is chosen by computing the smallest value of i for which

$$\sum_{j=1}^{i} p_j - R_1 \geq 0.$$

The coordinates of the source point are then given by

$$X = X_{i,min} + R_2(X_{i,max} - X_{i,min}),$$

$$Y = Y_{i,min} + R_3(Y_{i,max} - Y_{i,min}), \text{ and}$$

$$Z = Z_{i,min} + R_4(Z_{i,max} - Z_{i,min}).$$

The use of this option requires input tables giving the distribution of p and the coordinates that define each of the i subvolumes.

IC = 2 Spherical Volume Source. It is assumed that the total source distribution is known and that the distribution is dependent only on the radial distance r from the center of the sphere. The quantities p_i are defined as the source densities in the spherical shell volumes located between radii r_i and r_{i-1}.

The spherical shell volume in which the particle is to be started is chosen by computing the smallest value of i for which

$$\sum_{j=1}^{i} p_j - R_1 \geq 0.$$

The coordinates of the source point are then determined by choosing a radius

$$r = r_{i-1} + R_2(r_i - r_{i-1}) ,$$

and then computing

$$X = \left(\frac{2R_3 - 1}{a}\right) r,$$

$$Y = \left(\frac{2R_4 - 1}{a}\right) r, \text{ and}$$

$$Z = \left(\frac{2R_5 - 1}{a}\right) r,$$

where $a^2 = (2R_3 - 1)^2 + (2R_4 - 1)^2 + (2R_5 - 1)^2 \leq 1.$

A table giving the distribution of p as a function of r is required as program input.

IC = 3 Cylindrical Volume Source. It is assumed that the source distribution can be separated into two distributions: a distribution along the Z axis and a radial distribution. Tables giving the distribution of p as a function of Z and the distribution of q as a function of r are required as program input.

Values for i and j are determined by computing the smallest values of i and j for which

$$\sum_{n=1}^{i} p_n - R_1 \geq 0$$

and

$$\sum_{k=1}^{j} p_k - R_2 \geq 0.$$

Values for r and Z are then computed by use of the equations

$$r = r_{j-1} + R_3(r_j - r_{j-1})$$

and

$$Z = Z_{i-1} + R_4(Z_i - Z_{i-1}).$$

The source point coordinates for X and Y are determined from the equations

$$X = \left(\frac{2R_5 - 1}{b}\right) r$$

and

$$Y = \left(\frac{2R_6 - 1}{b}\right) r,$$

where $b^2 = (2R_5 - 1)^2 + (2R_6 - 1)^2 \leq 1$.

IC = 4 <u>Z-Plane Rectangular Surface Source</u>. The source is on the surface of a plane normal to the Z axis. The total area of the XY plane is divided into subareas with the sides of each subarea defined by $X_{i,min}$, $X_{i,max}$, and $Y_{i,min}$, $Y_{i,max}$ and the source density given as p_i. The Z coordinate of each source particle is taken to be zero.

The subarea containing the source point is determined by computing the smallest i for which

$$\sum_{j=1}^{i} p_j - R_1 \geq 0.$$

The X and Y coordinates of the source point are then computed from the equations

$$X = X_{i,min} + R_2(X_{i,max} - X_{i,min})$$

and

$$Y = Y_{i,min} + R_3(Y_{i,max} - Y_{i,min}).$$

Tables giving the distribution of p and the maximum and minimum X and Y coordinate for each of the subareas are required as program input.

IC = 5 <u>X-Plane Rectangular Surface Source</u>. The source is on the surface of a plane normal to the X axis. The method used in choosing the Y and Z coordinates for each source particle is the same as that used to

choose the X and Y coordinates when IC = 4. Tables giving the distributions of p and the maximum and minimum Y and Z coordinates for each of the subareas are required as program input.

IC = 6 Y-Plane Rectangular Surface Source. The source is on the surface of a plane normal to the Y axis. The method used in choosing the X and Z coordinates for each source point is the same as that used to choose coordinates when IC = 4 or 5. Tables giving the distribution of p and the maximum and minimum X and Z for each subarea are required as program input.

IC = 7 Z-Plane Disk Surface Source. The source approximates a disk surface located in a plane normal to the Z axis. It is assumed that the source can be defined in terms of the probability p_i that a particle will be born in the area located between r_i and r_{i-1}. The area from which the particle is to be started is determined by computing the smallest i for which

$$\sum_{j=1}^{i} p_j - R_1 \geq 0.$$

The X and Y coordinates of a source particle are computed by use of the equations

$$X = \left(\frac{2R_3 - 1}{b}\right) r$$

and

$$Y = \left(\frac{2R_4 - 1}{b}\right) r$$

where $r = r_{i-1} + R_2(r_i - r_{i-1})$ and

$$b^2 = (2R_3 - 1)^2 + (2R_4 - 1)^2 \leq 1.$$

A table giving the distribution of p as a function of r is required as program input.

IC = 8 Spherical Surface Source. The source approximates a spherical surface in which all the source particles are leaving the surface of the sphere in directions defined by the angular distribution of a point source located at the center of the sphere. The point source description assumes that the angular distribution of the leakage can be expressed in terms of only the polar angle θ about the positive Z axis.

The quantity p_i is defined as the fraction of the total leakage from the spherical surface that leaks out between θ_i and θ_{i-1}. The polar angle interval through which the particle is leaving the surface is determined by computing the smallest i for which

$$\sum_{j=1}^{i} p_j - R_1 \geq 0.$$

The polar angle θ is then determined from

$$\theta = \theta_{i-1} + R_2(\theta_i - \theta_{i-1}).$$

The spatial coordinates from which the source particle leaves the surface are given by

$$Z = r \cos\theta ,$$

$$X = (r^2 - Z^2)^{\frac{1}{2}}\cos\phi, \text{ and}$$

$$Y = (r^2 - Z^2)^{\frac{1}{2}}\sin\phi,$$

where r is the radius of the sphere, ϕ is the azimuthal angle assumed to be uniformly distributed, and

$$\cos\phi = \frac{(2R_3 - 1)}{[(2R_3 - 1)^2 + (2R_4 - 1)^2]^{\frac{1}{2}}}$$

and

$$\sin\phi = \frac{(2R_4 - 1)}{[(2R_3 - 1)^2 + (2R_4 - 1)^2]^{\frac{1}{2}}}$$

where $(2R_3 - 1)^2 + (2R_4 - 1)^2 \leq 1$.

The direction cosines of the source particle are given by

$$\alpha = \sin\theta\cos\phi,$$

$$\beta = \sin\theta\sin\phi, \text{ and}$$

$$\gamma = \cos\theta.$$

Tables giving the distribution of p as a function of θ and r are required as program input.

IC = 9 <u>Cylindrical Surface Source</u>. The source approximates a cylindrical surface from which the angular distribution of the leakage is defined in terms of a point source dependent only on the polar angle θ. The angular interval through which the particle leaves the

source is determined by computing the smallest value of i for which

$$\sum_{j=1}^{i} P_j - R_1 \geq 0.$$

The polar angle θ is then computed from

$$\theta = \theta_{i-1} + R_2(\theta_i - \theta_{i-1}).$$

The quantities θ_{min} and θ_{max} are defined as the minimum and maximum polar angles through which the source particles can leak out of the sides of the cylinder. The points Z_1 and Z_2 are defined as the Z coordinates of the planes bounding the ends of the cylinder. If $\theta \geq \theta_{max}$, then $Z = Z_1$. If $\theta \leq \theta_{min}$, then $Z = Z_2$. If $\theta_{min} < \theta < \theta_{max}$, Z is given by $Z = r \cot \theta$, where r is the radius of the cylinder. The X and Y coordinates of the source point are computed from the equations

$$X = Z\tan\theta\cos\phi \text{ and}$$

$$Y = Z\tan\theta\sin\phi,$$

where $\sin\phi$, $\cos\phi$, and the direction cosines α, β, and γ are defined as in IC = 8.

Tables giving the distribution of p as a function of θ, along with the quantities θ_{min}, θ_{max}, Z_1, Z_2 and r, are required as input to the program.

It should be noted when IC = 8 or 9 that the distribution for the initial directions of motion also define the initial spatial locations of the particles.

2.1.2 Direction Cosines

A control word, ID, is used as input to specify the method of selecting the particle direction cosines. The various methods are described below:

ID = 0 · The direction cosines are defined in the method used to generate spatial coordinates when IC = 8 or 9.

ID = 1 Constant Particle Direction. All particles leave the source with direction cosines α, β, and γ as specified in the program input. No probability tables are required as program input.

ID = 2 Isotropic Source. No probability distribution tables are required. The direction cosines are determined by use of a rejection technique illustrated in Figure 1 and may assume random values between +1 and -1.

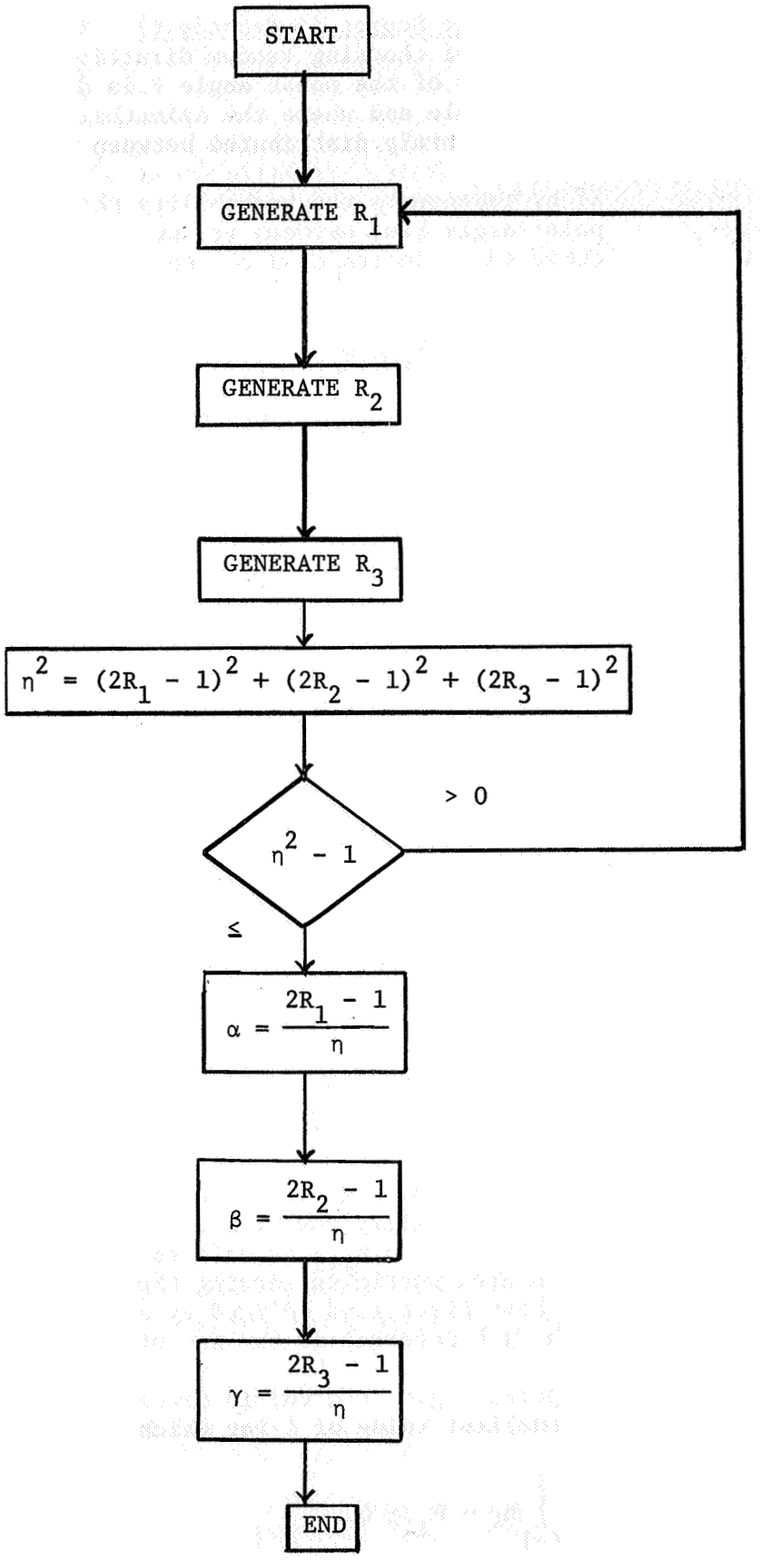

Figure 1. Selection of Random Direction Cosine in the Laboratory System

ID = 3 <u>Anisotropic Source (θ-dependent)</u>. This option provides a method of choosing random direction cosines where the cosine of the polar angle θ is defined by a probability table and where the azimuthal angle ϕ is assumed to be uniformly distributed between 0 and 2π.

If h_i represents the probability that the cosine of the polar angle lies between γ_i and γ_{i-1}, then the i can be computed by determining the smallest value of i for which

$$\sum_{j=1}^{i} h_j - R_1 \geq 0.$$

The direction cosine γ is then given by

$$\gamma = \gamma_{i-1} + R_2(\gamma_i - \gamma_{i-1}).$$

The direction cosines α and β are determined by first generating two random numbers, R_3 and R_4, for which

$$b^2 = (2R_3 - 1)^2 + (2R_4 - 1)^2 \leq 1,$$

and then evaluating equations

$$\alpha = \left(\frac{2R_3 - 1}{b}\right)(1-\gamma^2)^{\frac{1}{2}}$$

and

$$\beta = \left(\frac{2R_4 - 1}{b}\right)(1-\gamma^2)^{\frac{1}{2}}.$$

Tables giving the distribution of h as a function of the direction cosine γ and the upper limits of the ith cosine intervals γ_1 are required as program input.

ID = 4 <u>Anisotropic Source (θ- and ϕ-dependent)</u>. It is assumed that the angular distribution can be divided into a distribution for the cosine of the polar angle θ and a distribution for the azimuthal angle ϕ as a function of the angle θ. The variable h_i is defined as the probability that θ lies in the interval $(\theta_{i-1} - \theta_i)$. The distribution $q_{i,j}$ is defined as the probability that source particles leaving the ith interval of θ will have directions defined by an angle ϕ that lies in the jth interval of the azimuthal angle ϕ.

The polar angle interval is determined by computing the smallest value of i for which

$$\sum_{\ell=1}^{i} h_\ell - R_1 \geq 0.$$

and then computing the smallest value of j for which

$$\sum_{m=1}^{j} q_{i,m} - R_2 \geq 0,$$

where i is the interval of θ selected above.

The direction cosine γ and the angle ϕ are then computed by use of the equations

$$\gamma = \gamma_{i-1} + R_3(\gamma_i - \gamma_{i-1})$$

and

$$\phi = \phi_{i,j-1} + R_4(\phi_{i,j} - \phi_{i,j-1}).$$

The direction cosines α and β are then given by

$$\alpha = \cos\phi(1-\gamma^2)^{\frac{1}{2}}$$

and

$$\beta = \sin\phi(1-\gamma^2)^{\frac{1}{2}}.$$

Tables giving the distributions of h and q as a function of the direction cosine γ and the azimuthal angle ϕ are required as program input.

ID = 5 <u>Isotropic Source - Positive X Direction</u>. The direction cosines are chosen in the same manner as that described for option ID = 2 with the direction cosine α always being taken as positive. No probability tables are required for this option.

ID = 6 <u>Isotropic Source - Negative X Direction</u>. The direction cosines are chosen in the same manner as that described for option ID = 2, with the exception that the direction cosine α is always taken as negative. No probability tables are required for this option.

ID = 7 <u>Isotropic Source - Positive Y Direction</u>. The method used to choose the direction cosines is the same as that described for option ID = 2, with the exception that the direction cosine β is always taken as positive. No probability input tables are required for this option.

ID = 8 <u>Isotropic Source - Negative Y Direction</u>. The method used to choose the direction cosines is the same as that described for option ID = 2, with the exception that the direction cosine β is always taken as negative. No probability input tables are required for this option.

ID = 9 <u>Isotropic Source - Positive Z Direction</u>. The method used to choose direction cosines is the same as that

described for option ID = 2, with the exception that the direction cosine γ is always taken as positive. No probability input tables are required for this option.

ID = 10 Isotropic Source - Negative Z Direction. The method used to choose the direction cosines is the same as that described for option ID = 2, with the exception that the direction cosine γ is always taken as negative. No probability input tables are required for this option.

2.1.3 Energy Selection

A control word, IE, is used to determine the method of selecting the initial energy of each source particle. The various methods are described below.

IE = 1 Constant Energy. This option provides a method of starting all source particles with the same initial energy. When this option is used, the initial energy E is entered as input in the program.

IE = 2 Variable Energy. This option provides a method of selecting source energies from a continuous energy spectrum. The probability that a source particle will be emitted in the ith energy interval is denoted by p_i. A random value of i is determined by computing the smallest value of i for which

$$\sum_{j=1}^{i} p_j - R_1 \geq 0.$$

The initial energy assigned the particle is computed from the equation

$$E = E_{i-1} + R_2(E_i - E_{i-1}),$$

where E_i is the upper bound of the ith energy interval. A table giving the distribution of p as a function of the energy E is required as program input.

The energy values, E_i, should normally be input in Mev units.

2.2 S01 Utilization Instructions

The purpose of the S01 code is to produce a tape containing source particle data for use as input into the History-Generator Code. There are nine parameters defined for each source particle: the spatial coordinates, the direction cosines, the energy, the weight, and region in which the source particle originates. These nine parameters are written on tape for each of 14 particles to form one data record. The first record written on tape will be an identification record giving the number of histories, the tape identification number, and the type of source particles. The remaining records will be data records, each containing information for 14 source particles except for the last record, which may contain information for fewer than 14 particles.

2.2.1 Tape Usage

The S01 code utilizes one additional tape unit besides the regular input and output tape units, logical tapes 5 and 6. The source particle parameters are written on logical tape 3. The operator should be instructed to load a full blank reel on the unit corresponding to logical tape 3 before starting an S01 problem. At the completion of the problem, the operator should remove and label any tape remaining on that unit. These tapes are usually labeled as SOURCE XXXX, where XXXX is the number input for the variable ITAPE.

2.2.2 Card Input

The input data necessary for the running of an S01 problem are input on both problem and library decks. The cards making up the problem input and the library data for the S01 and all the routines in the COHORT family must be sequenced in columns 69 through 72. The first card in

each problem input or library data deck must have a 0001 in these columns and each succeeding card must contain the numbers in increasing sequence. In addition, the numbers in columns 67 and 68 of all cards in a deck must be 00 for a problem deck or the library number for a library deck. Instructions are included in the COHORT routines to verify the sequence of cards as they are read in and to check to determine whether all cards in a deck have the library number or 00 for problem data decks in columns 67 and 68. If the program detects a card out of sequence or an incorrect number in columns 67 and 68, an error statement will be printed and the problem will be terminated.

2.2.2.1 Problem Deck: S01 Code

Each problem run on the Primary-Source-Generator Code will require a problem data deck. The deck will follow immediately after the binary deck. The problem deck is made up of either 2 or 3 cards, depending on the value input for the parameter IC. Table I presents the data required on each problem card and the format to be used for each input item.

TABLE I

S01 Problem Input Data Format

(for Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1	6I10	N	Number of source particles to be generated	≤32,768
		NG	Type of particle NG = 0, neutron NG = 1, gamma ray	
		IC	Source coordinate option IC = 0, point source IC = 1, rectangular volume source IC = 2, spherical volume source IC = 3, cylindrical volume source IC = 4, rectangular area source (z = 0 plane) IC = 5, rectangular area source (x = 0 plane) IC = 6, rectangular area source (y = 0 plane) IC = 7, circular area source (z = 0 plane) IC = 8, spherical surface source (angular distribution outward radially) IC = 9, cylindrical surface source (angular distribution outward radially)	
		ID	Direction cosine option ID = 0, direction cosine defined as in IC options 8 or 9 ID = 1, monodirectional source ID = 2, isotropic source ID = 3, anisotropic source (input polar angle θ distribution, azimuthal angle evenly distributed between 0 and 2π) ID = 4, anisotropic source (input both polar and azimuthal angular distributions) ID = 5, isotropic in 2π space (positive x direction) ID = 6, isotropic in 2π space (negative x direction)	

TABLE I (continued)

Card	Format	Input Item	Definition	Limit
			ID = 7, isotropic in 2π space (positive y direction) ID = 8, isotropic in 2π space (negative y direction) ID = 9, isotropic in 2π space (positive z direction) ID = 10, isotropic in 2π space (negative z direction)	
		IE	IE = 1, monoenergetic source energy IE = 2, input energy spectrum	
		ITAPE	Tape identification number for output source tape	
2	2F10.2, 4E10.4, I1	R1	Input random number	
		R2	Second input random number	
		E	Energy of monoenergetic source if IE = 1 (leave blank if IE = 2)	
		R	Radius of disk, sphere, or cylinder when IC = 2, 3, 7, 8 or 9 (leave blank if IC = 0, 1, 4, 5 or 6)	
		Z3	Lower z plane for end of cylindrical source when IC = 3 or 9, otherwise leave blank.	
		Z4	Upper z plane for end of cylindrical source when IC = 3 or 9; otherwise leave blank.	
		LIST	Intermediate print option LIST = 0, do not print intermediate print LIST = 1, do print intermediate print (Enter value for list in column 61 of second problem card)	
3	2E10.4		(Omit card containing items 16 and 17 if IC ≠ 9)	
		THETA1	Minimum angle (radians) to corner of cylindrical source when IC = 9	
		THETA2	Maximum angle (radians) to corner of cylindrical source when IC = 9	

2.2.2.2 Library One: S01 Code

Library One should be omitted unless IC = 1, 4, 5 or 6. Data in Library One give information for dividing a rectangular volume or area source into subregions and the fraction of source particles that is to be generated in each subregion. The rectangular volume source degenerates into an area source when both the upper and lower x, y or z planes for all subregions are set equal to the same constant. The format to be used in making up a Library One input deck is shown in Table II.

TABLE II

S01 Library One Data Formats

(for Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1	I10	I	Number of subregions into which the source region is divided	≤999
2	6E10.4	P(M)	Fraction of source particles to be generated in subregion M	M=1,I
Follows last P(M) card	6E10.4		If IC = 5, leave blank fields for X1(M) and X2(M) If IC = 6, leave blank fields for Y1(M) and Y2(M)	
		X1(M)	Lower x plane for subregion M	
		X2(M)	Upper x plane for subregion M	
		Y1(M)	Lower y plane for subregion M	
		Y2(M)	Upper y plane for subregion M	
		Z1(M)	Lower z plane for subregion M	
		Z2(M)	Upper z plane for subregion M	M=1,I
			Items X1(M), X2(M), Y1(M), Y2(M), Z1(M) and Z2(M) describe one subregion so there should be one card containing these items for each subregion.	

2.2.2.3 Library Two: S01 Code

Library Two should be omitted unless IC = 2 or 7. Data in Library Two gives the radial distribution for either a spherical volume source or a circular disk source.

IC = 2, spherical volume source

IC = 7, circular disk source

The distribution is assumed to be uniform with radius rather than with area or volume within any given subregion. Therefore, the points, X1(M), used in defining the radial distribution should be the end points of straight line segments fitting the distribution plotted as a function of radius. The format to be used in making up a Library Two deck is shown in Table III.

TABLE III

S01 Library Two Data Formats

(for Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1	I10	I	Number of radial subregions into which the source will be divided	≤999
2	6E10.4	P(M)	Fraction of source particles to be generated in subregion	M=1,I
Follows last P(M) card	6E10.4	X1(M)	Radii bounding the subregions First boundary is smaller radius for first subregion and must be 0 if source distribution is non zero at the origin	M=1,I+1

2.2.2.4 Library Three: S01 Code

Library Three should be omitted unless IC = 3. This library describes the distribution of source particles in a cylindrical volume. It is assumed that the radial and axial distribution of the source particle's

position are independent. The format to be used in making up a Library Three deck is shown in Table IV.

TABLE IV

S01 Library Three Data Formats

(for Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1	2I10	I	Number of disk sections into which the cylindrical source is cut by Z planes	≤999
		J	Number of cylindrical sections into which each disk section is divided by cylindrical boundaries (the product I*J is the total number of subregions into which the cylindrical source is divided)	≤999
2	6E10.4	P(M)	Fraction of source particles to be generated between two consecutive Z planes	M=1,I
Follows last P(M) card	6E10.4	Z1(M)	Z planes dividing the cylindrical source	M=1,I+1
Follows last Z1(M) card	6E10.4	Q(M)	Fraction of source particles to be generated between two consecutive cylindrical boundaries (Radial and axial distributions assumed to be independent)	M=1,J
Follows last Q(M) card	6E10.4	X1(M)	Radii describing cylindrical boundaries (First radius equals 0)	M=1,J+1

2.2.2.5 Library Four: S01 Code

Library Four, which is omitted unless IC = 8, describes a source distributed over the surface of a sphere. The angular distribution for this source will be dependent upon the distribution of the source points over the surface of the sphere, since the direction of a given particle

will be assumed radially outward from the center of the sphere through the point on the sphere giving the source location. The format to be used in making up a Library Four deck is presented in Table V.

TABLE V

S01 Library Four Data Format

(for Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1	I10	I	The number of subdivision on the spherical surface (formed by the intersection of sphere and cones symmetrical about z axis)	≤999
2	6E10.4	P(M)	The fraction of source particles leaking through the surface of the sphere through the Mth subdivision	M=1,I
Follows last P(M) card	6E10.4	Z1(M)	The half angles of the cones (degrees) whose intersection with the sphere describe the subdivision	M=1,I+1

2.2.2.6 Library Five: S01 Code

Library Five, which is omitted unless IC = 9, describes a source distributed over the surface of a cylinder. The angular distribution for this source will be dependent upon the distribution of the source points over the surface of the cylinder, since the direction for a given particle will be assumed radially outward from the center of the cylinder through the point on the surface of the cylinder giving the source location. The format for making up a Library Five deck is presented in Table VI.

TABLE VI

S01 Library Five Data Format

(for Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1	I10	I	The number of subdivisions of the cylindrical surface source (divisions are made by the intersections of the cylindrical surface and cones with vertices at the origin and symmetrical about the z axis)	≤999
2	6E10.4	P(M)	The fraction of source particles leaking through the cylindrical surface through the Mth subdivision	M=1,I
Follows last P(M) card	6E10.4	X1(M)	The half angles (radians) of the cones whose intersection with the cylindrical surface form the subdivisions	M=1,I+1

2.2.2.7 Library Six: S01 Code

Library Six, which is omitted uness ID = 1, gives the directional cosines for a monodirectional source. A listing of the format to be used in making up a Library Six deck is given in Table VII.

TABLE VII

S01 Library Six Data Format

(for Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1*				
2	3E10.4	ALPHA	Cosine of angle between source direction and positive x axis	
		BETA	Cosine of angle between source direction and positive y axis	
		GAMMA	Cosine of angle between source direction and positive z axis	

* The first card of library six is blank except for the numbers in the identification field.

2.2.2.8 Library Seven: S01 Code

Library Seven, which is omitted unless ID = 3, gives the angular distribution of an anisotropic source that has an arbitrary polar angle distribution and a uniform azimuthal angle distribution. Input data for Library Seven should be prepared according to the format given in Table VIII.

TABLE VIII

Library Seven Data Format

(for Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1	I10	I	Number of polar angle intervals used to describe anisotropic source	≤ 49
2	6E10.4	CP(M)	Fraction of source particle to be emitted through Mth polar angle interval	M=1,I
Follows last CP(M) card	6E10.4	GAM(M)	Cosines of angles bounding the polar angle intervals (polar angle selected from this distribution will be measured from the positive z axis)	M=1,J+1

2.2.2.9 Library Eight: S01 Code:

Library Eight, which is omitted unless ID = 4, gives the polar and the azimuthal angular distribution for an anisotropic source that has both arbitrary polar and azimuthal angular distributions. It is assumed that the polar and azimuthal angle distributions are dependent. The format to be used in making up a Library Eight deck is given in Table IX.

TABLE IX

S01 Library Eight Data Format

(for Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1	2I10	K	Number of polar angle intervals used to describe anisotropic source distributions (measured from positive z axis)	≤49
		L	Number of azimuthal angle intervals used to describe anisotropic source distributions (measured from positive x axis)	≤49
2	6E10.4	CP(M)	Probability of source particle being emitted through the Mth polar angle interval	M=1,K
Follows last CP(M) card	6E10.4	GAM(M)	Cosines of angles bounding the polar angle intervals (descending order)	M=1,K+1
Follows last GAM(M) card	6E10.4	DCP(M,N)	Probability of a source particle that is emitted through the Mth polar angle interval also being emitted through the Nth azimuthal angle interval	M=1,K N=1,L
Follows last DCP(M,N) card	6E10.4	PHI(M,N)	Azimuthal angles (radians) bounding the Nth interval in the Mth polar angular interval	M=1,K N=1,L+1

2.2.2.10 Library Nine: S01 Code

Library Nine, which is omitted unless IE = 2, is used to describe an arbitrary energy spectrum. Table X presents the format to be used in making up a Library Nine deck.

TABLE X

S01 Library Nine Data Format

(for Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1	I(10)	K	Number of energy groups used to define spectrum	≤ 49
2	6E10.4	ECP(M)	Probability of source energy being in the Mth energy group	M=1,K
Follows last ECP(M) card	6E10.4	EG(M)	Energy bounds bounding the energy intervals	M=1,K+1

2.3 S01 Sample Problem

A sample problem is given in this section to illustrate the input and output formats for S01. The S01 sample problem was designed to describe a cylindrical volume gamma-ray source used by Lockheed in their evaluation of methods for computing nuclear rocket radiation fields (Ref. 3). Figures 2 and 3 show the normalized radial and axial fission distributions for the cylindrical volume core and Figure 4 shows the energy distribution of the fission gamma rays.

2.3.1 S01 Sample Input

Table XI shows a listing of the S01 input discussed above. The first card in Table XI gives the option numbers that identify the source as a cylindrical volume gamma-ray source with isotropic emission of the gamma rays. The second card gives two initial random numbers to start the random number sequence and, in addition, the radius and end planes of the cylindrical core. Cards 30001 through 30004 define the axial distribution and cards 30005 through 30008 define the radial distribution. The energy distribution is defined with cards 90001 through 90007.

2.3.2 S01 Sample Output

Table XII shows a listing of the output from the sample S01 problem. Source parameters were generated for 5040 source particles. For every 14 particles a record containing the parameters for all 14 particles is written on tape. Therefore, 360 data records are written on tape plus the first record which contains the values listed for NREC, the number of records, N, the number of histories, ITAPE, the tape identification number, and NG, the particle option. The last record on tape contains information for 14 source particles since the number of source particles is evenly divisible by 14.

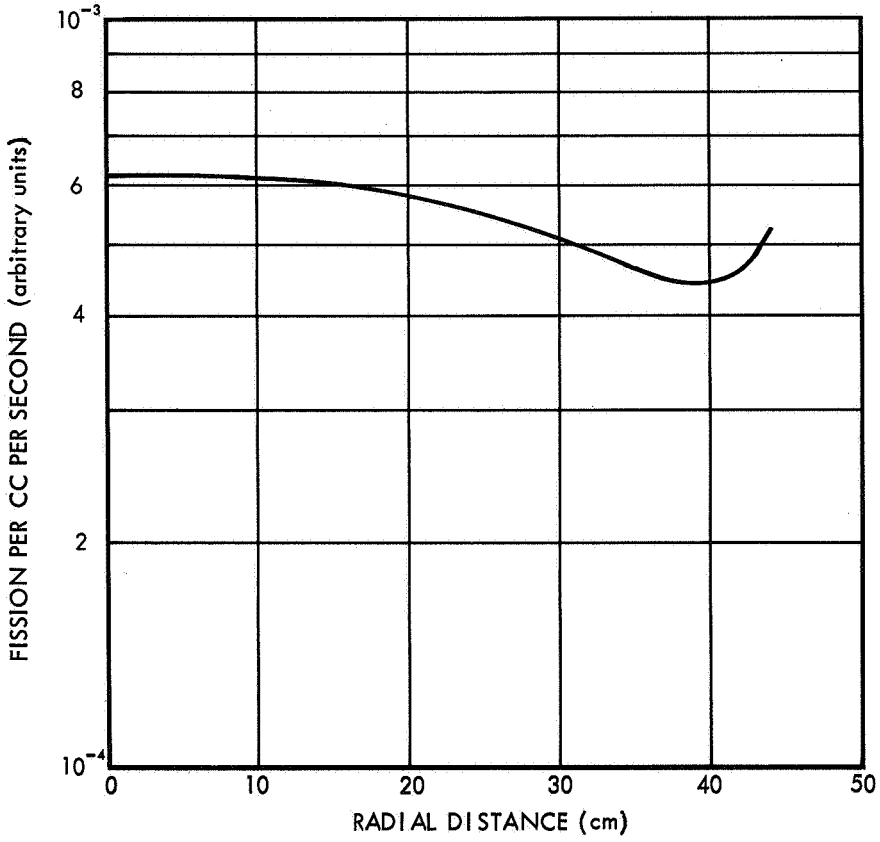

Fig. 2. Radial Fission Distribution

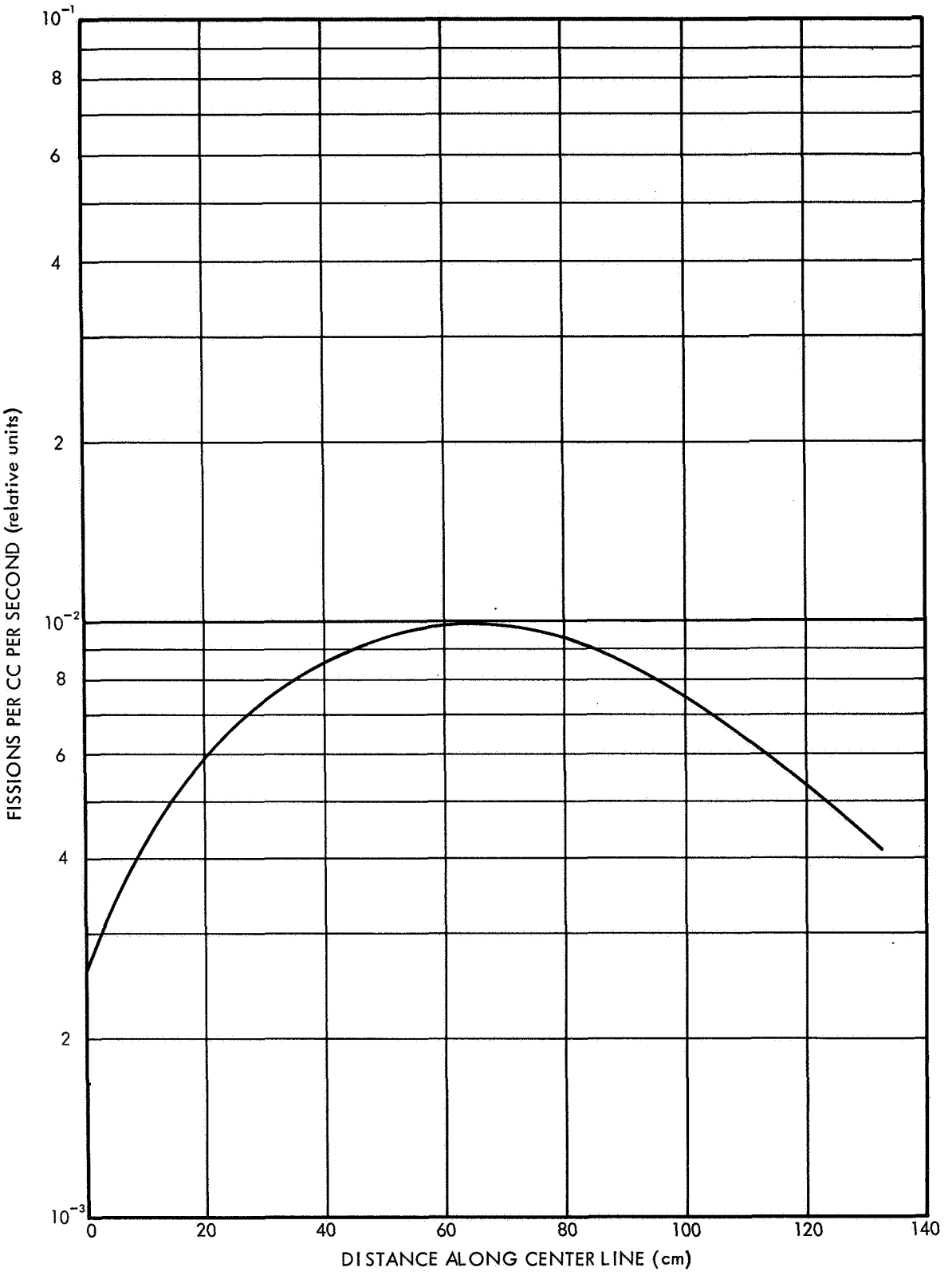

Fig. 3. Axial Fission Distribution

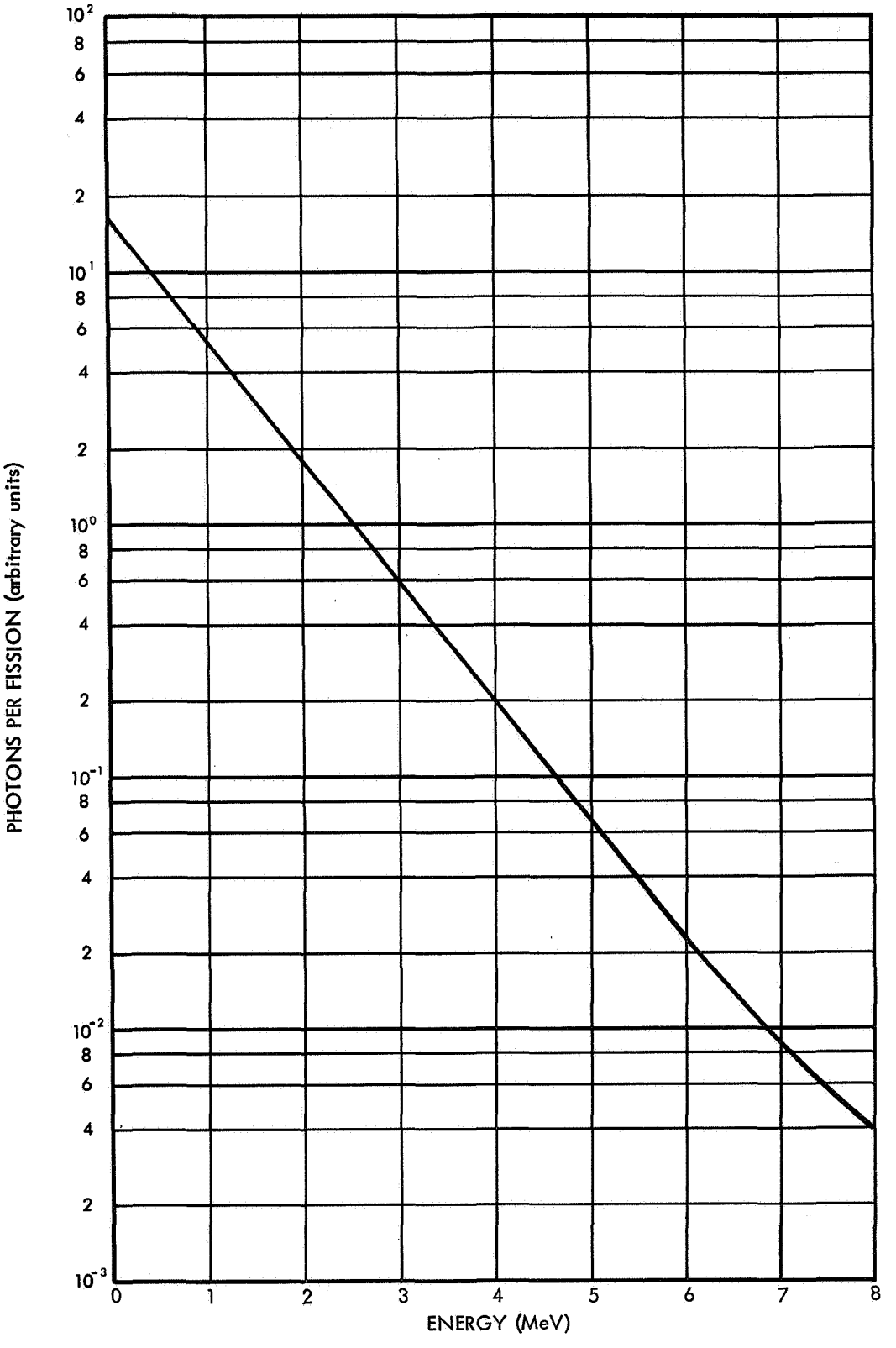

Fig. 4. Gamma Ray Source Spectrum

Table XI. S01 Sample Input Data

5040	1	3	2	2	518	518000001
75364981	53766421		44.0+00	0.0+00	1.330+02	518000002
6	8					518030001
1.52-02	1.044-01	3.620-01	4.290-01	8.10-02	8.40-03	518030002
0.0+00	5.0+00	2.50+01	6.50+01	1.15+02	1.31+02	518030003
1.33+02						518030004
5.9012-02	1.77037-01	2.95063-01	1.85261-01	1.05106-01	9.7181-02	518030005
3.8528-02	4.2812-02					518030006
0.0+00	1.0+01	2.0+01	3.0+01	3.6+01	3.9+01	518030007
4.2+01	4.3+01	4.4+01				518030008
14						518090001
1.958-01	1.576-01	1.2615-01	1.442-01	1.557-01	9.12-02	518090002
5.175-02	3.569-02	1.74-02	1.049-02	9.46-03	3.14-03	518090003
1.06-03	3.6-04					518090004
1.0-01	3.0-01	5.0-01	7.0-01	1.0+00	1.5+00	518090005
2.0+00	2.5+00	3.0+00	3.5+00	4.0+00	5.0+00	518090006
6.0+00	7.0+00	8.0+00				518090007

Table XII. S01 Sample Output Data

```
PRØBLEM CØMPLETE, SØURCE TAPE GENERATED HAS BEEN LABELED SØURCE  0.0518
THIS TAPE CØNTAINS - - -
          5040 = NUMBER ØF SØURCE PARTICLES
           361 = NUMBER ØF LØGICAL RECØRDS (MAX. ØF 14 PARTICLES PER RECØRD)
            14 = NUMBER ØF PARTICLES ØN LAST RECØRD
NREC=          1      N=      5040      ITAPE=       518      NG=     1

END ØF PRØBLEM
```

2.4 S01 FORTRAN Listings

```
C     MAIN PROGRAM FOR SOURCE ROUTINE.
      DIMENSION  P(1000),    Q(1000),    X1(1000),    X2(1000),
     1   CE(14), Y1(1000),  Y2(1000),    Z1(1000),    Z2(1000),
     2           CP(50),    DCP(50,50), ECP(50),     GAM(51),
     3           EG(51),    PHI(50,51), CX(14),      CY(14),  NOREG(14),
     4           CZ(14),    CA(14),  CB(14),  CC(14),WEIGHT(14)
      COMMON  I1      , J1      , I2      , J2      , I3      , J3
      COMMON  IC      , ID      , IE      , LIBT    , CS      , LIB1
      COMMON  CS1     , FLIB    , P       , E       , R       , Q
      COMMON  THETA1  , X1      , X2      , THETA2  , Y1      , Y2
      COMMON  Z1      , Z2      , CP      , Z3      , DCP     , Z4
      COMMON  ECP     , GAM     , EG      , PHI     , CX      , CY
      COMMON  CZ      , CA      , CB      , CC      , CE      , WEIGHT
      COMMON  NOREG   , LIST
      DATA JJJ5/3/
      READ  (5      ,10)N,NG,IC,ID,IE,ITAPE, PID, PNO,CS
   10 FORMAT(6I10,2XA4,F2.0,F4.0)
      IF(CS-1.0)                20, 30, 20
   20 PNO = PNO/100.0
      WRITE (6,25)PID, PNO, CS
   25 FORMAT (33H0DISCREPANCY IN ID FIELD OF CARD A4,F2.2,-4PF4.4)
      CALL EXIT
   30 READ  (5      ,40)R1,R2,E,R,Z3,Z4,LIST,PN1,CS1
   40 FORMAT  (2F10.2,4E10.4,I1,5XF2.0,F4.0)
      IF(PNO-PN1)               50, 45, 50
   45 IF(CS1-CS-1.0)            50, 60, 50
   50 PN1 = PN1/100.0
      WRITE (6,25)PID, PN1, CS1
      CALL EXIT
   60 IF(IC-9)                  100, 80, 70
   70 WRITE (6,75)
   75 FORMAT (61H0THERE IS AN ERROR IN A PROBLEM OPTION OR INDEXING PARA
     1METER.)
      CALL EXIT
   80 READ  (5      ,85)THETA1, THETA2, PNO, CS
   85 FORMAT      (2E10.4,46XF2.0,F4.0)
      IF(PNO-PN1)               20, 90, 20
   90 IF(CS-CS1-1.0)            20,100, 20
  100 NLIB = 0
      IF(IC)                    70, 120, 110
  110 NLIB = NLIB + 1
  120 ID1 = ID + 1
        IF(LIST)                      129, 129, 121
  121   WRITE (6,122)PID,PNO,N,NG,IC,ID,IE,ITAPE,R1,R2,E,R,   Z3,Z4,THET
     1A1,THETA2
  122   FORMAT (24H1INPUT DATA FOR PROBLEM A4,F2.0/26H  N, NG, IC, ID, I

     1E, ITAPE / 6I10 //38H  R1, R2, E, R, Z3, Z4, THETA1, THETA2/2F10.0
     2, 1P6E15.6 // )
```

```
140 IF(IE-1)                70, 175, 150
150 NLIB = NLIB+1
175 IF(NLIB)                70, 1000, 180
180 READ  (5      ,185)I,J, FLIB, LIBT,CS
      IF(LIST)                     189, 189, 181
181   WRITE (6,182)FLIB,LIBT,I,J
182   FORMAT(24H0INPUT DATA FOR LIBRARY A4,I2 // 5H I, J /2I10 )
185 FORMAT (2I10,42XA4,I2,F4.0)
189 IF(CS-1.0)                   190, 250, 190
190 PN1 = LIBT
    PN1 = PN1/100.0
    WRITE (6,25)FLIB, PN1, CS
200 FORMAT(33H0DISCREPANCY IN ID FIELD OF CARD A4,I2,-4PF4.4)
    CALL EXIT

250 GO TO (300, 350, 400, 350, 350, 450, 500, 600, 550), LIBT
300 CALL LIBR1(I,P(1))
    IF(CS1-CS)              310, 70, 320
310 CS1 = CS
320 CALL MESH(I,X1(1),X2(1),Y1(1),Y2(1),Z1(1),Z2(1))
    I1 = I
    J1 = 0
    NLIB = NLIB-1
      IF(LIST)                     340, 340, 330
330   WRITE (6,331)
331   FORMAT(4H0   ,1HI,7X,4HP(I),10X,5HX1(I),10X,5HX2(I),10X,5HY1(I),
   1  10X,5HY2(I),10X,5HZ1(I),10X,5HZ2(I) )
      DO 332   L=1,I
      WRITE (6,334)L,P(L),X1(L),X2(L),Y1(L),Y2(L),Z1(L),    Z2(L)
332   CONTINUE
334   FORMAT(1H ,I4,1P7E15.6)
340 GO TO 175
350 CALL LIBR1 (I,P(1))
    M1 = I+1
    IF(CS1-CS)              370, 70, 360
360 CS = CS1
370 CALL LIBR1(M1,X1(1))
    I1 = I
    J1 = 0
    NLIB = NLIB-1
      IF(LIST)                     390, 390, 380
380   WRITE (6,381)
381   FORMAT(4H0   ,1HI,7X,4HP(I),10X,5HX1(I) )
      DO 382  L=1,I
      WRITE (6,334)L,P(L),X1(L)
382   CONTINUE
390 GO TO 175
400 CALL LIBR1 (I,P(1))
    M1 = I+1
```

```
129 GO TO (140,130,140,130,130,140,140,140,140,140,140), ID1
130 NLIB = NLIB+1
    IF(CS1-CS)              410, 190, 405
405 CS = CS1
410 CALL LIBR1(M1,Z1(1))
    IF(CS1-CS)              420, 190, 415
415 CS = CS1
420 CALL LIBR1 (J,Q(1))
    M1 = J+1
    IF(CS1-CS)              430, 190, 425
425 CS = CS1
430 CALL LIBR1 (M1,X1(1))
    I1 = I
    J1 = J
    NLIB = NLIB-1
      IF(LIST)                      449, 449, 440
440   WRITE (6,441)
441   FORMAT(4H0    ,1HI,7X,4HP(I),10X,5HZ1(I),11X,4HQ(I),10X,5HX1(I))
      DO 442   L=1,I
      WRITE (6,334)L,P(L),Z1(L),Q(L),X1(L)
442   CONTINUE
449 GO TO 175
450 READ  (5      ,460)ALPHA, BETA, GAMMA, LIB1,CS1
460 FORMAT(3E10.4,36XI2,F4.0)
    IF(LIB1-LIBT)           480, 470, 480
470 IF(CS1-CS-1.0)          480, 490, 480
480 WRITE (6,200)FLIB , LIB1, CS1
    CALL EXIT
490 NLIB = NLIB-1
    I2 = 0
      IF(LIST)                      499, 499, 491
491   WRITE (6,492)ALPHA,BETA,GAMMA
492   FORMAT(7H0ALPHA=,1P1E15.6/7H  BETA=,E15.6/7H GAMMA=,E15.6)
499 GO TO 175
500 CALL LIBR1(I,CP(1))
C
    M1 = I+1
    IF(CS-CS1)              505, 480, 510
505 CS = CS1
510 CALL LIBR1(M1,GAM(1))
C
    I2 = I
    J2 = 0
    NLIB = NLIB - 1
      IF(LIST)                      540, 540, 520
520   WRITE (6,521)
521   FORMAT(4H0    ,1HI,6X,5HCP(I),9X,6HGAM(I) )
      DO 522   L=1,I
```

```
      WRITE (6,334)L,CP(L),GAM(L)
  522 CONTINUE
  540 GO TO 175
  550 CALL LIBR1(I,ECP(1))
      M1 = I+1
      IF(CS-CS1)                555, 480, 560
  555 CS = CS1
  560 CALL LIBR1(M1,EG(1))
      I3 = I
      NLIB = NLIB-1
      IF(LIST)                      580, 580, 570
  570 WRITE (6,571)
  571 FORMAT(4H0    ,1HI,5X,6HECP(I),10X,5HEG(I) )
      DO 572   L=1,I
      WRITE (6,334)L,ECP(L),EG(L)
  572 CONTINUE
  580 GO TO 175
  600 CALL LIBR1(I,CP(1))
      M1 = I+1
      IF(CS-CS1)                605, 480, 610
  605 CS = CS1
  610 CALL LIBR1(M1,GAM(1))
      IF(CS-CS1)                615, 480, 620
  615 CS = CS1
  620 CALL LIBR4(I,J,DCP(1,1))
      M1 = J+1
      IF(CS-CS1)                625, 480, 630
  625 CS = CS1
  630 CALL LIBR5(I,M1,PHI(1,1))
      I2 = I
      J2 = J
      NLIB = NLIB -1
      IF(LIST)                      650, 650, 640
  640 WRITE (6,641)
  641 FORMAT(4H0    ,1HI,6X,5HCP(I),9X,6HGAM(I),9X,6HDCP(I) )
      DO 642  L=1,I
      WRITE (6,334)L,CP(L),GAM(L),DCP(L,1)
  642 CONTINUE
  650 GO TO 175
C     LIBR5 = LIBR4 WITH DIMENSION B(50,51)
 1000 CALL RINT(R1,R2)
C     SUBROUTINE RINT SETS A FORK IN SUBPROGRAM RAND TO GENERATE
C     RANDOM NUMBERS FROM THE RANDOM INTEGERS R1,R2. THE RANDOM
C     NUMBERS GENERATED ARE UNIFORMLY DISTRIBUTED IN THE INTERVAL 0,1.
      IF(N)                     70, 70, 1010
 1010 IF(ID)                    70, 1020, 1020
 1020 IF(ID-10)                 1030, 1030, 70
 1030 IF(IE-2)                  1035, 1035, 70
```

```
 1035 CALL PROB
C
C
 1050 IZ = N/14
      IZ1 = N - 14*IZ
      NREC = 1
      REWIND JJJ5
      WRITE (JJJ5  )NREC, N, ITAPE, NG
      IF (IZ)                    1051, 1051, 1053
 1051 IF (IZ1)                   1500, 1500, 1052
 1052 IZ=1
      IK=IZ1
      KT=0
      GO TO 1055
 1053 KT=1
      IK=14
C
 1055 DO 1390 J = 1,IZ
      DO 1350 K = 1,IK
      IF(IC)                     1060, 1060, 1070
 1060 CX(K) = 0.0
      CY(K) = 0.0
      CZ(K) = 0.0
      GO TO 1080
 1070 CALL COORD(K)
 1080 IF(ID-1)                   1090, 1100, 1110
 1090 IF(IC-8)                        70, 1120, 1120
 1100 CA(K) = ALPHA
      CB(K) = BETA
      CC(K) = GAMMA
      GO TO 1120
 1110 CALL DIRCOS(K)
 1120 IF(IE-1)                   1130, 1130, 1140
 1130 CE(K) = E
      GO TO 1300
 1140 CALL ENERGY(K)
 1300 WEIGHT(K) = 1.0
      NO REG(K) = 1
 1350 CONTINUE
      WRITE (JJJ5  )(CX(L),CY(L),CZ(L),CA(L),CB(L),CC(L),CE(L),
     1               WEIGHT(L), NOREG(L),L=1,IK)
      NREC = NREC+1
 1390 CONTINUE
 1400 CONTINUE
      IF(KT)                     1500, 1500, 1405
 1405 IF(IZ1)                    1500, 1500, 1052
 1500 REWIND JJJ5
      PN1 = ITAPE
```

```
      IF (IZ1)                    1521, 1521, 1522
 1521 IZ1=14
 1522 WRITE (6,1540)PN1, N, NREC, IZ1
 1530 FORMAT (15HOEND OF PROBLEM)
 1540 FORMAT (64H1PROBLEM COMPLETE, SOURCE TAPE GENERATED HAS BEEN LABEL
     1ED SOURCE-4PF4.4/25H THIS TAPE CONTAINS - - -/I15,29H = NUMBER OF
     2SOURCE PARTICLES/I15,62H = NUMBER OF LOGICAL RECORDS (MAX. OF 14 P
     3ARTICLES PER RECORD)/I15,37H = NUMBFR OF PARTICLES ON LAST RECORD)
      IZ1 = ITAPE+1
      REWIND JJJ5
      READ(JJJ5)NREC, N, ITAPE, NG
      WRITE(6,11) NREC, N, ITAPE, NG
   11 FORMAT( 6H NREC=I10, 5X, 3H N=I10, 5X, 7H ITAPE=I10, 5X, 4H NG=I5)
      WRITE (6,1530)
        IF(LIST)                  1600, 1600, 1560
 1560   WRITE (6,1565)NREC,N,ITAPE,NG
 1565   FORMAT(6H1NREC=,I8,10X,2HN=,I8,10X,6HITAPE=,I9,10X,3HNG=,I8/)
        WRITE (6,1570)
 1570   FORMAT(4H0    ,7HI NOREG,4X,5HCX(I),9X,5HCY(I),9X,5HCZ(I),9X,5HCA
     1(I),9X,5HCB(I),9X,5HCC(I),9X,5HCE(I),7X,9HWEIGHT(I) )
        DO 1580   L=1, 10
        WRITE (6,1590)L,NOREG(L),CX(L),CY(L),CZ(L),CA(L),     CB(L),CC(L
     1),CE(L),WEIGHT(L)
 1580   CONTINUE
 1590   FORMAT(1H ,2I4,1P8E14.5)
 1600 CALL EXIT
      END
```

```
      SUBROUTINE LIBR1(M,A)
      DIMENSION A(1000)
      COMMON  I1      , J1      , I2      , J2      , I3      , J3
      COMMON  IC      , ID      , IE      , LIBT    , CS      , LIB1
      COMMON  CS1     , FLIB
C           THE FOLLOWING DATA STATEMENT(S) HAVE BEEN MANUFACTURED
      K1 = M/12
      K2 = M - 12*K1
      K3 = 0
      K4 = 0
      K5 = 0
      K6 = 0
      IF(K1)                  100, 100, 50
   50 DO 75 K = 1,K1
      K3 = K6+1
      K4 = K3+5
      K5 = K4+1
      K6 = K5+5
      READ  (5      ,500)(A(L),L=K3,K4),LIB1,CS1
      IF(LIB1-LIBT)           600, 55, 600
   55 IF(CS1-CS-1.0)          600, 60, 600
   60 READ  (5      ,500)(A(L),L=K5,K6),LIBT,CS

      IF(LIB1-LIBT)           650, 65, 650
   65 IF(CS-CS1-1.0)          650, 75, 650
   75 CONTINUE
  100 K3 = K6+1
      IF(K2)                  700, 700, 105
  105 GO TO (120, 150, 180, 210, 240, 270, 270, 270, 270, 270, 270), K2
  120 READ  (5      ,125)A(K3),LIB1,CS1
  125 FORMAT(E10.4,56XI2,F4.0)
      IF(LIB1-LIBT)           600, 130, 600
  130 IF(CS1-CS-1.0)          600, 700, 600
  150 READ  (5      ,160)A(K3),A(K3+1),LIB1,CS1
  160 FORMAT(2E10.4,46XI2,F4.0)
      IF(LIB1-LIBT)           600, 170, 600
  170 IF(CS1-CS-1.0)          600, 700, 600
  180 K4 = K3+2
      READ  (5      ,190)(A(K),K=K3,K4),LIB1,CS1
      IF(LIB1-LIBT)           600, 200, 600
  190 FORMAT(3E10.4,36XI2,F4.0)
  200 IF(CS1-CS-1.0)          600, 700, 600
  210 K4 = K3+3
      READ  (5      ,220)(A(K),K=K3,K4),LIB1,CS1
  220 FORMAT(4E10.4,26XI2,F4.0)
      IF(LIBT-LIB1)           600, 230, 600
  230 IF(CS1-CS-1.0)          600, 700, 600
  240 K4=K3+4
      READ  (5      ,250)(A(L),L=K3,K4),LIB1,CS1
```

```
250 FORMAT(5E10.4,16XI2,F4.0)                                          055C
    IF(LIB1-LIBT)            600, 260, 600                             056C
260 IF(CS1-CS-1.0)           600, 700, 600                             057C
270 K4 = K3 + 5                                                        058C
    READ  (5      ,500)(A(L),L=K3,K4),LIB1,CS1                         059C
    IF(LIB1-LIBT)            600, 280, 600                             060C
280 IF(CS1-CS-1.0)           600, 300, 600                             061C
300 K3 = K4+1                                                          062C
    K2 = K2-6                                                          063C
    CS = CS1                                                           064C
    IF(K2)  690, 690, 105                                              065C
500 FORMAT(6E10.4,6XI2,F4.0)                                           066C
550 FORMAT (35H0DISCREPANCY IN I.D. FIELD OF CARD A4,I2,F4.0)          067C
600 LIB1 = LIB1 + 100                                                  068C
    CS1= CS1 + 10000.0                                                 069C
    WRITE (6,550)FLIB, LIB1, CS1                                       070C
    CALL EXIT                                                          071C
650 LIB1 = LIB1 + 100                                                  072C
    CS = CS + 10000.0                                                  073C
    WRITE (6,550)FLIB, LIB1, CS                                        074C
    CALL EXIT                                                          075C
690 CS = CS1 - 1.0                                                     076C
700 RETURN                                                             077C
    END                                                                078C
```

```
      SUBROUTINE LIBR4(L,M,B)                                           SU002C
C  SUBROUTINE LIBR4 IN PRIMARY SOURCE CODE S01  (50,50)                 SU001C
      DIMENSION B(50,50)                                                SU003C
      COMMON  I1      , J1      , I2      , J2      , I3      , J3      SU004C
      COMMON  IC      , ID      , IE      , LIBT    , CS      , LIB1    SU005C
      COMMON  CS1     , FLIB                                            SU006C
      K1 = M/12                                                         SU014C
      K2 = M - 12*K1                                                    SU015C
      DO 350 L1 = 1,L                                                   SU016C
      K3 = 0                                                            SU017C
      K4 = 0                                                            SU018C
      K5 = 0                                                            SU019C
      K6 = 0                                                            SU020C
      K7 = K2                                                           SU021C
      IF(K1)                    100, 100, 50                            SU022C
   50 DO 75 K= 1,K1                                                     SU023C
      K3 = K6+1                                                         SU024C
      K4 = K3+5                                                         SU025C
      K5 = K4+1                                                         SU026C
      K6 = K5+5                                                         SU027C
      READ  (5      ,500)(B(L1,L2),L2=K3,K4),LIB1,CS1                   SU028C
      IF(LIB1-LIBT)             600, 55, 600                            SU029C
   55 IF(CS1-CS-1.0)            600, 60, 600                            SU030C
   60 READ  (5      ,500)(B(L1,L2),L2=K5,K6),LIBT,CS                    SU031C
      IF(LIB1-LIBT)             650, 65, 650                            SU032C
   65 IF(CS-CS1-1.0)            650, 75, 650                            SU033C
   75 CONTINUE                                                          SU034C
  100 K3 = K6+1                                                         SU035C
      IF(K2)                    350, 350, 105                           SU036C
  105 GO TO (120, 150, 180, 210, 240, 270, 270, 270, 270, 270, 270), K7 SU037C
  120 READ  (5      ,125)B(L1,K3), LIB1, CS1                            SU038C
  125 FORMAT(E10.4,56XI2,F4.0)                                          SU039C
  127 IF(LIB1-LIBT)             600, 130, 600                           SU040C
  130 IF(CS1-CS-1.0)            600, 140, 600                           SU041C
  140 CS = CS1                                                          SU042C
      GO TO 350                                                         SU043C
  150 READ  (5      ,155)B(L1,K3),B(L1,K3+1), LIB1, CS1                 SU044C
  155 FORMAT(2E10.4,46XI2,F4.0)                                         SU045C
      GO TO 127                                                         SU046C
  180 K4 = K3+2                                                         SU047C
      READ  (5      ,185)(B(L1,L2),L2=K3,K4), LIB1, CS1                 SU048C
  185 FORMAT(3E10.4,36XI2,F4.0)                                         SU049C
      GO TO 127                                                         SU050C

  210 K4 = K3+3                                                         SU051C
      READ  (5      ,215)(B(L1,L2),L2=K3,K4), LIB1, CS1                 SU052C
      GO TO 127                                                         SU053C
  215 FORMAT(4E10.4,26XI2,F4.0)                                         SU054C
  240 K4 = K3+4                                                         SU055C
```

```
      READ  (5      ,250)(B(L1,L2),L2=K3,K4),LIB1,CS1                    SU0560
  250 FORMAT(5E10.4,16XI2,F4.0)                                          SU0570
      GO TO 127                                                          SU0580
  270 K4 = K3+5                                                          SU0590
      READ  (5      ,500)(B(L1,L2),L2=K3,K4),LIB1,CS1                    SU0600
      IF(LIB1-LIBT)            600, 280, 600                             SU0610
  280 IF(CS1-CS-1.0)           600, 300, 600                             SU0620
  300 K3 = K4+1                                                          SU0630
      K7 = K7-6                                                          SU0640
      CS = CS1                                                           SU0650
      IF(K7)                   350, 350, 105                             SU0660
  350 CONTINUE                                                           SU0670
      CS = CS1 - 1.0                                                     SU0680
      GO TO 700                                                          SU0690
  500 FORMAT(6E10.4,6XI2,F4.0)                                           SU0700
  550 FORMAT (35H0DISCREPANCY IN I.D. FIELD OF CARD A4,I2,F4.0)          SU0710
  600 LIB1 = LIB1 + 100                                                  SU0720
      CS1 = CS1 + 10000.0                                                SU0730
      WRITE (6,550)FLIB, LIB1, CS1                                       SU0740
      CALL EXIT                                                          SU0750
  650 LIB1 = LIB1 + 100                                                  SU0760
      CS = CS + 10000.0                                                  SU0770
      WRITE (6,550)FLIB, LIB1, CS                                        SU0780
      CALL EXIT                                                          SU0790
  700 RETURN                                                             SU0800
      END                                                                SU0810
```

```
      SUBROUTINE MESH (M,A,B,C,D,E,F)
      DIMENSION A(1000),              B(1000),         C(1000),
     1          D(1000),              E(1000),         F(1000)
      COMMON  I1      , J1      , I2      , J2      , I3      , J3
      COMMON  IC      , ID      , IE      , LIBT    , CS      , LIB1
      COMMON  CS1     , FLIB
   30 DO 100 L = 1,M
      READ  (5      ,200)A(L),B(L),C(L),D(L),E(L),F(L),LIBT,CS
      IF(LIBT - LIB1)         150, 40, 150
   40 IF(CS-CS1-1.0)          150, 50, 150
   50 CS1 = CS
  100 CONTINUE
      GO TO 300
  150 WRITE (6,160)FLIB, LIBT, CS
      CALL EXIT
  160 FORMAT (35H0DISCREPANCY IN I.D. FIELD OF CARD A4,I2,F4.0)
  200 FORMAT(6E10.4,6XI2,F4.0)
  300 RETURN
      END
```

```
      SUBROUTINE LIBR5(L,M,B)                                           SU002C
C  SUBROUTINE LIBR5 IN PRIMARY SOURCE CODE S01  (50,51)                 SU001C
      DIMENSION B(50,51)                                                SU003C
      COMMON  I1      , J1      , I2      , J2      , I3      , J3      SU004C
      COMMON  IC      , ID      , IE      , LIBT    , CS      , LIB1    SU005C
      COMMON  CS1     , FLIB                                            SU006C
      K1 = M/12                                                         SU014C
      K2 = M - 12*K1                                                    SU015C
      DO 350 L1 = 1,L                                                   SU016C
      K3 = 0                                                            SU017C
      K4 = 0                                                            SU018C
      K5 = 0                                                            SU019C
      K6 = 0                                                            SU020C
      K7 = K2                                                           SU021C
      IF(K1)                  100, 100, 50                              SU022C
   50 DO 75 K= 1,K1                                                     SU023C
      K3 = K6+1                                                         SU024C
      K4 = K3+5                                                         SU025C
      K5 = K4+1                                                         SU026C
      K6 = K5+5                                                         SU027C
      READ  (5      ,500)(B(L1,L2),L2=K3,K4),LIB1,CS1                   SU028C
      IF(LIB1-LIBT)           600, 55, 600                              SU029C
   55 IF(CS1-CS-1.0)          600, 60, 600                              SU030C
   60 READ  (5      ,500)(B(L1,L2),L2=K5,K6),LIBT,CS                    SU031C
      IF(LIB1-LIBT)           650, 65, 650                              SU032C
   65 IF(CS-CS1-1.0)          650, 75, 650                              SU033C
   75 CONTINUE                                                          SU034C
  100 K3 = K6+1                                                         SU035C
      IF(K2)                  350, 350, 105                             SU036C
  105 GO TO (120, 150, 180, 210, 240, 270, 270, 270, 270, 270, 270), K7 SU037C
  120 READ  (5      ,125)B(L1,K3), LIB1, CS1                            SU038C
  125 FORMAT(E10.4,56XI2,F4.0)                                          SU039C
  127 IF(LIB1-LIBT)           600, 130, 600                             SU040C
  130 IF(CS1-CS-1.0)          600, 140, 600                             SU041C
  140 CS = CS1                                                          SU042C
      GO TO 350                                                         SU043C
  150 READ  (5      ,155)B(L1,K3),B(L1,K3+1), LIB1, CS1                 SU044C
  155 FORMAT(2E10.4,46XI2,F4.0)                                         SU045C
      GO TO 127                                                         SU046C
  180 K4 = K3+2                                                         SU047C
      READ  (5      ,185)(B(L1,L2),L2=K3,K4), LIB1, CS1                 SU048C
  185 FORMAT(3E10.4,36XI2,F4.0)                                         SU049C
      GO TO 127                                                         SU050C
  210 K4 = K3+3                                                         SU051C
      READ  (5      ,215)(B(L1,L2),L2=K3,K4), LIB1, CS1                 SU052C
      GO TO 127                                                         SU053C
  215 FORMAT(4E10.4,26XI2,F4.0)                                         SU054C
  240 K4 = K3+4                                                         SU055C
```

```
      READ  (5      ,250)(B(L1,L2),L2=K3,K4),LIB1,CS1                    SU0560
  250 FORMAT(5E10.4,16XI2,F4.0)                                          SU0570
      GO TO 127                                                          SU0580
  270 K4 = K3+5                                                          SU0590
      READ  (5      ,500)(B(L1,L2),L2=K3,K4),LIB1,CS1                    SU0600
      IF(LIB1-LIBT)           600, 280, 600                              SU0610
  280 IF(CS1-CS-1.0)          600, 300, 600                              SU0620
  300 K3 = K4+1                                                          SU0630
      K7 = K7-6                                                          SU0640
      CS = CS1                                                           SU0650
      IF(K7)                  350, 350, 105                              SU0660
  350 CONTINUE                                                           SU0670
      CS = CS1 - 1.0                                                     SU0680
      GO TO 700                                                          SU0690
  500 FORMAT(6E10.4,6XI2,F4.0)                                           SU0700
  550 FORMAT (35H0DISCREPANCY IN I.D. FIELD OF CARD A4,I2,F4.0)          SU0710
  600 LIB1 = LIB1 + 100                                                  SU0720
      CS1 = CS1 + 10000.0                                                SU0730
      WRITE (6,550)FLIB, LIB1, CS1                                       SU0740
      CALL EXIT                                                          SU0750
  650 LIB1 = LIB1 + 100                                                  SU0760
      CS = CS + 10000.0                                                  SU0770
      WRITE (6,550)FLIB, LIB1, CS                                        SU0780
      CALL EXIT                                                          SU0790
  700 RETURN                                                             SU0800
      END                                                                SU0810
```

```
      SUBROUTINE PROB
      DIMENSION  P(1000),    Q(1000),    X1(1000),    X2(1000),
     1   CE(14), Y1(1000),  Y2(1000),   Z1(1000),    Z2(1000),
     2           CP(50),    DCP(50,50), ECP(50),     GAM(51),
     3           EG(51),    PHI(50,51), CX(14),      CY(14),  NOREG(14),
     4           CZ(14),    CA(14),  CB(14),  CC(14),WEIGHT(14)
      COMMON  I1      , J1      , I2      , J2      , I3      , J3
      COMMON  IC      , ID      , IE      , LIBT    , CS      , LIB1
      COMMON  CS1     , FLIB    , P       , E       , R       , Q
      COMMON  THETA1  , X1      , X2      , THETA2  , Y1      , Y2
      COMMON  Z1      , Z2      , CP      , Z3      , DCP     , Z4
      COMMON  ECP     , GAM     , EG      , PHI     , CX      , CY
      COMMON  CZ      , CA      , CB      , CC      , CE      , WEIGHT
      COMMON  NOREG
C     DIMENSION STATEMENT SAME AS MAIN PROGRAM.
C     COMMON STATEMENT SAME AS MAIN PROGRAM.
      IF(IC)                  100, 100, 10
   10 SUM = 0.0
      DO 20 I=1,I1
      IF(P(I))                30, 15, 15
   15 SUM = SUM + P(I)
   20 CONTINUE
         IF (ABS(SUM-1.0)-.00001)          40, 40, 25
   25    JACK = 1
   30 WRITE (6,35)JACK , SUM
   35    FORMAT (40H0 ERROR IN A PROBABILITY TABLE, LOCATION,I2,
     1   6H SUM =, 1P1E15.6 )
         CALL EXIT
   40 IF(IC-3)                100, 45, 100
   45 SUM = 0.0
      DO 70 I = 1,J1
      IF(Q(I))                30, 50, 50
   50 SUM = SUM + Q(I)
   70 CONTINUE
         IF (ABS(SUM-1.0)-.00001)          100, 100, 75
   75    JACK = 2
         GO TO 30
  100 IF(ID-3)                200, 105, 110
  105 SUM = 0.0
      GO TO 115
  110 IF(ID-4)                200, 105, 200
  115 DO 130 I = 1,I2
      IF(CP(I))               30, 120, 120
  120 SUM = SUM + CP(I)
  130 CONTINUE
         IF (ABS(SUM-1.0)-.00001)          140, 140, 135
  135    JACK = 3
         GO TO 30
```

```
140 IF(ID-4)                    200, 150, 200
150 DO 180 I = 1,I2
    SUM = 0.0
    DO 170 J = 1,J2
    IF(DCP(I,J))                30, 160, 160
160 SUM = SUM + DCP(I,J)
170 CONTINUE
       IF (ABS(SUM-1.0)-.00001)          180, 180, 175
175    JACK = 4
       GO TO 30
180 CONTINUE
200 IF(IE-2)                    300, 205, 205
205 SUM = 0.0
    DO 250 I = 1,I3
    IF(ECP(I))                  30, 220, 220
220 SUM = SUM + ECP(I)
250 CONTINUE
       IF (ABS(SUM-1.0)-.00001)          300, 300, 260
260    JACK = 5
       GO TO 30
300 RETURN
    END
```

```
      SUBROUTINE COORD(M)
C     THIS SUBPROGRAM GENERATES PARTICLE COORDINATES ACCORDING TO
C     OPTION IC. DIMENSION AND COMMON STATEMENTS ARE THOSE
C     FROM THE MAIN PROGRAM
      DIMENSION  P(1000),   Q(1000),    X1(1000),   X2(1000),
     1   CE(14), Y1(1000),  Y2(1000),   Z1(1000),   Z2(1000),
     2           CP(50),    DCP(50,50), ECP(50),    GAM(51),
     3           EG(51),    PHI(50,51), CX(14),     CY(14),  NOREG(14),
     4           CZ(14),    CA(14),  CB(14),  CC(14),WEIGHT(14)
      COMMON  I1      , J1      , I2      , J2      , I3      , J3
      COMMON  IC      , ID      , IE      , LIBT    , CS      , LIB1
      COMMON  CS1     , FLIB    , P       , E       , R       , Q
      COMMON  THETA1  , X1      , X2      , THETA2  , Y1      , Y2
      COMMON  Z1      , Z2      , CP      , Z3      , DCP     , Z4
      COMMON  ECP     , GAM     , EG      , PHI     , CX      , CY
      COMMON  CZ      , CA      , CB      , CC      , CE      , WEIGHT
      COMMON  NOREG   , LIST
      K = M
      CALL RAND(RI)
      SUM = 0.0
      L   = 0
   10 L   = L+1
      SUM = SUM + P(L)
      IF(SUM - RI)          10, 20, 20
   20 GO TO (100,200,300,100,100,100,500,400,400), IC
  100 CALL RAND(RI)
      CX(K) = X1(L) + RI*(X2(L)-X1(L))
      CALL RAND(RI)
      CY(K) = Y1(L) + RI*(Y2(L)-Y1(L))
      CALL RAND(RI)
      CZ(K) = Z1(L) + RI*(Z2(L)-Z1(L))
      GO TO 1000
  200 CALL RAND(RI)
      RHO = X1(L) + RI*(X1(L+1)-X1(L))
  210 CALL RAND(RI)
      RI1 = RI+RI-1.0
      CALL RAND(RI)
      RI2 = RI + RI - 1.0
      CALL RAND(RI)
      RI3 = RI + RI - 1.0
      ETA = RI1*RI1 + RI2*RI2 + RI3*RI3
      IF(ETA - 1.0)         220, 220, 210
  220 ETA = SQRT(ETA)
      CX(K) = RI1*RHO/ETA
      CY(K) = RI2*RHO/ETA
      CZ(K) = RI3*RHO/ETA
      GO TO 1000
  300 CALL RAND(RI)
```

```
      CZ(K) = Z1(L) + RI*(Z1(L+1) - Z1(L))
      CALL RAND(RI)
      SUM = 0.0
      L   = 0
  310 L   = L+1
      SUM = SUM + Q(L)
      IF(SUM - RI)            310, 320, 320
  320 CALL RAND(RI)
      RHO = X1(L) + RI*(X1(L+1)-X1(L))
      DEL = 1.0
      GO TO 700
  400 CALL RAND(RI)
      TH = X1(L) + RI*(X1(L+1)-X1(L))
      STH = SIN(TH)
      CTH = COS(TH)
      IF(IC-8)                410, 410, 450
  410 CZ(K) = R*CTH
C     CORRECTION CARDS FOR SUBROUTINE COORD(K), (C-5).REPLACE CARD  0068
C     BY THE FOLLOWING. DELETE CARD 0069.
      RHO = R*STH
      DEL = 0.0
      GO TO 700
  450 IF(TH-THETA1)           455, 455, 470
  455 CZ(K) = Z4
  460 RHO   = CZ(K)*STH/CTH
      DEL   = 0.0
      GO TO 700
  470 IF(TH-THETA2)           480, 475, 475
  475 CZ(K) = Z3
      GO TO 460
  480 CZ(K) = R*CTH/STH
      RHO   = R
      DEL = 0.0
      GO TO 700
  500 CALL RAND(RI)
      RHO = X1(L) + RI*(X1(L+1)-X1(L))
      CZ(K) = 0.0
C     REPLACES CARD 0087. SUBROUTINE COORD(K), C-5.
      DEL     = 1.0
  700 CALL RAND(RI)
      RI1 = RI+RI-1.0
      CALL RAND(RI)
      RI2 = RI+RI-1.0
      ETA = RI1*RI1 + RI2*RI2
      IF(ETA - 1.0)           710, 710, 700
  710 ETA = SQRT(ETA)
      CPHI= RI1/ETA
      SPHI= RI2/ETA
```

```
      CX(K) =  RHO*CPHI                                                 1060
      CY(K) =  RHO*SPHI                                                 1070
      IF(DEL)                720, 720, 1000                             1080
  720 CA(K) =  STH*CPHI                                                 1090
      CB(K) =  STH*SPHI                                                 1100
      CC(K) =  CTH                                                      1110
 1000 RETURN                                                            1120
      END                                                               1130
```

```
      SUBROUTINE DIRCOS(M)
C     THIS SUBPROGRAM GENERATES DIRECTION COSINES ACCORDING TO OPTION.
C     DIMENSION AND COMMON STATEMENTS ARE THOSE OF THE MAIN PROGRAM.
      DIMENSION  P(1000),   Q(1000),    X1(1000),   X2(1000),
     1   CE(14), Y1(1000),  Y2(1000),   Z1(1000),   Z2(1000),
     2           CP(50),    DCP(50,50), ECP(50),    GAM(51),
     3           EG(51),    PHI(50,51), CX(14),     CY(14),  NOREG(14),
     4           CZ(14),    CA(14),  CB(14),  CC(14),WEIGHT(14)
      COMMON  I1      , J1      , I2      , J2      , I3      , J3
      COMMON  IC      , ID      , IE      , LIBT    , CS      , LIB1
      COMMON  CS1     , FLIB    , P       , E       , R       , Q
      COMMON  THETA1  , X1      , X2      , THETA2  , Y1      , Y2
      COMMON  Z1      , Z2      , CP      , Z3      , DCP     , Z4
      COMMON  ECP     , GAM     , EG      , PHI     , CX      , CY
      COMMON  CZ      , CA      , CB      , CC      , CE      , WEIGHT
      COMMON  NOREG   , LIST
      K = M
      GO TO (1000, 100, 300, 400, 100, 100, 100, 100, 100, 100), ID
  100 CALL RAND(RI)
      RI1 = RI + RI - 1.0
      CALL RAND(RI)
      RI2 = RI + RI - 1.0
      CALL RAND(RI)
      RI3 = RI + RI - 1.0
      ETA = RI1*RI1 + RI2*RI2 + RI3*RI3
      IF(ETA - 1.0)          110, 110, 100
  110 ETA = SQRT(ETA)
      CA(K) = RI1/ETA
      CB(K) = RI2/ETA
      CC(K) = RI3/ETA
      GO TO (1000,1000,1000,1000,120,130,140,150,160,170), ID
  120 CA(K) = ABS(CA(K))
      GO TO 1000
  130 CA(K) = -ABS(CA(K))
      GO TO 1000
  140 CB(K) = ABS(CB(K))
      GO TO 1000
  150 CB(K) = -ABS(CB(K))
      GO TO 1000
  160 CC(K) = ABS(CC(K))
      GO TO 1000
  170 CC(K) = -ABS(CC(K))
      GO TO 1000
  300 CALL RAND(RI)
      SUM = 0.0
      L   = 0
  310 L   = L+1
      SUM = SUM + CP(L)
```

```
      IF(SUM - RI)            310, 320, 320
  320 CALL RAND(RI)
      CC(K) = GAM(L) + RI*(GAM(L+1)-GAM(L))
  325 CALL RAND(RI)
      RI1 = RI+RI-1.0
      CALL RAND(RI)
      RI2 = RI+RI-1.0
      ETA = RI1*RI1 + RI2*RI2
      IF(ETA-1.0)             330, 330, 325
  330 ETA = SQRT(ETA)
      CPHI =  RI1/ETA
      SPHI =  RI2/ETA
      RI1  =  SQRT(1.0 - CC(K)*CC(K))
      CA(K) = RI1*CPHI
      CB(K) = RI1*SPHI
      GO TO 1000
  400 CALL RAND(RI)
      SUM = 0.0
      L   = 0
  410 L   = L+1
      SUM = SUM + CP(L)
      IF(SUM - RI)            410, 420, 420
  420 CALL RAND(RI)
      CC(K) = GAM(L) + RI*(GAM(L+1)-GAM(L))
      CALL RAND(RI)
      SUM = 0.0
      NIR = 0
  430 NIR = NIR+1
      SUM = SUM + DCP(L,NIR)
      IF(SUM - RI)            430, 440, 440
  440 CALL RAND(RI)
      ETA = PHI(L,NIR) + RI*(PHI(L,NIR+1)-PHI(L,NIR))
      CPHI = COS(ETA)
      SPHI = SIN(ETA)
      ETA  =  SQRT(1.0 - CC(K)*CC(K))
      CA(K) = ETA*CPHI
      CB(K) = ETA*SPHI
 1000 RETURN
      END
```

```
$IBFTC ENERGY  DECK
      SUBROUTINE ENERGY(M)                                                0030
C     THIS SUBROUTINE GENERATES PARTICLE ENERGIES.                        0010
C     SAME DIMENSION AND COMMON STATEMENTS AS MAIN PROGRAM.               0020
      DIMENSION  P(1000),   Q(1000),    X1(1000),   X2(1000),             0040
     1   CE(14), Y1(1000),  Y2(1000),   Z1(1000),   Z2(1000),             0050
     2           CP(50),    DCP(50,50), ECP(50),    GAM(51),              0060
     3           EG(51),    PHI(50,51), CX(14),     CY(14),  NOREG(14),   0070

     4           CZ(14),    CA(14),  CB(14),  CC(14),WEIGHT(14)           0080
      COMMON  I1      , J1      , I2      , J2      , I3      , J3        0090
      COMMON  IC      , ID      , IE      , LIBT    , CS      , LIB1      0100
      COMMON  CS1     , FLIB    , P       , E       , R       , Q         0110
      COMMON  THETA1  , X1      , X2      , THETA2  , Y1      , Y2        0120
      COMMON  Z1      , Z2      , CP      , Z3      , DCP     , Z4        0130
      COMMON  ECP     , GAM     , EG      , PHI     , CX      , CY        0140
      COMMON  CZ      , CA      , CB      , CC      , CE      , WEIGHT    0150
      COMMON  NOREG                                                       0160
      K = M                                                               0260
      CALL RAND(RI)                                                       0270
      SUM = 0.0                                                           0280
      L   = 0                                                             0290
   10 L   = L+1                                                           0300
      SUM = SUM + ECP(L)                                                  0310
      IF(SUM - RI)            10, 20, 20                                  0320
   20 CALL RAND(RI)                                                       0330
      CE(K) = EG(L) + RI*(EG(L+1)-EG(L))                                  0340
      RETURN                                                              0350
      END                                                                 0360
```

III Secondary Gamma-Ray Code "S02"

S02 is designed to write a source tape containing the source parameters for a secondary gamma-ray problem. The code uses as input a history tape generated with the history generator routine H01. The S02 code calculates secondary gamma-ray source parameters for either capture gamma rays or for inelastic gamma rays or both provided that the ranges of energies for the two events do not overlap. The source tape produced by S02 is identical in format to that produced by S01.

3.1 Method

The parameters describing the spatial, energy and direction coordinates, as well as the initial weight and region of birth for each secondary gamma source, are generated in the Secondary-Source Generator Code S02. The input to this code includes the tape output obtained from the running of a neutron problem on H01, and the cross sections discussed in Section 3.2.2. A problem option, INEL, is used to indicate whether or not secondary gammas are to be generated from inelastic scattering, neutron capture, or from both processes.

If a neutron with energy E_j has undergone a collision in a region containing material M, then the probability $P_M(E_j)$ that the collision is an inelastic scattering event is defined by the expression

$$P_M(E_j) = \frac{\sum_{i=1}^{NE} N_{M,i} \; \sigma_{i,n,n'}(E_j)}{\sum_{i=1}^{NE} N_{M,i} \; \sigma_{i,T}(E_j)}$$

where NE is the number of elements required to describe the materials contained in a given problem,

$N_{M,i}$ is the atomic density of element i in material M,

$\sigma_{i,n,n'}(E_j)$ is the microscopic inelastic scattering cross section for element i at energy E_j, and

$\sigma_{i,T}(E_j)$ is the microscopic total cross section for element i at energy E_j.

The quantity $\nu_M(E_j)$ is denoted as the average number of gamma rays emitted per inelastic scattering event at the neutron energy E_j in material M and is defined by

$$\nu_M(E_j) = \frac{\sum_{i=1}^{NE} N_{M,i}\sigma_{i,n,n'}(E_j)\nu_i(E_j)}{\sum_{i=1}^{NE} N_{M,i}\sigma_{i,n,n'}(E_j)}$$

where $\nu_i(E_j)$ is defined as the average number of gamma rays given off after an inelastic collision with element i and a neutron with energy E_j.

The quantity $q_{M,j,k}$ is denoted as the probability that a gamma ray with energy E_k will be given off after an inelastic collision in material M of a neutron with energy E_j, and is defined as follows:

$$q_{M,j,k} = \frac{\sum_{i=1}^{NE} N_{M,i}\sigma_{i,n,n'}(E_j)q_{i,j,k}}{\sum_{i=1}^{NE} N_{M,i}\sigma_{i,n,n'}(E_j)}$$

where $q_{i,j,k}$ is defined as the probability that a gamma ray with energy E_k will be given off following an inelastic collision with element i by a neutron with energy E_j.

Similar quantities, $p'_M(E_j)$, $\nu'_M(E_j)$, and $q'_{M,i,k}$ are defined for neutron capture. These quantities are defined in the same manner as

$p_M(E_j)$, $\nu_M(E_j)$, and $q_{M,i,k}$ with the inelastic cross section $\sigma_{i,n,n'}(E_j)$ in the above equations replaced by the neutron capture cross section $\sigma_{i,n,\gamma}(E_j)$. It is assumed that when a problem is to be run in which gamma rays are to be generated from both inelastic scattering and neutron capture processes, the energy ranges in which these processes are defined do not overlap. If the energy ranges do overlap, then separate problems should be run for each process.

A program option, IOP, is used to indicate that gamma rays are to be generated either from all neutron collisions for which the neutron energy falls within the energy range in which gamma-ray production can occur, or for only those collisions in which

$$p_M(E) - R \geq 0,$$

where R is a random number.

If all neutron collisions are used to generate gamma rays, then the number of gamma rays given off at each neutron collision is given by

$$W_\gamma = W\, p_M(E)\nu_M(E) \ ,$$

where W = the neutron weight before collision

and E = the neutron energy before collision.

If gamma rays are generated at random, then the number of gamma rays given off following a neutron collision is given by

$$W_\gamma = W\, \nu_M(E)$$

for each of the collisions for which $p_M(E) - R \geq 0$.

The angular distribution of the initial directions for gamma rays is assumed to be isotropic in the laboratory system. The initial direction cosines (α, β, and γ) are chosen at random by use of the rejection technique illustrated in Figure 1 (p. 9).

The initial energy of the gamma ray is determined by computing the smallest value of k for which

$$\sum_{\ell=1}^{k} q_{M,j,\ell} - R \geq 0.$$

The gamma-ray energy is then taken to be equal to the kth entry in the table of gamma energies input for the jth incident neutron energy group. The j used to look up the values of $q_{M,j,\ell}$ in the above expression is that value of j for which the neutron energy, E_n, satisfies the equation

$$E_j \leq E_n < E_{j+1}$$

The output of running a problem on S02 is a tape containing 14 sets of parameters (X, Y, Z, α, β, γ, E_k, W_γ, NR) per tape record. The initial coordinates X, Y and Z are the coordinates of the neutron collisions from which gamma rays result and NR is the number of the region containing the point (X,Y,Z).

3.2 S02 Utilization Instructions

The purpose of the S02 code is to produce a secondary gamma-ray source tape based upon neutron collision data generated by the History-Generator Code. The code will determine source parameters for gamma rays resulting from an inelastic or capture gamma-ray collision or both. The location, direction, energy, weight, and region of origination of each secondary gamma ray is recorded on tape which can be input in the History-Generator Code.

3.2.1 Tape Usage

The Secondary-Source Code uses six tape units in addition to the regular input and output units, logical tapes 5 and 6. Input HISTORY tapes should be loaded as logical tapes 1 and 2 before starting a

problem on S02. If only one HISTORY tape is available for input, it should be loaded on logical tape unit 1. If the minimum energy for inelastic scattering is greater than the maximum energy for capture, source tapes for both inelastic and capture gamma rays may be generated with the same problem. The inelastic gamma-ray source tape will be produced on logical tape unit 3 and the capture gamma-ray source tape will be produced on logical tape unit 4. If both the inelastic and capture events are possible for the same incident neutron energies, only one event may be considered in a problem. The logical tape units will still be three for inelastic gammas and four for capture gammas.

The operator should be advised that logical tape units 9 and 10 will be utilized as working tapes during the course of running a problem.

3.2.2 S02 Card Input

The input data for the S02 routine includes one or more sets of cards identified as problem input data and library data. Each set of cards must be sequenced in columns 69 through 70 beginning with 0001 in the first card. The library number must be punched in column 67 and 68 of all cards in each library deck and the number 00 must be punched in these columns of all cards in the problem data deck. Columns 63 through 66 of all cards are reserved for a deck identification number. The number punched in this field of the first card in the problem input data will be printed as the problem number on the printed output obtained from running an S02 problem.

3.2.2.1 Problem Deck: S02 Code

Each problem run on S02 will require the input of a problem deck. The problem deck follows immediately after the binary deck. The problem input data and the formats to be used in making up a problem deck are presented in Table XIII.

TABLE XIII

S02 Problem Input Data Format

(for Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1	12I5	NMAT	Number of materials	≤10
		NEL	Number of elements	≤8
		NREG	Number of regions	≤50
		NGI	Number of gamma rays of different energy given off in inelastic events over the whole inelastic energy range	≤25
		NGC	Number of gamma rays of different energy given off in capture events over the whole capture energy range	≤25
		INEL	Problem type: -1 = inelastic 0 = capture 1 = both	
		IOP	Option on number of gammas produced per event: 0 = random choice of events producing a gamma of weight 1 1 = each event produces a gamma reduced in weight by the ratio of event cross section to total cross section	
		ITAPE	Lowest (n,n') output tape number	
		ITAPE1	Lowest (n,γ) output tape number	
		NIT	Number of input history tapes	≤2
		NIO	Number of elements for which $\sigma_{n,n'} = 0$ (if INEL = 0, NIO = 0)	≤7
		NCO	Number of elements for which $\sigma_{n,\gamma} = 0$ (If INEL = -1, NCO = 0)	≤7
2	6E10.4	EMAX	Maximum neutron energy for cross-section input	=ENERG1(1) or ENERG2(1)

TABLE XIII (continued)

Card	Format	Input Item	Definition	Limit
		EIN	Threshold energy (minimum) for inelastic scattering	≤ENERG1(NM)
		ESEC	Threshold energy (maximum) for capture events	≤ENERG2(1)
		EMIN	Minimum neutron energy for cross-section input	ENERG1(NM) or ENERG2(NM)
3	2F10.0	R1	Random number	
		R2	Random number	
	2I5	NI	Number of neutron energy boundaries minus one in inelastic range (between these boundaries the probabilites of getting a different inelastic gamma are considered constant)	≤25
		NC	Number of neutron energy boundaries minus one in the capture range (between these boundaries the probabilities of getting different capture gammas are considered constant)	≤25
	I10	ITP	Option for intermediate printout = 0, no intermediate printout = 1, intermediate printout (If MTPREC(1)≥4, ITP should = 0)	
4	6E10.4	A(J)	Atomic weight of element J	J=1,NEL
Follows last A(J) card	6E10.4	DN(I,J)	Atomic density of element J in material I (Input with J varying most rapid.)	J=1,NEL I=1,NMAT
Follows last DN(I,J) card	6E10.4	ENI(K)	Neutron energy levels in inelastic energy range (Once an inelastic event with element J has been selected, the inelastic gamma rays given off for all incident neutron energies between ENI(K) and ENI(K+1) are determined from the same probability density table, Q1(J,K,M), library type 4.)	K≤26

TABLE XIII (continued)

Card	Format	Input Item	Definition	Limit
Follows last ENI(K) card	6E10.4	ENC(K)	Neutron energy levels in the capture energy range: (Comment similar to above)	$K \leq 26$
Follows last ENC(K) card	215	INTAPE(K)	Input history tape numbers	K=1,NIT
Follows last INTAPE(K) card	1215	MATREG(K)	Material reference number of region K. Material number should correspond to material I of DN(I,K) (MATREG(2) = 0, region 2 is always outside region)	K=1,NREG
Follows last MATREG(K) card	6E10.0	AWI(K)	Atomic weight of those elements, K, for which $\sigma_{n,n'} = 0$	K=1,NIO
Follows last AWI(K) card	6E10.0	AWC(K)	Atomic weight of those elements, K, for which $\sigma_{n,\gamma} = 0$	K=1,NCO
Follows last AWC(K) card	2I10	MTPREC(1)	Number of records on input history tape labeled HISTORY "INTAPE (NIT)"	K=NIT
		MTPREC(2)	Number of collisions on last record of above tape	

3.2.2.2 Library One: S02 Code

Library type 1 contains total neutron microscopic cross sections, TCS1(J,K), in the energy range in which inelastic scattering is possible. The index J is the element index and is ascertained by the input of the atomic weight of the element on the first card of this library, therefore, libraries of type 1 may be input in any order. The index K is the energy index and the energy it refers to is equal to the Kth energy of library 9. The cross sections should be input at the energy points listed in library type 9 since the code performs a linear interpolation to obtain the cross sections at energies between those tabulated in

library type 9. One type 1 library has to be input for each element used in the problem. The format to be used in making up Library type 1 decks is presented in Table XIV.

TABLE XIV

S02 Library One Data Format

(for Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1	2I10	IL	Library type number	=1
		NM	Number of cross sections to be read in for element J	≤126
	E10.4	AW	Atomic weight of element J	
2 continues on following cards	6E10.4	TCS1(J,K)	Total microscopic cross sections to be read in for element J at energies referred to in library type 9 (K varies most rapid.)	K=1,NM

3.2.2.3 Library Two: S02 Code

Library type 2 contains NM microscopic inelastic scattering cross sections, SCS1(J,K), in the energy range for inelastic scattering. The indexes J and K are defined in library type 1. One type 2 library has to be input for each element for which $\sigma^{i}_{n,n'} \neq 0$. Library type 2 data are to be input according to the format given in Table XV.

TABLE XV

S02 Library Two Data Format

(for Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1	2I10	IL	Library type number	=2
		NM	Number of cross sections to be read in for element J	≤126
	E10.4	AW	Atomic weight of element J	
2 continues on following cards	6E10.4	SCS1(J,K)	Microscopic inelastic scattering cross section to be read in for element J at energies referred to in Library type 9 (K varies most rapid.)	K=1,NM

3.2.2.4 Library Three: S02 Code

Library type 3 contains NM values of TTSC1(J,K) covering the inelastic scattering energy range. These values are the number of gammas given off per inelastic event versus incident neutron energy. The indexes J and K are defined in library type 1. One library type 3 is required for each element for which $\sigma^{i}_{n,n'} \neq 0$. Input library type 3 data according to the format shown in Table XVI.

TABLE XVI

S02 Library Three Data Format

(for Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1	2I10	FL	Library type number	=3
		NM	Number of energy points at which average number of gamma rays per inelastic event are given (must be same number as energies in Library 9)	<126
	E10.4	AW	Atomic weight of element J	
2	6E10.4	TTSC1(J,K)	Gammas per inelastic scatter for element J at energies defined by K in Library type 9	K=1,NM

3.2.2.5 Library Four: S02 Code

Library type 4 contains a complete list of the gamma energies, EGAM(M), that are possible from inelastic collisions with all elements. Each library type 4 contains this list and all these lists have to be identical. (M = 1 to NGI). Each library 4 also contains a probability density table, Q1(J,N,M).

The index J is the element index and is obtained by the program from the value of the atomic weight, AW, input in this library. The index N is the incident-neutron energy group index. Group N being from ENI(N) to ENI(N+1), N = 1 to NI, ENI(N)>ENI(N+1). The index M is the resultant gamma energy index. That is, if the gamma-ray index K is picked by a random process in the program, the resulting gamma energy is EGAM(K). One library type 4 is required for each element used in the problem for which $\sigma^{i}_{n,n'} \neq 0$. The Q1(J,N,M) of each library type 4 consists of a matrix of NI rows and NGI columns. The sum of the Q1 in any row must lie within the interval 1.000 ± .0001. Each Q1(J,N,M) in row N should be calculated to be the average probability of getting a gamma ray of energy EGAM(M) from an inelastic event with element J, assuming equally probable incident neutron energies from ENI(N) down to ENI(N+1) Mev. Input data for library type 4 are to be input according to the format shown in Table XVII.

TABLE XVII

S02 Library Four Data Format

(For Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1	2I10	IL	Library type number	=4
		NI	Number of neutron energy groups (Same as NI in problem input data)	=NI
	E10.4	AW	Atomic weight of element J	
2 cont'd on following cards	6E10.4	EGAM(M)	Gamma energy levels for which Q1(J,N,M) are input	M=1,NGI
Follows last EGAM(M) card	6E10.4	Q1(J,N,M)	Probability that a gamma ray of energy EGAM(M) will result from an inelastic event of a neutron from energy group index N with element J whose atomic weight is AW	N=1,NI M=1,NGI

3.2.2.6 Library Five: S02 Code

Library type 5 contains NM total neutron microscopic cross sections, TCS2(J,K), in the energy range for which neutron capture can occur. The index J is the element index and is ascertained by the input of the atomic weight of the element on the first card of each library. The index K is the energy index and the energy it refers to is equal to the Kth energy in library type 10. One type 5 library has to be input for each element used in the problem. The input data format illustrated in Table XVIII should be used in preparing a library type 5 input deck.

TABLE XVIII

S02 Library Five Data Format

(for Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1	2I10	IL	Library type number	=5
		NM	Number of cross sections to be read in	≤126
	E10.4	AW	Atomic weight of element for which cross sections are being read in	
2	6E10.4	TSC2(J,K)	Total microscopic cross sections to be read in for element J at energies referred to by index K,(E(K)>E(K+1))	

3.2.2.7 Library Six: S02 Code

Library type 6 contains NW microscopic capture cross sections, SCS2(J,K), in the energy range for which neutron capture can occur. The index J refers to the element number and the index K to the Kth energy value in library type 10. One type 6 library has to be input for each element for which $\sigma^{i}_{n,\gamma} \neq 0$. Table XIX presents the format to be used when preparing a library type 6 deck.

TABLE XIX

S02 Library Six Data Format

(for Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1	2I10	IL	Library type number	=6
		NM	Number of energy points at which microscopic capture cross sections are given	≤126
	E10.4	AW	Atomic weight of element J	
2	6E10.4	SCS2(J,K)	Microscopic capture cross section to be read in for element J at energies given in library type 10 (K varies most rapidly)	

3.2.2.8 Library Seven: S02 Code

Library type 7 contains NM values of the parameter TTSC2(J,K). The Kth value input for TTSC2(J,K) gives the average number of gammas given off per capture event by element J for the capture of neutrons with energy E_K where E_K is the Kth energy in library type 10. One library type 7 data is required for each element for which $\sigma^i_{n,\gamma} \neq 0$. Library type 7 data are to be input according to the format shown in Table XX.

TABLE XX

S02 Library Seven Data Format

(for Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1	2I10	FL	Library type number	=7
		NM	Number of cross sections to be read in for element J	≤126
	E10.4	AW	Atomic weight of element J	
2	6E10.4	TTSC2(J,K)	Gammas per inelastic scatter for element J at energies defined by K in library type 10	K=1,NM

3.2.2.9 Library Eight: S02 Code

Library type 8 contains a complete list of the gamma-ray energies, EGAMC(C), that are possible from capture events with all elements. Each library type 8 contains this list and all these lists have to be identical. (M = 1 to NGC: for NGC, see 5th item on 1st card of data input. Each library 8 also contains a probability density table, Q2(J,N,M). The index J is the element index and is obtained by the program from the value of the atomic weight, AW, input in this library. The index N is the incident-neutron-energy group index. Group N being from ENC(N) to ENC(N+1),

N = 1 to NC, (ENC(N)>ENC(N+1). The index M is the resultant gamma energy index. That is, if the gamma-ray index K is picked by a random process in the program, the resulting gamma-ray energy is EGAM(K). One library type 8 is required for each element used in the problem for which $\sigma^{i}_{n,\gamma} \neq 0$. The Q2(J,N,M) of each library type 8 consists of a matrix of NC rows and NGC columns. The sum of the Q2 in any row should lie in the interval (1,000 ± .0001). Each Q2(J,N,M) in row N should be calculated to be the average probability of getting a gamma ray of energy EGAM(M) from a capture event with element J, assuming equally probably incident neutron energies from ENC(N) down to ENC(N+1) Mev. The format to be used in preparing library type 8 input decks is shown in Table XXI.

TABLE XXI

S02 Library Eight Data Format

(for Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1	2I10	IL	Library type number	=4
		NC	Number of neutron capture energy groups (Same as NC in problem input data)	
	E10.4	AW	Atomic weight of element J	
2	6E10.4	EGAM(M)	Gamma-ray energies for neutron capture events. These energies must be identical for all elements.	
Follows last EGAM(M) card	6E10.4	Q2(J,N,M)	Probability that a gamma ray of energy EGAM(M) will result from a capture of a neutron with energy in energy group N by the element J whose atomic weight is given by AW	

3.2.2.10 Library Nine S02 Code

Library type 9 lists the set of energies at which the cross sections in the inelastic energy range are defined. The total microscopic cross

sections in the inelastic scattering energy range, TCS1(J,K), the microscopic inelastic scattering cross sections, SCS1(J,K), and the number of gamma rays given off per inelastic event, TTSC1(J,K), for all elements must be given for these sets of energies. The set of energies in this library may not overlap those given for neutron capture in library type 10. Table XXII gives the format to be used in preparing a library type 9 deck.

TABLE XXII

S02 Library Nine Data Format

(for Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1	2I10	IL	Library type number	=9
		NM	Number of energies for which cross sections in the energy range for inelastic scattering are listed	≤126
2	6E10.4	ENERG1(M)	Energy values for which cross sections are given (descending order)	M=1,NM

3.2.2.11 Library Ten: S02 Code

Library type 10 lists the set of energies at which the cross sections in the energy range for neutron capture are defined. The total microscopic cross section TCS2(J,K), the microscopic capture cross sections, SCS2(J,K), and the number of gamma rays given off per capture event, TTSC2(J,K), for all elements must be given for this set of energies. The set of energies in this library may not overlap those given in library type 9 for the inelastic events. Table XXIII presents the format to be used in preparing a Library type 10 data deck.

TABLE XXIII

S02 Library Ten Data Format

(for Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1	2I10	IL	Library type number	=10
		NM	Number of energies for which cross sections in the energy range for neutron capture are listed	≤126
2	6E10.4	ENERG2(M)	Energy values for which cross sections are given (descending order)	M=1,NM

3.3 S02 Sample Problem

A sample problem is given in this section to illustrate the input and output formats for S02. The S02 sample problem was designed to produce a capture gamma-ray source tape using the history tape from the H01 sample problem discussed in Volume III. The H01 sample problem produced a tape containing the collision parameters for 1,981 collisions in a concrete slab 50 mean-free-path lengths thick.

3.3.1 S02 Sample Input

Table XXIV shows the input data for the S02 sample problem. The option to use only a portion of the neutron collision data as secondary source points was applied. The fraction to be used is determined by the ratio of the capture cross section to the total cross sections of 7.53×10^{-1} and 1.958×10^{-2}, the average number of gamma rays (1.52) per capture is also required as input. The capture gamma-ray spectrum is also required as input.

Table XXIV

SO2 Sample Input Data

```
  1     1   11     0     7     0     0     0   66     1     0     0.  166000001     SO2
  3.0-8     3.0-8     3.0-8     1.0-8                                 166000002     SO2
71458 67  51962 83     0     1         0                              166000003     SO2
 33.0+0                                                               166000004     SO2
  1.0+0                                                               166000005     SO2
  2.9-8     2.0-8                                                     166000006     SO2
166                                                                   166000007     SO2
  1     0     1     1     1     1     1     1     1     1     1        166000008     SO2
    101         1                                                     166000009     SO2
      5         2    33.0+0     1.0-8     3.0-8                       166050001     SO2
  7.53-1    7.53-1                                                    166050002     SO2
      6         2    33.0+0     1.0-8     3.0-8                       166060001     SO2
 1.958-2   1.958-2                                                    166060002     SO2
      7         2    33.0+0     1.0-8     3.0-8                       166070001     SO2
  1.52+0    1.52+0                                                    166070002     SO2
      8         1    33.0+0     1.0-8     3.0-8                       166080001     SO2
  0.5+0     1.5+0     2.5+0     4.0+0     6.0+0     8.0+0               166080002     SO2
 10.0+0                                                               166080003     SO2
6.2829-2 3.67763-1 2.59540-1 1.76315-1 1.21382-1 1.18420-2            166080004     SO2
 3.29-4                                                               166080005     SO2
     10         2                                                     166100001     SO2
  3.0-8     2.0-8                                                     166100002     SO2
```

3.3.2 S02 Sample Output

Table XXV shows the output from the S02 sample problem. Forty-two secondary source particles were generated. These were divided into three records containing information for 14 source particles each. The first record containing information on the number of source particles and the tape identification number make a total of four records on the secondary gamma-ray source tape. The number of histories printed in the S02 output refers to the original number of neutron histories processed by the H01 problem which produce the input history tape used in the S02 sample problem.

Table XXV

S02 Sample Output Data

```
                              INPUT DATA

   1    1   11    0    7    0    0    0   66    1    0    0   166 0   1
3.000E-08 3.000E-08 3.000E-08 1.000E-08-0.000E-39-0.000E-39       0   2
71458067. 51962083.    0    1         0                         0   3
3.300E 01-0.000E-39-0.000E-39-0.000E-39-0.000E-39-0.000E-39       0   4
1.000E 00-0.000E-39-0.000E-39-0.000E-39-0.000E-39-0.000E-39       0   5
2.900E-08 2.000E-08-0.000E-39-0.000E-39-0.000E-39-0.000E-39       0   6
 166   -0                                                         0   7
   1    0    1    1    1    1    1    1    1    1   -0            0   8
      101         1                                               0   9
        5         2 3.300E 01 1.000E-08 3.000E-08            166 5   1
        6         2 3.300E 01 1.000E-08 3.000E-08            166 6   1
        7         2 3.300E 01 1.000E-08 3.000E-08            166 7   1
        8         1 3.300E 01 1.000E-08 3.000E-08            166 8   1
       10         2-0.000E-39-0.000E-39-0.000E-39            16610   1
TAPS01482
TAPS01762
TAPS02172

 PRØGRAM DETECTS NØ ERRØR IN SUBRØUTINE TAPS.
```

Table XXV (continued)

S02 Sample Output Data

```
TAPE LABELED CAPTURE**** WAS GENERATED BY SECØNDARY GAMMA SØURCE CØDE SØ2 PRØBLEM  166**
DATA PERTINENT TØ THIS TAPE ARE AS FØLLØWS.

          42. = NUMBER ØF SECØNDARY SØURCE PARTICLES ØN TAPE
           4 = NUMBER ØF LØGICAL RECØRDS (MAX. ØF 14 PARTICLES/RECØRD, BEGINNING WITH RECØRD 2)
          14 = NUMBER ØF PARTICLES ØN LAST RECØRD
          50 = NUMBER ØF HISTØRIES

          0.0 =NØ. ØF NEUTRØNS ØF ENERGY GREATER THAN EMAX
          0.0 =NØ. ØF NEUTRØNS ØF ENERGY LESS THAN EIN
          0.0 =NØ. ØF NEUTRØNS ØF ENERGY GREATER THAN ESEC
          0.0 = NØ. ØF NEUTRØNS ØF ENERGY LESS THAN ENC(NC+1)

          0.0 =NØ. ØF NEUTRØNS WITH REGIØN NUMBER LESS THAN ZERØ.

END ØF PRØBLEM
```

3.4 SO2 FORTRAN Listings

```
 DIMENSION          ENI(26)        , ENC(26)        , INTAPE(25)     ,      0150
1 A(8)            , AWI(8)         , AWC(8)         , MATREG(50)     ,      0160
2 EGAM(25)        , EGAMC(25)      , DN(10,8)       , TCS1(10,126)   ,      0170
3 SCS1(10,126)    , Q1(10,25,25)   , TCS2(10,126)   , Q2(10,25,25)   ,      0180
4 SCS2(10,126),    MTPREC(2) , ENERG1(130), ENERG2(130)
 COMMON  FLIB    , IL      , IS      , N1      , ENI     , ENC              0200
 COMMON  EMAX    , DN      , TCS1    , EL      , A       , AWI              0210
 COMMON  ITAPE   , IOP     , ITAPE1  , INTAPE  , NIT     , Q1               0220
 COMMON  SCS1    , NEL     , NC      , AWC     , INEL    , EGAM             0230
 COMMON  NIO     , NCO     , NI      , Q2      , SCS2    , NMAT             0240
 COMMON  MATREG  , NGI     , EGAMC   , NGC     , DELI    , DELC             0250
 COMMON  TCS2    , EIN     , ESEC    , NN      , PID     , MTPREC           0260
 COMMON  ENERG1,ENERG2,NUE1,NUE2
 CALL SO2
 CALL TAPS
 CALL SOURCE
 STOP
 END
```

```
$IBFTC FINDER  DECK
      SUBROUTINE FINDER (NENEGY,E,JAZ,ENERGY)
      DIMENSION ENERGY (130)
      FNEGY = NENEGY
      FNEGY = FNEGY/2.0
      STEP = FNEGY
      DO 30 I = 1,6
      STEP = STEP/2.0
      LOE = FNEGY
      IF  (E-ENERGY(LOE)) 10, 50, 20
   10 FNEGY=FNEGY+STEP
      GO TO 30
   20 FNEGY = FNEGY-STEP
   30 CONTINUE
      LOE = FNEGY
      IF (E-ENERGY(LOE)) 40,50,50
   40 JAZ = LOE
      GO TO 60
   50 JAZ = LOE - 1
      IF (JAZ.LE.0)   JAZ = 1
   60 RETURN
      END
```

```
C     COHORT -- S02
C SUBROUTINE LIB1 IN SECONDARY GAMMA CODE S02.
C
      SUBROUTINE LIB1 (N,K,B,L)
C
      DIMENSION    B(10,126)
      COMMON  FLIB    , IL      , IS      , N1
      K1 = N/12
      K2 = N-12*K1
      K3 = 0
      K4 = 0
      K5 = 0
      K6 = 0
      J = K
      IF (K1)                   100, 100, 50
   50 DO 75    I=1,K1
      K3 = K6 + 1
      K4 = K3 + 5
      K5 = K4 + 1
      K6 = K5 + 5
      READ  (5      ,500)(B(J,M),M=K3,K4), IL1, IS1
      IF (IL1-IL)               600, 55, 600
   55 IF (IS1-IS-N1)            600, 60, 600
   60 IS = IS1
      READ  (5      ,500)(B(J,M),M=K5,K6), IL1, IS1
      IF (IL1-IL)               600, 65, 600
   65 IF( IS1-IS-N1)            600, 70, 600
   70 IS=IS1
   75 CONTINUE
  100 K3=K6+1
      IF (K2)                   700, 700, 105
  105 GO TO (120,150,180,210,240,270,270,270,270,270,270), K2
  110 FORMAT ( E10.4,56XI2,I4)
  111 FORMAT (2E10.4,46XI2,I4)
  112 FORMAT (3E10.4,36XI2,I4)
  113 FORMAT (4E10.4,26XI2,I4)
  114 FORMAT (5E10.4,16XI2,I4)
  120 READ  (5      ,110)B(J,K3), IL1, IS1
  125 IF (IL1-IL)               600, 130, 600
  130 IF (IS1-IS-N1)            600, 135, 600
  135 IS = IS1
      GO TO 700
  150 READ  (5      ,111)B(J,K3), B(J,K3+1), IL1, IS1
      GO TO 125
  180 K4 = K3 + 2
      READ  (5      ,112)(B(J,M),M=K3,K4), IL1, IS1
      GO TO 125
  210 K4 = K3 + 3
      READ  (5      ,113)(B(J,M),M=K3,K4), IL1, IS1
      GO TO 125
```

```
  240 K4 = K3 + 4                                                       0600
      READ  (5      ,114)(B(J,M),M=K3,K4), IL1, IS1                    0610
      GO TO 125                                                         0620
  270 K4 = K3 + 5                                                       0630
      READ  (5      ,500)(B(J,M),M=K3,K4), IL1, IS1                    0640
      IF (IL1-IL)              600, 275, 600                            0650
  275 IF (IS1-IS-N1)           600, 280, 600                            0660
  280 IS=IS1                                                            0670
      K3=K4+1                                                           0680
      K2=K2-6                                                           0690
      IF (K2)                  700, 700, 105                            0700
  500 FORMAT (6E10.4,6XI2,I4)                                           0710
  550 FORMAT (35HODISCREPANCY IN I.D. FIELD OF CARD A4,I2,I4)           0720
  600 JS1 = IS1 + 10000                                                 0730
      JL1 = IL1 + 100                                                   0740
      WRITE (6,550)FLIB, JL1, JS1                                       0750
      CALL EXIT                                                         0760
C                                                                       0770
  700 K3 = N +1                                                         0780
      IF (K3-200)              715, 715, 725                            0790
  715 DO 720   M=K3,126                                                 0800
  720 B(J,M) = 0.0                                                      0810
  725 IF (L)                   850, 850, 800                            0820
  800 WRITE (L)J                                                        0830
      WRITE (L)(B(J,M), M=1,126)                                        0840
  850 RETURN                                                            0850
      END                                                               0860
```

```
C     COHORT -- S02
CSUBROUTINE LIB2 IN SECONDARY GAMMA CODE S02.                          0020
C                                                                      0030
      SUBROUTINE LIB2 (MZ,J,C,D,MY)                                    0040
C                                                                      0050
      DIMENSION  C(25), D(10,25,25), ENI(25), ENC(25)                  0060
      COMMON  FLIB    , IL      , IS      , N1      , ENI     , ENC    0070
      K1 = (MY-1)/6 + 1                                                0170
      K2 = K1                                                          0180
      K3 = 0                                                           0190
      K4 = 0                                                           0200
      IF (MY-24)                20, 20, 10                             0210
   10 K2 = 4                                                           0220
   20 DO  40     M1=1, K2                                              0230
      K3 = K4+1                                                        0240
      K4 = K3+5                                                        0250
      READ  (5      ,35)(C(I), I=K3,K4), IL1, IS1                      0260
      IF (IL1-IL)               70, 25, 70                             0270
   25 IF (IS1-IS-N1)            70, 30, 70                             0280
   30 IS=IS1                                                           0290
   35 FORMAT (6E10.4, 6XI2,I4)                                         0300
   40 CONTINUE                                                         0310
      IF (MY-24)                80, 80, 45                             0320
   45 READ  (5      ,50)C(25), IL1, IS1                                0330
   50 FORMAT (E10.4,56XI2,I4)                                          0340
      IF (IL1-IL)               70, 55, 70                             0350
   55 IF (IS1-IS-N1)            70, 80, 70                             0360
   70 JL1 = IL1 + 100                                                  0370
      JS1 = IS1 + 10000                                                0380
      WRITE (6,75)FLIB, JL1, JS1                                       0390
   75 FORMAT (35H0DISCREPANCY IN I.D. FIELD OF CARD A4,I2,I4)          0400
      CALL EXIT                                                        0410
   80 IS = IS1                                                         0420
      K1=MY/12                                                         0430
      K2=MY-12*K1                                                      0440
      DO 650    I= 1,MZ                                                0450
      K3 = 0                                                           0460
      K4 = 0                                                           0470
      IF (K1)                   400, 400, 100                          0480
  100 DO 375  K = 1, K1                                                0490
      DO 375  K5 =1,2                                                  0500
      K3=K4+1                                                          0510
      K4=K3+5                                                          0520
      READ  (5      ,35)(D(J,I,L),L=K3,K4), IL1, IS1                   0530
      IF (IL1-IL)               70, 110, 70                            0540
  110 IF (IS1-IS-N1)            70, 120, 70                            0550
  120 IS = IS1                                                         0560
  375 CONTINUE                                                         0570
  400 K3 = K4 + 1                                                      0580
      IF (K2)                   650, 650, 405                          0590
```

```
405 K7 = K2
410 GO TO (420,450,480,510,540,570,570,570,570,570,570), K7
412 FORMAT ( E10.4,56XI2,I4)
413 FORMAT (2E10.4,46XI2,I4)
414 FORMAT (3E10.4,36XI2,I4)
415 FORMAT (4E10.4,26XI2,I4)
416 FORMAT (5E10.4,16XI2,I4)
420 READ  (5      ,412)D(J,I,K3), IL1, IS1
425 IF (IL1-IL)              70, 430, 70
430 IF (IS1-IS-N1)           70, 435, 70
435 IS=IS1      *
    GO TO 650
450 READ  (5      ,413)D(J,I,K3), D(J,I,K3+1), IL1, IS1
    GO TO 425
480 K4 = K3+2
    READ  (5      ,414)(D(J,I,L),L=K3,K4), IL1, IS1
    GO TO 425
510 K4 = K3 + 3
    READ  (5      ,415)(D(J,I,L),L=K3,K4), IL1, IS1
    GO TO 425
540 K4 = K3 + 4
    READ  (5      ,416)(D(J,I,L),L=K3,K4), IL1, IS1
    GO TO 425
570 K4 = K3 + 5
    READ  (5      ,35)(D(J,I,L),L=K3,K4), IL1, IS1
    IF (IL1-IL)              70, 575, 70
575 IF (IS1-IS-N1)           70, 580, 70
580 IS=IS1
    K3=K4+1
    K7=K7-6
    IF (K7)                  650, 650, 410
650 CONTINUE
    DO662I=1,MZ
    SUM=0.0
    DO661L=1,MY
    SUM=SUM+D(J,I,L)
661 CONTINUE
     IF (SUM-1.001)       665,   670,   670
665   IF(SUM -0.999 )     670,   670,   662
670 WRITE (6,680)FLIB, IL, J, SUM
680 FORMAT(19H0 ERROR IN LIBRARY A4, 6H TYPE I2, 13H ELEMENT NO. I1,
   1  7H SUM = F11.8)
    CALL EXIT
662 CONTINUE
    RETURN
    END
```

```
      SUBROUTINE WEED (MY,A)
      DIMENSION  A(130)
      COMMON FLIB, IL, IS, N1
      K1 = MY/6
      K2 = MY-6*K1
      IF (K2)   50,50,25
   25 K1 = K1+1
   50 DO 100  I = 1,K1
      LAZY = 6*(I-1) + 1
      LOU = 6*I
      READ (5,52) (A(J),J=LAZY,LOU),IL1,IS1
   52 FORMAT (6E10.0,6XI2,I4)
      IF (IL1-IL)   80,60,80
   60 IF (IS1-IS-N1)  80,100,80
  100 IS = IS1
      GO TO 200
   80 WRITE (6,85) FLIB,IL1,IS1
   85 FORMAT (35H0DISCREPANCY IN I.D. FIELD OF CARD ,A4,I2,I4)
      CALL EXIT
  200 RETURN
      END
```

```
      SUBROUTINE S02
C     COHORT -- S02                                                     0010
C MAIN PROGRAM OF SECONDARY GAMMA GENERATION CODE S02.                  0020
C                                                                       0030
C TAPE UNITS -- LOGICAL TAPE  1 , INPUT HISTORY TAPES                   0040
C TAPE UNITS -- LOGICAL TAPE  2 , INPUT HISTORY TAPES
C               LOGICAL TAPE  9 , WORKING TAPE                          0060
C               LOGICAL TAPE 10 , WORKING TAPE
C               LOGICAL TAPE  3 , OUTPUT SOURCE TAPES, INELASTICS       0080
C               LOGICAL TAPE  4 , OUTPUT SOURCE TAPES, CAPTURES         0090
C                                                                       0140
C NOTE -- IF INEL = -1 , TAPES FROM  3 SHOULD BE SAVED.                 0110
C NOTE '' IF INEL =  0 , TAPES FROM  4 SHOULD BE SAVED.                 0120
C             INEL = +1 , TAPES FROM  3 AND  4 SHOULD BE SAVED.         0130
C                                                                       0100
      DIMENSION          ENI(26)        , ENC(26)        , INTAPE(25)    ,  0150
     1 A(8)            , AWI(8)         , AWC(8)         , MATREG(50)    ,  0160
     2 EGAM(25)        , EGAMC(25)      , DN(10,8)       , TCS1(10,126)  ,  0170
     3 SCS1(10,126)    , Q1(10,25,25)   , TCS2(10,126)   , Q2(10,25,25)  ,  0180
     4 SCS2(10,126),    MTPREC(2) , ENERG1(130), ENERG2(130),
     5  B(8)
      COMMON  FLIB   , IL     , IS     , N1     , ENI    , ENC            0200
      COMMON  EMAX   , DN     , TCS1   , EL     , A      , AWI            0210
      COMMON  ITAPE  , IOP    , ITAPE1 , INTAPE , NIT    , Q1             0220
      COMMON  SCS1   , NEL    , NC     , AWC    , INEL   , EGAM           0230
      COMMON  NIO    , NCO    , NI     , Q2     , SCS2   , NMAT           0240
      COMMON  MATREG , NGI    , EGAMC  , NGC    , DELI   , DELC           0250
      COMMON  TCS2   , EIN    , ESEC   , NN     , PID    , MTPREC         0260
      COMMON  ENERG1,ENERG2,NUE1,NUE2,ITP
      DATA JJJ3,JJJ10,JJJ2,JJJ4,JJ8,JJ5/ 1, 2, 9, 10,3, 4/
      REWIND JJ8                                                        0460
      REWIND JJ5                                                        0470
      N1 = 1                                                            0480
      READ  (5      ,10)NMAT, NEL, NREG, NGI, NGC, INEL, IOP, ITAPE, ITAP   0490
     1E1, NIT, NIO, NCO, PID, NN, IS                                    0500
      WRITE (6      ,11)NMAT, NEL, NREG, NGI, NGC, INEL, IOP, ITAPE, ITAP   0490
     1E1, NIT, NIO, NCO, PID, NN, IS
   10 FORMAT (12I5,2XA4,I2,I4)                                          0510
   11 FORMAT (1H1,30X,10HINPUT DATA // 12I5,2XA4,I2,I4)
      IF (IS-N1)              70, 20, 70                                0520
   20 READ  (5      ,25)EMAX,EIN,ESEC,EMIN,DELI,DELC,NN1,IS1            0530
      WRITE (6      ,26)EMAX,EIN,ESEC,EMIN,DELI,DELC,NN1,IS1            0530
   25 FORMAT (6E10.4,6XI2,I4)                                           0540
   26 FORMAT (1P6E10.3,6X,I2,I4)
      IF (NN1-NN)             80, 30, 80                                0550
   30 IF (IS1-IS-N1)          80, 35, 80                                0560
   35 IS=IS1                                                            0570
   40 FORMAT (2F10.0,  2I5,I10,26XI2,I4)                                 059
      READ  (5      ,40)R1, R2, NI, NC,ITP,  NN1,IS1                    0580
      WRITE (6      ,40)R1, R2, NI, NC,ITP,  NN1,IS1                    0580
```

```
      IF (NN1-NN)              80, 45, 80
   45 IF (IS1-IS-N1)           80, 50, 80
   50 IS=IS1
   52 FORMAT (6E10.0,6XI2,I4)
   53 FORMAT (2E10.0,46XI2,I4)
   54 FORMAT (1P6E10.3,6XI2,I4)
   56 FORMAT (1P2E10.3,46XI2,I4)
      READ  (5      ,52)(A(I),I=1,6), NN1, IS1
      WRITE (6      ,54)(A(I),I=1,6), NN1, IS1
      IF (NN1-NN)              80, 55, 80
   55 IF (IS1-IS-N1)           80, 57, 80
   57 IS=IS1
      IF (NEL-6) 59,59,58
   58 READ (5,53) (A(I),I=7,8),NN1,IS1
      WRITE(6,56) (A(I),I=7,8),NN1,IS1
      IF (NN1-NN)  80,2,80
    2 IF(IS1-IS-N1)  80,3,80
    3 IS=IS1
      GO TO 59
   59 DO 65  I=1,NMAT
      READ  (5      ,52)(DN(I,J),J=1,6), NN1, IS1
      WRITE (6      ,54)(DN(I,J),J=1,6), NN1, IS1
      IF (NN1-NN)              80, 60, 80
   60 IF (IS1-IS-N1)           80, 63, 80
   63 IS=IS1
      IF(NEL-6)  65,65,66
   66 READ (5,53) (DN(I,J),J=7,8),NN1,IS1
      WRITE(6,56) (DN(I,J),J=7,8),NN1,IS1
      IF(NN1-NN) 80,67,80
   67 IF(IS1-IS-N1)  80,68,80
   68 IS=IS1
   65 CONTINUE
      GO TO 90
C
   70 NNN = NN + 100
      ISP = IS + 10000
   73 WRITE (6,75)PID, NNN, ISP
      CALL EXIT
   75 FORMAT (35HODISCREPANCY IN I.D. FIELD OF CARD A4,I2,I4)
   80 NNN = NN1 + 100
      ISP = IS1 + 10000
      GO TO 73
C
   90 IF (INEL)                1100, 1200, 1100
 1100 READ  (5      ,25)(ENI(I),I=1,6), NN1, IS1
      WRITE (6      ,26)(ENI(I),I=1,6), NN1, IS1
      IF (NN1-NN)              80, 1102, 80
 1102 IF (IS1-IS-N1)           80, 1103, 80
 1103 IS=IS1
C NI IS THE NUMBER OF INPUT ENIS MINUS ONE, NC IS SIMILARLY DEFINED
```

```
      IF (NI-5)                1200, 1200, 1115
 1115 READ  (5      ,25)(ENI(I),I=7,12), NN1, IS1
      WRITE (6      ,26)(ENI(I),I=7,12), NN1, IS1
      IF (NN1-NN)              80, 1117, 80
 1117 IF (IS1-IS-N1)           80, 1118, 80
 1118 IS=IS1
      IF (NI-11)               1200, 1200, 1130
 1130 READ  (5      ,25)(ENI(I),I=13,18),NN1, IS1
      WRITE (6      ,26)(ENI(I),I=13,18),NN1, IS1
      IF (NN1-NN)              80, 1135, 80
 1135 IF (IS1-IS-N1)           80, 1140, 80
 1140 IS = IS1
      IF (NI-17)               1200, 1200, 1145
 1145 READ  (5      ,25)(ENI(I),I=19,24), NN1, IS1
      WRITE (6      ,26)(ENI(I),I=19,24), NN1, IS1
      IF (NN1-NN)              80, 1150, 80
 1150 IF (IS1-IS-N1)           80, 1155, 80
 1155 IS = IS1
      IF (NI-23)               1200, 1200, 1160
 1160 READ  (5      ,1165)(ENI(I),I=25,26), NN1, IS1
      WRITE (6      ,56  )(ENI(I),I=25,26), NN1, IS1
 1165 FORMAT (2E10.4,46XI2,I4)
      IF (NN1-NN)              80, 1170, 80
 1170 IF (IS1-IS-N1)           80, 1175, 80
 1175 IS=IS1
 1200 IF (INEL)              1290, 1215, 1215
 1215 READ  (5      ,25)(ENC(I), I=1,6), NN1, IS1
      WRITE (6      ,26)(ENC(I), I=1,6), NN1, IS1
      IF (NN1-NN)              80, 1220, 80
 1220 IF (IS1-IS-N1)           80, 1225, 80
 1225 IS=IS1
      IF (NC-5)                1290, 1290, 1230
 1230 READ  (5      ,25)(ENC(I), I=7,12), NN1, IS1
      WRITE (6      ,26)(ENC(I), I=7,12), NN1, IS1
      IF (NN1-NN)              80, 1235, 80
 1235 IF (IS1-IS-N1)           80, 1240, 80
 1240 IS=IS1
      IF (NC-11)               1290, 1290, 1245
 1245 READ  (5      ,25)(ENC(I), I=13,18), NN1, IS1
      WRITE (6      ,26)(ENC(I), I=13,18), NN1, IS1
      IF (NN1-NN)              80, 1250, 80
 1250 IF (IS1-IS-N1)           80, 1255, 80
 1255 IS=IS1
      IF (NC-17)               1290, 1290, 1260
 1260 READ  (5      ,25)(ENC(I), I=19,24), NN1, IS1
      WRITE (6      ,26)(ENC(I), I=19,24), NN1, IS1
      IF (NN1-NN)              80, 1265, 80
 1265 IF (IS1-IS-N1)           80, 1270, 80
 1270 IS=IS1
      IF (NC-23)               1290, 1290, 1275
```

```
1275 READ  (5      ,1165)(ENC(I),I=25,26), NN1, IS1                    1330
     WRITE (6      ,56  )(ENC(I),I=25,26), NN1, IS1
     IF (NN1-NN)              80, 1280, 80                             1340
1280 IF (IS1-IS-N1)           80, 1285, 80                             1350
1285 IS= IS1                                                           1360
1290 READ  (5      ,96)(INTAPE(I), I=1, 2), NN1, IS1                   1370
  96 FORMAT (2I5,56X,I2,I4)
     WRITE (6      ,96)(INTAPE(I), I=1, 2), NN1, IS1
  95 FORMAT (12I5,6X,I2,I4)
     IF (NN1-NN)              80, 100, 80                              1390
 100 IF (IS1-IS-N1)           80, 140, 80                              1400
 140 IS = IS1                                                           1520
 150 READ  (5      ,95)(MATREG(I), I=1,12), NN1, IS1                   1530
     WRITE (6      ,95)(MATREG(I), I=1,12), NN1, IS1                   1530
     IF (NN1-NN)              80, 155, 80                              1540
 155 IF (IS1-IS-N1)           80, 160, 80                              1550
 160 IS= IS1                                                            1560
     IF (NREG-12)             250, 250, 175                            1570
 175 READ  (5      ,95)(MATREG(I), I=13,24), NN1, IS1                  1580
     WRITE (6      ,95)(MATREG(I), I=13,24), NN1, IS1                  1580
     IF (NN1-NN)              80, 180, 80                              1590
 180 IF (IS1-IS-N1)           80, 185, 80                              1600
 185 IS=IS1                                                             1610
     IF (NREG-24)             250, 250, 190                            1620
 190 READ  (5      ,95)(MATREG(I),I=25,36), NN1, IS1                   1630
     WRITE (6      ,95)(MATREG(I),I=25,36), NN1, IS1                   1630
     IF (NN1-NN)              80, 195, 80                              1640
 195 IF (IS1-IS-N1)           80, 200, 80                              1650
 200 IS = IS1                                                           1660
     IF (NREG-36)             250, 250, 205                            1670
 205 READ  (5      ,95)(MATREG(I),I=37,48), NN1, IS1                   1680
     WRITE (6      ,95)(MATREG(I),I=37,48), NN1, IS1                   1680
     IF (NN1-NN)              80, 210, 80                              1690
 210 IF (IS1-IS-N1)           80, 215, 80                              1700
 215 IS=IS1                                                             1710
     IF (NREG-48)             250, 250, 220                            1720
 220 READ  (5      ,225)(MATREG(I),I=49,50), NN1, IS1                  1730
     WRITE (6      ,225)(MATREG(I),I=49,50), NN1, IS1                  1730
 225 FORMAT (2I5,56XI2,I4)                                              1740
     IF (NN1-NN)              80, 230, 80                              1750
 230 IF (IS1-IS-N1)           80, 235, 80                              1760
 235 IS=IS1                                                             1770
 250 IF (NIO)             2015,2015,270
 270 READ  (5      ,52)(AWI(I), I=1,6), NN1, IS1                       1800
     WRITE (6      ,54)(AWI(I), I=1,6), NN1, IS1
     IF (NN1-NN)              80, 275, 80                              1810
 275 IF (IS1-IS-N1)           80, 280, 80                              1820
 280 IS = IS1                                                           1830
     IF (NIO-6)      2015,2015,2000
2000 READ (5,  53 ) (AWI(I),I = 7,8) ,NN1, IS1
```

```
      WRITE(6,56)     (AWI(I),I = 7,8) ,NN1, IS1
      IF (NN1-NN)    80,2005,80
 2005 IF (IS1-IS-N1)    80,2010,80
 2010 IS = IS1
 2015 DO 2020 J = 1,8
 2020 B(J) = 0.0
      IF (NIO) 2030,2030,2025
 2025 DO 2028 J = 1,NIO
      DO 2027 I = 1,NEL
      IF (AWI(J)-A(I))      2027,2026,2027
 2026 B(I) = AWI(J)
      GO TO 2028
 2027 CONTINUE
 2028 CONTINUE
 2030 DO 2035 I = 1,8
 2035 AWI(I) = B(I)
 2001 IF (NCO)                2055,2055,285
  285 READ  (5      ,52)(AWC(I),I=1,6),  NN1, IS1                          1850
      WRITE (6      ,54)(AWC(I),I=1,6),  NN1, IS1
      IF (NN1-NN)              80, 290, 80                                 1860
  290 IF (IS1-IS-N1)           80, 295, 80                                 1870
  295 IS=IS1                                                               1880
      IF (NCO-6)     2055,2055,2040
 2040 READ (5    , 53 ) (AWC(I),I = 7,8), NN1,IS1
      WRITE(6,56)       (AWC(I),I = 7,8), NN1,IS1
      IF (NN1-NN)    80,2045,80
 2045 IF (IS1-IS-N1)  80,2050,80
 2050 IS = IS1
 2055 DO 2060 J = 1,8
 2060 B(J) = 0.0
      IF (NCO)  2070,2070,2065
 2065 DO 2068 J = 1,NCO
      DO 2067 I = 1,NEL
      IF (AWC(J)-A(I))     2067,2066,2067
 2066 B(I) = AWC(J)
      GO TO 2068
 2067 CONTINUE
 2068 CONTINUE
 2070 DO 2075 I = 1,8
 2075 AWC(I) = B(I)
  300 READ  (5      ,301)MTPREC(1), MTPREC(2), NN1, IS1                    1890
      WRITE (6      ,301)MTPREC(1), MTPREC(2), NN1, IS1                    1890
  301 FORMAT (2I10,46XI2,I4)                                               1900
      IF (NN1-NN)              80, 302, 80                                 1910
  302 IF (IS1-IS-N1)           80, 303, 80                                 1920
  303 IS = IS1                                                             1930
      IF (NREG)                370, 370, 305                               1940
  305 IF(NREG-50)              310, 310, 370                               1950
  310 IF(NIT)                  370, 370, 315                               1960
  315 IF(NIT-2 )               320, 320, 370                               1970
```

```
 320 IF(NEL)                    370, 370, 325
 325 IF(NEL-8)                  330, 330, 370
 330 IF(NMAT)                   370, 370, 335
 335 IF(NMAT-10)                340, 340, 370
 340 IF(NGI)                    370, 345, 345
 345 IF(NGI-25)                 350, 350, 370
 350 IF(NGC)                    370, 355, 355
 355 IF(NGC-25)                 360, 360, 370
 360 NLIB1 = 0
     NLIB2 = 0
     NLIB3 = 0
     NLIB4 = 0
     NLIB5 = 0

     NLIB6 = 0
     NLIB7 = 0
     NLIB8 = 0
 369 IPRT=0
     GO TO 371
 370 IPRT=1
 371 NPRT=0
     IF (INEL) 3000, 3010, 3000

3000 DO 1308 I=1,NI
     IF(ENI(I)-ENI(I+1)) 1307,1308,1308
1307 NPRT=1
1308 CONTINUE
3010 MPRT=0
     IF (INEL) 3030, 3020, 3020
3020 DO 1313 I=1,NC
     IF(ENC(I)-ENC(I+1)) 1312,1313,1313
1312 MPRT=1
1313 CONTINUE
3030 IF(IPRT) 1316,1316,1315
1315 WRITE (6,372)
1316 IF(NPRT) 1318,1318,1317
1317 WRITE (6,376)
1318 IF(MPRT) 1320,1320,1319
1319 WRITE (6,377)
1320 IF(IPRT+NPRT+MPRT) 373,373,1321
1321 CALL EXIT
 372 FORMAT (67H0 ERROR IN AN INDEXING PARAMETER, NREG, NIT, NEL, NMAT
    1 , NGI, NGC.)
 376 FORMAT (75H0 NEUTRON ENERGY LEVELS IN INELASTIC RANGE NOT LISTED
    1 IN DESENDING ORDER.)
 377 FORMAT (72H0 NEUTRON ENERGY LEVELS IN CAPTURE RANGE NOT LISTED IN
    1 DESENDING ORDER.)
 373 IF(ENI(1)-EMAX) 374, 374, 1322
1322 WRITE (6,1323)
1323 FORMAT (27H0 ENI(1) GREATER THEN EMAX.)
```

```
  374 IF(INEL) 375, 380, 385                                          2440
  375 NLIB = 4*NEL-3*NIO+1
      GO TO 400                                                       2460
  380 NLIB = 4*NEL-3*NCO+1                                            2470
      GO TO 400                                                       2480
  385 NLIB = 8*NEL-3*(NIO+NCO)+2                                      2490
  390 IF(NLIB)                 800, 800, 400                          2500
  400 READ (5,405)LIBNO,NM,AW,EL,ES,FLIB,  IL, IS                     2510
      WRITE(6,406)LIBNO,NM,AW,EL,ES,FLIB,  IL, IS
      IF (LIBNO.GT.8) GO TO 425
  405 FORMAT(2I10,3E10.4,12XA4,I2,I4)                                 2520
  406 FORMAT (2I10,1P3E10.3,12XA4,I2,I4)
      K1 = 0                                                          2530
      DO 415 I=1,NEL                                                  2540
      IF(AW-A(I))                  415, 410, 415                      2550
  410 K1 = I                                                          2560
      GO TO 420                                                       2570
  415 CONTINUE                                                        2580
  420 IF(K1)                       470, 470, 425                      2590
  425 GO TO (430,450,500,550,600,650,700,750,950,970),LIBNO           2600
C                                                                     2610
  430 CALL LIB1(NM,K1,TCS1(1,1),JJ8)                                  2620
      NLIB1 = NLIB1+1                                                 2630
      NLIB  = NLIB-1                                                  2640
      GO TO 390                                                       2650
C                                                                     2660
  950 CALL WEED (NM,ENERG1)
      NUE1=NM
      NLIB=NLIB-1
      GO TO 390
  970 CALL WEED (NM,ENERG2)
      NUE2=NM
      NLIB=NLIB-1
      GO TO 390
  450 CALL LIB1(NM,K1,SCS1(1,1),0)                                    2670
      NLIB2 = NLIB2+1                                                 2680
      NLIB  = NLIB-1                                                  2690
      GO TO 390                                                       2700
  470 WRITE (6,475)AW                                                 2710
      CALL EXIT                                                       2720
  475 FORMAT (28H0ELEMENT WITH ATOMIC WEIGHT F7.3,35H IS NOT CALLED FOR  2730
     1IN PROBLEM INPUT)                                               2740
  500 CALL LIB1(NM,K1,TCS1(1,1),  JJJ4)                               2750
      NLIB3 = NLIB3+1                                                 2760
      NLIB  = NLIB-1                                                  2770
      GO TO 390                                                       2780
  550 CALL LIB2(NM,K1,EGAM(1),Q1(1,1,1),NGI)                          2790
      NLIB4 = NLIB4+1                                                 2800
      NLIB  = NLIB-1                                                  2810
      GO TO 390                                                       2820
```

```
C
  600 CALL LIB1(NM,K1,TCS2(1,1),JJ5)
      NLIB5 = NLIB5+1
      NLIB  = NLIB-1
      GO TO 390
C
  650 CALL LIB1(NM,K1,SCS2(1,1),0)
      NLIB6 = NLIB6+1
      NLIB  = NLIB-1
      GO TO 390
  700 CALL LIB1(NM,K1,TCS2(1,1), JJJ2)
      NLIB7 = NLIB7+1
      NLIB  = NLIB-1
      GO TO 390
  750 CALL LIB2(NM,K1,EGAMC(1),Q2(1,1,1),NGC)
      NLIB8 = NLIB8+1
      NLIB  = NLIB-1
      GO TO 390
  800 IF(INEL)                 805, 830, 805
  805 IF(NLIB1-NEL)            870, 810, 870
  810 IF(NLIB2-NEL+NIO)        870, 815, 870
  815 IF(NLIB3+NIO-NEL)        870, 820, 870
  820 IF(NLIB4+NIO-NEL)        870, 825, 870
  825 IF(INEL)                 900, 900, 830
  830 IF(NLIB5-NEL)            870, 835, 870
  835 IF(NLIB6-NEL+NCO)        870, 840, 870
  840 IF(NLIB7-NEL+NCO)        870, 845, 870
  845 IF(NLIB8-NEL+NCO)        870, 900, 870
  870 WRITE (6,875)
      CALL EXIT
  875 FORMAT (79H0 WRONG NUMBER OF LIBRARY DECKS LOADED OR WRONG INEL
     1 INPUT FOR THIS PROBLEM.)
  900 CALL RINT (R1,R2)
      IF (ITP) 905, 905, 901
  901 WRITE (6,903)
  903 FORMAT (29H0 ALL INPUT DATA WAS READ IN.)
  905 RETURN
      END
```

```
C     COHORT -- S02                                                     0010
      SUBROUTINE TAPS                                                   0020
      DIMENSION  ENI(26),          ENC(26),        INTAPE(25),          0030
     1           AWI(8),           AWC(8),         MATREG(50),          0040
     2           EGAM(25),         EGAMC(25),      DN(10,8),            0050
     3           TCS1(10,126),     SCS1(10,126),   Q1(10,25,25),        0060
     4           TCS2(10,126),     Q2(10,25,25),   A(8),                0070
     4 SCS2(10,126),   MTPREC(2) , ENERG1(130), ENERG2(130)
      COMMON  FLIB   , FL      , CS      , S1      , ENI     , ENC       0090
      COMMON  EMAX   , DN      , TCS1    , EL      , A       , AWI       0100
      COMMON  ITAPE  , IOP     , ITAPE1  , INTAPE  , NIT     , Q1        0110
      COMMON  SCS1   , NEL     , NC      , AWC     , INEL    , EGAM      0120
      COMMON  NIO    , NCO     , NI      , Q2      , SCS2    , NMAT      0130
      COMMON  MATREG , NGI     , EGAMC   , NGC     , DELI    , DELC      0140
      COMMON  TCS2   , EIN     , ESEC    , NN      , PID     , MTPREC    0260
      COMMON  ENERG1,ENERG2,NUE1,NUE2,ITP
      DATA JJJ3,JJJ10,JJJ2,JJJ4,JJ8,JJ5/ 1, 2, 9, 10,3, 4/
      EL = EMAX                                                         0330
      K2 = NEL+1                                                        0340
      K3 = K2+1                                                         0350
      REWIND JJ8                                                        0360
      REWIND  JJJ4                                                      0370
      REWIND JJ5                                                        0380
      REWIND  JJJ2                                                      0390
      IF(INEL)                 10, 200, 10                              0400
C  READ INTO CORE ALL TOTAL CROSS SECTIONS IN INELASTIC RANGE FOR ALL    0410
C  ELEMENTS                                                             0420
   10 NZ = NEL-NIO                                                      0430
      DO 15 I=1,NEL                                                     0440
      READ  (JJ8   )K1                                                  0450
   15 READ  (JJ8   )(TCS1(K1,J),J=1,126)                                0460
      REWIND JJ8                                                        0470
      IF(NIO)                  45, 45, 20                               0480
   20 DO 40 I=1,NIO                                                     0490
      DO 35 J=1,NEL                                                     0500
      IF(AWI(I)-A(J))          35, 25, 35                               0510
   25 DO 30 K=1,126                                                     0520
   30 SCS1(J,K) =0.0                                                    0530
   35 CONTINUE                                                          0540
   40 CONTINUE                                                          0550
C  CALC OF PROBABILITY OF COLLISION IN MATERIAL I BEING AN INEL EVENT   0560
   45 DO 65 I=1,NMAT                                                    0570
      DO 60 J=1,126                                                     0580
      S1 = 0.0                                                          0590
      S2 = 0.0                                                          0600
      DO 55 K=1,NEL                                                     0610
      IF(DN(I,K))              55, 55, 50                               0620
   50 S1 = S1+DN(I,K)*SCS1(K,J)                                         0630
      S2 = S2+DN(I,K)*TCS1(K ,J)                                        0640
   55 CONTINUE                                                          0650
```

```
      IF(S2)                    56, 56, 58                                  0660
   56 TCS1(K2,J) = 0.0                                                       0670
      GO TO 60                                                               0680
   58 TCS1(K2,J) = S1/S2                                                     0690
   60 CONTINUE                                                               0700
      IF (ITP) 64, 64, 61
   61 WRITE (6,62) K2, I,(TCS1(K2,L),L=1,126)
   62 FORMAT (6H0 K2= ,I4,4H I= ,I4,/43H RATIO OF INELASTIC TO TOTAL CRO
     1SS SECTION /(1P6E11.4))
   64 WRITE (JJ8   )(TCS1(K2,L),L=1,126)                                     0710
   65 CONTINUE                                                               0720
C  READ INTO CORE ALL NO. OF GAMMAS PER INEL SCATTER                         0730
      WRITE (6,66)                                                           0740
   66  FORMAT(10H TAPS00495)                                                 0750
      DO 70 I=1,NZ                                                           0760
      READ  (JJJ4  )K1                                                       0770
   70 READ  (JJJ4  )(TCS1(K1,J),J=1,126)                                     0780
      REWIND  JJJ4                                                           0790
C  CALC AVE NO. OF GAMMAS GIVEN OFF PER INEL EVENT IN NMAT MATERIALS         0800
      DO 90 I = 1,NMAT                                                       0810
      DO 85 J = 1,126                                                        0820
      S1 = 0.0                                                               0830


      S2 = 0.0                                                               0840
      DO 80 K=1,NEL                                                          0850
      IF(DN(I,K))               80, 80, 75
   75 S1 = S1 + DN(I,K)*SCS1(K,J)*TCS1(K,J)                                  0880
      S2 = S2 + DN(I,K)*SCS1(K,J)                                            0890

   80 CONTINUE                                                               0900
      IF(S2)                    82, 82, 84                                  0910
   82 TCS1(K2,J) = 0.0                                                       0920
      GO TO 85                                                               0930
   84 TCS1(K2,J) = S1/S2                                                     0940
   85 CONTINUE                                                               0950
   89 WRITE (JJ8   )(TCS1(K2,L),L=1,126)                                     0960
      IF (ITP) 90, 90, 86
   86 WRITE (6,87) K2, I, (TCS1(K2,L),L=1,126)
   87 FORMAT (6H0 K2= ,I4,4H I= ,I4,/50H AVERAGE NUMBER OF GAMMAS PER IN
     1ELASTIC COLLISION / (1P6E11.4))
   90 CONTINUE                                                               0970
      WRITE (6,92)                                                           0980
   92  FORMAT(10H TAPS00702)                                                 0990
C  CALC OF AVE INEL CROSS SECTION FOR ENERGY GROUPS AS A FUNTION OF          1000
C  ELEMENT NUMBER. GROUP I BEING FROM ENI(I) TO ENI(I+1)                     1010


      DO 150 I=1,NI                                                          1020
                                                                             1030
```

```
      CALL FINDER(NUE1,ENI(I),J,ENERG1)                                 1030
      CALL FINDER (NUE1,ENI(I+1),J1,ENERG1)                             1040
      FJ = J                                                            1050
      IF (ITP)  94, 94, 93
   93 WRITE (6, 96) I, ENI(I), ENI(I+1),J, ENERG1(J), ENERG1(J+1),
     1 J1, ENERG1(J1),ENERG1(J1+1)
   96 FORMAT (5H0  I=,I4,13H     ENI(I)= ,1PE10.4,15H     ENI(I+1)= ,1PE
     110.4,/  5H   J=,I4,13H  ENERG1(J)= ,1PE10.4,15H  ENERG1(J+1)= ,1PE
     210.4,/  5H  J1=,I4,13H ENERG1(J1)= ,1PE10.4,15H ENERG1(J1+1)= ,1PE
     310.4)
   94 DO 145 K = 1,NEL
      IF (ITP)      97,97,99
   99 WRITE (6, 98)  SCS1(K,J),SCS1(K,J+1),SCS1(K,J1),SCS1(K,J1+1)
   98 FORMAT (13H0 SCS1(K,J)= ,1PE10.4,14H SCS1(K,J+1)= ,E10.4,
     1        13H SCS1(K,J1)= ,E10.4,15H SCS1(K,J1+1)= ,E10.4)
   97 IF(J1-J)                95, 95, 100                              1070
   95 Q1(K2,I,K)= SCS1(K,J+1) + (0.5*(ENI(I)+ENI(I+1))-ENERG1(J+1))*
     1((SCS1(K,J)-SCS1(K,J+1))/(ENERG1(J)-ENERG1(J+1)))
      GO TO 123                                                         1100
  100 IF(J1-J-1)              145, 105, 110                             1110
  105 Q1(K2,I,K) = (((SCS1(K,J1)+(ENI(I)-ENERG1(J1))*((SCS1(K,J)-SCS1(K,
     1J1))/(ENERG1(J)-ENERG1(J1)))+SCS1(K,J1))*((ENI(I)-ENERG1(J1))/2.0)
     2)+((SCS1(K,J1)  +(ENI(I+1)-ENERG1(J1))*((SCS1(K,J1)-SCS1(K,J1+1))/
     3(ENERG1(J1)-ENERG1(J1+1)))+SCS1(K,J1))*((ENERG1(J1)-ENI(I+1))/2.0)
     4))/(ENI(I)-ENI(I+1))
      GO TO 123                                                         1160
  110 Q1(K2,I,K) = ((SCS1(K,J+1)+(ENI(I)-ENERG1(J+1))*((SCS1(K,J)-SCS1(K
     1,J+1))/(ENERG1(J)-ENERG1(J+1))))+SCS1(K,J+1))*((ENI(I)-ENERG1(J+1)
     2)/2.0)
      LAZY = J1-J-1                                                     1190
      DO 120 L =1,LAZY                                                  1200
      J2 = J+L                                                          1210
  120 Q1(K2,I,K) = Q1(K2,I,K) + (SCS1(K,J2)+SCS1(K,J2+1))*((ENERG1(J2)-
     1ENERG1(J2+1))/2.0)
      S1 = J1                                                           1230
      Q1(K2,I,K) = (Q1(K2,I,K) +(SCS1(K,J1)+((ENERG1(J1)-ENI(I+1))/2.0)*
     1((SCS1(K,J1)-SCS1(K,J1+1))/(ENERG1(J1+1)-ENERG1(J1))))*(ENERG1(J1)
     2-ENI(I+1))) /(ENI(I)-ENI(I+1))
  123 IF (ITP) 145, 145, 125
  125 WRITE (6,130) K2, I, K, Q1(K2,I,K)
  130 FORMAT(6H0 K2= ,I4, 4H I= ,I4, 4H K= ,I4,13H Q1(K2,I,K)= ,1PE10.4)
  145 CONTINUE                                                          1270
  150 CONTINUE                                                          1280
      WRITE (6,151)                                                     1290
  151  FORMAT(10H TAPS00972)                                            1300
      IF(INEL)                400, 200, 200                             1310
  200 NZ = NEL - NC0                                                    1320
C  INPUT ALL TOTAL XSECTIONS IN CAPTURE RANGE                           1330
      DO 205 I = 1,NEL                                                  1340
      READ  (JJ5   )K1                                                  1350
```

```
  205 READ  (JJ5    )(TCS2(K1,J),J=1,126)
      REWIND JJ5
      IF(NCO)                245, 245, 220
  220 DO 240 I=1,NCO
      DO 235 J=1,NEL
      IF(AWC(I)-A(J))        235, 225, 235
  225 DO 230 K=1,126
  230 SCS2(J,K) = 0.0
  235 CONTINUE
  240 CONTINUE
C CALC OF PROBABILITY OF COLL IN MATERIAL I BEING A CAPTURE EVENT       T
      WRITE (6,242)
  242  FORMAT(10H TAPS01112)
  245 DO 265 I = 1,NMAT
      DO 260 J = 1,126
      S1 = 0.0
      S2 = 0.0
      DO 255 K=1,NEL
      IF(DN(I,K))            255, 255, 250
  250 S1 = S1 + DN(I,K)*SCS2(K,J)
      S2 = S2 + DN(I,K)*TCS2(K,J)
  255 CONTINUE
      IF(S2)                 256, 256, 258
  256 TCS2(K2,J) = 0.0
      GO TO 260
  258 TCS2(K2,J) = S1/S2
  260 CONTINUE
      IF (ITP) 264, 264, 261

  261 WRITE (6,262) K2,I,(TCS2(K2,L),L=1,126)
  262 FORMAT (5H0K2= ,I4,4H I= ,I4,/41H RATIO OF CAPTURE TO TOTAL CROSS
     ?SECTION / (1P6E11.4))
  264 WRITE (JJ5    )(TCS2(K2,L),L=1,126)
  265 CONTINUE
C  READ INTO CORE ALL NUMBER OF GAMMAS GIVEN OFF PER CAPTURE EVENT (EL)
      DO 270 I=1,NZ
      READ  (JJJ2   )K1
  270 READ  (JJJ2   )(TCS2(K1,J),J=1,126)
      REWIND  JJJ2
C  CALC AVE NO. OF GAMMAS GIVEN OFF PER CAPT EVENT AS A FUNCTION OF
C  MATERIAL AND INCIDENT NEUTRON ENERGY
      DO 290 I=1,NMAT
      DO 285 J=1,126
      S1 = 0.0
      S2 = 0.0
      DO 280 K = 1,NEL
      IF(DN(I,K))            280, 280, 275
  275 S1 = S1 + DN(I,K)*SCS2(K,J)*TCS2(K,J)
      S2 = S2 + DN(I,K)*SCS2(K,J)
  280 CONTINUE
```

```
      IF(S2)                    282, 282, 284                                  1820
  282 TCS2(K2,J) = 0.0                                                          1830
      GO TO 285                                                                 1840
  284 TCS2(K2,J) = S1/S2                                                        1850
  285 CONTINUE
      IF (ITP)  289, 289, 286
  286 WRITE (6,287) K2, I, (TCS2(K2,L),L=1,126)
  287 FORMAT (5H0K2= ,I4,4H I= ,I4,/57H AVERAGE NUMBER OF GAMMA RAY PER
     1THERMAL NEUTRON CAPTURE / (1P6E11.4))
  289 WRITE( JJ5 ) ( TCS2( K2, L ), L=1,126 )
  290  CONTINUE
      WRITE (6,292)                                                             1890
  292  FORMAT(10H TAPS01482)                                                    1900
C  CALC OF AVE CAPT XSECTION FOR ENERGY GROUPS AS A FUNCTION OF ELEMENT        1910
C  NUMBER. GROUP I BEING FROM ENC(I) TO ENC(I+1)                               1920
      DO 350 I = 1,NC                                                           1930
      CALL FINDER(NUE2,ENC(I),J,ENERG2)                                         1030
      CALL FINDER (NUE2,ENC(I+1),J1,ENERG2)                                     1040
      FJ = J                                                                    1960
      IF (ITP) 294,294,293
  293 WRITE (6,296) I, ENC(I), ENC(I+1),J, ENERG2(J), ENERG2(J+1),
     1 J1, ENERG2(J1),ENERG2(J1+1)
  296 FORMAT (5H0  I=,I4,13H     ENC(I)= ,1PE10.4,15H     ENC(I+1)= ,1PE
     110.4,/  5H   J=,I4,13H  ENERG2(J)= ,1PE10.4,15H  ENERG2(J+1)= ,1PE
     210.4,/  5H  J1=,I4,13H ENERG2(J1)= ,1PE10.4,15H ENERG2(J1+1)= ,1PE
     310.4)
  294 DO 345 K = 1,NEL
      IF (ITP)          298,298,297
  297 WRITE (6,299)  SCS2(K,J),SCS2(K,J+1),SCS2(K,J1),SCS2(K,J1+1)
  299 FORMAT (13H0 SCS2(K,J)= ,1PE10.4,14H SCS2(K,J+1)= ,E10.4,
     1        13H SCS2(K,J1)= ,E10.4,15H SCS2(K,J1+1)= ,E10.4)
  298 IF(J1-J)                295, 295, 300                                   1980
  295 Q2(K2,I,K)= SCS2(K,J+1) + (0.5*(ENC(I)+ENC(I+1))-ENERG2(J+1))*
     1((SCS2(K,J)-SCS2(K,J+1))/(ENERG2(J)-ENERG2(J+1)))
      GO TO 323                                                                 2010
  300 IF(J1-J-1)              345, 305, 310                                     2020
  305 Q2(K2,I,K) = (((SCS2(K,J1)+(ENC(I)-ENERG2(J1))*((SCS2(K,J)-SCS2(K,
     1J1))/(ENERG2(J)-ENERG2(J1)))+SCS2(K,J1))*((ENC(I)-ENERG2(J1))/2.0)
     2)+((SCS2(K,J1  )+(ENC(I+1)-ENERG2(J1))*((SCS2(K,J1)-SCS2(K,J1+1))/
     3(ENERG2(J1)-ENERG2(J1+1)))+SCS2(K,J1))*((ENERG2(J1)-ENC(I+1))/2.0)
     4))/(ENC(I)-ENC(I+1))
      GO TO 323                                                                 2080
  310 Q2(K2,I,K) = ((SCS2(K,J+1)+(ENC(I)-ENERG2(J+1))*((SCS2(K,J)-SCS2(K
     1,J+1))/(ENERG2(J)-ENERG2(J+1))))+SCS2(K,J+1))*((ENC(I)-ENERG2(J+1)
     2)/2.0)
      LAZY = J1-J-1                                                             2110
      DO 320 L = 1,LAZY                                                         2120
      J2 = J+L                                                                  2130
  320 Q2(K2,I,K) = Q2(K2,I,K) + (SCS2(K,J2)+SCS2(K,J2+1))*((ENERG2(J2)-
     1ENERG2(J2+1))/2.0)
```

```
      S1 = J1                                                           2150
      Q2(K2,I,K) = (Q2(K2,I,K) +(SCS2(K,J1)+((ENERG2(J1)-ENC(I+1))/2.0)*
     1((SCS2(K,J1)-SCS2(K,J1+1))/(ENERG2(J1+1)-ENERG2(J1))))*(ENERG2(J1)
     2-ENC(I+1))) /(ENC(I)-ENC(I+1))
  323 IF (ITP) 345, 345, 325
  330 FORMAT(6H0 K2= ,I4, 4H I= ,I4, 4H K= ,I4,13H Q2(K2,I,K)= ,1PE10.4)
  325 WRITE (6,330) K2, I, K, Q2(K2,I,K)
  345 CONTINUE                                                          2190
  350 CONTINUE                                                          2200
      WRITE (6,402)                                                     2210
  402  FORMAT(10H TAPS01762)                                            2220
  400 IF(INEL)                  410, 450, 410                           2230
C CALC OF PROB OF NEUTRON OF ENERGY GROUP J GIVING BIRTH TO AN  INEL    2240
C  GAMMA RAY WHOSE ENERGY INDEX IS K IN MATERIAL I                      2250
  410 DO 445 I=1,NMAT                                                   2260
      DO 440 J=1,NI                                                     2270
      DO 435 K=1,NGI                                                    2280
      S1 = 0.0                                                          2290
      S2 = 0.0                                                          2300
      DO 430 L=1,NEL                                                    2310
      IF(DN(I,L))               430, 430, 420
  420 S1 = S1+DN(I,L)*Q1(K2,J,L)*Q1(L,J,K)                              2340
      S2 = S2+DN(I,L)*Q1(K2,J,L)                                        2350
  430 CONTINUE                                                          2360
      IF(S2)                    432, 432, 434                           2370
  432 Q1(K3,J,K) = 0.0                                                  2380
      GO TO 435                                                         2390
  434 Q1(K3,J,K) = S1/S2                                                2400
  435 CONTINUE                                                          2410
      IF (ITP) 440, 440, 436
  436 WRITE (6,437) K3, J, I,(Q1(K3,J,L),L=1,NGI)
  437 FORMAT (5H0K3= ,I4,4H J= ,I4,4H I= ,I4,/83H PROBABILITY OF GAMMA R
     1AY WITH ENERGY K BEING EMITTED DUE TO COLLISION WITH NUTRON /29H
     2OF ENERGY J IN MATERIAL I. / (1P6E11.4))
  440 CONTINUE                                                          2420
  445 WRITE (JJ8    )((Q1(K3,J1,J2),J1=1,NI),J2=1,NGI)                  2430
      IF(INEL)                  500, 450, 450                           2440
C CALC OF PROB OF NEUTRON OF GROUP J GIVING BIRTH TO A CAPTURE GAMMA   T 2450
C  RAY WHOSE ENERGY INDEX IS K IN MATERIAL I                            2460
  450 DO 495 I=1,NMAT                                                   2470
      DO 490 J=1,NC                                                     2480
      DO 485 K = 1,NGC                                                  2490
      S1 = 0.0                                                          2500
      S2 = 0.0                                                          2510
      DO 480 L=1,NEL                                                    2520
      IF(DN(I,L))               480, 480, 470
  470 S1 = S1 + DN(I,L)*Q2(K2,J,L)*Q2(L,J,K)                            2550
      S2 = S2 + DN(I,L)*Q2(K2,J,L)                                      2560
  480 CONTINUE                                                          2570
```

```
      IF(S2)                    482, 482, 484
  482 Q2(K3,J,K) = 0.0
      GO TO 485
  484 Q2(K3,J,K) = S1/S2
  485 CONTINUE
      IF  (ITP) 490, 490, 486
  486 WRITE (6,487) K3, J, I, (Q2(K3,J,L),L=1,NGC)
  487 FORMAT (5H0K3= ,I4,4H J= ,I4,4H I= ,I4,/83H PROBABILITY OF GAMMA R
     1AY WITH ENERGY K BEING EMITTED DUE TO ABSORPTION OF NEUTRON /31H
     2WITH ENERGY J IN MATERIAL I. / (1P6E11.4))
  490 CONTINUE
      WRITE (JJ5   )((Q2(K3,J1,J2),J1=1,NC),J2=1,NGC)
  495 CONTINUE
  500 REWIND JJ8
      REWIND JJ5
      WRITE (6,502)
  502  FORMAT(10H TAPS02172)
      IF(INEL)                  510, 530, 510

  510 DO 515 I =1,NMAT
  515 READ  (JJ8   )(TCS1(I,J),J=1,126)

      DO 520 I=1,NMAT
  520 READ  (JJ8   )(SCS1(I,J),J=1,126)
      DO 525 I=1,NMAT
  525 READ  (JJ8   )((Q1(I,J,K),J=1,NI),K=1,NGI)
      IF (ITP)       530,530,526
  526 WRITE (6,630)(TCS1(1,J),SCS1(1,J),J=1,10)
  630 FORMAT (1H010X10H TCS1(1,J)14X10H SCS1(1,J)/(E21.4,E23.4))
      WRITE (6,640)(Q1(1,1,K),K=1,NGI)
  640 FORMAT (1H020X10H Q1(1,1,K)/(6E15.4))
      IF(INEL)                  600, 530, 530
  530 DO 535 I=1,NMAT
  535 READ  (JJ5   )(TCS2(I,J),J=1,126)
      DO 540 I=1,NMAT
  540 READ  (JJ5   )(SCS2(I,J),J=1,126)
      DO 545 I=1,NMAT

  545 READ  (JJ5   )((Q2(I,J,K),J=1,NC),K=1,NGC)

      IF (ITP)      600,600,546
  546 WRITE (6,650)(TCS2(1,J),SCS2(1,J),J=1,10)

  650 FORMAT (1H010X10H TCS2(1,J)14X10H SCS2(I,J)/(E21.4,E23.4))
      WRITE (6,660)(Q2(1,1,K),K=1,NGC)
  660 FORMAT (1H020X10H Q2(1,1,K)/(6E15.4))
  600 REWIND JJ8
      REWIND JJ5
      REWIND  JJJ4
      REWIND  JJJ2
```

```
610 CONTINUE                                                            2960
    WRITE (6,620)                                                       2970
620 FORMAT (46H0 PROGRAM DETECTS NO ERROR IN SUBROUTINE TAPS.)          2980
    RETURN                                                              2990
    END                                                                 3000
```

```
C     COHORT -- S02                                                     0010
      SUBROUTINE SOURCE                                                 0020
      DIMENSION  INTAPE(25),
     1          CE1(20), CW1(20), CX2(20), CY2(20), CZ2(20), CA2(20),   0040
     2CB2(20), CC2(20), CE2(20), CW2(20),                    NRS(20),    0050
     3MATREG(50), TCS1(10,126), W(14), SCS1(10,126), CX(14), CY(14),CZ(1 0060

     44), CA(14), CB(14), CC(14), ENI(26), Q1(10,25,25),CE(14), EGAM(25) 0070
     5, NOR(14), A(8), TCS2(10,126), W2(14), SCS2(10,126), X2(14), Y2(14 0080
     6), Z2(14), AC(14), BC(14), DC(14), ENC(26), Q2(10,25,25), EC(14),  0090
     7 EGAMC(25), NRE(14), AWI(8), AWC(8), DN(10,8),MTPREC(2)            0100
     4                          ,ENERG1(130), ENERG2(130)
      COMMON  FLIB    , IL      , IS      , N1      , ENI     , ENC      0110
      COMMON  EMAX    , DN      , TCS1    , EL      , A       , AWI      0120
      COMMON  ITAPE   , IOP     , ITAPE1  , INTAPE  , NIT     , Q1       0130
      COMMON  SCS1    , NEL     , NC      , AWC     , INEL    , EGAM     0140
      COMMON  NIO     , NCO     , NI      , Q2      , SCS2    , NMAT     0150
      COMMON  MATREG  , NGI     , EGAMC   , NGC     , DELI    , DELC     0160
      COMMON  TCS2    , EIN     , ESEC    , NN      , PID     , MTPREC   0170
      COMMON  ENERG1,ENERG2,NUE1,NUE2,ITP
      DATA JJJ3,JJJ10,JJJ2,JJJ4,JJ8,JJ5/ 1, 2, 9, 10,3, 4/
      REWIND JJJ3                                                       0350
      REWIND JJJ10                                                      0360
C                                                                       0370
C                                                                       0380
      NNN = NN + 100                                                    0390
      K1 = JJJ3                                                         0400
      JRECS=1                                                           0410
      K3 = 1                                                            0420
      K4 = 0                                                            0430
      I1 = 1                                                            0440

      J1 = 1                                                            0450
      NG=2                                                              0460
      K6=1                                                              0470
      P7=0.0                                                            0480
      P6=0.0                                                            0490
      P8=0.0                                                            0500
      P9=0.0                                                            0510
      P5 = 0.0                                                          0520
      I2 = JJ8                                                          0530
      J2 = JJ5                                                          0540
      I3 = ITAPE                                                        0550
      J3 = ITAPE1                                                       0560
      NTAPE=INTAPE(NIT)                                                 0570
      IRECS=1                                                           0580
  910 K2 = 0                                                            0610
      REWIND K1                                                         0620
      READ  (K1)NREC, NHIST, NG,ITA,NSR                                 0630
      IF(K6)        913, 913, 912                                       0640
```

```
  912 K6=0                                                              0650
      WRITE (JJ8    )NREC, NHIST, ITAPE, NG                             0660
      WRITE (JJ5    )NREC, NHIST, ITAPE1, NG                            0670
  913 DO 920 I=1, NIT                                                   0680
      IF(INTAPE(I)-ITA)       920, 915, 920                             0690
  915 INTAPE(I) = 0                                                     0700
      K2 = 1                                                            0710
      GO TO 925                                                         0720
  920 CONTINUE                                                          0730
  925 IF(K2)                  970, 970,  1000
  970 WRITE (6,975)ITA                                                  0900
      CALL EXIT                                                         0910
  975 FORMAT (22HOTAPE LABELED HISTORY I4,36H IS NOT CALLED FOR IN PROBL 0920
     1EM INPUT.)                                                        0930
 1000 IF (ITA-MTAPE)          1002, 1001, 1002                          0970
 1001 IF(MTPREC(1)-2) 982, 982, 983                                     0980
  982 NREC=1                                                            0990
      K5=0                                                              1000
      I20=MTPREC(2)                                                     1010
      GO TO 990                                                         1020
  983 NREC=MTPREC(1)-2                                                  1030
      K5=1                                                              1040
      GO TO 985                                                         1050
 1002 NREC=7999
      K5=0                                                              1070
  985 I20=20                                                            1080
  990 DO 1400 N=1, NREC                                                 1090
 1003 READ  (K1)(CX1   , CY1   , CZ1   , CA1   , CB1   , CC1   , CE1(I), 1100
     1 CW1(I), CX2(I), CY2(I), CZ2(I),                                C  1110
     2W2(I), NRS(I), AWTS   , CEX   , NRLC, I=1, I20)                   1120
 1004 DO 1400   I=1,I20                                                 1130
      IF(INEL)                1005, 1010, 1005                          1140
 1005 IF(CE1(I)-EMAX)         1007, 1025, 1006                          1150
C       P6=NO. OF NEUTRONS OF ENERGY GREATER THAN EMAX                  1160
 1006 P6=P6+1.0                                                         1170
      GO TO 1400                                                        1180
 1007 IF(EIN-CE1(I))          1025, 1008, 1008                          1190
 1008 IF(INEL)                1009, 1009, 1010                          1200
C       P7=NO. OF NEUTRONS OF ENERGY LESS THAN EIN                      1210
 1009 P7=P7+1.0                                                         1220
      GO TO 1400                                                        1230
 1010 IF(CE1(I)-ESEC)         1012, 1200, 1011                          1240
C       P8=NO. OF NEUTRONS OF ENERGY GREATER THAN ESEC                  1250
 1011 P8=P8+1.0                                                         1260
      GO TO 1400                                                        1270
 1012 IF(CE1(I)-ENC(NC+1))    1013, 1013, 1200                          1280
C       P9=NO. OF NEUTRONS OF ENERGY LESS THAN ENC(NC+1)                1290
 1013 P9=P9+1.0                                                         1300
      GO TO 1400                                                        1310
 1025 CALL FINDER (NUE1,CE1(I),J,ENERG1)
```

```
      FJ = J                                                            1330
      N2N= NRS(I)
      MR = MATREG(N2N)
      IF (ITP)     1031,1031,1033
 1033 WRITE (6  , 1034) I, N2N, NRS(I), MATREG(N2N), MR
 1034 FORMAT (5H0 I= ,I2,6H N2N= ,I3,9H NRS(I)= ,I4,12H MATREG(N)= ,I3,
     1          5H MR= ,I3)
 1031 IF(MR)                  1032, 1032, 1030                          1360
 1032 P5 = P5 + 1.0                                                     1370
      GO TO   1400                                                      1380
 1030 P1 = TCS1(MR,J+1)+(TCS1(MR,J)-TCS1(MR,J+1))*(CE1(I)-ENERG1(J+1))/ 1390
     1(ENERG1(J)-ENERG1(J+1))
      IF(IOP)                 1035, 1035, 1060                          1410
 1035 CALL RAND(R1)                                                     1420
      IF(P1-R1)               1400, 1040, 1040                          1430
 1040 W(I1) =   CW1(I)*(SCS1(MR,J+1)+(SCS1(MR,J)-SCS1(MR,J+1))*(CE1(I)-E 1440
     1NERG1(J+1))/(ENERG1(J)-ENERG1(J+1)))
      GO TO 1064
 1060 W(I1) =CW1(I)*P1*(SCS1(MR,J+1)+(SCS1(MR,J)-SCS1(MR,J+1))*(CE1(I)-E 1470
     1NERG1(J+1))/(ENERG1(J)-ENERG1(J+1)))
 1064 IF (ITP) 1070,1070,1065
 1065 WRITE (6,1066)  I, MR, J,          CW1(I), TCS1(MR,J), TCS1(MR,J+1)
     1,SCS1(MR,J), SCS1(MR,J+1), P1, W(I1), I1,CE1(I)
 1066 FORMAT (5H0 I= ,I4, 5H MR= ,I4,4H J= ,I4, 9H CW1(I)= ,1PE11.4,/
     113H TCS1(MR,J)= ,1PE11.4,15H TCS1(MR,J+1)= ,1PE11.4, /
     213H SCS1(MR,J)= ,1PE11.4,15H SCS1(MR,J+1)= ,1PE11.4, / 5H P1= ,
     31PE11.4, 8H W(I1)= ,1PE11.4, 5H I1= ,I4, 9H CE1(I)= ,1PE11.4)
 1070 CX(I1) = CX2(I)                                                   1490
      CY(I1) = CY2(I)                                                   1500
      CZ(I1) = CZ2(I)                                                   1510
 1080 CALL RAND(R1)                                                     1520
      CALL RAND(R2)                                                     1530
      CALL RAND(R3)                                                     1540
      P1 = (2.0*R1-1.0)*(2.0*R1-1.0)+(2.0*R2-1.0)*(2.0*R2-1.0)+(2.0*R3-1 1550
     1.0)*(2.0*R3-1.0)                                                  1560
      IF(P1-1.0)              1090, 1090, 1080                          1570
 1090 P1 = SQRT(P1)                                                     1580
      CA(I1) =  (2.0*R1-1.0)/P1                                         1590
      CB(I1) =  (2.0*R2-1.0)/P1                                         1600
      CC(I1) =  (2.0*R3-1.0)/P1                                         1610
      IF (ITP) 1093,1093,1091
 1091 WRITE (6,1092) I1, CX(I1), CY(I1), CZ(I1), R1, R2, R3, CA(I1),
     1 CB(I1), CC(I1)
 1092 FORMAT (6H0 I1= ,I4,/ 9H CX(I1)= ,1PE11.4,11H   CY(I1)= ,1PE11.4,
     111H   CZ(I1)= ,1PE11.4,/ 9H      R1= ,1PE11.4 ,11H        R2= ,
     21PE11.4,11H        R3= ,1PE11.4,/ 9H CA(I1)= ,1PE11.4,11H   CB(I1)=
     3 ,1PE11.4,11H   CC(I1)= ,1PE11.4)
C  BEGIN SEARCH FOR THAT INCIDENT NEUTRON ENERGY GROUP NUMBER OF LIBRARY 1620
C  TYPE 4 TO WHICH CE1(I) BELONGS, GROUP J BEING FROM ENI(J) TO ENI(J+1) 1630
 1093 CALL RAND(R1)
```

```
      SUM = 0.0
      NIPL=NI+1
      DO 1095  M=2, NIPL
      IF(CE1(I)-ENI(M))        1095, 1094, 1094
 1094 J = M-1
      GO TO 1097
 1095 CONTINUE
C  BEGIN RANDOM PICK OF ENERGY OF EMITTED GAMMA RAY (INELASTIC)
 1097 DO 1105 M = 1,NGI
      SUM = SUM + Q1(MR,J,M)
      IF(R1-SUM)               1100, 1100, 1105
 1100 CE(I1) = EGAM(M)


      K2 = 0
      GO TO 1110
 1105 CONTINUE
      IF (ITP) 1110,1110,1106
 1106 WRITE (6,1107) K2, SUM, NIPL, J, R1, EGAM(M), M
 1107 FORMAT (6H0 K2= ,I4, 6H SUM= ,1PE11.4, 7H NIPL= , I4, 4H J= ,I4,
     1 5H R1= ,1PE11.4,10H EGAM(M)= ,1PE11.4,4H M= ,I4)
 1110 IF(K2)                   1570, 1120, 1570
 1120 NOR(I1) = NRS(I)
      IF(I1-14)                1190, 1130, 1130
 1130 WRITE (I2)(CX(M), CY(M), CZ(M), CA(M), CB(M), CC(M), CE(M),   W(M)
     1,NOR(M), M=1,14)
      I1 = 1
      IRECS = IRECS+1
      IF(20000-IRECS)          1140, 1140, 1400
 1140 REWIND I2
      K2 = 1
 1144 I31 = I3 + 10000
      WRITE (6,1145)I31, PID, NNN

      ILAST = 14
      Q000FL= (IRECS-1)*14
      WRITE (6,1146)Q000FL, IRECS, ILAST, NHIST
 1145 FORMAT (23H1TAPE LABELED INELASTIC,I4,59H WAS GENERATED BY SECONDA
     1RY GAMMA SOURCE CODE S02, PROBLEM ,A4,I2/44H DATA PERTINENT TO THI
     2S TAPE ARE AS FOLLOWS.)
 1146 FORMAT (1H0,F13.0,47H = NUMBER OF SECONDARY SOURCE PARTICLES ON TA
     1PE/I15,83H = NUMBER OF LOGICAL RECORDS (MAX. OF 14 PARTICLES/RECOR
     2D, BEGINNING WITH RECORD 2)/I15,37H = NUMBER OF PARTICLES ON LAST
     3RECORD/I15,22H = NUMBER OF HISTORIES)
 1190 I1 = I1+1
      GO TO 1400
 1200 CALL FINDER (NUE2,CE1(I),J,ENERG2)
      FJ = J
      N2N= NRS(I)
```

```
      MR = MATREG(N2N)
      IF (ITP)              1201,1201,1203
 1203 WRITE (6  , 1034) I, N2N, NRS(I), MATREG(N2N), MR
 1201 IF(MR)                     1202, 1202, 1205
 1202 P5 = + 1.0 + P5
      GO TO   1400
 1205 P1 = TCS2(MR,J+1)+(TCS2(MR,J)-TCS2(MR,J+1))*(CE1(I)-ENERG2(J+1))/
     1(ENERG2(J)-ENERG2(J+1))
      IF(IOP)                    1210, 1210, 1225
 1210 CALL RAND(R1)
      IF(P1-R1)   ×              1400, 1220, 1220
 1220 W2(J1) = CW1(I)*(SCS2(MR,J+1)+(SCS2(MR,J)-SCS2(MR,J+1))*(CE1(I)
     1-ENERG2(J+1))/(ENERG2(J)-ENERG2(J+1)))
      GO TO 1229
 1225 W2(J1) = CW1(I)*P1*(SCS2(MR,J+1)+(SCS2(MR,J)-SCS2(MR,J+1))*(CE1(I)
     1-ENERG2(J+1))/(ENERG2(J)-ENERG2(J+1)))
 1229 IF (ITP) 1230,1230,1226
 1226 WRITE (6,1227)  I, MR, J,          CW1(I), TCS2(MR,J), TCS2(MR,J+1)
     1,SCS2(MR,J), SCS2(MR,J+1), P1, W2(J1),J1,CE1(I)
 1227 FORMAT (5H0 I= ,I4, 5H MR= ,I4,4H J= ,I4, 9H CW1(I)= ,1PE11.4,/
     113H TCS2(MR,J)= ,1PE11.4,15H TCS2(MR,J+1)= ,1PE11.4, /
     213H SCS2(MR,J)= ,1PE11.4,15H SCS2(MR,J+1)= ,1PE11.4, / 5H P1= ,
     31PE11.4, 9H W2(J1)= ,1PE11.4, 5H J1= ,I4 , 9H CE1(I)= , 1PE11.4)
 1230 X2(J1) = CX2(I)
      Y2(J1) = CY2(I)
      Z2(J1) = CZ2(I)
 1240 CALL RAND(R1)
      CALL RAND(R2)
      CALL RAND(R3)
      P1 = (2.0*R1-1.0)*(2.0*R1-1.0)+(2.0*R2-1.0)*(2.0*R2-1.0)+(2.0*R3-1
     1.0)*(2.0*R3-1.0)
      IF(P1-1.0)                 1250, 1250, 1240
 1250 P1 = SQRT(P1)
      AC(J1) = (2.0*R1-1.0)/P1
      BC(J1) = (2.0*R2-1.0)/P1
      DC(J1) = (2.0*R3-1.0)/P1
      IF (ITP) 1255,1255,1251
 1251 WRITE (6,1252) J1, X2(J1), Y2(J1), Z2(J1),  R1, R2, R3, AC(J1),
     1 BC(J1), DC(J1)
 1252 FORMAT (6H0 J1= ,I4,/ 9H X2(J1)= ,1PE11.4,11H   Y2(J1)= ,1PE11.4,
     111H   Z2(J1)= ,1PE11.4,/ 9H     R1= ,1PE11.4 ,11H       R2= ,
     21PE11.4,11H       R3= ,1PE11.4,/ 9H AC(J1)= ,1PE11.4,11H   BC(J1)=
     3 ,1PE11.4,11H   DC(J1)= ,1PE11.4)
 1255 CALL RAND(R1)

      SUM = 0.0
      NCPL=NC+1
      DO 1258 MN=2, NCPL
      IF(CE1(I)-ENC(MN))         1258, 1256, 1256
 1256 J = MN-1
```

```
      GO TO 1259
 1258 CONTINUE
 1259 DO 1270 M=1,NGC
      SUM = SUM + Q2(MR,J,M)
      IF(R1-SUM)              1260, 1260, 1270
 1260 EC(J1) = EGAMC(M)
      K2 = 0
      GO TO 1280
 1270 CONTINUE
      IF (ITP) 1280,1280,1271
 1271 WRITE (6,1272) K2, SUM, NCPL, J, R1, EGAMC(M), M
     1 5H R1= ,1PE11.4,11H EGAMC(M)= ,1PE11.4,4H M= ,I4)

 1280 IF(K2)                  1570, 1290, 1570
 1290 NRE(J1) = NRS(I)
      IF(J1-14)               1390, 1300, 1300
 1300 WRITE (J2)(X2(M), Y2(M), Z2(M), AC(M), BC(M), DC(M), EC(M),   W2(M
     1), NRE(M),M=1,14)
      J1 = 1
      JRECS = JRECS+1
      IF(20000-JRECS)         1310, 1310, 1400
 1310 REWIND J2
 1315 J31 = J3 + 10000
      WRITE (6,1316)J31, PID, NNN
      JLAST = 14
      Q000FL= (JRECS-1)*14
      WRITE (6,1146)Q000FL, JRECS, JLAST, NHIST
 1316 FORMAT (21H1TAPE LABELED CAPTURE,I4,58H WAS GENERATED BY SECONDARY
     1 GAMMA SOURCE CODE SO2 PROBLEM ,A4,I2/44H DATA PERTINENT TO THIS T
     2APE ARE AS FOLLOWS.)
 1390 J1 = J1+1
 1400 K2 = 1
 1401 IF(K5) 1402, 1402, 982
 1402 REWIND K1
      K4 = K4+1
      IF(K1.EQ.JJJ3)  GO TO 1430
 1420 K1 = JJJ3
      GO TO 1440
 1430 K1 = JJJ10
 1440 IF(K4-NIT)              910, 1450, 1450
 1450 IF(INEL)                1470, 1455, 1455
 1455 IF(J1-1)                1457, 1457, 1460
 1457 JLAST = 14
      GO TO   1462
 1460 JRECS=JRECS+1
      JLAST = J1-1
      WRITE (J2)(X2(I),Y2(I),Z2(I),AC(I),BC(I),DC(I),EC(I),W2(I),NRE(I),
     1I=1,JLAST)
 1462 Q000FL= (JRECS-2)*14 + JLAST
      J31 = J3 + 10000
```

```
      WRITE (6,1316)J31, PID, NNN
      WRITE (6,1146)Q000FL, JRECS, JLAST, NHIST
      REWIND J2
 1470 IF(INEL)                1472, 1490, 1472
 1472 IF(I1-1)                1173, 1173, 1473
 1173 ILAST = 14
      GO TO   1474
 1473 IRECS=IRECS+1
      ILAST = I1 - 1
      WRITE (I2)(CX(I),CY(I),CZ(I),CA(I),CB(I),CC(I),CE(I),W(I),NOR(I),I
     1=1,ILAST)
 1474 Q000FL= (IRECS-2)*14 + ILAST
      I31 = I3 + 10000
      WRITE (6,1145)I31, PID, NNN
      WRITE (6,1146)Q000FL, IRECS, ILAST, NHIST
      REWIND I2
      IF (ITP)        1601,1601,1490
 1490 WRITE (6,1680)P6,P7,P8,P9
      WRITE (6,1690)P5
 1601 WRITE (6,1675)
      GO TO 1700
 1570 WRITE (6,1575)
      CALL EXIT
 1575 FORMAT (41H0THERE IS AN ERROR IN A PROBABILITY TABLE)
 1675 FORMAT (15H0END OF PROBLEM)
 1680 FORMAT (1H0,F14.1,45H =NO. OF NEUTRONS OF ENERGY GREATER THAN EMAX
     1/F15.1,41H =NO. OF NEUTRONS OF ENERGY LESS THAN EIN/F15.1,45H =NO.
     2 OF NEUTRONS OF ENERGY GREATER THAN ESEC/F15.1,48H = NO. OF NEUTRO
     3NS OF ENERGY LESS THAN ENC(NC+1))
 1690 FORMAT (1H0,F14.1,52H =NO. OF NEUTRONS WITH REGION NUMBER LESS THA
     1N ZERO.)
 1700 RETURN
      END
```

IV Tape-Read Code "C01"

The "C01" Tape-Read Code is one of the family of seven routines that comprises the COHORT (Calculation of Heating or Radiation Transport) Code. The purpose of this code is to read a binary tape that has been written by one of either the primary or secondary Source-Generator Code, the History-Generator Code, the Tape-Sort Code or the Analysis Code, "A02."

4.1 Method

The code automatically reads the first two records written on the tape. The first record is an information record, and the second record is the first data record. After these two records are read, the code will select at random and read a given fraction of those records between the M1th and M2th records, unless the tape is one that has been produced by the Juggle (Tape Sort) code. In this case the code will select and read at random a given fraction of the records within each energy super-group. The fraction of records that the code reads within each energy super-group or between records M1 and M2 is determined by an input number. If this number is input as 1, the code reads all the records between M1 and M2 or in the energy group; but, if the input number is some fraction less than 1, the code reads approximately that portion of the records.

4.2 C01 Utilization Instructions

4.2.1 Tape Usage

The C01 code utilizes one tape unit in addition to the regular input and output tape units, logical tapes 5 and 6. The C01 code reads either a SOURCE, HISTORY, SORTED or LEAKAGE tape. Whichever tape is to be read must be placed on logical unit 3 before initiating the problem.

4.2.2 C01 Card Input

In order to use the C01 code a set of data cards and an input tape must be supplied. The cards provide the information necessary for reading the tape.

Input for the C01 Tape-Read Code consists only of a problem deck which should be placed immediately behind the binary deck. The data required for a C01 problem and the format to be used in making up a problem data deck are shown in Table XXVI.

TABLE XXVI

C01 Problem Input Data Format

(for Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1	7I5	K	Option number identifying type of tape to be read K = -1, SOURCE or LEAKAGE tape K = 0, HISTORY tape K = 1, SORTED tape	
		M1	Lower limit of the range of records to be read (M1 must be equal to or greater than 3. The program reads the first two records automatically and then reads all or a portion of the records in the range from M1 to M2. This value is not used by the program if K>0, but a number of 3 or greater must be entered in order to get the problem to run.)	3≤M1
		M2	Upper limit of the range of records to be read (M2 must be less than or equal to the number of full records on the tape. This value is not used by the program if K>0, but a number between 2 and NRECT must be entered in order for the problem to run.)	
		NSG	Number of energy groups into which the data on a SORTED tape is grouped (This number may be left blank if a SORTED tape is not being read.)	
		NRECT	Total number of records on tape being read	
		NLAST	Number of sets of data on last record of tape being read	
		K1	Option number to determine if last record on tape is to be read	
2	2F10.0 E10.4	R1	Input random number (8-digit interger)	
		R2	Second random number (8-digit interger)	
		RX	The fraction of records beyween and including records M1 and M2 that are to be read (This number not used if input tape is a SORTED tape.) If a SOURCE, HISTORY or LEAKAGE tape is being read, the remaining cards may be omitted.	

TABLE XXVI (continued)

Card	Format	Input Item	Definition	Limit
3	6E10.4	BEG(J)	The number of sets of data on the tape being read that have energies in energy group J (J = 1, NSG. These values are needed only if K>0, i.e., when a SORTED tape is being read.)	J=1,NSG
Follows last BEG(J) card	6E10.4	X(J)	The fraction of the records containing energies in energy group J that are to read (J = 1, NSG. These values are needed only if K>0, i.e., when a SORTED tape is being read.)	J=1,NSG

4.3 C01 Sample Problem

A sample problem is given to illustrate the input and output formats for C01. The C01 sample problem was designed to list the secondary gamma-ray source tape produced by the S02 sample problem discussed in Section 3.3.

4.3.1 C01 Sample Input

The total input for the C01 sample problem is contained on the two cards shown in Table XXVII. The minus 1 in columns 4 and 5 indicates that a source tape is to be listed. The range of records to be read, M1 to M2, is taken to be just the third through the fourth records since the first two records are automatically read by C01. The total number of records is four and K1 is set equal to 1 indicating that the last record is to be read. On the second card two input random numbers are given and the fraction of records from M1 to M2 to be read is set equal to 1.

4.3.2 C01 Sample Output

Table XXVIII shows the output for the C01 sample problem. The first record printed is the information record. The number of records and the particle option printed in the information record are erroneous. The number of records and the number of sets of data in the last record are always erroneous because this information is not known at the time the first record is written. Records two through four in Table XXVIII give the location (X, Y, Z), direction cosines (A, B, C), energy (E), weight (W) and region of origination (NR) of 14 secondary gamma rays each. Thus the source parameters for all 42 source gammas generated in the S02 sample problem are listed.

Table XXVII

C01 Sample Input Data

```
 -1     3     4            4     1     1
36458916  32567942     1.0+00
```

Table XXVIII

C01 Sample Output Data

```
BEGIN EXECUTIØN  164545
THE FIRST RECØRD ØF TAPE SØURCE  66 CØNTAINS THE FØLLØWING INFØRMATION.  NUMBER ØF RECØRDS =    1
, NUMBER ØF HISTØRIES =    50 , PARTICLE ØPTION IS  0 .


 PARTICLE CØØRDINATES  (X,Y,Z)       DIRECTIØN CØSINES  (A,B,C)        ENERGY(MEV)  WEIGHT       REGION

RECORD NUMBER    2
 2.16022E 00-6.81751E 00 9.73035E 00 9.95424E-02-8.99020E-01 4.26444E-01 2.50000E 00 5.13001E-01    7
 6.74968E 00-6.70966E 00 2.07632E 01 9.26890E-01-1.07114E-01 3.59723E-01 1.50000E 00 4.16086E-01    9
 5.01163E 00 4.42034E 00 4.42388E 00-5.68880E-02-1.44642E-01-9.87847E-01 2.50000E 00 1.06756E 00    5
 3.81230E 00 2.12585E 00 5.63603E 00 2.15162E-01 7.64643E-01-6.07475E-01 1.50000E 00 1.21682E 00    5
-3.90085E 00-1.50066E 01 3.90159E 00 5.42314E-01-8.62911E-02 8.35733E-01 2.50000E 00 8.88838E-01    4
-5.87204E 00-1.30480E 01 2.71300E 00-3.47340E-01-3.72587E-01-8.60543E-01 4.00000E 00 7.59664E-01    4
 1.06585E 01-3.67042E 00 1.27242E 01-7.39946E-01 4.03289E-01-5.38365E-01 1.50000E 00 5.47691E-01    7
 5.59805E-01 2.19793E-02 8.96385E-01-2.86841E-01-2.46002E-01 9.25854E-01 6.00000E 00 1.46148E 00    1
 7.66120E 00 1.93880E 00 5.24095E 00-8.95411E-01-3.60299E-01-2.61578E-01 6.00000E 00 1.18538E 00    5
 8.15489E 00 2.54448E 00 5.97729E 00-6.27556E-02-1.17239E-01 9.91119E-01 2.50000E 00 1.33355E 00    5
 7.20458E 00 1.31920E 01 1.33501E 01 7.34198E-01-6.67353E-01 1.24875E-01 5.00000E-01 6.93166E-01    8
 1.50946E 01 8.01483E 00 8.54124E 00-9.16185E-01-2.26118E-01-3.30870E-01 2.50000E 00 6.40821E-01    6
 1.91689E-01 5.66374E-01 3.78394E 00-1.61535E-01 6.30121E-02-9.84853E-01 5.00000E-01 1.46148E 00    4
 9.25198E-01-5.94641E-01 2.99390E 00 4.23085E-01-2.57095E-01-8.68851E-01 6.00000E 00 1.48073E 00    4

RECORD NUMBER    3
 4.30187E 00-3.87954E 00 6.25201E 00-1.70782E-01-3.84261E-01 9.07291E-01 1.50000E 00 8.43507E-01    5
-8.00506E 00 3.69069E 00 3.88681E 00-2.31026E-02 1.90972E-01-9.81324E-01 1.50000E 00 1.15476E 00    4
-1.26687E 00-4.16875E 00 1.31604E 01 1.15530E-01-9.76844E-01-1.80081E-01 1.50000E 00 6.16150E-01    7
 1.32988E 00 8.99813E-01 1.33574E 01-7.44743E-01 6.03474E-01-2.84916E-01 2.50000E 00 5.19758E-01    8
-8.47444E-01-2.09270E 00 1.43676E 00-9.51145E-01 2.47489E-01-1.84586E-01 1.50000E 00 1.06756E 00    3
-2.01510E 00-4.08845E 00 2.02850E 00-3.74207E-01 1.87377E-01 9.08218E-01 2.50000E 00 9.86938E-01    3
 1.41011E 00-3.15786E 00 8.33376E 00-4.27663E-01 2.18772E-01 8.77065E-01 2.50000E 00 8.21716E-01    6
 7.69417E-02-1.45811E 01 1.57462E 01 1.06897E-01 8.38970E-01-5.33576E-01 2.50000E 00 5.54905E-01    8
-3.85972E 00 2.77838E 00 4.94200E 00-6.19751E-01-5.02454E-01-6.02867E-01 4.00000E 00 1.31621E 00    5
 6.03737E 00 1.01023E 01 7.91440E-01 6.84795E-01-6.84540E-01-2.49922E-01 2.50000E 00 8.65876E-01    1
 4.06766E 00-3.95823E 00 9.44725E 00 6.31293E-01 2.71499E-01-7.26469E-01 1.50000E 00 1.31621E 00    7
 7.55864E 00-2.57819E 00 9.77007E 00 3.61446E-01 4.82670E-01 7.97738E-01 5.00000E-01 1.20100E 00    7
 2.20426E 01-3.23633E 00 1.31592E 01 2.98838E-01 7.78635E-01 5.51746E-01 4.00000E 00 5.62215E-01    7
 2.72105E 01-4.93628E 00 1.68545E 01-4.01484E-01 7.57881E-01 5.14225E-01 2.50000E 00 4.44222E-01    8
```

Table XXVIII (continued)

C01 Sample Output Data

```
RECORD NUMBER    4
-4.95015E 00 1.19287E 01 4.99204E 00-3.25413E-01-5.67921E-01 7.56024E-01 2.50000E 00 1.23285E 00    5
 0.00000E-39 0.00000E-39 1.84470E-02-8.62643E-01 5.02635E-01-5.66105E-02 5.00000E-01 1.52000E 00    1
-6.10933E-01 8.69394E-01 6.55051E 00 3.49633E-01 6.46120E-01-6.78443E-01 1.50000E 00 1.06756E 00    5
 2.59968E 00 5.64264E 00 1.21750E 00-3.49782E-01 5.26945E-01 7.74585E-01 1.50000E 00 1.13975E 00    1
 1.00518E 01-4.21751E 00 9.83795E 00-4.69607E-02-9.98713E-01-1.91383E-02 1.50000E 00 8.00488E-01    7
-2.74187E 00 6.52350E 00 1.41069E 01-1.86422E-01-5.64706E-02-9.80846E-01 1.50000E 00 6.16150E-01    8
 6.25908E-01 1.11705E 01 1.27662E 01-5.14886E-01 1.03176E-01-8.51027E-01 2.50000E 00 5.13001E-01    7
 2.10177E 00 1.30381E 01 1.57522E 01-7.04131E-02 4.86275E-01 8.70964E-01 4.00000E 00 4.62009E-01    8
 1.16151E 00 1.83227E-01 4.40163E 00-3.63407E-01 7.33940E-01 5.73818E-01 2.50000E 00 8.65876E-01    5
-5.80817E 00 5.12790E 00 7.45544E 00-5.22002E-01-3.39895E-01 7.82295E-01 1.50000E 00 1.03998E 00    6
-7.91733E 00 6.37483E-01 1.26011E 01-3.49859E-01-7.85758E-01-5.10081E-01 1.50000E 00 9.00546E-01    7
-8.78969E 00 2.02168E 00 1.11199E 01-4.31477E-01-5.16506E-01-7.39627E-01 2.50000E 00 8.32541E-01    7
-7.36344E 00 1.00005E 00 1.28075E 01 3.30830E-01 9.23237E-01 1.95410E-01 1.50000E 00 7.79809E-01    7
-9.16071E 00-5.32786E 00 1.88991E 01-1.88835E-01-9.67869E-01-1.66045E-01 1.50000E 00 6.66480E-01    9
```

4.4 C01 FORTRAN Listings

```
C     THIS CODE PRINTS INFORMATION WRITTEN ON SOURCE OR HISTORY TAPES
C
C                                                (K = -1  SOURCE TAPE
C  TAPE NO. 3 '' MOUNT, SAVE DATA TAPES, INPUT (K =  0  HISTORY TAPE
C                                                (K =  1  SORTED TAPE
C
C
      DIMENSION  X0(20),  Y0(20),  Z0(20),  A0(20),  B0(20),  C0(20),
     1           X1(20),  Y1(20),  Z1(20),  A1(20),  B1(20),  C1(20),
     2           E0(20),  W0(20),  E1(20),  W1(20), NR1(20),  AW(20),
     3           EX(20), BEG(20),   X(20),NRLC(20)
      COMMON  X0      , Y0      , Z0      , A0      , B0      , C0
      COMMON  X1      , Y1      , Z1      , A1      , B1      , C1
      COMMON  E0      , W0      , E1      , W1      , NR1     , AW
      COMMON  EX      , ITAPE   , M1      , M2      , X       , BEG
      COMMON  R1      , R2      , RX      , K       , K1      , NRECT
      COMMON  NLAST   , NRLC
      DATA JJJ3/3/
      READ  (5      ,20)K, M1, M2, NSG,NRECT, NLAST, K1
   20 FORMAT (7I5)
      IF (M1 - 3)                32, 21, 21
   21 IF (M2 - 2)                32, 22, 22
   22 IF (NRECT - 3)             27, 23, 23
   23 IF (NRECT - M2)            24, 24, 27
   24 WRITE (6,25)M2, NRECT
   25 FORMAT(5H0M2 =I5, 13H AND NRECT = I5, 78H.  M2 SHOULD BE LESS THAN
     1 NRECT.  PRINT OUT OF LAST RECORD SHOULD BE IN ERROR.)
   27 READ  (5      ,30)R1, R2, RX
   30 FORMAT (3F10.0)
      GO TO 37
   32 WRITE (6,35)M1, M2
   35 FORMAT  (5H0M1 =,I5,9H AND M2 =,I5,59H.  M1 SHOULD BE 3 OR GREATER
     1 AND M2 SHOULD BE 2 OR GREATER.)
      GO TO 1500
   37 LREC = 1
C
      CALL RINT(R1,R2)
C
      IF (K)             40, 500, 1000
   40 READ  (JJJ3  )NREC, N, ITAPE, NG
      ITAPE = ITAPE + 10000
      WRITE (6,50)ITAPE, NREC, N, NG
   50 FORMAT (32H THE FIRST RECORD OF TAPE SOURCE I4,58H CONTAINS THE FO
     1LLOWING INFORMATION.  NUMBER OF RECORDS = I4,/25H , NUMBER OF HIST
     2ORIES = I5,22H , PARTICLE OPTION IS I2,2H . )
C
      LREC = LREC +1
C
      WRITE (6,60)
   60 FORMAT (105H1 PARTICLE COORDINATES  (X,Y,Z)       DIRECTION COSINE
```

```
     1S  (A,B,C)          ENERGY(MEV)  WEIGHT        REGION )
      IF (LREC  - NRECT)      65, 145, 145
   65 READ  (JJJ3  )(X0(L),Y0(L),Z0(L),A0(L),B0(L),C0(L),E0(L),W0(L),
     1 NR1(L), L = 1,14)
C
      WRITE (6,70)LREC
   70 FORMAT (15HORECORD NUMBER I4)
C
      WRITE (6,80)(X0(L),Y0(L),Z0(L),A0(L),B0(L),C0(L),    E0(L),W0(L),N
     1R1(L), L = 1,14)
   80 FORMAT (1H ,1P8E12.5,I5)
      M=1
      IF (M2 - 2)                32,  125, 83
   83 M4 = M1 - 1
      IF (M4 - 2)            32, 90, 85
   85 DO 87  J= 3,M4
      LREC = LREC + 1
   87 READ  (JJJ3  )
C
C
   90 DO  120   J = M1, M2
      LREC = LREC +1
      CALL RAND (R)
C
      IF (R- RX )           95, 95, 100
C
   95 WRITE (6,70)LREC
C
      READ  (JJJ3  )(X0(L),Y0(L),Z0(L),A0(L),B0(L),C0(L),E0(L),W0(L),
     1 NR1(L),  L = 1,14)
C
      WRITE (6,80)(X0(L),Y0(L),Z0(L),A0(L),B0(L),C0(L),    E0(L),W0(L),N
     1R1(L), L = 1,14)
C
      GO TO 120
C
  100 READ  (JJJ3  )
C
  120 CONTINUE
C
      IF  (K1)            1500, 1500, 125
  125 IF  (M2 - NRECT + 1)         128, 140,  1500
  128 M3 = NRECT - 1
      M5 = M2 + 1
      DO   130  J =  M5,M3
      LREC = LREC + 1
  130 READ  (JJJ3  )
  140 LREC = LREC + 1
  145 WRITE (6,70)LREC
      READ  (JJJ3  )(X0(L),Y0(L),Z0(L),A0(L),B0(L),C0(L),E0(L),W0(L),
```

```
     1 NR1(L), L = 1,NLAST)
      WRITE (6,80)(X0(L),Y0(L),Z0(L),A0(L),B0(L),C0(L),    E0(L),W0(L),N
     1R1(L), L = 1,NLAST)
      GO TO 1500
C
  500 READ  (JJJ3  )NREC, N, NG, ITAPE, ILAST
      ITAPE = ITAPE + 10000
C
      WRITE (6,550)ITAPE, NREC, N, NG, ILAST
  550 FORMAT (33H THE FIRST RECORD OF TAPE HISTORY I4,58H CONTAINS THE F
     1OLLOWING INFORMATION.  NUMBER OF RECORDS = I4,/25H , NUMBER OF HIS
     2TORIES = I5,22H , PARTICLE OPTION IS I2,13H , THERE ARE I2,29H SET
     3S OF DATA ON LAST RECORD. )
C
      LREC = LREC + 1
C
      WRITE (6,600)

  600 FORMAT  (112H1    X0            Y0          Z0           A0
     1B0          C0           E0           W0           AW       NR1 / 70H
     2    X1           Y1           Z1           W1           EX           NR
     3LC )
      IF (LREC - NRECT)        625, 925, 925
  625 READ  (JJJ3  )(X0(L),Y0(L),Z0(L),A0(L),B0(L),C0(L),E0(L),W0(L),
     1 X1(L),Y1(L),Z1(L),                          W1(L),NR1(L),AW(L),
     2 EX(L),NRLC(L), L = 1,20)
C
      WRITE (6,70)LREC
      WRITE (6,650)(X0(L),Y0(L),Z0(L),A0(L),B0(L),C0(L),   E0(L),W0(L),A
     1W(L),NR1(L),X1(L),Y1(L),Z1(L),                                W1(L),E
     2X(L),NRLC(L), L = 1,20)
  650 FORMAT (1H01P9E12.5,I5,/1H 1P5E12.5,I5)
C
      M=1
C

      IF (M2 - 2)            32,  825, 700
  700 M4 = M1 - 1
      IF (M4 - 2)          750, 750, 725
  725 DO  740   J = 3,M1
      LREC = LREC + 1
  740 READ  (JJJ3  )

C
  750 DO 800  J= M1,M2
      LREC = LREC + 1
C
      CALL RAND (R)

C
```

```
      IF (R- RX )          780, 780, 790                                    1630
C                                                                            1650
  780 WRITE (6,70)LREC                                                       1660
C                                                                            1670
      READ  (JJJ3  )(X0(L),Y0(L),Z0(L),A0(L),B0(L),C0(L),E0(L),W0(L),        1680
     1 X1(L),Y1(L),Z1(L),                          W1(L),NR1(L),AW(L),       1400
     2 EX(L),NRLC(L), L = 1,20)                                              1700
C                                                                            1710
      WRITE (6,650)(X0(L),Y0(L),Z0(L),A0(L),B0(L),C0(L),   E0(L),W0(L),A     1720
     1W(L),NR1(L),X1(L),Y1(L),Z1(L),                              W1(L),E   1450
     2X(L),NRLC(L), L = 1,20)                                                1740
C                                                                            1750
      GO TO 800                                                              1760
C                                                                            1770
  790 READ  (JJJ3  )                                                         1780
C                                                                            1790
  800 CONTINUE                                                               1800
C                                                                            1810
      IF  (K1)        1500, 1500, 825                                        1820
  825 IF (M2 - NRECT + 1)          850, 900, 1500                            1830
  850 M3 = NRECT - 1                                                         1840
      M5 = M2 + 1                                                            1850
      DO   875  J = M5,M3                                                    1860
      LREC = LREC + 1                                                        1870
  875 READ  (JJJ3  )                                                         1880
  900 LREC = LREC + 1                                                        1890
  925 WRITE (6,70)LREC                                                       1900
      READ  (JJJ3  )(X0(L),Y0(L),Z0(L),A0(L),B0(L),C0(L),E0(L),W0(L),        1910
     1 X1(L),Y1(L),Z1(L),                          W1(L),NR1(L),AW(L),       1400
     2 EX(L),NRLC(L), L = 1,NLAST)                                           1930
      WRITE (6,650)(X0(L),Y0(L),Z0(L),A0(L),B0(L),C0(L),   E0(L),W0(L),A     1940
     1W(L),NR1(L),X1(L),Y1(L),Z1(L),                              W1(L),E   1450

     2X(L),NRLC(L), L = 1,NLAST)                                             1960
      GO TO 1500                                                             1970
C                                                                            1980
C                                                                            1990
 1000 READ  (5      ,1010)(BEG(J), J = 1,NSG)                                2000
 1010 FORMAT (6E10.0)                                                        2010
      READ  (5      ,1010)(X(J), J= 1,NSG)                                   2020
C                                                                            2030
      READ(JJJ3)NREC,N, NG, ITAPE, ILAST                                     2040
      ITAPE = ITAPE + 10000                                                  2050
C                                                                            2060
      WRITE (6,1020)ITAPE, NREC, N, NG, ILAST                                2070
 1020 FORMAT (32H THE FIRST RECORD OF TAPE SORTED I4,58H CONTAINS THE FO     2080
     1LLOWING INFORMATION.  NUMBER OF RECORDS = I4,/25H , NUMBER OF HIST     2090
     2ORIES = I5,22H , PARTICLE OPTION IS I2,13H , THERE ARE I2,29H SETS     2100
     3 OF DATA ON LAST RECORD. )                                             2110
      WRITE (6,600)                                                          2120
```

```
      F1 = 0.0
      F2 = 0.0
C
      DO 1400  I = 1,NSG
C
      BEG(I) = BEG(I) + F2
C
      N1 = BEG(I)/20.0
C
      F1 = N1
C
      F2 = BEG(I) - 20.0*F1
C
      IF (N1)             1050, 1050, 1100
 1050 K = 1
      GO TO 1300
 1100 K = 0
      LREC = LREC + 1
      WRITE (6,70)LREC
      READ  (JJJ3  )(X0(L),Y0(L),Z0(L),A0(L),B0(L),C0(L),E0(L),W0(L),
     1 X1(L),Y1(L),Z1(L),                          W1(L),NR1(L),AW(L),
     2 EX(L),NRLC(L), L = 1,20)
C
      WRITE (6,650)(X0(L),Y0(L),Z0(L),A0(L),B0(L),C0(L),   E0(L),W0(L),A
     1W(L),NR1(L),X1(L),Y1(L),Z1(L),                              W1(L),E
     2X(L),NRLC(L), L = 1,20)
C
      IF (N1 - 2)         1300, 1200, 1120
 1120 DO 1190   J = 3,N1
      LREC = LREC +1
      CALL RAND (R)
      IF (R - X(I))          1130, 1130, 1170
C
 1130 WRITE (6,70)LREC
C
      READ  (JJJ3  )(X0(L),Y0(L),Z0(L),A0(L),B0(L),C0(L),E0(L),W0(L),
     1 X1(L),Y1(L),Z1(L),                          W1(L),NR1(L),AW(L),
     2 EX(L),NRLC(L), L = 1,20)
C
      WRITE (6,650)(X0(L),Y0(L),Z0(L),A0(L),B0(L),C0(L),   E0(L),W0(L),A
     1W(L),NR1(L),X1(L),Y1(L),Z1(L),                              W1(L),E
     2X(L),NRLC(L), L = 1,20)
C
      GO TO 1190
C
 1170 READ  (JJJ3  )
 1190 CONTINUE
C
 1200 LREC = LREC + 1
      WRITE (6,70)LREC
```

```
C
      READ  (JJJ3  )(X0(L),Y0(L),Z0(L),A0(L),B0(L),C0(L),E0(L),W0(L),
     1 X1(L),Y1(L),Z1(L),                          W1(L),NR1(L),AW(L),
     2 EX(L),NRLC(L), L = 1,20)
C
      WRITE (6,650)(X0(L),Y0(L),Z0(L),A0(L),B0(L),C0(L),   E0(L),W0(L),A
     1W(L),NR1(L),X1(L),Y1(L),Z1(L),                                W1(L),E
     2X(L),NRLC(L), L = 1,20)
C
 1300 IF (I - NSG)        1400, 1410, 1410
C
 1400 CONTINUE
 1410 IF (F2)             1500, 1500, 1420
C
 1420 LREC = LREC +1
      J = F2
      WRITE (6,70)LREC
C
      READ  (JJJ3  )(X0(L),Y0(L),Z0(L),A0(L),B0(L),C0(L),E0(L),W0(L),
     1 X1(L),Y1(L),Z1(L),                          W1(L),NR1(L),AW(L),
     2 EX(L),NRLC(L), L = 1,J)
C
      WRITE (6,650)(X0(L),Y0(L),Z0(L),A0(L),B0(L),C0(L),   E0(L),W0(L),A
     1W(L),NR1(L),X1(L),Y1(L),Z1(L),                                W1(L),E
     2X(L),NRLC(L), L = 1,J)
 1500 CALL EXIT
      END
```

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