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Fort Worth, Texas

COHORT

A MONTE CARLO PROGRAM FOR CALCULATION OF RADIATION HEATING AND TRANSPORT

Volume IV: Utilization Instructions for AO1 and AO2 Analysis 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,
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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 two analysis routines A01 and A02 that are two of the family of seven routines designated as the COHORT (Calculation of Heating or Radiation Transport) Code (Ref. 1 & 2). The primary purposes of this document are to furnish information necessary for the preparation of input data for the two analysis routines, to provide operational instructions, and to identify the values printed as output data for the two codes.

Brief descriptions of the methods used in the two routines are given as an aid in the preparation of the input data.

Both of the analysis routines are designed to analyze the collision data written on the history tape by the History Generator routine, H01. The A01 routine gives an estimate of the scattered flux at each of a set of from one to five point receivers from each of the collisions written on the history tape. The scattered flux is recorded as a function of energy and as a function of the polar and azimuthal angles of the particle's direction as it passes through the receiver point. The A02 routine gives an estimate of the average number of track lengths within each region. The average number of track lengths within a region may be converted to flux by dividing by the volume of the region. The track lengths are recorded versus region and energy. The A02 routine also gives the angular distribution of the current leaking into the outside region.

II ANALYSIS CODE A01

The function of the A01 code is to estimate the scattered flux at each of a set of one to five point receivers that may be located at any position within the defined geometry. The geometry description for the A01 code is identical to that for the History-Generator Code H01 discussed in Volume III of this report. The position of the scattering centers, the energy, and direction of the particle before collision, the weight after collision, the type of collision, the target nucleus, and the region of scatter are furnished to the A01 code by the history tape written by the H01 code. A01 calculates the probability of scattering through the angle, ψ, between the particle's direction before collision and its direction after scattering toward the receiver positions. Next, the energy after collision and the attenuation of the particle weight from the collision center to the receiver is calculated and then multiplied by the probability of scattering through ψ to obtain an estimate of the flux scattered to the receiver from that collision center. The sum of the estimates from all collision centers to a given receiver position divided by the number of histories gives an estimate of the total scattered flux at that receiver position.

2.1 Flux at a Point Detector

The spatial coordinates of a point detector are denoted as x_i, y_i and z_i. The coordinates of the collision point are denoted as X, Y and Z. The distance between the collision point and the ith detector point is given by

$$d_i = [(X - x_i)^2 + (Y - y_i)^2 + (Z - z_i)^2]^{\frac{1}{2}}$$

and the direction cosines of the flight path to the detector are given by

$$\alpha_i = \frac{x_i - X}{d_i} ,$$

$$\beta_i = \frac{y_i - Y}{d_i} ,$$

$$\gamma_i = \frac{z_i - Z}{d_i} .$$

The laboratory system scattering angle through which the particle must scatter in order to be heading toward the detector is computed by the equation

$$\cos\psi_i = \alpha\alpha_i + \beta\beta_i + \gamma\gamma_i,$$

where α, β, and γ are the direction cosines of the particle before collision. The distances traveled through each region along the flight path between the collision point and the detector point are computed and multiplied by the total cross section for the energy after collision for each region to give the path length in each region.

The method used to compute the particle energy after scattering through the angle ψ is dependent on the type of particle being considered. If the particle is a neutron, the energy after a collision with any element of atomic weight A, except hydrogen, is computed by use of the equation

$$E_i = E[1 - \frac{2A}{(A+1)^2} + \frac{A^2}{(A+1)^2} (1-B) + \frac{2A}{(A+1)^2} B^{\frac{1}{2}} \cos \lambda_i] ,$$

where λ_i, the center-of-mass scattering angle, is given by

$$\cos\lambda_i = \frac{\cos^2\psi_i - 1 + \cos\psi_i \sqrt{\cos^2\psi_i + A^2B - 1}}{AB^{1/2}} .$$

In the above equations B is a parameter taking on the value B=1 if the collision is an elastic scattering event and the value $B = (1 - E_x/E)$ if the collision is an inelastic scattering event. The energy E is the neutron energy before collision.

The energy after a collision with a nucleus of hydrogen is given by $E_i = E\cos^2\psi_i$. If $\cos\psi \leq 10^{-3}$, the calculation of the flux at the detector is terminated, since neutron scattering through angles greater than 90° cannot occur physically.

If the particle being scattered is a gamma ray, the scattered energy is given by

$$E' = \frac{E}{1+\frac{E}{.511}(1-\cos\psi_i)} ,$$

where E is the gamma-ray energy before collision.

The probability that a neutron, undergoing a collision at X, Y, and Z will scatter per unit solid angle into the angle ψ_i so that it will be headed toward the detector is denoted by

$$\frac{\frac{d\sigma}{d\Omega}(K,\psi_i,E)}{\sigma_{K,S}(E)} ,$$

where $\frac{d\sigma}{d\Omega}(K,\psi,E)$ is the differential scattering cross section in the laboratory system for element K at angle ψ and energy E. The cross section $\sigma_{K,S}(E)$ is defined as

$$\sigma_{K,S}(E) = 2\pi \int_0^{\pi} \frac{d\sigma}{d\Omega}(E,\psi,E)\sin\psi d\psi.$$

When neutron elastic scattering is anisotropic in the center-of-mass system, the probability (see expression above) is computed from the input cumulative probability distribution tables for the element of collision as defined by the atomic weight A.

For those cases in which the elastic scattering is isotropic in the center-of-mass system, and for all inelastic scattering events, the probability of scattering per unit solid angle into the angle λ_i is $1/4\pi$.

The scattering probability in the center-of-mass system is converted to the laboratory system by use of the equation

$$\frac{\frac{d\sigma}{d\Omega}(K,\psi_i,E)}{\sigma_{K,S}(E)} = \frac{\frac{d\sigma}{d\Omega}(K,\lambda_i,E)}{\sigma_{K,S}(E)} \frac{(A^2 + 2\cos\lambda_i + 1)^{3/2}}{A^2\left|A + \cos\lambda_i\right|}$$

If the collision element is hydrogen, the scattering probability per unit solid angle in the laboratory system for angle ψ_i is given by $1/\pi\ (\cos\psi_i)$.

The angular scattering probability in the laboratory system for gamma rays is independent of the material in which the collision occurs and is computed from the Klein-Nishina formula by use of the expression

$$\frac{\frac{d\sigma}{d\Omega}(\psi_i,E)}{\sigma_s(E)} = \frac{r_o^{\ 2}}{2} \frac{(P + P^3 - P^2\sin^2\psi_i)}{\sigma_c(E)} ,$$

where $P = \dfrac{E}{1+\frac{E}{.511}(1-\cos\psi_i)}$,

r_o is the classical electron radius, and

$\sigma_c(E)$ is the gamma-ray scattering cross section per electron at energy E.

The cross section $\sigma_c(E)$ is computed from the expression

$$\sigma_c(E) = 2\pi r_o^2 \left\{ \frac{1+Q}{Q^3} \left[\frac{2Q(1+Q)}{1+2Q} - \ln(1+2Q) \right] + \frac{1}{2Q} \ln(1+2Q) - \frac{1+3Q}{(1+2Q)^3} \right\}$$

where Q = E/.511 for gamma-ray energy E in units of Mev.

The estimator used to compute the particle flux at the detector from each collision is given by

$$F = \frac{W}{d_i^2} \frac{\frac{d\sigma}{d\Omega}(E,\psi_i,E)}{\sigma_{K,S}(E)} e^{-\exp} ,$$

where exp is the sum of the mean free paths traversed through each region as the particle moves between the collision point and the detector, and W is the particle's weight after collision. The flux estimator is stored for each detector as a function of the particle's energy and the angles $\cos^{-1} \gamma_i$ and ϕ_i where ϕ_i is the azimuthal angle of the particle's path at the detector.

2.2 Utilization of Analysis Code A01

The purpose of the Analysis Code, A01, is to calculate the intensity and the energy and angular distributions of the scattered neutron or gamma-ray flux at a set of from one to five detector points. The code requires as input a HISTORY tape or, if the problem involves more than one energy super-group, a SORTED tape. The HISTORY or SORTED tape furnishes information generated by the History-Generator Code, giving data concerning collision points that were distributed throughout the described geometry by the Monte Carlo method. In most cases the geometry and cross-section data necessary for input into the A01 code will be exactly the same as that used in H01 when generating the HISTORY tape and, therefore, many of the library decks used in the H01 problem may be used in the A01 problem also.

2.2.1 Operator Instructions A01 Code

The A01 code may use as many as six logical tape units in addition to the regular input and output logical tape units 5 and 6. Input HISTORY or SORTED tapes should be loaded on logical tape units 3 and 4 before starting the problem. If there is only one input HISTORY or SORTED tape, it should be loaded on logical unit 3. If cross sections are to be input on tape, the cross-section tape should be loaded on logical unit 11. If cross sections are input on cards, they will be transferred to the tape on logical unit 10, and if desired, the operator may be instructed to save and label the tape on logical unit 10. In any event the operator should be informed that logical tape units 1, 9, 10 and 11 may be used during the process of running a problem with the A01 code.

2.2.2 A01 Input Data Formats

The cards making up the problem input and the library data for A01 must be sequenced in columns 69 through 72. The first card of 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 within a deck must be 00 for problem input data or the library number for library data decks. 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 correct number 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 A01 Problem Input Data

Each problem run on the Analysis Code, A01, will require a problem input data deck which must be placed immediately behind the "data" card that separates the binary and data decks. The format for the A01 problem data is shown in Table I.

TABLE I

A01 Problem Input Data Format

(for Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1	12I5	IEPMAX	Number of energies bounding printout energy groups	≤21
		IGPMAX	Number of angles bounding printout polar angle groups	≤21
		IPPMAX	Number of angles bounding printout azimuthal angle groups	≤5
		IREGSC	= 0	
		ND	Number of detector points	≤5
		NEL	Number of elements	≤8
		NG	Type of particles NG = 0, neutrons NG = 1, gamma rays NG = 2, secondary gamma rays	
		NHT	Number of input HISTORY or SORTED tapes	≤2
		NREG	Number of regions	3≤NREG≤50
		NUB	Number of outside boundaries	≤20
		NLIB	Number of input libraries (This number is checked against the number of libraries actually furnished and the number of libraries that the code calculates that are necessary for this problem)	
		NMAT	Number of materials	≤8

TABLE I (continued)

Card	Format	Input Item	Definition	Limit
2	1H,A6,A3, 10I5	H(1),H(2)	Label of input tapes (usually HISTORY or SORTED)	
		MHTAPE(K)	Input HISTORY or SORTED tape numbers (K=1 to NHT; if one of the tapes is only partially filled, the number of that tape should be the last one listed.)	≤10
3	8I5, E10.4	NSG	Number of energy super-groups	≤20
		IQID	Tape number of cross section tapes (If cross sections are input on cards rather than tapes, leave this field blank.)	
		NHIST	Number of histories	
		MKREC(1)	Number of records on last HISTORY or SORTED tape that is to be input	
		MKREC(2)	Number of sets of collision data in the last record of the last HISTORY or SORTED tape to be input	
		ISRCTP	HISTORY or SORTED tape option ISRCTP = 0, HISTORY or SORTED tape is available (A01, A02 library 5 not needed) ISRCTP = 1, Collision data will be input on cards rather than tape (A01, A02 library 5 is needed)	
		NTAP	Cross-section tape option NTAP = 0, cross sections not on tape (library 6's are needed for each super-group of every element) NTAP = 1, cross sections will be input on tape (library 6's are not needed.) (If cross sections are on tape, libraries 6 and 10 are not needed, but if cross sections are on cards, libraries 6 and 10 are needed. Cross-section tapes written by the H01 code will not be accepted as input into the A01 code.)	

TABLE I (continued)

Card	Format	Input Item	Definition	Limit
		JSENSE	Intermediate printout option JSENSE = 0, do not print out intermediate print data JSENSE = 1, do print out intermediate print data (JSENSE should be 0 if more than 50 histories are being run, otherwise too much intermediate printout will be received; 50 histories may give a stack of printout from 6 to 12 inches high.)	
		EPSL	Small increment used to move a particle's position off a boundary (This value when added to the largest distance to a boundary that is anticipated in the given problem should change that distance in the first eight significant places.)	
4	6E10.0	BEGGER(K,M)	Number of sets of collision data (+.5) for super-group M on HISTORY or SORTED tape I (if NHT = 0, omit cards with BEGGER(K,M) values.)	
5	12I5	IETAP(K)	Number of tabulated cross sections for super-group K (maximum of 100)	
Follows last IETAP(K) card	6E10.0	PPRINT(K)	Angles bounding printout azimuthal angle groups (degrees, ascending order; the first value is the lower bound of the first angle group and the remaining values are the upper bounds of the first through the last groups.)	K=1 IPPMAX
Follows last PPRINT(K) card	6E10.0	EPRINT(K)	Energies bounding printout energy groups (Mev, ascending order. The first energy bound should be equal to EMIN and the remaining values the upper bounds of each of the printout energy groups)	K=1 IEPMAX
Follows last EPRINT(K) card	6E10.0	GPRINT(K)	Angles bounding printout polar angle groups (degrees, ascending order. The first value is the lower bound of the first angle group and the remaining values are the upper bounds of the first through the last groups.)	K=1 IGPMAX

TABLE I (Continued)

Card	Format	Input Item	Definition	Limit
Follows last GPRINT(K) card	I10, 3E10.0	NRD(K)	Region in which the Kth detector is located (K = 1 to ND)	K=1,ND
		XK1(K) YD1(K) ZD1(K)	Spatial coordinates of detector K	
Follows last NRD(K) card	4E10.4*	EGRP(K)	Lower energy bound for energy group K	K=1,NSG
		EMAX(K)	Upper energy bound for energy group K	K=1,NSG
Follows last EGRP(K) card	6E10.0	ESI(K)	Energy below which elastic scattering is isotropic in the center-of-mass system for element K. (These values are not required for a gamma calculation, but a blank space must be left for each element of the problem.)	K=1,NEL
Follows last ESI(K) card	6E10.0	ATWT(K)	Atomic weight of element K (These values must be listed in the same order that they were listed in the H01 problem that wrote the tape used as input in this problem.)	K=1,NEL
Follows last ATWT(K) card	6E10.0	DN(J,K)	Atomic density of element K in material J (Start new card for each material.)	K=1,NEL J=1,NUMAT
Follows last DN(J,K) card	6I10	NB(K)	Number of boundaries defining region K	K=1,NREG
Follows last NB(K) card	6I10	MATREG(K)	Material in region K	K=1,NREG
			* Reading order: (EGRP(K), EMAX(K), K=1,NSG)	

2.2.2.2 Library One: H01, A01, A02 Codes

Library one contains information describing boundaries for the COHORT codes H01, A01 and A02. If A01, A02 and H01 problems are being run for the same geometry, the same library deck 1 may be used in the input in all three codes. In describing the boundaries, the outside boundaries must be described first. A boundary should not be used both as an inside

and outside boundary because once the program discerns that a particle has crossed an outside boundary from an inside region, the tracking of the particle is terminated. If the geometry is such that a boundary is both an outside and an inside boundary, it should be defined twice, first as an outside boundary and later as an inside boundary. The format for the data in library one is given in Table II.

TABLE II

Library One Input Data Format

(for Columns 1 through 62)

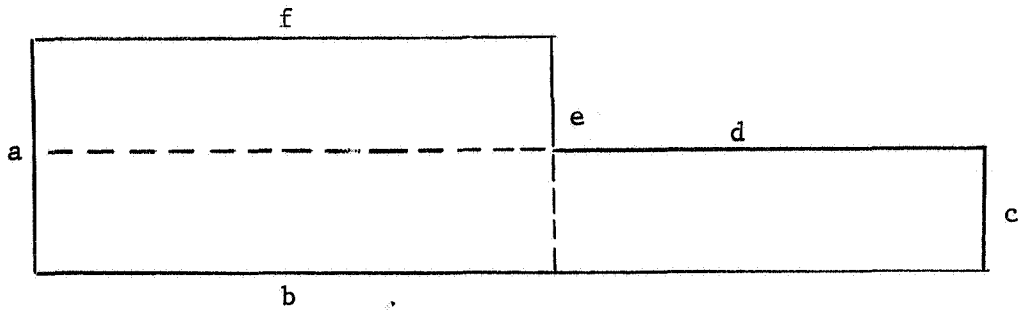
Card	Format	Input Item	Definition	Limit
1	2I10	LIBT	Type of library to be read in (LIBT = 1 for library one)	=1
		NBD	Number of boundaries described in library one	≤75 2≤NBD
	The next NUB cards should contain the boundary descriptions for the NUB outside boundaries of the geometry being described.			
2	I10,* 5E10.4	IBT(K)	Type of boundary for boundary K IBT(K) = 1, sphere, ellipsoid or hyperboloid IBT(K) = 2, paraboloid IBT(K) = 3, cones IBT(K) = 4, cylinders IBT(K) = 5, plane containing Z axis IBT(K) = 6, plane perpendicular to Z axis IBT(K) = 7, plane perpendicular to X axis IBT(K) = 8, plane perpendicular to Y axis IBT(K) = 9, arbitrarily oriented plane	K=1,NBD
		AF(K) ZF(K) CF(K) XF(K) YF(K)	Curve-fit coefficients for boundary K	

* Reading order: (IBT(K), AF(K), ZF(K), CF(K), XF(K), YF(K), K=1,NBD)

2.2.2.3 Library Two: H01, A01, A02 Codes

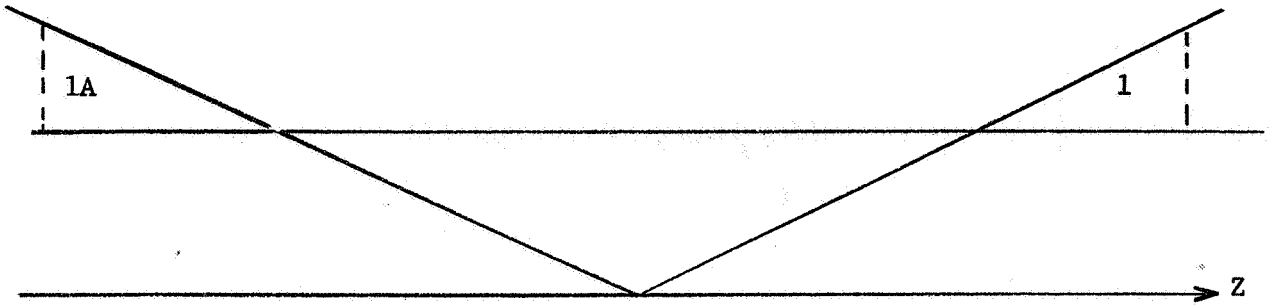
In Library Two the various inside regions in the geometry under consideration are described by giving the boundary numbers that encircle each of the regions. If the same geometry is being considered in H01, A01 and A02 problems, then the same library type 2 may be used in the input of all three codes. The material within any one region will be taken to be a homogeneous mixture. The History-Generator Code and the Analysis Code (A02) calculate respectively energy depositions and track lengths within regions; so the size of the regions should be chosen to give the best statistical results. The codes assume that the first region described is the source region. It is not necessary that all source particles originate in this region, but the problems will run more economically if most of the particles originate within this region. Region 2 is understood to be the outside region and is not described in this library. Inside regions may be listed in any order desired, but different arrangements may prove to be more economical, since upon a particle's crossing a boundary, a search is performed beginning with the most probable region of entry across that boundary and cycling through the regions in the order they are input from that point until the region containing the particle's location is found. In many instances, it may not be feasible to obtain the optimum arrangement of the order in which the regions should be input, but an effort should always be made to cause the code to do as little searching as possible.

Boundaries used in describing a region should not extend into the region. That is, an area such as that depicted below should not be



described as one region because boundaries e and d extend into the region. The codes calculate the distances from a particle's location inside a region to each boundary surrounding that region and assume that the least positive distance is the distance to the outer edge of the region measured along the direction the particle is moving. If a boundary extends inside a region, it would be possible to move the particle's location through this least positive distance and still not have moved the particle to the outer edge of the region. The region depicted above should be divided into two regions so that the boundaries surrounding either of the two regions would not extend into the region being surrounded. One such region would be that surrounded by boundaries a, f, e and b; the other region would be that surrounded by boundaries e, d, c and b.

Care should be taken to prevent a reflected region from appearing in the described geometry. A reflected region is one which is not described in the input but exists because the conditions required for a particle to be in a region are satisfied for some region described elsewhere in the configuration. The sketch below illustrates an example of the situation.



If the above figure is rotated about the Z axis, region 1 will form a cone which is the described region, and region 1A will form a cone which is the reflected region. Any particles in the cone formed by region 1A will satisfy the conditions that are required for a particle to be in region 1. To avoid the description of a reflected region, an additional boundary should be used in describing region 1. This boundary need not border region 1 but should be placed between regions 1 and 1A so that all points in region 1 would lie on one side of the boundary and points in region 1A would lie on the other side of the boundary. The format for data contained in library two is given in Table III.

TABLE III

Library Two Input Data Format

(for Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1	I10	LIBT	Type of library to be read in (LIBT = 2 for this library	
2	12I5*	IBN(K,N)	The nth boundary surrounding region K (see NOTE below)	K=1 or 3 through NREG K≠2
		MPR(K,N)	The most probable region of entry across the nth boundary from region K	NREG

* Reading order: ((IBN(K,N), MPR(K,N), N=1,NB(K); K=1 and 3, NREG)

If Region K has fewer than seven boundaries, a second card for that region is unnecessary. Two cards will be the maximum necessary for any region, since the maximum number of boundaries encircling a region is nine. The maximum number of regions for any one problem is 50.

NOTE: The boundary numbers must be given a sign that corresponds to the sign of XR which is calculated as shown in the text.

2.2.2.4 Library Five: A01, A02 Codes

Library five is omitted if the value ISRCTP in the problem input data is zero. Library five supplies information for up to 20 collision points and is used in lieu of an input HISTORY or SORTED tape when more control over input variables is desired for checkout purposes. The collision parameters that are entered into the code through library five should be sorted according to energy so that those sets of parameters for the energies in the first super-group are read in first, those in the second gorup, next, and so on. The format to be used when preparing a library type 5 data deck is shown in Table IV.

TABLE IV

Library Five Input Data Format

(for Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1	I10,10X, I5	LIBT	Library type (LIBT = 5 for this library)	=5
		ISRCRC	Number of collisions for which collision parameters are to be read in	≤20
2	6E10.4*	X1(K)		K=1,ISRCRC
		Y1(K)	Coordinates of collision point	
		Z1(K)		
		A0(K)		
		B0(K)	Direction cosines of particle's direction before collision	
		C0(K)		
		E0(K)	Particle's energy before collision	
		A(K)	Atomic weight of element with which collision occurred	
		W1(K)	Particle's weight	
		NR1(K)	Region in which collision occurred	
		EX1(K)	Excitation level of target nucleus	

* Reading order: (X1(K), Y1(K), Z1(K), A0(K), B0(K), C0(K), E0(K), A(K), W1(K), NR1(K), EX1(K), K=1, ISRCRC)

2.2.2.5 Library Six: H01, A01, A02 Codes

A library six is required for each energy super-group for every element. This library, for which the input format is given in Table V, gives the total, scattering, and elastic cross sections for neutrons or the total, Compton plus pair production, and Compton cross sections for gamma rays for arbitrarily spaced energy points within the energy super-group. Only the total neutron or gamma-ray cross sections are necessary

for the A01 and A02 codes, but if a library has been made up for the H01 code, it may be used "as is" in the input for the A01 and A02 codes. The range and spacing of the energy points within a given energy super-group must be the same for the different elements. The cross sections are listed first for the highest energy of the group and then in descending order to the lowest energy of the group.

Libraries type 6 may be loaded behind the problem input data in any order, since the codes write the cross-section data on tape as it is read in and then rearranges the data according to super-group after all library data are read in.

TABLE V

Library Six Input Data Format

(for Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1	2I10,2I5	LIBT	Library type (LIBT = 6 for this library	=6
		K	Number of energy points at which cross sections are read in	≤100
		J	Element number (Elements are numbered in the order that their atomic weights are listed in the problem input data.)	
		L	Energy super-group number (Energy super-groups must be numbered beginning with the group of highest energies as Group 1 and increasing the group number as the energies within the groups decrease.)	
2 through M+1 cards	4E10.4*	ENERGY(M)	Energy points (descending order) within the super-group at which cross sections are defined (These energies should be the same for all library sixes for a given super-group.)	
		TM(J,M)	Total microscopic cross section for Element J (M = 1 to K) NRG = 0, neutron cross sections NRG = 0, gamma-ray cross sections	
		SM(J,M)	Microscopic scattering cross section for Element J (M = 1 to K) NRG = 0, neutron scattering cross section NRG > 0, gamma-ray Compton plus pair-production cross section	
		ESM(J,M)	Microscopic elastic cross section for neutrons or Compton scattering cross section for gammas for element J (M = 1 to K)	

* Reading Order: (ENERGY(J,M), TM(J,M), SM(J,M), ESM(J,M), M=1,K)

2.2.2.6 Library Ten H01 and A01 Codes

A library ten is required for every energy super-group within which neutron elastic scattering is on an element basis and is non-isotropic in the center-of-mass system. That is, if the value ESI(J) for the element J is less than the maximum energy of the super-group, then a library ten is required for this super-group for element J. A library ten is not required for neutron elastic scattering by hydrogen or for gamma-ray problems.

Library ten gives the cosines of the center-of-mass scattering angles for equal values of the cumulative probabilities for intervals of 0.05 from 0.05 to 1.0. Both a library ten and a library eleven should not be input for the same super-group, since values in libraries ten and eleven occupy the same storage locations in the core. The format to be used in making up a library type ten is illustrated in Table VI.

TABLE VI

Library Ten Input Data Format

(for Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1	2I10,2I5	LIBT	Library type (LIBT = 10 for this library)	
		K	K = 20, the number of probabilities for which the cosines of the scattering angles are listed. (This number must always be 20.)	
		J	Element number (The elements are numbered in the order that the atomic weights are listed in the problem input data.)	
		L	Energy super-group number (The super-groups are numbered beginning with the group of highest energies as group 1 and the number of the groups increasing as the energies of the groups decrease.)	
2	6E10.4	NCROS(J)	Number of incident-energy groups for which scattering probabilities are input for element J (Maximum of 25)	
Follows last NCROS(J) card	6E10.4	ESCAT(J,N)	Upper bounds of the incident-neutron energy groups listed in descending order from 1 to NCROS(J))	
Follows last ESCAT(J,N) card	6E10.4	DES(J,N,M)	Cosines of the center-of-mass scattering angles for element J tabulated for equal cumulative probabilities of 0.05 from 0.05 to 1.00 (20 values of cosines in descending order)	

2.3 A01 Sample Problem

An A01 sample problem was designed to analyze the history tape generated by the H01 routine in running the H01 sample problem discussed in Volume III. The A01 problem reads the collision data from the tape labeled HISTORY 166 and calculates by statistical estimation

the scattered thermal neutron flux within the concrete slab at the position X = 0.0, Y = 0.0, Z = 11.288.

2.3.1 A01 Sample Input

Table VII lists the input data for the A01 sample problem. The problem input data is contained in the first 20 cards shown in Table VII. The remainder of the input data for the A01 sample problem is the same as that for libraries 1, 2 and 6 in the H01 sample problem. The history tape used as input contained information on 1981 collisions in 101 records. The first record is an information record and the last record contains the collision parameters for only one collision.

2.3.2 A01 Sample Output

The output from the A01 sample problem is listed in Table VIII. The coordinates of the detector position are listed to identify the position at which the scattered fluxes are calculated. The scattered flux is printed as a function of polar and azimuthal angle for each energy printout group. The last page of printout gives the scattered intensity summed over all energies as a function of polar and azimuthal angle. The scattered fluxes in the H01 output have not been normalized to flux per unit source particle. To do this, the fluxes should be divided by the number of histories run with the H01 sample problem that produced the history tape used as input in the A01 sample problem. The polar angles used in defining the A01 output are measured from the positive Z axis of the coordinate system used in defining the A01 geometry. The azimuthal angles are measured counter clockwise from the positive X axis.

TABLE VII A01 Sample Input Data

2	19	5	0	1	1	0	1	11	3	3	1	1660000001	
HISTØRY		166										1660000002	
1		50	101	1	0	0	0	1.0-03				1660000003	
1981.5+00												1660000004	
2												1660000005	
0.0+00		90.0+00		180.0+00		270.0+00		360.0+00				1660000006	
1.0-08		3.0-08										1660000007	
0.0+00		10.0+00		20.0+00		30.0+00		40.0+00		50.0+00		1660000008	
60.0+00		70.0+00		80.0+00		90.0+00		100.0+00		110.0+00		1660000009	
120.0+00		130.0+00		140.0+00		150.0+00		160.0+00		170.0+00		1660000010	
180.0+00												1660000011	
	7	0.0+00		0.0+00		11.288+00						1660000012	
1.0-08		3.0-08										1660000013	
3.0-08												1660000014	
33.0+00												1660000015	
1.0+00												1660000016	
	3		3		3		3		3		3	1660000017	
	3		3		3		3		3			1660000018	
	1		0		1		1		1		1	1660000019	
	1		1		1		1		1			1660000020	
	1		12									166010001	H01
	6	0.0+0										166010002	H01
	4	3.0+2										166010003	
	6	66.4+0										166010004	H01
	6	1.328+0										166010005	H01
	6	2.656+0										166010006	H01
	6	3.984+0										166010007	H01
	6	6.640+0										166010008	H01
	6	9.296+0										166010009	H01
	6	13.280+0										166010010	H01
	6	18.592+0										166010011	H01
	6	26.560+0										166010012	H01
	6	39.840+0										166010013	H01
	2											166020001	H01
1	2	-2	2	-4	3							166020002	H01
4	1	-2	2	-5	4							166020003	H01
5	3	-2	2	-6	5							166020004	H01
6	4	-2	2	-7	6							166020005	H01
7	5	-2	2	-8	7							166020006	H01
8	6	-2	2	-9	8							166020007	H01
9	7	-2	2	-10	9							166020008	H01
10	8	-2	2	-11	10							166020009	H01
11	9	-2	2	-12	11							166020010	H01
12	10	-2	2	- 3	2							166020011	H01
	6		2	1	1							166060001	H01
3.0-8		7.53-1		7.4321-1		7.4321-1						166060002	H01
1.0-8		7.53-1		7.4321-1		7.4321-1						166060003	H01

TABLE VIII. A01 Sample Output Data

```
CRØSS SECTIØN TAPE LABELED CRØSS   -0 WAS GENERATED AND CØNTAINS THE FØLLØWING INFØRMATIØN.
    2 = NUMBER ØF RECØRDS ØN THIS TAPE
   11 = NUMBER ØF REGIØNS
    1 = NUMBER ØF ELEMENTS
    1 = NUMBER ØF MATERIALS
    1 = NUMBER ØF SUPERGRØUPS
    0 = NEUTRØNS, GAMMAS, ØR SECØNDARY GAMMAS

PRØBLEM NUMBER 1660 0
HISTØRY TAPES LABELED   HISTØRY 166 THRØUGH   HISTØRY 166
```

TABLE VIII A01 Sample Output Data (cont'd)

```
DETECTØR NUMBER    1
CØØRDINATES     X =  0.000E-38,   Y =  0.000E-38,   Z =  0.113E 02
```

TABLE VIII A01 Sample Output Data (cont'd)

PARTICLE ENERGY = 0.100E-07 TØ 0.300E-07 MEV

PØLAR ANGLE (DEG)	AZIMUTHAL ANGLE (DEGREES) 0.0- 90.0	90.0-*****	180.0-*****	270.0-*****	SUM
10.0	0.52850E-03	0.24832E-03	0.13902E-04	0.87758E-04	0.87848E-03
20.0	0.00000E-38	0.38321E-03	0.46140E-03	0.42865E-03	0.12733E-02
30.0	0.27314E-03	0.79285E-02	0.25053E-03	0.84139E-03	0.92936E-02
40.0	0.00000E-38	0.56215E-05	0.18388E-03	0.33781E-04	0.22328E-03
50.0	0.14978E-01	0.81135E-05	0.93982E-06	0.15774E-05	0.14989E-01
60.0	0.27767E-06	0.49471E-03	0.60483E-04	0.11559E-05	0.55662E-03
70.0	0.32221E-07	0.50304E-02	0.23984E-02	0.17782E-04	0.74466E-02
80.0	0.39651E-02	0.30164E-04	0.51177E-03	0.10588E-04	0.45176E-02
90.0	0.00000E-38	0.21913E-02	0.18997E-02	0.88623E-08	0.40911E-02
100.0	0.96410E-07	0.87461E-03	0.87365E-02	0.79055E-07	0.96112E-02
110.0	0.37692E-06	0.15471E-03	0.51103E-03	0.21206E-04	0.68733E-03
120.0	0.18218E-07	0.11694E-02	0.29066E-07	0.64048E-05	0.11759E-02
130.0	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38
140.0	0.00000E-38	0.12134E-06	0.00000E-38	0.00000E-38	0.12134E-06
150.0	0.00000E-38	0.71838E-05	0.14492E-02	0.00000E-38	0.14564E-02
160.0	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38
170.0	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38
180.0	0.00000E-38	0.00000E-38	0.00000E-38	0.23709E-03	0.23709E-03
SUM	0.19745E-01	0.18526E-01	0.16478E-01	0.16875E-02	0.56437E-01

2.4 A01 FORTRAN-IV Listings

```
C THIS PROGRAM CALCULATES FLUXES AT DETECTOR POINTS (5 MAXIMUM)
C TAPE UNIT ALLOCATIONS --- TAPE NO. 1  LATENT DATA ( WORKING TAPE )
C                           TAPE NO. 2  LATENT DATA ( WORKING TAPE )
C                           TAPE NO. 3  HISTORY PARTICLE DATA ( SAVE )
C                           TAPE NO. 4  HISTORY PARTICLE DATA ( SAVE )
C                           TAPE NO. 9  CROSS SECTIONS ( SAVE )
C                           TAPE NO.10  CROSS SECTIONS ( WORKING TAPE )
      COMMON /SCTAP/ IDT, AD, BD, CD, D, X, Y, Z, W, NR, EI, DESL,
     1 ICOL, ICOL1, JSENSE, KREC, KLMAX
      COMMON /WEDWIT/ IDTA1(20), ADA1(20), BDA1(20), CDA1(20), DA1(20),
     1 XA1(20), YA1(20), ZA1(20), WA1(20), NRA1(20), EIA1(20), DESA1(20)
      COMMON /CROSS/ NENEGY, ENERGY(100), TCS(8,100), NCROS(8),
     1 ESCAT(8,25), DES(8,25,20)
      COMMON /JUNK/ A, A0(20), API2, AT, AT1(20), ATWT(8), B, B0(20),
     1 C, C0(20), CLMDA, CPSI, CPSI2, CROS, CRSS, DELCT,       DISTM,
     2 DSQD, E, E0(20), EGRP(20),     ESI(8), ESUM(20), EPRINT(21),
     3 EX, EX1(20), ESP, FLUX(20,20,20), FLUXE(20,20), FSUM(8),
     4 GPRINT(21), GRAD(21), H(2), HELP, IEE, IEINTV, IEMAX, IEPMAX,
     5 IETAB(20), IGINTV, IGPMAX, IH1, IH2, IHTAPE, IHEAD, ILAST,
     6 IPPMAX, IREGSC, J2NO, J1NO, JM, JTAPE, JTAPE1, JTAPE2, JA, JI,
     7  K, K1, KESC2, KGRP(3,20), KS, KTAPE, L1, L2, L3, LBJ, LZ,
     8 MATREG(50), MHTAPE(20), MIGHT(20), MNO, NB1, ND, NEL, NG, NHT,
     9 NHIST, NOINT, NN, NR1(20), NR2, NREC, NRD(5), NLIB, NSG, PID
      COMMON  PPRINT(5), PRAD(5), Q, IQID, S, SUMS, TM(8,100), W1(20),
     1 X1(20), X2, XD1(5), XD, Y1(20), Y2, YD, YD1(5), Z1(20), Z2,
     2 ZZZZ1, ZZZZ2, ZD, ZD1(5), DN(8,8), ISRCTP, ISRCRC, NMAT,
     3 ETM, ILOC, BEG(20), BEGGER(20,20), MKREC(2), NTAP, AW(20),
     4 EMAX(20), INLIBR(11), INSUPR(20), INELEM(8)
     5 /GEOM1/ IBT( 75), AF( 75), ZF( 75), CF( 75), XF( 75), YF( 75),
     6 IBN(50,9), MPR(50,9), NB(50), EPSL, NBD, NREG
     2 /CARDC/ IS, IS1, IL, IL1, FLIB, NPRINT(9), MS
      COMMON /FLXDO/ FTD, FTOD(100), DOSE(5,20,20)
      CALL MAIN 3
      CALL BUTTER
      CALL FPRINT
      CALL EXIT
      STOP
      END
```

```
 SUBROUTINE PRINTS (I,L)
 COMMON /SCTAP/ IDT, AD, BD, CD, D, X, Y, Z, W, NR, EI, DESL,
1 ICOL, ICOL1, JSENSE, KREC, KLMAX
 COMMON /WEDWIT/ IDTA1(20), ADA1(20), BDA1(20), CDA1(20), DA1(20),
1 XA1(20), YA1(20), ZA1(20), WA1(20), NRA1(20), EIA1(20), DESA1(20)
 COMMON /CROSS/ NENEGY, ENERGY(100), TCS(8,100), NCROS(8),
1 ESCAT(8,25), DES(8,25,20)
 COMMON /JUNK/ A, A0(20), API2, AT, AT1(20), ATWT(8), B, B0(20),
1 C, C0(20), CLMDA, CPSI, CPSI2, CROS, CRSS, DELCT,       DISTM,
2 DSQD, E, E0(20), EGRP(20),     ESI(8), ESUM(20), EPRINT(21),
3 EX, EX1(20), ESP, FLUX(20,20,20), FLUXE(20,20), FSUM(8),
4 GPRINT(21), GRAD(21), H(2), HELP, IEE, IEINTV, IEMAX, IEPMAX,
5 IETAB(20), IGINTV, IGPMAX, IH1, IH2, IHTAPE, IHEAD, ILAST,
6 IPPMAX, IREGSC, J2NO, J1NO, JM, JTAPE, JTAPE1, JTAPE2, JA, JI,
7  K, K1, KESC2, KGRP(3,20), KS, KTAPE, L1, L2, L3, LBJ, LZ,
8 MATREG(50), MHTAPE(20), MIGHT(20), MNO, NB1, ND, NEL, NG, NHT,
9 NHIST, NOINT, NN, NR1(20), NR2, NREC, NRD(5), NLIB, NSG, PID
 COMMON  PPRINT(5), PRAD(5), Q, IQID, S, SUMS, TM(8,100), W1(20),
1 X1(20), X2, XD1(5), XD, Y1(20), Y2, YD, YD1(5), Z1(20), Z2,
2 ZZZZ1, ZZZZ2, ZD, ZD1(5), DN(8,8), ISRCTP, ISRCRC, NMAT,
3 ETM, ILOC, BEG(20), BEGGER(20,20), MKREC(2), NTAP, AW(20),
4 EMAX(20), INLIBR(11), INSUPR(20), INELEM(8)
5 /GEOM1/ IBT( 75), AF( 75), ZF( 75), CF( 75), XF( 75), YF( 75),
6 IBN(50,9), MPR(50,9), NB(50), EPSL, NBD, NREG
2 /CARDC/ IS, IS1, IL, IL1, FLIB, NPRINT(9), MS
 CALL DUMP
 RETURN
 END
```

```
      SUBROUTINE  MAIN 3
C MAIN PROGRAM IN ANALYSIS CODE A01
C
      COMMON /SCTAP/ IDT, AD, BD, CD, D, X, Y, Z, W, NR, EI, DESL,
     1 ICOL, ICOL1, JSENSE, KREC, KLMAX
      COMMON /WEDWIT/ IDTA1(20), ADA1(20), BDA1(20), CDA1(20), DA1(20),
     1 XA1(20), YA1(20), ZA1(20), WA1(20), NRA1(20), EIA1(20), DESA1(20)
      COMMON /CROSS/ NENEGY, ENERGY(100), TCS(8,100), NCROS(8),
     1 ESCAT(8,25), DES(8,25,20)
      COMMON /JUNK/ A, A0(20), API2, AT, AT1(20), ATWT(8), B, B0(20),
     1 C, C0(20), CLMDA, CPSI, CPSI2, CROS, CRSS, DELCT,       DISTM,
     2 DSQD, E, E0(20), EGRP(20),      ESI(8), ESUM(20), EPRINT(21),
     3 EX, EX1(20), ESP, FLUX(20,20,20), FLUXE(20,20), FSUM(8),
     4 GPRINT(21), GRAD(21), H(2), HELP, IEE, IEINTV, IEMAX, IEPMAX,
     5 IETAB(20), IGINTV, IGPMAX, IH1, IH2, IHTAPE, IHEAD, ILAST,
     6 IPPMAX, IREGSC, J2NO, J1NO, JM, JTAPE, JTAPE1, JTAPE2, JA, JI,
     7  K, K1, KESC2, KGRP(3,20), KS, KTAPE, L1, L2, L3, LBJ, LZ,
     8 MATREG(50), MHTAPE(20), MIGHT(20), MNO, NB1, ND, NEL, NG, NHT,
     9 NHIST, NOINT, NN, NR1(20), NR2, NREC, NRD(5), NLIB, NSG, PID
      COMMON  PPRINT(5), PRAD(5), Q, IQID, S, SUMS, TM(8,100), W1(20),
     1 X1(20), X2, XD1(5), XD, Y1(20), Y2, YD, YD1(5), Z1(20), Z2,
     2 ZZZZ1, ZZZZ2, ZD, ZD1(5), DN(8,8), ISRCTP, ISRCRC, NMAT,
     3 ETM, ILOC, BEG(20), BEGGER(20,20), MKREC(2), NTAP, AW(20),
     4 EMAX(20), INLIBR(11), INSUPR(20), INELEM(8)
     5 /GEOM1/ IBT( 75), AF( 75), ZF( 75), CF( 75), XF( 75), YF( 75),
     6 IBN(50,9), MPR(50,9), NB(50), EPSL, NBD, NREG
     2 /CARDC/ IS, IS1, IL, IL1, FLIB, NPRINT(9), MS
      READ  (5      ,30)IEPMAX, IGPMAX, IPPMAX, IREGSC, ND, NEL,   NG, NH
     1T, NREG, NUB, NLIB, NMAT, PID, NN1, IS1
   30 FORMAT (12I5, 2XA4,I2,I4)
      N1=1
      READ  (5      ,40)H(1), H(2), (MHTAPE(I), I=1,10), NN, IS
   40 FORMAT (1H , A6, A3, 10I5, 6X I2, I4)
      IF (IS1-N1)              80, 50, 80
   50 IF (IS-IS1-N1)           70, 60, 70
   60 IF (NN1-NN)              70, 1040, 70
   70 NN = NN + 100
      IS = IS + 10000
      WRITE (6,85)PID, NN, IS
      CALL EXIT
   80 NN1= NN1+ 100
      IS1= IS1+ 10000
      WRITE (6,85)PID, NN1,IS1
      CALL EXIT
   85 FORMAT (35H0DISCREPANCY IN I.D. FIELD OF CARD, A4, I2, I4)
 1040 READ  (5      ,1070)NSG, IQID, NHIST, MKREC(1), MKREC(2),    ISRCTP
     1, NTAP, JSENSE, EPSL, NN1, IS1
      IF (IS1-IS-N1)           80, 1050, 80
 1050 IF (NN1-NN)              80, 1060, 80
 1060 IS = IS1
```

```
1070 FORMAT (8I5, 1E10.4,16XI2, I4)
1080 FORMAT (8I5,26XI2,I4)
     IF (NHT)                90, 90, 1085
1085 DO 1140   IXZ=1,NHT
     READ  (5      ,95)(BEGGER(IXZ,IP),IP=1, 6), NN1, IS1
     IF (IS1-IS-N1)          80, 1090, 80
1090 IF (NN1-NN)             80, 1100, 80
1100 IS=IS1
     IF (NSG- 6)             1140, 1140, 1110
1110 READ  (5      ,95)(BEGGER(IXZ,IP),IP= 7,12), NN1, IS1
     IF (IS1-IS-N1)          80, 1120, 80
1120 IF (NN1-NN)             80, 1130, 80
1130 IS = IS1
     IF (NSG-12)             1140, 1140, 1131
1131 READ  (5      ,95)(BEGGER(IXZ,IP),IP=13,18),NN1,IS1
     IF (IS1-IS-N1)          80, 1132, 80
1132 IF (NN1-NN)             80, 1133, 80
1133 IS=IS1
     IF (NSG-18)             1140, 1140, 1134
1134 READ  (5      ,1137)BEGGER(IXZ,19), BEGGER(IXZ,20),NN1,IS1
     IF (IS1-IS-N1)          80, 1135, 80
1135 IF (NN1-NN)             80, 1136, 80
1136 IS=IS1
1137 FORMAT (2E10.0,46XI2,I4)
1140 CONTINUE
  90 READ  (5      ,91)(IETAB(I), I=1,12), NN1, IS1
  91 FORMAT (12I5, 6XI2,I4)
  95 FORMAT (6E10.0,6XI2,I4)
  96 FORMAT (4E10.4, 26XI2,I4)
     CALL SLITE (0)
     IF (IS1-IS-N1)          80, 97, 80
  97 IF (NN1-NN)             80, 99, 80
  99 IS=IS1
     IF (NSG-12)            106, 106, 101
 101 READ  (5      ,1080)(IETAB(I), I=13,20), NN1, IS1
     IF (IS1-IS-N1)          80, 102, 80
 102 IF (NN1-NN)             80, 103, 80
 103 IS=IS1
 106 READ  (5      ,107)(PPRINT(I), I= 1, 5), NN, IS
 107 FORMAT (5E10.0, 16X I2,I4)
     IF (IS-IS1-N1)          70, 109, 70
 109 IF (NN-NN1)             70, 110, 70
 110 CALL ANGRED (IEPMAX,IS,IS1,NN,NN1, EPRINT(1))
     CALL SLITET(1,K000FX)
      GO TO(80,112),K000FX
 112 CALL ANGRED (IGPMAX,IS,IS1,NN,NN1, GPRINT(1))
     CALL SLITET(1,K000FX)
      GO TO(80,114),K000FX
 114 DO 120   IDT = 1, ND
     READ  (5      ,122)NRD(IDT), XD1(IDT), YD1(IDT), ZD1(IDT),    NN1,
```

```
   1IS1
    IF (IS1-IS-N1)          80, 116, 80
116 IF (NN1-NN)             80, 118, 80
118 IS=IS1
120 CONTINUE
122 FORMAT (I10, 3E10.0, 26X I2, I4)
    IQID= IQID+10000
    ICOL=0
    KREC  =0
    DO 124   I=1, IPPMAX
124 PRAD(I) = PPRINT(I) * .0174533
    DO 126   I=1, IGPMAX
126 GRAD(I) = GPRINT(I) * .0174533
    DO 128   I = 1, NHT
128 MIGHT(I) = MHTAPE(I)
C
130 JZ=NSG/4
    K1=NSG-4*JZ
    K2=0
    K3=0
    K4=0
    K5=0
    IF(JZ)                  160, 160, 140
140 DO 150   I=1,JZ
    K2 = K5+1
    K3 = K2+1
    K4 = K3+1
    K5 = K4+1
    READ  (5      ,96)(EGRP(M),EMAX(M),       M=K2,K3),NN,IS
    JACK=4
    IF (NN-NN1)             70, 142, 70
142 IF (IS-IS1-N1)          70, 144, 70
144 READ  (5      ,96)(EGRP(M),EMAX(M),       M=K4,K5),NN1,IS1
    JACK=5
    IF (NN-NN1)             80, 146, 80
146 IF (IS1-IS-N1)          80, 150, 80
150 CONTINUE
160 K2=K5+1
    IF(K1)                  195, 195, 162
162 GO TO (170, 180, 180), K1
170 READ  (5      ,164)EGRP(K2),EMAX(K2),        NN,IS
164 FORMAT (2E10.4, 46X     I2,I4)
    JACK= 6
    IF (NN-NN1)             70, 175, 70
175 IF (IS-IS1-N1)          70, 195, 70
180 READ  (5      ,96)EGRP(K2),EMAX(K2),EGRP(K2+1),EMAX(K2+1),NN,IS
    JACK=7
    IF (NN-NN1)             70, 182, 70
182 IF (IS-IS1-N1)          70, 185, 70
185 IF (K1-2)               195, 195, 190
```

```
190 READ  (5      ,164)EGRP(K2+2),EMAX(K2+2),          NN,IS1
    JACK=8
    IF (NN-NN1)              80, 192, 80
192 IF (IS1-IS-N1)           80, 195, 80
195 IF (IS1-IS)              197, 197, 200
197 IS1=IS
200 READ  (5      ,95)(ESI(I), I=1,6), NN, IS
    JACK=9
    IF (NN-NN1)              70, 205, 70
205 IF (IS-IS1-N1)           70, 210, 70
210 IF (NEL-6)               230, 230, 215
212 FORMAT (2E10.4, 46X      I2,I4)
215 READ  (5      ,212)ESI(7), ESI(8), NN1, IS1
    JACK=10
    IF (NN-NN1)              80, 220, 80
220 IF (IS1-IS-N1)           80, 225, 80
225 IS=IS1
230 READ  (5      ,95)(ATWT(I),I=1,6), NN1, IS1
    JACK=11
    IF (NN-NN1)              80, 235, 80
235 IF (IS1-IS-N1)           80, 240, 80
240 IF (NEL-6)               260, 260, 245
245 READ  (5      ,212)ATWT(7),ATWT(8),NN , IS
    JACK=12
    IF (NN-NN1)              70, 250, 70
250 IF (IS-IS1-N1)           70, 255, 70
255 IS1=IS
260 DO 300  I=1,NMAT
    READ  (5      ,95)(DN(I,J),J=1,6),NN , IS
    JACK=13
    IF (NN-NN1)              70, 265, 70
265 IF (IS-IS1-N1)           70, 270, 70
270 IF (NEL-6)               295, 295, 275
275 READ  (5      ,212)DN(I,7),DN(I,8),NN1, IS1
    JACK=14
    IF (NN-NN1)              80, 280, 80
280 IF (IS1-IS-N1)           80, 300, 80
295 IS1=IS
300 CONTINUE
    I1=NREG/12
    K1=0
    K2=0
    K3=0
    K4=0
    IF(I1)                   350, 350, 305
305 DO 329  I=1,I1
    K1=K4+1
    K2=K1+5
    K3=K2+1
    K4=K3+5
```

```
      READ  (5      ,310)(NB(J), J=K1, K2), NN, IS
  310 FORMAT (6I10,     6X     I2,I4)
      JACK=15
      IF (NN-NN1)             70, 315, 70
  315 IF (IS-IS1-N1)          70, 320, 70
  320 READ  (5      ,310)(NB(J), J=K3, K4), NN1,IS1
      JACK=16
      IF (NN-NN1)             80, 325, 80
  325 IF (IS1-IS-N1)          80, 329, 80
  329 CONTINUE
      GO TO 350
  330 IF (IS1-IS-N1)          80, 331, 80
  331 IF (NN-NN1)             80, 332, 80
  332 GO TO (420,415,434,440,446,452,458,464,470,476,500), ILOC
  333 IF (IS-IS1-N1)          70, 334, 70
  334 IF (NN-NN1)             70, 332, 70
  350 K1=K4+1
      I1=NREG-12*I1
      IF (I1)                 420, 420, 352
  352 GO TO(360,370,380,390,400,410,410,410,410,410,410),I1
  360 READ  (5      ,362)NB(K1), NN, IS
  362 FORMAT (I10,     56X     I2,I4)
  363 JACK=17
      ILOC=1
      GO TO 333
  370 READ  (5      ,381)NB(K1),NB(K1+1), NN, IS
      GO TO 363
  380 K2=K1+2
      READ  (5      ,382)(NB(J), J=K1,K2), NN, IS
  381 FORMAT (2I10,    46X     I2,I4)
  382 FORMAT (3I10,    36X     I2,I4)
      GO TO 363
  390 K2=K1+3
      READ  (5      ,392)(NB(J), J=K1,K2), NN, IS
  392 FORMAT (4I10,    26X     I2,I4)
      GO TO 363
  400 K2=K1+4
      READ  (5      ,402)(NB(J), J=K1,K2), NN, IS
  402 FORMAT (5I10,    16X     I2,I4)
      GO TO 363
  410 K2=K1+5
      READ  (5      ,310)(NB(J),J=K1,K2), NN, IS
      JACK=18
      ILOC=2
      GO TO 333
  415 K1=K2+1
      IS1=IS
      I1=I1-6
      IF(I1)                  420, 420, 352
  420 IF (IS-IS1)             425, 430, 430
```

```
425 IS=IS1
430 READ  (5      ,310)(MATREG(I),I= 1,6), NN1 , IS1
    JACK=19
    ILOC=3
    GO TO 330
434 IF(NREG-6)              500, 500, 436
436 READ  (5      ,310)(MATREG(I),I= 7,12), NN , IS
    ILOC=4
    GO TO 333
440 IF(NREG-12)             500, 500, 442
442 READ  (5      ,310)(MATREG(I),I=13,18),NN1 , IS1
    ILOC=5
    GO TO 330
446 IF(NREG-18)             500, 500, 448
448 READ  (5      ,310)(MATREG(I),I=19,24), NN , IS
    ILOC=6
    GO TO 333
452 IF(NREG-24)             500, 500, 454
454 READ  (5      ,310)(MATREG(I),I=25,30),NN1 , IS1
    ILOC=7
    GO TO 330
458 IF(NREG-30)             500, 500, 460
460 READ  (5      ,310)(MATREG(I),I=31,36), NN , IS
    ILOC=8
    GO TO 333
464 IF(NREG-36)             500, 500, 466
466 READ  (5      ,310)(MATREG(I),I=37,42),NN1 , IS1
    ILOC=9
    GO TO 330
470 IF(NREG-42)             500, 500, 472
472 READ  (5      ,310)(MATREG(I),I=43,48), NN , IS
    ILOC=10
    GO TO 333
476 IF(NREG-48)             500, 500, 478
478 READ  (5      ,479)MATREG(49),MATREG(50), NN1, IS1
479 FORMAT (2I10,    46X     I2,I4)
    ILOC=11
    GO TO 330
500 IF (IS-IS1)             505, 505, 510
505 IS=IS1
510 IH1 = MHTAPE (1) + 10000
    IH2 = MHTAPE(NHT)+10000
    CALL INDATA
    RETURN
    END
```

```
C SUBROUTINE INDATA IN ANALYSIS CODE A01.
      SUBROUTINE INDATA
      COMMON /SCTAP/ IDT, AD, BD, CD, D, X, Y, Z, W, NR, EI, DESL,
     1 ICOL, ICOL1, JSENSE, KREC, KLMAX
      COMMON /WEDWIT/ IDTA1(20), ADA1(20), BDA1(20), CDA1(20), DA1(20),
     1 XA1(20), YA1(20), ZA1(20), WA1(20), NRA1(20), EIA1(20), DESA1(20)
      COMMON /CROSS/ NENEGY, ENERGY(100), TCS(8,100), NCROS(8),
     1 ESCAT(8,25), DES(8,25,20)
      COMMON /JUNK/ A, A0(20), API2, AT, AT1(20), ATWT(8), B, B0(20),
     1 C, C0(20), CLMDA, CPSI, CPSI2, CROS, CRSS, DELCT,       DISTM,
     2 DSQD, E, E0(20), EGRP(20),      ESI(8), ESUM(20), EPRINT(21),
     3 EX, EX1(20), ESP, FLUX(20,20,20), FLUXE(20,20), FSUM(8),
     4 GPRINT(21), GRAD(21), H(2), HELP, IEE, IEINTV, IEMAX, IEPMAX,
     5 IETAB(20), IGINTV, IGPMAX, IH1, IH2, IHTAPE, IHEAD, ILAST,
     6 IPPMAX, IREGSC, J2NO, J1NO, JM, JTAPE, JTAPE1, JTAPE2, JA, JI,
     7  K, K1, KESC2, KGRP(3,20), KS, KTAPE, L1, L2, L3, LBJ, LZ,
     8 MATREG(50), MHTAPE(20), MIGHT(20), MNO, NB1, ND, NEL, NG, NHT,
     9 NHIST, NOINT, NN, NR1(20), NR2, NREC, NRD(5), NLIB, NSG, PID
      COMMON  PPRINT(5), PRAD(5), Q, IQID, S, SUMS, TM(8,100), W1(20),
     1 X1(20), X2, XD1(5), XD, Y1(20), Y2, YD, YD1(5), Z1(20), Z2,
     2 ZZZZ1, ZZZZ2, ZD, ZD1(5), DN(8,8), ISRCTP, ISRCRC, NMAT,
     3 ETM, ILOC, BEG(20), BEGGER(20,20), MKREC(2), NTAP, AW(20),
     4 EMAX(20), INLIBR(11), INSUPR(20), INELEM(8)
     5 /GEOM1/ IBT( 75), AF( 75), ZF( 75), CF( 75), XF( 75), YF( 75),
     6 IBN(50,9), MPR(50,9), NB(50), EPSL, NBD, NREG
     2 /CARDC/ IS, IS1, IL, IL1, FLIB, NPRINT(9), MS
      COMMON /FLXDO/ FTD, FTOD(100), DOSE(5,20,20)
      L11REC = 0
      NRG = NG
      MS = 1
      NLIBC=2
      DO 2  L=1,2
    2 INLIBR(L)=1
      DO 4  L=3,11
    4 INLIBR(L)=0
      DO 6  L=1,20
    6 INSUPR(L)=0
      DO 8  L=1,8
    8 INELEM(L)=0
      IF (ISRCTP)              12, 12, 10
   10 INLIBR(5)=1
      NLIBC=NLIBC+1
   12 IF (NTAP)                41, 14, 41
   14 DO 40 M=1,NSG
   16 INLIBR(6)=INLIBR(6)+NEL
   18 INSUPR(M)=INSUPR(M)+NEL

      DO 20  L=1,NEL
   20 INELEM(L)=INELEM(L)+1
      NLIBC=NLIBC+NEL
```

```
      IF (NRG-1)                32, 40, 40
   32 DO 38  L=1,NEL
      IF (ESI(L)-EMAX(M))       36, 38, 38
   36 IF (ATWT(L)-1.5)          38, 38, 37
   37 INLIBR(10)=INLIBR(10)+1
      INSUPR(M)= INSUPR (M)+1
      INELEM(L)= INELEM (L)+1
      NLIBC=NLIBC+1
   38 CONTINUE
   40 CONTINUE
   41 IF (NLIBC-NLIB)           42,180,42
   42 WRITE (6,44)NLIBC, NLIB
   44 FORMAT ( 11HOTHERE ARE , I5, 36H LIBRARIES REQUIRED IN THIS PROBLE
     1M./1H , I5, 38H LIBRARIES WERE SUPPLIED IN THE INPUT. )
      WRITE (6,46)
   46 FORMAT (89HOTHE FOLLOWING LIST OF LIBRARY PARAMETER WILL HELP DETE
     1RMINE WHICH LIBRARIES ARE MISSING. )
      GO TO 581
  110 FORMAT (2I10,4I5, 22X A4, I2, I4)
  120 FORMAT (14HOLIBRARY DECK A4, I2, 13H IS IN ERROR.)
  130 IL = IL + 100
      WRITE (6,120)FLIB, IL
  140 CALL EXIT
  150 IL=IL + 100
      IS=IS + 10000
  160 FORMAT (35HODISCREPANCY IN I.D. FIELD OF CARD , A4, I2, I4)
      WRITE (6,160)FLIB, IL, IS
      GO TO 140
  170 IL = IL1
      IS = IS1
      GO TO 150
C
  180 L11REC = 0
      L4REC = 1 + NSG
      REWIND  9
      CALL SLITE (0)
  200 READ  (5      ,110)LIBT, I, J, K, N, N1, FLIB, IL,IS
      IF (IS-MS)                150, 210, 150
  210 IF (LIBT)                 130, 130, 220
  220 IF (LIBT-11)              230, 230, 130
  230 GO TO (240,280,360,360,301,310,360,360,360,460,360),LIBT
  240 NBD=I
      CALL LIB1
      INLIBR(LIBT)=INLIBR(LIBT)-1
  250 NLIB=NLIB-1
      CALL SLITET(1,K000FX)
       GO TO(150,260),K000FX
  260 CALL SLITET(2,K000FX)
       GO TO(170,270),K000FX
  270 IF (NLIB)                 565, 565, 200
```

```
  280 CALL LIB2
      INLIBR(LIBT)=INLIBR(LIBT)-1
      GO TO 250
  301 ISRCRC = J
      DO 306  L=1,J
      READ  (5      ,302)X1(L),Y1(L),Z1(L),A0(L),B0(L), C0(L),        IL1,
     1IS1
  302 FORMAT(6E10.4, 6X   I2,I4)
      IF (IL1-IL)              130, 303, 130
  303 IF (IS1-IS-MS)           170, 304, 170
  304  READ  (5      ,307)E0(L),AW(L),W1(L),NR1(L),EX1(L),IL,IS
      IF (IL1-IL)              130, 305, 130
  305 IF (IS-IS1-MS)           150, 306, 150
  306 CONTINUE
  307 FORMAT (3E10.4, I10, E10.4, 16X I2, I4)
      NLIB=NLIB-1


      INLIBR(LIBT)=INLIBR(LIBT)-1
      GO TO 270
C                          LIBRARY TYPE 6

  310 DO 350  L=1,I
      READ(5,321) ENERGY(L), TM(J,L), FTOD(L),IL1, IS1
  321 FORMAT ( 2E10.4, 20X  E10.4, 16X  I2,I4)
  320 FORMAT(2E10.4,46X I2,I4)
      IF (IL1-IL)              130, 330, 130
  330 IF (IS1-IS-MS)           170, 340, 170
  340 IS=IS1
  350 CONTINUE
      WRITE ( 9     )LIBT, I, J, K, N, N1
      L11REC = L11REC + 1
      WRITE ( 9     ) (ENERGY(L),TM(J,L),L=1,I)
  355 INLIBR(LIBT)=INLIBR(LIBT)-1
      INSUPR(K)=INSUPR(K)-1
      INELEM(J)=INELEM(J)-1
  357 L11REC = L11REC + 1
      NLIB=NLIB-1
      GO TO 270
C  LIBRARY TYPES 3, 4, 7, 8, 9 AND 11 ARE NOT USED IN THIS CODE
  360 WRITE (6,370)LIBT
  370 FORMAT (13HOLIBRARY TYPE,I3,22H WAS INPUT BY MISTAKE.)
      CALL EXIT
C                          LIBRARY TYPE 10
  460 CALL CREAD2 (J,N,ESCAT,8,25)
      CALL LBSEP (J,N,I,DES,8,25,15)
      WRITE ( 9  ) LIBT, I,J,K,N,N1
      L11REC = L11REC + 1
      WRITE ( 9  )  (ESCAT(J,NE),NE=1,N),((DES(J,KE,IN),KE=1,N),IN=1,I)
      GO TO 355
```

```
  565 DO 567  L=1,11
      IF(INLIBR(L))          575, 567, 575
  567 CONTINUE
      DO 569  L=1,NSG
      IF(INSUPR(L))          575, 569, 575
  569 CONTINUE
      DO 571  L=1,NEL
      IF(INELEM(L))          575, 571, 575
  571 CONTINUE
      GO TO 600

  575 WRITE (6,580)

  580 FORMAT (49H0THE TOTAL NUMBER OF INPUT LIBRARIES WAS CORRECT./
     1 65H HOWEVER, THE NUMBER OF ELEMENTS AND/OR SUPERGROUPS IS INCORRE
     2CT.)
  581 WRITE (6,582)
  582 FORMAT(40H1  L   INSUPR(L)   INLIBR(L)   INELEM(L))
  584 FORMAT(1H ,I3,I8,2I12)
      DO 586  L=1,8
  586 WRITE (6,584)L,INSUPR(L),INLIBR(L),INELEM(L)
      DO 588  L=9,11
  588 WRITE (6,584)L,INSUPR(L),INLIBR(L)
      DO 590  L=12,20
  590 WRITE (6,584)L,INSUPR(L)
      CALL EXIT
  600 REWIND  3
      IF (NTAP)              855, 602, 855
  602 DO 800 M=1,NSG
C                   WRITE ALL CROSS SECTIONS ON TAPE 9
      REWIND   9
      L=0
  610 L=L+2
  620 READ  ( 9    )LIBT, I, J, K, N, N1
      IF (M-K)               640, 630, 640
  630 LT = LIBT-5
      GO TO (660,360,360,360,700,360),  LT
  640 READ  ( 9    )
  650 IF (L-L11REC)          610, 720, 720
C                   LIBRARY TYPE 6
  660 READ  ( 9    )(ENERGY(L1),TM(J,L1),L1=1,I)
      NENEGY = I
      GO TO 650
C                   LIBRARY TYPE 10
  700 NCROS(J)=N
      READ  ( 9    )(ESCAT(J,NE),NE=1,N),((DES(J,KE,IN),KE=1,N),IN=1,I)
      GO TO 650
C                  CALCULATE MACROSCOPIC CROSS-SECTIONS
  720 DO 760    M1 = 1, NMAT
      DO 750  M2=1,NENEGY
```

```
      TCS(M1,M2)=0.0
      DO 740  M3=1,NEL
      TCS(M1,M2)=TCS(M1,M2) + TM (M3,M2)*DN(M1,M3)
  740 CONTINUE


  750 CONTINUE
  760 CONTINUE
  770 CALL CRSWRT
  800 CONTINUE

      REWIND  9
  810 FORMAT( 34H1CROSS SECTION TAPE LABELED CROSS I4,54H WAS GENERATED

     1AND CONTAINS THE FOLLOWING INFORMATION.)
      WRITE (6,810)IQID
  815 WRITE (6,820)L4REC,NREG,NEL,NMAT, NSG,NRG
  820 FORMAT(1H ,I5,33H = NUMBER OF RECORDS ON THIS TAPE/I6,20H = NUMBER
     1 OF REGIONS/I6,21H = NUMBER OF ELEMENTS/I6,22H = NUMBER OF MATERIA
     2LS/I6,24H = NUMBER OF SUPERGROUPS/I6,40H = NEUTRONS, GAMMAS, OR SE
     3CONDARY GAMMAS)

  850 REWIND  9
      GO TO 1000
  855 WRITE (6,870)IQID
  870 FORMAT(34H1CROSS SECTION TAPE LABELED CROSS I4,65H WAS USED IN THI
     1S PROBLEM AND CONTAINS THE FOLLOWING INFORMATION.)
      GO TO 815
 1000 RETURN
      END
```

```
      SUBROUTINE LIB1
C     SUBROUTINE LIB1 IN HISTORY GENERATION CODE                        0010
      COMMON /GEOM1/ IBT( 75), AF( 75), ZF( 75), CF( 75), XF( 75),
     1 YF( 75), IBN(50,9), MPR(50,9), NB(50), EPSL, NBD, NREG
     2 /CARDC/ IS, IS1, IL, IL1, FLIB, NPRINT(9), MS
C                                                                       0240
      I1 = NBD/2                                                        0250
      I2 = NBD-2*I1                                                     0260
      K1 = 0                                                            0270
      K2 = 0                                                            0280
      DO 50 I=1,I1                                                      0290
      K1 = K2+1                                                         0300
      K2 = K1+1                                                         0310
      READ (5,75) IBT(K1), AF(K1), ZF(K1),CF(K1), XF(K1), YF(K1), IL1,
     1IS1
      IF (IL-IL1)              100, 10, 100                             0330
   10 IF (IS1-IS-MS)           100, 20, 100                             0340
   20 READ (5,75) IBT(K2), AF(K2), ZF(K2),CF(K2), XF(K2), YF(K2), IL,IS
      IF (IL1-IL)              110, 30, 110                             0360
   30 IF (IS-IS1-MS)           110, 50, 110                             0370
   50 CONTINUE                                                          0380
      IF(I2)                   200, 200, 60                             0390
   60 K1 = K2+1                                                         0400
      READ (5,75) IBT(K1),AF(K1),ZF(K1),CF(K1),XF(K1),YF(K1),IL1,IS1
      IF (IL-IL1)              100, 70, 100                             0420
   70 IF (IS1-IS-MS)           100, 200, 100                            0430
   75 FORMAT (I10,5E10.4,6XI2,I4)
  100 CALL SLITE (1)                                                    0450
      GO TO 200                                                         0460
  110 CALL SLITE (2)                                                    0470
  200 RETURN                                                            0480
      END                                                               0490
```

```
      SUBROUTINE LIB2                                                   0020
C     SUBROUTINE LIB2 IN HISTORY GENERATION CODE                        0010
C                                                                       0030
      COMMON /GEOM1/ IBT( 75), AF( 75), ZF( 75), CF( 75), XF( 75),
     1 YF( 75), IBN(50,9), MPR(50,9), NB(50), EPSL, NBD, NREG
     3 /CARDC/ IS, IS1, IL, IL1, FLIB, NPRINT(9), MS
C                                                                       0210
      READ  (5      ,10)(IBN(1,J),MPR(1,J),J=1,6), IL1, IS1           0220
   10 FORMAT (12I5, 6X I2,I4)                                           0230
      IF (IL-IL1)           80, 20, 80                                0240
   20 IF (IS1-IS-MS)        80, 30, 80                                0250
   30 IF(NB(1)-6)           100, 100, 40                              0260
   40 READ  (5      ,45)(IBN(1,J),MPR(1,J),J=7,9), IL, IS             0270
   45 FORMAT (6I5, 36X I2,I4)                                           0280
      IF (IL-IL1)           70, 50, 70                                0290
   50 IF (IS-IS1-MS)        70,100, 70                                0300
   70 CALL SLITE (1)                                                   0310
   80 CALL SLITE (2)                                                   0320
      GO TO 200                                                        0330
  100 DO 160 I=3,NREG                                                  0340
      IF (IS1-IS)           110, 110, 105                             0350
  105 IS= IS1                                                          0360
  110 READ  (5      ,10)(IBN(I,J),MPR(I,J),J=1,6), IL1, IS1           0370
      IF (IL-IL1)            80, 120, 80                              0380
  120 IF (IS1-IS-MS)         80, 130, 80                              0390
  130 IF(NB(I)-6)           160, 160, 140                             0400
  140 READ  (5      ,45)(IBN(I,J),MPR(I,J),J=7,9), IL, IS             0410
      IF (IL-IL1)            70, 145, 70                              0420
  145 IF (IS-IS1-MS)         70, 160, 70                              0430
  160 CONTINUE                                                         0440
  200 RETURN                                                           0450
      END                                                              0460
```

```
C SUBROUTINE ANGRED IN ANALYSIS CODE A01.
      SUBROUTINE ANGRED (J, IS,IS1,NN,NN1,A)
      DIMENSION   A(21)
      N1 = 1
      READ  (5      ,10)(A(I),I=1,6), NN1, IS1
   10 FORMAT (6E10.0, 6X I2, I4)
      IF (IS1-IS-N1)          30, 20, 30
   20 IF (NN1-NN)             30, 40, 30
   30 CALL SLITE (1)
      GO TO 150
   40 IS = IS1
      IF (J-6)                150,150, 50
   50 READ  (5      ,10)(A(I),I=7,12), NN1,IS1
      IF (IS1-IS-N1)          30, 60, 30
   60 IF (NN1-NN)             30, 70, 30
   70 IS = IS1
      IF (J-12)               150, 150, 80
   80 READ  (5      ,10)(A(I),I=13,18),NN1,IS1
      IF(IS1-IS-N1)           30, 90 , 30
   90 IF(NN1-NN)              30, 100, 30
  100 IS= IS1
  110 READ  (5      ,120)(A(I), I=19,21), NN1, IS1
  120 FORMAT (3E10.0, 36X I2, I4)
      IF (IS1-IS-N1)          30, 130, 30
  130 IF (NN1-NN)             30, 140, 30
  140 IS=IS1
  150 RETURN
      END
```

```
C SUBROUTINE CRSWRT IN ANALYSIS CODE A01.
      SUBROUTINE CRSWRT
      COMMON /CROSS/ DUM(5109)
C
      WRITE (  3   )(DUM(N), N=    1, 5109)
      RETURN
      END
```

```
      SUBROUTINE BUTTER                                                 0002
C  ROUTINE BUTTER IN ANALYSIS CODE A01.                                 0003
      COMMON /SCTAP/ IDT, AD, BD, CD, D, X, Y, Z, W, NR, EI, DESL,      0004
     1 ICOL, ICOL1, JSENSE, KREC, KLMAX                                 0005
      COMMON /WEDWIT/ IDTA1(20), ADA1(20), BDA1(20), CDA1(20), DA1(20),  0006
     1 XA1(20), YA1(20), ZA1(20), WA1(20), NRA1(20), EIA1(20), DESA1(20) 0007
      COMMON /CROSS/ NENEGY, ENERGY(100), TCS(8,100), NCROS(8),         0008
     1 ESCAT(8,25), DES(8,25,20)                                        0009
      COMMON /JUNK/ A, A0(20), API2, AT, AT1(20), ATWT(8), B, B0(20),   0010
     1 C, C0(20), CLMDA, CPSI, CPSI2, CROS, CRSS, DELCT,       DISTM,    0011
     2 DSQD, E, E0(20), EGRP(20),      ESI(8), ESUM(20), EPRINT(21),   0012
     3 EX, EX1(20), ESP, FLUX(20,20,20), FLUXE(20,20), FSUM(8),         0013
     4 GPRINT(21), GRAD(21), H(2), HELP, IEE, IEINTV, IEMAX, IEPMAX,    0014
     5 IETAB(20), IGINTV, IGPMAX, IH1, IH2, IHTAPE, IHEAD, ILAST,       0015
     6 IPPMAX, IREGSC, J2NO, J1NO, JM, JTAPE, JTAPE1, JTAPE2, JA, JI,   0016
     7  K, K1, KESC2, KGRP(3,20), KS, KTAPE, L1, L2, L3, LBJ, LZ,       0017
     8 MATREG(50), MHTAPE(20), MIGHT(20), MNO, NB1, ND, NEL, NG, NHT,   0018
     9 NHIST, NOINT, NN, NR1(20), NR2, NREC, NRD(5), NLIB, NSG, PID     0019
      COMMON  PPRINT(5), PRAD(5), Q, IQID, S, SUMS, TM(8,100), W1(20),  0020
     1 X1(20), X2, XD1(5), XD, Y1(20), Y2, YD, YD1(5), Z1(20), Z2,       0021
     2 ZZZZ1, ZZZZ2, ZD, ZD1(5), DN(8,8), ISRCTP, ISRCRC, NMAT,         0022
     3 ETM, ILOC, BEG(20), BEGGER(20,20), MKREC(2), NTAP, AW(20),       0023
     4 EMAX(20), INLIBR(11), INSUPR(20), INELEM(8)                      0024
     5 /GEOM1/ IBT( 75), AF( 75), ZF( 75), CF( 75), XF( 75), YF( 75),   0025
     6 IBN(50,9), MPR(50,9), NB(50), EPSL, NBD, NREG                    0026
     2 /CARDC/ IS, IS1, IL, IL1, FLIB, NPRINT(9), MS                    0027
      COMMON /FLXDO/ FTD, FTOD(100), DOSE(5,20,20)
      COMMON/FLU/ANHIST
      ANHIST = NHIST
      DO  7   I = 1,5
      DO  7   J = 1,20
      DO  7   K = 1,20
    7 DOSE(I,J,K) = 0.0
      DO 8 I = 1, 20                                                    0028
      DO 8 J = 1, 20                                                    0029
      DO 8 K = 1, 20                                                    0030
    8 FLUX( I, J, K ) = 0.0                                             0031
      LPT1 = 1                                                          0032
      LPT2 = 11                                                         0033
      IRED=0                                                            0034
      REWIND  3                                                         0035
      IF (ISRCTP)              30, 30, 10                               0036
   10 CALL CRSRED                                                       0037
      M1 = 1                                                            0038
      DO 20   KLP=1, ISRCRC                                             0039
      IF  (E0(KLP) - EGRP(M1))      15, 15, 19                          0040
   15 M1 = M1 + 1                                                       0041
      CALL CRSRED                                                       0042
      IF (ICOL)                18, 18, 16                               0043
   16 WRITE (LPT1)(IDTA1(I),ADA1(I),BDA1(I),CDA1(I),DA1(I),XA1(I),  YA1(  0044
```

```
     1I), ZA1(I), WA1(I), NRA1(I),EIA1(I),DESA1(I), I=1, ICOL )
      KREC = KREC +1
      REWIND LPT1
   18 ICOL1=ICOL
      ICOL=0
      KLMAX=KREC
      KREC=0
      CALL WEED (M1,LPT1,LPT2)
      IF(IRED)          19,  19,  21
   19 CALL CHEEZE  (KLP,M1,LPT1)
   20 CONTINUE
   21 IF(M1-NSG)        22, 1000, 1000
   22 IRED=1
      GO TO  15
C        -----READ FIRST RECORD OF FIRST HISTORY TAPE.
   30 K1=0
      IX = 10
      REWIND IX
      READ  (IX)NREC, NHIST, NG, IHTAPE, ILAST
C        -----VERIFY TAPE PUT ON UNIT IX.
      DO 50  I=1, NHT
      IF (IHTAPE-MIGHT(I))   50, 40, 50
   40 K1=1
      MIGHT(I)=0
      II=I
      GO TO 60
   50 II=I
C        -----ERROR IF WRONG TAPE PUT ON TAPE UNIT.
   60 IF (K1)                 80, 80, 70
   70 IF (IHTAPE-MHTAPE(II)) 80, 100, 80
   80 WRITE (6,90)H(1), H(2), IHTAPE, H(1), H(2), MHTAPE(II)
   90 FORMAT (14H0TAPE LABELED , A6,A3,I4,36H WAS LOADED INSTEAD OF TAPE
     1 LABELED ,A6,A3,I4,19H.  PROBLEM STOPPED. )
      CALL EXIT
C        -----RESET BEG AND KGRP.
  100 DO 110   M1=1, 20
      BEG(M1) = BEGGER(II,M1)
      DO 110   M2=1, 3
  110 KGRP(M2,M1) = 0
C        -----DETERMINE NO.OF RECORDS(NH1) AND NO. OF L.REC.COL.(NHP).
      BSUM = 0.0
      NHP  = 0
      NH1  = 7999
      IF(II-NHT)              130, 120, 120
  120 NH1  = MKREC(1) - 1
  130 CALL RECORD (NSG, NH1, BEG(1), KGRP(1,1))
      IF(II-NHT)              160, 140, 140
  140 IF (MKREC(2)-20)        150, 160, 160
  150 NH1 = NH1 - 1
      NHP = MKREC(2)
```

```
C         -----PUT CORRECT SET OF CROSS-SECTIONS INTO CORE FROM TAPE.
  160 REWIND  3
      DO 180    M1 = 1, NSG
      IF (BEG(M1) -0.6)       170, 170, 190
  170 READ  ( 3    )
  180 CONTINUE
  190 CALL CRSRED
C         -----NH1 FULL RECORDS OF COLLISION DATA WILL BE CONSIDERED.
      IF (NH1)                310, 310, 200
  200 I20 = 20
      REWIND LPT1
  210 DO 300 IKE = 1, NH1
      READ  (IX)(X0L,Y0L,Z0L, A0(L), B0(L), C0(L), E0(L), W0L, X1(L), Y1
     1(L), Z1(L),                    W1(L), NR1(L), AW(L),EX1(L),      NR0
     2L, L = 1,I20)
      DO 300   KLP = 1, I20
      BSUM = BSUM + 1.0
      IF (W1(KLP)-0.0)  300, 300, 209
  209 ME1 = NR1(KLP)
      ME2 = NREG
      ME3 = 0
  211 DO  213  J = ME1,ME2
      IF (J - 2)      212, 213, 212
  212 CALL SEARCH (J,X1(KLP),Y1(KLP),Z1(KLP),NR1(KLP),MSRCH,KESC2)
      IF (MSRCH)       213, 213, 218
  213 CONTINUE
        IF  (ME3)         214, 214, 216
  214 ME1 = 1
      ME2 = NR1(KLP)
      ME3 = 1
      GO TO 211
  216 WRITE (6,217)X1(KLP),Y1(KLP),Z1(KLP)
  217 FORMAT (57H0CANNOT FIND INSIDE REGION FOR PARTICLE WITH COORDINATE
     1S , 1P3E12.4)
      GO TO 300
  218 NR1(KLP) = J
      IF (BSUM - BEG(M1))     290, 290, 215
  215 CALL CRSRED
      M1 = M1 + 1
      BSUM = 0.0
C         -----WRITE LAST RECORD OF LATENT PARTICLE TAPE 1.
      IF (ICOL)               250, 250, 230
  230 WRITE (LPT1)(IDTA1(I),ADA1(I),BDA1(I),CDA1(I),DA1(I),XA1(I),  YA1(
     1I), ZA1(I), WA1(I), NRA1(I),EIA1(I),DESA1(I), I=1, ICOL )
      KREC = KREC +1
      REWIND LPT1
  250 IF (KREC)   290, 290, 270
  270 ICOL1 = ICOL
      ICOL  = 0
      KLMAX = KREC
```

```
      KREC  = 0
      CALL WEED (M1,LPT1,LPT2)
      IF(IRED)            290,  290,  361
  290 CALL CHEEZE (KLP,M1,LPT1)
  300 CONTINUE
C        -----READ PARTIAL RECORD.
  310 IF( NHP )      330, 330, 320
  320 I20 = NHP
      NHP = 0
      NH1 = 1
      GO TO 210
  330 CALL SLITE ( 0 )
      DO 350 I = 1, NHT
      IF( MIGHT(I))      350, 350, 340
  340 CALL SLITE ( 1 )
      FI = MIGHT(I)
      MIGHT(I) = 0
      GO TO 360
  350 CONTINUE
  360 CALL SLITET(1,K000FX )
      GO TO (370, 1000),K000FX
  361 IF(M1-NSG )           362, 1000, 1000
  362 IRED = 1
      GO TO 215
  370 IX = 4
      REWIND IX
      READ( IX ) NREC, NHIST, NG, IHTAPE, ILAST
      GO TO 70
 1000 RETURN
      END
```

```
C SUBROUTINE RECORD IN CODES A01 AND A02, WHICH CALCULATIONS KGRG(I,J)
      SUBROUTINE RECORD (NSG, LATJ1, BEG, KGRG)
      DIMENSION  BEG(20), KGRG(3,20)
C
C  I=1 -- NUMBER OF COLLISIONS FOR SUPERGROUP J ON FIRST RECORD
C  I=2 -- NUMBER OF FULL RECORDS FOR SUPERGROUP J
C  I=3 -- NUMBER OF COLLISIONS FOR SUPERGROUP J ON LAST RECORD
C
      BJ = 0.0
      DO 100   J=1, NSG
      IF  (BEG(J)-.6)            100, 100, 10
   10 IF  (BJ - BEG(J))           30,  20, 20
   20 KGRG(1,J) = BEG(J)
      KGRG(2,J) = 0
      KGRG(3,J) = 0
      F1 = KGRG(1,J)
      BJ = BJ - F1
      GO TO  100
   30 KGRG(1,J) = BJ
      KGRG(2,J) = (BEG(J)-BJ)/20.0
      F1 = KGRG(2,J)
      KGRG(3,J) =  BEG(J) - BJ - 20.0*F1
      BJ = 20 - KGRG(3,J)
      IF (BJ - 20.0)             100,  40, 40
   40 BJ = 0.0
  100 CONTINUE
      KSUM = 0
      K1   = 0
      DO 200  J=1, NSG
      IF (BEG(J)-.6)          200, 200, 110
  110 KSUM = KSUM + KGRG(2,J)
      IF (KGRG(3,J))          200, 200, 120
  120 KSUM = KSUM + 1
  200 CONTINUE
      IF (LATJ1 - KSUM)       210, 300, 210
  210 JHTAPE = JHTAPE + 10000
      WRITE(6,220) JHTAPE
  220 FORMAT (85H0THERE IS AN INCONSISTENCY BETWEEN THE NUMBER OF RECORD
     1S ON TAPE TO BE LABELED SORTED,I4  /41H AND THE NUMBER OF ENTRIES
     2PER SUPERGROUP)
      CALL EXIT
  300 RETURN
      END
```

```
C SUBROUTINE A1A2     IN ANALYSIS CODE A01.
      SUBROUTINE A1A2 (KSUPG,KDTT)
      COMMON /SCTAP/ IDT, AD, BD, CD, D, X, Y, Z, W, NR, EI, DESL,
     1 ICOL, ICOL1, JSENSE, KREC, KLMAX
      COMMON /WEDWIT/ IDTA1(20), ADA1(20), BDA1(20), CDA1(20), DA1(20),
     1 XA1(20), YA1(20), ZA1(20), WA1(20), NRA1(20), EIA1(20), DESA1(20)
      COMMON /CROSS/ NENEGY, ENERGY(100), TCS(8,100), NCROS(8),
     1 ESCAT(8,25), DES(8,25,20)
      COMMON /JUNK/ A, A0(20), API2, AT, AT1(20), ATWT(8), B, B0(20),
     1 C, C0(20), CLMDA, CPSI, CPSI2, CROS, CRSS, DELCT,       DISTM,
     2 DSQD, E, E0(20), EGRP(20),      ESI(8), ESUM(20), EPRINT(21),
     3 EX, EX1(20), ESP, FLUX(20,20,20), FLUXE(20,20), FSUM(8),
     4 GPRINT(21), GRAD(21), H(2), HELP, IEE, IEINTV, IEMAX, IEPMAX,
     5 IETAB(20), IGINTV, IGPMAX, IH1, IH2, IHTAPE, IHEAD, ILAST,
     6 IPPMAX, IREGSC, J2NO, J1NO, JM, JTAPE, JTAPE1, JTAPE2, JA, JI,
     7  K, K1, KESC2, KGRP(3,20), KS, KTAPE, L1, L2, L3, LBJ, LZ,
     8 MATREG(50), MHTAPE(20), MIGHT(20), MNO, NB1, ND, NEL, NG, NHT,
     9 NHIST, NOINT, NN, NR1(20), NR2, NREC, NRD(5), NLIB, NSG, PID
      COMMON  PPRINT(5), PRAD(5), Q, IQID, S, SUMS, TM(8,100), W1(20),
     1 X1(20), X2, XD1(5), XD, Y1(20), Y2, YD, YD1(5), Z1(20), Z2,
     2 ZZZZ1, ZZZZ2, ZD, ZD1(5), DN(8,8), ISRCTP, ISRCRC, NMAT,
     3 ETM, ILOC, BEG(20), BEGGER(20,20), MKREC(2), NTAP, AW(20),
     4 EMAX(20), INLIBR(11), INSUPR(20), INELEM(8)
     5 /GEOM1/ IBT( 75), AF( 75), ZF( 75), CF( 75), XF( 75), YF( 75),
     6 IBN(50,9), MPR(50,9), NB(50), EPSL, NBD, NREG
     2 /CARDC/ IS, IS1, IL, IL1, FLIB, NPRINT(9), MS
C
      IDT=KDTT
      KS=KSUPG
      CALL SLITE (4)
      KESC2 = 0
  465 IF (NR-2)                510, 470, 510
  470 S=2.0*D
      GO TO 600
  510 DISTM=1.0E+6
      NB1=NB(NR)
      J1=0
      DO 550  I3=1,NB1
      J3=IABS(IBN(NR,I3) )
      CALL DIST(X,Y,Z,A,B,C,J3,S,P1,P2,P3)
      IF (JSENSE)            518, 518, 512
  512  WRITE (6,514)NB1, J3, I3, NR, S, DISTM
  514  FORMAT (5HONB1=,I2, 5H  J3=,I3,  5H  I3=,I2, 5H  NR=,I3,
     1 4H  S=,E11.4, 8H  DISTM=,E11.4)
  518 CALL SLITET(3,K000FX)
       GO TO(550,520),K000FX
  520 IF (S-DISTM)            530, 550, 550
  530 DISTM=S
      J1=I3
  550 CONTINUE
```

```
      S=DISTM
      IF (JSENSE)          580, 580, 560
  560 WRITE (6,570)IDT, NRD(IDT), NR, J1, S, SUMS, D
  570 FORMAT (5H0IDT=,I2, 10H NRD(IDT)=,I3, 4H NR=,I3, 4H J1=,I3/
     13H S=,E11.4, 6H SUMS=,E11.4, 3H D=,E11.4)
  580 IF  (J1)           585, 585, 590
  585 WRITE (6,588)
  588 FORMAT (62H0PROGRAM EXITS  FROM DO 550 WITH J1 LESS THAN OR EQUAL
     1TO ZERO)
      GO TO 625
  590 NB1= IABS(IBN(NR,J1))
      NR3=MPR(NR,J1)
  600 MNO = MATREG(NR)
      IF(NR-NRD(IDT))          640, 610, 640
  610 IF(S+SUMS-D)             615, 620, 620
  615 SUMS=SUMS+S
      GO TO 650
  620 S=D - SUMS
      SUMS=SUMS+S
      IF(ABS(D-SUMS)-.001)  630, 630, 625
  625 WRITE (6,626)
  626 FORMAT ( 55H0THE DISTANCE EQUATIONS IN ROUTINE  A1A2  ARE IN ERROR
     1.)
      WRITE (6,570)IDT, NRD(IDT), NR, J1, S, SUMS, D
      DSQD = 0.0
      GO TO 1900
  630 CALL INTERP(EI,MNO,CROS)
      ESP=ESP+S*CROS
      IF (JSENSE)          1900, 1900, 633
  633 WRITE (6,635)ESP, S, CROS, D
  635 FORMAT ( 5H0ESP=,E11.4, 3H S=,E11.4, 6H CROS=,E11.4, 3H D=,E11.4)
      GO TO 1900
  640 SUMS=SUMS+S
      IF(D-SUMS)               625, 625, 650
  650 CALL INTERP(EI,MNO,CROS)
      ESP=ESP+S*CROS
      X=X+A*S
      Y=Y+B*S
      Z=Z+C*S
      IF (JSENSE)          700, 700, 660
  660  WRITE (6,670)KESC2,NR3, NREG, NUB, NB1, X , Y , Z ,  NR, IBT(NB1)
     1, AF(NB1), ZF(NB1), CF(NB1), NB(NR), IBN(NR,J1)
  670  FORMAT (7H0KESC2=,I3, 6H  NR3=,I3, 7H  NREG=,I3, 6H  NUB=,I3,
     1 6H  NB1=,I4, 5H  X2=,E11.4, 5H  Y2=,E11.4, 5H  Z2=,E11.4/
     2 5H  NR=,I3, 11H  IBT(NB1)=,I2, 10H  AF(NB1)=,E11.4,
     3 10H  ZF(NB1)=,E11.4, 10H  CF(NB1)=,E11.4/  9H  NB(NR)=,I2,
     4 13H  IBN(NR,J1)=,I3)
  700 CALL DF7 (NR,X,Y,Z,NB1,NR3,KESC2)
      GO TO 465
 1900 RETURN
```

0102

END

```
C SUBROUTINE CHEEZE IN ANALYSIS CODE A01.
      SUBROUTINE CHEEZE(KZ,MZ,LAZY)
      COMMON /SCTAP/ IDT, AD, BD, CD, D, X, Y, Z, W, NR, EI, DESL,
     1 ICOL, ICOL1, JSENSE, KREC, KLMAX
      COMMON /WEDWIT/ IDTA1(20), ADA1(20), BDA1(20), CDA1(20), DA1(20),
     1 XA1(20), YA1(20), ZA1(20), WA1(20), NRA1(20), EIA1(20), DESA1(20)
      COMMON /CROSS/ NENEGY, ENERGY(100), TCS(8,100), NCROS(8),
     1 ESCAT(8,25), DES(8,25,20)
      COMMON /JUNK/ A, A0(20), API2, AT, AT1(20), ATWT(8), B, B0(20),
     1 C, C0(20), CLMDA, CPSI, CPSI2, CROS, CRSS, DELCT,       DISTM,
     2 DSQD, E, E0(20), EGRP(20),      ESI(8), ESUM(20), EPRINT(21),
     3 EX, EX1(20), ESP, FLUX(20,20,20), FLUXE(20,20), FSUM(8),
     4 GPRINT(21), GRAD(21), H(2), HELP, IEE, IEINTV, IEMAX, IEPMAX,
     5 IETAB(20), IGINTV, IGPMAX, IH1, IH2, IHTAPE, IHEAD, ILAST,
     6 IPPMAX, IREGSC, J2NO, J1NO, JM, JTAPE, JTAPE1, JTAPE2, JA, JI,
     7  K, K1, KESC2, KGRP(3,20), KS, KTAPE, L1, L2, L3, LBJ, LZ,
     8 MATREG(50), MHTAPE(20), MIGHT(20), MNO, NB1, ND, NEL, NG, NHT,
     9 NHIST, NOINT, NN, NR1(20), NR2, NREC, NRD(5), NLIB, NSG, PID
      COMMON  PPRINT(5), PRAD(5), Q, IQID, S, SUMS, TM(8,100), W1(20),
     1 X1(20), X2, XD1(5), XD, Y1(20), Y2, YD, YD1(5), Z1(20), Z2,
     2 ZZZZ1, ZZZZ2, ZD, ZD1(5), DN(8,8), ISRCTP, ISRCRC, NMAT,
     3 ETM, ILOC, BEG(20), BEGGER(20,20), MKREC(2), NTAP, AW(20),
     4 EMAX(20), INLIBR(11), INSUPR(20), INELEM(8)
     5 /GEOM1/ IBT( 75), AF( 75), ZF( 75), CF( 75), XF( 75), YF( 75),
     6 IBN(50,9), MPR(50,9), NB(50), EPSL, NBD, NREG
     2 /CARDC/ IS, IS1, IL, IL1, FLIB, NPRINT(9), MS
      LPT1 = LAZY
      K=KZ
      KS=MZ
      CALL SLITE (0)
  280 DO 600   IDT = 1, ND
      X  = X1 (K)
      Y  = Y1 (K)
      Z  = Z1 (K)
      A  = A0 (K)
      B  = B0 (K)
      C  = C0 (K)
      E  = E0 (K)
      AT=AW (K)
      W  = W1 (K)
      NR = NR1(K)
      EX = EX1(K)
      XD = XD1(IDT)
      YD = YD1(IDT)
      ZD = ZD1(IDT)
      IF  (JSENSE)            289,  289,  285
  285 WRITE (6,287)X, Y, Z, A, B, C
  287 FORMAT  (6E10.3)
      WRITE (6,287)XD, YD, ZD, E, AT, W
      WRITE (6,288)NR,  EX
```

```
288 FORMAT  ( I10, E10.3)
289 CALL DESCAL
    CALL SLITET(1,K000FX)
     GO TO(600,290),K000FX
290 CALL FCAL(KS,IDT,LPT1)
600 CONTINUE
700 RETURN
    END
```

```
C SUBROUTINE DESCAL    IN ANALYSIS CODE A01.
      SUBROUTINE DESCAL
      COMMON /SCTAP/ IDT, AD, BD, CD, D, X, Y, Z, W, NR, EI, DESL,
     1 ICOL, ICOL1, JSENSE, KREC, KLMAX
      COMMON /WEDWIT/ IDTA1(20), ADA1(20), BDA1(20), CDA1(20), DA1(20),
     1 XA1(20), YA1(20), ZA1(20), WA1(20), NRA1(20), EIA1(20), DESA1(20)
      COMMON /CROSS/ NENEGY, ENERGY(100), TCS(8,100), NCROS(8),
     1 ESCAT(8,25), DES(8,25,20)
      COMMON /JUNK/ A, A0(20), API2, AT, AT1(20), ATWT(8), B, B0(20),
     1 C, C0(20), CLMDA, CPSI, CPSI2, CROS, CRSS, DELCT,       DISTM,
     2 DSQD, E, E0(20), EGRP(20),      ESI(8), ESUM(20), EPRINT(21),
     3 EX, EX1(20), ESP, FLUX(20,20,20), FLUXE(20,20), FSUM(8),
     4 GPRINT(21), GRAD(21), H(2), HELP, IEE, IEINTV, IEMAX, IEPMAX,
     5 IETAB(20), IGINTV, IGPMAX, IH1, IH2, IHTAPE, IHEAD, ILAST,
     6 IPPMAX, IREGSC, J2NO, J1NO, JM, JTAPE, JTAPE1, JTAPE2, JA, JI,
     7  K, K1, KESC2, KGRP(3,20), KS, KTAPE, L1, L2, L3, LBJ, LZ,
     8 MATREG(50), MHTAPE(20), MIGHT(20), MNO, NB1, ND, NEL, NG, NHT,
     9 NHIST, NOINT, NN, NR1(20), NR2, NREC, NRD(5), NLIB, NSG, PID
      COMMON  PPRINT(5), PRAD(5), Q, IQID, S, SUMS, TM(8,100), W1(20),
     1 X1(20), X2, XD1(5), XD, Y1(20), Y2, YD, YD1(5), Z1(20), Z2,
     2 ZZZZ1, ZZZZ2, ZD, ZD1(5), DN(8,8), ISRCTP, ISRCRC, NMAT,
     3 ETM, ILOC, BEG(20), BEGGER(20,20), MKREC(2), NTAP, AW(20),
     4 EMAX(20), INLIBR(11), INSUPR(20), INELEM(8)
     5 /GEOM1/ IBT( 75), AF( 75), ZF( 75), CF( 75), XF( 75), YF( 75),
     6 IBN(50,9), MPR(50,9), NB(50), EPSL, NBD, NREG
     2 /CARDC/ IS, IS1, IL, IL1, FLIB, NPRINT(9), MS
      DSQD = (X-XD)**2 + (Y-YD)**2 + (Z-ZD)**2
      D = SQRT(DSQD)
      AD = (XD -X) / D
      BD = (YD -Y) / D
      CD = (ZD -Z) / D
      CPSI = A*AD + B*BD + C*CD
      IF (JSENSE)       110, 110, 105
  105 WRITE (6,106)CPSI
  106 FORMAT  (8H0CPSI = ,E10.5)
  110 IF (NG)                 130, 130, 120
  120 IF (EX)                 127, 127, 125
  125 EI = 0.511
      DESL = .159154942
      GO TO 350
  127 Q = E/0.511
       P = 1.0/(1.0+Q-Q*CPSI)
      EI = E*P
      Z5 = 2.0*Q
      Z2 = 1.0+Q
      Z3 = 1.0+Z5
      Z4= ALOG(Z3)
      CRSS=0.75*((Z2/Q**3)*( (Z5*Z2/Z3)-Z4) + Z4/Z5 - (1.0+3.0*Q)/Z3**2)
      DESL= (P+P**3-(P**2)*(SIN(ARCOS (CPSI))**2))*(.059683103/CRSS)
      GO TO 350
```

```
130 IF (AT-1.5)              140, 160, 160
140 IF (CPSI-.001)           345, 345, 150
150 CLMDA = 2.0 * CPSI * CPSI - 1.0
    EI = E * CPSI * CPSI
    DESL= .31830989 * CPSI
    GO TO  350
160 CPSI2 = CPSI**2
    IF (EX)                171, 171, 170
170 EC = (AT+1.0)*EX/AT
    IF (E-EC)              171, 171, 172
171 BET = 1.0
    SBET = 1.0
    GO TO  173
172 BET =  1.0 - EC/E
    SBET = SQRT(BET)
173 CLMDA = (CPSI2-1.0+CPSI*SQRT(CPSI2-1.0+BET*(AT)**2))/              (
   1AT*SBET)
    EI =((1.0+2.0*AT*SBET*CLMDA+BET*(AT)**2)/(AT+1.0)**2 ) * E
    IF (EX)                176, 176, 174
174 IF (BET-1.0)           175, 220, 220
175 AEC = AT/SQRT(E/(E-EC))
    GO TO  225
176 DO 180  IA=1,NEL
    IF (ABS(ATWT(IA)-AT)-0.5)   200, 200, 180
180 CONTINUE
    WRITE( 6,190 )
190 FORMAT (61H0THE ATOMIC WEIGHT AT IS NOT ONE SUPPLIED IN THE ATWT M
   1ATRIX.)
    CALL EXIT
200 JA = IA
    IF (E-ESI(JA))         220, 220, 230
220 AEC = AT
225 HELP = .079577471
    GO TO 340
230 IEMAX = NCROS(JA)
    DO 250  IE=1,IEMAX
    IF (ESCAT(JA,IE)-E)     240, 240, 250
240 IEE = IE
    GO TO 260
250 CONTINUE
260 DO 280  LA = 1,19
    IF (DES (JA,IE,LA)-CLMDA)  270, 270, 280
270 LBJ = LA
    GO TO 300
280 CONTINUE
290 DELCT = ABS(1.0+DES (JA,IE,19))
    GO TO 330
300 IF(LBJ-1)               310, 310, 320
310 DELCT = ABS(1.0-DES (JA,IE,1))
    GO TO 330
```

```
320 DELCT = ABS(DES (JA,IE,LBJ)-DES (JA,IE,LBJ-1))
330 HELP  = .007957747/DELCT
    AEC = AT
340 DESL = HELP * SQRT(AEC**2+2.0*AEC*CLMDA+1.0)**3 /                (
   1(AEC**2)*ABS(AEC+CLMDA))
    GO TO 350
345 CALL SLITE (1)
350 IF (JSENSE)              600, 600, 360
360 WRITE (6,370)X, XD, A, AD, Q, CPSI, CRSS, DSQD, Y,   YD, B, BD, D,
   1 EX, DESL, DELCT, Z, ZD, C, CD, E, EI, CLMDA, HELP
370 FORMAT (3H0X=,E10.3, 4H XD=,E10.3, 3H A=,E10.3, 4H AD=,E10.3,
   1 3H Q=, E10.3, 6H CPSI=,E10.3, 7H CRSS =,E10.3,7H DSQD =,E10.3/
   2 3H Y=, E10.3, 4H YD=, E10.3, 3H B=, E10.3, 4H BD=, E10.3,3H D=,
   3 E10.3, 6H EX  =, E10.3, 7H DESL =, E10.3, 7H DELCT=, E10.3 /
   4 3H Z=, E10.3, 4H ZD=, E10.3, 3H C=, E10.3, 4H CD=, E10.3, 3H E=,
   5 E10.3, 6H EI  =, E10.3, 7H CLMDA=, E10.3, 7H HELP =,E10.3 )
600 RETURN
    END
```

```
C     SUBROUTINE FCAL(KS,KDDT) IN ANALYSIS CODE A01.
      SUBROUTINE FCAL(KSS,KDDT,LAZY)
      COMMON /SCTAP/ IDT, AD, BD, CD, D, X, Y, Z, W, NR, EI, DESL,
     1 ICOL, ICOL1, JSENSE, KREC, KLMAX
      COMMON /WEDWIT/ IDTA1(20), ADA1(20), BDA1(20), CDA1(20), DA1(20),
     1 XA1(20), YA1(20), ZA1(20), WA1(20), NRA1(20), EIA1(20), DESA1(20)
      COMMON /CROSS/ NENEGY, ENERGY(100), TCS(8,100), NCROS(8),
     1 ESCAT(8,25), DES(8,25,20)
      COMMON /JUNK/ A, A0(20), API2, AT, AT1(20), ATWT(8), B, B0(20),
     1 C, C0(20), CLMDA, CPSI, CPSI2, CROS, CRSS, DELCT,       DISTM,
     2 DSQD, E, E0(20), EGRP(20),      ESI(8), ESUM(20), EPRINT(21),
     3 EX, EX1(20), ESP, FLUX(20,20,20), FLUXE(20,20), FSUM(8),
     4 GPRINT(21), GRAD(21), H(2), HELP, IEE, IEINTV, IEMAX, IEPMAX,
     5 IETAB(20), IGINTV, IGPMAX, IH1, IH2, IHTAPE, IHEAD, ILAST,
     6 IPPMAX, IREGSC, J2NO, J1NO, JM, JTAPE, JTAPE1, JTAPE2, JA, JI,
     7  K, K1, KESC2, KGRP(3,20), KS, KTAPE, L1, L2, L3, LBJ, LZ,
     8 MATREG(50), MHTAPE(20), MIGHT(20), MNO, NB1, ND, NEL, NG, NHT,
     9 NHIST, NOINT, NN, NR1(20), NR2, NREC, NRD(5), NLIB, NSG, PID
      COMMON  PPRINT(5), PRAD(5), Q, IQID, S, SUMS, TM(8,100), W1(20),
     1 X1(20), X2, XD1(5), XD, Y1(20), Y2, YD, YD1(5), Z1(20), Z2,
     2 ZZZZ1, ZZZZ2, ZD, ZD1(5), DN(8,8), ISRCTP, ISRCRC, NMAT,
     3 ETM, ILOC, BEG(20), BEGGER(20,20), MKREC(2), NTAP, AW(20),
     4 EMAX(20), INLIBR(11), INSUPR(20), INELEM(8)
     5 /GEOM1/ IBT( 75), AF( 75), ZF( 75), CF( 75), XF( 75), YF( 75),
     6 IBN(50,9), MPR(50,9), NB(50), EPSL, NBD, NREG
     2 /CARDC/ IS, IS1, IL, IL1, FLIB, NPRINT(9), MS
      COMMON /FLXDO/ FTD, FTOD(100), DOSE(5,20,20)
      COMMON/FLU/ANHIST
      LPT1=LAZY
      KS=KSS
      IDT=KDDT
      A = AD
      B = BD
      C = CD
  290 IF (EI-EGRP(KS))          292, 310, 310
  292 IF (JSENSE)               300, 300, 295
  295 WRITE (6,296)ICOL
  296 FORMAT (6H0ICOL=,I3)
  300 CALL WITE (LPT1)
      GO TO 600
  310 ESP = 0
      SUMS=0
      IF (JSENSE)          315, 315, 312
  312  WRITE (6,313)X, Y, Z, A, B, C,      KS, IDT, EI
  313  FORMAT (3H0X=,E11.4, 3H Y=,E11.4, 3H Z=,E11.4/
     1 3H A=,E11.4, 3H B=,E11.4,3H C=,E11.4/
     2 4H KS=,I2, 5H IDT=,I2, 4H EI=,E11.4)
  315 CALL A1A2(KS,IDT)
      IF (DSQD)       600, 600, 314
  314 F = W * DESL* EXP(-ESP )/ DSQD
```

```
      IF  (JSENSE)              319, 319, 316
  316 WRITE (6,317)W, DESL,  ESP, DSQD
  317 FORMAT (3HOW=,E11.4, 6H DESL=,E11.4, 6H ESP =,E11.4, 6H DSQD=,E11.
     14)
  319 SPHI = SQRT(1.0-CD**2)
      IF(SPHI-.0001) 323, 322, 322
  322 CPHI = AD /SPHI
      SPHI = BD /SPHI
      XSP = ABS(SPHI)
      IF(XSP-1.0) 321, 325, 325
  321 PHI = ARSIN(XSP)
      GO TO 324
  325 PHI= 1.5707963
      GO TO 324
  323 SPHI = 0.0
  324 IF (CPHI)                320, 360, 390
  320 IF (SPHI)                330, 340, 350
  330 P1=2.0
      GO TO 430
  340 P1=2.0
      PHI=0.0
      GO TO 430
  350 P1=1.0
      GO TO 430
  360 IF (SPHI)               370, 430, 380
  370 P1=3.0
      PHI = 0.0
      GO TO 430
  380 P1=1.0
      PHI = 0.0
      GO TO 430
  390 IF (SPHI)                400, 410, 420
  400 P1=3.0
      GO TO 430
  410 P1=0.0
      PHI=0.0
      GO TO 430
  420 P1=0.0
  430 PHI = PHI + P1*1.5707963
      IPHID = IPPMAX
      DO 431  J = 2,IPPMAX
      IF(PHI - PRAD(J))        432, 432, 431
  431 CONTINUE
  432 IPHID = J - 1
      IF (IPHID - IPPMAX)      438, 435, 435
  435 WRITE (6,436)IPHID
  436 FORMAT (55HOONE OF THE FLUX SUBSCRIPTS IS TOO LARGE.  SUBSCRIPT =
     1,I2)
      CALL EXIT
  438 IPHID = IPHID + 4 * (IDT - 1)
```

```
      GAM = ARCOS(CD)
      KE=IEPMAX
      DO 450   J=2,IEPMAX
      IF(EI-EPRINT(J))        440, 450, 450
  440 KE=J-1
      GO TO 460
  450 CONTINUE
  460 JGAM=IGPMAX
      DO 480  J=1,IGPMAX
      IF (GAM-GRAD  (J))      470, 480, 480
  480  CONTINUE
  470 JGAM=J-1
      IF(JGAM - IGPMAX)       485, 481, 481
  481 WRITE (6,436)JGAM
  485 IF(KE - IEPMAX)         490, 486, 486
  486 WRITE (6,436)KE
  490 FLUX(IPHID,JGAM,KE) = FLUX(IPHID,JGAM,KE) + F
      DUMF = (F *FTD ) / ANHIST
      DOSE(IDT,JGAM,KE) = DOSE(IDT,JGAM,KE) + DUMF
      F = 0.0
      IF (JSENSE)             600, 600, 530
  530 WRITE (6,540)F, IPHID, JGAM, KE, FLUX(IPHID,JGAM,KE)
  540 FORMAT (3H F=, E11.4, 7H IPHID=, I4,    6H JGAM=, I4, 4H KE=,I4,
     123H FLUX(IPHID, JGAM, KE)=, E13.6 )
      WRITE(6,550) FTD,IDT,DOSE(IDT,JGAM,KE)
  550 FORMAT ( 30H  FTD, IDT, DOSE(IDT,JGAM,KE)   / 5X   I5, 1P2E10.4)
  600 RETURN
      END
```

```
C SUBROUTINE WEED IN  ANALYSIS CODE A01.
      SUBROUTINE WEED (KM,LAZY,LOU)
      COMMON /SCTAP/ IDT, AD, BD, CD, D, X, Y, Z, W, NR, EI, DESL,
     1 ICOL, ICOL1, JSENSE, KREC, KLMAX
      COMMON /WEDWIT/ IDTA1(20), ADA1(20), BDA1(20), CDA1(20), DA1(20),
     1 XA1(20), YA1(20), ZA1(20), WA1(20), NRA1(20), EIA1(20), DESA1(20)
      LPT1 = LAZY
      LPT2 = LOU
      KK=KM
      REWIND LPT1
  100 IF (KLMAX-1)            500, 210, 105
  105 KTMAX = KLMAX-1
      I20=20
  110 DO 200  IL = 1, KTMAX
      READ  (LPT1)(IDTA1(M),ADA1(M),BDA1(M),CDA1(M),DA1(M),XA1(M),   YA1
     1(M),ZA1(M),WA1(M),NRA1(M),EIA1(M),DESA1(M), M = 1, I20)
      DO 200  K2 = 1, I20
      IF  (JSENSE)          125, 125, 115
  115 WRITE (6,120)K2, IDTA1( K2 ), ADA1( K2 ), BDA1( K2 ), CDA1( K2 ),
     1DA1( K2 ), XA1( K2 ), YA1( K2 ), ZA1( K2 ),          WA1( K2 ), NRA
     21( K2 ), EIA1( K2 ), DESA1( K2 )
  120 FORMAT (6H0  K2=,I3,16H    IDTA1(ICOL)=,I2,15H    ADA1(ICOL)=,E11.
     14,15H    BDA1(ICOL)=,E11.4,15H    CDA1(ICOL)=,E11.4/11H DA1(ICOL)=
     2,E11.4,14H    XA1(ICOL)=,E11.4,14H    YA1(ICOL)=,E11.4,14H    ZA1(
     3ICOL)=,E11.4/11H WA1(ICOL)=,E11.4,15H    NRA1(ICOL)=,I3,15H    EIA
     41(ICOL)=,E11.4,16H    DESA1(ICOL)=,E11.4)
  125 IDT = IDT A1(K2)
      AD  = AD  A1(K2)
      BD  = BD  A1(K2)
      CD  = CD  A1(K2)
      D   = D   A1(K2)
      X   = X   A1(K2)
      Y   = Y   A1(K2)
      Z   = Z   A1(K2)
      W   = W   A1(K2)
      NR  = NR  A1(K2)
      EI  = EI  A1(K2)
      DESL= DES A1(K2)
  127 CALL FCAL (KK,IDT,LPT2)
  200 CONTINUE
      IF (ICOL1)              400, 400, 210
  210 KTMAX = 1
  215 I20 = ICOL1
      ICOL1 = 0
      GO TO 110
  400 LAZY = LPT2
      LOU  = LPT1
  500 RETURN
      END
```

```
C SUBROUTINE WITE IN ANALYSIS CODE A01.
      SUBROUTINE WITE (LAZY)
      COMMON /SCTAP/ IDT, AD, BD, CD, D, X, Y, Z, W, NR, EI, DESL,
     1 ICOL, ICOL1, JSENSE, KREC, KLMAX
      COMMON /WEDWIT/ IDTA1(20), ADA1(20), BDA1(20), CDA1(20), DA1(20),
     1 XA1(20), YA1(20), ZA1(20), WA1(20), NRA1(20), EIA1(20), DESA1(20)
      LPT1 = LAZY
      ICOL = ICOL + 1
      IDT A1(ICOL) = IDT
      AD  A1(ICOL) = AD
      BD  A1(ICOL) = BD
      CD  A1(ICOL) = CD
      D   A1(ICOL) = D
      X   A1(ICOL) = X
      Y   A1(ICOL) = Y
      Z   A1(ICOL) = Z
      W   A1(ICOL) = W
      NR  A1(ICOL) = NR
      EI  A1(ICOL) = EI
      DES A1(ICOL) = DESL
      IF (JSENSE)            15,  15,  5
    5 WRITE (6,10)ICOL, IDTA1(ICOL), ADA1(ICOL), BDA1(ICOL), CDA1(ICOL),
     1 DA1(ICOL), XA1(ICOL), YA1(ICOL), ZA1(ICOL),         WA1(ICOL), NR
     2A1(ICOL), EIA1(ICOL), DESA1(ICOL)
   10 FORMAT (6H0ICOL=,I3,16H    IDTA1(ICOL)=,I2,15H    ADA1(ICOL)=,E11.
     14,15H    BDA1(ICOL)=,E11.4,15H    CDA1(ICOL)=,E11.4/11H DA1(ICOL)=
     2,E11.4,14H    XA1(ICOL)=,E11.4,14H    YA1(ICOL)=,E11.4,14H    ZA1(
     3ICOL)=,E11.4/11H WA1(ICOL)=,E11.4,15H    NRA1(ICOL)=,I3,15H    EIA
     41(ICOL)=,E11.4,16H    DESA1(ICOL)=,E11.4)
   15 IF (ICOL-20)           80 , 20, 20
   20 KREC = KREC +1
      WRITE (LPT1)(IDTA1(I),ADA1(I),BDA1(I),CDA1(I),DA1(I),XA1(I),  YA1(
     1I),ZA1(I),WA1(I),NRA1(I),EIA1(I),DESA1(I), I=1,20 )
      ICOL = 0
   80 RETURN
      END
```

```
C SUBROUTINE CRSRED IN ANALYSIS CODE A01.
      SUBROUTINE CRSRED
      COMMON /CROSS/ DUM(5109)
      READ (  3  ) (DUM(N),N= 1,5109)
      RETURN
      END
```

```
 SUBROUTINE INTERP (E,MNO,CROS)
 COMMON /CROSS/ NENEGY, ENERGY(100), TCS(8,100), NCROS(8),
1 ESCAT(8,25), DES(8,25,20)
 COMMON /FLXDO/ FTD, FTOD(100), DOSE(5,20,20)
 CALL FINDER (NENEGY,E,JAZ,ENERGY)
 CROS = TCS(MNO,JAZ) + (TCS(MNO,JAZ+1)-TCS(MNO,JAZ))*((E-ENERGY(JAZ
1))/(ENERGY(JAZ+1)-ENERGY(JAZ)))
 FTD= FTOD(JAZ) + (FTOD(JAZ+1) - FTOD(JAZ)) * ((E-ENERGY(JAZ))
1  /(ENERGY(JAZ+1) - ENERGY(JAZ)))
 RETURN
 END
```

```
      SUBROUTINE DIST (X,Y,Z,A,B,C,I,S,P1,P2,P3)
      COMMON /GEOM1/ IBT( 75), AF( 75), ZF( 75), CF( 75), XF( 75),
     1 YF( 75), IBN(50,9), MPR(50,9), NB(50), EPSL, NBD, NREG
      I1 = I
      I2 = IBT(I1)
      GO TO (10,20,30,40,50,60,70,80,90) , I2
   10 P1 = A**2 + B**2 - AF(I1)*C**2
      P2 = A*(X-XF(I1)) + B*(Y-YF(I1)) - C*AF(I1)*(Z-ZF(I1))
      P3 = (X-XF(I1))**2 + (Y-YF(I1))**2 -AF(I1)*(Z-ZF(I1))**2 - CF(I1)
      GO TO 100
   20 P1 = A**2 + B**2
      P2 = A*(X-XF(I1)) + B*(Y-YF(I1)) - 0.5*AF(I1)*C
      P3 = (X-XF(I1))**2 + (Y-YF(I1))**2 - AF(I1)*(Z-ZF(I1))
      GO TO 100
   30 P1 = A**2 + B**2 -(AF(I1)*C)**2
      P2 = A*(X-XF(I1)) + B*(Y-YF(I1)) - (AF(I1)**2)*C*(Z-ZF(I1))
      P3 = (X-XF(I1))**2 + (Y-YF(I1))**2 - (AF(I1)*(Z-ZF(I1)))**2
      GO TO 100
   40 P1 = A**2 + B**2
      P2 = A*(X-XF(I1)) + B*(Y-YF(I1))
      P3 = (X-XF(I1))**2 + (Y-YF(I1))**2 - AF(I1)**2
      GO TO 100
   50 P1 = SIN(AF(I1))
      P2 = COS(AF(I1))
      P3 = -A*P1 + B*P2
      IF (P3)            55, 200, 55
   55 S = ((X-XF(I1))*P1 - (Y-YF(I1))*P2)/P3 + EPSL
      GO TO 150
   60 IF (C)             65, 200, 65
   65 S = ((AF(I1)-Z)/C) + EPSL
      GO TO 150
   70 IF (A)             75, 200, 75
   75 S = ((AF(I1)-X)/A) + EPSL
      GO TO 150
   80 IF (B)             85, 200, 85
   85 S = ((AF(I1)-Y)/B) + EPSL
      GO TO 150
   90 P1 = A*AF(I1) + B*ZF(I1) + C*CF(I1)
      IF (P1)            95, 200, 95
   95 S = (XF(I1) - X*AF(I1) - Y*ZF(I1) - Z*CF(I1))/P1 + EPSL
      GO TO 150
  100 IF(ABS(P1)-1.0E-7)     105, 105, 110
  105 IF(ABS(P2)-1.0E-7)     200, 200, 106
  106 S = -0.5 * P3/P2 + EPSL
      GO TO 150
  110 P2 = P2/P1
      P3 = P3/P1
      IF (P2)                120, 120, 112
  112 IF (P3)                130, 130, 200
  120 P4 =P2**2 - P3
```

```
    IF  (P4+1.0E-5)        200, 200, 125
125 IF (P3)                130, 140, 140
130 S = -P2 + SQRT(P2**2-P3) + EPSL
    GO TO 150
140 S = -P2 - SQRT(P2**2-P3) + EPSL
150 IF (S - EPSL)          200, 200, 300
200 CALL SLITE (3)
250 S = 2.0 * EPSL
300 RETURN
    END
```

```
      SUBROUTINE SEARCH (KA,X1,Y1,Z1,NR1,MSRCH,KESC2)
      COMMON /GEOM1/ IBT( 75), AF( 75), ZF( 75), CF( 75), XF( 75),
     1 YF( 75), IBN(50,9), MPR(50,9), NB(50), EPSL, NBD, NREG
      MSRCH = 0
      K = KA
      JZ = NB(K)
      DO 200 I=1,JZ
      JZ1 = IABS(IBN(K,I))
      JZ2 = IBT(JZ1)
      IF (JZ2)                    6, 6, 5
    5 IF (JZ2-9)                  8, 8, 6
    6 WRITE (6,7)  JZ2, JZ1, K, JZ, NR1
    7 FORMAT (18H THE VALUE OF IBT=,I5,20H FOR BOUNDARY NUMBER,I5,1H,/
     128H OR NB(NR2) MAY BE IN ERROR./ 4H NB(,I2,2H)=,I3,5H,NR1=,I2)
      CALL EXIT
    8 GO TO    (10,20,30,40,50,60,70,80,90), JZ2
   10 XR =(X1-XF(JZ1))**2 + (Y1-YF(JZ1))**2 - AF(JZ1)*(Z1-ZF(JZ1))**2
     1 -CF(JZ1)
      GO TO 100
   20 XR =(X1-XF(JZ1))**2 + (Y1-YF(JZ1))**2 - AF(JZ1)*(Z1-ZF(JZ1))**2
      GO TO 100
   30 XR =(X1-XF(JZ1))**2 + (Y1-YF(JZ1))**2 -  (AF(JZ1)*(Z1-ZF(JZ1)))
     1**2
      GO TO 100
   40 XR =(X1-XF(JZ1))**2 + (Y1-YF(JZ1))**2 - AF(JZ1)**2
      GO TO 100
   50 XR =(-X1+XF(JZ1))*SIN(AF(JZ1)) + (Y1-YF(JZ1))*COS(AF(JZ1))
      GO TO 100
   60 XR =Z1-AF(JZ1)
      GO TO 100
   70 XR =X1-AF(JZ1)
      GO TO 100
   80 XR =Y1-AF(JZ1)
      GO TO 100
   90 XR =X1*AF(JZ1) + Y1*ZF(JZ1) + Z1*CF(JZ1) - XF(JZ1)
      GO TO 100
  100 IF (IBN(K,I))             110, 130, 130
  110 IF (XR)                   200, 200, 250
  130 IF (XR)                   250, 200, 200
  200 CONTINUE
      MSRCH = 1
      KESC2 = NR1
      NR1 = K
  250 RETURN
      END
```

```
C SUBROUTINE DF7 FOR CODES H01, A01, AND A02.                          SUB0010
      SUBROUTINE DF7 (NR1,X1,Y1,Z1,NB1,NR2,KESC2)
      COMMON /GEOM1/ IBT( 75), AF( 75), ZF( 75), CF( 75), XF( 75),
     1 YF( 75), IBN(50,9), MPR(50,9), NB(50), EPSL, NBD, NREG
  525 FORMAT (49H0CANNOT FIND REGION FOR PARTICLE WITH COORDINATES,      SUB0220
     1 1P3E12.4 )                                                        SUB0230
  600 IF (NR2-2)                    605, 602, 605                        SUB0240
  602 KESC2 = NR1                                                        SUB0250
      NR1 = 2                                                            SUB0260
      GO TO 700                                                          SUB0270
  605 JEZ = NREG                                                         SUB0280
      JAZ = NR2                                                          SUB0290
      NCY = 0                                                            SUB0300
  610 DO 650  I=JAZ,JEZ                                                  SUB0310
      IF (I - 2)   620, 650, 620                                         SUB0320
  620 CALL SEARCH (I,X1,Y1,Z1,NR1,MSRCH,KESC2)                           SUB0330
      IF(MSRCH)650,650,700                                               SUB0350
  650 CONTINUE                                                           SUB0360
      IF (NCY - 1)            655, 665, 670                              SUB0370
  655 JEZ = 1                                                            SUB0380
      JAZ = 1                                                            SUB0390
      NCY = 1                                                            SUB0400
      GO TO 610                                                          SUB0410
  665 JAZ = 3                                                            SUB0420
      JEZ = NR2                                                          SUB0430
      NCY = 2                                                            SUB0440
      GO TO 610                                                          SUB0450
  670 WRITE (6,525)X1, Y1, Z1                                            SUB0460
      GO TO 602                                                          SUB0470
  700 RETURN                                                             SUB0480
      END                                                                SUB0490
```

```
      SUBROUTINE FINDER (NENEGY,E,JAZ,ENERGY)
      DIMENSION  ENERGY(100)
      FNEGY = NENEGY
      JUMP =  FNEGY/2.0 + 0.5
      LOE = JUMP
      DO 30 I=1,6
      FJUMP = JUMP
      JUMP =FJUMP/2.0 + 0.5
      IF (E - ENERGY(LOE))        10, 50, 20
   10 LOE = LOE + JUMP
      GO TO 30
   20 LOE = LOE - JUMP
   30 CONTINUE
      IF (E - ENERGY(LOE))        40, 50, 50
   40 JAZ = LOE
      GO TO 60
   50 JAZ = LOE - 1
   60 RETURN
      END
```

```
      SUBROUTINE FPRINT                                                 0002
C SUBROUTINE FPRINT IN ANALYSIS CODE A01                                0003
C     SUBROUTINE FPRINT                                                 0004
      DIMENSION DSUME(20,21),  DSUMA(20)
      DIMENSION GSUM(20)                                                0005
      COMMON /SCTAP/ IDT, AD, BD, CD, D, X, Y, Z, W, NR, EI, DESL,      0006
     1 ICOL, ICOL1, JSENSE, KREC, KLMAX                                 0007
      COMMON /WEDWIT/ IDTA1(20), ADA1(20), BDA1(20), CDA1(20), DA1(20), 0008
     1 XA1(20), YA1(20), ZA1(20), WA1(20), NRA1(20), EIA1(20), DESA1(20) 0009
      COMMON /CROSS/ NENEGY, ENERGY(100), TCS(8,100), NCROS(8),         0010
     1 ESCAT(8,25), DES(8,25,20)                                        0011
      COMMON /JUNK/ A, A0(20), API2, AT, AT1(20), ATWT(8), B, B0(20),   0012
     1 C, C0(20), CLMDA, CPSI, CPSI2, CROS, CRSS, DELCT,       DISTM,   0013
     2 DSQD, E, E0(20), EGRP(20),      ESI(8), ESUM(20), EPRINT(21),   0014
     3 EX, EX1(20), ESP, FLUX(20,20,20), FLUXE(20,20), FSUM(8),         0015
     4 GPRINT(21), GRAD(21), H(2), HELP, IEE, IEINTV, IEMAX, IEPMAX,    0016
     5 IETAB(20), IGINTV, IGPMAX, IH1, IH2, IHTAPE, IHEAD, ILAST,       0017
     6 IPPMAX, IREGSC, J2NO, J1NO, JM, JTAPE, JTAPE1, JTAPE2, JA, JI,   0018
     7  K, K1, KESC2, KGRP(3,20), KS, KTAPE, L1, L2, L3, LBJ, LZ,       0019
     8 MATREG(50), MHTAPE(20), MIGHT(20), MNO, NB1, ND, NEL, NG, NHT,   0020
     9 NHIST, NOINT, NN, NR1(20), NR2, NREC, NRD(5), NLIB, NSG, PID     0021
      COMMON  PPRINT(5), PRAD(5), Q, IQID, S, SUMS, TM(8,100), W1(20),  0022
     1 X1(20), X2, XD1(5), XD, Y1(20), Y2, YD, YD1(5), Z1(20), Z2,      0023
     2 ZZZZ1, ZZZZ2, ZD, ZD1(5), DN(8,8), ISRCTP, ISRCRC, NMAT,         0024
     3 ETM, ILOC, BEG(20), BEGGER(20,20), MKREC(2), NTAP, AW(20),       0025
     4 EMAX(20), INLIBR(11), INSUPR(20), INELEM(8)                      0026
     5 /GEOM1/ IBT( 75), AF( 75), ZF( 75), CF( 75), XF( 75), YF( 75),   0027
     6 IBN(50,9), MPR(50,9), NB(50), EPSL, NBD, NREG                    0028
     2 /CARDC/ IS, IS1, IL, IL1, FLIB, NPRINT(9), MS                    0029
      COMMON /FLXDO/ FTD, FTOD(100), DOSE(5,20,20)
      I=I                                                               0030
   40 FORMAT (16HOPROBLEM NUMBER ,A4,I2/23H HISTORY TAPES LABELED ,A6,A3 0031
     1,I4,9H THROUGH ,A6,A3,I4/)                                        0032
      WRITE (6,40)PID,NN,H(1),H(2),IH1,H(1),H(2),IH2                    0033
C                                                                       0034
C                                                                       0035
  100 FORMAT (1H1,17X,17HPARTICLE ENERGY =,E10.3,3H TO,E10.3,4H MEV )   0036
  110 FORMAT (1H1,  14X,17HPARTICLE ENERGY =,E10.3,3H TO,E10.3,4H MEV ) 0037
  111 FORMAT (1H1,2(14X,17HPARTICLE ENERGY =,E10.3,3H TO,E10.3,4H MEV )) 0038
  120 FORMAT (1H0,10X,  12HPARTICLE E.=,E10.3,3H TO,E10.3,4H MEV,9X)    0039
  121 FORMAT (1H0,10X,2(12HPARTICLE E.=,E10.3,3H TO,E10.3,4H MEV,9X))   0040
  130 FORMAT (1H0,15X,17HAZIMUTHAL ANGLE =,F6.1,3H TO,F6.1,8H DEGREES)  0041
  200 FORMAT (6H POLAR/6H ANGLE,18X,25HAZIMUTHAL ANGLE (DEGREES) /      0042
     16H (DEG),5X,4(F7.1,1H-,F5.1),6X,3HSUM )                           0043
  210 FORMAT (6H POLAR/6H ANGLE,  12X,25HAZIMUTHAL ANGLE (DEGREES)     / 0044
     16H (DEG),6X,3(F6.1,1H-,F5.1),6X,3HSUM )                           0045
  211 FORMAT (6H POLAR/6H ANGLE,12X,25HAZIMUTHAL ANGLE (DEGREES),32X,25H 0046
     1AZIMUTHAL ANGLE (DEGREES) /6H (DEG),6X,3(F6.1,1H-,F5.1),6X,3HSUM, 0047
     213X,3(F6.1,1H-,F5.1),6X,3HSUM )                                   0048
  220 FORMAT (6H POLAR/6H ANGLE,8X,21HAZIMUTHAL ANGLE (DEG)/6H (DEG),6X, 0049
```

```
   12(F6.1,1H-,F5.1),6X,3HSUM )
221 FORMAT (6H POLAR/6H ANGLE,2(8X,21HAZIMUTHAL ANGLE (DEG),19X)/6H (D
   1EG),2(6X,2(F6.1,1H-,F5.1),6X,3HSUM,10X))
230 FORMAT(6H POLAR,4X,21HPARTICLE ENERGY (MEV))
301 FORMAT(7H ANGLE , (E12.3))
311 FORMAT(7H (DEG) , (E12.3))
320 FORMAT(1H+12X3HSUM)
321 FORMAT(1H+ 26X3HSUM)
322 FORMAT(1H+ 38X3HSUM)
323 FORMAT(1H+ 50X3HSUM)
324 FORMAT(1H+ 62X3HSUM)
325 FORMAT(1H+ 74X3HSUM)
326 FORMAT(1H+ 86X3HSUM)
327 FORMAT(1H+ 98X3HSUM)
328 FORMAT(1H+110X3HSUM)
400 FORMAT(1H0,F5.1,5X,4E13.5,E14.5)
410 FORMAT(1H0,F5.1,6X,3E12.5,E14.5)
411 FORMAT(1H0,F5.1,6X,3E12.5,E14.5,8X,3E12.5,E14.5)
420 FORMAT(1H0,F5.1, (6X,2E12.5,E14.5,5X) )
430 FORMAT(1H0,F5.1,E14.5,8E12.5)
431 FORMAT(1H0,F5.1,E14.5)
432 FORMAT(1H0,F5.1,2E14.5)
433 FORMAT(1H0,F5.1,E14.5, E12.5,E14.5)
434 FORMAT(1H0,F5.1,E14.5,2E12.5,E14.5)
435 FORMAT(1H0,F5.1,E14.5,3E12.5,E14.5)
436 FORMAT(1H0,F5.1,E14.5,4E12.5,E14.5)
437 FORMAT(1H0,F5.1,E14.5,5E12.5,E14.5)
438 FORMAT(1H0,F5.1,E14.5,6E12.5,E14.5)
439 FORMAT(1H0,F5.1,E14.5,7E12.5,E14.5)
440 FORMAT(1H0 /4H SUM,7X,4E13.5,E14.5)
441 FORMAT(1H0 /4H SUM,7X,3E12.5,E14.5,8X,3E12.5,E14.5)
442 FORMAT(1H0 /6H SUM  ,(6X,2E12.5,E14.5,5X))
443 FORMAT(1H0 /6H SUM  , 6X,E14.5, 8E12.5)
451 FORMAT(1H0/6H SUM  , E14.5 )
452 FORMAT(1H0/6H SUM  , 2E14.5)
453 FORMAT(1H0/6H SUM  , E14.5, E12.5, E14.5)
454 FORMAT(1H0/6H SUM  , E14.5,2E12.5, E14.5)
455 FORMAT(1H0/6H SUM  , E14.5,3E12.5, E14.5)
456 FORMAT(1H0/6H SUM  , E14.5,4E12.5, E14.5)
457 FORMAT(1H0/6H SUM  , E14.5,5E12.5, E14.5)
458 FORMAT(1H0/6H SUM  , E14.5,6E12.5, E14.5)
459 FORMAT(1H0/6H SUM  , E14.5,7E12.5, E14.5)
    IPINTV = IPPMAX-1
    IGINTV = IGPMAX - 1
    IEINTV = IEPMAX - 1
    MG = IEINTV/2
    IEXTRA = IEINTV-2*MG
    ME = (IEINTV/9) + 1
    IHEAD = 1
    GO TO (1100,900,700,500), IPINTV
```

```
C FOUR AZIMUTHAL INTERVALS
  500 DO 600  IDT= 1, ND
      WRITE (6,501)IDT, XD1(IDT), YD1(IDT), ZD1(IDT)
  501 FORMAT (16H1DETECTOR NUMBER, I4/20H COORDINATES     X = ,E10.3,7H,
     1 Y = ,E10.3,7H,  Z = ,E10.3    )
      DO 540  KE = 1, IEINTV
      WRITE (6,100)EPRINT(KE), EPRINT(KE+1)
      WRITE (6,200)(PPRINT(K),  PPRINT(K+1) , K=1,4)
      DO 505  K=1,5
  505 FSUM(K) = 0.0
      DO 520  JGAM = 1, IGINTV
      SUM = 0.0
      DO 510  IPHI = 1,4
      IPHID = IPHI + 4*(IDT-1)
      SUM = SUM + FLUX(IPHID,JGAM,KE)
  510 FSUM(IPHI) = FSUM(IPHI) + FLUX(IPHID,JGAM,KE)
      FSUM(5) = FSUM(5) + SUM
      K2 = IPHID
      K1 = K2-3
      WRITE (6,400)GPRINT(JGAM+1),(FLUX(K3,JGAM,KE),K3=K1,K2), SUM
  520 CONTINUE
      WRITE (6,440)(FSUM(K3), K3=1,5)
  540 CONTINUE
      DO 550  IPHI=1,4
      DO 550  JGAM=1,IGINTV
  550 FLUXE(IPHI,JGAM) = 0.0
      DO 560  IPHI=1,4
      IPHID=IPHI+4*(IDT-1)
      DO 560  JGAM=1,IGINTV
      DO 560    KE=1,IEINTV
  560 FLUXE(IPHI ,JGAM) = FLUXE(IPHI,JGAM) + FLUX(IPHID,JGAM,KE)
      WRITE (6,100)EPRINT(1), EPRINT(IEPMAX)
      WRITE (6,200)(PPRINT(K), PPRINT(K+1), K=1,4)
      DO 570  K=1,5
  570 FSUM(K) = 0.0
      DO 590  JGAM=1, IGINTV
      SUM = 0.0
      DO 580  IPHI = 1,4
      SUM = SUM + FLUXE(IPHI,JGAM)
  580 FSUM(IPHI) = FSUM(IPHI) + FLUXE(IPHI,JGAM)
      FSUM(5) = FSUM(5) + SUM
      WRITE (6,400)GPRINT(JGAM+1),(FLUXE(IPHI,JGAM),IPHI=1,4), SUM
  590 CONTINUE
      WRITE (6,440)(FSUM(K3), K3=1,5)
  600 CONTINUE
      GO TO 1200
  700 DO 890  IDT = 1, ND
      WRITE (6,501)IDT, XD1(IDT), YD1(IDT), ZD1(IDT)
      IF (IEXTRA)              705, 705, 800
  705 IF (IEINTV-1)            800, 800, 710
```

```
  710 DO 730   KE=1,MG
C AN EVEN NUMBER OF ENERGY INTERVALS
      WRITE (6,111)EPRINT(2*KE-1),EPRINT(2*KE),EPRINT(2*KE), EPRINT(2*KE
     1+1)
      WRITE (6,211)((PPRINT(J),PPRINT(J+1),J=1,3),K3=1,2)
      DO 715  J=1,8
  715 FSUM(J)=0.0
      DO 725  JGAM=1,IGINTV
      SUM1=0.0
      SUM2=0.0
      DO 720  IPHI=1,3
      IPHID = IPHI + 4*(IDT-1)
      SUM1=SUM1+FLUX(IPHID,JGAM,2*KE-1)
      SUM2=SUM2+FLUX(IPHID,JGAM,2*KE)
      FSUM(IPHI)=FSUM(IPHI)+FLUX(IPHID,JGAM,2*KE-1)
  720 FSUM(IPHI+4)=FSUM(IPHI+4)+FLUX(IPHID,JGAM,2*KE)
      FSUM(8)=FSUM(8)+SUM2
      FSUM(4)=FSUM(4)+SUM1+SUM2
      K2 = IPHID
      K1 = K2-2
      WRITE (6,411)GPRINT(JGAM+1),(FLUX(K3,JGAM,2*KE-1),K3  =K1,K2),SUM1
     1                ,(FLUX(K3,JGAM,2*KE),K3=K1,K2),SUM2
  725 CONTINUE
      WRITE (6,441)(FSUM(K3), K3=1,8)
  730 CONTINUE
      IF (IEXTRA)             827, 827, 800
C PRINTING OF 1 SET OF 3 PHI ANGLES PER PAGE
  800 KE1=IEINTV
      WRITE (6,110)EPRINT(KE1)     ,EPRINT(KE1+1)
      WRITE (6,210)(PPRINT(J),PPRINT(J+1),J=1,3)
      DO 815  J=1,4
  815 FSUM(J)=0.0
      DO 825  JGAM=1,IGINTV
      SUM=0.0
      DO 820  IPHI=1,3
      IPHID=IPHI + 4*(IDT-1)
      SUM=SUM+FLUX(IPHID,JGAM,KE1)
  820 FSUM(IPHI)=FSUM(IPHI)+FLUX(IPHID,JGAM,KE1)
      FSUM(4)=FSUM(4)+SUM
      K2=IPHID
      K1=K2-2
      WRITE (6,410)GPRINT(JGAM+1), (FLUX(K3,JGAM,KE1),      K3=K1,K2), S
     1UM
  825 CONTINUE
      WRITE (6,441)(FSUM(K3), K3=1,4)
C SUM OVER ALL ENERGIES TO PRINT PHI VS. GAMMA -- 3 PHI ANGLES
  827 DO 830   JGAM=1,IGINTV
      DO 830   IPHI = 1,3
  830 FLUXE(IPHI,JGAM) = 0.0
      DO 835   IPHI = 1,3
```

```
      IPHID = IPHI + 4*(IDT-1)
      DO 835   JGAM = 1, IGINTV
      DO 835     KE = 1, IEINTV
  835 FLUXE(IPHI,JGAM)=FLUXE(IPHI,JGAM) + FLUX(IPHID,JGAM,KE)
      WRITE (6,110)EPRINT(1), EPRINT(IEINTV+1)
      WRITE (6,210)(PPRINT(J),PPRINT(J+1),J=1,3)
      DO 840 J=1,4
  840 FSUM(J)=0.0
      DO 850  JGAM=1,IGINTV
      SUM=0.0
      DO 845  IPHI=1,3
      SUM=SUM + FLUXE(IPHI,JGAM)
  845 FSUM(IPHI) = FSUM(IPHI) + FLUXE(IPHI,JGAM)
      FSUM(4) = FSUM(4) + SUM
      WRITE (6,410)GPRINT(JGAM+1), (FLUXE(IPHI,JGAM),IPHI=  1,3), SUM
  850 CONTINUE
      WRITE (6,441)(FSUM(K3), K3=1,4)
  890 CONTINUE
      GO TO 1200
C TWO AZIMUTHAL INTERVALS
  900 DO 1090  IDT=1,ND
      WRITE (6,501)IDT, XD1(IDT), YD1(IDT), ZD1(IDT)
      IF (IEXTRA)              905, 905, 1000
  905 IF (IEINTV-1)            1000, 1000, 910
  910 DO 930  KE=1,MG
C AN EVEN NUMBER OF ENERGY INTERVALS
      WRITE (6,121)EPRINT(2*KE-1),EPRINT(2*KE),EPRINT(2*KE), EPRINT(2*KE
     1+1)
      WRITE (6,221)((PPRINT(K),PPRINT(K+1),K=1,2),K3=1,2)
      DO 915 J=1,6
  915 FSUM(J)=0.0
      DO 925 JGAM=1,IGINTV
      SUM1=0.0
      SUM2=0.0
      DO 920 IPHI=1,2
      IPHID = IPHI + 4*(IDT-1)
      SUM1=SUM1 + FLUX(IPHID,JGAM,2*KE-1)
      SUM2=SUM2 + FLUX(IPHID,JGAM,2*KE)
      FSUM(IPHI)  =FSUM(IPHI)  + FLUX(IPHID,JGAM,2*KE+1)
  920 FSUM(IPHI+3)=FSUM(IPHI+3)+ FLUX(IPHID,JGAM,2*KE)
      FSUM(3)=FSUM(3)+ SUM1
      FSUM(6)=FSUM(6)+ SUM2
      K2=IPHID
      K1=K2-1
      WRITE (6,420)GPRINT(JGAM+1),(FLUX(K3,JGAM,2*KE-1),K3  =K1,K2),SUM1
     1,(FLUX(K3,JGAM,2*KE),K3=K1,K2),SUM2
  925 CONTINUE
      WRITE (6,442)(FSUM(K3), K3=1,6)
  930 CONTINUE
      IF (IEXTRA)              1027, 1027, 1000
```

```
C PRINTING OF 1 SET OF 2 PHI ANGLES PER PAGE
 1000 KE1=IEINTV
      WRITE (6,120)EPRINT(KE1), EPRINT(KE1+1)
      WRITE (6,220)(PPRINT(J), PPRINT(J+1),J=1,2)
      DO 1015  J=1,3
 1015 FSUM(J)=0.0
      DO 1025  JGAM=1,IGINTV
      SUM=0.0
      DO 1020  IPHI=1,2
      IPHID=IPHI + 4*(IDT-1)
      SUM = SUM + FLUX(IPHI,JGAM,KE1)
 1020 FSUM(IPHI) = FSUM(IPHI) + FLUX(IPHID,JGAM,KE1)
      FSUM(3)=FSUM(3)+SUM
      K2=IPHID
      K1=K2-1
      WRITE (6,420)GPRINT(JGAM+1),(FLUX(K3,JGAM,KE1),       K3=K1,K2), S
     1UM
 1025 CONTINUE
      WRITE (6,442)(FSUM(K3),K3=1,3)
C SUM OVER ALL ENERGIES TO PRINT PHI VS. GAMMA -- 2PHI ANGLES
 1027 DO 1030  JGAM=1,IGINTV
      DO 1030  IPHI=1,2
 1030 FLUXE(IPHI,JGAM)=0.0
      DO 1035  IPHI = 1,2
      IPHID = IPHI + 4*(IDT-1)
      DO 1035  JGAM = 1, IGINTV
      DO 1035    KE = 1, IEINTV
 1035 FLUXE(IPHI,JGAM)=FLUXE(IPHI,JGAM) + FLUX(IPHID,JGAM,KE)
      WRITE (6,120)EPRINT(1), EPRINT(IEINTV+1)
      WRITE (6,220)(PPRINT(J),PPRINT(J+1),J=1,2)
      DO 1040 J=1,3
 1040 FSUM(J)=0.0
      DO 1050  JGAM=1,IGINTV
      SUM=0.0
      DO 1045  IPHI = 1,2
      SUM = SUM + FLUXE (IPHI,JGAM)
 1045 FSUM(IPHI) = FSUM(IPHI) + FLUXE(IPHI,JGAM)
      FSUM(3) = FSUM(3) + SUM
      WRITE (6,420)GPRINT(JGAM+1), (FLUXE(IPHI,JGAM), IPHI  = 1,2), SUM
 1050 CONTINUE
      WRITE (6,442)(FSUM(K3),K3=1,3)
 1090 CONTINUE
      GO TO 1200
C ONE AZIMUTHAL ANGLE
 1100 DO 1195   IDT = 1, ND
      WRITE (6,501)IDT, XD1(IDT), YD1(IDT), ZD1(IDT)
      DO 1105   JGAM = 1, IGINTV
 1105 ESUM(JGAM)=0.0
      DO 1110   KE = 1, IEINTV
 1110 GSUM(KE)=0.0
```

```
      IPHID = 1+4*(IDT-1)
      K2=0
      IE1=IEINTV
      DO 1115   JGAM=1,IGINTV
      DO 1115     KE=1,IEINTV
      ESUM(JGAM) = ESUM(JGAM) +   FLUX(IPHID,JGAM,KE)
 1115 GSUM(KE)   = GSUM(KE)   +   FLUX(IPHID,JGAM,KE)
      ME1=ME
 1117 IF (ME1-1)              1120, 1120, 1165
 1120 IE1 = IE1+1
C LESS THAN 9 ENERGIES TO BE PRINTED.
      K1=K2+1
      K2=IEINTV
      WRITE (6,130)PPRINT(1), PPRINT(IPPMAX)
      WRITE (6,230)
      WRITE (6,301)(EPRINT(K3), K3=K1,K2)
      K4=K1+1
      K5=K2+1
      WRITE (6,311)(EPRINT(K3),K3=K4,K5)
      GO TO (1125,1126,1127,1128,1129,1130,1131,1132,1133), IE1
 1125 WRITE (6,320)
      GO TO 1135
 1126 WRITE (6,321)
      GO TO 1135
 1127 WRITE (6,322)
      GO TO 1135
 1128 WRITE (6,323)
      GO TO 1135
 1129 WRITE (6,324)
      GO TO 1135
 1130 WRITE (6,325)
      GO TO 1135
 1131 WRITE (6,326)
      GO TO 1135
 1132 WRITE (6,327)
      GO TO 1135
 1133 WRITE (6,328)
 1135 DO 1150 JGAM = 1, IGINTV
      GO TO (1140,1141,1142,1143,1144,1145,1146,1147,1148),IE1
 1140 WRITE (6,431)GPRINT(JGAM+1), ESUM(JGAM)
      GO TO 1150
 1141 WRITE (6,432)GPRINT(JGAM+1), FLUX(IPHID,JGAM,IEINTV),  ESUM(JGAM)
      GO TO 1150
 1142 WRITE (6,433)GPRINT(JGAM+1),(FLUX(IPHID,JGAM,K3),K3=K1, K2), ESUM(
     1JGAM)
      GO TO 1150
 1143 WRITE (6,434)GPRINT(JGAM+1),(FLUX(IPHID,JGAM,K3),K3=K1, K2), ESUM(
     1JGAM)
      GO TO 1150
 1144 WRITE (6,435)GPRINT(JGAM+1),(FLUX(IPHID,JGAM,K3),K3=K1, K2), ESUM(
```

```
     1JGAM)
      GO TO 1150
 1145 WRITE (6,436)GPRINT(JGAM+1),(FLUX(IPHID,JGAM,K3),K3=K1, K2), ESUM(
     1JGAM)
      GO TO 1150
 1146 WRITE (6,437)GPRINT(JGAM+1),(FLUX(IPHID,JGAM,K3),K3=K1, K2), ESUM(
     1JGAM)
      GO TO 1150
 1147 WRITE (6,438)GPRINT(JGAM+1),(FLUX(IPHID,JGAM,K3),K3=K1, K2), ESUM(
     1JGAM)
      GO TO 1150
 1148 WRITE (6,439)GPRINT(JGAM+1),(FLUX(IPHID,JGAM,K3),K3=K1, K2), ESUM(
     1JGAM)
 1150 CONTINUE
      SUM=0.0
      DO 1151   KE=1,IEINTV
 1151 SUM=SUM + GSUM(KE)
      GO TO (1155,1156,1157,1158,1159,1160,1161,1162,1163), IE1
 1155 WRITE (6,451)SUM
      GO TO 1195
 1156 WRITE (6,452)(GSUM(KE),KE=K1,K2), SUM
      GO TO 1195
 1157 WRITE (6,453)(GSUM(KE),KE=K1,K2), SUM
      GO TO 1195
 1158 WRITE (6,454)(GSUM(KE),KE=K1,K2), SUM
      GO TO 1195
 1159 WRITE (6,455)(GSUM(KE),KE=K1,K2), SUM
      GO TO 1195
 1160 WRITE (6,456)(GSUM(KE),KE=K1,K2), SUM
      GO TO 1195
 1161 WRITE (6,457)(GSUM(KE),KE=K1,K2), SUM
      GO TO 1195
 1162 WRITE (6,458)(GSUM(KE),KE=K1,K2), SUM
      GO TO 1195
 1163 WRITE (6,459)(GSUM(KE),KE=K1,K2), SUM
      GO TO 1195
C NINE ENERGIES PER PAGE
 1165 K1=K2+1
      K2=K1+8
      WRITE (6,130)PPRINT(1), PPRINT(IPPMAX)
      WRITE (6,230)
      WRITE (6,301)(EPRINT(K3), K3= K1,K2)
      K4=K1+1
      K5=K2+1
      WRITE (6,311)(EPRINT(K3),K3= K1,K2)
      DO 1170  JGAM = 1, IGINTV
      WRITE (6,430)GPRINT(JGAM+1),(FLUX(IPHID,JGAM,K3), K3=  K1,K2)
 1170 CONTINUE
      WRITE (6,443)(GSUM(K3), K3=K1,K2)
      ME1=ME1-1
```

```
      IE1=IE1-9                                                         0400
      GO TO 1117                                                        0401
 1195 CONTINUE                                                          0402
 1200 NN = NN + 100                                                     0403
      DO 1530  IDT = 1,ND
      TDSUM = 0.0
      DO 1202  JGAM = 1,20
      DO 1202  KE=1,21
      DSUMA(JGAM) = 0.0.
 1202 DSUME(JGAM,KE) = 0.0
      WRITE (6,501) IDT, XD1(IDT), YD1(IDT), ZD1(IDT)
      IF  (IEINTV.GT.10)       GO TO 1500
      WRITE (6,1405) (EPRINT(KE+1),KE=1,10)
 1405 FORMAT (// 60X 10H DOSE RATE /2X 5HPOLAR  55X 6HENERGY /
     1 2X 5HANGLE/    2X 5H(DEG)  6X 10(F5.2,5X) ,1X 3HSUM / )
      WRITE (6,1406)
 1406 FORMAT (1H )
       DO 1416  JGAM = 1,IGINTV
      DO 1410  KE = 1, IEINTV
      DSUME(JGAM,11) = DSUME(JGAM,11) + DOSE(IDT,JGAM,KE)
 1410 DSUMA(KE) = DSUMA(KE) + DOSE(IDT,JGAM,KE)
      TDSUM = TDSUM + DSUME(JGAM,11)
      WRITE(6,1415) GPRINT(JGAM+1),(DOSE(IDT,JGAM,KE),KE=1,10),
     1        DSUME(JGAM,11)
 1415 FORMAT(    3X  F5.1,2X  1P11E10.3)
 1416 CONTINUE
      WRITE(6,1417)  (DSUMA(KE),KE=1,10), TDSUM
 1417 FORMAT (   /  4X  6HSUM   ,1P11E10.3)
      GO TO 1530
 1500 DO 1521  JGAM = 1, IGINTV
      DO 1510   KE = 1, IEINTV
      DSUME(JGAM,21) = DSUME(JGAM,21) + DOSE(IDT,JGAM,KE)
      TDSUM = TDSUM + DSUME(JGAM,KE)
 1510 DSUMA(KE) = DSUMA(KE) + DOSE(IDT,JGAM,KE)
 1521 CONTINUE
      WRITE(6,1520)   (EPRINT(KE+1),KE=1,10)
 1520 FORMAT (// 60X 10H DOSE RATE /2X 5HPOLAR  55X 6HENERGY /
     1 2X 5HANGLE /    2X 5H(DEG)  6X 10(F5.2,5X) / )
      DO 1524  JGAM = 1, IGINTV
 1524 WRITE (6,1415) GPRINT(JGAM+1), (DOSE(IDT,JGAM,KE),KE=1,10)
      WRITE(6,1417) (DSUMA(KE),KE=1,10)
      WRITE (6,1526) (EPRINT(KE+1),KE=11,20)
 1526 FORMAT(  //12X 10(F5.2,5X),1X 3HSUM   )
      DO 1527  JGAM = 1, IGINTV
 1527 WRITE(6,1415) GPRINT(JGAM+1),(DOSE(IDT,JGAM,KE),KE= 11,20),
     1       DSUME(JGAM,21)
      WRITE(6,1417) (DSUMA(KE),KE=11,20),TDSUM
 1530 CONTINUE
      WRITE (6,1350)PID, NN                                             0404
 1350 FORMAT(15H1END OF PROBLEM , A4, I2  )                             0405
```

```
CALL EXIT                                                    0406
STOP                                                         0407
END                                                          0408
```

III ANALYSIS CODE A02

The history tapes containing all the pertinent details of each particle collision can be used in the Analysis Code, A02, to calculate the particle flux within a region and the particle leakage from the defined geometry. The A02 code calculates the total flux within each region of the defined geometry, while the A01 code calculates only the scattered flux at each detector point.

The particle leakage calculated by the A02 code is proportional to the number current rather than the flux. An option is provided for printing out the particle leakage or for recording the leakage data on tape for future use as an approximate point source. If a leakage tape is written, it may be used as input into the History Generator Code or read as a SOURCE tape with the C01 Tape Read Code.

3.1 Flux Within a Region

The expectation flux for each region is computed from a knowledge of the particle's weight, energy and direction after each collision and from the length of the particle's path through each region intersected by the path. The weight of the particle emerging from a collision is denoted by W. The probability that the particle will undergo a collision within the distance S through the region J which contains the collision point is defined as

$$[1 - e^{-S\Sigma_{J,T}(E)}] ,$$

where $\Sigma_{J,T}(E)$ is the total macroscopic cross section for region J at the energy E of the particle.

The average expectation track length through region J for the particle is given by

$$TL_J = \frac{W}{\Sigma_{J,T}(E)} (1 - e^{-S\Sigma_{J,T}(E)}).$$

The weight of a particle entering region number K, a region not containing the collision point, is

$$W' = W e^{-EXP},$$

where EXP is the sum of the mean free paths traveled by the particle along the flight path before intersecting a boundary of region K.

The average expectation track length through region K is

$$TL_K = \frac{W'}{\Sigma_{K,T}(E)} (1 - e^{-S\Sigma_{K,T}(E)}).$$

The expectation track length through region K when the material in the region is a vacuum is

$$TL_K = W'S.$$

The expectation flux for a region is proportional to the sum of the average expectation track lengths in the region for all particles that have a non-zero probability of reaching the region.

The average expectation track length per unit source strength in each region is obtained by dividing the sum of the track lengths in the region by the number of source particle histories from which the history tape was generated.

The expectation flux per unit source strength for a region can be obtained by dividing the average expectation track length per unit source strength in the region by the volume of the region. The quantity computed by program A02 is the average expectation track

length per unit source strength for each region. This quantity is printed as a function of the energy groups defined for that purpose in the program input.

3.2 Particle Leakage

The weight of a particle entering the unbounded region after undergoing a collision in a bounded region, is defined by

$$W\ell = W\, e^{-EXP},$$

where EXP = the sum of the mean free paths traveled by the particle between the collision point and the boundary of Region 2,

W = the particle weight following the collision, and

$W\ell$ = an estimator of the number current leaking out of the bounded regions.

The sum of the quantities $W\ell$ computed from each collision is normalized by dividing by the total number of source particles followed. When the input parameter LSO = 1, the normalized number current leaking out into the unbounded region is printed as a function of the energy E after collision and the angle $\cos^{-1}\gamma$. The results so obtained can be used as the energy and angular distribution of a point source representation of the system. When LSO = 2, a tape is prepared that contains for each collision the following quantities:

$W\ell$ = normalized number current $\left(\frac{\text{particles/sec}}{\text{source particle/sec}}\right)$,

NR1 = number of region from which the particle entered Region 2,

X,Y,Z = coordinates of the entrance point into Region 2,

α,β,γ = direction cosines of the particle,

E = energy of the particle as it enters Region 2.

When LSO = 0, no leakage data are computed.

3.3 Utilization of Analysis Code A02

The purpose of the Analysis Code, A02, is to calculate the number of track lengths in each region of the defined geometry. The total flux may be obtained by dividing the number of track lengths in a region by the volume of the region. In addition, the angular distribution of the current leaking from the entire system may be obtained in the event that it is desired to describe an equivalent point source.

The code requires as input a HISTORY tape or, if the problem involves more than one energy super-group, a SORTED tape. The HISTORY or SORTED tape furnishes information generated by the History Generator Code, giving data concerning collision points that were distributed throughout the described geometry by the Monte Carlo method. In most cases the geometry and cross-section data necessary for input into the A02 code will be the same as that used in a previously run history generation problem. Therefore, many of the library decks used in the H01 problem may also be used in the A02 problem.

3.3.1 Operator Instructions

The A02 code may use as many as four tape units in addition to the regular input and output logical tape units 5 and 6. Input HISTORY or SORTED tapes should be loaded on logical tape units 1 and 2 before starting the problem. If there is only one input HISTORY or SORTED tape, it should be loaded on logical unit 1. If cross sections are input on cards, they will be transferred to the tape on

logical unit 9 and, if desired, the operator may be instructed to save and label the tape on logical unit 9. The operator should be informed that logical tape units 3 and 9 may be used during the process of running a problem with the A02 code.

3.3.2 A02 Input Data Formats

The cards making up the problem input and the library data for A02 must be sequenced in columns 69 through 72. The first card of 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 within a deck must be 00 for problem input data or the library number for library data decks. 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 correct number 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.

3.3.2.1 A02 Problem Input Data

Each problem run on the Analysis Code, A02, will require a problem input data deck which must be placed immediately behind the "data" card that separates the binary and data decks. The format to be used in preparing an A02 problem deck is given in Table IX.

TABLE IX

A02 Problem Input Data Format

(for Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1	3I5,E10.4 7I5	IEPMAX	Number of energies bounding printout energy groups	≤21
		IGPMAX	Number of angles bounding printout polar angle groups	≤21
		LSO	Printout option LSO = 0, Only track lengths versus region and particle energy will be printed. LSO = 1, The number current leaking from a system versus angle and energy will be printed as well as the track lengths versus region and energy. LSO = 2, The same printout is given as when LSO = 1 and, in addition, a tape is written giving: the number current, the region number of the last region before escaping into a vacuum, the final particle energy, the coordinates of the particle at the exit point, and the direction cosines.	
		ELOCUT	Lower cutoff energy	
		NEL	Number of elements	≤8
		NG	Type of particle NG = 0, neutrons NG = 1, gamma rays NG = 2, secondary gamma rays	
		NHT	Number of input HISTORY or SORTED tapes	≤2
		NREG	Number of geometrical regions	≤50
		NUB	Number of boundaries bounding the outside region	≤20

TABLE IX (continued)

Card	Format	Input Item	Definition	Limit
		NLIB	Number of input libraries (The code compares this number with the actual number of libraries supplied and with the number that is calculated to be necessary using other input data. If the three numbers are not the same, the code will give an error print.)	
		NMAT	Number of materials	≤8
2	1H,A6,A3 1X,A6,A3,8I5	H(1),H(2)	Label on input history tapes (usually HISTORY or SORTED)	
		HE(1),HE(2)	Label on output leakage tapes (usually LEAKAGE)	
		J2NO	Tape number to be assigned to a LEAKGE tape	
		NSG	Number of energy super-groups	≤20
		IQID	Tape number of cross-section tapes (IF cross sections are input on cards rather than tapes, leave this field blank.)	
		NHIST	Number of histories	
		MKREC(1)	Number of records on last HISTORY or SORTED tape that is to be input	
		MKREC(2)	Number of sets of collision data in the last record of the last HISTORY or SORTED tape to be input	
		ISRCTP	HISTORY or SORTED tape option ISRCTP = 0, HISTORY or SORTED tape is available ISRCTP = 1, collision data will be input on cards rather than tape (An A01, A02 library is needed.)	
		NTAP	Cross-section tape option NTAP = 0, cross sections not on tape NTAP = 1, cross sections will be input on tape	

TABLE IX (continued)

Card	Format	Input Item	Definition	Limit
			(If cross sections are on tape, library 6 is not needed; otherwise, a library 6 is needed for each super-group of every element. Cross-section tapes written by the H01 code will not be accepted as input into the A02 code.	
3	E10.4	EPSL	Small increment used to move a particle's position off a boundary. (This value, when added to the largest distance to a boundary that is anticipated in the given problem, should change that distance in the first eight significant figures.)	
4	3I10	MHTAPE(K)	Input HISTORY or SORTED tape number (K = 1, NHT). If one of the tapes is only partially filled, the number of that tpae should be the last one listed.	
		JSENSE	Intermediate printout option JSENSE = 0, do not print out intermediate print data JSENSE = 1, do print out intermediate data (JSENSE should be 0 if number of histories is greater than 50.)	
5	6E10.0	BEGGER(K,M)	Number of sets of collision data +.5 for super-group M on HISTORY or SORTED tape K. (If NHT = 0, omit cards with BEGGER(K,M) values.)	
Follows last BEGGER(K,M) card	12I5	IETAB(K)	Number of tabulated cross sections for super-group K	≤100
Follows last IETAB(K) card	6E10.0	EPRINT(K)	Energies bounding printout energy groups (ascending order. The first energy bound should be the minimum energy for the problem and the remaining values should be the upper bounds for the first to the last printout energy groups.)	K=1,IEPMAX

TABLE IX (continued)

Card	Format	Input Item	Definition	Limit
Follows last EPRINT(K) card	6E10.0	GPRINT(K)	Angles bounding the printout polar angle groups (degrees, ascending order. The first value is the lower bound of the first angle group and the remaining values are the upper bounds of the first through the last groups.	K=1,IGPMAX
Follows last GPRINT(K) card	4E10.4*	EGRP(K)	Lower energy bound for energy group K	K=1,NSG
		EMAX(K)	Upper energy bound for energy group K	K=1,NSG
Follows last EGRP(K) card	6E10.0	ESI(K)	Energy below which elastic scattering is isotropic in the center-of-mass system for element K. (These values are not required for a gamma calculation, but a blank space must be left for each element of the problem.)	K=1,NEL
Follows last ESI(K) card	6E10.0	ATWT(K)	Atomic weight of element K. (These values must be listed in the same order that they were listed in the H01 problem that wrote the tapes used as input in this problem.)	K=1,NEL
Follows last ATWT(K) card	6E10.0	DN(J,K)	Atomic density of element K in material J. K varies most rapidly; start new card for each material.	K=1,NEL J=1,NUMAT
Follows last DN(J,K) card	6I10	NB(K)	Number of boundaries defining region K	K=1,NREG
Follows last NB(K) card	6K10	MATREG(K)	Material in region K	K=1,NREG

* Reading order: (EGRP(K), EMAX(K), K=1,NSG)

3.3.2.2 Library One: H01, A01, A02 Codes

Library one contains information describing boundaries for the COHORT codes H01, A01 and A02. If A01, A02 and H01 problems are being

run for the same geometry, the same library deck 1 may be used in the input in all three codes. In describing the boundaries, the outside boundaries must be described first. A boundary should not be used both as an inside and outside boundary because once the program discerns that a particle has crossed an outside boundary from an inside region, the tracking of the particle is terminated. If the geometry is such that a boundary is both an outside and an inside boundary, it should be defined twice, first as an outside boundary and later as an inside boundary. The formats to be used in making up a library one deck are given in Table X.

TABLE X

Library One Input Data Format

(for Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1	2I10	LIBT	Type of library to be read in (LIBT = 1 for library one)	=1
		NBD	Number of boundaries described in library one (maximum of 150)	≤75
	The next NUB cards should contain the boundary descriptions for the NUB outside boundaries of the geometry being described.			
2	I10,* 5E10.4	IBT(K)	Type of boundary for boundary K IBT(K) = 1, sphere, ellipsoid or hyperboloid IBT(K) = 2, paraboloid IBT(K) = 3, cones IBT(K) = 4, cylinders IBT(K) = 5, plane containing Z axis IBT(K) = 6, plane perpendicular to Z axis IBT(K) = 7, plane perpendicular to X axis IBT(K) = 8, plane perpendicular to Y axis IBT(K) = 9, arbitrarily oriented plane	K=1,NBD
		AF(K) ZF(K) CF(K) XF(K) YF(K)	Curve-fit coefficients for boundary K	K=1,NBD

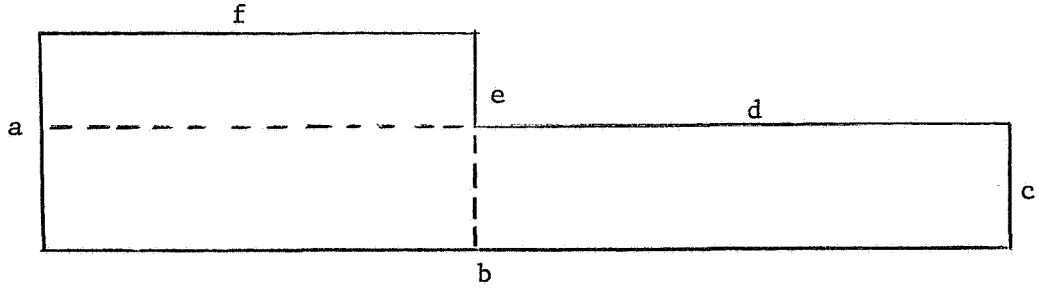
* Reading order: (IBT(K), AF(K), ZF(K), XF(K), XF(K), YF(K), K=1,NBD)

3.3.2.3 Library Two: H01, A01, A02 Codes

In Library Two the various inside regions in the geometry under consideration are described by giving the boundary numbers that encircle each of the regions. If the same geometry is being considered in H01, A01 and A02 problems, then the same library type 2 may be used

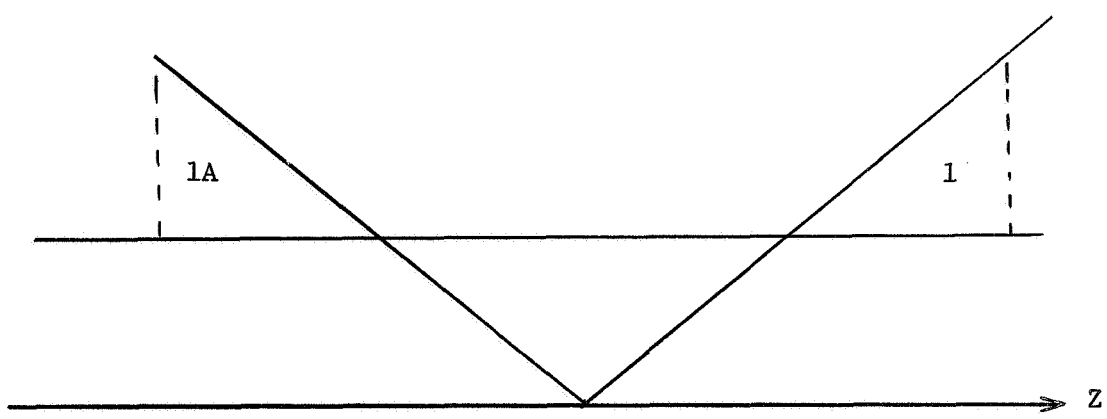
in the input of all three codes. The material within any one region will be taken to be a homogeneous mixture. The History-Generator Code and the Analysis Code (A02) calculate respectively energy depositions and track lengths within regions; so the size of the regions should be chosen to give the best statistical results. The codes assume that the first region described is the source region. It is not necessary that all source particles originate in this region, but the problems will run more economically if most of the particles originate within this region. Region 2 is understood to be the outside region and is not described in this library. Inside regions may be listed in any order desired, but different arrangements may prove to be more economical, since upon a particle's crossing a boundary, a search is performed beginning with the most probable region of entry across that boundary and cycling through the regions in the order they are input from that point until the region containing the particle's location is found. In many instances, it may not be feasible to obtain the optimum arrangement of the order in which the regions should be input, but an effort should always be made to cause the code to do as little searching as possible.

Boundaries used in describing a region should not extend into the region. That is, an area such as that depicted below should not



be described as one region because boundaries e and d extend into the region. The codes calculate the distances from a particle's location inside a region to each boundary surrounding that region and assume that the least positive distance is the distance to the outer edge of the region measured along the direction the particle is moving. If a boundary extends inside a region, it would be possible to move the particle's location through this least positive distance and still not have moved the particle to the outer edge of the region. The region depicted above should be divided into two regions so that the boundaries surrounding either of the two regions would not extend into the region being surrounded. One such region would be that surrounded by boundaries a, f, e and b; the other region would be that surrounded by boundaries e, d, c and b.

Care should be taken to prevent a reflected region from appearing in the described geometry. A reflected region is one which is not described in the input but exists because the conditions required for a particle to be in a region are satisfied for some region described elsewhere in the configuration. The sketch below illustrates an example of the situation.



If the above figure is rotated about the Z axis, region 1 will form a cone which is the described region, and region 1A will form a cone which is the reflected region. Any particles in the cone formed by region 1A will satisfy the conditions that are required for a particle to be in region 1. To avoid the description of a reflected region, an additional boundary should be used in describing region 1. This boundary need not border region 1 but should be placed between regions 1 and 1A so that all points in region 1 would lie on one side of the boundary and points in region 1A would lie on the other side of the boundary. Table XI shows the format to be used in preparing a library type 2.

TABLE XI

Library Two Input Data Format

(for Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1	I10	LIBT	Type of library to be read in (LIBT = 2 for this library)	=2
2	12I5*	IBN(K,N)	The nth boundary surrounding region K (see NOTE below)	K=1 & 3, NREG, K≠2
		MPR(K,N)	The most probable region of entry across the nth boundary from region K	

* Reading order: ((IBN(K,N), MPR(K,N), N=1,NB(K)), K=1 & 3, NREG)

If Region K has fewer than seven boundaries, a second card for that region is unnecessary. Two cards will be the maximum necessary for any region, since the maximum number of boundaries encircling a region is nine. The maximum number of regions for any one problem is 50.

NOTE: The boundary numbers must be given a sign that corresponds to the sign of XR which is calculated as shown in the text.

3.3.2.4 Library Five: A01, A02 Codes

Library five is omitted if the value ISRCTP in the problem input data is zero. Library five supplies information for up to 20 collision points and is used in lieu of an input HISTORY or SORTED tape when more control over input variables is desired for checkout purposes. The collision parameters that are entered into the code through library five should be sorted according to energy so that those sets of parameters for the energies in the first super-group are read in first, those in the second group next, and so on. The format to be used when preparing a library type 5 data deck is shown in Table XII.

TABLE XII

Library Five Input Data Format

(for Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1	I10,10X, I5	LIBT	Library type (LIBT = 5 for this library)	
		ISRCRC	Number of collisions for which collision parameters are to be read in	<20
2	6E10.0*	X1(K) Y1 K) Z1(K)	Coordinates of collision point	
		A0(K) B0(K) C0(K)	Direction cosines of particle's direction before collision	
3	3E10.0* I10 E10.8	E0(K)	Particle's energy before collision	
		A(K)	Atomic weight of element with which collision occurred	
		W1(K)	Particle's weight	
		NR1(K)	Region in which collision occurred	
		EX1(K)	Excitation level of target nucleus	

* Reading order: (X1(K), Y1(K), Z1(K), A0(K), B0(K), C0(K), E0(K), A(K), W1(K), NR1(K), EX1(K), K=1,ISRCRC)

3.3.2.5 Library Six: H01, A01, A02 Codes

A library six is required for each energy super-group for every element. This library, for which the input format is given in Table XIII, gives the total, scattering, and elastic cross sections for neutrons or the total, Compton plus pair production, and Compton cross sections for gamma rays for arbitrarily spaced energy points within the energy super-group. Only the total neutron or gamma-ray cross sections are necessary for the A01 and A02 codes, but if a library has been made up for the H01 code, it may be used "as is" in the input for the A01 and A02 codes. The range and spacing of the energy points within a given energy super-group must be the same for the different elements. The cross sections are listed first for the highest energy of the group and then in descending order to the lowest energy of the group.

Libraries type 6 may be loaded behind the problem input data in any order, since the codes write the cross-section data on tape as it is read in and then rearranges the data according to super-group after all library data are read in.

TABLE XIII

Library Six Input Data Format

(for Columns 1 through 62)

Card	Format	Input Item	Definition	Limit
1	2I10,2I5	LIBT	Library type (LIBT = 6 for this library)	=6
		K	Number of energy points at which cross sections are read in	≤100
		J	Element number (Elements are numbered in the order that their atomic weights are listed in the problem input data.)	
		L	Energy super-group number (Energy super-groups must be numbered beginning with the group of highest energies as Group 1 and increasing the group number as the energies within the groups decrease.)	
2 through M+1	4E10.0*	ENERGY(M)	Energy points (descending order) within a super-group at which cross sections are defined. (These energies should be the same for all library sixes for a given super-group.)	
		TM(J,M)	Total microscopic cross section for element J (M = 1 to K) NRG = 0, neutron cross sections NRG = 1, gamma-ray cross sections	
		SM(J,M)	Microscopic scattering cross section for element J (M = 1 to K) NRG = 0, neutron scattering cross section NRG = 1, gamma-ray Compton plus pair production cross section	
		ESM(J,M)	Microscopic elastic cross section for neutrons or Compton scattering cross section for gammas for element J (M = 1 to K)	

* Reading order: (ENERGY(M), TM(J,M), SM(J,M), ESM(J,M), M=1,K)

3.4 A02 Sample Problem

The A02 sample problem given in this section was designed to calculate the capture gamma-ray differential dose rate albedo for a concrete slab. The sample problem requires as input a history tape from an H01 problem which generated capture gamma-ray histories using the capture gamma-ray source tape produced by the S02 sample problem discussed in Volume II. The problem input and output data for the H01 secondary gamma-ray problem, which was run to generate the input tape for the A02 sample problem, are given in Tables XIV and XV.

3.4.1 A02 Sample Input

The problem input data for the A02 sample problem are listed in Table XVI. The A02 sample problem also requires as input the libraries one and two and all eight of the library sixes listed in Table XIV.

3.4.2 A02 Sample Output

The output from the A02 sample problem is listed in Table XVII. The first three pages give the total current as a function of energy and angle leaking from the concrete slab. The current leaking from the slab for angles less than or equal to 90 degrees is the transmitted current. The current leaking from the slab for angles greater than 90° is the reflected current. Pages four and five of Table XVII give the average total number of secondary gamma-ray track lengths in each region as a function of energy. These track lengths may be converted to flux by dividing by the volume of the region or, in this case, where the reciprocity principle is applied to the results for a normal incident line beam thermal-neutron source to predict the

TABLE XIV H01 Secondary Gamma-Ray Problem Input

```
  2     2     2     2     2     0     5     1            11     0     0  1660000001     H01
 50    11     8     1     1    30     2   167     1                      1660000002     H01
                                                                          1660000003     H01
  0.0+00     0.0+00     0.0+00     3.0+02     1.0-02     0.0+00  1660000004     H01
  2.0+01                1.0-01                                            1660000005     H01
  1.0-02     2.0+01                                                       1660000006     H01
                                                                          1660000007     H01
                                                                          1660000008     H01
1.008+00  12.01+00   16.0+00  40.08+00  28.09+00  24.32+00  1660000009     H01
55.85+00  26.98+00                                                        1660000010     H01
 8.50-03   2.02-02   3.55-02   1.11-02   1.70-03   1.86-03  1660000011     H01
 1.93-04   5.56-04                                                        1660000012     H01
       3         3         3         3         3         3  1660000013     H01
       3         3         3         3         3            1660000014     H01
       1         0         1         1         1         1  1660000015     H01
       1         1         1         1         1            1660000016     H01
  SOURCE    66                                                            1660000017     H01
81658793  23562485   1.0-03                                               1660000018     H01
       7        11                                                        1660070001     H01
       1    0.0+00                                                        1660070002     H01
       1    0.0+00                                                        1660070003     H01
       1    0.0+00                                                        1660070004     H01
       1    0.0+00                                                        1660070005     H01
       1    0.0+00                                                        1660070006     H01
       1    0.0+00                                                        1660070007     H01
       1    0.0+00                                                        1660070008     H01
       1    0.0+00                                                        1660070009     H01
       1    0.0+00                                                        1660070010     H01
       1    0.0+00                                                        1660070011     H01
       1    0.0+00                                                        1660070012     H01
       1        12                                                         166010001     H01
       6     0.0+0                                                         166010002     H01
       4     3.0+2                                                         166010003     H01
       6    66.4+0                                                         166010004     H01
       6   1.328+0                                                         166010005     H01
       6   2.656+0                                                         166010006     H01
       6   3.984+0                                                         166010007     H01
       6   6.640+0                                                         166010008     H01
       6   9.296+0                                                         166010009     H01
       6  13.280+0                                                         166010010     H01
       6  18.592+0                                                         166010011     H01
       6  26.560+0                                                         166010012     H01
       6  39.840+0                                                         166010013     H01
       2                                                                   166020001     H01
  1    2    -2     2    -4     3                                          166020002     H01
  4    1    -2     2    -5     4                                          166020003     H01
  5    3    -2     2    -6     5                                          166020004     H01
  6    4    -2     2    -7     6                                          166020005     H01
  7    5    -2     2    -8     7                                          166020006     H01
  8    6    -2     2    -9     8                                          166020007     H01
  9    7    -2     2   -10     9                                          166020008     H01
 10    8    -2     2   -11    10                                          166020009     H01
 11    9    -2     2   -12    11                                          166020010     H01
 12   10    -2     2    - 3     2                                         166020011     H01
       6        27     1     1                                          HYDR060001     H01
   2.0+1    3.35-2    3.35-2    3.02-2                                   HYDR060002     H01
   1.5+1    4.05-2    4.05-2    3.77-2                                   HYDR060003     H01
   1.0+1    5.31-2    5.31-2    5.10-2                                   HYDR060004     H01
   8.0+0    6.17-2    6.17-2    5.99-2                                   HYDR060005     H01
   6.0+0    7.45-2    7.45-2    7.32-2                                   HYDR060006     H01
   5.0+0    8.39-2    8.39-2    8.28-2                                   HYDR060007     H01
```

TABLE XIV (continued)

4.0+0	9.682-2	9.682-2	9.60-2	HYDR060008	H01
3.0+0	1.1561-1	1.1561-1	1.151-1	HYDR060009	H01
2.0+0	1.4658-1	1.4658-1	1.464-1	HYDR060010	H01
1.5+0	1.7164-1	1.7164-1	1.716-1	HYDR060011	H01
1.0+0	2.11-1	2.11-1	2.11-1	HYDR060012	H01
8.0-1	2.35-1	2.35-1	2.35-1	HYDR060013	H01
6.0-1	2.68-1	2.68-1	2.68-1	HYDR060014	H01
5.0-1	2.89-1	2.89-1	2.89-1	HYDR060015	H01
4.0-1	3.17-1	3.17-1	3.17-1	HYDR060016	H01
3.0-1	3.54-1	3.54-1	3.54-1	HYDR060017	H01
2.0-1	4.07-1	4.07-1	4.07-1	HYDR060018	H01
1.5-1	4.44-1	4.44-1	4.44-1	HYDR060019	H01
1.0-1	4.93-1	4.93-1	4.93-1	HYDR060020	H01
8.0-2	5.17-1	5.17-1	5.17-1	HYDR060021	MAERKER
6.0-2	5.46-1	5.46-1	5.46-1	HYDR060022	MAERKER
5.0-2	5.61-1	5.61-1	5.61-1	HYDR060023	MAERKER
4.0-2	5.78-1	5.78-1	5.78-1	HYDR060024	MAERKER
3.0-2	5.97-1	5.97-1	5.97-1	HYDR060025	MAERKER
2.0-2	6.18-1	6.18-1	6.18-1	HYDR060026	MAERKER
1.5-2	6.301-1	6.29-1	6.29-1	HYDR060027	MAERKER
1.0-2	6.446-1	6.40-1	6.40-1	HYDR060028	MAERKER
6	27	2 1		CARB060001	MAERKER
2.0+1	2.974-1	2.974-1	1.814-1	CARB060002	MAERKER
1.5+1	3.25-1	3.25-1	2.26-1	CARB060003	MAERKER
1.0+1	3.82-1	3.82-1	3.06-1	CARB060004	MAERKER
8.0+0	4.22-1	4.22-1	3.59-1	CARB060005	MAERKER
6.0+0	4.87-1	4.87-1	4.39-1	CARB060006	MAERKER
5.0+0	5.37-1	5.37-1	4.97-1	CARB060007	MAERKER
4.0+0	6.06-1	6.06-1	5.76-1	CARB060008	MAERKER
3.0+0	7.09-1	7.09-1	6.91-1	CARB060009	MAERKER
2.0+0	8.843-1	8.843-1	8.78-1	CARB060010	MAERKER
1.5+0	1.0316+0	1.0316+0	1.030+0	CARB060011	MAERKER
1.0+0	1.267+0	1.267+0	1.267+0	CARB060012	MAERKER
8.0-1	1.410+0	1.410+0	1.410+0	CARB060013	MAERKER
6.0-1	1.605+0	1.605+0	1.605+0	CARB060014	MAERKER
5.0-1	1.735+0	1.735+0	1.735+0	CARB060015	MAERKER
4.0-1	1.900+0	1.900+0	1.900+0	CARB060016	MAERKER
3.0-1	2.12+0	2.12+0	2.12+0	CARB060017	MAERKER
2.0-1	2.44+0	2.44+0	2.44+0	CARB060018	MAERKER
1.5-1	2.664+0	2.66+0	2.66+0	CARB060019	MAERKER
1.0-1	2.977+0	2.96+0	2.96+0	CARB060020	MAERKER
8.0-2	3.137+0	3.10+0	3.10+0	CARB060021	MAERKER
6.0-2	3.376+0	3.28+0	3.28+0	CARB060022	MAERKER
5.0-2	3.55+0	3.37+0	3.37+0	CARB060023	MAERKER
4.0-2	3.85+0	3.47+0	3.47+0	CARB060024	MAERKER
3.0-2	4.58+0	3.58+0	3.58+0	CARB060025	MAERKER
2.0-2	7.62+0	3.71+0	3.71+0	CARB060026	MAERKER
1.5-2	1.397+1	3.77+0	3.77+0	CARB060027	MAERKER
1.0-2	4.244+1	3.84+0	3.84+0	CARB060028	MAERKER
6	27	3 1		OXYG060001	MAERKER
2.0+1	4.48-1	4.48-1	2.42-1	OXYG060002	MAERKER
1.5+1	4.82-1	4.82-1	3.02-1	OXYG060003	MAERKER
1.0+1	5.42-1	5.42-1	4.08-1	OXYG060004	MAERKER
8.0+0	5.91-1	5.91-1	4.79-1	OXYG060005	MAERKER
6.0+0	6.72-1	6.72-1	5.86-1	OXYG060006	MAERKER
5.0+0	7.33-1	7.33-1	6.63-1	OXYG060007	MAERKER
4.0+0	8.21-1	8.21-1	7.68-1	OXYG060008	MAERKER
3.0+0	9.53-1	9.53-1	9.21-1	OXYG060009	MAERKER
2.0+0	1.182+0	1.182+0	1.171+0	OXYG060010	MAERKER
1.5+0	1.3758+0	1.3758+0	1.373+0	OXYG060011	MAERKER
1.0+0	1.690+0	1.690+0	1.690+0	OXYG060012	MAERKER

TABLE XIV (continued)

8.0-1	1.880+0	1.880+0	1.880+0	OXYG060013	MAERKER
6.0-1	2.14+0	2.14+0	2.14+0	OXYG060014	MAERKER
5.0-1	2.31+0	2.31+0	2.31+0	OXYG060015	MAERKER
4.0-1	2.53+0	2.53+0	2.53+0	OXYG060016	MAERKER
3.0-1	2.83+0	2.83+0	2.83+0	OXYG060017	MAERKER
2.0-1	3.26+0	3.25+0	3.25+0	OXYG060018	MAERKER
1.5-1	3.57+0	3.55+0	3.55+0	OXYG060019	MAERKER
1.0-1	4.011+0	3.94+0	3.94+0	OXYG060020	MAERKER
8.0-2	4.29+0	4.14+0	4.14+0	OXYG060021	MAERKER
6.0-2	4.77+0	4.37+0	4.37+0	OXYG060022	MAERKER
5.0-2	5.22+0	4.49+0	4.49+0	OXYG060023	MAERKER
4.0-2	6.17+0	4.62+0	4.62+0	OXYG060024	MAERKER
3.0-2	8.87+0	4.78+0	4.78+0	OXYG060025	MAERKER
2.0-2	2.034+1	4.94+0	4.94+0	OXYG060026	MAERKER
1.5-2	4.463+1	5.03+0	5.03+0	OXYG060027	MAERKER
1.0-2	1.5112+2	5.12+0	5.12+0	OXYG060028	MAERKER
6	27	4	1	CALC060001	MAERKER
2.0+1	1.865+0	1.865+0	6.05-1	CALC060002	MAERKER
1.5+1	1.835+0	1.835+0	7.55-1	CALC060003	MAERKER
1.0+1	1.850+0	1.850+0	1.020+0	CALC060004	MAERKER
8.0+0	1.888+0	1.888+0	1.198+0	CALC060005	MAERKER
6.0+0	2.004+0	2.004+0	1.464+0	CALC060006	MAERKER
5.0+0	2.097+0	2.097+0	1.657+0	CALC060007	MAERKER
4.0+0	2.249+0	2.249+0	1.919+0	CALC060008	MAERKER
3.0+0	2.50+0	2.50+0	2.30+0	CALC060009	MAERKER
2.0+0	3.002+0	3.002+0	2.93+0	CALC060010	MAERKER
1.5+0	3.448+0	3.448+0	3.43+0	CALC060011	MAERKER
1.0+0	4.22+0	4.22+0	4.22+0	CALC060012	MAERKER
8.0-1	4.71+0	4.70+0	4.70+0	CALC060013	MAERKER
6.0-1	5.38+0	5.35+0	5.35+0	CALC060014	MAERKER
5.0-1	5.83+0	5.78+0	5.78+0	CALC060015	MAERKER
4.0-1	6.42+0	6.33+0	6.33+0	CALC060016	MAERKER
3.0-1	7.27+0	7.07+0	7.07+0	CALC060017	MAERKER
2.0-1	8.80+0	8.13+0	8.13+0	CALC060018	MAERKER
1.5-1	1.05+1	8.87+0	8.87+0	CALC060019	MAERKER
1.0-1	1.586+1	9.86+0	9.86+0	CALC060020	MAERKER
8.0-2	2.194+1	1.034+1	1.034+1	CALC060021	MAERKER
6.0-2	3.972+1	1.092+1	1.092+1	CALC060022	MAERKER
5.0-2	6.182+1	1.122+1	1.122+1	CALC060023	MAERKER
4.0-2	1.1356+2	1.156+1	1.156+1	CALC060024	MAERKER
3.0-2	2.6594+2	1.194+1	1.194+1	CALC060025	MAERKER
2.0-2	8.7136+2	1.236+1	1.236+1	CALC060026	MAERKER
1.5-2	2.0226+3	1.258+1	1.258+1	CALC060027	MAERKER
1.0-2	6.3928+3	1.280+1	1.280+1	CALC060028	MAERKER
6	27	5	1	SILI060001	MAERKER
2.0+1	1.046+0	1.046+0	4.23-1	SILI060002	MAERKER
1.5+1	1.061+0	1.061+0	5.28-1	SILI060003	MAERKER
1.0+1	1.122+0	1.122+0	7.14-1	SILI060004	MAERKER
8.0+0	1.180+0	1.180+0	8.38-1	SILI060005	MAERKER
6.0+0	1.289+0	1.289+0	1.025+0	SILI060006	MAERKER
5.0+0	1.376+0	1.376+0	1.160+0	SILI060007	MAERKER
4.0+0	1.505+0	1.505+0	1.343+0	SILI060008	MAERKER
3.0+0	1.711+0	1.711+0	1.611+0	SILI060009	MAERKER
2.0+0	2.085+0	2.085+0	2.05+0	SILI060010	MAERKER
1.5+0	2.4088+0	2.4088+0	2.40+0	SILI060011	MAERKER
1.0+0	2.96+0	2.96+0	2.96+0	SILI060012	MAERKER
8.0-1	3.29+0	3.29+0	3.29+0	SILI060013	MAERKER
6.0-1	3.74+0	3.74+0	3.74+0	SILI060014	MAERKER
5.0-1	4.05+0	4.05+0	4.05+0	SILI060015	MAERKER
4.0-1	4.45+0	4.43+0	4.43+0	SILI060016	MAERKER
3.0-1	4.99+0	4.95+0	4.95+0	SILI060017	MAERKER

TABLE XIV (continued)

2.0-1	5.81+0	5.69+0	5.69+0	SILI060018 MAERKER
1.5-1	6.50+0	6.21+0	6.21+0	SILI060019 MAERKER
1.0-1	8.01+0	6.90+0	6.90+0	SILI060020 MAERKER
8.0-2	9.54+0	7.24+0	7.24+0	SILI060021 MAERKER
6.0-2	1.344+1	7.64+0	7.64+0	SILI060022 MAERKER
5.0-2	1.815+1	7.85+0	7.85+0	SILI060023 MAERKER
4.0-2	2.949+1	8.09+0	8.09+0	SILI060024 MAERKER
3.0-2	6.276+1	8.36+0	8.36+0	SILI060025 MAERKER
2.0-2	2.0265+2	8.65+0	8.65+0	SILI060026 MAERKER
1.5-2	4.7881+2	8.81+0	8.81+0	SILI060027 MAERKER
1.0-2	1.58896+3	8.96+0	8.96+0	SILI060028 MAERKER
6	27	6 1		MAGN060001 MAERKER
2.0+1	8.22-1	8.22-1	3.63-1	MAGN060002 MAERKER
1.5+1	8.46-1	8.46-1	4.53-1	MAGN060003 MAERKER
1.0+1	9.12-1	9.12-1	6.12-1	MAGN060004 MAERKER
8.0+0	9.70-1	9.70-1	7.19-1	MAGN060005 MAERKER
6.0+0	1.072+0	1.072+0	8.78-1	MAGN060006 MAERKER
5.0+0	1.153+0	1.153+0	9.94-1	MAGN060007 MAERKER
4.0+0	1.271+0	1.271+0	1.152+0	MAGN060008 MAERKER
3.0+0	1.454+0	1.454+0	1.381+0	MAGN060009 MAERKER
2.0+0	1.783+0	1.783+0	1.757+0	MAGN060010 MAERKER
1.5+0	2.0664+0	2.0664+0	2.06+0	MAGN060011 MAERKER
1.0+0	2.53+0	2.53+0	2.53+0	MAGN060012 MAERKER
8.0-1	2.82+0	2.82+0	2.82+0	MAGN060013 MAERKER
6.0-1	3.21+0	3.21+0	3.21+0	MAGN060014 MAERKER
5.0-1	3.47+0	3.47+0	3.47+0	MAGN060015 MAERKER
4.0-1	3.81+0	3.80+0	3.80+0	MAGN060016 MAERKER
3.0-1	4.26+0	4.24+0	4.24+0	MAGN060017 MAERKER
2.0-1	4.94+0	4.88+0	4.88+0	MAGN060018 MAERKER
1.5-1	5.46+0	5.32+0	5.32+0	MAGN060019 MAERKER
1.0-1	6.44+0	5.91+0	5.91+0	MAGN060020 MAERKER
8.0-2	7.31+0	6.20+0	6.20+0	MAGN060021 MAERKER
6.0-2	9.35+0	6.55+0	6.55+0	MAGN060022 MAERKER
5.0-2	1.183+1	6.73+0	6.73+0	MAGN060023 MAERKER
4.0-2	1.754+1	6.94+0	6.94+0	MAGN060024 MAERKER
3.0-2	3.436+1	7.16+0	7.16+0	MAGN060025 MAERKER
2.0-2	1.0712+2	7.42+0	7.42+0	MAGN060026 MAERKER
1.5-2	2.5355+2	7.55+0	7.55+0	MAGN060027 MAERKER
1.0-2	8.5468+2	7.68+0	7.68+0	MAGN060028 MAERKER
6	27	7 1		IRON060001 MAERKER
2.0+1	2.886+0	2.886+0	7.86-1	IRON060002 MAERKER
1.5+1	2.791+0	2.791+0	9.81-1	IRON060003 MAERKER
1.0+1	2.716+0	2.716+0	1.326+0	IRON060004 MAERKER
8.0+0	2.727+0	2.727+0	1.557+0	IRON060005 MAERKER
6.0+0	2.813+0	2.813+0	1.903+0	IRON060006 MAERKER
5.0+0	2.90+0	2.90+0	2.15+0	IRON060007 MAERKER
4.0+0	3.06+0	3.06+0	2.50+0	IRON060008 MAERKER
3.0+0	3.34+0	3.34+0	2.99+0	IRON060009 MAERKER
2.0+0	3.93+0	3.93+0	3.81+0	IRON060010 MAERKER
1.5+0	4.492+0	4.492+0	4.46+0	IRON060011 MAERKER
1.0+0	5.52+0	5.49+0	5.49+0	IRON060012 MAERKER
8.0-1	6.16+0	6.11+0	6.11+0	IRON060013 MAERKER
6.0-1	7.06+0	6.96+0	6.96+0	IRON060014 MAERKER
5.0-1	7.68+0	7.52+0	7.52+0	IRON060015 MAERKER
4.0-1	8.52+0	8.23+0	8.23+0	IRON060016 MAERKER
3.0-1	9.85+0	9.19+0	9.19+0	IRON060017 MAERKER
2.0-1	1.28+1	1.057+1	1.057+1	IRON060018 MAERKER
1.5-1	1.693+1	1.153+1	1.153+1	IRON060019 MAERKER
1.0-1	3.192+1	1.282+1	1.282+1	IRON060020 MAERKER
8.0-2	5.144+1	1.344+1	1.344+1	IRON060021 MAERKER
6.0-2	1.052+2	1.420+1	1.420+1	IRON060022 MAERKER

TABLE XIV (continued)

5.0-2	1.6959+2	1.459+1	1.459+1	IRON060023	MAERKER
4.0-2	3.2303+2	1.503+1	1.503+1	IRON060024	MAERKER
3.0-2	7.4452+2	1.552+1	1.552+1	IRON060025	MAERKER
2.0-2	2.3961+3	1.607+1	1.607+1	IRON060026	MAERKER
1.5-2	5.3964+3	1.635+1	1.635+1	IRON060027	MAERKER
1.0-2	1.6517+4	1.664+1	1.664+1	IRON060028	MAERKER
6	27	8 1		ALUM060001	MAERKER
2.0+1	9.32-1	9.32-1	3.93-1	ALUM060002	MAERKER
1.5+1	9.50-1	9.50-1	4.90-1	ALUM060003	MAERKER
1.0+1	1.016+0	1.016+0	6.63-1	ALUM060004	MAERKER
8.0+0	1.073+0	1.073+0	7.78-1	ALUM060005	MAERKER
6.0+0	1.179+0	1.179+0	9.52-1	ALUM060006	MAERKER
5.0+0	1.263+0	1.263+0	1.077+0	ALUM060007	MAERKER
4.0+0	1.387+0	1.387+0	1.247+0	ALUM060008	MAERKER
3.0+0	1.582+0	1.582+0	1.496+0	ALUM060009	MAERKER
2.0+0	1.933+0	1.933+0	1.903+0	ALUM060010	MAERKER
1.5+0	2.2376+0	2.2376+0	2.23+0	ALUM060011	MAERKER
1.0+0	2.75+0	2.75+0	2.75+0	ALUM060012	MAERKER
8.0-1	3.06+0	3.06+0	3.06+0	ALUM060013	MAERKER
6.0-1	3.48+0	3.48+0	3.48+0	ALUM060014	MAERKER
5.0-1	3.76+0	3.76+0	3.76+0	ALUM060015	MAERKER
4.0-1	4.13+0	4.12+0	4.12+0	ALUM060016	MAERKER
3.0-1	4.62+0	4.60+0	4.60+0	ALUM060017	MAERKER
2.0-1	5.37+0	5.29+0	5.29+0	ALUM060018	MAERKER
1.5-1	5.98+0	5.77+0	5.77+0	ALUM060019	MAERKER
1.0-1	7.19+0	6.41+0	6.41+0	ALUM060020	MAERKER
8.0-2	8.33+0	6.72+0	6.72+0	ALUM060021	MAERKER
6.0-2	1.11+1	7.10+0	7.10+0	ALUM060022	MAERKER
5.0-2	1.459+1	7.29+0	7.29+0	ALUM060023	MAERKER
4.0-2	2.271+1	7.51+0	7.51+0	ALUM060024	MAERKER
3.0-2	4.676+1	7.76+0	7.76+0	ALUM060025	MAERKER
2.0-2	1.4903+2	8.03+0	8.03+0	ALUM060026	MAERKER
1.5-2	3.5118+2	8.18+0	8.18+0	ALUM060027	MAERKER
1.0-2	1.17832+3	8.32+0	8.32+0	ALUM060028	MAERKER

TABLE XV H01 Secondary Gamma-Ray Problem Output

```
PRØBLEM NUMBER 1660 0, SECØNDARY GAMMAS
INPUT DATA

NLIB   =      0          XO   = 0.00000E-38
NTAP   =      0          YO   = 0.00000E-38
ISRCTP =      0          ZO   = 0.00000E-38
IQID   =     -0          DMAX = 0.30000E 03
NHIST  =     50          EMIN = 0.10000E-01
NREG   =     11          WMIN = 0.00000E-38
NUB    =******           ELD  = 0.20000E 02
NEL    =      8          ETM  =-0.00000E-38
NMAT   =      1          RR   = 0.10000E 00
NSG    =      1          ELØW =-0.00000E-38
MAXCØL =     30          TEMP =-0.00000E-38
NRG    =      2          R1 =         0.
IHTAPE =    167          R2 =         0.
NSØT   =      1
NTYP   =      1          NBUNCH =      1

NPRINT(6)
   2    2    2    2    2    0

MTPREC(3)
   5    1   -0

NST(3)
   1   -0   -0

NØPTSM(10)
  -0

EGRP(20)
  0.10000E-01

EMAX(20)
  0.20000E 02

ESI(8)
 -0.00000E-38  -0.00000E-38  -0.00000E-38  -0.00000E-38  -0.00000E-38  -0.00000E-38  -0.00000E-38  -0.00000E-38

ATWT(8)
  0.10080E 01  0.12010E 02  0.16000E 02  0.40080E 02  0.28090E 02  0.24320E 02  0.55850E 02  0.26980E 02

DN(10,8)
  0.85000E-02  0.20200E-01  0.35500E-01  0.11100E-01  0.17000E-02  0.18600E-02  0.19300E-03  0.55600E-03

NB(50)
   3    3    3    3    3    3    3    3    3    3    3

MATREG(50)
   1    0    1    1    1    1    1    1    1    1    1

T(2), ISTAP(25)
    SØURCE        0
```

TABLE XV (continued)

PARTICLE HISTØRY TERMINATIØNS

NUMBER ØF PARTICLES	REASØNS FØR TERMINATIØNS
27	NUMBER ØF CØLLISIØNS = 30, THE MAXIMUM ALLØWED
0	THE SCATTERED ENERGY IS LESS THAN 0.1000E-01 MEV, THE MINIMUM ALLØWED
0	THE WEIGHT IS LESS THAN 0.0000E-38, THE MINIMUM ALLØWED
0	THE CØLLISIØN PØINT IS FARTHER THAN 0.300E 03 CM FRØM THE SØURCE
0	ESCAPES FRØM SØURCE REGIØN INTØ VACUUM WITHØUT UNDERGØING A CØLLISIØN
0	ESCAPES FRØM SØURCE REGIØN INTØ VACUUM AFTER UNDERGØING AT LEAST ØNE CØLLISIØN
16	ESCAPES FRØM MAIN GEØMETRY INTØ VACUUM

0.891000E 03=TØTAL NUMBER ØF CØLLISIØNS

TABLE XV (continued)

PRØBLEM NUMBER 1660 0, SECØNDARY GAMMAS

ENERGY DEPØSITIØN (MEV) BY REGIØN

REGIØN NUMBER	ABSØRPTIØN	STD. DEV.	SCATTERING	STD. DEV.	MINIMUM WT. AND ENERGY	STD. DEV.	TØTAL	STD. DEV.
1	2.61092E-03	8.16983E-04	5.74975E-02	3.00986E-02	0.00000E-39	0.00000E-39	6.01084E-02	3.00580E-02
2	0.00000E-39	0.00000E-39	0.00000E-39	0.00000E-39	0.00000E-39	0.00000E-39	0.00000E-39	0.00000E-39
3	9.90604E-04	3.41819E-04	2.77488E-01	1.36589E-01	0.00000E-39	0.00000E-39	2.78478E-01	1.36558E-01
4	5.24465E-03	8.93480E-04	5.91461E-02	2.27135E-02	0.00000E-39	0.00000E-39	6.43908E-02	2.25759E-02
5	1.02359E-02	1.33182E-03	2.16177E-01	5.02188E-02	0.00000E-39	0.00000E-39	2.26413E-01	4.94551E-02
6	2.44539E-03	4.89987E-04	1.55902E-01	5.95502E-02	0.00000E-39	0.00000E-39	1.58348E-01	5.94569E-02
7	1.00560E-02	7.84025E-04	2.47664E-01	8.19159E-02	0.00000E-39	0.00000E-39	2.57720E-01	8.13656E-02
8	7.18258E-03	8.91556E-04	1.09554E-01	4.55087E-02	0.00000E-39	0.00000E-39	1.16736E-01	4.52096E-02
9	4.24112E-03	6.71701E-04	1.59628E-01	7.16552E-02	0.00000E-39	0.00000E-39	1.63870E-01	7.14879E-02
10	3.49445E-03	4.64083E-04	1.32702E-02	4.73204E-03	0.00000E-39	0.00000E-39	1.67647E-02	4.67323E-03
11	1.35825E-03	4.15768E-04	5.61321E-02	4.51468E-02	0.00000E-39	0.00000E-39	5.74903E-02	4.51223E-02
TØTAL	4.78599E-02		1.35246E 00		0.00000E-39		1.40032E 00	

TAPE LABELED HISTØRY 167 WAS GENERATED. IT CØNTAINS 46 RECØRDS.
THE LAST RECØRD CØNTAINS 11 SETS ØF CØLLISIØN DATA.

TABLE XVI

A02 Sample Input Data

```
12    19     1      1.0-2     8     2     1    11     3    10     1  1660000001
HISTORY    LEAKAGE            1           50    46    11     0     0  1660000002
 1.0-03                                                              1660000003
    167                                                           0  1660000004
  891.5                                                              1660000005
27                                                                   1660000006
  1.0-1     2.0-1     5.0-1     7.5-1     1.0+0     1.5+0            1660000007
  2.0+0     3.0+0     4.5+0     6.0+0     8.0+0     1.0+1            1660000008
  0.0+0    10.0+0    20.0+0    30.0+0    40.0+0    50.0+0            1660000009
 60.0+0    70.0+0    80.0+0    90.0+0   100.0+0   110.0+0            1660000010
120.0+0   130.0+0   140.0+0   150.0+0   160.0+0   170.0+0            1660000011
180.0+0                                                              1660000012
  1.0-2     2.0+1                                                    1660000013
                                                                     1660000014
                                                                     1660000015
1.008+00  12.01+00  16.0+00  40.08+00  28.09+00  24.32+00            1660000016
55.85+00  26.98+00                                                   1660000017
8.50-03   2.02-02   3.55-02   1.11-02   1.70-03   1.86-03            1660000018
1.93-04   5.56-04                                                    1660000019
      3         3         3         3         3         3            1660000020
      3         3         3         3         3                      1660000021
      1         0         1         1         1         1            1660000022
      1         1         1         1         1                      1660000023
```

TABLE XVII A02 Sample Output Data

NUMBER CURRENT VERSUS ANGLE AND ENERGY

ENERGY (MEV) ,	POLAR ANGLE (DEGREES) 10.000	20.000	30.000	40.000	50.000	60.000	70.000	80.000
0.20000E 00	0.27287E-35	0.23879E-11	0.43561E-10	0.31713E-10	0.51720E-07	0.66911E-04	0.55959E-04	0.34741E-05
0.50000E 00	0.00000E-38	0.72007E-03	0.32281E-08	0.16925E-07	0.74621E-08	0.12143E-03	0.49648E-11	0.57886E-07
0.75000E 00	0.00000E-38	0.14154E-05	0.46524E-05	0.34104E-06	0.49276E-07	0.15489E-08	0.51131E-12	0.41270E-16
0.10000E 01	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.85201E-07	0.00000E-38	0.49808E-10	0.40480E-17
0.15000E 01	0.00000E-38	0.00000E-38	0.49442E-05	0.14439E-05	0.00000E-38	0.00000E-38	0.22942E-08	0.42942E-17
0.20000E 01	0.00000E-38	0.00000E-38	0.15359E-04	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38
0.30000E 01	0.76190E-04	0.00000E-38	0.86766E-04	0.18642E-04	0.18085E-04	0.27273E-05	0.40907E-07	0.00000E-38
0.45000E 01	0.00000E-38	0.00000E-38	0.14182E-03	0.13012E-02	0.00000E-38	0.10599E-04	0.00000E-38	0.00000E-38
0.60000E 01	0.00000E-38	0.00000E-38	0.36980E-03	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38
0.80000E 01	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38
0.10000E 02	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38
SUM	0.76190E-04	0.72149E-03	0.62334E-03	0.13216E-02	0.18279E-04	0.20167E-03	0.56002E-04	0.35320E-05

TABLE XVII (continued)

NUMBER CURRENT VERSUS ANGLE AND ENERGY

ENERGY (MEV) ,	POLAR ANGLE (DEGREES) 90.000	100.000	110.000	120.000	130.000	140.000	150.000	160.000
0.20000E 00	0.31117E-11	0.31796E-07	0.47625E-04	0.15588E-03	0.86762E-02	0.96095E-02	0.21614E-02	0.10027E-01
0.50000E 00	0.13738E-27	0.33400E-02	0.16906E-01	0.87633E-02	0.29617E-02	0.14440E-02	0.97219E-02	0.00000E-38
0.75000E 00	0.45957E-23	0.34488E-25	0.39143E-02	0.45334E-03	0.14364E-01	0.00000E-38	0.00000E-38	0.87076E-02
0.10000E 01	0.00000E-38	0.00000E-38	0.44805E-07	0.13891E-01	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38
0.15000E 01	0.23223E-17	0.65592E-04	0.53671E-02	0.00000E-38	0.21656E-01	0.89859E-02	0.17714E-01	0.16839E-01
0.20000E 01	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.51366E-02	0.30099E-02	0.00000E-38	0.00000E-38
0.30000E 01	0.00000E-38	0.00000E-38	0.13013E-01	0.32459E-02	0.13132E-02	0.12871E-01	0.35160E-02	0.00000E-38
0.45000E 01	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.19540E-02	0.00000E-38	0.12786E-01	0.00000E-38
0.60000E 01	0.00000E-38	0.00000E-38	0.55883E-02	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.25234E-01
0.80000E 01	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38
0.10000E 02	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38
SUM	0.31117E-11	0.34056E-02	0.44836E-01	0.26510E-01	0.56062E-01	0.35920E-01	0.45899E-01	0.60807E-01

TABLE XVII (continued)

NUMBER CURRENT VERSUS ANGLE AND ENERGY

ENERGY (MEV) ,	POLAR ANGLE (DEGREES) 170.000	180.000	SUM
0.20000E 00	0.13644E-02	0.56108E-03	0.32730E-01
0.50000E 00	0.66722E-02	0.33509E-02	0.54001E-01
0.75000E 00	0.00000E-38	0.00000E-38	0.27446E-01
0.10000E 01	0.00000E-38	0.00000E-38	0.13892E-01
0.15000E 01	0.30055E-01	0.00000E-38	0.10069E 00
0.20000E 01	0.00000E-38	0.00000E-38	0.81619E-02
0.30000E 01	0.32772E-01	0.13489E-01	0.80423E-01
0.45000E 01	0.00000E-38	0.00000E-38	0.16194E-01
0.60000E 01	0.00000E-38	0.00000E-38	0.31192E-01
0.80000E 01	0.00000E-38	0.00000E-38	0.00000E-38
0.10000E 02	0.00000E-38	0.00000E-38	0.00000E-38
SUM	0.70864E-01	0.17401E-01	0.36473E 00

TABLE XVII (continued)

FLUXES VERSUS REGIØN AND ENERGY

ENERGY (MEV)	REGIØN NUMBER 1	2	3	4	5	6	7	8
0.20000E 00	0.10595E 00	0.00000E-38	0.23494E 00	0.43479E 00	0.11996E 01	0.54744E 00	0.10604E 01	0.72272E 00
0.50000E 00	0.44932E 00	0.00000E-38	0.32100E 00	0.38424E 00	0.82687E 00	0.65579E 00	0.90441E 00	0.42403E 00
0.75000E 00	0.92143E-01	0.00000E-38	0.20253E 00	0.34167E 00	0.31946E 00	0.26636E 00	0.45763E 00	0.23684E 00
0.10000E 01	0.50581E-01	0.00000E-38	0.30072E-01	0.72945E-01	0.18548E 00	0.15152E 00	0.21222E 00	0.47209E-01
0.15000E 01	0.45798E 00	0.00000E-38	0.27122E 00	0.37296E 00	0.90743E 00	0.53532E 00	0.34645E 00	0.70264E-01
0.20000E 01	0.19953E-01	0.00000E-38	0.25386E-01	0.32305E-01	0.93476E-01	0.13253E 00	0.10048E-01	0.75371E-02
0.30000E 01	0.20208E 00	0.00000E-38	0.13397E 00	0.14951E 00	0.36269E 00	0.38668E 00	0.70172E 00	0.40035E 00
0.45000E 01	0.25566E-01	0.00000E-38	0.28478E-01	0.64576E-02	0.16517E-01	0.22829E-01	0.96474E-01	0.14775E 00
0.60000E 01	0.73793E-01	0.00000E-38	0.57522E-01	0.62541E-01	0.17679E 00	0.00000E-38	0.00000E-38	0.00000E-38
0.80000E 01	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38
0.10000E 02	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38
SUM	0.14774E 01	0.00000E-38	0.13051E 01	0.18574E 01	0.40883E 01	0.26985E 01	0.37893E 01	0.20567E 01

TABLE XVII (continued)

FLUXES VERSUS REGIØN AND ENERGY

ENERGY (MEV)	REGIØN NUMBER 9	10	11	SUM
0.20000E 00	0.49676E 00	0.28434E 00	0.15136E 00	0.52382E 01
0.50000E 00	0.26096E 00	0.25901E 00	0.16542E 00	0.46511E 01
0.75000E 00	0.32336E 00	0.13003E 00	0.76898E-02	0.23777E 01
0.10000E 01	0.13049E 00	0.13081E-01	0.14601E-03	0.89374E 00
0.15000E 01	0.90218E-01	0.21562E-01	0.21565E-02	0.30756E 01
0.20000E 01	0.43282E-01	0.19478E-01	0.40491E-02	0.38804E 00
0.30000E 01	0.27617E 00	0.13070E 00	0.34632E-01	0.27785E 01
0.45000E 01	0.10809E 00	0.61525E-01	0.18616E 00	0.69985E 00
0.60000E 01	0.48478E-01	0.50542E-01	0.29330E-01	0.49900E 00
0.80000E 01	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38
0.10000E 02	0.00000E-38	0.00000E-38	0.00000E-38	0.00000E-38
SUM	0.17778E 01	0.97027E 00	0.58094E 00	0.20602E 02

secondary gamma-ray flux for a plane parallel source, the track lengths should be divided by only the thickness of the region. Both the current as a function of energy and angle and the fluxes as a function of region and energy have been normalized to a unit current incident upon the slab by dividing by the number of histories.

3.5 A02 FORTRAN-IV Listings

```
C     A02      FLUX ANALYSIS CODE
C THIS ROUTINE OVERLAYS THE LINKS OF THE A02 ANALYSIS PROGRAM
C  TAPE ALLOCATIONS ''' TAPE NO. 1   HISTORY PARTICLE DATA
C                       TAPE NO. 2   HISTORY PARTICLE DATA ( IF NEEDED )
C                       TAPE NO. 3   PARTICLE LEAKAGE
C                       TAPE NO. 4   PARTICLE LEAKAGE  ( IF NEEDED )
C                       TAPE NO. 9   CROSS SECTIONS
      COMMON /CROSS/ NENEGY, ENERGY(100), TCS(8,100)
      COMMON /JUNK/ A, A0(20), AA1(20), AP12, AT, AT1(20), ATWT(8),
     1 B, B0(20), BA1(20), C, C0(20), CA1(20), CROS, CRSS, DELCT,
     2 DISTM, DSQD, E, EA1(20), E0(20), ELOCUT, EGRP(20), ESI(8),
     3 ESUM(20), EPRINT(21), GPRINT(21), ESP, GRAD(21), H(2), HE(2),
     4 ICOL, IEINTV, IEMAX, IEPMAX, IETAB(20), IGINTV, IGPMAX, IH1,
     5 IH2, IHTAPE, J1NO, ILAST, IPPMAX, IREGSC, J2NO, JM, JTAPE,
     6 JTAPE1, JTAPE2, JA, JI, K, K1, KESC2, KGRP(3,20), KLMAX, KREC,
     7 KS, KTAPE, L1, L2, L3, LBJ, LZ, MATREG(50), MHTAPE(2), MIGHT(2),
     8 MNO, NB1, NEL, NG, NHT, NHIST, NOINT, NN, NR, NR1(20), NR2,
     9 NR1A1(20), NREC, NUB, NLIB, NSG, PID, Q, IQID, S, SUMS, T(50,20)
      COMMON TM(8,100), WEXP(20,20), WEXPA1(20), W0(20), X, X0(20),
     1 X2, XA1(20), Y, Y0(20), Y2, YA1(20), Z, Z0(20), Z2, ZA1(20),
     2 DN(10,8), ISRCTP, ISRCRC, NMAT, ETM, EMAX(20), ILOC, TL(21),
     3 BEG(20), LSO, ILOCUT, WEXPD, BEGGER(20,20), NTAP, JSENSE,
     4  AW(20), IX1, MKREC(2), INLIBR(11), INSUPR(20), INELEM(8),
     5 GSUM(20), P(50,20)
     5 /GEOM1/ IBT( 75), AF( 75), ZF( 75), CF( 75), XF( 75), YF( 75),
     6 IBN(50,9), MPR(50,9), NB(50), EPSL, NBD, NREG
     2 /CARDC/ IS, IS1, IL, IL1, FLIB, NPRINT(9), MS
      CALL ANAL02
      CALL HEAT1
      CALL RESULT
      STOP
      END
```

```
      SUBROUTINE PRINTS (I,L)
      COMMON /CROSS/ NENEGY, ENERGY(100), TCS(8,100)
      COMMON /JUNK/ A, A0(20), AA1(20), AP12, AT, AT1(20), ATWT(8),
     1 B, B0(20), BA1(20), C, C0(20), CA1(20), CROS, CRSS, DELCT,
     2 DISTM, DSQD, E, EA1(20), E0(20), ELOCUT, EGRP(20), ESI(8),
     3 ESUM(20), EPRINT(21), GPRINT(21), ESP, GRAD(21), H(2), HE(2),
     4 ICOL, IEINTV, IEMAX, IEPMAX, IETAB(20), IGINTV, IGPMAX, IH1,
     5 IH2, IHTAPE, J1NO, ILAST, IPPMAX, IREGSC, J2NO, JM, JTAPE,
     6 JTAPE1, JTAPE2, JA, JI, K, K1, KESC2, KGRP(3,20), KLMAX, KREC,
     7 KS, KTAPE, L1, L2, L3, LBJ, LZ, MATREG(50), MHTAPE(2), MIGHT(2),
     8 MNO, NB1, NEL, NG, NHT, NHIST, NOINT, NN, NR, NR1(20), NR2,
     9 NR1A1(20), NREC, NUB, NLIB, NSG, PID, Q, IQID, S, SUMS, T(50,20)
      COMMON TM(8,100), WEXP(20,20), WEXPA1(20), W0(20), X, X0(20),
     1 X2, XA1(20), Y, Y0(20), Y2, YA1(20), Z, Z0(20), Z2, ZA1(20),
     2 DN(10,8), ISRCTP, ISRCRC, NMAT, ETM, EMAX(20), ILOC, TL(21),
     3 BEG(20), LSO, ILOCUT, WEXPD, BEGGER(20,20), NTAP, JSENSE,
     4  AW(20), IX1, MKREC(2), INLIBR(11), INSUPR(20), INELEM(8),
     5 GSUM(20), P(50,20)
     5 /GEOM1/ IBT( 75), AF( 75), ZF( 75), CF( 75), XF( 75), YF( 75),
     6 IBN(50,9), MPR(50,9), NB(50), EPSL, NBD, NREG
     2 /CARDC/ IS, IS1, IL, IL1, FLIB, NPRINT(9), MS
      CALL DUMP
      RETURN
      END
```

```
      SUBROUTINE ANAL02
C
      COMMON /CROSS/ NENEGY, ENERGY(100), TCS(8,100)
      COMMON /JUNK/ A, A0(20), AA1(20), AP12, AT, AT1(20), ATWT(8),
     1 B, B0(20), BA1(20), C, C0(20), CA1(20), CROS, CRSS, DELCT,
     2 DISTM, DSQD, E, EA1(20), E0(20), ELOCUT, EGRP(20), ESI(8),
     3 ESUM(20), EPRINT(21), GPRINT(21), ESP, GRAD(21), H(2), HE(2),
     4 ICOL, IEINTV, IEMAX, IEPMAX, IETAB(20), IGINTV, IGPMAX, IH1,
     5 IH2, IHTAPE, J1NO, ILAST, IPPMAX, IREGSC, J2NO, JM, JTAPE,
     6 JTAPE1, JTAPE2, JA, JI, K, K1, KESC2, KGRP(3,20), KLMAX, KREC,
     7 KS, KTAPE, L1, L2, L3, LBJ, LZ, MATREG(50), MHTAPE(2), MIGHT(2),
     8 MNO, NB1, NEL, NG, NHT, NHIST, NOINT, NN, NR, NR1(20), NR2,
     9 NR1A1(20), NREC, NUB, NLIB, NSG, PID, Q, IQID, S, SUMS, T(50,20)
      COMMON TM(8,100), WEXP(20,20), WEXPA1(20), W0(20), X, X0(20),
     1 X2, XA1(20), Y, Y0(20), Y2, YA1(20), Z, Z0(20), Z2, ZA1(20),
     2 DN(10,8), ISRCTP, ISRCRC, NMAT, ETM, EMAX(20), ILOC, TL(21),
     3 BEG(20), LSO, ILOCUT, WEXPD, BEGGER(20,20), NTAP, JSENSE,
     4  AW(20), IX1, MKREC(2), INLIBR(11), INSUPR(20), INELEM(8),
     5 GSUM(20), P(50,20)
     5 /GEOM1/ IBT( 75), AF( 75), ZF( 75), CF( 75), XF( 75), YF( 75),
     6 IBN(50,9), MPR(50,9), NB(50), EPSL, NBD, NREG
     2 /CARDC/ IS, IS1, IL, IL1, FLIB, NPRINT(9), MS
C
      READ  (5      ,5)IEPMAX, IGPMAX, LSO, ELOCUT,     NEL,       NG, NH
     1T, NREG, NUB, NLIB, NMAT, PID, NN1, IS1
   30 FORMAT (12I5, 2XA4,I2,I4)
    5 FORMAT(3I5,E10.0,7I5,2XA4,I2,I4)
      LSO = LSO + 1
   20 N1=1
      READ  (5      ,40)H(1), H(2), HE(1), HE(2), J2NO, NSG, IQID,  NHIST
     1, MKREC(1), MKREC(2), ISRCTP, NTAP, NN, IS
   40 FORMAT (1H , A6,A3,1XA6,A3,8I5,6XI2,I4)
      IF (IS1-N1)             80, 50, 80
   50 IF (IS-IS1-N1)          70, 60, 70
   60 IF (NN1-NN)             70, 87, 70
   70 NN = NN + 100
      IS = IS + 10000

      WRITE (6,85)PID,NN,IS
      CALL EXIT
   80 NN1= NN1+ 100
      IS1= IS1+ 10000
      WRITE (6,85)PID,NN1,IS1
      CALL EXIT
   85 FORMAT (35H0DISCREPANCY IN I.D. FIELD OF CARD, A4, I2, I4)
   87 READ  (5      ,25)EPSL, NN1, IS1
   25 FORMAT (1E10.4,56XI2,I4)
      IF (NN - NN1)           80, 88, 80
   88 IF (IS1 -IS - N1)            70, 89, 70
   89 IS = IS1
```

```
      READ  (5      ,1000)(MHTAPE(I), I=1,2 ),JSENSE, NN1, IS1
 1000 FORMAT  (3I10, 36XI2,I4 )
      IF (IS1-IS-N1)            80, 1010, 80
 1010 IF (NN1-NN)               80, 1020, 80
 1020 IS = IS1
 1070 IF (NHT)                  90, 90, 1085
 1085 DO 1140   IXZ = 1,NHT
      READ  (5      ,95)(BEGGER(IXZ,IP), IP=1,6), NN1, IS1
      IF (IS1-IS-N1)            80, 1090, 80
 1090 IF (NN1-NN)               80, 1100, 80
 1100 IS = IS1
      IF (NSG - 6)            1140, 1140, 1110
 1110 READ  (5      ,95)(BEGGER(IXZ,IP), IP=7,12), NN1, IS1
      IF (IS1-IS-N1)            80, 1120, 80
 1120 IF (NN1-NN)               80, 1130, 80
 1130 IS = IS1
      IF (NSG-12)             1140, 1140, 1131
 1131 READ  (5      ,95)(BEGGER(IXZ,IP), IP=13,18), NN1,IS1
      IF (IS1-IS-N1)            80, 1132, 80
 1132 IF (NN1-NN)               80, 1133, 80
 1133 IS = IS1
      IF (NSG-18)             1140, 1140, 1134
 1134 READ  (5      ,1137)BEGGER(IXZ,19), BEGGER(IXZ,20),NN1,IS1
      IF (IS1-IS-N1)            80, 1135, 80
 1135 IF (NN1-NN)               80, 1136, 80
 1136 IS = IS1
 1137 FORMAT (2E10.0,46XI2,I4)
 1140 CONTINUE
   90 READ  (5      ,91)(IETAB(I), I=1,12), NN1, IS1
   91 FORMAT (12I5, 6XI2,I4)
   95 FORMAT (6E10.0,6XI2,I4)
   96  FORMAT (4E10.0,26XI2,I4)
      CALL SLITE (0)
      IF (IS1-IS-N1)           80, 97, 80
   97 IF (NN1-NN)              80, 99, 80
   99 IS=IS1
      IF (NSG-12)              110, 110, 101
  101 READ  (5      ,1080)(IETAB(I), I=13,20), NN1, IS1
 1080 FORMAT  (8I5,  26XI2,  I4)
      IF (IS1-IS-N1)           80, 102, 80
  102 IF (NN1-NN)              80, 103, 80
  103 IS=IS1
  110 CALL ANGRED (IEPMAX,IS,IS1,NN,NN1, EPRINT(1))
      CALL SLITET(1,K000FX)
       GO TO(80,112),K000FX
  112 CALL ANGRED (IGPMAX,IS,IS1,NN,NN1, GPRINT(1))
      CALL SLITET(1,K000FX)
       GO TO(80,114),K000FX
  114 IQID= IQID+10000
```

```
      ICOL=0
      JTAPE1=0
      JTAPE2=1
      KREC  =0

      J2NO = J2NO + 10000
      DO 126   I=1, IGPMAX
  126 GRAD(I) = COS(GPRINT(I)*.0174533)
      DO 128   I = 1, NHT
  128 MIGHT(I) = MHTAPE(I)
C
C CARDS A130 THRU A304 WERE REPRODUCED FROM CODE H01, MAIN PROGRAM
  130 JZ=NSG/4
      K1=NSG-4*JZ
      K2=0
      K3=0
      K4=0
      K5=0
      IF(JZ)                  160, 160, 140
  140 DO 150   I=1,JZ
      K2 = K5+1
      K3 = K2+1
      K4 = K3+1
      K5 = K4+1
      READ  (5      ,96)(EGRP(M),EMAX(M),       M=K2,K3),NN,IS
      JACK=4
      IF (NN-NN1)             70, 142, 70
  142 IF (IS-IS1-N1)          70, 144, 70
  144 READ  (5      ,96)(EGRP(M),EMAX(M),       M=K4,K5),NN1,IS1
      JACK=5
      IF (NN-NN1)             80, 146, 80
  146 IF (IS1-IS-N1)          80, 150, 80
  150 CONTINUE
  160 K2=K5+1
      IF(K1)                  195, 195, 162
  162 GO TO (170, 180, 180), K1
  170 READ  (5      ,164)EGRP(K2),EMAX(K2),        NN,IS
  164 FORMAT (2E10.4, 46X     I2,I4)
      JACK= 6
      IF (NN-NN1)             70, 175, 70
  175 IF (IS-IS1-N1)          70, 195, 70
  180 READ  (5      ,96)EGRP(K2),EMAX(K2),EGRP(K2+1),EMAX(K2+1),NN,IS
      JACK=7
      IF (NN-NN1)             70, 182, 70
  182 IF (IS-IS1-N1)          70, 185, 70
  185 IF (K1-2)               195, 195, 190
  190 READ  (5      ,164)EGRP(K2+2),EMAX(K2+2),          NN,IS1
      JACK=8
      IF (NN-NN1)             80, 192, 80
  192 IF (IS1-IS-N1)          80, 195, 80
```

```
195 IF (IS1-IS)                197, 197, 200
197 IS1=IS
200 READ  (5      ,95)(ESI(I), I=1,6), NN, IS

    JACK=9
    IF (NN-NN1)                70, 205, 70
205 IF (IS-IS1-N1)             70, 210, 70
210 IF (NEL-6)                 230, 230, 215
212 FORMAT (2E10.4, 46X,   I2,I4)
215 READ  (5      ,212)ESI(7), ESI(8), NN1, IS1
    JACK=10
    IF (NN-NN1)                80, 220, 80
220 IF (IS1-IS-N1)             80, 225, 80
225 IS=IS1
230 READ  (5      ,95)(ATWT(I),I=1,6), NN1, IS1
    JACK=11
    IF (NN-NN1)                80, 235, 80
235 IF (IS1-IS-N1)             80, 240, 80
240 IF (NEL-6)                 260, 260, 245
245 READ  (5      ,212)ATWT(7),ATWT(8),NN , IS
    JACK=12
    IF (NN-NN1)                70, 250, 70
250 IF (IS-IS1-N1)             70, 255, 70
255 IS1=IS
260 DO 300  I=1,NMAT
    READ  (5      ,95)(DN(I,J),J=1,6),NN , IS
    JACK=13
    IF (NN-NN1)                70, 265, 70
265 IF (IS-IS1-N1)             70, 270, 70
270 IF (NEL-6)                 295, 295, 275
275 READ  (5      ,212)DN(I,7),DN(I,8),NN1, IS1
    JACK=14
    IF (NN-NN1)                80, 280, 80
280 IF (IS1-IS-N1)             80, 300, 80
295 IS1=IS
300 CONTINUE
    I1=NREG/12
    K1=0
    K2=0
    K3=0
    K4=0
    IF(I1)                     350, 350, 305
305 DO 329  I=1,I1
    K1=K4+1
    K2=K1+5
    K3=K2+1
    K4=K3+5
    READ  (5      ,310)(NB(J), J=K1, K2), NN, IS
310 FORMAT (6I10,     6X     I2,I4)
    JACK=15
```

```
    IF (NN-NN1)                70, 315, 70
315 IF (IS-IS1-N1)             70, 320, 70
320 READ  (5      ,310)(NB(J), J=K3, K4), NN1,IS1
    JACK=16
    IF (NN-NN1)                80, 325, 80
325 IF (IS1-IS-N1)             80, 329, 80
329 CONTINUE
    GO TO 350
330 IF (IS1-IS-N1)             80, 331, 80
331 IF (NN-NN1)                80, 332, 80
332 GO TO (420,415,434,440,446,452,458,464,470,476,500), ILOC
333 IF (IS-IS1-N1)             70, 334, 70
334 IF (NN-NN1)                70, 332, 70
350 K1=K4+1
    I1=NREG-12*I1
    IF (I1)                    420, 420, 352
352 GO TO(360,370,380,390,400,410,410,410,410,410,410),I1
360 READ  (5      ,362)NB(K1), NN, IS
362 FORMAT (I10,     56X     I2,I4)
363 JACK=17
    ILOC=1
    GO TO 333
370 READ  (5      ,381)NB(K1),NB(K1+1), NN, IS
    GO TO 363
380 K2=K1+2
    READ  (5      ,382)(NB(J), J=K1,K2), NN, IS
381 FORMAT (2I10,    46X     I2,I4)
382 FORMAT (3I10,    36X     I2,I4)
    GO TO 363
390 K2=K1+3
    READ  (5      ,392)(NB(J), J=K1,K2), NN, IS
392 FORMAT (4I10,    26X     I2,I4)
    GO TO 363
400 K2=K1+4
    READ  (5      ,402)(NB(J), J=K1,K2), NN, IS
402 FORMAT (5I10,    16X     I2,I4)
    GO TO 363
410 K2=K1+5
    READ  (5      ,310)(NB(J),J=K1,K2), NN, IS
    JACK=18
    ILOC=2
    GO TO 333
415 K1=K2+1
    IS1=IS
    I1=I1-6
    IF(I1)                     420, 420, 352
420 IF (IS-IS1)                425, 430, 430
425 IS=IS1
430 READ  (5      ,310)(MATREG(I),I= 1,6), NN1 , IS1
    JACK=19
```

```
      ILOC=3
      GO TO 330
  434 IF(NREG-6)              500, 500, 436
  436 READ  (5      ,310)(MATREG(I),I= 7,12), NN , IS
      ILOC=4
      GO TO 333
  440 IF(NREG-12)             500, 500, 442
  442 READ  (5      ,310)(MATREG(I),I=13,18),NN1 , IS1
      ILOC=5
      GO TO 330
  446 IF(NREG-18)             500, 500, 448
  448 READ  (5      ,310)(MATREG(I),I=19,24), NN , IS
      ILOC=6
      GO TO 333
  452 IF(NREG-24)             500, 500, 454
  454 READ  (5      ,310)(MATREG(I),I=25,30),NN1 , IS1
      ILOC=7
      GO TO 330
  458 IF(NREG-30)             500, 500, 460
  460 READ  (5      ,310)(MATREG(I),I=31,36), NN , IS
      ILOC=8
      GO TO 333
  464 IF(NREG-36)             500, 500, 466
  466 READ  (5      ,310)(MATREG(I),I=37,42),NN1 , IS1
      ILOC=9
      GO TO 330
  470 IF(NREG-42)             500, 500, 472
  472 READ  (5      ,310)(MATREG(I),I=43,48), NN , IS
      ILOC=10
      GO TO 333
  476 IF(NREG-48)             500, 500, 478
  478 READ  (5      ,479)MATREG(49),MATREG(50), NN1, IS1
  479 FORMAT (2I10,    46X     I2,I4)
      ILOC=11
      GO TO 330
  500 IF (IS-IS1)             505, 505, 510
  505 IS=IS1
C
  510 IH1 = MHTAPE (1) + 10000
      IH2 = MHTAPE(NHT)+10000
C
      CALL LIBRED
      RETURN
      END
```

```
C SUBROUTINE CRSWRT IN ANALYSIS CODE A02.                              SUB0010
      SUBROUTINE CRSWRT                                                SUB0020
C                                                                      SUB0080
      COMMON /CROSS/ DUM(901)
      WRITE ( 9     )(DUM(N),N=1,  901)
      RETURN                                                           SUB0130
      END                                                              SUB0140
```

```
C SUBROUTINE LIBRED IN ANALYSIS CODE A02.                                SUB0010
      SUBROUTINE LIBRED                                                  SUB0020
C                                                                        SUB0030
      COMMON /CROSS/ NENEGY, ENERGY(100), TCS(8,100)
      COMMON /JUNK/ A, A0(20), AA1(20), AP12, AT, AT1(20), ATWT(8),
     1 B, B0(20), BA1(20), C, C0(20), CA1(20), CROS, CRSS, DELCT,
     2 DISTM, DSQD, E, EA1(20), E0(20), ELOCUT, EGRP(20), ESI(8),
     3 ESUM(20), EPRINT(21), GPRINT(21), ESP, GRAD(21), H(2), HE(2),
     4 ICOL, IEINTV, IEMAX, IEPMAX, IETAB(20), IGINTV, IGPMAX, IH1,
     5 IH2, IHTAPE, J1NO, ILAST, IPPMAX, IREGSC, J2NO, JM, JTAPE,
     6 JTAPE1, JTAPE2, JA, JI, K, K1, KESC2, KGRP(3,20), KLMAX, KREC,
     7 KS, KTAPE, L1, L2, L3, LBJ, LZ, MATREG(50), MHTAPE(2), MIGHT(2),
     8 MNO, NB1, NEL, NG, NHT, NHIST, NOINT, NN, NR, NR1(20), NR2,
     9 NR1A1(20), NREC, NUB, NLIB, NSG, PID, Q, IQID, S, SUMS, T(50,20)
      COMMON TM(8,100), WEXP(20,20), WEXPA1(20), W0(20), X, X0(20),
     1 X2, XA1(20), Y, Y0(20), Y2, YA1(20), Z, Z0(20), Z2, ZA1(20),
     2 DN(10,8), ISRCTP, ISRCRC, NMAT, ETM, EMAX(20), ILOC, TL(21),
     3 BEG(20), LSO, ILOCUT, WEXPD, BEGGER(20,20), NTAP, JSENSE,
     4  AW(20), IX1, MKREC(2), INLIBR(11), INSUPR(20), INELEM(8),
     5 GSUM(20), P(50,20)
     5 /GEOM1/ IBT( 75), AF( 75), ZF( 75), CF( 75), XF( 75), YF( 75),
     6 IBN(50,9), MPR(50,9), NB(50), EPSL, NBD, NREG
     2 /CARDC/ IS, IS1, IL, IL1, FLIB, NPRINT(9), MS
      L11REC = 0
      NRG = NG                                                           SUB0900
      MS = 1                                                             SUB0910
      NLIBC=2                                                            SUB0920
      DO 2  L=1,2                                                        SUB0930
    2 INLIBR(L)=1                                                        SUB0940
      DO 4  L=3,11                                                       SUB0950
    4 INLIBR(L)=0                                                        SUB0960
      DO 6  L=1,20                                                       SUB0970
    6 INSUPR(L)=0                                                        SUB0980
      DO 8  L=1,8                                                        SUB0990
    8 INELEM(L)=0                                                        SUB1000
      IF (ISRCTP)                                                        SUB1010
   10 INLIBR(5)=1                                                        SUB1020
      NLIBC=NLIBC+1                                                      SUB1030
   12 IF (NTAP)                                                          SUB1040
   14 DO 40 M=1,NSG                                                      SUB1050
   16 INLIBR(6)=INLIBR(6)+NEL                                            SUB1060
   18 INSUPR(M)=INSUPR(M)+NEL                                            SUB1070
      DO 20  L=1,NEL                                                     SUB1080
   20 INELEM(L)=INELEM(L)+1                                              SUB1090
      NLIBC = NLIBC + NEL                                                SUB1100
   40 CONTINUE                                                           SUB1110
   41 IF (NLIBC-NLIB)        42,180,42                                   SUB1120
   42 WRITE (6,44)NLIBC, NLIB                                            SUB1130
   44 FORMAT ( 11HOTHERE ARE , I5, 36H LIBRARIES REQUIRED IN THIS PROBLE SUB1140
     1M./1H , I5, 38H LIBRARIES WERE SUPPLIED IN THE INPUT. )            SUB1150
```

```
      WRITE (6,46)                                                      SUB1160
   46 FORMAT (89HOTHE FOLLOWING LIST OF LIBRARY PARAMETER WILL HELP DETE SUB1170
     1RMINE WHICH LIBRARIES ARE MISSING. )                              SUB1180
      GO TO 581                                                         SUB1190
  110 FORMAT (2I10,4I5, 22X A4, I2, I4)                                 SUB1200
  120 FORMAT (14HOLIBRARY DECK A4, I2, 13H IS IN ERROR.)                SUB1210
  130 IL = IL + 100                                                     SUB1220
      WRITE (6,120)FLIB, IL                                             SUB1230
  140 CALL  EXIT                                                        SUB1240
  150 IL=IL + 100                                                       SUB1250
      IS=IS + 10000                                                     SUB1260
  160 FORMAT (35HODISCREPANCY IN I.D. FIELD OF CARD , A4, I2, I4)       SUB1270
      WRITE (6,160)FLIB, IL, IS                                         SUB1280
      GO TO 140                                                         SUB1290
  170 IL = IL1                                                          SUB1300
      IS = IS1                                                          SUB1310
      GO TO 150                                                         SUB1320
C                                                                       SUB1330
  180 REWIND 9                                                          SUB1340
      L4REC = 1 + NSG                                                   SUB1350
      REWIND 3
      CALL SLITE (0)                                                    SUB1370
      L11REC = 0                                                        SUB1380
  200 READ  (5      ,110)LIBT, I, J, K, N, N1, FLIB, IL,IS              SUB1390
      IF (IS-MS)                150, 210, 150                           SUB1400
  210 IF (LIBT)                 130, 130, 220                           SUB1410
  220 IF (LIBT- 11)             230, 230, 130                           SUB1420
  230 GO TO (240,280,360,360,301,310,360,360,360,360,360),LIBT          SUB1430
  240 NBD=I                                                             SUB1440
      CALL LIB1                                                         SUB1450
      INLIBR(LIBT)=INLIBR(LIBT)-1                                       SUB1460
  250 NLIB=NLIB-1                                                       SUB1470
      CALL SLITET(1,K000FX)                                             SUB1480
       GO TO(150,260),K000FX                                            SUB1490
  260 CALL SLITET(2,K000FX)                                             SUB1500
       GO TO(170,270),K000FX                                            SUB1510
  270 IF (NLIB)                 565, 565, 200                           SUB1520
  280 CALL LIB2                                                         SUB1530
      INLIBR(LIBT)=INLIBR(LIBT)-1                                       SUB1540
      GO TO 250                                                         SUB1550
  301 ISRCRC = J                                                        SUB1620
      DO 306  L=1,J                                                     SUB1630
      READ  (5      ,302)X0(L),Y0(L),Z0(L),A0(L),B0(L), C0(L),       IL1, SUB1640
     1IS1                                                               SUB1650
  302 FORMAT(6E10.4, 6X   I2,I4)                                        SUB1660
      IF (IL1-IL)               130, 303, 130                           SUB1670
  303 IF (IS1-IS-MS)            170, 304, 170                           SUB1680
  304  READ  (5      ,307)E0(L),AW(L),W0(L),NR1(L),EXXXXX,IL,IS         SUB1690
      IF (IL1-IL)               130, 305, 130                           SUB1700
  305 IF (IS-IS1-MS)            150, 306, 150                           SUB1710
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```
  306 CONTINUE                                                          SUB1720
  307 FORMAT (3E10.4, I10, E10.4, 16X I2, I4)                           SUB1730
      NLIB=NLIB-1                                                       SUB1740
      INLIBR(LIBT)=INLIBR(LIBT)-1                                       SUB1750
      GO TO 270                                                         SUB1760
C                          LIBRARY TYPE 6                               SUB1770
  310 DO 350  L=1,I                                                     SUB1780
      READ  (5      ,320)ENERGY(L),TM(J,L),IL1,IS1                      SUB1790
  320 FORMAT ( 2E10.4,46X, I2,I4)                                         SUB18
      IF (IL1-IL)              130, 330, 130                            SUB1810
  330 IF (IS1-IS-MS)           170, 340, 170                            SUB1820
  340 IS=IS1                                                            SUB1830
  350 CONTINUE                                                          SUB1840
      WRITE ( 3     )LIBT, I, J, K, N, N1                               SUB1850
      L11REC = L11REC + 1                                               SUB1860
      WRITE ( 3     )(ENERGY(L),TM(J,L),L=1,I)
  355 INLIBR(LIBT)=INLIBR(LIBT)-1                                       SUB1880
      INSUPR(K)=INSUPR(K)-1                                             SUB1890
      INELEM(J)=INELEM(J)-1                                             SUB1900
  357 L11REC = L11REC + 1                                               SUB1910
      NLIB=NLIB-1                                                       SUB1920
      GO TO 270                                                         SUB1930
C  LIBRARY TYPES 3, 4, 7, 8, 9, 10 AND 11 ARE NOT NEEDED IN THIS CODE
  360 WRITE (6,370)LIBT                                                 SUB1950
  370 FORMAT (13H0LIBRARY TYPE,I3,22H WAS INPUT BY MISTAKE.)            SUB1960
      CALL EXIT                                                         SUB1970
  565 DO 567  L=1,11                                                    SUB2070
      IF(INLIBR(L))            575, 567, 575                            SUB2080
  567 CONTINUE                                                          SUB2090
      DO 569  L=1,NSG                                                   SUB2100
      IF(INSUPR(L))            575, 569, 575                            SUB2110
  569 CONTINUE                                                          SUB2120
      DO 571  L=1,NEL                                                   SUB2130
      IF(INELEM(L))            575, 571, 575                            SUB2140
  571 CONTINUE                                                          SUB2150
      GO TO 600                                                         SUB2160
  575 WRITE (6,580)                                                     SUB2170
  580 FORMAT (49H0THE TOTAL NUMBER OF INPUT LIBRARIES WAS CORRECT./     SUB2180
     1 65H HOWEVER, THE NUMBER OF ELEMENTS AND/OR SUPERGROUPS IS INCORRE SUB2190
     2CT.)                                                              SUB2200
  581 WRITE (6,582)                                                     SUB2210
  582 FORMAT(40H1  L   INSUPR(L)   INLIBR(L)   INELEM(L))               SUB2220
  584 FORMAT(1H ,I3,I8,2I12)                                            SUB2230
      DO 586  L=1,8                                                     SUB2240
  586 WRITE (6,584)L,INSUPR(L),INLIBR(L),INELEM(L)                      SUB2250
      DO 588  L=9,11                                                    SUB2260
  588 WRITE (6,584)L,INSUPR(L),INLIBR(L)                                SUB2270
      DO 590  L=12,20                                                   SUB2280
  590 WRITF (6,584)L,INSUPR(L)                                          SUB2290
      CALL EXIT                                                         SUB2300
```

```
  600 IF (NTAP)                855, 602, 855                                SUB2310
  602 DO 800 M=1,NSG                                                        SUB2320
C                   WRITE ALL CROSS SECTIONS ON TAPE 3                      SUB2330
      REWIND 3
      L=0                                                                   SUB2350
  610 L=L+2                                                                 SUB2360
  620 READ  ( 3     )LIBT, I, J, K, N, N1                                   SUB2370
      IF (M-K)                 640, 630, 640                                SUB2380
  630 LT = LIBT-5                                                           SUB2390
      GO TO (660,360,360,360,360,360),  LT                                  SUB2400
  640 READ  ( 3     )
  650 IF (L-L11REC)            610, 720, 720                                SUB2420
C                   LIBRARY TYPE 6                                          SUB2430
  660 READ  ( 3     )(ENERGY(L1),TM(J,L1),L1 = 1,I)                          SUB244
      NENEGY = I                                                            SUB2450
      GO TO 650                                                             SUB2460
C                  CALCULATE MACROSCOPIC CROSS-SECTIONS                     SUB2470
  720 DO 760  M1=1,NMAT                                                     SUB2480
      DO 750  M2=1,NENEGY                                                   SUB2490
      TCS(M1,M2)=0.0                                                        SUB2500
      DO 740  M3=1,NEL                                                      SUB2510
      TCS(M1,M2)=TCS(M1,M2) + TM (M3,M2)*DN(M1,M3)                          SUB2520
  740 CONTINUE                                                              SUB2530
  750 CONTINUE                                                              SUB2540
  760 CONTINUE                                                              SUB2550
  770 CALL CRSWRT                                                           SUB2560
  800 CONTINUE                                                              SUB2570
      REWIND 9
  810 FORMAT( 34H1CROSS SECTION TAPE LABELED CROSS I4,54H WAS GENERATED     SUB2590
     1AND CONTAINS THE FOLLOWING INFORMATION.)                              SUB2600
      WRITE (6,810)IQID                                                     SUB2610
  815 WRITE (6,820)L4REC,NREG,NEL,NMAT, NSG,NRG                             SUB2620
  820 FORMAT(1H ,I5,33H = NUMBER OF RECORDS ON THIS TAPE/I6,20H = NUMBER    SUB2630
     1 OF REGIONS/I6,21H = NUMBER OF ELEMENTS/I6,22H = NUMBER OF MATERIA    SUB2640
     2LS/I6,24H = NUMBER OF SUPERGROUPS/I6,40H = NEUTRONS, GAMMAS, OR SE    SUB2650
     3CONDARY GAMMAS)                                                       SUB2660
  850 REWIND 9
      GO TO 1000                                                            SUB2680
  855 WRITE (6,870)IQID                                                     SUB2690
  870 FORMAT(34H1CROSS SECTION TAPE LABELED CROSS I4,65H WAS USED IN THI    SUB2700
     1S PROBLEM AND CONTAINS THE FOLLOWING INFORMATION.)                    SUB2710
      GO TO 815                                                             SUB2720
 1000 RETURN                                                                SUB2730
      END                                                                   SUB2740
```

```
C SUBROUTINE ANGRED IN ANALYSIS CODE A01.                                SUB0010
      SUBROUTINE ANGRED (J, IS,IS1,NN,NN1,A)                             SUB0020
      DIMENSION   A(21)                                                  SUB0030
      N1 = 1                                                             SUB0100
      READ  (5      ,10)(A(I),I=1,6), NN1, IS1                           SUB0110
   10 FORMAT (6E10.0, 6X I2, I4)                                         SUB0120
      IF (IS1-IS-N1)          30, 20, 30                                 SUB0130
   20 IF (NN1-NN)             30, 40, 30                                 SUB0140
   30 CALL SLITE (1)                                                     SUB0150
      GO TO 150                                                          SUB0160
   40 IS = IS1                                                           SUB0170
      IF (J-6)                150,150, 50                                SUB0180
   50 READ  (5      ,10)(A(I),I=7,12), NN1,IS1                           SUB0190
      IF (IS1-IS-N1)          30, 60, 30                                 SUB0200
   60 IF (NN1-NN)             30, 70, 30                                 SUB0210
   70 IS = IS1                                                           SUB0220
      IF (J-12)               150, 150, 80                               SUB0230
   80 READ  (5      ,10)(A(I),I=13,18),NN1,IS1                           SUB0240
      IF(IS1-IS-N1)           30, 90 , 30                                SUB0250
   90 IF(NN1-NN)              30, 100, 30                                SUB0260
  100 IS= IS1                                                            SUB0270
      IF(J-18) 150, 150, 110                                             SUB0280
  110 READ  (5      ,120)(A(I), I=19,21), NN1, IS1                       SUB0290
  120 FORMAT (3E10.0, 36X I2, I4)                                        SUB0300
      IF (IS1-IS-N1)          30, 130, 30                                SUB0310
  130 IF (NN1-NN)             30, 140, 30                                SUB0320
  140 IS=IS1                                                             SUB0330
  150 RETURN                                                             SUB0340
      END                                                                SUB0350
```

```
      SUBROUTINE LIB1
C     SUBROUTINE LIB1 IN HISTORY GENERATION CODE                        0010
      COMMON /GEOM1/ IBT( 75), AF( 75), ZF( 75), CF( 75), XF( 75),
     1 YF( 75), IBN(50,9), MPR(50,9), NB(50), EPSL, NBD, NREG
     2 /CARDC/ IS, IS1, IL, IL1, FLIB, NPRINT(9), MS
C                                                                       0240
      I1 = NBD/2                                                        0250
      I2 = NBD-2*I1                                                     0260
      K1 = 0                                                            0270
      K2 = 0                                                            0280
      DO 50 I=1,I1                                                      0290
      K1 = K2+1                                                         0300
      K2 = K1+1                                                         0310
      READ (5,75) IBT(K1), AF(K1), ZF(K1),CF(K1), XF(K1), YF(K1), IL1,
     1IS1
      IF (IL-IL1)              100, 10, 100                             0330
   10 IF (IS1-IS-MS)           100, 20, 100                             0340
   20 READ (5,75) IBT(K2), AF(K2), ZF(K2),CF(K2), XF(K2), YF(K2), IL,IS
      IF (IL1-IL)              110, 30, 110                             0360
   30 IF (IS-IS1-MS)           110, 50, 110                             0370
   50 CONTINUE                                                          0380
      IF(I2)                   200, 200, 60                             0390
   60 K1 = K2+1                                                         0400
      READ (5,75) IBT(K1),AF(K1),ZF(K1),CF(K1),XF(K1),YF(K1),IL1,IS1
      IF (IL-IL1)              100, 70, 100                             0420
   70 IF (IS1-IS-MS)           100, 200, 100                            0430
   75 FORMAT (I10,5E10.4,6XI2,I4)
  100 CALL SLITE (1)                                                    0450
      GO TO 200                                                         0460
  110 CALL SLITE (2)                                                    0470
  200 RETURN                                                            0480
      END                                                               0490
```

```
      SUBROUTINE LIB2                                                   0020
C     SUBROUTINE LIB2 IN HISTORY GENERATION CODE                        0010
C                                                                       0030
      COMMON /GEOM1/ IBT( 75), AF( 75), ZF( 75), CF( 75), XF( 75),
     1 YF( 75), IBN(50,9), MPR(50,9), NB(50), EPSL, NBD, NREG
     3 /CARDC/ IS, IS1, IL, IL1, FLIB, NPRINT(9), MS
C                                                                       0210
      READ  (5      ,10)(IBN(I,J),MPR(1,J),J=1,6), IL1, IS1           0220
   10 FORMAT (12I5, 6X I2,I4)                                           0230
      IF (IL-IL1)              80, 20, 80                              0240
   20 IF (IS1-IS-MS)           80, 30, 80                              0250
   30 IF(NB(1)-6)              100, 100, 40                            0260
   40 READ  (5      ,45)(IBN(1,J),MPR(1,J),J=7,9), IL, IS              0270
   45 FORMAT (6I5, 36X I2,I4)                                           0280
      IF (IL-IL1)              70, 50, 70                              0290
   50 IF (IS-IS1-MS)           70,100, 70                              0300
   70 CALL SLITE (1)                                                   0310
   80 CALL SLITE (2)                                                   0320
      GO TO 200                                                        0330
  100 DO 160 I=3,NREG                                                  0340
      IF (IS1-IS)              110, 110, 105                           0350
  105 IS= IS1                                                          0360
  110 READ  (5      ,10)(IBN(I,J),MPR(I,J),J=1,6), IL1, IS1            0370
      IF (IL-IL1)               80, 120, 80                            0380
  120 IF (IS1-IS-MS)            80, 130, 80                            0390
  130 IF(NB(I)-6)              160, 160, 140                           0400
  140 READ  (5      ,45)(IBN(I,J),MPR(I,J),J=7,9), IL, IS              0410
      IF (IL-IL1)               70, 145, 70                            0420
  145 IF (IS-IS1-MS)            70, 160, 70                            0430
  160 CONTINUE                                                         0440
  200 RETURN                                                           0450
      END                                                              0460
```

```
      SUBROUTINE HEAT1                                                  0010
C ROUTINE HEAT1 IN ANALYSIS CODE A02.                                   0020
      COMMON /CROSS/ NENEGY, ENERGY(100), TCS(8,100)
      COMMON /JUNK/ A, A0(20), AA1(20), AP12, AT, AT1(20), ATWT(8),
     1 B, B0(20), BA1(20), C, C0(20), CA1(20), CROS, CRSS, DELCT,
     2 DISTM, DSQD, E, EA1(20), E0(20), ELOCUT, EGRP(20), ESI(8),
     3 ESUM(20), EPRINT(21), GPRINT(21), ESP, GRAD(21), H(2), HE(2),
     4 ICOL, IEINTV, IEMAX, IEPMAX, IETAB(20), IGINTV, IGPMAX, IH1,
     5 IH2, IHTAPE, J1NO, ILAST, IPPMAX, IREGSC, J2NO, JM, JTAPE,
     6 JTAPE1, JTAPE2, JA, JI, K, K1, KESC2, KGRP(3,20), KLMAX, KREC,
     7 KS, KTAPE, L1, L2, L3, LBJ, LZ, MATREG(50), MHTAPE(2), MIGHT(2),
     8 MNO, NB1, NEL, NG, NHT, NHIST, NOINT, NN, NR, NR1(20), NR2,
     9 NR1A1(20), NREC, NUB, NLIB, NSG, PID, Q, IQID, S, SUMS, T(50,20)
      COMMON TM(8,100), WEXP(20,20), WEXPA1(20), W0(20), X, X0(20),
     1 X2, XA1(20), Y, Y0(20), Y2, YA1(20), Z, Z0(20), Z2, ZA1(20),
     2 DN(10,8), ISRCTP, ISRCRC, NMAT, ETM, EMAX(20), ILOC, TL(21),
     3 BEG(20), LSO, ILOCUT, WEXPD, BEGGER(20,20), NTAP, JSENSE,
     4  AW(20), IX1, MKREC(2), INLIBR(11), INSUPR(20), INELEM(8),
     5 GSUM(20), P(50,20)
     5 /GEOM1/ IBT( 75), AF( 75), ZF( 75), CF( 75), XF( 75), YF( 75),
     6 IBN(50,9), MPR(50,9), NB(50), EPSL, NBD, NREG
     2 /CARDC/ IS, IS1, IL, IL1, FLIB, NPRINT(9), MS
C                                                                       0860
      TL(1) = 0.0
      DO 5 NOE = 1, 20
      TL( NOE+1 ) = 0.0
      DO 5 NOA = 1, 20
      WEXP( NOA, NOE ) = 0.0
      DO 5 NOR = 1, 50
    5 T( NOR, NOE ) = 0.0
      IF (ISRCTP)              30, 30, 10                             0870
   10 CALL CRSRED                                                      0880
      M1 = 1                                                           0890
      DO 20 KLP= 1,ISRCRC                                              0900
      IF (E0(KLP)-EGRP(M1))    15, 15, 19                              0910
   15 M1 = M1 + 1                                                      0920
      CALL CRSRED                                                      0930
   19 CALL HEAT2 (KLP,M1)                                              0940
   20 CONTINUE                                                         0950
      GO TO 1000                                                       0960
C        -----READ FIRST RECORD OF FIRST HISTORY TAPE.                 0970
   30 K1 = 0                                                           0980
      IX = 1
      IX1 = 3
      REWIND IX                                                        1000
      READ  (IX)NREC, NHIST, NG, IHTAPE, ILAST                         1010
C        -----VERIFY TAPE PUT ON UNIT IX.                              1020
      DO 50  I = 1, NHT                                                1030
      IF (IHTAPE-MIGHT(I))    50, 40, 50                               1040
   40 K1 = 1                                                           1050
```

```
      MIGHT(I) = 0
      J=I
      GO TO 60
   50 J = I
C        -----ERROR IF WRONG TAPE PUT ON TAPE UNIT.
   60 IF (K1)                  80, 80, 70
   70 IF (IHTAPE-MHTAPE(J))  80, 100, 80
   80 WRITE (6,90)H(1), H(2), IHTAPE, H(1), H(2), MHTAPE(J)
   90 FORMAT (14H0TAPE LABELED , A6,A3,I4,36H WAS LOADED INSTEAD OF TAPE
     1 LABELED ,A6,A3,I4,19H.  PROBLEM STOPPED. )
      CALL EXIT
C        -----RESET BEG AND KGRP.
  100 DO 110     M1=1,20
      BEG(M1) = BEGGER(J,M1)
      DO 110     M2=1,3
  110 KGRP(M2,M1) = 0
C        -----DETERMINE NO.OF RECORDS(NH1) AND NO. OF L.REC.COL.(NHP).
      BSUM = 0.0
      NHP = 0
      NH1 = 7999
      IF (J-NHT)                 130, 120, 120
  120 NH1 = MKREC(1) - 1
  130 CALL RECORD (NSG, NH1, BEG(1), KGRP(1,1))
      IF (J-NHT)                 160, 140, 140
  140 IF (MKREC(2)-20)           150, 150, 160
  150 NH1 = NH1 - 1
      NHP = MKREC(2)
C        -----PUT CORRECT SET OF CROSS-SECTIONS INTO CORE FROM TAPE)
  160 REWIND IX1
      DO 180   M1=1, NSG
      IF (BEG(M1)-0.6)           170, 170, 190
  170 READ  (  9    )
  180 CONTINUE
  190 CALL CRSRED
C    -----NH1 FULL RECORDS OF COLLISION DATA WILL BE CONSIDERED.
      IF (NH1)                   310, 310, 200
  200 I20 = 20
  210 DO 300    I= 1, NH1
      READ  (IX)(X0(L), Y0(L), Z0(L), A0(L), B0(L), C0(L), E0(L),     W0(
     1L), XZZ,YZZ,ZZZ,                    WZZ, NRZZ   , AW(L),EXZZ,       NR1
     2(L), L=1,I20)
      DO 300    KLP = 1, I20
      BSUM = BSUM + 1.0
      ME1 = NR1(KLP)
      ME2 = NREG
      ME3 = 0
  230 DO  260  J = ME1,ME2
      IF  (J - 2)            235, 260, 235
  235 CALL SEARCH  (J,X0(KLP),Y0(KLP),Z0(KLP),NR1(KLP),MSRCH,KESC2)
      IF   (MSRCH)           260, 260, 280
```

```
  260 CONTINUE
      IF  (ME3)        265, 265, 270
  265 ME1 = 1
      ME2 = NR1(KLP)
      ME3 = 1
      GO TO 230
  270 WRITE (6,275)X0(KLP), Y0(KLP), Z0(KLP)
  275 FORMAT (57H0CANNOT FIND INSIDE REGION FOR PARTICLE WITH COORDINATE
     1S ,1P3E12.4,2X,10H IN HEAT1  )
      GO TO 300
  280 NR1(KLP) = J
      IF (BSUM - BEG(M1))     290, 290, 215
  215 M1 = M1 + 1
      BSUM = 0.0
      CALL CRSRED
  290 CALL HEAT2 (KLP, M1)
  300 CONTINUE
C        -----READ PARTIAL RECORD.
  310 IF (NHP)                330, 330, 320
  320 I20 = NHP
      NHP = 0
      NH1 = 1
      GO TO 210
C        -----SEARCH FOR ANOTHER HISTORY TAPE.
  330 CALL SLITE (0)
      DO 350  I = 1, NHT
      IF (MIGHT(I))           350, 350, 340
  340 CALL SLITE (1)
      FI = MIGHT(I)
      MIGHT(I) = 0
      J=I
      GO TO 360
  350 J=I
  360 CALL SLITET(1,K000FX)
       GO TO(370,1000),K000FX
C        -----PUT NEW HISTORY TAPE ON A TAPE UNIT.
  370 IX = 2
      REWIND IX
      READ  (IX)NREC, NHIST, NG, IHTAPE, ILAST
      GO TO 70
 1000 RETURN
      END
```

```
C SUBROUTINE HEAT2 IN ANALYSIS CODE A02.                                SUB0010
      SUBROUTINE HEAT2 (KZ,MZ)                                          SUB0020
      COMMON /CROSS/ NENEGY, ENERGY(100), TCS(8,100)
      COMMON /JUNK/ A, A0(20), AA1(20), AP12, AT, AT1(20), ATWT(8),
     1 B, B0(20), BA1(20), C, C0(20), CA1(20), CROS, CRSS, DELCT,
     2 DISTM, DSQD, E, EA1(20), E0(20), ELOCUT, EGRP(20), ESI(8),
     3 ESUM(20), EPRINT(21), GPRINT(21), ESP, GRAD(21), H(2), HE(2),
     4 ICOL, IEINTV, IEMAX, IEPMAX, IETAB(20), IGINTV, IGPMAX, IH1,
     5 IH2, IHTAPE, J1NO, ILAST, IPPMAX, IREGSC, J2NO, JM, JTAPE,
     6 JTAPE1, JTAPE2, JA, JI, K, K1, KESC2, KGRP(3,20), KLMAX, KREC,
     7 KS, KTAPE, L1, L2, L3, LBJ, LZ, MATREG(50), MHTAPE(2), MIGHT(2),
     8 MNO, NB1, NEL, NG, NHT, NHIST, NOINT, NN, NR, NR1(20), NR2,
     9 NR1A1(20), NREC, NUB, NLIB, NSG, PID, Q, IQID, S, SUMS, T(50,20)
      COMMON TM(8,100), WEXP(20,20), WEXPA1(20), W0(20), X, X0(20),
     1 X2, XA1(20), Y, Y0(20), Y2, YA1(20), Z, Z0(20), Z2, ZA1(20),
     2 DN(10,8), ISRCTP, ISRCRC, NMAT, ETM, EMAX(20), ILOC, TL(21),
     3 BEG(20), LSO, ILOCUT, WEXPD, BEGGER(20,20), NTAP, JSENSE,

     4  AW(20), IX1, MKREC(2), INLIBR(11), INSUPR(20), INELEM(8),
     5 GSUM(20), P(50,20)
     5 /GEOM1/ IBT( 75), AF( 75), ZF( 75), CF( 75), XF( 75), YF( 75),
     6 IBN(50,9), MPR(50,9), NB(50), EPSL, NBD, NREG
     2 /CARDC/ IS, IS1, IL, IL1, FLIB, NPRINT(9), MS
C                                                                       SUB0800
      ZHIST=NHIST                                                       SUB0810
  100 FORMAT (15H0HEAT2 LOCATION, I3)                                   SUB0820
      IRND = 0                                                          SUB0830
      K = KZ                                                            SUB0840
      KS = MZ                                                           SUB0850
      CALL SLITE (0)                                                    SUB0860
      X = X0 (K)                                                        SUB0870
      Y = Y0 (K)                                                        SUB0880
      Z = Z0 (K)                                                        SUB0890
      A = A0 (K)                                                        SUB0900
      B = B0 (K)                                                        SUB0910
      C = C0 (K)                                                        SUB0920
      E = E0 (K)                                                        SUB0930
      W = W0 (K)                                                        SUB0940
      NR= NR1(K)                                                        SUB0950
      AT= AW (K)                                                        SUB0960
      IF (JSENSE)              465, 465, 200                            SUB0970
  200 MP=1                                                              SUB0980
      WRITE (6,100)MP                                                   SUB0990
      WRITE (6,205)K, KS, NR, E, W, AT                                  SUB1000
  205 FORMAT (20H0K, KS, NR, E, W, AT/5X,3I6,3E12.4)                    SUB1010
      WRITE (6,206)X, Y, Z, A, B, C                                     SUB1020
  206 FORMAT (20H0A,  B,  C, X, Y, Z /5X,6E12.4)                        SUB1030
C                                                                       SUB1040
C CARDS M102 THRU M128 ARE DUPLICATES OF A PART OF A1A2 (ANALYSIS A01)  SUB1050
  465 IF (NR-2)              510, 470, 510                              SUB1060
```

```
  470 NOINT=1                                                           SUB1210
      S=1.0E+6                                                          SUB1220
      GO TO 600                                                         SUB1230
  510 DISTM=1.0E+6                                                      SUB1240
      NB1=NB(NR)                                                        SUB1250
      J1=0                                                              SUB1260
      DO 550  I3=1,NB1                                                  SUB1270
      J3=IABS(IBN(NR,I3))                                               SUB1280
      CALL DIST (X,Y,Z,A,B,C,J3,S,P1,P2,P3)
      CALL SLITET(3,K000FX)                                             SUB1300
       GO TO(550,520),K000FX                                            SUB1310
  520 IF (S-DISTM)            530, 550, 550                             SUB1320
  530 DISTM=S                                                           SUB1330
      J1=I3                                                             SUB1340
  550 CONTINUE                                                          SUB1350
      S=DISTM                                                           SUB1360
      NR3=MPR(NR,J1)                                                    SUB1370
      NB1= IABS(IBN(NR,J1))                                             SUB1380
      MNO = MATREG(NR)                                                  SUB1390
C                                                                       SUB1400
      IF (IRND)                   990, 600, 990                         SUB1410
  600 CALL INTERP (E,MNO,CROS)                                          SUB1420
      IF (JSENSE)                 615, 615, 605                         SUB1430
  605 MP=2                                                              SUB1440
      WRITE (6,100)MP                                                   SUB1450
      WRITE (6,610)KS,IETAB(KS),MNO,EMAX(KS),E,CROS                     SUB1460
  610 FORMAT(47H0KS, IETAB(KS), MNO, EMAX(KS), E, CROS /                SUB1470
     1 5X,3I6,3E12.4)                                                   SUB1480
  615 DO 630  J=2, IEPMAX                                               SUB1490
      IF (E-EPRINT(J))            620, 620, 630                         SUB1500
  620 KE = J-1                                                          SUB1510
      GO TO 640                                                         SUB1520
  630 CONTINUE                                                          SUB1530
  640 IF (MNO)                    645, 647, 645                         SUB1540
  645 TL(KE) =(W/CROS)*(1.0-EXP(-S*CROS))                               SUB1550
      GO TO 650                                                         SUB1560
  647 TL(KE) = W*S                                                      SUB1570
  650 T(NR ,KE) = T(NR ,KE) + TL(KE)                                    SUB1580
      EXP0= 1.0                                                         SUB1590
  660 EXP0= EXP0* (EXP(-S*CROS))                                        SUB1600
      X  = X  + A*S                                                     SUB1610
      Y  = Y  + B*S                                                     SUB1620
      Z  = Z  + C*S                                                     SUB1630
      CALL DF7 (NR,X,Y,Z,NB1,NR3,KESC2)
      IF (JSENSE)                 668, 668, 662                         SUB1660
  662 MP=3                                                              SUB1670
      WRITE (6,100)MP                                                   SUB1680
      WRITE (6,664)KE,NR3,NR,W,S,TL(KE),T(NR,KE)                        SUB1690
  664 FORMAT(36H0KE, NR3, NR, W, S, TL(KE), T(NR,KE)/5X,3I6,4E12.4)     SUB1700
      WRITE (6,666)EXP0,X,Y,Z,X2,Y2,Z2                                  SUB1710
```

```
 666 FORMAT(26H0EXPO, X, Y, Z, X2, Y2, Z2/5X,7E12.4)                SUB1720
 668 IF (NR -2)              670,1100, 670                          SUB1730
 670 IRND = 2                                                       SUB1740
     GO TO 510                                                      SUB1750
 990 CALL INTERP (E,MNO,CROS)                                       SUB1760
     DO 1010   J = 2, IEPMAX                                        SUB1770
     IF (E - EPRINT(J))      1000, 1000, 1010                       SUB1780
1000 KE = J - 1                                                     SUB1790
     GO TO 1020                                                     SUB1800
1010 CONTINUE                                                       SUB1810
1020 IF (MNO)                1040, 1030, 1040                       SUB1820
1030 TL(KE) = W*EXPO*S                                              SUB1830
     GO TO 1050                                                     SUB1840
1040 TL(KE) = (W/CROS) * EXPO* (1.0-EXP(-S * CROS))                 SUB1850
1050 T(NR ,KE) = T(NR ,KE) + TL(KE)                                 SUB1860
     GO TO 660                                                      SUB1870
1100 GO TO (2000, 1150, 1200), LSO                                  SUB1880
1150 GAM = C                                                        SUB1890
     JGAM = IGPMAX                                                  SUB1900
     DO 1170   J = 1, IGPMAX                                        SUB1910
     IF (GAM-GRAD(J))        1170, 1170, 1160                       SUB1920
1160 JGAM = J-1                                                     SUB1930
     GO TO 1180                                                     SUB1940
1170 CONTINUE                                                       SUB1950
1180 WEXP(JGAM,KE) = WEXP(JGAM,KE) +  W*EXPO
     IF (JSENSE)             2000, 2000, 1185                       SUB1970
1185 MP=4                                                           SUB1980
     WRITE (6,100)MP                                                SUB1990
     WRITE (6,1190)KE,JGAM,W,EXPO,WEXP(JGAM,KE),GAM,GRAD(J)         SUB2000
1190 FORMAT(47H0KE, JGAM, W, EXPO, WEXP(JGAM,KE), GAM, GRAD(J)/5X,2I6, SUB2010
    1 5E12.4)                                                       SUB2020
     GO TO 2000                                                     SUB2030
1200 WEXPD = W*EXPO/ZHIST                                           SUB2040
     CALL ESCAPE                                                    SUB2050
     IF (JSENSE)             2000, 2000, 1210                       SUB2060
1210 MP=5                                                           SUB2070
     WRITE (6,100)MP                                                SUB2080
     WRITE (6,1220)W,EXPO,ZHIST,WEXPD                               SUB2090
1220 FORMAT (22H0W, EXPO, ZHIST, WEXPD/5X,4E12.4)                   SUB2100
2000 RETURN                                                         SUB2110
     END                                                            SUB2120
```

```
C SUBROUTINE CRSRED IN ANALYSIS CODE A02.                          SUB0010
      SUBROUTINE CRSRED                                            SUB0020
      COMMON /CROSS/ DUM(901)
C                                                                  SUB0080
      READ  ( 9     )(DUM(N), N=1, 901 )                           SUB0120
      RETURN                                                       SUB0130
      END                                                          SUB0140
```

```
 SUBROUTINE INTERP (E,MNO,CROS)
 COMMON /CROSS/ NENEGY, ENERGY(100), TCS(8,100)
 CALL FINDER (NENEGY,E,JAZ,ENERGY)
 CROS = TCS(MNO,JAZ) + (TCS(MNO,JAZ+1)-TCS(MNO,JAZ))*((E-ENERGY(JAZ
1))/(ENERGY(JAZ+1)-ENERGY(JAZ)))
 RETURN
 END
```

```
C SUBROUTINE ESCAPE IN ANALYSIS CODE A02                                SUB0010
      SUBROUTINE ESCAPE                                                 SUB0020
C                                                                       SUB0030
      COMMON /CROSS/ NENEGY, ENERGY(100), TCS(8,100)
      COMMON /JUNK/ A, A0(20), AA1(20), AP12, AT, AT1(20), ATWT(8),
     1 B, B0(20), BA1(20), C, C0(20), CA1(20), CROS, CRSS, DELCT,
     2 DISTM, DSQD, E, EA1(20), E0(20), ELOCUT, EGRP(20), ESI(8),
     3 ESUM(20), EPRINT(21), GPRINT(21), ESP, GRAD(21), H(2), HE(2),
     4 ICOL, IEINTV, IEMAX, IEPMAX, IETAB(20), IGINTV, IGPMAX, IH1,
     5 IH2, IHTAPE, J1NO, ILAST, IPPMAX, IREGSC, J2NO, JM, JTAPE,
     6 JTAPE1, JTAPE2, JA, JI, K, K1, KESC2, KGRP(3,20), KLMAX, KREC,
     7 KS, KTAPE, L1, L2, L3, LBJ, LZ, MATREG(50), MHTAPE(2), MIGHT(2),
     8 MNO, NB1, NEL, NG, NHT, NHIST, NOINT, NN, NR, NR1(20), NR2,
     9 NR1A1(20), NREC, NUB, NLIB, NSG, PID, Q, IQID, S, SUMS, T(50,20)
      COMMON TM(8,100), WEXP(20,20), WEXPA1(20), W0(20), X, X0(20),
     1 X2, XA1(20), Y, Y0(20), Y2, YA1(20), Z, Z0(20), Z2, ZA1(20),
     2 DN(10,8), ISRCTP, ISRCRC, NMAT, ETM, EMAX(20), ILOC, TL(21),
     3 BEG(20), LSO, ILOCUT, WEXPD, BEGGER(20,20), NTAP, JSENSE,
     4  AW(20), IX1, MKREC(2), INLIBR(11). INSUPR(20), INELEM(8),
     5 GSUM(20), P(50,20)
     5 /GEOM1/ IBT( 75), AF( 75), ZF( 75), CF( 75), XF( 75), YF( 75),
     6 IBN(50,9), MPR(50,9), NB(50), EPSL, NBD, NREG
     2 /CARDC/ IS, IS1, IL, IL1, FLIB, NPRINT(9), MS
C                                                                       SUB0860
      ICOL = ICOL + 1                                                   SUB0870
      WEXP A1(ICOL) = WEXPD                                             SUB0880
         E A1(ICOL) = E                                                 SUB0890
         X A1(ICOL) = X                                                 SUB0900
         Y A1(ICOL) = Y                                                 SUB0910
         Z A1(ICOL) = Z                                                 SUB0920
         A A1(ICOL) = A                                                 SUB0930
         B A1(ICOL) = B                                                 SUB0940
         C A1(ICOL) = C                                                 SUB0950
       NR1 A1(ICOL) = NR                                                SUB0960
      IF (ICOL-20)            50, 20, 50                                SUB0970
   20 KREC = KREC + 1                                                   SUB0980
      WRITE ( IX1  )(XA1(I),YA1(I),ZA1(I),AA1(I),BA1(I),CA1(I),        E SUB0990
     1A1(I),WEXPA1(I),NR1A1(I),I=1,20 )                                 SUB1000
      ICOL = 0                                                          SUB1010
      IF (KREC - 8000)        50, 30, 30                                SUB1020
   30 JTAPE2 = JTAPE2 + 1                                               SUB1040
      IF (NG-1)               31, 33, 35                                SUB1050
   31 WRITE (6,32)                                                      SUB1060
   32 FORMAT (1H1,47X7HNEUTRON)                                         SUB1070
      GO TO 37                                                          SUB1080
   33 WRITE (6,34)                                                      SUB1090
   34 FORMAT (1H1,48X5HGAMMA)                                           SUB1100
      GO TO 37                                                          SUB1110
   35 WRITE (6,36)                                                      SUB1120
   36 FORMAT (1H1,44X15HSECONDARY GAMMA)                                SUB1130
```

```
37 NNN = NN + 100                                                       SUB1140
   WRITE (6,38)HE(1),HE(2),J2NO,PID,NNN,KREC,NHIST                      SUB1150
38 FORMAT(14H+TAPE LABELED ,A6,A3,I4,42H WAS GENERATED IN               SUB1160
  1     PROBLEM ,A4,I2/ 13H IT CONTAINS ,I5,19H RECORDS, BASED ON ,I6 SUB1170
  2,19H INITIAL HISTORIES.)                                             SUB1180
   KREC = 0                                                             SUB1190
   IX1 = 4
   J2NO = J2NO + 1                                                      SUB1240
   REWIND  IX1                                                          SUB1250
50 RETURN                                                               SUB1260
   END                                                                  SUB1270
```

```
      SUBROUTINE SEARCH (KA,X1,Y1,Z1,NR1,MSRCH,KESC2)
      COMMON /GEOM1/ IBT( 75), AF( 75), ZF( 75), CF( 75), XF( 75),
     1 YF( 75), IBN(50,9), MPR(50,9), NB(50), EPSL, NBD, NREG
      MSRCH = 0
      K = KA
      JZ = NB(K)
      DO 200 I=1,JZ
      JZ1 = IABS(IBN(K,I))
      JZ2 = IBT(JZ1)
      IF (JZ2)                    6, 6, 5
    5 IF (JZ2-9)                  8, 8, 6
    6 WRITE (6,7)  JZ2, JZ1, K, JZ, NR1
    7 FORMAT (18H THE VALUE OF IBT=,I5,20H FOR BOUNDARY NUMBER,I5,1H,/
     128H OR NB(NR2) MAY BE IN ERROR./ 4H NB(,I2,2H)=,I3,5H,NR1=,I2)
      CALL EXIT
    8 GO TO    (10,20,30,40,50,60,70,80,90), JZ2
   10 XR =(X1-XF(JZ1))**2 + (Y1-YF(JZ1))**2 - AF(JZ1)*(Z1-ZF(JZ1))**2
     1 -CF(JZ1)
      GO TO 100
   20 XR =(X1-XF(JZ1))**2 + (Y1-YF(JZ1))**2 - AF(JZ1)*(Z1-ZF(JZ1))**2
      GO TO 100
   30 XR =(X1-XF(JZ1))**2 + (Y1-YF(JZ1))**2 -  (AF(JZ1)*(Z1-ZF(JZ1)))
     1**2
      GO TO 100
   40 XR =(X1-XF(JZ1))**2 + (Y1-YF(JZ1))**2 - AF(JZ1)**2
      GO TO 100
   50 XR =(-X1+XF(JZ1))*SIN(AF(JZ1)) + (Y1-YF(JZ1))*COS(AF(JZ1))
      GO TO 100
   60 XR =Z1-AF(JZ1)
      GO TO 100
   70 XR =X1-AF(JZ1)
      GO TO 100
   80 XR =Y1-AF(JZ1)
      GO TO 100
   90 XR =X1*AF(JZ1) + Y1*ZF(JZ1) + Z1*CF(JZ1) - XF(JZ1)
      GO TO 100
  100 IF (IBN(K,I))             110, 130, 130
  110 IF (XR)                   200, 200, 250
  130 IF (XR)                   250, 200, 200
  200 CONTINUE
      MSRCH = 1
      KESC2 = NR1
      NR1 = K
  250 RETURN
      END
```

```
C SUBROUTINE DF7 FOR CODES H01, A01, AND A02.                          SUB0010
      SUBROUTINE DF7 (NR1,X1,Y1,Z1,NB1,NR2,KESC2)
      COMMON /GEOM1/ IBT( 75), AF( 75), ZF( 75), CF( 75), XF( 75),
     1 YF( 75), IBN(50,9), MPR(50,9), NB(50), EPSL, NBD, NREG
  525 FORMAT (49H0CANNOT FIND REGION FOR PARTICLE WITH COORDINATES,      SUB0220
     1 1P3E12.4 )                                                        SUB0230
  600 IF (NR2-2)                    605, 602, 605                        SUB0240
  602 KESC2 = NR1                                                        SUB0250
      NR1 = 2                                                            SUB0260
      GO TO 700                                                          SUB0270
  605 JEZ = NREG                                                         SUB0280
      JAZ = NR2                                                          SUB0290
      NCY = 0                                                            SUB0300
  610 DO 650  I=JAZ,JEZ                                                  SUB0310
      IF (I - 2)   620, 650, 620                                         SUB0320
  620 CALL SEARCH (I,X1,Y1,Z1,NR1,MSRCH,KESC2)                           SUB0330
      IF(MSRCH)650,650,700                                               SUB0350
  650 CONTINUE                                                           SUB0360

      IF (NCY - 1)                                                       SUB0370
  655 JEZ = 1                                                            SUB0380
      JAZ = 1                                                            SUB0390
      NCY = 1                                                            SUB0400
      GO TO 610                                                          SUB0410
  665 JAZ = 3                                                            SUB0420
      JEZ = NR2                                                          SUB0430
      NCY = 2                                                            SUB0440
      GO TO 610                                                          SUB0450
  670 WRITE (6,525)X1, Y1, Z1                                            SUB0460
      GO TO 602                                                          SUB0470
  700 RETURN                                                             SUB0480
      END                                                                SUB0490
```

```
      SUBROUTINE FINDER (NENEGY,E,JAZ,ENERGY)
      DIMENSION  ENERGY(100)
      FNEGY = NENEGY
      JUMP =  FNEGY/2.0 + 0.5
      LOE = JUMP
      DO 30 I=1,6
      FJUMP = JUMP
      JUMP =FJUMP/2.0 + 0.5
      IF (E - ENERGY(LOE))     .  10, 50, 20
   10 LOE = LOE + JUMP
      GO TO 30
   20 LOE = LOE - JUMP
   30 CONTINUE
      IF (E - ENERGY(LOE))       40, 50, 50
   40 JAZ = LOE
      GO TO 60
   50 JAZ = LOE - 1
   60 RETURN
      END
```

```
      SUBROUTINE DIST (X,Y,Z,A,B,C,I,S,P1,P2,P3)
      COMMON /GEOM1/ IBT( 75), AF( 75), ZF( 75), CF( 75), XF( 75),
     1 YF( 75), IBN(50,9), MPR(50,9), NB(50), EPSL, NBD, NREG
      I1 = I
      I2 = IBT(I1)
      GO TO (10,20,30,40,50,60,70,80,90) , I2
   10 P1 = A**2 + B**2 - AF(I1)*C**2
      P2 = A*(X-XF(I1)) + B*(Y-YF(I1)) - C*AF(I1)*(Z-ZF(I1))
      P3 = (X-XF(I1))**2 + (Y-YF(I1))**2 -AF(I1)*(Z-ZF(I1))**2 - CF(I1)
      GO TO 100
   20 P1 = A**2 + B**2
      P2 = A*(X-XF(I1)) + B*(Y-YF(I1)) - 0.5*AF(I1)*C
      P3 = (X-XF(I1))**2 + (Y-YF(I1))**2 - AF(I1)*(Z-ZF(I1))
      GO TO 100
   30 P1 = A**2 + B**2 -(AF(I1)*C)**2
      P2 = A*(X-XF(I1)) + B*(Y-YF(I1)) - (AF(I1)**2)*C*(Z-ZF(I1))
      P3 = (X-XF(I1))**2 + (Y-YF(I1))**2 - (AF(I1)*(Z-ZF(I1)))**2
      GO TO 100
   40 P1 = A**2 + B**2
      P2 = A*(X-XF(I1)) + B*(Y-YF(I1))
      P3 = (X-XF(I1))**2 + (Y-YF(I1))**2 - AF(I1)**2
      GO TO 100
   50 P1 = SIN(AF(I1))
      P2 = COS(AF(I1))
      P3 = -A*P1 + B*P2
      IF (P3)            55, 200, 55
   55 S = ((X-XF(I1))*P1 - (Y-YF(I1))*P2)/P3 + EPSL
      GO TO 150
   60 IF (C)             65, 200, 65
   65 S = ((AF(I1)-Z)/C) + EPSL
      GO TO 150
   70 IF (A)             75, 200, 75
   75 S = ((AF(I1)-X)/A) + EPSL
      GO TO 150
   80 IF (B)             85, 200, 85
   85 S = ((AF(I1)-Y)/B) + EPSL
      GO TO 150
   90 P1 = A*AF(I1) + B*ZF(I1) + C*CF(I1)
      IF (P1)            95, 200, 95
   95 S = (XF(I1) - X*AF(I1) - Y*ZF(I1) - Z*CF(I1))/P1 + EPSL
      GO TO 150
  100 IF(ABS(P1)-1.0E-7)     105, 105, 110
  105 IF(ABS(P2)-1.0E-7)     200, 200, 106
  106 S = -0.5 * P3/P2 + EPSL
      GO TO 150
  110 P2 = P2/P1
      P3 = P3/P1
      IF (P2)                120, 120, 112
  112 IF (P3)                130, 130, 200
  120 P4 =P2**2 - P3
```

```
    IF  (P4+1.0E-5)        200, 200, 125
125 IF (P3)                130, 140, 140
130 S = -P2 + SQRT(P2**2-P3) + EPSL
    GO TO 150
140 S = -P2 - SQRT(P2**2-P3) + EPSL
150 IF (S - EPSL)          200, 200, 300
200 CALL SLITE (3)
250 S = 2.0 * EPSL
300 RETURN
    END
```

```
C SUBROUTINE RECORD IN CODES A01 AND A02, WHICH CALCULATIONS KGRG(I,J)
      SUBROUTINE RECORD (NSG, LATJ1, BEG, KGRG)
      DIMENSION  BEG(20), KGRG(3,20)
C
C  I=1 -- NUMBER OF COLLISIONS FOR SUPERGROUP J ON FIRST RECORD
C  I=2 -- NUMBER OF FULL RECORDS FOR SUPERGROUP J
C  I=3 -- NUMBER OF COLLISIONS FOR SUPERGROUP J ON LAST RECORD

      BJ = 0.0
      DO 100   J=1, NSG
      IF  (BEG(J)-.6)            100, 100, 10
   10 IF  (BJ - BEG(J))           30,  20, 20
   20 KGRG(1,J) = BEG(J)
      KGRG(2,J) = 0
      KGRG(3,J) = 0
      F1 = KGRG(1,J)
      BJ = BJ - F1
      GO TO  100
   30 KGRG(1,J) = BJ
      KGRG(2,J) = (BEG(J)-BJ)/20.0
      F1 = KGRG(2,J)
      KGRG(3,J) =  BEG(J) - BJ - 20.0*F1
      BJ = 20 - KGRG(3,J)
      IF (BJ - 20.0)             100,  40, 40
   40 BJ = 0.0
  100 CONTINUE
      KSUM = 0
      K1   = 0
      DO 200  J=1, NSG
      IF (BEG(J)-.6)          200, 200, 110
  110 KSUM = KSUM + KGRG(2,J)
      IF (KGRG(3,J))          200, 200, 120
  120 KSUM = KSUM + 1
  200 CONTINUE
      IF (LATJ1 - KSUM)       210, 300, 210
  210 JHTAPE = JHTAPE + 10000
      WRITE(6,220) JHTAPE
  220 FORMAT (85HOTHERE IS AN INCONSISTENCY BETWEEN THE NUMBER OF RECORD
     1S ON TAPE TO BE LABELED SORTED,I4  /41H AND THE NUMBER OF ENTRIES
     2PER SUPERGROUP)
      CALL EXIT
  300 RETURN
      END
```

```
      SUBROUTINE RESULT                                                 0010
C ROUTINE RESULTS IN HISTORY GENERATION CODE A02.                       0020
      COMMON /CROSS/ NENEGY, ENERGY(100), TCS(8,100)
      COMMON /JUNK/ A, A0(20), AA1(20), AP12, AT, AT1(20), ATWT(8),
     1 B, B0(20), BA1(20), C, C0(20), CA1(20), CROS, CRSS, DELCT,
     2 DISTM, DSQD, E, EA1(20), E0(20), ELOCUT, EGRP(20), ESI(8),
     3 ESUM(20), EPRINT(21), GPRINT(21), ESP, GRAD(21), H(2), HE(2),
     4 ICOL, IEINTV, IEMAX, IEPMAX, IETAB(20), IGINTV, IGPMAX, IH1,
     5 IH2, IHTAPE, J1NO, ILAST, IPPMAX, IREGSC, J2NO, JM, JTAPE,
     6 JTAPE1, JTAPE2, JA, JI, K, K1, KESC2, KGRP(3,20), KLMAX, KREC,
     7 KS, KTAPE, L1, L2, L3, LBJ, LZ, MATREG(50), MHTAPE(2), MIGHT(2),
     8 MNO, NB1, NEL, NG, NHT, NHIST, NOINT, NN, NR, NR1(20), NR2,
     9 NR1A1(20), NREC, NUB, NLIB, NSG, PID, Q, IQID, S, SUMS, T(50,20)
      COMMON TM(8,100), WEXP(20,20), WEXPA1(20), W0(20), X, X0(20),
     1 X2, XA1(20), Y, Y0(20), Y2, YA1(20), Z, Z0(20), Z2, ZA1(20),
     2 DN(10,8), ISRCTP, ISRCRC, NMAT, ETM, EMAX(20), ILOC, TL(21),
     3 BEG(20), LSO, ILOCUT, WEXPD, BEGGER(20,20), NTAP, JSENSE,
     4  AW(20), IX1, MKREC(2), INLIBR(11), INSUPR(20), INELEM(8),
     5 GSUM(20), P(50,20)
     5 /GEOM1/ IBT( 75), AF( 75), ZF( 75), CF( 75), XF( 75), YF( 75),
     6 IBN(50,9), MPR(50,9), NB(50), EPSL, NBD, NREG
     2 /CARDC/ IS, IS1, IL, IL1, FLIB, NPRINT(9), MS
C                                                                       0880
      ZHIST = NHIST                                                     0890
      IGINTV = IGPMAX - 1                                               0900
      IEINTV = IEPMAX - 1                                               0910
      READ  (5      ,20)                                                0920
      READ  (5      ,30)                                                0930
   20 FORMAT (62H                                                       0940
     1         )                                                        0950
   30 FORMAT (62H                                                       0960
     1         )                                                        0970
   40 FORMAT (16H0PROBLEM NUMBER , A4,I2 )                              0980
   50 FORMAT (1H+26X,8HNEUTRONS)                                        0990
   60 FORMAT (1H+26X,6HGAMMAS)                                          1000
   70 FORMAT (1H+26X,16HSECONDARY GAMMAS)                               1010
   80 FORMAT (23H HISTORY TAPES LABELED ,A6,A3,I4,9H THROUGH ,A6,A3,I4) 1020
   90 FORMAT (22H LOWER ENERGY CUTOFF =, E12.5,5H MEV.)                 1030
C                                                                       1040
      WRITE (6,20)                                                      1050
      WRITE (6,30)                                                      1060
      WRITE (6,40)PID, NN                                               1070
      IF (NG-1)              100, 110, 120                              1080
  100 WRITE (6,50)                                                      1090
      GO TO 130                                                         1100
  110 WRITE (6,60)                                                      1110
      GO TO 130                                                         1120
  120 WRITE (6,70)                                                      1130
  130 WRITE (6,80)H(1),H(2),IH1,H(1),H(2),IH2                           1140
      WRITE (6,90)ELOCUT                                                1150
```

```
      IF (JSENSE)              140, 140, 135                                1160
  135 WRITE (6,137)LSO                                                      1170
  137 FORMAT (12H0 RESULTS 1.// 6H LSO =,I2)                                1180
  140 GO TO (300, 150, 200), LSO                                            1190
  150 MOP = 0                                                               1200
      DO 160  KE = 1, IEINTV                                                1210
      DO 160  JGAM = 1, IGINTV                                              1220
      IF (JSENSE)              159, 159, 153
  153 WRITE (6,156)JGAM, KE, WEXP(JGAM,KE)
  156 FORMAT (6H WEXP(,I2,1H,I2,4H) = ,1PE12.4)                             1250
  159  P(JGAM, KE ) = 0.0
  160    P(JGAM,KE) = WEXP(JGAM,KE) / ZHIST
      CALL MPRINT(MOP,IGINTV,IEINTV,GPRINT(1),EPRINT(1),    P(1,1))         1270
      GO TO 300                                                             1280
  200 JTAPE2 = JTAPE2 + 1                                                   1300
      NNN = NN + 100                                                        1420
      WRITE (6,220)PID, NN                                                  1430
  220 FORMAT (71H0THE FOLLOWING TAPES CONTAINING LEAKAGE DATA WERE GENER    1440
     1ATED IN PROBLEM ,A4,I2/17X10HTAPE LABEL,5X14HNO. OF RECORDS,5X16HN    1450
     2O. OF HISTORIES,5X13HTYPE PARTICLE  )                                 1460
      K4 = J2NO - JTAPE2 + 1                                                1470
      DO 230   K3= K4, J2NO                                                 1480
      KRECE = 8000
      IF (K3-J2NO)             226, 225, 226                                1500
  225 KRECE = KREC                                                          1510
  226 WRITE (6,240)HE(1), HE(2), K3,KRECE,NHIST,NG                          1520
  230 CONTINUE                                                              1530
  240 FORMAT (1H0,15XA6,A3,I4,I12,I20,I18)                                  1540
  300 MOP = 1                                                               1550
      DO 310  KE = 1, IEINTV                                                1560
      DO 310  NAP= 1, NREG                                                  1570
      IF (JSENSE)                  309, 309, 303                            1580
  303 WRITE (6,306)NAP, KE, T(NAP,KE)                                       1590
  306 FORMAT (3H T(,I2,1H,I2,4H) = ,1PE12.4)                                1600
  309 P(NAP,KE) = 0.0
  310 P(NAP,KE) = T(NAP,KE) / ZHIST
      CALL MPRINT (MOP,NREG,IEINTV, GPRINT(1), EPRINT(1), P(1,1))           1630
      DO 340  I=1,NHT                                                       1710
      MAY = MHTAPE(I) + 10000                                               1720
  340 CONTINUE                                                              1740
      WRITE (6,350)PID, NNN                                                 1750
  350 FORMAT (15H1END OF PROBLEM , A4,I2)                                   1760
      RETURN
      END                                                                   1780
```

```
C SUBROUTINE MPRINT IN ANALYSIS CODE A02.                                SUB0010
      SUBROUTINE MPRINT (MOP,IGINTV,IEINTV,GPRINT,EPRINT,WEXP)           SUB0020
      DIMENSION   GPRINT(51), EPRINT(21), WEXP(50,20), ESUM(50),GSUM(20) SUB0030
     1,MRAT(50)                                                          SUB0040
      DO 300  K3 = 1, IGINTV                                             SUB0070
  300 MRAT(K3) = K3                                                      SUB0080
      ME = IGINTV/8                                                      SUB0090
  320 FORMAT (1H+ 17X3HSUM)                                              SUB0100
  321 FORMAT (1H+ 30X3HSUM)                                              SUB0110
  322 FORMAT (1H+ 43X3HSUM)                                              SUB0120
  323 FORMAT (1H+ 56X3HSUM)                                              SUB0130
  324 FORMAT (1H+ 69X3HSUM)                                              SUB0140
  325 FORMAT (1H+ 82X3HSUM)                                              SUB0150
  326 FORMAT (1H+ 95X3HSUM)                                              SUB0160
  327 FORMAT (1H+108X3HSUM)                                              SUB0170
  431 FORMAT (1H0,E11.5,8E13.5)                                          SUB0180
  443 FORMAT (1H0/5X3HSUM,4X,8E13.5)                                     SUB0190
      DO 1105  JGAM=1,IGINTV                                             SUB0200
 1105 ESUM(JGAM) = 0.0                                                   SUB0210
      DO 1110  KE =1, IEINTV                                             SUB0220
 1110 GSUM(KE) = 0.0                                                     SUB0230
      K2 = 0                                                             SUB0240
      IE1 = IGINTV                                                       SUB0250
      DO 1115  JGAM = 1, IGINTV                                          SUB0260
      DO 1115  KE   = 1, IEINTV                                          SUB0270
      ESUM(JGAM) = ESUM(JGAM) + WEXP(JGAM,KE)
 1115 GSUM(KE)   = GSUM(KE)   + WEXP(JGAM,KE)
      ME1 = ME                                                           SUB0300
C                                                                        SUB0310
 1117 IF (ME1  )              1120, 1120, 1165                           SUB0320
 1120 IE1 = IE1 + 1                                                      SUB0330
C LESS THAN 9 ANGLES AND/OR REGIONS TO BE PRINTED.                       SUB0340
      K1 = K2 + 1                                                        SUB0350
      K2 = IGINTV                                                        SUB0360
      K4=K1+1                                                            SUB0370
      K5=K2+1                                                            SUB0380
      IF (MOP)                1121, 1121, 1124                           SUB0390
 1121 WRITE (6,1122)                                                     SUB0400
 1122 FORMAT(1H0,13X38HNUMBER CURRENT VERSUS ANGLE AND ENERGY //8H  ENER SUB0410
     1GY,15X21HPOLAR ANGLE (DEGREES)  )                                  SUB0420
      WRITE (6,1123)(GPRINT(K3), K3=K4,K5)                               SUB0430
 1123 FORMAT (10H  (MEV) ,   8F13.3)                                     SUB0440
      GO TO 1127                                                         SUB0450
 1124 WRITE (6,1125)                                                     SUB0460
 1125 FORMAT(1H0,13X31HFLUXES VERSUS REGION AND ENERGY //8H  ENERGY,20X1 SUB0470
     13HREGION NUMBER )                                                  SUB0480
      WRITE (6,1126)(MRAT(K3), K3=K1,K2)                                 SUB0490
 1126 FORMAT (7H  (MEV), 8I13)                                           SUB0500
 1127 GO TO (1130,1131,1132,1133,1134,1135,1136,1137), IE1               SUB0510
 1130 WRITE (6,320)                                                      SUB0520
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      GO TO 1140                                                        SUB0530
 1131 WRITE (6,321)                                                     SUB0540
      GO TO 1140                                                        SUB0550
 1132 WRITE (6,322)                                                     SUB0560
      GO TO 1140                                                        SUB0570
 1133 WRITE (6,323)                                                     SUB0580
      GO TO 1140                                                        SUB0590
 1134 WRITE (6,324)                                                     SUB0600
      GO TO 1140                                                        SUB0610
 1135 WRITE (6,325)                                                     SUB0620
      GO TO 1140                                                        SUB0630
 1136 WRITE (6,326)                                                     SUB0640
      GO TO 1140                                                        SUB0650
 1137 WRITE (6,327)                                                     SUB0660
 1140 DO 1150    KE = 1, IEINTV                                         SUB0670
      IF (IE1-2)              1141, 1142, 1143                          SUB0680
 1141 WRITE (6,431)EPRINT(KE+1), GSUM(KE)                               SUB0690
      GO TO 1150                                                        SUB0700
 1142 WRITE (6,431)EPRINT(KE+1), WEXP(IGINTV,KE),GSUM(KE)               SUB0710
      GO TO 1150                                                        SUB0720
 1143 WRITE (6,431)EPRINT(KE+1),(WEXP(K3,KE),K3=K1,K2),     GSUM(KE)    SUB0730
 1150 CONTINUE                                                          SUB0740
      SUM = 0.0                                                         SUB0750
      DO 1151  KE = 1, IEINTV                                           SUB0760
 1151 SUM = SUM + GSUM(KE)                                              SUB0770
      IF (IE1-2)              1152, 1153, 1153                          SUB0780
 1152 WRITE (6,443)SUM                                                  SUB0790
      GO TO 1195                                                        SUB0800
 1153 WRITE (6,443)(ESUM(KE), KE=K1,K2), SUM                            SUB0810
      GO TO 1195                                                        SUB0820
C   EIGHT(8) ' POLAR ANGLES/GEOMETRIC REGIONS PER PAGE
 1165 K1=K2+1                                                           SUB0840
      K2=K1+7                                                           SUB0850
      K4=K1+1                                                           SUB0860
      K5=K2+1                                                           SUB0870
      IF (MOP)                1166, 1166, 1170                          SUB0880
 1166 WRITE (6,1122)                                                    SUB0890
      WRITE (6,1123)(GPRINT(K3), K3=K4,K5)                              SUB0900
      GO TO 1171                                                        SUB0910
 1170 WRITE (6,1125)                                                    SUB0920
      WRITE (6,1126)(MRAT(K3), K3=K1,K2)                                SUB0930
 1171 DO 1175   KE = 1, IEINTV                                          SUB0940
      WRITE (6,431)EPRINT(KE+1),(WEXP(K3,KE), K3=K1,K2)                 SUB0950
 1175 CONTINUE                                                          SUB0960
      WRITE (6,443)(ESUM(K3), K3=K1,K2)                                 SUB0970
      ME1 = ME1-1                                                       SUB0980
      IE1 = IE1-8                                                       SUB0990
      GO TO 1117                                                        SUB1000
C                                                                       SUB1010
 1195 RETURN                                                            SUB1020
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                                                                    SUB1030
END
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REFERENCES

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2. Collins, D. G. and DeVries, T. W., Monte Carlo Calculations of Energy Depositions and Radiation Transport - Volume I: Validation of COHORT Codes and Volume II: Utilization of COHORT Codes, General Dynamics/ Fort Worth Reports FZK 176-1 and FZK-176-2 (21 December 1963)(U)