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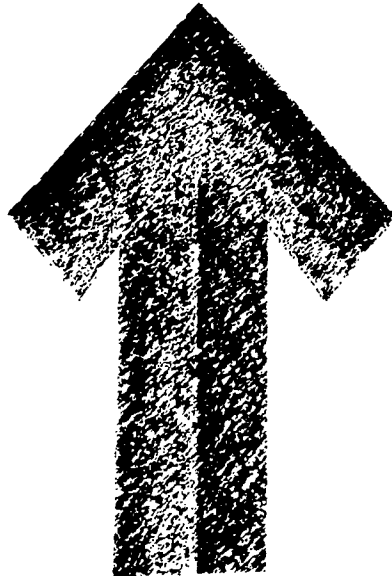
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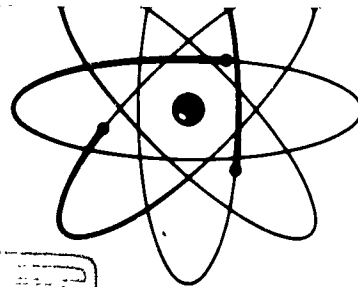
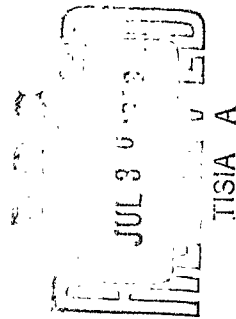
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MND-MC-2856
Report Number



United States Atomic Energy Commission
Division of Technical Information

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MASTER

⑥ GENERALIZED MONTE CARLO PROGRAM
FOR NEUTRONS--GMCM-9

July 15, 1962
MND-712-132000

⑩ by M. Knieller
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Nuclear Division
Martin Marietta Corporation

⑫ superseded MND-MC-
1113
K.C.

⑭ MND-MC-2856

FOREWORD

This report is submitted by the Nuclear Division of the Martin Marietta Corporation in compliance with Contract AF 33(616)-6818. The report outlines the theory appearing in the GMCM-9 code, and presents the information necessary for use and interpretation of the results of the code. This report supersedes report MND-MC-2193. The code described in MND-MC-2193 was never completely checked out. The code described in this report achieves the goal set forth in MND-MC-2193 by means of a method different than the method used in MND-MC-2193, and has embodied in it features not included in the code described in MND-MC-2193. Appreciation is extended to Mr. Richard Verga of Wright Air Development Division and Mr. Sidney Auslander of Pratt and Whitney Aircraft Corporation for their aid.

MND-MC-2856

SUMMARY

The GMCM-9 code for the IBM 7090 is a three-dimensional, multi-region, multienergy group, time-dependent, neutron random walk solution for reactor and shielding problems. A large enough number of particles* must be followed so that their total behavior is representative of the behavior of the particles in the situation being studied. The nuclear events considered (Chapter V) are particle absorption, fission, and scattering (elastic and inelastic) with provision to add breeding at a later date. The particles are followed from one region to another through the bounding surfaces (Chapter II, Geometry) defining the regions. A particle or its descendant is followed for a period of time specified by an input number; if the particle or its descendant survives time period, it is saved so that it can be used in the next time step.

The initial particles followed are obtained through the generator (Chapter IV) or by using information obtained in a previous run. The generator provides the initial distribution of particles according to the information given it, and stores the necessary coordinates of a number of particles on a tape called the initial value (IV) tape. The particles that reach census time are stored on a census tape. When all particles and their descendants from the IV tape have been followed, the census tape is used to obtain the particles to be followed in the next time step is to be studied.

The answers obtained are from straightforward Monte Carlo calculations and from analytic estimation. Analytic estimation is useful in obtaining answers for those regions where the Monte Carlo sampling is small. The answers obtainable for each census period are:

- (1) The number of particles leaking from the system.
- (2) The number of neutrons leaking from the system.
- (3) The number of neutrons entering the special tally regions (Chapter II) versus energy.
- (4) System criticality.
- (5) Number of neutrons scattered elastically.
- (6) Number of neutrons scattered inelastically.

*See Chapter III for definition of a particle.

ABSTRACT

GMCM-9 is a FORTRAN coded three-dimensional, multi-region, multienergy group, neutron random walk solution for reactor and shielding problems. Estimates are provided on the neutron flux within various zones of the configuration, the leakage at outer boundaries, and the criticality of reactor configurations. Answers are also obtained on the number of neutrons emerging from elastic scattering, inelastic scattering, and fission for the various materials. The program takes time into account, and may be used to obtain the above answers for successive time periods to investigate the time-dependent nature of a particular reactor configuration.

- (7) Number of fission neutrons born versus energy.
- (8) Number of neutrons absorbed.
- (9) Number of particles and neutrons starting their life history for the census period.
- (10) Number of particles and neutrons that remain in the system after the census period.
- (11) Neutron flux versus region and energy group.
- (12) Number of neutrons crossing from region l to region l' (maximum of 10 l ; l' pairs).
- (13) Number of neutrons scattered elastically versus material and energy group.
- (14) Number of neutrons scattered inelastically versus material and energy group.
- (15) Number of neutrons born in fission versus material and energy group.
- (16) Number of times the collision routine was entered versus material and energy group.
- (17) Total number of times the collision routine was entered.
- (18) Total number of particles on census tape.
- (19) The number of neutrons and particles that falls below the energy cutoff.
- (20) The last random number used in the calculation.

It is impossible to give the running time for a sample problem that will allow extrapolation to predict running times for a different type of problem. This situation exists because the running time of Monte Carlo is highly dependent on the geometry of the system being studied, the reactivity of the system, and the magnitudes of the elastic and inelastic scattering and absorption cross sections for the materials present in the system.

GMCM-9 is coded in FORTRAN for operation on a 32 K IBM 7090, and can be run at any installation that uses the SHARE mode of op-

eration. The code requires a maximum of 10 magnetic tapes, but may operate with as few as six magnetic tapes (see the note on Card Type 2 in Chapter IV). The input, output and chain tapes are those assigned by the installation. The code is instructed through the input which tapes to use as input, output and chain tapes. No magnetic drums are used.

In addition to the above-mentioned facts, GMCM-9 embodies the following features:

- (1) Inelastic scattering matrix is included in the collision routine (Chapter V).
- (2) A scheme (Russian Roulette) to ensure that the weight of the particle being followed is large enough to make significant contributions to the results (Appendix 1).
- (3) GMCM-9 is a time study problem in that it follows the particles and their descendants for a specified time called the census time (Chapter II) to obtain the Monte Carlo and analytic estimation results. The problem can be run for more than one time step using as sources the particles that had reached census time on a previous run (Chapter VI). The length of a census period is an input number. During each run, the particles that reach census time are written on a tape referred to as the census tape; it is the information on the census tape that describes the source for the next run.
- (4) Splitting of the particles into prescribed number of particles with a corresponding reduction of weight for each of the split particles takes place in certain predetermined regions when a collision occurs in these regions. The purpose here is to increase the reliability of the results by increasing the number of particles followed in regions far removed from the source. The number of particles into which the original particle splits as well as the regions where this process is to occur is entered as input (Chapter VI).
- (5) The geometrical configurations that can be studied are very general. The surfaces bounding a region are defined in the Cartesian coordinate system (x , y and z) by generalized quadratic equations (Chapter II, 5).
- (6) The distance a particle travels before suffering a collision is found by picking from an exponential distribution; the procedure for picking out of this distribution is outlined in Appendix C.

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- (7) The neutron collision routine uses random sampling from the appropriate discrete distributions to select either an elastic scatter event, an inelastic scattering event, a fission event, or an absorption event.
- (8) For a fission event the weight of the incident neutron is considered in determining the actual number of particles to follow. The angular distribution of the fission-produced particles is assumed isotropic in the laboratory system.
- (9) The emission of gamma rays due to inelastic scattering is allowed and the appropriate coordinates for the gammas are stored on magnetic tape.

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I. INTRODUCTION

GMCM-9 is a three-dimensional, multiregion, multienergy, time-dependent neutronic random walk solution for reactor and shielding problems.

GMCM-9 has been coded in FORTRAN for the IBM 7090 for the Wright Air Development Division by the Martin Marietta Corporation.

II. GENERAL INFORMATION

A. PROBABILITY THEORY

The method of calculation relies on the following fact. If sufficient neutronic random walks are formulated during the calculation in a way consistent with the nuclear and geometrical properties of the configuration, then the population of neutron path lengths, leakages, and collisions determined in the calculation will be a statistical approximation of the population that would occur in a real system of the same configuration. Thus, the calculation is primarily concerned with creating neutronic random walks which are as consistent as is practical with the physical model that is to be investigated.

Much of the physical information can be treated according to the laws of probability. For example, neutrons born in fission must be assigned energies which reflect the available information on the fission neutron energy spectrum. This energy spectrum is interpreted as a probability density function that provides the necessary information on the relative frequencies at which fission neutrons appear in the various portions of the energy scale. The code then uses a method (into which the information in the probability density function is incorporated) which assigns energies to neutrons born in fission in such a way that the probability that an assigned energy will be in a particular portion of the energy scale is proportional to the relative frequency of birth of fission neutrons in that portion of the energy scale. By this method particular values can be chosen for the variables which describe the neutronic random walk, and each phase of the random walk can be consistent with the available knowledge on neutron diffusion through material bodies.

B. TYPICAL PROBLEMS SOLVED BY GMCM-9

GMCM-9 can provide information on the neutron flux within the neutron leakage from a geometrical configuration which may simulate either a reactor, shield, or both. An example of a practical configuration which can be simulated by GMCM-9 is the Oak Ridge National Laboratory (ORNL) Lid Tank and any ordinary arrangement of shielding materials in it. Fission neutrons with approximately the correct distribution in both space and energy can be started from within the mockup source plate, and their neutronic random walks can be followed through the mockup lid tank configuration. Flux information is then available for each of the various energy groups in each of the regions of the configuration. Information on the source of inelastic gamma rays is available. Further fissions in the source plate, due to neutrons born in the source plate, are automatically calculated by the code.

Another configuration that can be simulated is a reactor with parallel fuel plates. The original population of neutrons is specified to start from the fuel plates, and succeeding generations of neutrons are born in a source density which is more and more characteristic of that configuration. The time required for the source to settle down to the equilibrium distribution is equivalent to the time required for a real reactor of this configuration to settle down to an equilibrium spatial distribution of the source (if the initial conditions for that source are the same as for the calculation). The criticality of the system, as well as the flux and leakage, can be estimated by this calculation. The calculation is limited for this application in that the effect of delayed neutrons is not included, although it could be. However, for an equilibrium flux the knowledge of the source that effected it and the fission ratio consistent with that flux provides an estimate of the criticality of the system.

C. CENSUS TIME

Census time is the real lifetime for which a neutron or its descendants is followed by the code. Census time is entered as an input number (Chapter VI).

Upon reaching census time the particle coordinates are written on a census tape for further processing.

D. DELW

DELW is the fraction of the original weight* W of each particle that is used as the criterion for either continuing to follow the particle or playing Russian Roulette (Appendix I). In the game of Russian Roulette, the particle is either killed (life history is terminated) or its weight is increased and its life history is continued to be followed.

The weight (W) of the particles being traced by the code is compared to DELW at appropriate points in its life history to ensure that its contribution to the results will be significant. More detailed information can be found in the flow diagrams.

*The original weight of the particle is the weight of the particle at the beginning of its life history.

E. GEOMETRY

1. Surfaces-Unique

In describing the system of interest, the system is divided into a number of regions sufficient to describe the actual system. Each of the regions used in modeling up the system is bounded by one or more surfaces. Each surface bounding a region must also be the boundary of at least one of the neighboring regions. Therefore, to eliminate duplication of input, the unique surfaces bounding all regions are input separate from the regions. In describing the boundaries of a region it is then necessary to specify the number of the surface as determined by its position in the input.

The general equation for a surface is

$$Ax^2 + X_0x + By^2 + Y_0y + Cz^2 + Z_0z = K \quad (2.5.1)$$

where A, B, C, K, X_0 , Y_0 , and Z_0 are constants and x, y, and z are the Cartesian coordinates of the surface. To permit more rapid calculation, six special forms of the equation are used. Introduction of these special forms necessitates the use of another constant, NT, which designates the form of the equation to be used. For the general equation, NT = 1. The six special forms of the equation and the corresponding value of NT are:

NT	Equation
2	$0 = A(x - X_0)^2 + B(y - Y_0)^2 + C(z - Z_0)^2 - K \quad (2.5.2)$
3	$0 = (x - X_0)^2 + (y - Y_0)^2 - K \quad (2.5.3)$
4	$0 = x - K \quad (2.5.4)$
5	$0 = y - K \quad (2.5.5)$
6	$0 = z - K \quad (2.5.6)$
7	$0 = X_0x + Y_0y + Z_0z - K \quad (2.5.7)$

Input for each surface consists of the eight constants NT, A, B, C, K, X_0 , Y_0 , and Z_0 (Card Types 14 and 15) even though, for some forms of the equation, they are not all used, i.e., NT = 4, A, B, C, Y_0 , Z_0 are all 0.0 and $X_0 = 1.0$; any number could be input for any of

these constants since the equations used by the code do not require their use.

Surfaces that can be represented by the general equation and its six special forms range from any generalized quadratic surface to a plane. However, for speed in computation it is best to represent a surface using the simplest possible form of the equation.

2. Region

A region is a volume of the system being studied. Each region is identified by the value of the index NR assigned to each region, based on the order of input. The material assigned to each region is treated as a homogeneous mixture and is assigned by the number MN (Card Type 16), the location of the material in the list of materials.

3. Inside-Outside Regions

If a region is one in which a particle's history is of interest, the region is an inside region. An outside region is one for which a particle's history is no longer of interest. Particles entering outside regions are said to have leaked from the system. For an inside region, the input number (Card Type 16), NOR is 0 and for an outside region, NOR = 1.

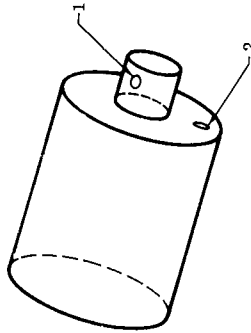
The input number NPFC (Card Type 16) is the number of particles to be followed from an elastic or inelastic scattering in this region. NPFC must be an integer. An input of 0 for this number is equivalent to an absorption when following the scattered particle. If the interaction of a particle in this region is a fission, NPFC is multiplied by the number of particles per fission (determined by NFISF) to give the total number of particles followed from the fission event. In all cases, the weight of particles after the interaction are adjusted to conserve neutrons.

4. Surfaces as Related to Regions

A region can be bounded by a maximum of six surfaces. The number of surfaces bounding a region is an input number, NSMAX (Card Type 7).

5. Ambiguous Boundaries

Using the concept of ambiguous boundaries can simplify input to the problem and increase the generality of possible region shapes. An ambiguous boundary is a true boundary of part of the region. In general, if a region has one ambiguous boundary it has at least two. Input for a region is limited to the cases of no ambiguous boundaries or two ambiguous boundaries (see Fig. 1). Consider the total volume enclosed



1. This surface is a true boundary for the smaller cylinder but is ambiguous for the region represented by the two cylinders
2. This surface is a true boundary for the larger cylinder but is ambiguous for the region represented by the two cylinders

Fig. 1. Example of Ambiguous Boundaries

by both cylinders in Fig. 1. Surface (1) is a true boundary for the smaller cylinder but is ambiguous for the region represented by the two cylinders. Surface (2) is a true boundary for the larger cylinder but is ambiguous for the region represented by the two cylinders. With the concept of ambiguous boundaries, a region represented by the two cylinders can be input as one region. It can also be input as two regions if desired.

If a region has ambiguous boundaries, the input number NAB = 1 (Card Type 16). If there are no ambiguous boundaries, NAB = 0.

In describing the surfaces bordering a region, ambiguous boundaries-if any-must be described first. For all other surfaces, the sequence of description is of little importance.

6. Ambiguity Index for Surfaces

For each surface bordering the region specified by NOS (Card Type 17), the location of the surface in the list of unique surfaces, there is the input number AI (Card Type 17) the ambiguity index of the surface. This number is + 1.0 if the function $r = (Ax^2 + X_0^2 + By^2 + Y_0^2 + Cz^2 + Z_0^2 - K)$ changes from negative to positive as a particle leaves the region through the surface. (x, y, z are the coordinates of the particle and A, B, C, X₀, Y₀, Z₀, K are the surface constants.) In this case the surface is called an outside surface of the region. Similarly, AI = - 1.0 if r changes from positive to negative as a neutron crosses the surface in leaving the region. In this instance the surface is said to be an inside surface of the region.

7. Calculation of Distance to Boundary

The equations for the surfaces are used for determining the distance between a point in a region and each of its boundaries along a line in the direction that a particle is travelling.

Let

- x, y, z = coordinates of the point
- α, β, γ = direction cosines of the velocity vector
- x', y', z' = coordinates of the point on the boundary where the intersection occurs
- S = distance between the two points.

Then

$$\begin{aligned}x' &= x + \alpha S & (2.5.8) \\y' &= y + \beta S & (2.5.9) \\z' &= z + \gamma S & (2.5.10)\end{aligned}$$

Substituting in the general equation of the surface

$$\begin{aligned}A(x + \alpha S)^2 + X_0^2 + B(y + \beta S)^2 + Y_0^2 + C(z + \gamma S)^2 + Z_0^2 - K &= 0\end{aligned}$$

requires the form

$$hS^2 + 2eS + r = 0$$

Then

$$\begin{aligned}h &= A\alpha^2 + B\beta^2 + C\gamma^2 & (2.5.11) \\e &= \alpha(Ax + X_0) + \beta(By + Y_0) + \gamma(Cz + Z_0) & (2.5.12) \\r &= x(Ax + X_0) + y(By + Y_0) + z(Cz + Z_0) - K & (2.5.13)\end{aligned}$$

with similar equations for the other forms of the general equation.

The distance, S, to the surface is calculated as

$$S = \frac{1}{h} \left[-e \pm \sqrt{e^2 - hr} \right] \quad (2.5.14)$$

The smallest, finite, positive root is accepted as the distance to the boundary. If there is no such root, no intersection exists. An attempt is made to calculate an S for each boundary assigned to the region. The smallest of the acceptable S's is designated SP, and the boundary, NS, for which this S was calculated is chosen as the one that would be crossed if the particle travels that far before collision or census time. The calculation is accepted as correct unless the region has ambiguous boundaries and the smallest distance corresponds to one of these boundaries. In this case the coordinates of the particle are sterped over the boundary and a test made to see if the particle is actually outside the region. If so, the calculated SP is then accepted as correct. If it is found that the particle would still be inside the region, SP is rejected and the next smallest of the S's is chosen as SP and is accepted as correct unless it corresponds to the other ambiguous boundary, in which case the same test is made again. More detailed information on the calculation of distances can be found in Subroutine SFIND.

8. Next Region

The equations of the surfaces are also used to determine the next region entered by a particle if it does cross a boundary. For each boundary of a region, the four most probable next regions a particle would enter on crossing that boundary are specified by input as MP(J), $J = 1, 2, 3, 4$ (Card Type 17).

On testing a region for acceptance as the next region entered by a particle the following test is made. First $r = (Ax^2 + X_0x + By^2 + Y_0y + Cz^2 + Z_0z - K)$ times AI is calculated for each surface of the region. If all are negative the region is accepted. If one is positive and corresponds to an ambiguous surface of the region, the region is accepted. In all other cases the region is rejected.

In locating the next region entered by the particle, region number MP(1) is tested first. If it is accepted the search stops. If not accepted, regions MP(2), MP(3), and MP(4) are tested next. If no region is accepted the search continues with region MP(4) + 1 to region NRMAX and from there to region 1 through region MP(4) - 1. If at any time a region is accepted as the correct region the search stops.

The four regions specified as most probable next regions do not have to be correct. They must however, be in the list of regions, that is, $1 < MP(J) < NRMAX$. A more detailed description of the location of the region a particle resides in can be found in Subroutine RFIND.

9. Error in Calculations

If there is faulty region or surface input and it is impossible to find an SP or the next region, a tally, NREJCT, is increased by 1 and a new particle is followed. When this tally reaches 5, tracing of particles is discontinued and such tallies as have been made are written on the output tape and the calculation terminated.

10. Rules for Mockup

The following rules must be followed in formulating the input for the geometry of a problem:

- (1) No two regions may overlap (have any common volume).
- (2) The space occupied by the system must be occupied by either inside regions or outside regions.

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- (3) The outermost regions of the system must be outside regions (allows the possibility of an isolated outside region(s) surrounded on all sides by inside regions).
- (4) All regions must be assigned at least one boundary.
- (5) Ambiguous boundaries, if any, must be assigned first.

It is evident from the sequence of events in both the search for a region and the calculation of a distance to boundary--two portions of the code in which a great portion of the calculation time is spent--that the choice of boundaries and regions and the manner in which they are sequenced in that portion of the input that describes the regions for a particular problem can greatly affect the running time needed for that problem. In some problems the choice between a good and a poor way of describing the geometry can easily alter the running time by a factor of two. The poor method for describing the geometry will give results identical to those which could be achieved with the faster calculation.

F. SPLITTING

Splitting results in a change in the number of particles being followed, and occurs at points of collision. The number of particles into which a particle splits in each region is entered as an input number (NPFC on Card Type 16, Chapter VI). The particles' weights must be adjusted to eliminate the bias introduced by this scheme. This is accomplished by requiring that the total number of neutrons involved before and after the collision be conserved:

$$\text{Weight of each particle after scattering} = W'$$

$$\text{Weight of particle before scattering} = W$$

$$\text{Number of particles after split} = \text{NPFC}$$

$$W' = \frac{W}{\text{NPFC}}$$

If the collision process is a fission, the code follows either 3 or JMAG particles after a collision (if NPFC = 1) depending on the input number NPFSF described on Card Type 8 in Chapter VI. In either case the weight W' must be adjusted according to the following formula

$$W' = \frac{W \cdot \nu}{\text{NPFC} \cdot \beta} \quad \text{if } 3 \cdot \text{NPFC particles are followed or}$$

$$W' = \frac{W \cdot \nu}{\text{NPFC} \cdot \text{JMAG}} \quad \text{if NPFC} \cdot \text{JMAG particles are followed,}$$

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where v is the number of particles per fission.

G. GAMMAS DUE TO INELASTIC SCATTERING

If it is desired, the coordinates of the gammas born of inelastic scattering can be saved on a magnetic tape to be processed at a later time. The coordinates that are written in binary in blocks of 30 each time an inelastic scattering event occurs are:

x, y, z ; the Cartesian coordinates of the scattering point

MRG; the region in which the scattering occurred

EGAM; the energy of the gamma

W; the weight of the neutron that was scattered.

The control word (NGAM) which instructs the code to calculate or delete the calculation of and writing of the gamma coordinates due to inelastic scattering on a tape is entered on Card Type 8. Further details can be found in the flow diagrams.

H. BREEDING

Breeding is considered in the present code only to the extent that the weight of the particle causing breeding and the region index in which the event takes place is saved on a tape for future processing. If breeding is to be considered in the calculation, the isotope which will cause breeding must be the first isotope in the description of the material. In order to keep track of the neutron economy, a breeding event is tallied as an absorption by the code. A separate tally is made of the number of neutrons which suffer a breeding event. The input number (NBREED) which instructs the code that the first isotope of the material is a breeder is entered on Card Type 18. Further details can be found in the COLISEN flow diagram (see Fig. D-3).

I. SPECIAL TALLY REGIONS

Any three regions of the system studied may be designated as special tally regions. The total number of neutrons entering each of these regions will be tallied for each census time. The three special tally regions (NSTR) are input on Card Type 10.

J. MIGRATION TALLIES FROM REGION l TO REGION l'

It is possible to designate up to 10 pairs of regions (l, l') for which a tally is made of the neutrons crossing from region l to region l' .

The number of region pairs for which this type of tally is made is input on Card Type 8. The region pairs for which the tallies are to be made are input on Card Type 11.

III. PROGRAM SEQUENCE OF OPERATIONS

An attempt is made here to give a brief word description of the operation of GCM-3. It is hoped that this overall picture of the flow of information in the code will aid in understanding the code. For details beyond this brief word picture, reference must be made to the flow diagrams.

In a true physical situation, neutrons are identified as whole neutrons; statistically speaking, the neutrons are said to have a weight of one. In this program a neutron may have a weight different from one in which case the neutron of weight (W) is referred to as a particle.

The program is divided into three distinct parts (Chains 1, 2 and 3), each chain depending on the one which precedes it. In general, the first chain reads the input, writes the input on the output tape, calculates the storage requirements, generates the coordinates of the particles to be followed (unless they are on tape) and calculates the total macroscopic cross section for each material along with the cumulative probabilities of interaction (breeding, absorption, fission, elastic scattering and inelastic scattering) for each energy group and isotope in each material. The second chain follows the life histories of the particles and tallies the answers. The third chain performs additional calculations on the tallies to express some of them in more meaningful form, and writes the answers on output tape. With this general picture in mind, the remainder of this chapter will be devoted to a more detailed explanation of Chains 1 and 2.

A. CHAIN 1

The object program and the input is read from cards onto the input tape. The P-PREP routine of Chain 1 writes the input, variable by variable, on the output tape as the variables are read in from the input tape. This scheme provides a check on data which may be incorrect in the sense of being out of order or in the incorrect mode (see input). The storage requirements are then calculated. If the storage requirements exceed 18,000, the code indicates that the storage requirements have been exceeded and stops. The problem can be resubmitted after it has been rearranged to reduce some of the storage required. The means of accomplishing this is discussed in Chapter VI under Trading Storage.

The next calculation performed in Chain 1 is that f_c : the total macroscopic cross section for each material and energy group along with the cumulative probabilities of breeding, absorption, fission, and

scattering, elastically and inelastically, for each isotope and energy group in each material.

The coordinates for the number of particles (position, direction, velocity, region, energy group, weight and time) requested in the input is then generated by picking from the appropriate cumulative probability distribution tables. The coordinates are written on the IV tape in records of 10 particles. The code then enters Chain 2 for its next operation. If the coordinates of the particle are on tape (labeled the census tape)* the particle coordinate generator portion of P-PREP is bypassed and Chain 2 is entered.

B. CHAIN 2

The main program of Chain 2 performs the calculation of the histories of the particles. The answers are tallied by straight Monte Carlo methods and/or analytic estimation (Appendix G). Chain 2 begins by selecting the coordinates of a single source particle from memory. If no coordinates are available in memory, then a record of coordinates of particles is loaded into memory from the magnetic tape generated in Chain 1 or from the census tape (CT). If there are no more records of particles on tape, then Chain 3 is entered. If the particle coordinates are taken from the IV tape, the number of mean free paths to the next collision is picked from a random exponential distribution (EXPP). If the particle chosen is from the CT, the number of mean free paths to collision is included with the particle coordinates. In either case the appropriate contributors are made to the particle and neutron tallies of the number of particles and neutrons followed.

If analytic estimation is not requested, the distance the particle must travel in order to escape the region is determined in subroutine SFIND. SFIND determines this distance by calculating the distances to each surface bounding the region from the spatial coordinates and direction cosines of the particle. The smallest of these distances (provided the path length to the surface lies in the region) is the distance the particle must travel in order to escape from the region. The material for the region is found and the time the particle will be in the region until the particle escapes from the region is added to the time the particle has been in the system. If this time exceeds the census time, the distances the particle must travel with velocity VEL in order to reach census time is determined. If at any point during the history of

*The census tape contains the coordinates of the particles that have exceeded the census time on a previous run. The coordinates saved are position, direction, velocity, energy group, region, weight, weight cutoff and the number of mean free paths to the next collision.

the particle the cross section for the region is zero, appropriate forks are set in the code to eliminate unnecessary calculations. The particle is checked to determine if a collision has occurred for the particle with its present set of direction cosines. The number of mean free paths the particle will have traveled from the Cartesian coordinates of the particle as it came from tape or the last point of collision to the point where it will escape the region it is in or exceed census time (SPMFP) is then compared with EXPP, the number chosen from the exponential distribution. If SPMFP is larger than EXPP, the flux is tallied and the collision routine (COLSN) is entered. The collision routine is described in some detail in the appendix and in the flow diagrams; the routine essentially determines the type of interaction the neutron will experience, assigns new direction cosines and velocity to the particle or makes provisions for these to be calculated at another point in the calculation, depending on the type of interaction, and makes appropriate tallies. The code then searches for a new particle to follow. If no collision is to occur (SPMFP < EXPP), the flux is tallied for the material and energy group and the time is checked against the census time. If the census time has been exceeded, the appropriate particle coordinates are written on the census tape and the code searches for another particle to follow. If the census time is not exceeded, the region the particle will enter next is determined by subroutine RFIND and the process is repeated by starting with the calculation of the distance required to escape from the new region.

If analytic estimation answers are requested the particle history is followed exactly as in the case described above (no analytic estimation answers requested), with the exception that certain tallies are made by using the analytic estimation results instead of the straightforward Monte Carlo results (see Chapter VII) and the code continues to follow the particle even after a collision has occurred until the particle escapes from the system, exceeds census time, or falls below the weight cutoff so that analytic estimation answers may be tabulated. If a collision has occurred before a particle has exceeded census time (analytic estimation answers requested) the particle coordinates are not written on the census tape. After the code is finished following a particle, a new particle is chosen to follow.

IV. PARTICLE COORDINATE GENERATOR OF CHAIN 1

The generator portion of the first chain prepares the initial value tape. The input number, NKASE (Card Type 29), represents the number of times the generator calculation will be repeated to obtain a more detailed representation of the source. If NKASE is zero, the generator is bypassed. In this case a previously prepared initial value tape, which fits the structure of the problem, must be used. This does not mean a census tape from a previous problem, since the census tape includes several additional coordinates.

The initial value tape contains all quantities needed to describe the source particles. These are the Cartesian coordinates, direction cosines, velocity, energy group, weight, region, and time of birth. These generalized coordinates are written in records of 10 particles each on the initial value tape.

The Cartesian coordinates (x , y , and z), direction cosines (α , β , and γ), velocity, and energy group are generated from several input table pairs (Card Types 35 and 36): $L-L'$, $M-M'$, $N-N'$, $O-O'$, $P-P'$, $R-R'$, and $S-S'$ corresponding to $j = 1, 2, \dots, 7$. The unprimed table of a given pair is a set of integrated probabilities of which the first is 1.0 and the last 0.0. The primed table of this pair is a set of coordinates from which a particle coordinate will be chosen. For example, the L , L' tables are used to select the value of a coordinate, the z coordinate; L consists of a set of L_1 , and L' consists of a set of L_1' . L_1 is the probability that $z \leq L_1$ (see Appendix D). The number of entries in each table of a given pair, corresponding to j , is $IMX(j)$ an input quantity (Card Types 32 and 33). The tables used depend on the input numbers NA and NE (Card Type 30).

NA determines the tables and method used in generating the Cartesian coordinates of the particles. These are:

NA = 1 Z, X, Y are generated using the table pairs $L-L'$, $M-M'$, and $N-N'$, respectively. Special cases are:

(A) Plane source:

(1) Parallel to XY plane:

(a) Use two entries in $L-L'$ tables

(b) Set $L_1 = 1.0$, $L_2 = 0.0$

(c) Set $L_1' = Z_0$, $L_2' = Z_0$

(2) Similarly for planes parallel to XZ and YZ planes.

(B) Line source:

(1) Parallel to X-axis:

(a) Use two entries in L-L' and N-N' tables.

(b) Set L_1 and $N_1 = 1.0$, L_2 and $N_2 = 0.0$.

(c) Set $L_1' = Z_0$, $L_2' = Z_0$; $N_1' = Y_0$, $N_2' = Y_0$.

(2) Similarly for lines parallel to Y and Z axis.

(C) Point source:

(1) Use 2 entries in L-L', M-M', and N-N' tables.

(2) Set L_1 , M_1 , $N_1 = 1.0$; L_2 , M_2 , $N_2 = 0.0$.

(3) Set L_1' , $L_2' = Z_0$; M_1' , $M_2' = X_0$; N_1' , $N_2' = Y_0$.

NA = 2 Z is generated using the L-L' tables. $\rho = \sqrt{x^2 + y^2}$ is chosen from the 0-0' tables. $|x|$ is selected at random from a uniform distribution between 0.0 and ρ . $|y|$ is calculated as $|y| = \sqrt{\rho^2 - x^2}$. The signs of x and y are chosen at random.

(D) Special cases:

(1) Plane source parallel to XY plane.

(2) Line source along Z axis.

(3) Point source at (0, 0, Z_0).

NA = 3, 4 Z is generated using the L-L' tables. $\rho = \sqrt{x^2 + y^2}$ is chosen from the 0-0' tables. $|x|$ and $|y|$ are calculated subject to the restriction $0 \leq \sqrt{x^2 + y^2} \leq 0_1 - 1$ where the 0_1 's are entries in the 0' table and the values of $|x|$ and $|y|$ used are $|x| = \xi_{1,1-1}$ and $|y| = \xi_{2,1-1}$ where ξ_1 , ξ_2 are random numbers between

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0 and 1.0. After meeting this restriction the signs of x and y are chosen at random.

(E) Special case:

Plane source parallel to XY plane

NA = 5 $r = \sqrt{x^2 + y^2 + z^2}$ is chosen from the L-L' table $|x|$, $|y|$, and $|z|$ are chosen with the restriction L_1'
 $\leq \sqrt{x^2 + y^2 + z^2} \leq L_1'$ where the L_1' 's are entries in the L' table. The values used for $|x|$, $|y|$, and $|z|$ are: $|x| = \xi_{1,1-1}$; $|y| = \xi_{2,1-1}$, and $|z| = \xi_{3,1-1}$. After locating suitable values for ξ_1 , ξ_2 and ξ_3 the signs of x, y, and z are chosen at random.

Also used in the generation of the Cartesian coordinates are the input numbers NTRA (Card Type 30), XZRO, YZRO, and ZZRO (Card Type 31). If NTRA = 0, the X, Y, and Z coordinates are written on the initial value tape as calculated. If NTRA = 1, the coordinates are translated by XZRO, YZRO, and ZZRO before being written on tape. This allows the generation of a spherical or cylindrical source other than at the origin.

NE (Card Type 30) determines the method of calculating the direction cosines. These are:

NE = 1 α , β , γ are chosen isotropically using no tables.

NE = 2 γ is chosen from the R' table ($-1 \leq \gamma \leq 1$), α and β are chosen uniformly over their intervals subject to the condition that $\alpha^2 + \beta^2 = 1 - \gamma^2$ Special Case $\gamma = \gamma_0$.

NE = 3 γ is selected from the R' table ($-1 \leq \gamma \leq 1$), α is selected from the S' table ($-1 \leq \alpha \leq 1$) and β is calculated as $\beta = \sqrt{1 - \alpha^2 - \gamma^2}$ Special Case $\gamma = \gamma_0$, $\alpha = \alpha_0$, $\beta = \sqrt{1 - \alpha_0^2 - \gamma_0^2}$.

The velocity group and the energy group are generated using the P-P' table. ξ ($0 \leq \xi \leq 1$) is located in the P table ($P_1 \leq \xi \leq P_{1-1}$). The energy group is 1-1, and the velocity is chosen from a uniform

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V. CROSS-SECTION PORTION OF CHAIN 1

The nuclear data needed by the code is supplied by card input. For several problems having identical material and isotope input, the cross-section tape generated by the first problem can be used to input the majority of the nuclear data for successive problems.

The input can be divided into two sections: the first section describes materials, and the second section describes isotopes. The material input consists of:

MMAX = total number of materials
 NIMAX(M) = number of isotopes of the Mth material
 NBREED(M) = breeding option for the Mth material
 RHO(M) = density (g/cm^3) of the Mth material
 K(NI,M) = identification of the NIth isotope of the Mth material (location of the isotope in the input for isotopes)

WTF(NI,M) = weight fraction of the NIth isotope of the Mth material.

The isotope (used interchangeably with element) input used in calculating cross sections and interaction probabilities consists of:

NFI = total number of fissionable isotopes
 IMAX = total number of isotopes (including fissionable isotopes)
 A(I) = atomic mass (amu) of the Ith isotope
 SEL(J,I) = microscopic elastic scattering cross section
 SIN(J,I) = microscopic inelastic scattering cross section
 SFIS(J,I) = microscopic fission cross section
 SCAP(J,I) = microscopic capture cross section,

where J is the energy group. The microscopic cross sections all have units of barns.

distribution between P_{i-1} and P_i . For a monoenergetic source of energy E_0 corresponding to the energy group J_0 , input the $P-P$ tables with $J_0 + 1$ entries each with $P_i = 1.0$ for $i = 1, 2, \dots, J_0$ and $P_{J_0+1} = 0.0$ and input all $P_i = E_0$.

The weight of each particle generated is WIN and input number (Card Type 31). The time of birth of the particle is dependent on NH, an input number (Card Type 30). If NH = 0 the time of birth is set at 0.0. If NH = 1, the time of birth is selected from a uniform distribution between 0.0 and TIN, an input time (Card Type 31).

The region of birth of each particle is also input as NRIN (Card Type 30). The coordinates generated must correspond to this region for the problem to run.

It is possible to generate particles using more than one set of input table pairs L-L', M-M', N-N', O-O', P-P', R-R'. In this case NKASE represents the number of input table pairs. The total number of particles generated for each case is determined by NPIV, an input number (Card Type 30). NPIV is the total number of particles generated up to and including a given set of generator input.

The coordinates of the first 50 particles generated and written on the initial value tape are also written on the printout.

Also input for each fissionable isotope are:

FS(J,I) = probability of a particle being born at the energy level J or below (fission spectrum)

PNU(J,I) = neutrons born per fission for an incident neutron in energy group J.

The input for fissionable isotopes must precede that of the other isotopes. Also, when assigning isotopes to materials, if the material is to have breeding, the breeding isotope must be the first isotope assigned. Fissionable isotopes must also be assigned to a material before other isotopes. If a material has fissionable isotopes it can have breeding only if the first fissionable isotope and the breeder isotope are identical.

This input is used to calculate the following quantities used in tracing particles:

XSECT(J,M) = total cross section (cm^{-1}) for material M, energy group J

PSE(NI,J,M) = probability of an elastic scatter off the NIth isotope of material M for a particle in energy group J

PSI(NI,J,M) = probability of an inelastic scatter off the NIth isotope of material M for a particle in energy group J

PSF(NI,J,M) = probability of a fission with the NIth isotope of material M for a particle in energy group J

PS(L,J,M) = L = 1, neutrons from elastic scattering

L = 2, neutrons from inelastic scattering

L = 3, neutrons from fission scattering

for an interaction with material M by a neutron in the Jth energy group

PB(J,M) = probability of breeding (capture by the first isotope of material M for a particle in the Jth energy group interacting with the Mth material

These quantities are calculated for material M using the following intermediate quantities:

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$$\text{SUM } 1 \text{ (NI, J)} = \sum_{N=1}^{\text{NI}} \frac{\text{SEL}(J, I) * \text{WTF}(N, M) / A(I)}{K(N, M) \text{ and } \text{WTF}(N, M) \text{ is the weight fraction of isotope N in material M.}}$$

$$\text{SUM } 2 \text{ (NI, J)} = \sum_{N=1}^{\text{NI}} \frac{\text{SIN}(J, I) * \text{WTF}(N, M) / A(I)}{K(N, M)} \quad 5.2$$

$$\text{SUM } 3 \text{ (NI, J)} = \sum_{N=1}^{\text{NI}} \frac{\text{SFIS}(J, I) * \text{WTF}(N, M) / A(I)}{K(N, M)} \quad 5.3$$

$$\text{SUM } 4 \text{ (J)} = \sum_{N=1}^{\text{NIMAX}(M)} [\text{SEL}(J, I) + \text{SIN}(J, I) + \text{SFIS}(J, I)] \quad 5.4$$

+ SCAP(J, I) * WTF(N, M) / A(I), where I = K(N, M) is the index used in identifying the isotope's atomic mass and cross sections.

Using these quantities, the calculation proceeds as follows:

$$\text{XSECT}(J, M) = 0.6023 * R \text{ HO}(M) * \text{SUM } 4 \text{ (J)} \quad 5.5$$

$$\text{PSE}(\text{NI, J, M}) = \text{SUM } 1 \text{ (NI, J)} / \text{SUM } 4 \text{ (J)} \quad 5.6$$

$$\text{PSI}(1, J, M) = \text{PSE}(\text{NIMAX}(M), J, M) \quad 5.7$$

$$\text{PSI}(\text{NI, J, M}) = \text{PSI}(1, J, M) + \text{SUM } 2 \text{ (NI, J)} / \text{SUM } 4 \text{ (J)} \quad 5.8$$

$$\text{PS}(2, J, M) = \text{PSI}(\text{NIMAX}(M), J, M) - \text{PSI}(1, J, M) \quad 5.9$$

$$\text{PSF}(\text{NI, J, M}) = \text{PSI}(\text{NIMAX}(M), J, M) + \frac{\text{SUM } 3 \text{ (NI, J)}}{\text{SUM } 4 \text{ (J)}} \quad 5.10$$

$$\text{If NBREED}(M) = 1$$

$$\text{PB}(J, M) = \text{PSF}(\text{NIMAX}(M), J, M) + \frac{\text{SCAP}(J, I) * \text{WTF}(I, M)}{A(I) * \text{SUM } 4 \text{ (J)}} \quad 5.11$$

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where $I = K(I, M)$

$$PS(3, J, M) = \frac{\left[\sum_{N=1}^{NMAX} SFIS(J, I) * WTF(N, M) * PNU(J, I) / A(I) \right]}{SUM 4(J)} \quad 5.12$$

where $I = K(N, M)$ and $NMAX$ is the total number of fissionable isotopes in material M .

This method of calculation gives probabilities for interaction of the following type.

In choosing the interaction and isotope for a particle in the J th energy group having a collision in the M th material, the probabilities in ascending order are:

PSE(1, J, M)
 (2, J, M)
 .
 .
 (NI, J, M)
 .
 .
 (NIMAX(M), J, M) = PS(1, J, M)

These cumulative probabilities are monotonically increasing, the first being > 0 , and the last being ≤ 1.0

PS(1, J, M)
 (2, J, M)
 .
 .
 (NI, J, M)
 .
 .

(NIMAX(M), J, M) = PS(1, J, M) + PS(2, J, M)

PSF(1, J, M)

(2, J, M)

.

.

(NI, J, M)

.

.

(NIMAX(M), J, M)

and, if NBREED(M) = 1

PB(J, M)

The probabilities, $PS(L, J, M)$ are used in the analytic estimation routine for making tallies of neutrons from elastic and inelastic scattering and fission.

Input for each isotope also includes the inelastic scattering matrix (Card Type 22). If all inelastic scattering cross sections are zero it will not be used, but must still be input. This matrix, consisting of the elements $P(J', J, I)$ is a triangular matrix, since inelastic scattering is only to energies below the incident particle energy. $P(J', J, I)$ is the probability of a particle scattering inelastically from isotope I , originally in energy group J , and ending up in energy J' . The inelastic scattering matrix is tabulated for the center of mass coordinates.

VI. INPUT

A. SEQUENCE OF GMCM-9 DECK

The sequence of GMCM-9 Deck is shown in Fig. 2.

B. INPUT FORMAT

The input is entered into the machine in one of the three formats which are described below.

FORMAT 1. Fixed point (I12). The decimal point is not punched and is assumed after the last digit. The number is punched so that its last digit is in either column 12, 24, 36, 48, 60, or 72 depending on whether it is the 1st, 2nd, 3rd, 4th, 5th, or 6th piece of information on the card.

FORMAT 2. Floating point (E12.5). The decimal point must appear in the number. The exponent may appear in addition if the number is too large. The last digit describing the number must appear in either column 12, 24, 36, 48, 60, or 72 depending on whether it is the 1st, 2nd, 3rd, 4th, 5th, or 6th piece of information on the card.

(Example: -36. could appear as -0.36+2 or -36.+0 or -36. or -3.6+1 and +0.021 could appear as 0.21-1 or 0.021 or 21.-3 or 0.021.)

FORMAT 3. Octal (012). The octal number is the same as the fixed point number, but the number is an octal number; i.e. a number to the base 8.

C. CONTINUATION OF INPUT ON MORE THAN ONE CARD TYPE

Information being input may occupy more than one card of a particular type. If this is the case, more than one card of a particular type may be used. As an example consider Card Type 6 which describes the number of isotope in each material. If there are 9 materials, containing respectively 1, 2, 3, 4, 5, 6, 5, 4, 3 isotopes, then there would be two Card Type 6 input cards. The first card would describe the first 6 materials and would have the numbers 1, 2, 3, 4, 5, 6 in columns 12, 24, 36, 48, 60, 72, respectively, and the second card would describe the last three materials and would have 5, 4, 3 in columns 12, 24, 36, respectively.

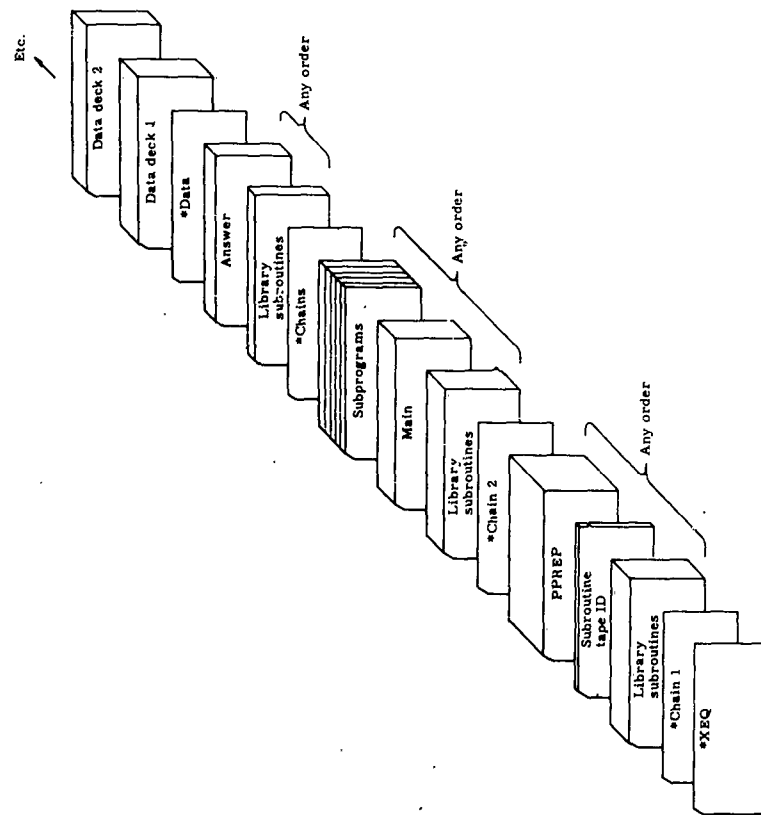


Fig. 2. Sequence of GMCH-9 Deck

D. TRADING STORAGE

It is possible that the problem will stop before a single particle history has been followed because the storage requirements have exceeded 18,000 words. This situation can be remedied by rearranging the problem to reduce the storage requirements. The problem can be rearranged by:

- (1) Reducing some of the regions.
- (2) Deleting the request for answers which may be of little importance to the user and which require large blocks of information such as:
 - (a) The number of neutrons scattered elastically, in-elastically versus material and energy group.
 - (b) The number of neutrons from fission versus material and energy group.
 - (c) The neutron flux versus region and energy group.
- (3) Reducing the number of materials and/or isotopes and/or energy groups.

E. INPUT DESCRIPTION

The input forms (Pages 32 to 78) describe the information to be inputted, the format of each piece of input data, the physical units (if any) of the input data, the symbol used in the code to represent the data, and the order in which the data must be entered to perform a calculation. In addition, where arrays of data must be inputted, auxiliary information is included with the input forms to aid in establishing the order of the input cards for these arrays. Columns 73 to 80 of the input cards may be used to identify the information on the card. A suggested method of identification is the card type number which appears on the left of the input forms.

WORD	1	2	3	4	5	6
COLUMNS	1-12	12-24	24-36	36-48	48-60	60-72
FORMAT	112 Paced Point	112 Paced Point	112 Paced Point	112 Paced Point	112 Paced Point	112 Paced Point
D E S C R I P T I O N	Logical designation of input tape unit	Logical designation of input tape unit	Logical designation of cross-section tape unit	Logical designation of initial tape unit (from previous problem)	Logical designation of intermediate tape unit	Logical designation of final tape unit
UNITS	Name M10	Name M8	Name M4	Name M3	Name M2	Name M1
SYMBOL						

CARD
TYPE
1

MMD-MC-2000

MINIJ-MLC-2000

WORD	1	2	3	4	5	6
FORMAT	1-12 Paced Point	12-24 Paced Point	24-36 Paced Point	36-48 Paced Point	48-60 Paced Point	60-72 Paced Point
	Logical designation of output tape unit	Logical designation of output tape unit	Logical designation of cross-section tape unit	Logical designation of initial tape unit (new from previous problem)	Logical designation of transfer tape unit	Logical designation of final tape unit
D E S C R I P T I O N						
CARD TYPE						
UNITS	Name M10	Name M8	Name M4	Name M1	Name M5	Name M5
SYMBOL						

CARD TYPE

MND-MC-2850

11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

WORD COLUMNS	1		2		3		4	
	1-13	Piled Point	17-24	Piled Point	31-38	Piled Point	45-52	Piled Point
FORMAT	Logical designation of cross-lane wall	Logical designation of chain lane wall	Logical designation of chain lane tape unit	Logical designation of chain lane tape unit	Logical designation of chain lane tape unit	Logical designation of chain lane tape unit	Logical designation of chain lane tape unit	Logical designation of chain lane tape unit
D								
E								
S								
C								
R								
I								
P								
T								
I								
O								
N								

CARD TYPE 2

NOTE: All lanes are used by this code at least once i.e., start MR, MT, MR, MS, M4, M5, M6, and M7 are reserved and therefore must be assigned an initial number. These tapes that are not to be used later are shown in bold type.

NOTE: The other logical designations, lane places in this category are as follows: cross section tape not saved; no brace; AP; action cross sections are reserved and therefore cannot be used.

CARD TYPE 3	WORD	2-72
	COLUMNS	10/11/12/13
	FORMAT	
D E S C R I P T I O N		
UNITS SYMBOL		

NOTE: Input 3--card type 3 (three cards with any information desired)

WORD	COLUMNS	1-17 Fixed Point	18-24 Fixed Point	25-35 Fixed Point	36-40 Fixed Point
FORMAT					
D		NET = 0 This problem uses a built-in value type from the particle generator.	NOPAE = 0 The analytic estimation subroutine is not entered.	Total number of particles on the initial value tape for this problem. Initial value tape for problem.	SATVAL equals random number. TNSR is a 12-digit number.
E					
S					
R					
I					
P					
T					
J					
O					
N					

CARD TYPE 4

WORD COLUMNS	1		2		3		4		5		6	
	1-12	13-24	25-36	37-48	49-60	61-72	73-84	85-96	97-108	109-120	121-132	133-144
FORMAT	Fixed Point	Fixed Point	Fixed Point	Fixed Point	Fixed Point	Fixed Point	Fixed Point	Fixed Point	Fixed Point	Fixed Point	Fixed Point	Fixed Point
D E S C R I P T I O N	Total number of materials ≤ 10	Total number of regions in all materials ≤ 10	Total number of stations from CMAA These must be the flow NPI (except for Isotope Input)	Total number of energy groups ≤ 12	Total number of regions ≤ 100	Total number of surfaces for regions (Total number of materials × number of distinct surfaces)						
UNITS SYMBOL	None	None	None	None	None	None	None	None	None	None	None	None
	MAX	MAX	NFI	JMAX	NMAX	NMAX	NMAX	NMAX	NMAX	NMAX	NMAX	NMAX

WORD	COLUMNS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
FORMAT	1-12	13-24	25-36	37-48	49-60	61-72	73-84	85-96	97-108	109-120	121-132	133-144	145-156	157-168	169-180	181-192	193-204	205-216	217-228	229-240	241-252	253-264	265-276	277-288	289-300	301-312	313-324	325-336	337-348	349-360	361-372	373-384	385-396	397-408	409-420	421-432	433-444	445-456	457-468	469-480	481-492	493-504	505-516	517-528	529-540	541-552	553-564	565-576	577-588	589-600	601-612	613-624	625-636	637-648	649-660	661-672	673-684	685-696	697-708	709-720	721-732	733-744	745-756	757-768	769-780	781-792	793-804	805-816	817-828	829-840	841-852	853-864	865-876	877-888	889-900	901-912	913-924	925-936	937-948	949-960	961-972	973-984	985-996	997-1008	1009-1020	1021-1032	1033-1044	1045-1056	1057-1068	1069-1080	1081-1092	1093-1104	1105-1116	1117-1128	1129-1140	1141-1152	1153-1164	1165-1176	1177-1188	1189-1200	1201-1212	1213-1224	1225-1236	1237-1248	1249-1260	1261-1272	1273-1284	1285-1296	1297-1308	1309-1320	1321-1332	1333-1344	1345-1356	1357-1368	1369-1380	1381-1392	1393-1404	1405-1416	1417-1428	1429-1440	1441-1452	1453-1464	1465-1476	1477-1488	1489-1500	1501-1512	1513-1524	1525-1536	1537-1548	1549-1560	1561-1572	1573-1584	1585-1596	1597-1608	1609-1620	1621-1632	1633-1644	1645-1656	1657-1668	1669-1680	1681-1692	1693-1704	1705-1716	1717-1728	1729-1740	1741-1752	1753-1764	1765-1776	1777-1788	1789-1800	1801-1812	1813-1824	1825-1836	1837-1848	1849-1860	1861-1872	1873-1884	1885-1896	1897-1908	1909-1920	1921-1932	1933-1944	1945-1956	1957-1968	1969-1980	1981-1992	1993-2004	2005-2016	2017-2028	2029-2040	2041-2052	2053-2064	2065-2076	2077-2088	2089-2100	2101-2112	2113-2124	2125-2136	2137-2148	2149-2160	2161-2172	2173-2184	2185-2196	2197-2208	2209-2220	2221-2232	2233-2244	2245-2256	2257-2268	2269-2280	2281-2292	2293-2304	2305-2316	2317-2328	2329-2340	2341-2352	2353-2364	2365-2376	2377-2388	2389-2400	2401-2412	2413-2424	2425-2436	2437-2448	2449-2460	2461-2472	2473-2484	2485-2496	2497-2508	2509-2520	2521-2532	2533-2544	2545-2556	2557-2568	2569-2580	2581-2592	2593-2604	2605-2616	2617-2628	2629-2640	2641-2652	2653-2664	2665-2676	2677-2688	2689-2700	2701-2712	2713-2724	2725-2736	2737-2748	2749-2760	2761-2772	2773-2784	2785-2796	2797-2808	2809-2820	2821-2832	2833-2844	2845-2856	2857-2868	2869-2880	2881-2892	2893-2904	2905-2916	2917-2928	2929-2940	2941-2952	2953-2964	2965-2976	2977-2988	2989-3000	3001-3012	3013-3024	3025-3036	3037-3048	3049-3060	3061-3072	3073-3084	3085-3096	3097-3108	3109-3120	3121-3132	3133-3144	3145-3156	3157-3168	3169-3180	3181-3192	3193-3204	3205-3216	3217-3228	3229-3240	3241-3252	3253-3264	3265-3276	3277-3288	3289-3300	3301-3312	3313-3324	3325-3336	3337-3348	3349-3360	3361-3372	3373-3384	3385-3396	3397-3408	3409-3420	3421-3432	3433-3444	3445-3456	3457-3468	3469-3480	3481-3492	3493-3504	3505-3516	3517-3528	3529-3540	3541-3552	3553-3564	3565-3576	3577-3588	3589-3600	3601-3612	3613-3624	3625-3636	3637-3648	3649-3660	3661-3672	3673-3684	3685-3696	3697-3708	3709-3720	3721-3732	3733-3744	3745-3756	3757-3768	3769-3780	3781-3792	3793-3804	3805-3816	3817-3828	3829-3840	3841-3852	3853-3864	3865-3876	3877-3888	3889-3900	3901-3912	3913-3924	3925-3936	3937-3948	3949-3960	3961-3972	3973-3984	3985-3996	3997-4008	4009-4020	4021-4032	4033-4044	4045-4056	4057-4068	4069-4080	4081-4092	4093-4104	4105-4116	4117-4128	4129-4140	4141-4152	4153-4164	4165-4176	4177-4188	4189-4200	4201-4212	4213-4224	4225-4236	4237-4248	4249-4260	4261-4272	4273-4284	4285-4296	4297-4308	4309-4320	4321-4332	4333-4344	4345-4356	4357-4368	4369-4380	4381-4392	4393-4404	4405-4416	4417-4428	4429-4440	4441-4452	4453-4464	4465-4476	4477-4488	4489-4500	4501-4512	4513-4524	4525-4536	4537-4548	4549-4560	4561-4572	4573-4584	4585-4596	4597-4608	4609-4620	4621-4632	4633-4644	4645-4656	4657-4668	4669-4680	4681-4692	4693-4704	4705-4716	4717-4728	4729-4740	4741-4752	4753-4764	4765-4776	4777-4788	4789-4800	4801-4812	4813-4824	4825-4836	4837-4848	4849-4860	4861-4872	4873-4884	4885-4896	4897-4908	4909-4920	4921-4932	4933-4944	4945-4956	4957-4968	4969-4980	4981-4992	4993-5004	5005-5016	5017-5028	5029-5040	5041-5052	5053-5064	5065-5076	5077-5088	5089-5100	5101-5112	5113-5124	5125-5136	5137-5148	5149-5160	5161-5172	5173-5184	5185-5196	5197-5208	5209-5220	5221-5232	5233-5244	5245-5256	5257-5268	5269-5280	5281-5292	5293-5304	5305-5316	5317-5328	5329-5340	5341-5352	5353-5364	5365-5376	5377-5388	5389-5400	5401-5412	5413-5424	5425-5436	5437-5448	5449-5460	5461-5472	5473-5484	5485-5496	5497-5508	5509-5520	5521-5532	5533-5544	5545-5556	5557-5568	5569-5580	5581-5592	5593-5604	5605-5616	5617-5628	5629-5640	5641-5652	5653-5664	5665-5676	5677-5688	5689-5700	5701-5712	5713-5724	5725-5736	5737-5748	5749-5760	5761-5772	5773-5784	5785-5796	5797-5808	5809-5820	5821-5832	5833-5844	5845-5856	5857-5868	5869-5880	5881-5892	5893-5904	5905-5916	5917-5928	5929-5940	5941-5952	5953-5964	5965-5976	5977-5988	5989-6000	6001-6012	6013-6024	6025-6036	6037-6048	6049-6060	6061-6072	6073-6084	6085-6096	6097-6108	6109-6120	6121-6132	6133-6144	6145-6156	6157-6168	6169-6180	6181-6192	6193-6204	6205-6216	6217-6228	6229-6240	6241-6252	6253-6264	6265-6276	6277-6288	6289-6300	6301-6312	6313-6324	6325-6336	6337-6348	6349-6360	6361-6372	6373-6384	6385-6396	6397-6408	6409-6420	6421-6432	6433-6444	6445-6456	6457-6468	6469-6480	6481-6492	6493-6504	6505-6516	6517-6528	6529-6540	6541-6552	6553-6564	6565-6576	6577-6588	6589-6600	6601-6612	6613-6624	6625-6636	6637-6648	6649-6660	6661-6672	6673-6684	6685-6696	6697-6708	6709-6720	6721-6732	6733-6744	6745-6756	6757-6768	6769-6780	6781-6792	6793-6804	6805-6816	6817-6828	6829-6840	6841-6852	6853-6864	6865-6876	6877-6888	6889-6900	6901-6912	6913-6924	6925-6936	6937-6948	6949-6960	6961-6972	6973-6984	6985-6996	6997-7008	7009-7020	7021-7032	7033-7044	7045-7056	7057-7068	7069-7080	7081-7092	7093-7104	7105-7116	7117-7128	7129-7140	7141-7152	7153-7164	7165-7176	7177-7188	7189-7200	7201-7212	7213-7224	7225-7236	7237-7248	7249-7260	7261-7272	7273-7284	7285-7296	7297-7308	7309-7320	7321-7332	7333-7344	7345-7356	7357-7368	7369-7380	7381-7392	7393-7404	7405-7416	7417-7428	7429-7440	7441-7452	7453-7464	7465-7476	7477-7488	7489-7500	7501-7512	7513-7524	7525-7536	7537-7548	7549-7560	7561-7572	7573-7584	7585-7596	7597-7608	7609-7620	7621-7632	7633-7644	7645-7656	7657-7668	7669-7680	7681-7692	7693-7704	7705-7716	7717-7728	7729-7740	7741-7752	7753-7764	7765-7776	7777-7788	7789-7800	7801-7812	7813-7824	7825-7836	7837-7848	7849-7860	7861-7872	7873-7884	7885-7896	7897-7908	7909-7920	7921-7932	7933-7944	7945-7956	7957-7968	7969-7980	7981-7992	7993-8004	8005-8016	8017-8028	8029-8040	8041-8052	8053-8064	8065-8076	8077-8088	8089-8100	8101-8112	8113-8124	8125-8136	8137-8148	8149-8160	8161-8172	8173-8184	8185-8196	8197-8208	8209-8220	8221-8232	8233-8244	8245-8256	8257-8268	8269-8280	8281-8292	8293-8304	8305-8316	8317-8328	8329-8340	8341-8352	8353-8364	8365-8376	8377-8388	8389-8400	8401-8412	8413-8424	8425-8436	8437-8448	8449-8460	8461-8472	8473-8484	8485-8496	8497-8508	8509-8520	8521-8532	8533-8544	8545-8556	8557-8568	8569-8580	8581-8592	8593-8604	8605-8616	8617-8628	8629-8640	8641-8652	8653-8664	8665-8676	8677-8688	8689-8700	8701-8712	8713-8724	8725-8736	8737-8748	8749-8760	8761-8772	8773-8784	8785-8796	8797-8808	8809-8820	8821-8832	8833-8844	8845-8856	8857-8868	8869-8880	8881-8892	8893-8904	8905-8916	8917-8928	8929-8940	8941-8952	8953-8964	8965-8976	8977-8988	8989-9000	9001-9012	9013-9024	9025-9036	9037-9048	9049-9060	9061-9072	9073-9084	9085-9096	9097-9108	9109-9120	9121-9132	9133-9144	9145-9156	9157-9168	9169-9180	9181-9192	9193-9204	9205-9216	9217-9228	9229-9240	9241-9252	9253-9264	9265-9276	9277-9288	9289-9300	9301-9312	9313-9324	9325-9336

WORD COLUMNS	1	2	NR	NR MAX
FORMAT	1-11 Fixed Point	12-24 Fixed Point	1-11 Fixed Point	1-11 Fixed Point
	Number of surface bounding Region No. 1	Number of surface bounding Region No. 2	Number of surface bounding Region No. NR	Number of surface bounding the last region.
DESCRIPTI O N				
CARD TYPE				
UNITS SYMBOL	None NSMAX(1)	None NSMAX(2)	None NSMAX(NR)	None NSMAX(NR MAX)

WORD COLUMNS	1 1-12 Fixed Point	2 13-24 Fixed Point	3 25-36 Fixed Point	4 37-48 Fixed Point	5 49-60 Fixed Point
FORMAT	Number of region pairs for which boundary conditions are specified as follows: 1. NOPAR = 0 2.10 If NMRZM = 0 omit card type 11.	Number of materials for which the number of neutrons per second are calculated as follows: 1. NMRZM = 0 2.10 If NMRZM = 0 omit card type 12.	Number of regions for which the flux is to be calculated as follows: 1. NMRZM = 0 2.10 If NMRZM = 0 omit card type 13.	Number of particles per generation from the fission interaction NMRZM = 2 JMAG particles are generated from the fission interaction	Number of particles per generation from the fission interaction NMRZM = 1 The energy, X, Y, Z, coordinates, and weight of tape-MI (if it is not processed in any form).
D					
E					
S					
C					
K					
J					
P					
T					
I					
O					
N					

CARD
TYPE
8

[illegible]

WORD COLUMNS	1	2	3
FORMAT	112 First Point	124 Place Point	112 Third Point
First special half region (STR1). Truly a straight Name Code 1 NAME 0.	Second STR	Third STR	
D E S C R I P T I O N			
CARD TYPE 10			
UNITS STR1(1)	NAME STR1(1)	NAME STR1(1)	NAME STR1(1)

NOTE:
 STR1(1) > STR1(2)
 STR1(2) > STR1(1)
 Input in decreasing order.

WORK COLUMNS FORMAT	1 112 Fixed Point Region which particle leaves	2 113 Fixed Point Region which particle enters	3 114 Fixed Point Region which particle enters	4 115 Fixed Point Region which particle enters	5 116 Fixed Point Region which particle enters	6 117 Fixed Point Region which particle enters
D E S C R I P T I O N CARD TYPE 11	Place column pair for which ally of boundary crossings will be made. Column are initial Name Code (1) NOFAE - 8)	Place column pair for which ally of boundary crossings will be made. Column are initial Name Code (1) NOFAE - 8)	Place column pair for which ally of boundary crossings will be made. Column are initial Name Code (1) NOFAE - 8)	Place column pair for which ally of boundary crossings will be made. Column are initial Name Code (1) NOFAE - 8)	Place column pair for which ally of boundary crossings will be made. Column are initial Name Code (1) NOFAE - 8)	Place column pair for which ally of boundary crossings will be made. Column are initial Name Code (1) NOFAE - 8)

MND-MC-2856

NOTE: If MND-10, card type 11 MND-10 is on card type 11.

WORD COLUMNS	1-12	13-24	25-36	37-48	49-60	61-72	73-84	85-96	97-108	109-120	121-132	133-144	145-156	157-168	169-180	181-192	193-204	205-216	217-228	229-240	241-252	253-264	265-276	277-288	289-300	301-312	313-324	325-336	337-348	349-360	361-372	373-384	385-396	397-408	409-420	421-432	433-444	445-456	457-468	469-480	481-492	493-504	505-516	517-528	529-540	541-552	553-564	565-576	577-588	589-600	601-612	613-624	625-636	637-648	649-660	661-672	673-684	685-696	697-708	709-720	721-732	733-744	745-756	757-768	769-780	781-792	793-804	805-816	817-828	829-840	841-852	853-864	865-876	877-888	889-900	901-912	913-924	925-936	937-948	949-960	961-972	973-984	985-996	997-1008	1009-1020	1021-1032	1033-1044	1045-1056	1057-1068	1069-1080	1081-1092	1093-1104	1105-1116	1117-1128	1129-1140	1141-1152	1153-1164	1165-1176	1177-1188	1189-1200	1201-1212	1213-1224	1225-1236	1237-1248	1249-1260	1261-1272	1273-1284	1285-1296	1297-1308	1309-1320	1321-1332	1333-1344	1345-1356	1357-1368	1369-1380	1381-1392	1393-1404	1405-1416	1417-1428	1429-1440	1441-1452	1453-1464	1465-1476	1477-1488	1489-1500	1501-1512	1513-1524	1525-1536	1537-1548	1549-1560	1561-1572	1573-1584	1585-1596	1597-1608	1609-1620	1621-1632	1633-1644	1645-1656	1657-1668	1669-1680	1681-1692	1693-1704	1705-1716	1717-1728	1729-1740	1741-1752	1753-1764	1765-1776	1777-1788	1789-1800	1801-1812	1813-1824	1825-1836	1837-1848	1849-1860	1861-1872	1873-1884	1885-1896	1897-1908	1909-1920	1921-1932	1933-1944	1945-1956	1957-1968	1969-1980	1981-1992	1993-2004	2005-2016	2017-2028	2029-2040	2041-2052	2053-2064	2065-2076	2077-2088	2089-2100	2101-2112	2113-2124	2125-2136	2137-2148	2149-2160	2161-2172	2173-2184	2185-2196	2197-2208	2209-2220	2221-2232	2233-2244	2245-2256	2257-2268	2269-2280	2281-2292	2293-2304	2305-2316	2317-2328	2329-2340	2341-2352	2353-2364	2365-2376	2377-2388	2389-2400	2401-2412	2413-2424	2425-2436	2437-2448	2449-2460	2461-2472	2473-2484	2485-2496	2497-2508	2509-2520	2521-2532	2533-2544	2545-2556	2557-2568	2569-2580	2581-2592	2593-2604	2605-2616	2617-2628	2629-2640	2641-2652	2653-2664	2665-2676	2677-2688	2689-2700	2701-2712	2713-2724	2725-2736	2737-2748	2749-2760	2761-2772	2773-2784	2785-2796	2797-2808	2809-2820	2821-2832	2833-2844	2845-2856	2857-2868	2869-2880	2881-2892	2893-2904	2905-2916	2917-2928	2929-2940	2941-2952	2953-2964	2965-2976	2977-2988	2989-3000	3001-3012	3013-3024	3025-3036	3037-3048	3049-3060	3061-3072	3073-3084	3085-3096	3097-3108	3109-3120	3121-3132	3133-3144	3145-3156	3157-3168	3169-3180	3181-3192	3193-3204	3205-3216	3217-3228	3229-3240	3241-3252	3253-3264	3265-3276	3277-3288	3289-3300	3301-3312	3313-3324	3325-3336	3337-3348	3349-3360	3361-3372	3373-3384	3385-3396	3397-3408	3409-3420	3421-3432	3433-3444	3445-3456	3457-3468	3469-3480	3481-3492	3493-3504	3505-3516	3517-3528	3529-3540	3541-3552	3553-3564	3565-3576	3577-3588	3589-3600	3601-3612	3613-3624	3625-3636	3637-3648	3649-3660	3661-3672	3673-3684	3685-3696	3697-3708	3709-3720	3721-3732	3733-3744	3745-3756	3757-3768	3769-3780	3781-3792	3793-3804	3805-3816	3817-3828	3829-3840	3841-3852	3853-3864	3865-3876	3877-3888	3889-3900	3901-3912	3913-3924	3925-3936	3937-3948	3949-3960	3961-3972	3973-3984	3985-3996	3997-4008	4009-4020	4021-4032	4033-4044	4045-4056	4057-4068	4069-4080	4081-4092	4093-4104	4105-4116	4117-4128	4129-4140	4141-4152	4153-4164	4165-4176	4177-4188	4189-4200	4201-4212	4213-4224	4225-4236	4237-4248	4249-4260	4261-4272	4273-4284	4285-4296	4297-4308	4309-4320	4321-4332	4333-4344	4345-4356	4357-4368	4369-4380	4381-4392	4393-4404	4405-4416	4417-4428	4429-4440	4441-4452	4453-4464	4465-4476	4477-4488	4489-4500	4501-4512	4513-4524	4525-4536	4537-4548	4549-4560	4561-4572	4573-4584	4585-4596	4597-4608	4609-4620	4621-4632	4633-4644	4645-4656	4657-4668	4669-4680	4681-4692	4693-4704	4705-4716	4717-4728	4729-4740	4741-4752	4753-4764	4765-4776	4777-4788	4789-4800	4801-4812	4813-4824	4825-4836	4837-4848	4849-4860	4861-4872	4873-4884	4885-4896	4897-4908	4909-4920	4921-4932	4933-4944	4945-4956	4957-4968	4969-4980	4981-4992	4993-5004	5005-5016	5017-5028	5029-5040	5041-5052	5053-5064	5065-5076	5077-5088	5089-5100	5101-5112	5113-5124	5125-5136	5137-5148	5149-5160	5161-5172	5173-5184	5185-5196	5197-5208	5209-5220	5221-5232	5233-5244	5245-5256	5257-5268	5269-5280	5281-5292	5293-5304	5305-5316	5317-5328	5329-5340	5341-5352	5353-5364	5365-5376	5377-5388	5389-5400	5401-5412	5413-5424	5425-5436	5437-5448	5449-5460	5461-5472	5473-5484	5485-5496	5497-5508	5509-5520	5521-5532	5533-5544	5545-5556	5557-5568	5569-5580	5581-5592	5593-5604	5605-5616	5617-5628	5629-5640	5641-5652	5653-5664	5665-5676	5677-5688	5689-5700	5701-5712	5713-5724	5725-5736	5737-5748	5749-5760	5761-5772	5773-5784	5785-5796	5797-5808	5809-5820	5821-5832	5833-5844	5845-5856	5857-5868	5869-5880	5881-5892	5893-5904	5905-5916	5917-5928	5929-5940	5941-5952	5953-5964	5965-5976	5977-5988	5989-6000	6001-6012	6013-6024	6025-6036	6037-6048	6049-6060	6061-6072	6073-6084	6085-6096	6097-6108	6109-6120	6121-6132	6133-6144	6145-6156	6157-6168	6169-6180	6181-6192	6193-6204	6205-6216	6217-6228	6229-6240	6241-6252	6253-6264	6265-6276	6277-6288	6289-6300	6301-6312	6313-6324	6325-6336	6337-6348	6349-6360	6361-6372	6373-6384	6385-6396	6397-6408	6409-6420	6421-6432	6433-6444	6445-6456	6457-6468	6469-6480	6481-6492	6493-6504	6505-6516	6517-6528	6529-6540	6541-6552	6553-6564	6565-6576	6577-6588	6589-6600	6601-6612	6613-6624	6625-6636	6637-6648	6649-6660	6661-6672	6673-6684	6685-6696	6697-6708	6709-6720	6721-6732	6733-6744	6745-6756	6757-6768	6769-6780	6781-6792	6793-6804	6805-6816	6817-6828	6829-6840	6841-6852	6853-6864	6865-6876	6877-6888	6889-6900	6901-6912	6913-6924	6925-6936	6937-6948	6949-6960	6961-6972	6973-6984	6985-6996	6997-7008	7009-7020	7021-7032	7033-7044	7045-7056	7057-7068	7069-7080	7081-7092	7093-7104	7105-7116	7117-7128	7129-7140	7141-7152	7153-7164	7165-7176	7177-7188	7189-7200	7201-7212	7213-7224	7225-7236	7237-7248	7249-7260	7261-7272	7273-7284	7285-7296	7297-7308	7309-7320	7321-7332	7333-7344	7345-7356	7357-7368	7369-7380	7381-7392	7393-7404	7405-7416	7417-7428	7429-7440	7441-7452	7453-7464	7465-7476	7477-7488	7489-7500	7501-7512	7513-7524	7525-7536	7537-7548	7549-7560	7561-7572	7573-7584	7585-7596	7597-7608	7609-7620	7621-7632	7633-7644	7645-7656	7657-7668	7669-7680	7681-7692	7693-7704	7705-7716	7717-7728	7729-7740	7741-7752	7753-7764	7765-7776	7777-7788	7789-7800	7801-7812	7813-7824	7825-7836	7837-7848	7849-7860	7861-7872	7873-7884	7885-7896	7897-7908	7909-7920	7921-7932	7933-7944	7945-7956	7957-7968	7969-7980	7981-7992	7993-8004	8005-8016	8017-8028	8029-8040	8041-8052	8053-8064	8065-8076	8077-8088	8089-8100	8101-8112	8113-8124	8125-8136	8137-8148	8149-8160	8161-8172	8173-8184	8185-8196	8197-8208	8209-8220	8221-8232	8233-8244	8245-8256	8257-8268	8269-8280	8281-8292	8293-8304	8305-8316	8317-8328	8329-8340	8341-8352	8353-8364	8365-8376	8377-8388	8389-8400	8401-8412	8413-8424	8425-8436	8437-8448	8449-8460	8461-8472	8473-8484	8485-8496	8497-8508	8509-8520	8521-8532	8533-8544	8545-8556	8557-8568	8569-8580	8581-8592	8593-8604	8605-8616	8617-8628	8629-8640	8641-8652	8653-8664	8665-8676	8677-8688	8689-8700	8701-8712	8713-8724	8725-8736	8737-8748	8749-8760	8761-8772	8773-8784	8785-8796	8797-8808	8809-8820	8821-8832	8833-8844	8845-8856	8857-8868	8869-8880	8881-8892	8893-8904	8905-8916	8917-8928	8929-8940	8941-8952	8953-8964	8965-8976	8977-8988	8989-9000	9001-9012	9013-9024	9025-9036	9037-9048	9049-9060	9061-9072	9073-9084	9085-9096	9097-9108	9109-9120	9121-9132	9133-9144	9145-9156	9157-9168	9169-9180	9181-9192	9193-9204	9205-9216	9217-9228	9229-9240	9241-9252	9253-9264	9265-9276	9277-9288	9289-9300	9301-9312	9313-9324	9325-9336	9337-9348	9349-9360	9361-9372	9373-9384	9385-9396	9397-9408	9409-9420	9421-9432	9433-9444	9445-9456	9457-9468	9469-9480	9481-9492	9493-9504	9505-9516	9517-9528	9529-9540	9541-9552	9553-9564	9565-9576	9577-9588	9589-9600	9601-9612	9613-9624	9625-9636	9637-9648	9649-9660	9661-9672	9673-9684	9685-9696	9697-9708	9709-9720	9721-9732	9733-9744	9745-9756	9757-9768	9769-9780	9781-9792	9793-9804	9805-9816	9817-9828	9829-9840	9841-9852	9853-9864	9865-9876	9877-9888	9889-9900	9901-9912	9913-9924	9925-9936	9937-9948	9949-9960	9961-9972	9973-9984	9985-9996	9997-10000	10001-10012	10013-10024	10025-10036	10037-10048	10049-10060	10061-10072	10073-10084	10085-10096	10097-10108	10109-10120	10121-10132	10133-10144	10145-10156	10157-10168	10169-10180	10181-10192	10193-10204	10205-10216	10217-10228	10229-10240	10241-10252	10253-10264	10265-10276	10277-10288	10289-10300	10301-10312	10313-10324	10325-10336	10337-10348	10349-10360	10361-10372	10373-10384	10385-10396	10397-10408	10409-10420	10421-10432	10433-10444	10445-10456	10457-10468	10469-10480	10481-10492	10493-10504	10505-10516	10517-10528	10529-10540	10541-10552	10553-10564	10565-10576	10577-10588	10589-10600	10601-10612
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WORD COLUMNS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
FORMAT	1-12	13-24	25-36	37-48	49-60	61-72	73-84	85-96	97-108	109-120	121-132	133-144	145-156	157-168	169-180	181-192	193-204	205-216	217-228	229-240	241-252	253-264	265-276	277-288	289-300	301-312	313-324	325-336	337-348	349-360	361-372	373-384	385-396	397-408	409-420	421-432	433-444	445-456	457-468	469-480	481-492	493-504	505-516	517-528	529-540	541-552	553-564	565-576	577-588	589-600	601-612	613-624	625-636	637-648	649-660	661-672	673-684	685-696	697-708	709-720	721-732	733-744	745-756	757-768	769-780	781-792	793-804	805-816	817-828	829-840	841-852	853-864	865-876	877-888	889-900	901-912	913-924	925-936	937-948	949-960	961-972	973-984	985-996	997-1008	1009-1020	1021-1032	1033-1044	1045-1056	1057-1068	1069-1080	1081-1092	1093-1104	1105-1116	1117-1128	1129-1140	1141-1152	1153-1164	1165-1176	1177-1188	1189-1200	1201-1212	1213-1224	1225-1236	1237-1248	1249-1260	1261-1272	1273-1284	1285-1296	1297-1308	1309-1320	1321-1332	1333-1344	1345-1356	1357-1368	1369-1380	1381-1392	1393-1404	1405-1416	1417-1428	1429-1440	1441-1452	1453-1464	1465-1476	1477-1488	1489-1500	1501-1512	1513-1524	1525-1536	1537-1548	1549-1560	1561-1572	1573-1584	1585-1596	1597-1608	1609-1620	1621-1632	1633-1644	1645-1656	1657-1668	1669-1680	1681-1692	1693-1704	1705-1716	1717-1728	1729-1740	1741-1752	1753-1764	1765-1776	1777-1788	1789-1800	1801-1812	1813-1824	1825-1836	1837-1848	1849-1860	1861-1872	1873-1884	1885-1896	1897-1908	1909-1920	1921-1932	1933-1944	1945-1956	1957-1968	1969-1980	1981-1992	1993-2004	2005-2016	2017-2028	2029-2040	2041-2052	2053-2064	2065-2076	2077-2088	2089-2100	2101-2112	2113-2124	2125-2136	2137-2148	2149-2160	2161-2172	2173-2184	2185-2196	2197-2208	2209-2220	2221-2232	2233-2244	2245-2256	2257-2268	2269-2280	2281-2292	2293-2304	2305-2316	2317-2328	2329-2340	2341-2352	2353-2364	2365-2376	2377-2388	2389-2400	2401-2412	2413-2424	2425-2436	2437-2448	2449-2460	2461-2472	2473-2484	2485-2496	2497-2508	2509-2520	2521-2532	2533-2544	2545-2556	2557-2568	2569-2580	2581-2592	2593-2604	2605-2616	2617-2628	2629-2640	2641-2652	2653-2664	2665-2676	2677-2688	2689-2700	2701-2712	2713-2724	2725-2736	2737-2748	2749-2760	2761-2772	2773-2784	2785-2796	2797-2808	2809-2820	2821-2832	2833-2844	2845-2856	2857-2868	2869-2880	2881-2892	2893-2904	2905-2916	2917-2928	2929-2940	2941-2952	2953-2964	2965-2976	2977-2988	2989-3000	3001-3012	3013-3024	3025-3036	3037-3048	3049-3060	3061-3072	3073-3084	3085-3096	3097-3108	3109-3120	3121-3132	3133-3144	3145-3156	3157-3168	3169-3180	3181-3192	3193-3204	3205-3216	3217-3228	3229-3240	3241-3252	3253-3264	3265-3276	3277-3288	3289-3300	3301-3312	3313-3324	3325-3336	3337-3348	3349-3360	3361-3372	3373-3384	3385-3396	3397-3408	3409-3420	3421-3432	3433-3444	3445-3456	3457-3468	3469-3480	3481-3492	3493-3504	3505-3516	3517-3528	3529-3540	3541-3552	3553-3564	3565-3576	3577-3588	3589-3600	3601-3612	3613-3624	3625-3636	3637-3648	3649-3660	3661-3672	3673-3684	3685-3696	3697-3708	3709-3720	3721-3732	3733-3744	3745-3756	3757-3768	3769-3780	3781-3792	3793-3804	3805-3816	3817-3828	3829-3840	3841-3852	3853-3864	3865-3876	3877-3888	3889-3900	3901-3912	3913-3924	3925-3936	3937-3948	3949-3960	3961-3972	3973-3984	3985-3996	3997-4008	4009-4020	4021-4032	4033-4044	4045-4056	4057-4068	4069-4080	4081-4092	4093-4104	4105-4116	4117-4128	4129-4140	4141-4152	4153-4164	4165-4176	4177-4188	4189-4200	4201-4212	4213-4224	4225-4236	4237-4248	4249-4260	4261-4272	4273-4284	4285-4296	4297-4308	4309-4320	4321-4332	4333-4344	4345-4356	4357-4368	4369-4380	4381-4392	4393-4404	4405-4416	4417-4428	4429-4440	4441-4452	4453-4464	4465-4476	4477-4488	4489-4500	4501-4512	4513-4524	4525-4536	4537-4548	4549-4560	4561-4572	4573-4584	4585-4596	4597-4608	4609-4620	4621-4632	4633-4644	4645-4656	4657-4668	4669-4680	4681-4692	4693-4704	4705-4716	4717-4728	4729-4740	4741-4752	4753-4764	4765-4776	4777-4788	4789-4800	4801-4812	4813-4824	4825-4836	4837-4848	4849-4860	4861-4872	4873-4884	4885-4896	4897-4908	4909-4920	4921-4932	4933-4944	4945-4956	4957-4968	4969-4980	4981-4992	4993-5004	5005-5016	5017-5028	5029-5040	5041-5052	5053-5064	5065-5076	5077-5088	5089-5100	5101-5112	5113-5124	5125-5136	5137-5148	5149-5160	5161-5172	5173-5184	5185-5196	5197-5208	5209-5220	5221-5232	5233-5244	5245-5256	5257-5268	5269-5280	5281-5292	5293-5304	5305-5316	5317-5328	5329-5340	5341-5352	5353-5364	5365-5376	5377-5388	5389-5400	5401-5412	5413-5424	5425-5436	5437-5448	5449-5460	5461-5472	5473-5484	5485-5496	5497-5508	5509-5520	5521-5532	5533-5544	5545-5556	5557-5568	5569-5580	5581-5592	5593-5604	5605-5616	5617-5628	5629-5640	5641-5652	5653-5664	5665-5676	5677-5688	5689-5700	5701-5712	5713-5724	5725-5736	5737-5748	5749-5760	5761-5772	5773-5784	5785-5796	5797-5808	5809-5820	5821-5832	5833-5844	5845-5856	5857-5868	5869-5880	5881-5892	5893-5904	5905-5916	5917-5928	5929-5940	5941-5952	5953-5964	5965-5976	5977-5988	5989-6000	6001-6012	6013-6024	6025-6036	6037-6048	6049-6060	6061-6072	6073-6084	6085-6096	6097-6108	6109-6120	6121-6132	6133-6144	6145-6156	6157-6168	6169-6180	6181-6192	6193-6204	6205-6216	6217-6228	6229-6240	6241-6252	6253-6264	6265-6276	6277-6288	6289-6300	6301-6312	6313-6324	6325-6336	6337-6348	6349-6360	6361-6372	6373-6384	6385-6396	6397-6408	6409-6420	6421-6432	6433-6444	6445-6456	6457-6468	6469-6480	6481-6492	6493-6504	6505-6516	6517-6528	6529-6540	6541-6552	6553-6564	6565-6576	6577-6588	6589-6600	6601-6612	6613-6624	6625-6636	6637-6648	6649-6660	6661-6672	6673-6684	6685-6696	6697-6708	6709-6720	6721-6732	6733-6744	6745-6756	6757-6768	6769-6780	6781-6792	6793-6804	6805-6816	6817-6828	6829-6840	6841-6852	6853-6864	6865-6876	6877-6888	6889-6900	6901-6912	6913-6924	6925-6936	6937-6948	6949-6960	6961-6972	6973-6984	6985-6996	6997-7008	7009-7020	7021-7032	7033-7044	7045-7056	7057-7068	7069-7080	7081-7092	7093-7104	7105-7116	7117-7128	7129-7140	7141-7152	7153-7164	7165-7176	7177-7188	7189-7200	7201-7212	7213-7224	7225-7236	7237-7248	7249-7260	7261-7272	7273-7284	7285-7296	7297-7308	7309-7320	7321-7332	7333-7344	7345-7356	7357-7368	7369-7380	7381-7392	7393-7404	7405-7416	7417-7428	7429-7440	7441-7452	7453-7464	7465-7476	7477-7488	7489-7500	7501-7512	7513-7524	7525-7536	7537-7548	7549-7560	7561-7572	7573-7584	7585-7596	7597-7608	7609-7620	7621-7632	7633-7644	7645-7656	7657-7668	7669-7680	7681-7692	7693-7704	7705-7716	7717-7728	7729-7740	7741-7752	7753-7764	7765-7776	7777-7788	7789-7800	7801-7812	7813-7824	7825-7836	7837-7848	7849-7860	7861-7872	7873-7884	7885-7896	7897-7908	7909-7920	7921-7932	7933-7944	7945-7956	7957-7968	7969-7980	7981-7992	7993-8004	8005-8016	8017-8028	8029-8040	8041-8052	8053-8064	8065-8076	8077-8088	8089-8100	8101-8112	8113-8124	8125-8136	8137-8148	8149-8160	8161-8172	8173-8184	8185-8196	8197-8208	8209-8220	8221-8232	8233-8244	8245-8256	8257-8268	8269-8280	8281-8292	8293-8304	8305-8316	8317-8328	8329-8340	8341-8352	8353-8364	8365-8376	8377-8388	8389-8400	8401-8412	8413-8424	8425-8436	8437-8448	8449-8460	8461-8472	8473-8484	8485-8496	8497-8508	8509-8520	8521-8532	8533-8544	8545-8556	8557-8568	8569-8580	8581-8592	8593-8604	8605-8616	8617-8628	8629-8640	8641-8652	8653-8664	8665-8676	8677-8688	8689-8700	8701-8712	8713-8724	8725-8736	8737-8748	8749-8760	8761-8772	8773-8784	8785-8796	8797-8808	8809-8820	8821-8832	8833-8844	8845-8856	8857-8868	8869-8880	8881-8892	8893-8904	8905-8916	8917-8928	8929-8940	8941-8952	8953-8964	8965-8976	8977-8988	8989-9000	9001-9012	9013-9024	9025-9036	9037-9048	9049-9060	9061-9072	9073-9084	9085-9096	9097-9108	9109-9120	9121-9132	9133-9144	9145-9156	9157-9168	9169-9180	9181-9192	9193-9204	9205-9216	9217-9228	9229-9240	9241-9252	9253-9264	9265-9276	9277-9288	9289-9300	9301-9312	9313-9324	9325-9336	9337-9348	9349-9360	9361-9372	9373-9384	9385-9396	9397-9408	9409-9420	9421-9432	9433-9444	9445-9456	9457-9468	9469-9480	9481-9492	9493-9504	9505-9516	9517-9528	9529-9540	9541-9552	9553-9564	9565-9576	9577-9588	9589-9600	9601-9612	9613-9624	9625-9636	9637-9648	9649-9660	9661-9672	9673-9684	9685-9696	9697-9708	9709-9720	9721-9732	9733-9744	9745-9756	9757-9768	9769-9780	9781-9792	9793-9804	9805-9816	9817-9828	9829-9840	9841-9852	9853-9864	9865-9876	9877-9888	9889-9900	9901-9912	9913-9924	9925-9936	9937-9948	9949-9960	9961-9972	9973-9984	9985-9996	9997-10000

MWD-MC-2856

CARD
TYPE
12

WORD	1	2	3	4	5
COLUMNS	1-12	13-24	25-36	37-48	49-60
FORMAT	Fixed Point R12.5	Floating Point R12.5	Floating Point R12.5	Floating Point R12.5	Floating Point R12.5
Surface Type	MTNS1.1 $A^2 + X_0^2 + Y_0^2 + Z_0^2 + K = 0$	A. In the equation of the surface	B. In the equation of the surface	C. In the equation of the surface	D. In the equation of the surface
D	MTNS1.1 $A^2 + X_0^2 + Y_0^2 + Z_0^2 + K = 0$				
E	MTNS1.2 $A^2 + X_0^2 + Y_0^2 + Z_0^2 + K = 0$				
S	MTNS1.3 $A^2 + X_0^2 + Y_0^2 + Z_0^2 + K = 0$				
C	MTNS1.4 $A^2 + X_0^2 + Y_0^2 + Z_0^2 + K = 0$				
R	MTNS1.5 $A^2 + X_0^2 + Y_0^2 + Z_0^2 + K = 0$				
I	MTNS1.6 $A^2 + X_0^2 + Y_0^2 + Z_0^2 + K = 0$				
P	MTNS1.7 $A^2 + X_0^2 + Y_0^2 + Z_0^2 + K = 0$				
T	MTNS1.8 $A^2 + X_0^2 + Y_0^2 + Z_0^2 + K = 0$				
I	MTNS1.9 $A^2 + X_0^2 + Y_0^2 + Z_0^2 + K = 0$				
O	MTNS1.10 $A^2 + X_0^2 + Y_0^2 + Z_0^2 + K = 0$				
N	MTNS1.11 $A^2 + X_0^2 + Y_0^2 + Z_0^2 + K = 0$				
UNITS	None	None	None	None	Centimeters
SYMBOL	MTNS1	MTNS1	MTNS1	MTNS1	MTNS1

NOTE: Input card 14 and card 15 for NS = 1, 2, ..., NSTOT (NSTOT is on card type 3) in the order: 14, 15, 16, 17, ..., 14, 15. See page following card type 15.

WORD	1	2	3
COLUMNS	1-13	13-24	25-38
FORMAT	Plane Point	Plane Point	Plane Point
D	X_{10} in the Equation of the surface	X_{10} in the equation of the surface	Z_{10} in the equation of the surface
E			
S			
C			
R			
I			
P			
T			
I			
O			
N			

CARD TYPE 15

NOTE: Input card 14 and card 15 for NS = 1, 2, ... NSTOT (NSTOT is on card type 5) in the order: 14, 15, 14, 15, ...; 14, 15, NS = 1, NS = 2, NS = 3, NS = NS, NS = NSTOT

Order of Input: Card Type 14 and Card Type 15

Symbol	Definition	Quantities on Card			
NS	Surface number (in the list of unique surfaces)				
NT(NS)	Surface type (see Card Type 14, the first word)				
AC(NS)	A in the equation of the surface	AC(1)	BC(1)	CC(1)	XX(1) {
BC(NS)	B in the equation of the surface	YZ(1)	ZZ(1)		XX(2) {
CC(NS)	C in the equation of the surface	AC(2)	BC(2)	CC(2)	
XK(NS)	K in the equation of the surface	YZ(2)	ZZ(2)		
XZ(NS)	X ₀ in the equation of the surface				
YZ(NS)	Y ₀ in the equation of the surface				
ZZ(NS)	Z ₀ in the equation of the surface				
<u>Card</u>					
Card Type 14	NT(1)				
Card Type 15	XZ(1)				NS = 1
Card Type 14	NT(1)	AC(1)	BC(1)	CC(1)	NS = 2
Card Type 15	XZ(2)	YZ(1)	ZZ(1)		
		AC(2)	BC(2)	CC(2)	
		YZ(2)	ZZ(2)		
Card Type 14	NT(NS)	AC(NS)	CC(NS)		
Card Type 15	XZ(NS)	YZ(NS)	ZZ(NS)		NS = NS
Card Type 14	NT(NSTOT)	AC(NSTOT)	CC(NSTOT)		
Card Type 15	XZ(NSTOT)	YZ(NSTOT)	ZZ(NSTOT)	CC(NSTOT)	NS = NSTOT
				XX(NSTOT)	

MND-MC-2856

WORD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
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WORD COLUMN	1 1-12	2 13-24	31 25-36	32 37-48
FORMAT	1-12 Fixed Point	13-24 Fixed Point	25-36 Fixed Point	37-48 Fixed Point
Number of the first isotope of No. M in the list of isotopes	1-12 Fixed Point	13-24 Fixed Point	25-36 Fixed Point	37-48 Fixed Point
Number of the second isotope of No. M in the list of isotopes	1-12 Fixed Point	13-24 Fixed Point	25-36 Fixed Point	37-48 Fixed Point
Number of the third isotope of No. M in the list of isotopes	1-12 Fixed Point	13-24 Fixed Point	25-36 Fixed Point	37-48 Fixed Point
NOTE: Plausible isotopes must be listed first (if any)	1-12 Fixed Point	13-24 Fixed Point	25-36 Fixed Point	37-48 Fixed Point
UNITS SYMBOL	None KIT, M	None KIT, M	None KIT, M	None KIT, M
CARD TYPE	None KIT, M	None KIT, M	None KIT, M	None KIT, M

NOTE: Input card 18 for M = 1, 2, ..., 10000

WORD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648	649	650	651	652	653	654	655	656	657	658	659	660	661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680	681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700	701	702	703	704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720	721	722	723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739	740	741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756	757	758	759	760	761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800	801	802	803	804	805	806	807	808	809	810	811	812	813	814	815	816	817	818	819	820	821	822	823	824	825	826	827	828	829	830	831	832	833	834	835	836	837	838	839	840	841	842	843	844	845	846	847	848	849	850	851	852	853	854	855	856	857	858	859	860	861	862	863	864	865	866	867	868	869	870	871	872	873	874	875	876	877	878	879	880	881	882	883	884	885	886	887	888	889	890	891	892	893	894	895	896	897	898	899	900	901	902	903	904	905	906	907	908	909	910	911	912	913	914	915	916	917	918	919	920	921	922	923	924	925	926	927	928	929	930	931	932	933	934	935	936	937	938	939	940	941	942	943	944	945	946	947	948	949	950	951	952	953	954	955	956	957	958	959	960	961	962	963	964	965	966	967	968	969	970	971	972	973	974	975	976	977	978	979	980	981	982	983	984	985	986	987	988	989	990	991	992	993	994	995	996	997	998	999	1000	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012	1013	1014	1015	1016	1017	1018	1019	1020	1021	1022	1023	1024	1025	1026	1027	1028	1029	1030	1031	1032	1033	1034	1035	1036	1037	1038	1039	1040	1041	1042	1043	1044	1045	1046	1047	1048	1049	1050	1051	1052	1053	1054	1055	1056	1057	1058	1059	1060	1061	1062	1063	1064	1065	1066	1067	1068	1069	1070	1071	1072	1073	1074	1075	1076	1077	1078	1079	1080	1081	1082	1083	1084	1085	1086	1087	1088	1089	1090	1091	1092	1093	1094	1095	1096	1097	1098	1099	1100	1101	1102	1103	1104	1105	1106	1107	1108	1109	1110	1111	1112	1113	1114	1115	1116	1117	1118	1119	1120	1121	1122	1123	1124	1125	1126	1127	1128	1129	1130	1131	1132	1133	1134	1135	1136	1137	1138	1139	1140	1141	1142	1143	1144	1145	1146	1147	1148	1149	1150	1151	1152	1153	1154	1155	1156	1157	1158	1159	1160	1161	1162	1163	1164	1165	1166	1167	1168	1169	1170	1171	1172	1173	1174	1175	1176	1177	1178	1179	1180	1181	1182	1183	1184	1185	1186	1187	1188	1189	1190	1191	1192	1193	1194	1195	1196	1197	1198	1199	1200	1201	1202	1203	1204	1205	1206	1207	1208	1209	1210	1211	1212	1213	1214	1215	1216	1217	1218	1219	1220	12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[illegible]

WORD	1	2	3	JMAX
COLUMNS	1-12	13-24	25-36	37-48
FORMAT	R12.5 Floating Point	R12.5 Floating Point	R12.5 Floating Point	R12.5 Floating Point
D	Fission spectrum probability of neutron being born at energy or below	Fission spectrum probability of neutron being born at energy or below	Fission spectrum probability of neutron being born at energy or below	Fission spectrum probability of neutron being born at energy or below
E	NOTE: PS(1,1) = 0.			
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UNITS	None PS(1,1)	None PS(2,1)	None PS(3,1)	None PS(JMAX,1)
SYMBOLS				

NOTE: Omit if 1
Omit if 2-5 set

WORD COLUMN	1	2	3	4	5	JMAG
FORMAT	1-13 Planning Point Neutron yield for fission of isotope 1 with incident neutron in energy group 1	12-24 Planning Point Neutron yield for fission of isotope 2 with incident neutron in energy group 2	Planning Point Similarly for incident neutron in energy group 3	Planning Point Similarly for incident neutron in energy group 4	Planning Point Similarly for incident neutron in the lowest energy group, JMAG	
D E S C R I P T I O N						
END TYPE N						
UNIT	Neutrons/Fission PMU1.13	Neutrons/Fission PMU2.13	Neutrons/Fission PMU3.13	Neutrons/Fission PMU4.13	Neutrons/Fission PMUJMAG.13	
NOTE: Check II > 999						

WORD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
FORMAT	1-12	13-24	25-36	37-48	49-60	61-72	73-84	85-96	97-108	109-120	121-132	133-144	145-156	157-168	169-180	181-192	193-204	205-216	217-228	229-240	241-252	253-264	265-276	277-288	289-300	301-312	313-324	325-336	337-348	349-360	361-372	373-384	385-396	397-408	409-420	421-432	433-444	445-456	457-468	469-480	481-492	493-504	505-516	517-528	529-540	541-552	553-564	565-576	577-588	589-600	601-612	613-624	625-636	637-648	649-660	661-672	673-684	685-696	697-708	709-720	721-732	733-744	745-756	757-768	769-780	781-792	793-804	805-816	817-828	829-840	841-852	853-864	865-876	877-888	889-900	901-912	913-924	925-936	937-948	949-960	961-972	973-984	985-996	997-1008	1009-1020	1021-1032	1033-1044	1045-1056	1057-1068	1069-1080	1081-1092	1093-1104	1105-1116	1117-1128	1129-1140	1141-1152	1153-1164	1165-1176	1177-1188	1189-1200	1201-1212	1213-1224	1225-1236	1237-1248	1249-1260	1261-1272	1273-1284	1285-1296	1297-1308	1309-1320	1321-1332	1333-1344	1345-1356	1357-1368	1369-1380	1381-1392	1393-1404	1405-1416	1417-1428	1429-1440	1441-1452	1453-1464	1465-1476	1477-1488	1489-1500	1501-1512	1513-1524	1525-1536	1537-1548	1549-1560	1561-1572	1573-1584	1585-1596	1597-1608	1609-1620	1621-1632	1633-1644	1645-1656	1657-1668	1669-1680	1681-1692	1693-1704	1705-1716	1717-1728	1729-1740	1741-1752	1753-1764	1765-1776	1777-1788	1789-1800	1801-1812	1813-1824	1825-1836	1837-1848	1849-1860	1861-1872	1873-1884	1885-1896	1897-1908	1909-1920	1921-1932	1933-1944	1945-1956	1957-1968	1969-1980	1981-1992	1993-2004	2005-2016	2017-2028	2029-2040	2041-2052	2053-2064	2065-2076	2077-2088	2089-2100	2101-2112	2113-2124	2125-2136	2137-2148	2149-2160	2161-2172	2173-2184	2185-2196	2197-2208	2209-2220	2221-2232	2233-2244	2245-2256	2257-2268	2269-2280	2281-2292	2293-2304	2305-2316	2317-2328	2329-2340	2341-2352	2353-2364	2365-2376	2377-2388	2389-2400	2401-2412	2413-2424	2425-2436	2437-2448	2449-2460	2461-2472	2473-2484	2485-2496	2497-2508	2509-2520	2521-2532	2533-2544	2545-2556	2557-2568	2569-2580	2581-2592	2593-2604	2605-2616	2617-2628	2629-2640	2641-2652	2653-2664	2665-2676	2677-2688	2689-2700	2701-2712	2713-2724	2725-2736	2737-2748	2749-2760	2761-2772	2773-2784	2785-2796	2797-2808	2809-2820	2821-2832	2833-2844	2845-2856	2857-2868	2869-2880	2881-2892	2893-2904	2905-2916	2917-2928	2929-2940	2941-2952	2953-2964	2965-2976	2977-2988	2989-3000	3001-3012	3013-3024	3025-3036	3037-3048	3049-3060	3061-3072	3073-3084	3085-3096	3097-3108	3109-3120	3121-3132	3133-3144	3145-3156	3157-3168	3169-3180	3181-3192	3193-3204	3205-3216	3217-3228	3229-3240	3241-3252	3253-3264	3265-3276	3277-3288	3289-3300	3301-3312	3313-3324	3325-3336	3337-3348	3349-3360	3361-3372	3373-3384	3385-3396	3397-3408	3409-3420	3421-3432	3433-3444	3445-3456	3457-3468	3469-3480	3481-3492	3493-3504	3505-3516	3517-3528	3529-3540	3541-3552	3553-3564	3565-3576	3577-3588	3589-3600	3601-3612	3613-3624	3625-3636	3637-3648	3649-3660	3661-3672	3673-3684	3685-3696	3697-3708	3709-3720	3721-3732	3733-3744	3745-3756	3757-3768	3769-3780	3781-3792	3793-3804	3805-3816	3817-3828	3829-3840	3841-3852	3853-3864	3865-3876	3877-3888	3889-3900	3901-3912	3913-3924	3925-3936	3937-3948	3949-3960	3961-3972	3973-3984	3985-3996	3997-4008	4009-4020	4021-4032	4033-4044	4045-4056	4057-4068	4069-4080	4081-4092	4093-4104	4105-4116	4117-4128	4129-4140	4141-4152	4153-4164	4165-4176	4177-4188	4189-4200	4201-4212	4213-4224	4225-4236	4237-4248	4249-4260	4261-4272	4273-4284	4285-4296	4297-4308	4309-4320	4321-4332	4333-4344	4345-4356	4357-4368	4369-4380	4381-4392	4393-4404	4405-4416	4417-4428	4429-4440	4441-4452	4453-4464	4465-4476	4477-4488	4489-4500	4501-4512	4513-4524	4525-4536	4537-4548	4549-4560	4561-4572	4573-4584	4585-4596	4597-4608	4609-4620	4621-4632	4633-4644	4645-4656	4657-4668	4669-4680	4681-4692	4693-4704	4705-4716	4717-4728	4729-4740	4741-4752	4753-4764	4765-4776	4777-4788	4789-4800	4801-4812	4813-4824	4825-4836	4837-4848	4849-4860	4861-4872	4873-4884	4885-4896	4897-4908	4909-4920	4921-4932	4933-4944	4945-4956	4957-4968	4969-4980	4981-4992	4993-5004	5005-5016	5017-5028	5029-5040	5041-5052	5053-5064	5065-5076	5077-5088	5089-5100	5101-5112	5113-5124	5125-5136	5137-5148	5149-5160	5161-5172	5173-5184	5185-5196	5197-5208	5209-5220	5221-5232	5233-5244	5245-5256	5257-5268	5269-5280	5281-5292	5293-5304	5305-5316	5317-5328	5329-5340	5341-5352	5353-5364	5365-5376	5377-5388	5389-5400	5401-5412	5413-5424	5425-5436	5437-5448	5449-5460	5461-5472	5473-5484	5485-5496	5497-5508	5509-5520	5521-5532	5533-5544	5545-5556	5557-5568	5569-5580	5581-5592	5593-5604	5605-5616	5617-5628	5629-5640	5641-5652	5653-5664	5665-5676	5677-5688	5689-5700	5701-5712	5713-5724	5725-5736	5737-5748	5749-5760	5761-5772	5773-5784	5785-5796	5797-5808	5809-5820	5821-5832	5833-5844	5845-5856	5857-5868	5869-5880	5881-5892	5893-5904	5905-5916	5917-5928	5929-5940	5941-5952	5953-5964	5965-5976	5977-5988	5989-6000	6001-6012	6013-6024	6025-6036	6037-6048	6049-6060	6061-6072	6073-6084	6085-6096	6097-6108	6109-6120	6121-6132	6133-6144	6145-6156	6157-6168	6169-6180	6181-6192	6193-6204	6205-6216	6217-6228	6229-6240	6241-6252	6253-6264	6265-6276	6277-6288	6289-6300	6301-6312	6313-6324	6325-6336	6337-6348	6349-6360	6361-6372	6373-6384	6385-6396	6397-6408	6409-6420	6421-6432	6433-6444	6445-6456	6457-6468	6469-6480	6481-6492	6493-6504	6505-6516	6517-6528	6529-6540	6541-6552	6553-6564	6565-6576	6577-6588	6589-6600	6601-6612	6613-6624	6625-6636	6637-6648	6649-6660	6661-6672	6673-6684	6685-6696	6697-6708	6709-6720	6721-6732	6733-6744	6745-6756	6757-6768	6769-6780	6781-6792	6793-6804	6805-6816	6817-6828	6829-6840	6841-6852	6853-6864	6865-6876	6877-6888	6889-6900	6901-6912	6913-6924	6925-6936	6937-6948	6949-6960	6961-6972	6973-6984	6985-6996	6997-7008	7009-7020	7021-7032	7033-7044	7045-7056	7057-7068	7069-7080	7081-7092	7093-7104	7105-7116	7117-7128	7129-7140	7141-7152	7153-7164	7165-7176	7177-7188	7189-7200	7201-7212	7213-7224	7225-7236	7237-7248	7249-7260	7261-7272	7273-7284	7285-7296	7297-7308	7309-7320	7321-7332	7333-7344	7345-7356	7357-7368	7369-7380	7381-7392	7393-7404	7405-7416	7417-7428	7429-7440	7441-7452	7453-7464	7465-7476	7477-7488	7489-7500	7501-7512	7513-7524	7525-7536	7537-7548	7549-7560	7561-7572	7573-7584	7585-7596	7597-7608	7609-7620	7621-7632	7633-7644	7645-7656	7657-7668	7669-7680	7681-7692	7693-7704	7705-7716	7717-7728	7729-7740	7741-7752	7753-7764	7765-7776	7777-7788	7789-7800	7801-7812	7813-7824	7825-7836	7837-7848	7849-7860	7861-7872	7873-7884	7885-7896	7897-7908	7909-7920	7921-7932	7933-7944	7945-7956	7957-7968	7969-7980	7981-7992	7993-8004	8005-8016	8017-8028	8029-8040	8041-8052	8053-8064	8065-8076	8077-8088	8089-8100	8101-8112	8113-8124	8125-8136	8137-8148	8149-8160	8161-8172	8173-8184	8185-8196	8197-8208	8209-8220	8221-8232	8233-8244	8245-8256	8257-8268	8269-8280	8281-8292	8293-8304	8305-8316	8317-8328	8329-8340	8341-8352	8353-8364	8365-8376	8377-8388	8389-8400	8401-8412	8413-8424	8425-8436	8437-8448	8449-8460	8461-8472	8473-8484	8485-8496	8497-8508	8509-8520	8521-8532	8533-8544	8545-8556	8557-8568	8569-8580	8581-8592	8593-8604	8605-8616	8617-8628	8629-8640	8641-8652	8653-8664	8665-8676	8677-8688	8689-8700	8701-8712	8713-8724	8725-8736	8737-8748	8749-8760	8761-8772	8773-8784	8785-8796	8797-8808	8809-8820	8821-8832	8833-8844	8845-8856	8857-8868	8869-8880	8881-8892	8893-8904	8905-8916	8917-8928	8929-8940	8941-8952	8953-8964	8965-8976	8977-8988	8989-9000	9001-9012	9013-9024	9025-9036	9037-9048	9049-9060	9061-9072	9073-9084	9085-9096	9097-9108	9109-9120	9121-9132	9133-9144	9145-9156	9157-9168	9169-9180	9181-9192	9193-9204	9205-9216	9217-9228	9229-9240	9241-9252	9253-9264	9265-9276	9277-9288	9289-9300	9301-9312	9313-9324	9325-9336	9337

Quantiles on the Card

[illegible]

WORD COLUMNS	1				2				3				4				5			
	1-12				13-24				25-36				37-48				49-60			
FORMAT	FIELD 1 Planching Point Weight of Material No. M				FIELD 2 Planching Point Weight of Material No. M				FIELD 3 Planching Point Weight of Material No. M				FIELD 4 Planching Point Weight of Material No. M				FIELD 5 Planching Point Weight of Material No. M			
DESCRIPTION																				
UNITS	None				None				None				None				None			
SYMBOL	WTF1(M)				WTF2(M)				WTF3(M)				WTF4(M)				WTF5(M)			

NOTE: Input Card Type 25 for M = 1, 2, ..., MAX

WORD	1	2	3	4
COLUMNS	1-12	13-24	25-36	37-48
FORMAT	212.5 Plastic Panel	212.5 Plastic Panel	212.5 Plastic Panel	212.5 Plastic Panel
DESCRIPTION	Basic scattering cross section for Group 1 of Group 1	Basic scattering cross section for Group 2 of Group 1	Basic scattering cross section for Group 3 of Group 1	Basic scattering cross section for Group 4 of Group 1
UNITS	None	None	None	None
Symbols	None	None	None	None
NOTE: Input Card Type 21 from 1 to 12, JMAX; 1 to 12, JMAX in the order: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12

Further details on the use of card type 21 can be found on the page following card type 21

WORD COLUMNS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
FORMAT	1-12	13-24	25-36	37-48	49-60	61-72	73-84	85-96	97-108	109-120	121-132	133-144	145-156	157-168	169-180	181-192	193-204	205-216	217-228	229-240	241-252	253-264	265-276	277-288	289-300	301-312	313-324	325-336	337-348	349-360	361-372	373-384	385-396	397-408	409-420	421-432	433-444	445-456	457-468	469-480	481-492	493-504	505-516	517-528	529-540	541-552	553-564	565-576	577-588	589-600	601-612	613-624	625-636	637-648	649-660	661-672	673-684	685-696	697-708	709-720	721-732	733-744	745-756	757-768	769-780	781-792	793-804	805-816	817-828	829-840	841-852	853-864	865-876	877-888	889-900	901-912	913-924	925-936	937-948	949-960	961-972	973-984	985-996	997-1008	1009-1020	1021-1032	1033-1044	1045-1056	1057-1068	1069-1080	1081-1092	1093-1104	1105-1116	1117-1128	1129-1140	1141-1152	1153-1164	1165-1176	1177-1188	1189-1200	1201-1212	1213-1224	1225-1236	1237-1248	1249-1260	1261-1272	1273-1284	1285-1296	1297-1308	1309-1320	1321-1332	1333-1344	1345-1356	1357-1368	1369-1380	1381-1392	1393-1404	1405-1416	1417-1428	1429-1440	1441-1452	1453-1464	1465-1476	1477-1488	1489-1500	1501-1512	1513-1524	1525-1536	1537-1548	1549-1560	1561-1572	1573-1584	1585-1596	1597-1608	1609-1620	1621-1632	1633-1644	1645-1656	1657-1668	1669-1680	1681-1692	1693-1704	1705-1716	1717-1728	1729-1740	1741-1752	1753-1764	1765-1776	1777-1788	1789-1800	1801-1812	1813-1824	1825-1836	1837-1848	1849-1860	1861-1872	1873-1884	1885-1896	1897-1908	1909-1920	1921-1932	1933-1944	1945-1956	1957-1968	1969-1980	1981-1992	1993-2004	2005-2016	2017-2028	2029-2040	2041-2052	2053-2064	2065-2076	2077-2088	2089-2100	2101-2112	2113-2124	2125-2136	2137-2148	2149-2160	2161-2172	2173-2184	2185-2196	2197-2208	2209-2220	2221-2232	2233-2244	2245-2256	2257-2268	2269-2280	2281-2292	2293-2304	2305-2316	2317-2328	2329-2340	2341-2352	2353-2364	2365-2376	2377-2388	2389-2400	2401-2412	2413-2424	2425-2436	2437-2448	2449-2460	2461-2472	2473-2484	2485-2496	2497-2508	2509-2520	2521-2532	2533-2544	2545-2556	2557-2568	2569-2580	2581-2592	2593-2604	2605-2616	2617-2628	2629-2640	2641-2652	2653-2664	2665-2676	2677-2688	2689-2700	2701-2712	2713-2724	2725-2736	2737-2748	2749-2760	2761-2772	2773-2784	2785-2796	2797-2808	2809-2820	2821-2832	2833-2844	2845-2856	2857-2868	2869-2880	2881-2892	2893-2904	2905-2916	2917-2928	2929-2940	2941-2952	2953-2964	2965-2976	2977-2988	2989-3000	3001-3012	3013-3024	3025-3036	3037-3048	3049-3060	3061-3072	3073-3084	3085-3096	3097-3108	3109-3120	3121-3132	3133-3144	3145-3156	3157-3168	3169-3180	3181-3192	3193-3204	3205-3216	3217-3228	3229-3240	3241-3252	3253-3264	3265-3276	3277-3288	3289-3300	3301-3312	3313-3324	3325-3336	3337-3348	3349-3360	3361-3372	3373-3384	3385-3396	3397-3408	3409-3420	3421-3432	3433-3444	3445-3456	3457-3468	3469-3480	3481-3492	3493-3504	3505-3516	3517-3528	3529-3540	3541-3552	3553-3564	3565-3576	3577-3588	3589-3600	3601-3612	3613-3624	3625-3636	3637-3648	3649-3660	3661-3672	3673-3684	3685-3696	3697-3708	3709-3720	3721-3732	3733-3744	3745-3756	3757-3768	3769-3780	3781-3792	3793-3804	3805-3816	3817-3828	3829-3840	3841-3852	3853-3864	3865-3876	3877-3888	3889-3900	3901-3912	3913-3924	3925-3936	3937-3948	3949-3960	3961-3972	3973-3984	3985-3996	3997-4008	4009-4020	4021-4032	4033-4044	4045-4056	4057-4068	4069-4080	4081-4092	4093-4104	4105-4116	4117-4128	4129-4140	4141-4152	4153-4164	4165-4176	4177-4188	4189-4200	4201-4212	4213-4224	4225-4236	4237-4248	4249-4260	4261-4272	4273-4284	4285-4296	4297-4308	4309-4320	4321-4332	4333-4344	4345-4356	4357-4368	4369-4380	4381-4392	4393-4404	4405-4416	4417-4428	4429-4440	4441-4452	4453-4464	4465-4476	4477-4488	4489-4500	4501-4512	4513-4524	4525-4536	4537-4548	4549-4560	4561-4572	4573-4584	4585-4596	4597-4608	4609-4620	4621-4632	4633-4644	4645-4656	4657-4668	4669-4680	4681-4692	4693-4704	4705-4716	4717-4728	4729-4740	4741-4752	4753-4764	4765-4776	4777-4788	4789-4800	4801-4812	4813-4824	4825-4836	4837-4848	4849-4860	4861-4872	4873-4884	4885-4896	4897-4908	4909-4920	4921-4932	4933-4944	4945-4956	4957-4968	4969-4980	4981-4992	4993-5004	5005-5016	5017-5028	5029-5040	5041-5052	5053-5064	5065-5076	5077-5088	5089-5100	5101-5112	5113-5124	5125-5136	5137-5148	5149-5160	5161-5172	5173-5184	5185-5196	5197-5208	5209-5220	5221-5232	5233-5244	5245-5256	5257-5268	5269-5280	5281-5292	5293-5304	5305-5316	5317-5328	5329-5340	5341-5352	5353-5364	5365-5376	5377-5388	5389-5400	5401-5412	5413-5424	5425-5436	5437-5448	5449-5460	5461-5472	5473-5484	5485-5496	5497-5508	5509-5520	5521-5532	5533-5544	5545-5556	5557-5568	5569-5580	5581-5592	5593-5604	5605-5616	5617-5628	5629-5640	5641-5652	5653-5664	5665-5676	5677-5688	5689-5700	5701-5712	5713-5724	5725-5736	5737-5748	5749-5760	5761-5772	5773-5784	5785-5796	5797-5808	5809-5820	5821-5832	5833-5844	5845-5856	5857-5868	5869-5880	5881-5892	5893-5904	5905-5916	5917-5928	5929-5940	5941-5952	5953-5964	5965-5976	5977-5988	5989-6000	6001-6012	6013-6024	6025-6036	6037-6048	6049-6060	6061-6072	6073-6084	6085-6096	6097-6108	6109-6120	6121-6132	6133-6144	6145-6156	6157-6168	6169-6180	6181-6192	6193-6204	6205-6216	6217-6228	6229-6240	6241-6252	6253-6264	6265-6276	6277-6288	6289-6300	6301-6312	6313-6324	6325-6336	6337-6348	6349-6360	6361-6372	6373-6384	6385-6396	6397-6408	6409-6420	6421-6432	6433-6444	6445-6456	6457-6468	6469-6480	6481-6492	6493-6504	6505-6516	6517-6528	6529-6540	6541-6552	6553-6564	6565-6576	6577-6588	6589-6600	6601-6612	6613-6624	6625-6636	6637-6648	6649-6660	6661-6672	6673-6684	6685-6696	6697-6708	6709-6720	6721-6732	6733-6744	6745-6756	6757-6768	6769-6780	6781-6792	6793-6804	6805-6816	6817-6828	6829-6840	6841-6852	6853-6864	6865-6876	6877-6888	6889-6900	6901-6912	6913-6924	6925-6936	6937-6948	6949-6960	6961-6972	6973-6984	6985-6996	6997-7008	7009-7020	7021-7032	7033-7044	7045-7056	7057-7068	7069-7080	7081-7092	7093-7104	7105-7116	7117-7128	7129-7140	7141-7152	7153-7164	7165-7176	7177-7188	7189-7200	7201-7212	7213-7224	7225-7236	7237-7248	7249-7260	7261-7272	7273-7284	7285-7296	7297-7308	7309-7320	7321-7332	7333-7344	7345-7356	7357-7368	7369-7380	7381-7392	7393-7404	7405-7416	7417-7428	7429-7440	7441-7452	7453-7464	7465-7476	7477-7488	7489-7500	7501-7512	7513-7524	7525-7536	7537-7548	7549-7560	7561-7572	7573-7584	7585-7596	7597-7608	7609-7620	7621-7632	7633-7644	7645-7656	7657-7668	7669-7680	7681-7692	7693-7704	7705-7716	7717-7728	7729-7740	7741-7752	7753-7764	7765-7776	7777-7788	7789-7800	7801-7812	7813-7824	7825-7836	7837-7848	7849-7860	7861-7872	7873-7884	7885-7896	7897-7908	7909-7920	7921-7932	7933-7944	7945-7956	7957-7968	7969-7980	7981-7992	7993-8004	8005-8016	8017-8028	8029-8040	8041-8052	8053-8064	8065-8076	8077-8088	8089-8100	8101-8112	8113-8124	8125-8136	8137-8148	8149-8160	8161-8172	8173-8184	8185-8196	8197-8208	8209-8220	8221-8232	8233-8244	8245-8256	8257-8268	8269-8280	8281-8292	8293-8304	8305-8316	8317-8328	8329-8340	8341-8352	8353-8364	8365-8376	8377-8388	8389-8400	8401-8412	8413-8424	8425-8436	8437-8448	8449-8460	8461-8472	8473-8484	8485-8496	8497-8508	8509-8520	8521-8532	8533-8544	8545-8556	8557-8568	8569-8580	8581-8592	8593-8604	8605-8616	8617-8628	8629-8640	8641-8652	8653-8664	8665-8676	8677-8688	8689-8700	8701-8712	8713-8724	8725-8736	8737-8748	8749-8760	8761-8772	8773-8784	8785-8796	8797-8808	8809-8820	8821-8832	8833-8844	8845-8856	8857-8868	8869-8880	8881-8892	8893-8904	8905-8916	8917-8928	8929-8940	8941-8952	8953-8964	8965-8976	8977-8988	8989-9000	9001-9012	9013-9024	9025-9036	9037-9048	9049-9060	9061-9072	9073-9084	9085-9096	9097-9108	9109-9120	9121-9132	9133-9144	9145-9156	9157-9168	9169-9180	9181-9192	9193-9204	9205-9216	9217-9228	9229-9240	9241-9252	9253-9264	9265-9276	9277-9288	9289-9300	9301-9312	9313-9324	9325-9336	9337-9348	9349-9360	9361-9372	9373-9384	9385-9396	9397-9408	9409-9420	9421-9432	9433-9444	9445-9456	9457-9468	9469-9480	9481-9492	9493-9504	9505-9516	9517-9528	9529-9540	9541-9552	9553-9564	9565-9576	9577-9588	9589-9600	9601-9612	9613-9624	9625-9636	9637-9648	9649-9660	9661-9672	9673-9684	9685-9696	9697-9708	9709-9720	9721-9732	9733-9744	9745-9756	9757-9768	9769-9780	9781-9792	9793-9804	9805-9816	9817-9828	9829-9840	9841-9852	9853-9864	9865-9876	9877-9888	9889-9900	9901-9912	9913-9924	9925-9936	9937-9948	9949-9960	9961-9972	9973-9984	9985-9996	9997-10000	10001-10012	10013-10024	10025-10036	10037-10048	10049-10060	10061-10072	10073-10084

WORD COLUMNS FORMAT	1	Num- of cases of glomerulonephritis NICKER-2 Glomerulonephritis is a disease of the kidney in which the glomeruli are severely damaged and the kidney loses its filtering function. NICKER-2 The disease is most common in the middle aged. NICKER-2	UNITS SYMBOL None None
	1-12		
1-12	Word Pair		
D E S C R I P T I O N			
CARD TYPE 25			

Order of Input: Card Type 27		Definition	
Symbols			
J	Energy group		
SEL(J, I)	Isotope number (in list of unique isotopes)		
SIN(J, I)	Elastic scattering cross section (energy group J, isotope I)		
SPS(J, I)	Elastic scattering cross section (energy group J, isotope I)		
SCA(J, I)	Capture cross section (energy group J, isotope I)		
Number of Card Type 27		Quantities on Card	
1		SEL(1, 1)	SIN(1, 1)
			SPS(1, 1)
			SCA(1, 1)
	1 + 1	SEL(J, 1)	SIN(J, 1)
			SPS(J, 1)
			SCA(J, 1)
JMAG		SEL(JMAG, 1)	SIN(JMAG, 1)
JMAG + 1		SEL(1, 2)	SPS(JMAG, 1)
			SCA(JMAG, 1)
			SPS(1, 2)
			SCA(1, 2)
JMAG + J	1 + 2	SEL(J, 2)	SIN(J, 2)
			SPS(J, 2)
			SCA(J, 2)
2 * JMAG		SEL(JMAG, 2)	SIN(JMAG, 2)
			SPS(JMAG, 2)
			SCA(JMAG, 2)
(I - 1) * JMAG + 1		SEL(1, I)	SIN(1, I)
			SPS(1, I)
			SCA(1, I)
(I - 1) * JMAG + J	1 + 1	SEL(J, I)	SIN(J, I)
			SPS(J, I)
			SCA(J, I)
I * JMAG		SEL(JMAG, I)	SIN(JMAG, I)
			SPS(JMAG, I)
			SCA(JMAG, I)
(IMAX - 1) * JMAG + 1		SEL(1, IMAX)	SIN(1, IMAX)
			SPS(1, IMAX)
			SCA(1, IMAX)
(IMAX - 1) * JMAG + J	1 + IMAX	SEL(J, IMAX)	SIN(J, IMAX)
			SPS(J, IMAX)
			SCA(J, IMAX)
IMAX * JMAG		SEL(JMAG, IMAX)	SIN(JMAG, IMAX)
			SPS(JMAG, IMAX)
			SCA(JMAG, IMAX)

WORD	1	2	3	4	5	6
COLUMNS	1-12	13-24	25-36	37-48	49-60	61-72
FORMAT	Fixed Point	Fixed Point	Fixed Point	Fixed Point	Fixed Point	Fixed Point
D	Determines selection of X, Y, Z of particle	Determines selection of direction cosine of particle	Determines selection of time at which particle is born	Region in which particles are born	Total number of particles on the IV tape at the end of this generation. The number of particles generated is determined by this case.	NTBA = 0 X, Y, Z written on tape as calculated in the generated case. NTBA = 1 X, Y, Z each translated by XERO, YERO, and ZERO. The number of particles written on IV tape
E	MA = 1 Uses Tables 1, 2, 3, 4 Can set IMX(1) = 0	ME = 1 a, b, c chosen independently. Can set IMX(1), IMX(2) = 0	NE = 0 Time at birth = 0			
S	MA = 2 Uses Tables 1 and 4. Can set IMX(1), IMX(2) = 0	ME = 2 Uses Tables 5, 6, 7 Can set IMX(1), IMX(2) = 0	NE = 1 Time at birth = (PIN - random number) * 1000			
C	MA = 3, 4 Uses Tables 1 and 4. Can set IMX(1), IMX(2) = 0	ME = 3 Uses Tables 6 and 7	NE = 2 Time at birth = (PIN - random number) * 1000			
R	MA = 5 Uses Table 1. Can set IMX(1), IMX(2), IMX(3) = 0					
I						
P						
T						
I						
O						
N						
UNITS	None	None	None	None	None	None
SYMBOL	NA	ME	NE	NRIN	NRIV	NTBA

WORD	1	2	3	4	5
CELESTINE	1-12	13-24	25-36	37-48	49-60
FORMAT	E12.5 Framing Point	E12.5 Blaming Point	E12.5 Framing Point	E12.5 Framing Point	E12.5 Framing Point
	Spot time.	Number of neutrons particle generated	Translation in X-direction	Translation in Y-direction	Translation in Z-direction
	MS = 6				
	Spot time not used				
	MS = 1				
	Time at which particle is born = 1472N				
D					
E					
S					
C					
R					
I					
P					
T					
I					
O					
N					
UNITS	Microseconds TR	None	Centimeters	Centimeters	Centimeters
SYMBOL		None			

WORD	1	1-13	Number of entries in 5- fields used to find 2; 100-12 5 300
COLUMNS	1-13	1-13	
FORMAT	1-13	1-13	
D E S C R I P T I O N			
CARD TYPE 33			
LIMITS	1-13	1-13	None
SYMBOL	1-13	1-13	(BACIT)

WORD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
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WORD COLUMN FORMAT	INCHES			
	1-12	13-24	25-36	37-48
D E S C R I P T I O N	First entry in the table of X-coordinates	Second entry in the table of X-coordinates	Third entry in the table of X-coordinates	Fourth entry in the table of X-coordinates
	Centimeters Q12.1	Centimeters Q12.2	Centimeters Q12.3	Centimeters Q12.4
UNIT SYMBOL	Centimeters Q12.1	Centimeters Q12.2	Centimeters Q12.3	Centimeters Q12.4

NOTE: Omit card 34 and card 35 for J = 2 if INK(2) = 0.

CARD
TYPE
35
(5 - 3)

NOTE: Omit card 34 and card 35 for $J = 3$ if $IMX(3) = 0$.

WORD COLUMN	1	2	3	4	5
FORMAT	First entry in table of $p \left(\sqrt{Q^2 + 1} \right)$	Second entry in table of $p \left(\sqrt{Q^2 + 1} \right)$ $QPM, 2) < QPM, 1)$	Third entry in table of $p \left(\sqrt{Q^2 + 1} \right)$ $QPM, 1) < QPM, 2)$	Fourth entry in table of $p \left(\sqrt{Q^2 + 1} \right)$ $QPM, 1) < QPM, 2)$	Continuation QPM, 3)
DESCRIPTION					
UNIT TYPE	Continuation QPM, 1)	Continuation QPM, 2)	Continuation QPM, 3)	Continuation QPM, 4)	Continuation QPM, 5)

NOTE: Check units 24 and 24.2.5 for 2 + 4 + 2.5(4) = 0.

WORD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
COLUMNS	1-12	13-24	25-36	37-48	49-60	61-72	73-84	85-96	97-108	109-120	121-132	133-144	145-156	157-168	169-180	181-192	193-204	205-216	217-228	229-240	241-252	253-264	265-276	277-288	289-300	301-312	313-324	325-336	337-348	349-360	361-372	373-384	385-396	397-408	409-420	421-432	433-444	445-456	457-468	469-480	481-492	493-504	505-516	517-528	529-540	541-552	553-564	565-576	577-588	589-600	601-612	613-624	625-636	637-648	649-660	661-672	673-684	685-696	697-708	709-720	721-732	733-744	745-756	757-768	769-780	781-792	793-804	805-816	817-828	829-840	841-852	853-864	865-876	877-888	889-900	901-912	913-924	925-936	937-948	949-960	961-972	973-984	985-996	997-1008	1009-1020	1021-1032	1033-1044	1045-1056	1057-1068	1069-1080	1081-1092	1093-1104	1105-1116	1117-1128	1129-1140	1141-1152	1153-1164	1165-1176	1177-1188	1189-1200	1201-1212	1213-1224	1225-1236	1237-1248	1249-1260	1261-1272	1273-1284	1285-1296	1297-1308	1309-1320	1321-1332	1333-1344	1345-1356	1357-1368	1369-1380	1381-1392	1393-1404	1405-1416	1417-1428	1429-1440	1441-1452	1453-1464	1465-1476	1477-1488	1489-1500	1501-1512	1513-1524	1525-1536	1537-1548	1549-1560	1561-1572	1573-1584	1585-1596	1597-1608	1609-1620	1621-1632	1633-1644	1645-1656	1657-1668	1669-1680	1681-1692	1693-1704	1705-1716	1717-1728	1729-1740	1741-1752	1753-1764	1765-1776	1777-1788	1789-1800	1801-1812	1813-1824	1825-1836	1837-1848	1849-1860	1861-1872	1873-1884	1885-1896	1897-1908	1909-1920	1921-1932	1933-1944	1945-1956	1957-1968	1969-1980	1981-1992	1993-2004	2005-2016	2017-2028	2029-2040	2041-2052	2053-2064	2065-2076	2077-2088	2089-2100	2101-2112	2113-2124	2125-2136	2137-2148	2149-2160	2161-2172	2173-2184	2185-2196	2197-2208	2209-2220	2221-2232	2233-2244	2245-2256	2257-2268	2269-2280	2281-2292	2293-2304	2305-2316	2317-2328	2329-2340	2341-2352	2353-2364	2365-2376	2377-2388	2389-2400	2401-2412	2413-2424	2425-2436	2437-2448	2449-2460	2461-2472	2473-2484	2485-2496	2497-2508	2509-2520	2521-2532	2533-2544	2545-2556	2557-2568	2569-2580	2581-2592	2593-2604	2605-2616	2617-2628	2629-2640	2641-2652	2653-2664	2665-2676	2677-2688	2689-2700	2701-2712	2713-2724	2725-2736	2737-2748	2749-2760	2761-2772	2773-2784	2785-2796	2797-2808	2809-2820	2821-2832	2833-2844	2845-2856	2857-2868	2869-2880	2881-2892	2893-2904	2905-2916	2917-2928	2929-2940	2941-2952	2953-2964	2965-2976	2977-2988	2989-3000	3001-3012	3013-3024	3025-3036	3037-3048	3049-3060	3061-3072	3073-3084	3085-3096	3097-3108	3109-3120	3121-3132	3133-3144	3145-3156	3157-3168	3169-3180	3181-3192	3193-3204	3205-3216	3217-3228	3229-3240	3241-3252	3253-3264	3265-3276	3277-3288	3289-3300	3301-3312	3313-3324	3325-3336	3337-3348	3349-3360	3361-3372	3373-3384	3385-3396	3397-3408	3409-3420	3421-3432	3433-3444	3445-3456	3457-3468	3469-3480	3481-3492	3493-3504	3505-3516	3517-3528	3529-3540	3541-3552	3553-3564	3565-3576	3577-3588	3589-3600	3601-3612	3613-3624	3625-3636	3637-3648	3649-3660	3661-3672	3673-3684	3685-3696	3697-3708	3709-3720	3721-3732	3733-3744	3745-3756	3757-3768	3769-3780	3781-3792	3793-3804	3805-3816	3817-3828	3829-3840	3841-3852	3853-3864	3865-3876	3877-3888	3889-3900	3901-3912	3913-3924	3925-3936	3937-3948	3949-3960	3961-3972	3973-3984	3985-3996	3997-4008	4009-4020	4021-4032	4033-4044	4045-4056	4057-4068	4069-4080	4081-4092	4093-4104	4105-4116	4117-4128	4129-4140	4141-4152	4153-4164	4165-4176	4177-4188	4189-4200	4201-4212	4213-4224	4225-4236	4237-4248	4249-4260	4261-4272	4273-4284	4285-4296	4297-4308	4309-4320	4321-4332	4333-4344	4345-4356	4357-4368	4369-4380	4381-4392	4393-4404	4405-4416	4417-4428	4429-4440	4441-4452	4453-4464	4465-4476	4477-4488	4489-4500	4501-4512	4513-4524	4525-4536	4537-4548	4549-4560	4561-4572	4573-4584	4585-4596	4597-4608	4609-4620	4621-4632	4633-4644	4645-4656	4657-4668	4669-4680	4681-4692	4693-4704	4705-4716	4717-4728	4729-4740	4741-4752	4753-4764	4765-4776	4777-4788	4789-4800	4801-4812	4813-4824	4825-4836	4837-4848	4849-4860	4861-4872	4873-4884	4885-4896	4897-4908	4909-4920	4921-4932	4933-4944	4945-4956	4957-4968	4969-4980	4981-4992	4993-5004	5005-5016	5017-5028	5029-5040	5041-5052	5053-5064	5065-5076	5077-5088	5089-5100	5101-5112	5113-5124	5125-5136	5137-5148	5149-5160	5161-5172	5173-5184	5185-5196	5197-5208	5209-5220	5221-5232	5233-5244	5245-5256	5257-5268	5269-5280	5281-5292	5293-5304	5305-5316	5317-5328	5329-5340	5341-5352	5353-5364	5365-5376	5377-5388	5389-5400	5401-5412	5413-5424	5425-5436	5437-5448	5449-5460	5461-5472	5473-5484	5485-5496	5497-5508	5509-5520	5521-5532	5533-5544	5545-5556	5557-5568	5569-5580	5581-5592	5593-5604	5605-5616	5617-5628	5629-5640	5641-5652	5653-5664	5665-5676	5677-5688	5689-5700	5701-5712	5713-5724	5725-5736	5737-5748	5749-5760	5761-5772	5773-5784	5785-5796	5797-5808	5809-5820	5821-5832	5833-5844	5845-5856	5857-5868	5869-5880	5881-5892	5893-5904	5905-5916	5917-5928	5929-5940	5941-5952	5953-5964	5965-5976	5977-5988	5989-6000	6001-6012	6013-6024	6025-6036	6037-6048	6049-6060	6061-6072	6073-6084	6085-6096	6097-6108	6109-6120	6121-6132	6133-6144	6145-6156	6157-6168	6169-6180	6181-6192	6193-6204	6205-6216	6217-6228	6229-6240	6241-6252	6253-6264	6265-6276	6277-6288	6289-6300	6301-6312	6313-6324	6325-6336	6337-6348	6349-6360	6361-6372	6373-6384	6385-6396	6397-6408	6409-6420	6421-6432	6433-6444	6445-6456	6457-6468	6469-6480	6481-6492	6493-6504	6505-6516	6517-6528	6529-6540	6541-6552	6553-6564	6565-6576	6577-6588	6589-6600	6601-6612	6613-6624	6625-6636	6637-6648	6649-6660	6661-6672	6673-6684	6685-6696	6697-6708	6709-6720	6721-6732	6733-6744	6745-6756	6757-6768	6769-6780	6781-6792	6793-6804	6805-6816	6817-6828	6829-6840	6841-6852	6853-6864	6865-6876	6877-6888	6889-6900	6901-6912	6913-6924	6925-6936	6937-6948	6949-6960	6961-6972	6973-6984	6985-6996	6997-7008	7009-7020	7021-7032	7033-7044	7045-7056	7057-7068	7069-7080	7081-7092	7093-7104	7105-7116	7117-7128	7129-7140	7141-7152	7153-7164	7165-7176	7177-7188	7189-7200	7201-7212	7213-7224	7225-7236	7237-7248	7249-7260	7261-7272	7273-7284	7285-7296	7297-7308	7309-7320	7321-7332	7333-7344	7345-7356	7357-7368	7369-7380	7381-7392	7393-7404	7405-7416	7417-7428	7429-7440	7441-7452	7453-7464	7465-7476	7477-7488	7489-7500	7501-7512	7513-7524	7525-7536	7537-7548	7549-7560	7561-7572	7573-7584	7585-7596	7597-7608	7609-7620	7621-7632	7633-7644	7645-7656	7657-7668	7669-7680	7681-7692	7693-7704	7705-7716	7717-7728	7729-7740	7741-7752	7753-7764	7765-7776	7777-7788	7789-7800	7801-7812	7813-7824	7825-7836	7837-7848	7849-7860	7861-7872	7873-7884	7885-7896	7897-7908	7909-7920	7921-7932	7933-7944	7945-7956	7957-7968	7969-7980	7981-7992	7993-8004	8005-8016	8017-8028	8029-8040	8041-8052	8053-8064	8065-8076	8077-8088	8089-8100	8101-8112	8113-8124	8125-8136	8137-8148	8149-8160	8161-8172	8173-8184	8185-8196	8197-8208	8209-8220	8221-8232	8233-8244	8245-8256	8257-8268	8269-8280	8281-8292	8293-8304	8305-8316	8317-8328	8329-8340	8341-8352	8353-8364	8365-8376	8377-8388	8389-8400	8401-8412	8413-8424	8425-8436	8437-8448	8449-8460	8461-8472	8473-8484	8485-8496	8497-8508	8509-8520	8521-8532	8533-8544	8545-8556	8557-8568	8569-8580	8581-8592	8593-8604	8605-8616	8617-8628	8629-8640	8641-8652	8653-8664	8665-8676	8677-8688	8689-8700	8701-8712	8713-8724	8725-8736	8737-8748	8749-8760	8761-8772	8773-8784	8785-8796	8797-8808	8809-8820	8821-8832	8833-8844	8845-8856	8857-8868	8869-8880	8881-8892	8893-8904	8905-8916	8917-8928	8929-8940	8941-8952	8953-8964	8965-8976	8977-8988	8989-9000	9001-9012	9013-9024	9025-9036	9037-9048	9049-9060	9061-9072	9073-9084	9085-9096	9097-9108	9109-9120	9121-9132	9133-9144	9145-9156	9157-9168	9169-9180	9181-9192	9193-9204	9205-9216	9217-9228	9229-9240	9241-9252	9253-9264	9265-9276	9277-9288	9289-9300	9301-9312	9313-9324	9325-9336	9337-9348	9349-9360	9361-9372	9373-9384	9385-9396	9397-9408	9409-9420	9421-9432	9433-9444	9445-9456	9457-9468	9469-9480	9481-9492	9493-9504	9505-9516	9517-9528	9529-9540	9541-9552	9553-9564	9565-9576	9577-9588	9589-9600	9601-9612	9613-9624	9625-9636	9637-9648	9649-9660	9661-9672	9673-9684	9685-9696	9697-9708	9709-9720	9721-9732	9733-9744	9745-9756	9757-9768	9769-9780	9781-9792	9793-9804	9805-9816	9817-9828	9829-9840	9841-9852	9853-9864	9865-9876	9877-9888	9889-9900	9901-9912	9913-9924	9925-9936	9937-9948	9949-9960	9961-9972	9973-9984	9985-9996	9997-10000
FORMAT	First entry in table of values (converted internally) QPS, 1) * VSC(1) (card type 20)	Second entry in table of values (converted internally) QPS, 2) * VSC(1) (card type 20)	Third entry in table of values (converted internally) QPS, 3) * VSC(1) (																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															

WORD	1-12	13-25	26-37	38-49	50-61	62-73	74-85	86-97	98-109	110-121	122-133	134-145	146-157	158-169	170-181	182-193	194-205	206-217	218-229	230-241	242-253	254-265	266-277	278-289	290-301	302-313	314-325	326-337	338-349	350-361	362-373	374-385	386-397	398-409	410-421	422-433	434-445	446-457	458-469	470-481	482-493	494-505	506-517	518-529	530-541	542-553	554-565	566-577	578-589	590-601	602-613	614-625	626-637	638-649	650-661	662-673	674-685	686-697	698-709	710-721	722-733	734-745	746-757	758-769	770-781	782-793	794-805	806-817	818-829	830-841	842-853	854-865	866-877	878-889	890-901	902-913	914-925	926-937	938-949	950-961	962-973	974-985	986-997	998-1009	1010-1021	1022-1033	1034-1045	1046-1057	1058-1069	1070-1081	1082-1093	1094-1105	1106-1117	1118-1129	1130-1141	1142-1153	1154-1165	1166-1177	1178-1189	1190-1201	1202-1213	1214-1225	1226-1237	1238-1249	1250-1261	1262-1273	1274-1285	1286-1297	1298-1309	1310-1321	1322-1333	1334-1345	1346-1357	1358-1369	1370-1381	1382-1393	1394-1405	1406-1417	1418-1429	1430-1441	1442-1453	1454-1465	1466-1477	1478-1489	1490-1501	1502-1513	1514-1525	1526-1537	1538-1549	1550-1561	1562-1573	1574-1585	1586-1597	1598-1609	1610-1621	1622-1633	1634-1645	1646-1657	1658-1669	1670-1681	1682-1693	1694-1705	1706-1717	1718-1729	1730-1741	1742-1753	1754-1765	1766-1777	1778-1789	1790-1801	1802-1813	1814-1825	1826-1837	1838-1849	1850-1861	1862-1873	1874-1885	1886-1897	1898-1909	1910-1921	1922-1933	1934-1945	1946-1957	1958-1969	1970-1981	1982-1993	1994-2005	2006-2017	2018-2029	2030-2041	2042-2053	2054-2065	2066-2077	2078-2089	2090-2101	2102-2113	2114-2125	2126-2137	2138-2149	2150-2161	2162-2173	2174-2185	2186-2197	2198-2209	2210-2221	2222-2233	2234-2245	2246-2257	2258-2269	2270-2281	2282-2293	2294-2305	2306-2317	2318-2329	2330-2341	2342-2353	2354-2365	2366-2377	2378-2389	2390-2401	2402-2413	2414-2425	2426-2437	2438-2449	2450-2461	2462-2473	2474-2485	2486-2497	2498-2509	2510-2521	2522-2533	2534-2545	2546-2557	2558-2569	2570-2581	2582-2593	2594-2605	2606-2617	2618-2629	2630-2641	2642-2653	2654-2665	2666-2677	2678-2689	2690-2701	2702-2713	2714-2725	2726-2737	2738-2749	2750-2761	2762-2773	2774-2785	2786-2797	2798-2809	2810-2821	2822-2833	2834-2845	2846-2857	2858-2869	2870-2881	2882-2893	2894-2905	2906-2917	2918-2929	2930-2941	2942-2953	2954-2965	2966-2977	2978-2989	2990-3001	3002-3013	3014-3025	3026-3037	3038-3049	3050-3061	3062-3073	3074-3085	3086-3097	3098-3109	3110-3121	3122-3133	3134-3145	3146-3157	3158-3169	3170-3181	3182-3193	3194-3205	3206-3217	3218-3229	3230-3241	3242-3253	3254-3265	3266-3277	3278-3289	3290-3301	3302-3313	3314-3325	3326-3337	3338-3349	3350-3361	3362-3373	3374-3385	3386-3397	3398-3409	
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Order of Input: Card Type 34 and Card Type 35

For the definition of symbols, see Card Type 34 and Card Type 35

Card			
Card Type 34	$\left\{ \begin{array}{l} \text{*Omit if} \\ \text{IMX(1) = 0} \end{array} \right\}$ $\left\{ \begin{array}{l} \text{*Omit if} \\ \text{IMX(2) = 0} \end{array} \right\}$	$\left\{ \begin{array}{l} Q(1, 1) \\ QP(1, 1) \\ Q(2, 1) \\ QP(2, 1) \end{array} \right\}$	$J = 1$ $J = 2$
Card Type 35		$\left\{ \begin{array}{l} Q(1, 2) \dots Q(1, J) \\ QP(1, 1) \dots QP(1, J) \\ Q(2, 2) \dots Q(2, J) \\ QP(2, 1) \dots QP(2, J) \end{array} \right\}$	
Card Type 34	$\left\{ \begin{array}{l} \text{*Omit if} \\ \text{IMX(J) = 0} \end{array} \right\}$ $\left\{ \begin{array}{l} \text{*Omit if} \\ \text{IMX(7) = 0} \end{array} \right\}$	$\left\{ \begin{array}{l} Q(J, 1) \\ QP(J, 1) \\ Q(7, 1) \\ QP(7, 1) \end{array} \right\}$	$J = J$ $J = 7$
Card Type 35		$\left\{ \begin{array}{l} Q(J, 2) \dots Q(J, J) \\ QP(J, 1) \dots QP(J, J) \\ Q(7, 2) \dots Q(7, J) \\ QP(7, 1) \dots QP(7, J) \end{array} \right\}$	
Card Type 34	$\left\{ \begin{array}{l} \text{*Omit if} \\ \text{IMX(7) = 0} \end{array} \right\}$	$\left\{ \begin{array}{l} Q(7, 1) \\ QP(7, 1) \end{array} \right\}$	$J = 7$
Card Type 35		$\left\{ \begin{array}{l} Q(7, 2) \dots Q(7, J) \\ QP(7, 1) \dots QP(7, J) \end{array} \right\}$	
$\text{IMX(J) } J = 1, 2, \dots, 6 \text{ is on card type 32}$ $\text{IMX(7) is on card type 33}$			

NOTE: Flux is defined as neutrons/cm²-sec.

F. RESTART USING THE CENSUS TAPE

To run the next time step of a problem the following procedure is followed:

- (1) The census tape of the previous time step is mounted on the initial value tape unit and is now the initial value tape.
- (2) A new census tape is mounted on the census tape unit.
- (3) Card Types 1 through 4 and Card Type 36 are input.
- (4) NIV (Card Type 4) must be the number of particles on the new initial value tape as obtained from the printout of the previous time step.

Since NIV must be input for each time step, it is impossible to run successive time steps during one machine run. However, two or more problems of one time step each can be run at once by placing the data deck for each directly behind that for the preceding problem.

G. SAMPLE INPUT

The sample problem contains a list of the input as it was entered from the cards. Columns 73 to 80 indicate the card type and the card number of each card type. For example, if there were two Card Type 6 cards, they would be labeled 6-1 and 6-2 in columns 73, 74 and 75.

VII. RESULTS

A. ANSWERS GENERATED BY THE CODE

The code will generate all or part of the results listed below for a given census time. The results generated depend upon the requests made through the input. Certain results are not dependent on input requests. Certain results are either straight Monte Carlo results (SMC) or analytic estimation results (AE) depending on whether the analytic estimation routine is requested in the calculation. Some results are gotten by both SMC and AE if the analytic estimation routine is requested in the calculation. The results listed as follows are labeled SMC, SMC, and/or AE.

- (1) Number of particles leaking from the system (SMC and AE).
- (2) Number of neutrons leaking from the system (SMC and AE).
- (3) Number of neutrons entering special tally regions (SMC or AE).
- (4) Estimation of criticality (SMC).
- (5) Number of neutrons scattered elastically (SMC).
- (6) Number of neutrons scattered inelastically (SMC).
- (7) Number of fission neutrons born versus energy (SMC).
- (8) Number of particles starting life histories (SMC).
- (9) Number of neutrons starting life histories (SMC).
- (10) Number of particles on the census tape after census period (SMC).
- (11) Number of neutrons on the census tape after census period (SMC).
- (12) Neutron flux versus region and energy group (SMC or AE).
- (13) Number of neutrons crossing from region k to region k' (SMC or AE).
- (14) Number of neutrons scattered elastically versus material and energy group (SMC or AE).

- (15) Number of neutrons scattered inelastically versus material and energy group (SMC or AE).
- (16) Number of neutrons born in fission versus material and energy group (SMC or AE).
- (17) Number of times the collision routine was entered versus material and energy group (SMC).
- (18) Number of times the collision routine was entered (SMC).
- (19) Number of particles that have fallen below the energy cutoff (SMC).
- (20) Number of neutrons that have fallen below the energy cutoff (SMC).
- (21) Dose rate versus region and energy group (SMC or AE).
- (22) Total dose versus region (SMC or AE).
- (23) Last random number used in the calculation.

B. SAMPLE PROBLEM

The sample problem consists of a point source of fission neutrons located at the origin, surrounded by 10 regions, all regions containing water. The geometry is described in Fig. 3.

The input cards as they were entered on tape are labeled INPUT CARDS. A printout of the input with the indirect address results are next presented and are labeled INPUT. The results of the straight Monte Carlo calculation of 10,000 particle histories are presented last and are labeled RESULTS.

This problem ran approximately 8 minutes. No splitting was requested. An examination of the fluxes for regions 3, 5, 7 and 9 show a trend that is to be expected; i.e., the flux results for regions close to the source seem to be more reliable, in that more energy groups are occupied than in regions further removed from the source. This situation could be improved (more energy groups could be occupied in regions far removed from the source, and thus would impart a larger degree of confidence in the results) by both splitting and/or requesting that analytic estimation answers be generated.

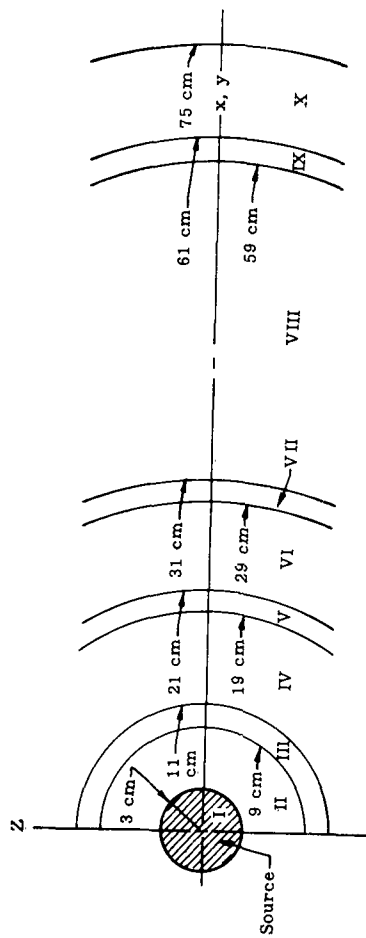


Fig. 3. Spherical Geometry of Sample Problem

INPUT

- - MARTIN-MARIETTA CORP - - 1962 - - M. J. KNIEDLER - T. M. JORDAN -
 TEST PROBLEM - ATTENUATION OF FISSION NEUTRONS IN WATER
 STRAIGHT MONTE CARLO ANSWERS
 ONE PARTICLE PER SCATTER
 DESIGNATION OF TAPE UNITS
 3 = M10, OUTPUT TAPE
 2 = M9, INPUT TAPE
 15 = M8, CROSS-SECTION TAPE
 5 = M7, INITIAL VALUE TAPE
 16 = M6, BREEDER TAPE
 16 = M5, FISSION TAPE
 6 = M4, CENSUS TAPE
 4 = M3, CHAIN LOADER
 7 = M2, COLLISION TAPE
 16 = M1, INELASTIC SCATTERING GAMMA TAPE

CASE NUMBER 1
 THIS IS THE FIRST CASE OF A SERIES. THE INITIAL VALUE TAPE IS GENERATED
 FROM CARD INPUT. ALL DATA FOR THE NEXT CASE IS SAVED ON THE CENSUS TAPE
 OF THIS CASE WITH THE EXCEPTION OF, NOT, WHICH DETERMINES WHETHER THE
 PROBLEM IS AN INITIAL OR
 RESTART PROBLEM
 S, THE INITIAL OCTAL RANDOM NUMBER
 NOPAE, THE ANALYTIC ESTIMATION OPTION
 NIV, THE NUMBER OF PARTICLES ON THE
 INITIAL VALUE TAPE
 FOR THIS CASE, NOT = 0
 TOTAL STORAGE ALLOCATED TO INDIRECTLY ADDRESSED ARRAYS = 18000
 TOTAL STORAGE REQUIRED BY THIS PROBLEM FOR INDIRECTLY ADDRESSED ARRAYS = 494

INDIRECT ADDRESS FOR INTERPOLATING IN ARRAYS STORED BY ENERGY GROUP.
 $N3(J) = 3 \cdot (J - 1)$ USED WITH NTCC(M)
 $NTDB(J) = J \cdot (J - 1) / 2$ USED WITH NTDA(L)

J	N3(J)	NTDB(J)
1	0	0
2	3	1
3	6	3
4	9	6
5	12	10
6	15	15
7	18	21
8	21	28
9	24	36
10	27	45

INDIRECT ADDRESS USED IN INTERPOLATING WITHIN ARRAYS LOCATED BY NTAINJ,
 NTB(M), AND NTC(M)
 $NTMAX(M) = \text{NUMBER OF ISOTOPES IN MATERIAL M}$
 $JNTM(J,M) = J \cdot NTMAX(M)$

M	J	JNTM(J,M)
1	1	2
1	2	4
1	3	6
1	4	8
1	5	10
1	6	12
1	7	14
1	8	16
1	9	18
1	10	20

INDIRECT ADDRESSES
 INDIRECT ADDRESS FOR MATERIALS
 $M = \text{MATERIAL NUMBER}$
 $NTAINJ = \text{INDIRECT ADDRESS FOR ELASTIC SCATTERING PROBABILITIES}$
 $NTBIMJ = \text{INDIRECT ADDRESS FOR INELASTIC SCATTERING PROBABILITIES}$
 $NTCIMJ = \text{INDIRECT ADDRESS FOR FISSION PROBABILITIES}$
 $NTCBIMJ = \text{INDIRECT ADDRESS FOR BREEDING PROBABILITIES}$
 $NTCC(M) = \text{INDIRECT ADDRESS FOR NEUTRONS FROM ELASTIC AND INELASTIC SCATTER AND FISSION}$

M	NTAINJ	NTBIMJ	NTCIMJ	NTCBIMJ	NTCC(M)
1	10	30	50	70	80

NTD = INDIRECT ADDRESS FOR NEUTRON YIELD OF FISSIONABLE ISOTOPES = 110
 NTDAJ = INDIRECT ADDRESS FOR THE FISSION SPECTRUM OF THESE ISOTOPES = 110

INDIRECT ADDRESSES FOR INELASTIC SCATTERING MATRICES
 $J = \text{ISOTOPE NUMBER}$
 $NTDAIJ = \text{INDIRECT ADDRESS FOR PROBABILITIES}$

J	NTDAIJ
1	110
2	165

INDIRECT ADDRESS FOR IALLIES AND CROSS-SECTIONS

NUM(I) = JMAC*(I - 1)

I	NUM(I)
1	0
2	10
3	20
4	30
5	40
6	50
7	60
8	70
9	80
10	90
11	100
12	110
13	120
14	130
15	140
16	150
17	160
18	170
19	180
20	190

10000 = NUMBER OF PARTICLES ON THE INITIAL VALUE TAPE

301643467471 = INITIAL OCTAL RANDOM NUMBER, S

1.00000E-03 = MINIMUM NEUTRON WEIGHT, DELW

0.10000E 01 MICRO-SECS. = CENSUS TIME, CT

0.20000E 02 AMU = LIGHT HEAVY SCATTERING CUTOFF, APRIME

0.50000E-02 CM = DISTANCE INCREMENT FOR BOUNDARY CROSSING, EPSLON

0 = ANALYTIC ESTIMATION OPTION, NOPAE

0 = OPTION ON PARTICLES/FISSION, NFI5F

0 = OPTION ON INELASTIC SCATTERING GAMMAS, NGAP

INDIRECT ADDRESSES FOR REGION INPUT

NR = REGION NUMBER

NTE(NR) = INDIRECT ADDRESS

NR	NTE(NR)
1	220
2	231
3	248
4	265
5	282
6	299
7	316
8	333
9	350
10	367

NTF = INDIRECT ADDRESS FOR SURFACE INPUT = 384

NTG = INDIRECT ADDRESS FOR ELASTICALLY SCATTERED NEUTRONS = 464

NTM = INDIRECT ADDRESS FOR INELASTICALLY SCATTERED NEUTRONS= 464

NTI = INDIRECT ADDRESS FOR NEUTRONS FROM FISSION = 464

NTJ = INDIRECT ADDRESS FOR NEUTRON FLUX = 464

NTK = INDIRECT ADDRESS FOR THE NUMBER OF COLLISIONS = 504

ANSWERS CALCULATED FOR THIS PROBLEM WILL INCLUDE

NEUTRONS ENTERING SPECIAL TALLY REGIONS	
3	
5	
7	

BOUNDARY CROSSINGS FOR 7 REGION PAIRS

FROM REGION	TO REGION
2	3
4	3
4	5
6	5
6	7
8	7
8	9

FLUX CALCULATION FOR 4 REGIONS

REGION	VOL (CU CM)
3	0.25200E 04
5	0.10100E 05
7	0.22600E 05
9	0.90900E 05

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NUMBER OF UNIQUE SURFACES FOR ALL REGIONS = 10

GENERAL EQUATION OF SURFACE BY TYPE

TYPE EQUATION

1	$A \cdot X^{**2} + XZERO \cdot X + B \cdot Y^{**2} + YZERO \cdot Y + C \cdot Z^{**2} + ZZERO \cdot Z - K = 0$
2	$A \cdot (X - XZERO)^{**2} + B \cdot (Y - YZERO)^{**2} + C \cdot (Z - ZZERO)^{**2} - K = 0$
3	$(X - XZERO)^{**2} + (Y - YZERO)^{**2} - K = 0$
4	$X - K = 0$
5	$Y - K = 0$
6	$Z - K = 0$
7	$XZERO \cdot X + YZERO \cdot Y + ZZERO \cdot Z - K = 0$

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CONSTANTS FOR INPUT SURFACES

NUMBER	TYPE	A	B	C	K	ZLRO	YZHO	ZLLO
1	2	0.10000E 01	0.10000E 01	0.10000E 01	0.00000E 01	0.	0.	0.
2	2	0.10000E 01	0.10000E 01	0.10000E 01	0.81000E 02	0.	0.	0.
3	2	0.10000E 01	0.10000E 01	0.10000E 01	0.12100E 03	0.	0.	0.
4	2	0.10000E 01	0.10000E 01	0.10000E 01	0.36100E 01	0.	0.	0.
5	2	0.10000E 01	0.10000E 01	0.10000E 01	0.44100E 03	0.	0.	0.
6	2	0.10000E 01	0.10000E 01	0.10000E 01	0.84100E 01	0.	0.	0.
7	2	0.10000E 01	0.10000E 01	0.10000E 01	0.96100E 03	0.	0.	0.
8	2	0.10000E 01	0.10000E 01	0.10000E 01	0.34810E 04	0.	0.	0.
9	2	0.10000E 01	0.10000E 01	0.10000E 01	0.17210E 04	0.	0.	0.
10	2	0.10000E 01	0.10000E 01	0.10000E 01	0.64000E 04	0.	0.	0.

NUMBER OF REGIONS = 10

DEFINITION OF SYMBOLS

NSMAX = NUMBER OF SURFACES BOUNDING THE REGION

MN = MATERIAL NUMBER OF THE REGION

NAB = AMBIGUOUS BOUNDARY TEST

= 0, NO AMBIGUOUS BOUNDARIES (FIRST SURFACE REPEATED)

= 1, YES AMBIGUOUS BOUNDARIES (FIRST 2 IN LIST)

NOR = 0, REGION IS AN INSIDE REGION

= 1, REGION IS AN OUTSIDE REGION

NPPC = NUMBER OF PARTICLES/COLLISION

AI = AMBIGUITY INDEX OF SURFACE

NOS = SURFACE NUMBER IN LIST OF ALL SURFACES

MPI = FIRST MOST PROBABLE NEXT REGION

HP4 = FOURTH

REGION NUMBER 1									
NSMAX= 1									
MN = 1									
NAB = 0									
NOR = 0									
NPPC = 1									
SURFACE									
1	AI	NOS	MP1	MP2	MP3	MP4			
	0.10000E 01	1	2	2	2	2			

REGION NUMBER 2									
NSMAX= 2									
MN = 1									
NAB = 0									
NOR = 0									
NPPC = 1									
SURFACE									
1	AI	NOS	MP1	MP2	MP3	MP4			
	-0.10000E 01	1	1	1	1	1			
2	0.10000E 01	2	3	3	3	3			

REGION NUMBER 3												
NSMAX= 2												
MN = 1												
NAB = 0												
NOR = 0												
NPPC = 1												
SURFACE												
	AI	NOS	MP1	MP2	MP3	MP4						
1	-0.10000E 01	2	2	2	2	2						
2	0.10000E 01	3	4	4	4	4						
REGION NUMBER 4												
NSMAX= 2												
MN = 1												
NAB = 0												
NOR = 0												
NPPC = 1												
SURFACE												
	AI	NOS	MP1	MP2	MP3	MP4						
1	-0.10000E 01	3	3	3	3	3						
2	0.10000E 01	4	5	5	5	5						

REGION NUMBER	5	6	7	8
NSMAX=	2	2	2	2
MN =	1	1	1	1
NAB =	0	0	0	0
NOR =	0	0	0	0
NPPC =	1	1	1	1
SURFACE				
1	AI -0.10000E 01	NDS 4	MP1 4	MP2 4
2	0.10000E 01	5	6	6
MP3	4	6	6	6
MP4	4	6	6	6
REGION NUMBER	5	6	7	8
NSMAX=	2	2	2	2
MN =	1	1	1	1
NAB =	0	0	0	0
NOR =	0	0	0	0
NPPC =	1	1	1	1
SURFACE				
1	AI -0.10000E 01	NDS 5	MP1 5	MP2 5
2	0.10000E 01	6	7	7
MP3	5	7	7	7
MP4	5	7	7	7
REGION NUMBER	5	6	7	8
NSMAX=	2	2	2	2
MN =	1	1	1	1
NAB =	0	0	0	0
NOR =	0	0	0	0
NPPC =	1	1	1	1
SURFACE				
1	AI -0.10000E 01	NDS 5	MP1 5	MP2 5
2	0.10000E 01	6	7	7
MP3	5	7	7	7
MP4	5	7	7	7
REGION NUMBER	5	6	7	8
NSMAX=	2	2	2	2
MN =	1	1	1	1
NAB =	0	0	0	0
NOR =	0	0	0	0
NPPC =	1	1	1	1
SURFACE				
1	AI -0.10000E 01	NDS 5	MP1 5	MP2 5
2	0.10000E 01	6	7	7
MP3	5	7	7	7
MP4	5	7	7	7
REGION NUMBER	5	6	7	8
NSMAX=	2	2	2	2
MN =	1	1	1	1
NAB =	0	0	0	0
NOR =	0	0	0	0
NPPC =	1	1	1	1
SURFACE				
1	AI -0.10000E 01	NDS 5	MP1 5	MP2 5
2	0.10000E 01	6	7	7
MP3	5	7	7	7
MP4	5	7	7	7
REGION NUMBER	5	6	7	8
NSMAX=	2	2	2	2
MN =	1	1	1	1
NAB =	0	0	0	0
NOR =	0	0	0	0
NPPC =	1	1	1	1
SURFACE				
1	AI -0.10000E 01	NDS 5	MP1 5	MP2 5
2	0.10000E 01	6	7	7
MP3	5	7	7	7
MP4	5	7	7	7
REGION NUMBER	5	6	7	8
NSMAX=	2	2	2	2
MN =	1	1	1	1
NAB =	0	0	0	0
NOR =	0	0	0	0
NPPC =	1	1	1	1
SURFACE				
1	AI -0.10000E 01	NDS 5	MP1 5	MP2 5
2	0.10000E 01	6	7	7
MP3	5	7	7	7
MP4	5	7	7	7
REGION NUMBER	5	6	7	8
NSMAX=	2	2	2	2
MN =	1	1	1	1
NAB =	0	0	0	0
NOR =	0	0	0	0
NPPC =	1	1	1	1
SURFACE				
1	AI -0.10000E 01	NDS 5	MP1 5	MP2 5
2	0.10000E 01	6	7	7
MP3	5	7	7	7
MP4	5	7	7	7
REGION NUMBER	5	6	7	8
NSMAX=	2	2	2	2</

REGION NUMBER 9		TOTAL NUMBER OF MATERIALS = 1	
NSMAX = 2			
MN = 1			
NAB = 0		MATERIAL NUMBER 1	
NOR = 0		THIS MATERIAL CONTAINS 2 ISOTOPES	
NPPC = 1		NBREED = 0	
SURFACE		IDENTIFICATION OF ISOTOPES IN THIS MATERIAL	
1	A1	NI	KIN1
2	-0.10000E 01	1	1
	0.10000E 01	2	2
REGION NUMBER 10			
NSMAX = 2			
MN = 1			
NAB = 0		TOTAL NUMBER OF ISOTOPES = 2	
NOR = 1		NO. OF FISSIONABLE ISOTOPES = 0	
NPPC = 1		LTEST = 0 THE REQUIRED PROBABILITIES AND CROSS-SECTIONS ARE READ AND	
SURFACE		CALCULATED FROM CARD INPUT AND SAVED ON THE CROSS-SECTION	
1	A1	TAPE, M8, FOR INPUT TO ANOTHER PROGRAM.	
2	-0.10000E 01		
	0.10000E 01		

ISOTOPE NUMBER	1	ATOMIC WEIGHT = 0.10000E 01 AMU
INELASTIC SCATTERING MATRIX		
J	1	2
1	0.	0.
2	0.	0.
3	0.	0.
4	0.	0.
5	0.	0.
6	0.	0.
7	0.	0.
8	0.	0.
9	0.	0.
10	0.	0.

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ISOTOPE NUMBER	2	ATOMIC WEIGHT = 0.16000E 02 AMU
INELASTIC SCATTERING MATRIX		
J	1	2
1	0.	0.
2	0.	0.
3	0.	0.
4	0.	0.
5	0.	0.
6	0.	0.
7	0.	0.
8	0.	0.
9	0.	0.
10	0.	0.

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INPUT FOR PROBABILITY CALCULATIONS

J = ENERGY GROUP

SEL = ELASTIC SCATTERING CROSS-SECTION

SIN = INELASTIC SCATTERING CROSS-SECTION

SFIS = FISSION CROSS-SECTION

SCAP = CAPTURE CROSS-SECTION

ALL CROSS-SECTIONS HAVE UNITS OF BARNS

MATERIAL 1 DENSITY 0.10000E 01 GM/CM3

ISOTOPE WEIGHT FRACTION
1 0.11110E-00
2 0.88890E 00

ISOTOPE	1	J	SEL	SIN	SFIS	SCAP
	1	1	0.87800E 00	0.0	0.0	0.0
	2	2	0.10600E 01	0.0	0.0	0.0
	3	3	0.13100E 01	0.0	0.0	0.0
	4	4	0.15600E 01	0.0	0.0	0.0
	5	5	0.18000E 01	0.0	0.0	0.0
	6	6	0.21100E 01	0.0	0.0	0.0
	7	7	0.26300E 01	0.0	0.0	0.0
	8	8	0.35600E 01	0.0	0.0	0.0
	9	9	0.53000E 01	0.0	0.0	0.0
	10	10	0.88000E 01	0.0	0.0	0.0

ISOTOPE	2	J	SEL	SIN	SFIS	SCAP
	1	1	0.30000E-00	0.0	0.0	0.90000E 00
	2	2	0.45000E-00	0.0	0.0	0.66000E 00
	3	3	0.86000E 00	0.0	0.0	0.24000E-00
	4	4	0.11000E 01	0.0	0.0	0.15000E-00
	5	5	0.19000E 01	0.0	0.0	0.12000E-00
	6	6	0.28000E 01	0.0	0.0	0.50000E-01
	7	7	0.18300E 01	0.0	0.0	0.0
	8	8	0.18300E 01	0.0	0.0	0.0
	9	9	0.18300E 01	0.0	0.0	0.0
	10	10	0.18300E 01	0.0	0.0	0.0

PROBABILITIES FOR NEUTRON INTERACTIONS - MATERIAL NUMBER

ENERGY GROUP		NI	PSE	PSI	PSF
1		1	0.59405E	00 0.69553E	00 0.69553E
		2	0.69553E	00 0.69553E	00 0.69553E
			XSECT = 0.98901E-01		
			PS1 = 0.69553E	00	
2			PS2 = 0.		
			PS3 = 0.		
		NI	PSE <th>PSI</th> <th>PSF</th>	PSI	PSF
		1	0.65635E	00 0.79567E	00 0.79567E
3		2	0.79567E	00 0.79567E	00 0.79567E
			XSECT = 0.10807E-00		
			PS1 = 0.79567E	00	
			PS2 = 0.		
4			PS3 = 0.		
		NI	PSE <th>PSI</th> <th>PSF</th>	PSI	PSF
		1	0.70430E	00 0.93548E	00 0.93548E
		2	0.93548E	00 0.93548E	00 0.93548E
5			XSECT = 0.12446E-00		
			PS1 = 0.93548E	00	
			PS2 = 0.		
			PS3 = 0.		
6		NI	PSI <th>PSI</th> <th>PSF</th>	PSI	PSF
		1	0.71396E	00 0.96568E	00 0.96568E
		2	0.96568E	00 0.96568E	00 0.96568E
			XSECT = 0.14621E-00		
7			PS1 = 0.96568E	00	
			PS2 = 0.		
			PS3 = 0.		

CALCULATED PROBABILITIES

NI = ISOTOPE NUMBER (OF THE MATERIAL)

PSF = PROBABILITY FOR ELASTIC SCATTERING

PSI = PROBABILITY FOR IN-ELASTIC SCATTERING

PSF = PROBABILITY FOR FISSION

$PBREED = \text{PROBABILITY FOR BREEDING (FIRST ISOTOPE ONLY, ONLY IF NBREED} = 1)$

PS1 = NEUTRONS PER ELASTIC SCATTER

PS2 = NEUTRONS PER INELASTIC SCATTER

PS3_____ = NEUTRONS PER FISSION

XSECT = NEUTRON REMOVAL CROSS-SECTION (1/CM)

5	NI	PSE	PSI	PSF
	1	0.64057E 00	0.97865E 00	0.97865E 00
	2	0.97865E 00	0.97865E 00	0.97865E 00
XSECT = 0.18803E-00				
	PS1	= 0.97865E 00		
	PS2	= 0.		
	PS3	= 0.		
6	NI	PSE	PSI	PSF
	1	0.59489E 00	0.99293E 00	0.99293E 00
	2	0.99293E 00	0.99293E 00	0.99293E 00
XSECT = 0.23655E-00				
	PS1	= 0.99293E 00		
	PS2	= 0.		
	PS3	= 0.		
7	NI	PSE	PSI	PSF
	1	0.74189E 00	1.00000E 00	1.00000E 00
	2	1.00000E 00	1.00000E 00	1.00000E 00
XSECT = 0.23722E-00				
	PS1	= 1.00000E 00		
	PS2	= 0.		
	PS3	= 0.		
8	NI	PSE	PSI	PSF
	1	0.73553E 00	1.00000E 00	1.00000E 00
	2	1.00000E 00	1.00000E 00	1.00000E 00
XSECT = 0.29945E-00				
	PS1	= 1.00000E 00		
	PS2	= 0.		
	PS3	= 0.		
9	NI	PSE	PSI	PSF
	1	0.85278E 00	1.00000E 00	1.00000E 00
	2	1.00000E 00	1.00000E 00	1.00000E 00
XSECT = 0.41588E-00				
	PS1	= 1.00000E 00		
	PS2	= 0.		
	PS3	= 0.		
10	NI	PSE	PSI	PSF
	1	0.90582E 00	1.00000E 00	1.00000E 00
	2	1.00000E 00	1.00000E 00	1.00000E 00
XSECT = 0.65008E 00				
	PS1	= 1.00000E 00		
	PS2	= 0.		
	PS3	= 0.		

ENERGY AND VELOCITY VERSUS ENERGY LEVEL			
ENERGY LEVEL	ENERGY (ELECTRON-VOLTS)	VELOCITY (CM/MICRO-SEC)	
1	0.50000E 06	0.97521E 03	
2	0.10000E 07	0.13792E 04	
3	0.15000E 07	0.16891E 04	
4	0.20000E 07	0.19504E 04	
5	0.25000E 07	0.21806E 04	
6	0.30000E 07	0.23888E 04	
7	0.40000E 07	0.27583E 04	
8	0.50000E 07	0.30839E 04	
9	0.70000E 07	0.36489E 04	
10	0.90000E 07	0.41375E 04	
11	0.12000E 08	0.47775E 04	

PARTICLE GENERATOR INPUT

1 CASES

CASE NUMBER 1

NP1V = 10000 = TOTAL NUMBER OF PARTICLES GENERATED AT THE END OF THIS CASE

NA = 5 DETERMINES SELECTION OF COORDINATES

NE = 1 DETERMINES SELECTION OF DIRECTION COSINES

NH = 1 DETERMINES SELECTION OF TIME

NRIN = 1 = REGION IN WHICH PARTICLE IS BORN

TIN = 0.10000E 04 = INPUT TIME

WIN = 0.10000E 01 = WEIGHT OF PARTICLE

NTRA = -0 OPTION ON COORDINATE TRANSLATION

TRANSLATION COORDINATES

-0. = XZRO

-0. = YZRO

-0. = ZZRO

TABLE NUMBER 1 - 7 ENTRIES

Q-TABLE
COORDINATE
0.10000E 01
0.30000E 01
0.57610E 00
0.29600E-00
0.12480E-00
0.37000E-01
0.46000E-02
0.

TABLE NUMBER 5 - 11 ENTRIES

Q-TABLE
COORDINATE
0.10000E 01
0.82500E 00
0.63200E 00
0.49300E-00
0.34640E-00
0.25000E-00
0.12630E-00
0.61100E-01
0.13720E-01
0.28550E-02
0.

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INPUT CARDS

* DATA	3	2	15	5	16	161
TEST PROBLEM - ATTENUATION OF FISSION NEUTRONS IN WATER	6	4	7	16		2
STRAIGHT MONTE CARLO ANSWERS						3-1
ONE PARTICLE PER SCATTER	0	0	10000001643467471			3-2
	1	2	0	10		3-3
	2					4
	1	2	2	2	2	105
	2	2	2	2	2	6
	2	2	2	2	2	27-1
	2	2	2	2	2	7-2
	2	2	2	2	2	8
1+0	1-3	20.00000+0	5.00000-3			9
	3	5	7			10
	2	3	4	3	4	511-1
	6	5	6	7	8	711-2
	8	9				11-3
	3	2.52+3	5	1.01+4	7	2.28+413-1
	9	9.05+4				13-2
	2	1.00000+0	1.00000+0	1.00000+0	9.30000+0	14-1
0.00000+0	0.00000+0	0.00000+0	0.00000+0			15-2
	2	1.00000+0	1.00000+0	1.00000+0	8.10000+1	14-2
0.00000+0	0.00000+0	0.00000+0	0.00000+0			15-2
	2	1.00000+0	1.00000+0	1.00000+0	1.21000+2	14-3
0.00000+0	0.00000+0	0.00000+0	0.00000+0			15-3
	2	1.00000+0	1.00000+0	1.00000+0	3.61000+2	14-4
0.00000+0	0.00000+0	0.00000+0	0.00000+0			15-4
	2	1.00000+0	1.00000+0	1.00000+0	4.41000+2	14-5
0.00000+0	0.00000+0	0.00000+0	0.00000+0			15-5
	2	1.00000+0	1.00000+0	1.00000+0	8.41000+2	14-6
0.00000+0	0.00000+0	0.00000+0	0.00000+0			15-6
	2	1.00000+0	1.00000+0	1.00000+0	9.61000+2	14-7
0.00000+0	0.00000+0	0.00000+0	0.00000+0			15-7
	2	1.00000+0	1.00000+0	1.00000+0	3.78100+3	14-8
0.00000+0	0.00000+0	0.00000+0	0.00000+0			15-8
	2	1.00000+0	1.00000+0	1.00000+0	3.72100+3	14-9
0.00000+0	0.00000+0	0.00000+0	0.00000+0			15-9
	2	1.00000+0	1.00000+0	1.00000+0	5.43000+3	14-10
0.00000+0	0.00000+0	0.00000+0	0.00000+0			15-10
	1	0	0	1	2	217-1-1

[illegible]

5	1.000000	1	1	1	10000	30
7	1.000000	0	0	0	11	31
0						032
1.	.5781	.296	.1248	.037		33
0.						34-1-2
0.	2.5	2.	1.5	1.		35-1-1
1.	.825	.632	.493	.344		35-1-2
.1263	.0617	.01372	.002855	0.		34-5-2
.5+6	1.4+6	1.5+6	2.4+6	2.5+6		3.4+635-3-1
4.+6	5.+6	7.+6	9.+6	12.+6		35-5-2
9.3-9	1.28-8	1.44-8	1.81-8	1.63-8		2.01-836-1
2.01-8	2.01-8	2.01-8	2.01-8			36-2

COORDINATES OF FIRST 50 PARTICLES

X	Y	Z	ALPHA	BETA	GAMMA
-0.17903E	01 0.61813E	00-0.12320E	01-0.74593E	00-0.45784E	00 0.48371E-00
-0.18536E	01-0.20752E	01-0.80542E	00 0.17685E	00 0.81890E	00-0.54602E-00
-0.18245E	01-0.79909E	01 0.12183E	01 0.37351E	00-0.69964E	00 0.60910E-00
-0.42708E	00-0.21931E	01-0.40764E	00-0.53196E	00 0.26830E	00 0.80314E-00
-0.22571E	01-0.14191E	01 0.18723E	00-0.89256E	00 0.40043E	00 0.20736E-00
-0.93773E	00 0.10945E	01-0.51056E	00-0.31088E	00-0.91543E	00 0.25562E-00
-0.11027E	01 0.14473E	01 0.42762E	00 0.80221E	00-0.56141E	00 0.13571E-00
-0.13586E	01-0.16105E	01 0.36808E	00 0.21021E	00-0.95398E	00 0.21388E-00
-0.85561E	00-0.54607E	00 0.19211E	01-0.10025E	00 0.75168E	00-0.65186E-00
-0.14223E	01 0.65046E	00 0.28650E	00 0.97027E	00-0.86021E	01 0.22624E-00

M	T	V	J	NK
0.10000E	01 0.	0.10383E	04	1
0.10000E	01 0.	0.46411E	04	1
0.10000E	01 0.	0.12191E	04	1
0.10000E	01 0.	0.34856E	04	1
0.10000E	01 0.	0.22649E	04	1
0.10000E	01 0.	0.33918E	04	1
0.10000E	01 0.	0.16276E	04	1
0.10000E	01 0.	0.22788E	04	1
0.10000E	01 0.	0.15430E	04	1
0.10000E	01 0.	0.13437E	04	1

X	Y	Z	ALPHA	BETA	GAMMA
-0.40483E	00 0.28876E	01 0.81599E	01-0.19128E	00-0.97780E	00-0.55586E-01
-0.11872E	01-0.75446E	00 0.24498E	01-0.89838E	00-0.35849E	00 0.25379E-00
-0.25375E	00 0.45494E	00 0.28601E	01-0.77627E	00 0.17671E	00 0.60513E-00
-0.25013E	01-0.53030E	01-0.37847E	00-0.33232E	00-0.74425E	00-0.57936E-00
0.11206E	01-0.10797E	01 0.10513E	01-0.49897E	00-0.77783E	00-0.36210E-00
0.94645E	00-0.17907E	01 0.17311E	01-0.84060E	00-0.23954E	00-0.48581E-00
-0.14548E	00 0.11461E	01-0.16579E	01 0.13635E	00-0.78862E	01-0.94752E-00
-0.24091E	01 0.16299E	01-0.83380E	01-0.86102E	00 0.40335E	00 0.30978E-00
0.80516E	00 0.51853E	00-0.12721E	01 0.50425E	00-0.23542E	00 0.63095E-00
0.11292E	01-0.85893E	00-0.14607E	01-0.41545E	00-0.88271E	00-0.21960E-00

M	T	V	J	NK
0.10000E	01 0.	0.16706E	04	2
0.10000E	01 0.	0.21426E	04	2
0.10000E	01 0.	0.11917E	04	1
0.10000E	01 0.	0.17151E	04	3
0.10000E	01 0.	0.14404E	04	2
0.10000E	01 0.	0.18880E	04	3
0.10000E	01 0.	0.14875E	04	2
0.10000E	01 0.	0.16562E	04	2
0.10000E	01 0.	0.26777E	04	6
0.10000E	01 0.	0.14797E	04	2

X	Y	Z	ALPHA	BETA	GAMMA
-0.42033E-00	0.71209E-00	0.48583E-00	0.86182E-00	0.10805E-00	0.49557E-00
-0.15559E-01	0.19072E-01	0.60148E-00	0.63798E-00	0.74590E-00	0.20731E-00
-0.22904E-00	0.16813E-01	0.2374E-01	0.31325E-01	0.12222E-00	0.9201E-00
-0.40859E-00	0.75634E-00	0.12328E-00	0.90600E-00	0.41032E-00	0.10311E-00
-0.19864E-01	0.64763E-00	0.80765E-00	0.95158E-00	0.30739E-00	0.26312E-02
-0.10288E-01	0.13566E-01	0.12069E-01	0.35039E-00	0.72372E-00	0.59452E-00
-0.28756E-00	0.46468E-00	0.27614E-01	0.64719E-00	0.18152E-00	0.74040E-00
-0.2373E-01	0.96562E-00	0.14529E-00	0.15915E-00	0.95095E-00	0.26526E-00
-0.34734E-00	0.20297E-01	0.21262E-01	0.85030E-00	0.52527E-00	0.18613E-01
-0.20385E-01	0.85316E-00	0.11032E-01	0.67542E-00	0.15022E-00	0.72197E-00
W	T	V	J	NR	
0.10000E-01	0.19678E-04	0.22780E-04	4	1	
0.10000E-01	0.22780E-04	0.27231E-04	5	1	
0.10000E-01	0.27231E-04	0.18892E-04	6	1	
0.10000E-01	0.18892E-04	0.29066E-04	7	1	
0.10000E-01	0.29066E-04	0.27608E-04	7	1	
0.10000E-01	0.10424E-04	0.10424E-04	1	1	
0.10000E-01	0.23752E-04	0.23752E-04	5	1	
0.10000E-01	0.26459E-04	0.26459E-04	6	1	
0.10000E-01	0.19414E-04	0.19414E-04	3	1	
X	Y	Z	ALPHA	BETA	GAMMA
0.14500E-01	0.10778E-01	0.86044E-00	0.40563E-00	0.54779E-00	0.73171E-00
0.11394E-01	0.33793E-00	0.17667E-01	0.84308E-00	0.13836E-00	0.51968E-00
0.42962E-00	0.90635E-00	0.11837E-01	0.47955E-00	0.19273E-00	0.85609E-00
0.16657E-01	0.15706E-01	0.18569E-01	0.62474E-00	0.47354E-00	0.62086E-00
0.23221E-01	0.16450E-01	0.44822E-00	0.49724E-00	0.84846E-00	0.18131E-00
0.22000E-01	0.11849E-01	0.35138E-00	0.39696E-00	0.46761E-00	0.78979E-00
-0.76851E-00	0.31574E-00	0.26297E-01	0.43139E-00	0.47247E-00	0.76855E-00
-0.44724E-00	0.59334E-00	0.68059E-01	0.93956E-00	0.34198E-00	0.16624E-01
-0.14633E-00	0.66663E-00	0.14813E-01	0.22026E-00	0.17983E-00	0.95872E-00
-0.14969E-01	0.16559E-01	0.10081E-01	0.94984E-00	0.19454E-00	0.24480E-00
W	T	V	J	NR	
0.10000E-01	0.24824E-04	0.24824E-04	6	1	
0.10000E-01	0.23347E-04	0.13127E-04	5	1	
0.10000E-01	0.13127E-04	0.21090E-04	1	1	
0.10000E-01	0.21090E-04	0.20237E-04	4	1	
0.10000E-01	0.20237E-04	0.17736E-04	3	1	
0.10000E-01	0.17736E-04	0.15538E-04	2	1	
0.10000E-01	0.15538E-04	0.25651E-04	6	1	
0.10000E-01	0.25651E-04	0.31299E-04	8	1	
0.10000E-01	0.31299E-04	0.15896E-04	2	1	

X	Y	Z	ALPHA	BETA	GAMMA
-0.20085E-01	0.78763E-00	0.0.15876E-01	0.34595E-01	0.87131E-00	0.48950E-00
-0.69463E-00	0.20846E-00	0.23549E-01	0.99498E-00	0.18734E-01	0.98315E-01
-0.10687E-01	0.21631E-01	0.15662E-01	0.24566E-00	0.12222E-00	0.30130E-00
-0.51777E-00	0.38720E-00	0.89955E-00	0.66509E-00	0.48911E-00	0.56441E-00
0.12160E-01	0.35425E-00	0.97164E-01	0.71099E-00	0.47619E-01	0.70158E-00
-0.10985E-01	0.50079E-01	0.71729E-00	0.52843E-00	0.76488E-00	0.36840E-00
-0.13186E-01	0.11207E-01	0.14627E-00	0.60669E-00	0.71507E-00	0.34728E-00
-0.14879E-01	0.14471E-01	0.16469E-01	0.72736E-00	0.24250E-00	0.64196E-00
-0.18929E-01	0.97527E-00	0.49118E-00	0.45803E-00	0.80966E-00	0.36696E-00
0.10779E-01	0.13471E-01	0.21218E-01	0.52951E-00	0.45156E-00	0.71814E-00
W	T	V	J	NR	
0.10000E-01	0.25817E-04	0.25817E-04	6	1	
0.10000E-01	0.18962E-04	0.20099E-04	3	1	
0.10000E-01	0.20099E-04	0.14637E-04	4	1	
0.10000E-01	0.14637E-04	0.10792E-04	2	1	
0.10000E-01	0.10792E-04	0.14375E-04	2	1	
0.10000E-01	0.14375E-04	0.29139E-04	7	1	
0.10000E-01	0.29139E-04	0.99239E-03	1	1	
0.10000E-01	0.99239E-03	0.19068E-04	3	1	
0.10000E-01	0.19068E-04	0.30401E-04	7	1	

RESULTS

TOTAL NUMBER OF PARTICLES REJECTED IN RFINO AND SFIND	=	0.	0
TOTAL NUMBER OF NEUTRONS REJECTED IN RFINO AND SFIND	=	0.	0
TOTAL NUMBER OF PARTICLES REJECTED IN SPLT	=	0.	0
TOTAL NUMBER OF NEUTRONS REJECTED IN SPLT	=	0.	0
TOTAL NUMBER OF PARTICLES KILLED BY RUSSIAN ROULETTE	=	0.	0
TOTAL NUMBER OF NEUTRONS KILLED BY RUSSIAN ROULETTE	=	0.	0
TOTAL NUMBER OF RECORDS OF 20 GAMMAS EACH ON TAPE M1	=		0
NUMBER OF UNIQUE GAMMAS IN THE LAST RECORD	=		0

STRAIGHT MONTE CARLO RESULTS

TOTAL NUMBER OF PARTICLES AT THE START OF THE CENSUS PERIOD	=	10000
TOTAL NUMBER OF PARTICLES AT THE END OF THE CENSUS PERIOD	=	0
TOTAL NUMBER OF NEUTRONS AT THE START OF THE CENSUS PERIOD	=	0.10000E 05
TOTAL NUMBER OF NEUTRONS AT THE END OF THE CENSUS PERIOD	=	0.
TOTAL NUMBER OF NEUTRONS SCATTERED ELASTICALLY	=	0.21663E 05
TOTAL NUMBER OF NEUTRONS SCATTERED IN-ELASTICALLY	=	0.
TOTAL NUMBER OF NEUTRONS CAUSING FISSION	=	0.
TOTAL NUMBER OF NEUTRONS BORN IN FISSION	=	0.
TOTAL NUMBER OF NEUTRONS ABSORBED	=	0.36160E 04
TOTAL NUMBER OF NEUTRONS CAUSING BREEDING	=	0.
TOTAL NUMBER OF PARTICLES BELOW ENERGY CUTOFF	=	6227
TOTAL NUMBER OF NEUTRONS BELOW ENERGY CUTOFF	=	0.62270E 04
TOTAL NUMBER OF TIMES THE COLLISION ROUTINE WAS ENTERED	=	25279

ESTIMATION OF K-EFFECTIVE
 FNT = NEUTRONS BORN IN FISSION
 TW = NEUTRONS STARTING OUT
 ABNTS = NEUTRONS ADSORBED
 XLEAK = NEUTRONS THAT ESCAPED
 WNNOCCT = NEUTRONS AT END
 FSNTS = NEUTRONS CAUSING FISSION
 ENGCT = NEUTRONS BELOW ENERGY CUTOFF
 WVELCT = NEUTRONS REJECTED IN SPLT

WREJCT = NEUTRONS REJECTED IN SFIND AND RFIND
 ABRCUT = NEUTRONS KILLED BY RUSSIAN ROULETTE
 ABSRB = FSNTS + ABNTS + XLEAK + ENGCT + WVELCT + WREJCT + ABRCUT

WNNOCCT/TW = 0.

FNT/ABSRB = 0.

NUMBER OF FISSION NEUTRONS BORN VERSUS INCIDENT NEUTRON ENERGY

ENERGY GROUP	NEUTRONS BORN
1	0.
2	0.
3	0.
4	0.
5	0.
6	0.
7	0.
8	0.
9	0.
10	0.

NUMBER OF FISSION NEUTRONS BORN VERSUS ENERGY AT BIRTH

ENERGY GROUP	NEUTRONS BORN
1	0.
2	0.
3	0.
4	0.
5	0.
6	0.
7	0.
8	0.
9	0.
10	0.

TOTAL NUMBER OF FISSIONABLE ATOMS FORMED FROM ABSORPTION VERSUS REGION

REGION	ATOMS FORMED
--------	--------------

TOTAL NUMBER OF NEUTRONS GOING FROM REGION L TO REGION LP

REGION L	REGION LP	NEUTRONS
2	3	0.66820E 04
4	3	0.16606E 03
4	5	0.35030E 04
6	5	0.78000E 02
6	7	0.17260E 04

TOTAL NUMBER OF NEUTRONS ENTERING SPECIAL TALLY REGIONS

REGION	NEUTRONS
3	0.68460E 04
5	0.35010E 04
7	0.17640E 04

FLUX TO DOSE RATL. CONVERSION FACTOR VERSUS ENRGY GROUP

ENERGY GROUP	CONVERSION FACTOR
1	0.93000E-08
2	0.12600E-07
3	0.14400E-07
4	0.15100E-07
5	0.16300E-07
6	0.20100E-07
7	0.20100E-07
8	0.20100E-07
9	0.20100E-07
10	0.20100E-07

NEUTRON FLUX AND DOSE RATE VERSUS ENERGY GROUP FOR REGION 3

ENERGY GROUP	NEUTRONS PER SQCM-SLC	DOSE RATE
1	0.37070E 06	0.34475E-02
2	0.35539E 06	0.42259E-02
3	0.25833E 06	0.37199E-02
4	0.21902E 06	0.33072E-02
5	0.12592E 06	0.20525E-02
6	0.12369E 06	0.24862E-02
7	0.45702E 05	0.91862E-03
8	0.19722E 05	0.39641E-03
9	0.29246E 04	0.58784E-04
10	0.43976E 02	0.88392E-06
TOTAL		0.20614E-01

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NEUTRON FLUX AND DOSE RATE VERSUS ENRGY GROUP FOR REGION 5

ENERGY GROUP	NEUTRONS PER SQCM-SEC	DOSE RATE
1	0.71509E 05	0.66504E-03
2	0.51943E 05	0.65448E-03
3	0.35584E 05	0.51240E-03
4	0.17019E 05	0.25699E-03
5	0.92005E 04	0.14997E-03
6	0.42052E 04	0.84525E-04
7	0.12292E 04	0.24706E-04
8	0.62906E 03	0.12644E-04
9	0.	0.
10	0.	0.
TOTAL		0.23608E-02

NEUTRON FLUX AND DOSE RATE VERSUS ENERGY GROUP FOR REGION 7

ENERGY GROUP	NEUTRONS PER SQCM-SLC	DOSE RATE
1	0.18947E 05	0.17620E-03
2	0.11316E 05	0.14258E-03
3	0.53472E 04	0.76999E-04
4	0.22518E 04	0.34003E-04
5	0.10126E 04	0.16506E-04
6	0.17669E 03	0.35515E-05
7	0.83136E 02	0.16710E-05
8	0.	0.
9	0.	0.
10	0.	0.
TOTAL		0.45151E-03

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NEUTRON FLUX AND DOSE RATE VERSUS ENERGY GROUP FOR REGION

9

ENERGY GROUP	NEUTRONS PER SQCM-SEC	DOSE RATE
1	0.62013E 03	0.57672E-05
2	0.21676E 03	0.27312E-05
3	0.46158E 02	0.66487E-06
4	0.24023E 02	0.36275E-06
5	0.22263E 02	0.36289E-06
6	0.	0.
7	0.	0.
8	0.	0.
9	0.	0.
10	0.	0.
TOTAL		0.98889E-05

TOTAL LEAKAGE FROM THE SYSTEM

PARTICLES
MONTE CARLO
157

NEUTRONS
MONTE CARLO
0.15700E 03

314024013145 = FINAL OCTAL RANDOM NUMBER, S

1242 LINES OUTPUT THIS JOB.
DATE BEGIN JOB 620728
DATE END JOB 230738
LINES 231533
1242

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VIII. MAIN PROGRAMS AND SUBROUTINES IN EACH CHAIN

The flow diagrams in Appendix A provide a detailed description of the code. The function of the main program in each chain and the sub-routines controlled by each chain are given here.

A. CHAIN 1

1. P-PREP--Main Program of Chain One

P-PREP reads input from input tape; writes input on output tape; generates the coordinates of the particles (Chapter IV) for the desired regions (if requested); calculates the probabilities of breeding, scattering (inelastically and elastically), fission, and absorption for materials and isotopes in each material (Chapter V); and calculates the storage requirements.

2. RANNO--Subroutine of Chain One

RANNO generates random numbers.

3. TAPEID

TAPEID reads logical designation of tape units.

B. CHAIN 2

1. MAIN--Main Program of Chain Two

MAIN is the heart of the calculation, since the actual particle histories are controlled by the MAIN program (Chapter III).

2. SFIND--Subroutine of Chain Two

SFIND is used to calculate the distance required to escape out of a region, provided the position coordinates (x, y, z), direction cosine coordinates (α , β , γ), and region are known.

3. RFIND--Subroutine of Chain Two

Given the position coordinates (x, y, z), RFIND locates the region index (the region number used to identify the particular region).

4. RNEXP--Subroutine of Chain Two

RNEXP selects the number of mean free paths to be traveled by a particle from an exponential distribution.

5. ANAE--Subroutine of Chain Two

ANAE is used in performing the analytic estimation calculation (Appendix G). The answers resulting from analytic estimation tallies are made in ANAE.

6. SPLT--Subroutine of Chain Two

SPLT keeps track of the number of particles to be followed resulting from a collision in a region where splitting (Chapter II) will occur.

7. COLISN--Subroutine of Chain Two

COLISN determines the type of interaction a particle will experience, and makes provision to either follow the particle if the event is a scattering or fission event or to select a new particle to follow if the event is an absorption.

8. COORDA--Subroutine of Chain Two

COORDA picks the direction cosines of the particles that are starting their life histories, that have suffered an elastic collision, or that have resulted from fission. The direction the particle takes is taken from an isotropic distribution.

9. RANNO--Subroutine of Chain Two

RANNO generates random numbers.

C. CHAIN 3

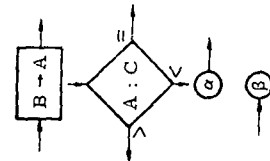
1. ANSWER--Main Program of Chain Three

ANSWER converts some of the results to a more meaningful form, and writes the results on an output tape.

APPENDICES

APPENDIX A

FLOW DIAGRAMS

1. Flow Diagram Notation

Normal box--no decision is made.
Example: The quantity B is calculated or obtained in any other manner; then A is set equal to B.

Decision box
Example: If $A < C$, an exit occurs downward; if $A = C$, an exit is made to the right; and if $A > C$, an exit is made to the left.

Entry box
(Enter from an α entry box.)

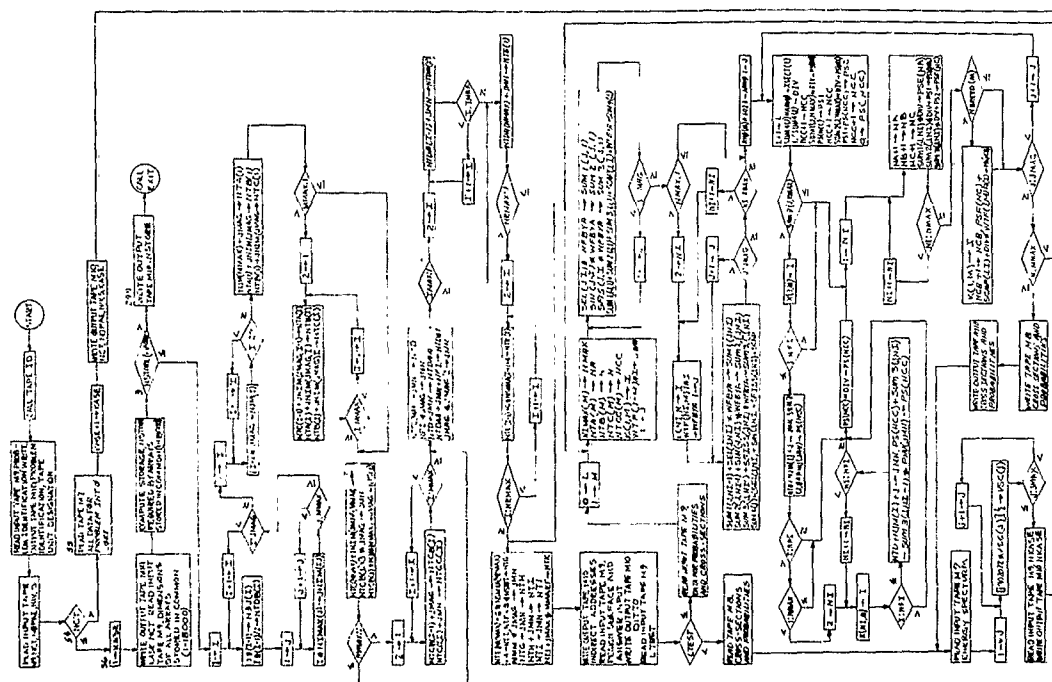
Exit box
(Exit to β entry box.)

2. Flow Diagrams

The flow diagrams are as follows:

- (1) PPREP (Fig. A-1)
- (2) Subroutine TAPID (Fig. A-2)
- (3) MAIN (Fig. A-3)
- (4) Subroutine SFIND (Fig. A-3)
- (5) Subroutine RFIND (Fig. A-3)
- (6) Subroutine RNEXP (Fig. A-6)
- (7) Subroutine ANAEST (Fig. A-7)
- (8) Subroutine SPLT (Fig. A-8)
- (9) Subroutine COLISN (Fig. A-9)
- (10) Subroutine COORDA (Fig. A-10)
- (11) Subroutine RANNO (Fig. A-11)
- (12) ANSWER (Fig. A-12)

MND-MC-2856



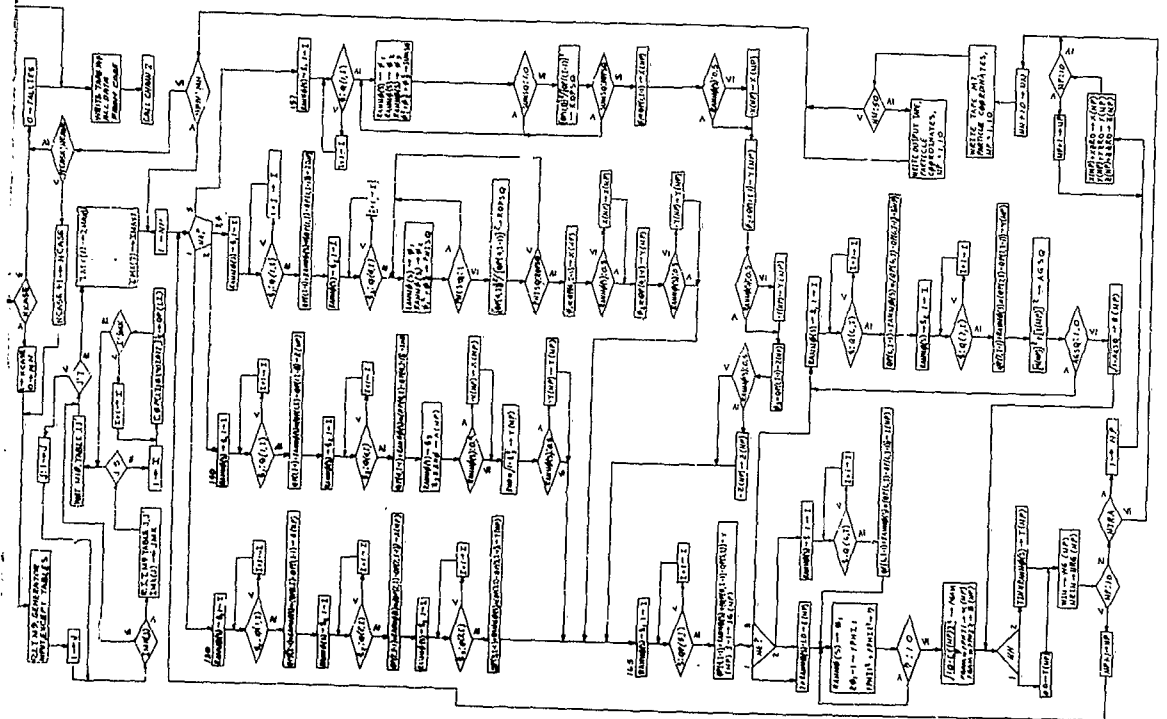


Fig. A-1. PPREP

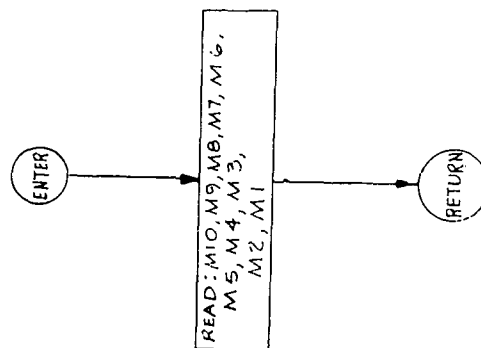
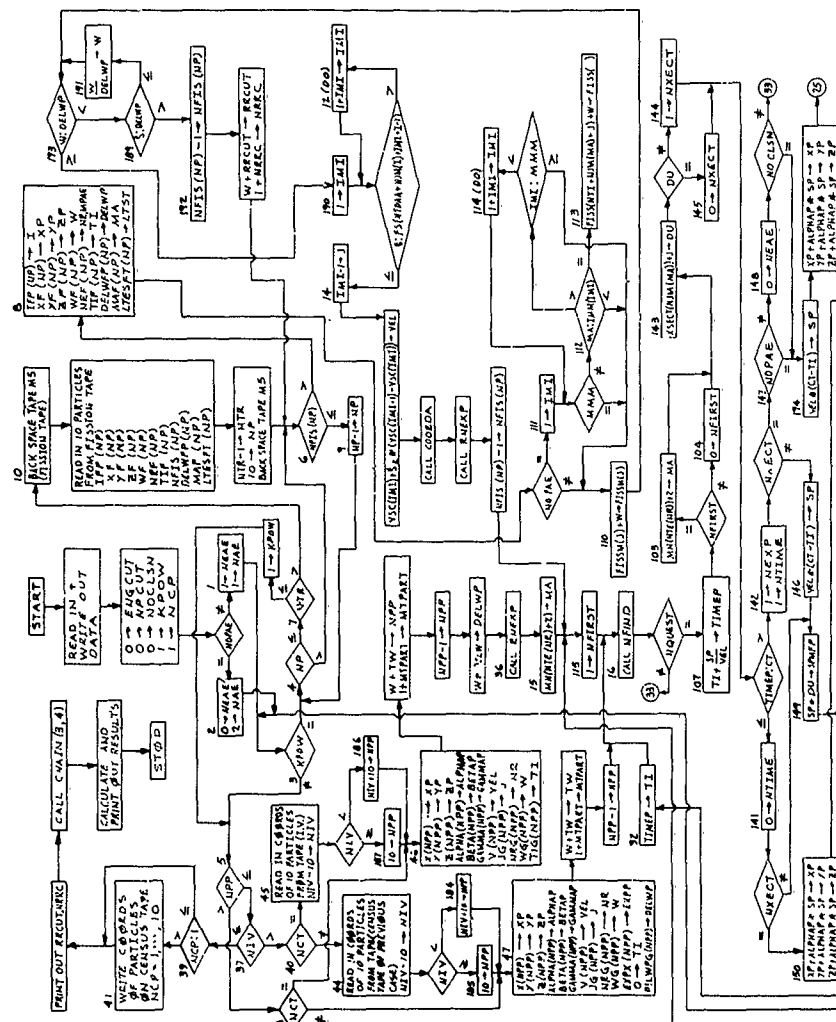


Fig. A-2. Subroutine TAPID



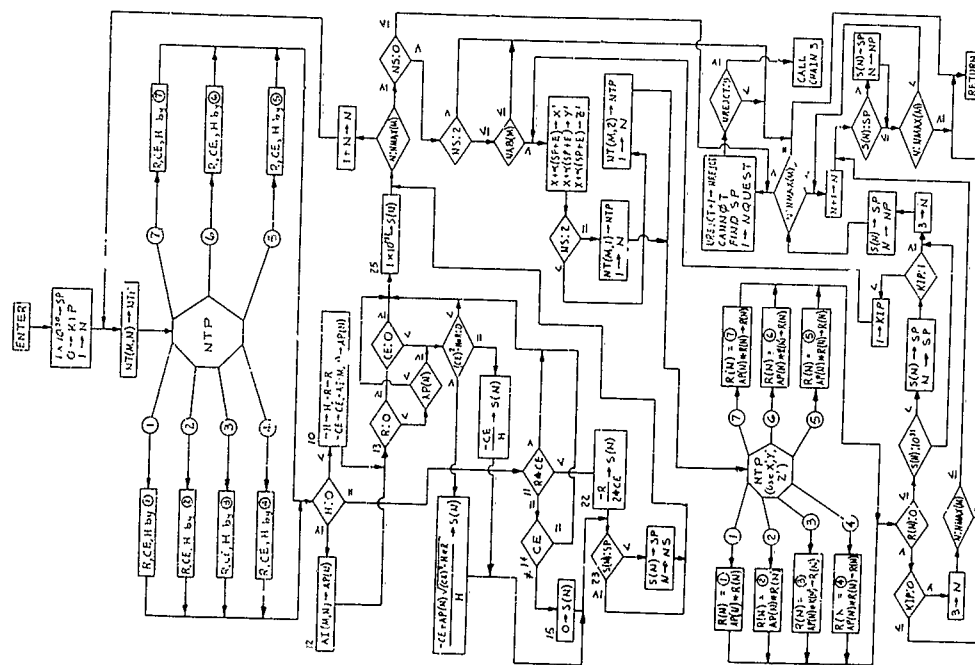


Fig. A-4. Subroutine SFIND

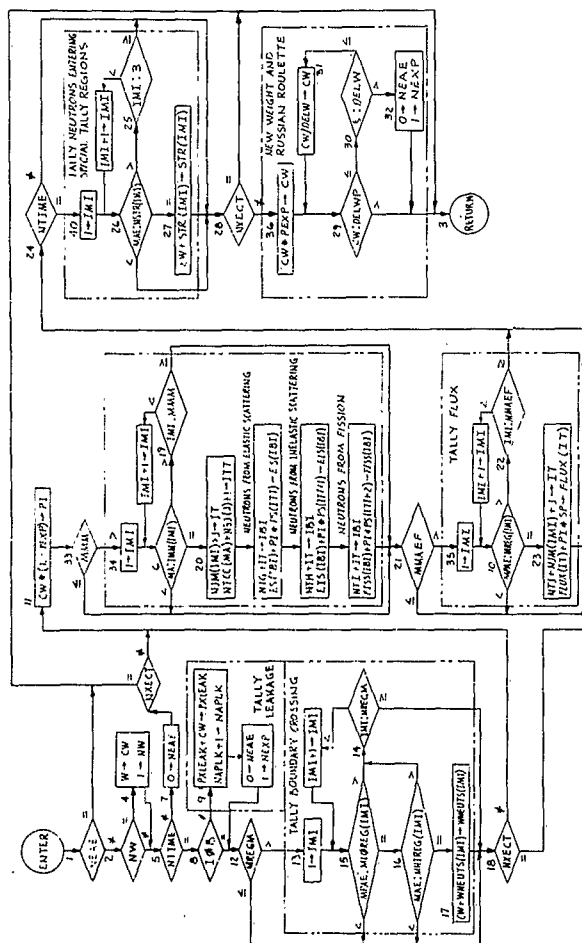
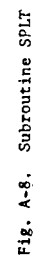


Fig. A-7. Subroutine ANAEST



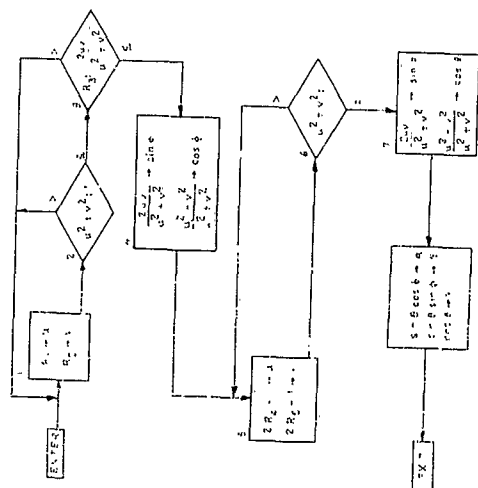


Fig. A-10. Subroutine COORDA

R_1, R_2 are 12-digit numbers to the base R . R_1 is fixed in the code; R is the last random number to be used by the code.

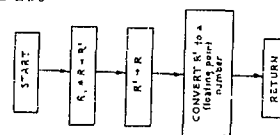


Fig. A-11. Subroutine RANNO

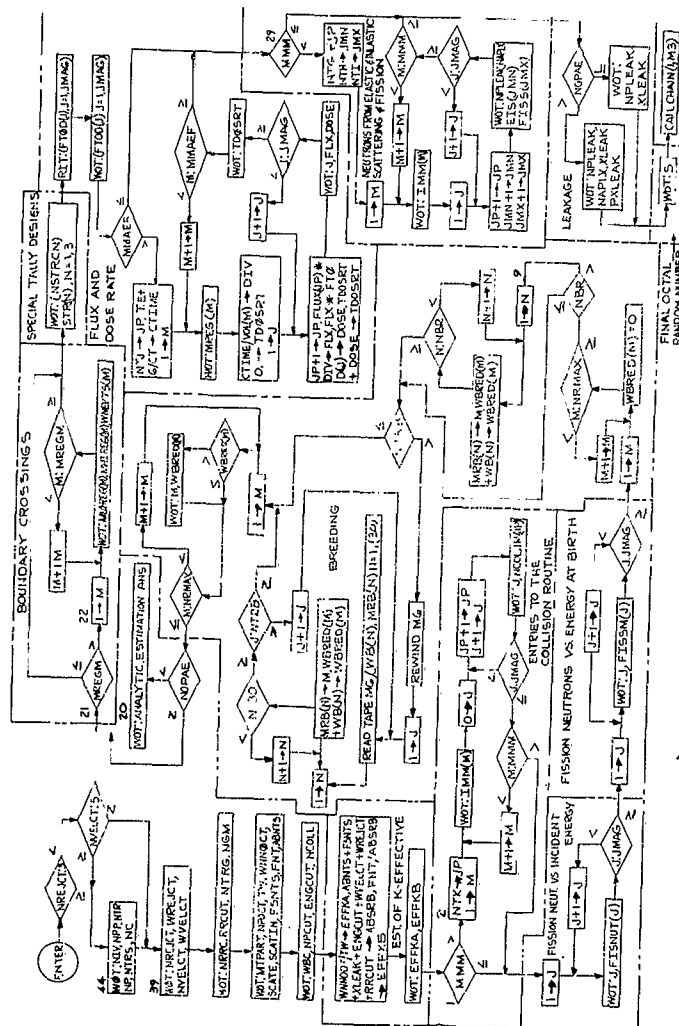


Fig. A-12. ANSWER

APPENDIX B

DEFINITION OF TERMS

A(I)	Atomic weight of isotope I
ABNTS	Number of neutrons absorbed
AC(NS)	A--of equations of surface (see geometry)
AI(NR, N)	Ambiguity index of surface N = 1.0 if N is outside surface = -1.0 if N is inside surface
AIP	= AI(NR, N), intermediate storage for ambiguity index
ALPHAP, BETAP, GAMMAP	Direction cosines of particle
ALPHAS, BETAS, GAMMAS	Direction cosines of scattered particle
APRIME	Light-heavy scattering cutoff
ARHO	= $.6023 \times 10^{24} \times 10^{-24}$
BC(NS)	B--of equations of surface (see geometry)
C(I) I = 1, 2, 3	Direction cosines from COORDA
CC(NS)	C--of equations of surface (see geometry)
CT	Census time
CW	Weight of particle in ANAEST
DELW	Minimum weight cutoff (input)
DIV	= $1/\text{SUM } 4(J)$ used in calculating PSE, PSI, PSF, XSECT
EGAM(NGM)	Energy of inelastic scattering gamma

ENGCVT	Number of neutrons below energy cutoff	JNIM(J, M)	Used to interpolate in indirectly addressed arrays
FISNUT(J)	Number of neutrons born in fission process for each energy group J (straight Monte Carlo result)	JR JRMALX JRMALN	Used in DO LOOP in locating next region (RFIND)
FLUX(NR, J)	Average flux in a region (neutrons/cm ² -sec)	K2, K2M	Limits used in writing PS
FS(J, I)	Fission spectrum (input)	K(NI, M)	Identification of the isotope in material M
I	Isotope number	KPOW	= 0; take particle to be followed from fission neutrons (if any) = 1; take particle to be followed from I.V. or generator tape
IFP(NP)	Code No. of isotope that causes fission (used to store isotope code No. in fission part of COLMSN)	L	Used in storing XSECT (J, M)
IMAX	Maximum number of isotopes for all material ≤ 10	LTEST	Used in finding next region
IMAX 1, IMAX 2, IMAX 7	Intermediate calculation--limits of tables used in generator	M, MA	Material number
IMM(k)	Code No. of materials for which a tally is made of the neutrons arising from fission, elastic, and inelastic scattering	MAE, MPAL	Region indices used in ANAEST
IMX(J)	Number of entries in Jth Q-QP table pairs	MHREG(k) MLOREG(k)	Used to tally the number of neutrons crossing boundaries
IOB	= 0; particle did not enter outside region = 1; particle did not enter outside region	MMAEF	Maximum number of regions in which flux is tallied (input). MMAEF ≤ 20
IS	Interaction index 1--elastic 2--inelastic 3--fission 4--absorption	MMAX	Maximum number of materials (≤ 10)
IT	Location in common area	MMM	Maximum number of materials in which the number of particles due to elastic and inelastic collisions are tallied. MMM ≤ 10
J	Energy group index	MN(NR)	Material No. for region NR.
JES	Energy group index of scattered particle	MP(NR, N, K)	Kth most probable next region for particle through surface N of region NR (K = 1, 2, 3, and 4)
JG(k)	Energy group index as brought in from IV tape	MREG(k)	Region code Nos. in which the flux is to be tallied. (input)
JMAG	Maximum number of energy groups ≤ 32		
JMAX	Number of energy levels = JMAG + 1		

MRB Tags the region as one which is used for breeding

MREGM The number of pairs of MLOREG, MHIREG (input). MREGM ≤ 10

NA = NTA(M) used to store PSE

NA, NE, NH Determine tables used in the particle generator

NAB(NR) = 0; no ambiguous boundaries
= 1; yes, ambiguous boundaries

NAE Used in assigned GO TO, set in MAIN
1--go to ANAEST
2--do not go to ANAEST

NAPLK Tally of number of neutrons escaping system by going out of outer boundaries by analytical estimations

NB = NTB(M) used to store PSI

NBR Number of breeding events in core storage

NBREED(M) = 1; if NBREED is one, the number of particles W, the time TI and region number NR are stored so that the code can later adjust the number of fissionable materials.
= 0; if NBREED is zero, this part of the calculation is bypassed (absorption).

NC = NTC(M) used to store PSF

NCT = 0; particles to be followed are obtained from the I, V, tape; i.e., the coordinates were generated in the in the generator
= 1; particles to be followed are obtained from the census tape (CT); i.e., the coordinates are those of the particle that have exceeded the census time (input)

NCP Counter (number of particles to be written on census tape)

ND = NDT(M) used to store PS (intermediate storage)

NE = NTE(NR) + 1 (used to locate arrays in common)

NEAE Set internally by the code. If NEAE is 1, the ANAEST routine is entered; if NEAE is 0, the ANAEST routine is not entered. This ensures that the particle is not followed beyond census time. If CW $\leq$ DELW, NEAE = 0

NEUTS(k) Tally of number of neutrons crossing specified boundaries in traveling from one region to another.

NEXP = 0; census time has not been reached, or no collision has occurred, or particle has not escaped in SMC
= 1; census time has been reached, or a collision has occurred, or the particle has escaped from the system in straight Monte Carlo calculation.

NFI Number of isotopes that are fissionable (input). NFI ≤ 10

NFIS(NP) Counter No. of particle to be followed whose origin is due to fission. Set internally in FISSION

NFISF Index which indicates the scheme to be used in calculating the number of particles to be followed after fission occurs. 0 indicates that the code will follow 3 particles. 1 indicates that the code will follow JMAG particles. If 3 particles are followed, the weight will be $\frac{1}{3}$ * (the weight of particle which fissioned). If JMAG particles are followed the weight of each particle will be $\frac{1}{\text{JMAG}}$ *

NGAM	Region for inelastic scattering gamma	NPOCT	Number of particles on census tape after census period (output)
NGM	Number of inelastic scattering gammas in core	NPP	Number of particles from I. V. tape that are in core and remain to be followed
NI	Isotope No. in material	NQP, NQ	Used in calculating indirect addresses
NIMAX(M)	Total number of isotopes in material $M < 10$	NR	Region No.
NIV	Number of particles to be followed (on I. V. or census tape)	NRIN	Input region for the generator
NJMN(N)	$NJMN(N) = (N-1) \times JMAG$, $N = 1, 2, \dots, 20$ (table, calculated internally)	NRC(k)	Region index as brought in from I.V. or generator tape (MAIN)
NKASE	Number of sets of generator input	NRMAX	Number of regions
NMAX	$= NIMAX(M)$ (used for DO LOOP LIMIT) $= NSMAX(NR)$ (used for DO LOOP LIMIT)	NRS	Region in which particle scattered
NOCLSN	$= 0$; enter COLISN routine (set internally) $= 1$; do not enter COLISN routine	NS	Surface No.
NOR(NR)	$= 0$; NR is inside region $= 1$; NR is outside region	NSMAX(NR)	Number of surfaces in region NR (< 6)
NOSIN, NR)	Surface number of the Nth surface of region NR	NSTOT	Number of unique surfaces
NP	Index for NFIS(NP), $NP = 1, \dots, 10$. When $NP > 10$ the coordinates of particles are written on a tape.	NSTR(k)	Region index of special tally regions (input), 3 special tally regions
NPCUT	Tally of number of particles below energy cutoff.	NT(NS)	Surface type for surface NS. (NT = 1, 2, ..., 7)
NPIV	Total particles generated at the end of a given generator case	NTA(M)	Indirect address for PSE
NPLEAK	Number of particles leaking from system (tallied in SMC)	NTB(M)	Indirect address for PSI
		NTC(M)	Indirect address for PSF
		NTCB(M)	Indirect address for PB
		NTD(M)	Indirect address for PS
		NTE(NR)	Indirect address for arrays indexed on NR
		NTIME	= 0; CT not exceeded = 1; CT exceeded

NTM, NT	Used in writing items stored in common	PXLEAK	Tally number of particles escaping system (going out of outer boundaries) by analytical estimation
NTPART	Total number of particles on I. V. tape before census period	Q(J, I)	Cumulative probability tables--generator
NTR	Counter on number of records of particles born in fission that are on tape	QP(J, I)	Coordinate tables--generator
NTRA	Generator translation option	R(N)	Distance to surface N
NTRB	Records of 30 inelastic scattering gammas each on tape	RHO(M)	Density of material M (g/cm^3)
NW	= 0; first time in ANAEEST for particle = 1; --Nth time in ANAEEST for particle, $N > 1$	S	Octal random number
P(J ¹ , J, I)	Inelastic scattering matrix	SCAP(K, I)	Capture cross section, energy group J, isotope I
PB(J, M)	Probability of breeding--material M, energy group J (defined for first isotope only)	SCATE	Number of neutrons scattered elastically
PEXP	= $e^{-\mu x}$	SCATN	Number of neutrons scattered inelastically
PI	= $CW(1 - e^{-\mu x})$	SEL(J, I)	Elastic scattering cross section; energy group J, isotope I
PNU	The number of neutrons arising from fission (input)	SFIS(J, I)	Fission cross section: energy group J, isotope I
PS(K, J, M)	Neutrons/interaction for type of interaction K = 1; elastic 2; inelastic 3; fission	SIN(J, I)	Inelastic scattering cross section; energy group J, isotope I
PSI	Used in calculating PSI	S(N)	Distance to surface N
PS2	Used in calculating PSF	STR(k)	Tally of number of neutrons entering special tally regions
PSE(NL, J, M)	Elastic scattering probability	SUM 1(NL, J)	Intermediate storage used in calculating PSF
PSF(NL, J, M)	Fission probability	SUM 2(NL, J)	Intermediate storage used in calculating PSI
PSI(NL, J, M)	Inelastic scattering probability	SUM 3(NL, J)	Intermediate storage used in calculating PSF
PSIB	Sine of polar angle between original and scattered particle directions	SUM 4(J)	Intermediate storage used in calculating XSECT
PSIE	Cosine of polar angle between original and scattered particle directions		

TI	Time particle stays in system (MAIN)	WTF(NI, M)	Weight fraction of the isotope
TIF(NP)	Time at which fission occurred	XK(NS)	K of equations of surface
TIME	Time particle stays in system (MAIN)	XSECT(J, M)	Total macroscopic cross section (cm^{-1})
TIMEP	Time particle stays in system (ANAESE)	XF, YF, ZF	Coordinate of fission particles
TIN	Generator-input time	XP, YP, ZP	Coordinate of I. V. particles
TIS	Time for scattered particle	XS, YS, ZS	Coordinate of scattered particles
TW	Total number of neutrons of I. V. tape before census period	XX, YX, ZX ALPHAX, BETAX, GAMMAX, VELS, JEX, NRX, WS	Coordinates to be written on census tape in blocks of 10
VEL	Velocity of particle ($\text{cm}/\mu\text{sec}$)	XZ(NS)	$\left. \begin{matrix} X_o \\ Y_o \\ Z_o \end{matrix} \right\}$ of equation of surface
VELP	Intermediate calculation of scattered velocity	YZ(NS)	
VELS		ZZ(NS)	
VPP, VPO, VPR		XZRO YZRO ZZRO	Translation coordinates in the generator
VSC(J)	End points of energy interval, $J = 1, 2, \dots$, JMAX + 1; VSC(J) > VSC(J - 1) (input as energies in ev, and converted to velocities in $\text{cm}/\mu\text{sec}$)	ZETA	Floating random number
W	Weight of particle		
WB(k)	Weight, used in breeding portion of collision routine		
WBC	Number of neutrons that form potentially fissionable material (absorption)		
WF(NP)	Weight of fission particles		
WFBYA	= WTF(NI, M)/A(I)		
WG(k)	Weight of particle as brought in from I. V. or generator tape (MAIN)		
WNNOC	Number of neutrons on census tape after census period (output)		
WP	Weight of particle from I. V. tape		
WS	Weight of scattered particle		

APPENDIX G

THE EXPONENTIAL DISTRIBUTION

The flow diagram in Appendix A titled RNEXP is used for obtaining numbers which have the following distribution:

$$f(d) = e^{-d} \quad \text{for } 0 < d < \infty$$

These numbers are used by the program as the distance (in mean free paths) to collision. The numbers, ξ_i , are random numbers in the range (0, 1). This method is due to J. Von Neuman, and can be found in AECU 3259, "Applications of Monte Carlo," by Herman Kahn, The Rand Corporation, Santa Monica, California.

APPENDIX D

PROBABILITY DISTRIBUTION TABLES

Information, in tabular form, must be available on various distributions and must be available to the program during calculation and during operation of the generator. The calculation portion also requires information in this form.

The generator has available to it various probability distribution tables. These tables are used for determining the values of various coordinates of the particles. The generator options determine which of the tables will be used and how they will be used. The coordinates of a particle, which are fixed in the generator and which may depend on these tables, are the position, velocity, and directional cosines.

All the probability distribution tables are of the same form with the exception of the inelastic scattering distribution tables. Each table is made up of two separate parts. One part is a cumulative distribution function (cdf), H_i ; the other part is the random variable, q_i . There are equal numbers of entries in each part of the table. If $H(q)$ is the probability density function (pdf) normalized in the interval (q_i, q_n) , then the following relation exists between a particular entry, H_i , and the corresponding q_i :

$$H_i = 1 - \int_{q_i}^{q_n} h(q) dq \quad (D-1)$$

Therefore, $H_1 = 1.0$ and $H_n = 0.0$, where n is the number of entries in each half of the table.

In choosing a particular value of q from a table, two random numbers are used. Let ξ_1 and ξ_2 be the two numbers. Then, the value of i is found which

$$H_{i-1} < \xi < H_i$$

q is then accepted as the value of the random variable and is calculated according to the following equation:

$$q = q_{i-1} + \xi_2 (q_i - q_{i-1}) \quad (D-2)$$

The effect of representing a pdf in this tabular form and of choosing q in the manner described above is to reduce it to a histogram having $n-1$ intervals. This is illustrated in Fig. D-1.

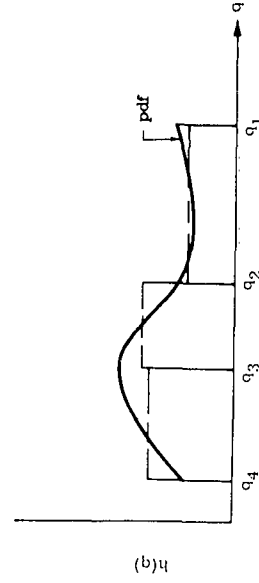
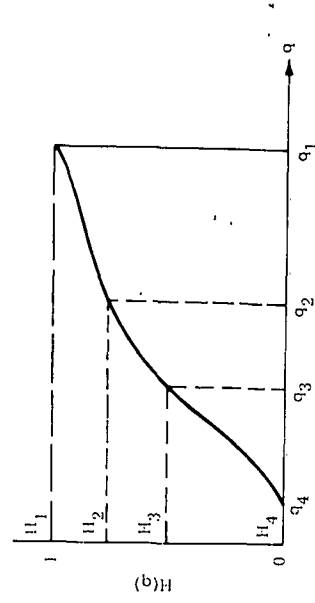


Fig. D-1. Histogram of Probability Distributions

APPENDIX E

ISOTROPIC DISTRIBUTION IN SPACE

If α' , β' , and γ' are directional cosines, the direction they define will be isotropically distributed if the directional cosines are obtained in the manner described by the flow diagram labeled COORDA in Appendix A.

APPENDIX F SCATTERING

All scattering is assumed to be isotropic in the center of mass (CM) system.



α , β , γ = directional cosines in the laboratory system (L)
 α'' , β'' , γ'' = directional cosines in the CM system after collision
 α' , β' , γ' = directional cosines in the L system after collision.

where

α'' , β'' and γ'' are chosen from an isotropic distribution (Appendix H)
 m = projectile mass
 M = target mass
 V = speed of the projectile before collision in the L system
 v = speed of the CM system with respect to L system
 V''' = speed of the projectile before collision in CM system
 V'' = speed of the projectile after collision in CM system
 V' = speed of the projectile after collision in L system.

The speed, v , is taken as that of the target before collision in the CM system. The speed of the projectile in the CM system before collision (V''') can be found as a function of m , M , and v by using the fact that momentum is conserved in the CM system:

$$m \mathbf{V}^{111} = M \mathbf{V}$$

$$\mathbf{V}^{111} = \frac{M}{m} \mathbf{V}$$

and that momentum is conserved before collision between the CM and L systems:

$$m \mathbf{\bar{V}} = (m + M) \mathbf{V}$$

$$\mathbf{V} = \frac{m}{M + m} \mathbf{V}.$$

Then

$$\mathbf{V}^{111} = \frac{M}{m} \mathbf{V} = \frac{M}{m} \left(\frac{m}{M + m} \right) \mathbf{V}$$

$$= \frac{M}{M + m} \mathbf{V}.$$

The directional cosines and the speed in the L system after collision can be found as a function of $(\alpha', \beta', \gamma')$, (α, β, γ) , $\mathbf{V}$, $\mathbf{V}'$, $\mathbf{r}$, $\mathbf{r}'$, and M by the following means:

$$\mathbf{\bar{V}}^1 = \mathbf{\bar{V}}'' + \mathbf{v}.$$

Since $\mathbf{v} = \frac{m}{m + M} \mathbf{V}$, and unit vectors

$$\hat{\mathbf{i}} = \hat{\mathbf{i}}', \text{ then}$$

$$\mathbf{\bar{V}}^1 = \mathbf{\bar{V}}'' + \frac{m}{M + m} \mathbf{\bar{V}}$$

$$= \alpha' \mathbf{V}' \hat{\mathbf{i}} + \beta' \mathbf{V}' \hat{\mathbf{j}} + \gamma' \mathbf{V}' \hat{\mathbf{k}}; \hat{\mathbf{i}}, \hat{\mathbf{j}}, \hat{\mathbf{k}} \text{ are unit orthogonal vectors.}$$

$$= (\alpha'' \mathbf{V}'' + \alpha \frac{m}{m + M} \mathbf{V}) \hat{\mathbf{i}} + (\beta'' \mathbf{V}'' + \beta \frac{m}{m + M} \mathbf{V}) \hat{\mathbf{j}}$$

$$+ (\gamma'' \mathbf{V}'' + \gamma \frac{m}{m + M} \mathbf{V}) \hat{\mathbf{k}}.$$

$$\text{Then } V'^2 = (V''^2 + \left(\frac{m}{M + m} \right)^2 V^2 + 2 \frac{m}{M + m} (\alpha'' \alpha + \beta'' \beta + \gamma'' \gamma) V'' V)$$

$$\text{and } V' = \left[V''^2 + \left(\frac{1}{A + 1} \right)^2 V^2 + 2 \frac{1}{A + 1} (\alpha'' \alpha + \beta'' \beta + \gamma'' \gamma) V'' V \right]^{1/2} \quad (\text{G-1})$$

Therefore,

$$\alpha' = \frac{\alpha'' V'' + \alpha \frac{1}{A + 1} V}{V} \quad (\text{G-2})$$

$$\beta' = \frac{\beta'' V'' + \beta \frac{1}{A + 1} V}{V} \quad (\text{G-3})$$

$$\gamma' = \frac{\gamma'' V'' + \gamma \frac{1}{A + 1} V}{V} \quad (\text{G-4})$$

where

$$\frac{m}{M + m} = \frac{1}{A + 1}.$$

1. Case 1--Elastic Scattering

$$V'' = \frac{M}{M + m} V = \frac{A}{A + 1} V.$$

Then

$$V' = \frac{V}{A + 1} \left[A^2 + 1 + 2A (\alpha'' \alpha + \beta'' \beta + \gamma'' \gamma) \right]^{1/2} \quad (\text{G-5})$$

$$\alpha' = (\alpha'' A + \alpha) \frac{1}{A + 1} \frac{V}{V'} \quad (\text{G-6})$$

$$\beta' = (\beta'' A + \beta) \frac{1}{A + 1} \frac{V}{V'} \quad (\text{G-7})$$

$$\gamma' = (\gamma'' A + \gamma) \frac{1}{A + 1} \frac{V}{V'}. \quad (\text{G-8})$$

2. Case 2--Heavy Elastic Scattering

An option is provided in the code through the input of the number A^1 such that for $A_i \geq A^1$, the nucleus is assumed to have infinite mass. The equations then reduce to:

$$\begin{aligned} V' &= V \\ \alpha' &= \alpha'' \\ \beta' &= \beta'' \\ \gamma' &= \gamma'' \end{aligned}$$

3. Case 3--Inelastic Scattering

The velocity, V'' , is assigned a value determined from the inelastic scattering matrix. Equations (P-1), (P-2), (P-3), and (P-4) are then used to calculate the velocity and direction cosines of the inelastically scattered neutron.

The change in internal energy of the target nucleus for inelastic scattering is the energy attributed to the gamma rays due to inelastic scattering.

$$E = \frac{m}{2} \left[\left(\frac{A_i}{A_i + 1} \right)^2 V^2 - V''^2 \right] \quad (J-1)$$

$$E \text{ (ev)} = 0.5258 \left[\left(\frac{A_i}{A_i + 1} \right)^2 V^2 - V''^2 \right] \quad (J-2)$$

where the velocities are in cm/ μ sec.

The coordinates of the gamma ray $[x, y, z]$, region index, energy (ev) and weight of the particle after scattering are stored on a tape (not the output tape) and are available for later use.

The calculation and writing of the inelastic gamma sources on tape are controlled by option NCAM (Card Type 8).

4. Case 4--Heavy Inelastic Scattering

The equations for the velocity and directions cosines after inelastic scattering reduce to:

$$\begin{aligned} V' &= V'' \\ \alpha' &= \alpha'' \\ \beta' &= \beta'' \\ \gamma' &= \gamma'' \end{aligned}$$

for heavy inelastic scattering. However, the approximation is not only a function of A_i ; it also depends on V and V'' . For elastic scattering they are functionally related, but this is not the case in inelastic scattering.

For an error equivalent to that introduced in elastic scattering by the approximation of a nucleus with infinite mass, the following relation must hold for inelastic scattering.

$$V''^2 > \frac{A^1 * \left[\frac{V}{A_i + 1} * \left(\frac{V}{A_i + 1} + 2 * V'' * (\alpha \alpha'' + \beta \beta'' + \gamma \gamma'') \right) \right]}{2}$$

APPENDIX G

ANALYTIC ESTIMATION

A particle scattered elastically or inelastically, born in fission or starting its life history from some Cartesian coordinate (x, y, z) with direction cosines (α, β, γ) and with weight W has a certain probability of continuing in a straight line path (not changing direction cosines), remaining in the same energy group and making contributions to various answers. The term analytic estimation used in this report is taken to mean the above described process. The contributions each particle makes to the respective answers in the analytic estimation routine is terminated only when the particle escapes from the system, exceeds census time, or falls below the minimum weight cutoff. The contributions made to the respective answers are in the form of tallies. The tallies for the following are described in some detail:

- (1) Number of particles and neutrons leaking from the system.
- (2) Number of neutrons entering the special tally regions.
- (3) Neutron flux versus region and energy group.
- (4) Number of neutrons scattered elastically and inelastically versus material and energy group.
- (5) Number of neutrons born in fission versus material and energy group.
- (6) Numbers of neutrons crossing from Region ℓ to Region ℓ' .

1. Number of Particles and Neutrons Leaking from the System

The following tallies are made when a particle escapes from the system.

- (G.1) Weight of the particle * probability that the particle will reach the outer bound of the system:

$$W \sum_{i=1}^m I_i^{\mu} x_i$$

- (G.2) 1 * Probability that the particle will reach the outer

$$-\sum_{i=1}^n \mu_i x_i$$
 bound of the system = $1 * e^{-\sum_{i=1}^n \mu_i x_i}$, where $X_1, X_2, \dots, X_n$ are the straight line distances through the regions traversed by the particle and $\mu_1, \mu_2, \dots, \mu_n$ are the total macroscopic cross sections of these regions. G.1 represents the contribution made to the number of neutrons leaking from the system, and G.2 represents the contributions to the numbers of particles leaking from the system.

2. Number of Neutrons Entering the Special Tally Regions

The following tally is made when the particle enters any one of the three special tally regions.

- (G.3) Weight of the particle * Probability that the particle will reach the special tally region when the contribution is

$$-\sum_{i=1}^n \mu_i x_i$$
 made = $W * e^{-\sum_{i=1}^n \mu_i x_i}$, where $X_1, X_2, \dots, X_n$ are the distances traversed by the particle until it reaches the special tally region and $\mu_1, \mu_2, \dots, \mu_n$ are the macroscopic cross sections associated with these regions.

3. Neutron Flux Versus Region and Energy Group

The following tally is made for the energy group occupied by the particle and if the region occupied by the particle is one for which the flux is to be tallied.

- (G.4) Weight of particle x probability the particle will reach Region n * average path length through Region n
$$\frac{\text{Volume of Region n} * \text{census time}}{\text{Volume of Region n} * \text{census time}} =$$

$$W * e^{-\sum_{i=1}^n \mu_i x_i} * \frac{1}{\mu_n} (1 - e^{-\mu_n X_n})$$

5. Number of Neutrons Born in Fission Versus Material and Energy Group

The following tally is made for each energy group and material for which it is requested.

- (G.7) Weight of particle * Probability the particle will reach Region n containing material m * Probability the event is * Number of neutrons per fission =

$$W * e^{-\sum_{i=1}^m \mu_i x_i} (1 - e^{-\mu_n X_n}) * PF_m * \nu$$

where μ_i, x_i are defined as above, and

PF_m = Probability that the event will be a fission event

ν = Number of neutrons released in fission.

6. Number of Neutrons Crossing from Region l to Region l'

The following tally is made for a particle crossing from Region to Region l'.

- (G.8) Weight of particle * Probability the particle will reach Region l' =

$$W * (1 - e^{-\sum_{i=1}^m \mu_i x_i})$$

where μ_i, x_i are defined as above and X_n is the distance traveled through Region l.

where

$X_1, X_2, \dots, X_{n-1}$ = distances traveled by the particle to reach Region n
 X_n = distance traveled by particle through Region n
 $\mu_1, \mu_2, \dots, \mu_n$ = macroscopic cross sections of the respective regions
 V_n = volume of Region n
 T = census time

The average path length through Region n , $(\bar{X})$ is obtained as follows:

$$(G.5) \quad \bar{X} = \int_0^{\bar{X}} e^{-\mu x} dx = (1 - e^{-\mu \bar{X}}), \text{ where } \bar{X} \text{ is the actual distance traveled by the particle through Region } n.$$

4. Number of Neutrons Scattered Elastically and Inelastically Versus Material and Energy Group

The following tally is made for each energy group and material for which it is requested.

(G.6) Weight of particle * Probability that the particle will reach the region containing the material * Probability that the particle will be stopped in the region * Probability that the event will be an $\begin{pmatrix} \text{elastic} \\ \text{inelastic} \end{pmatrix}$ event =

$$W * e^{-\sum_{i=1}^{m-1} \mu_i X_i} * (1 - e^{-\mu_n X_n}) * \begin{pmatrix} PE_m \\ PI_m \end{pmatrix},$$

where the μ_i and X_i are defined as above, and

PE_m = Probability that the event will be an elastic scattering with material m

PI_m = Probability that the event will be an elastic scattering with material m .

APPENDIX H

MAP OF COMMON 1 TO 18,000 INDIRECT ADDRESSES

Quantity	Location in Common
XSECT(1,1)	XSECT(NJM(1)+1)
XSECT(J,1)	XSECT(NJM(1)+J)
XSECT(JMAG,1)	XSECT(NJM(1)+JMAG)
XSECT(J,M)	XSECT(NJM(M)+J)
XSECT(JMAG,MMAX)	XSECT(NJM(MMAX)+JMAG)
PSE(1,1,1)	PSE(NTA(1)+JNIM(1,1)+1)
PSE(NI,1,1)	PSE(NTA(1)+JNIM(1,1)+NI)
PSE(NIMAX(1),1,1)	PSE(NTA(1)+JNIM(1,1)+NIMAX(1))
PSE(NI,J,1)	PSE(NTA(1)+JNIM(J,1)+NI)
PSE(NIMAX(1),JMAG,1)	PSE(NTA(1)+JNIM(JMAG,1)+NIMAX(1))
PSI(1,1,1)	PSI(NTB(1)+JNIM(1,1)+1)
PSI(NI,J,1)	PSI(NTB(1)+JNIM(J,1)+NI)
PSI(NIMAX(1),JMAG,1)	PSI(NTB(1)+JNIM(JMAG,1)+NIMAX(1))
PSF(1,1,1)	PSF(NTC(1)+JNIM(1,1)+1)
PSF(NI,J,1)	PSF(NTC(1)+JNIM(J,1)+NI)
PSF(NIMAX(1),JMAG,1)	PSF(NTC(1)+JNIM(JMAG,1)+NIMAX(1))
PSE(NI,J,M)	PSE(NTA(M)+JNIM(J,M)+NI)

Quantity		Location in Common		Quantity		Location in Common	
PNU(J, 1)		PNU(NTD+NJM(1)+J)		PS(NI, J, M)		PS(NTB(M)+JNIM(J, M)+NI)	
PNU(JMAG, 1)		PNU(NTD+NJM(1)+JMAG)		PSF(NI, J, M)		PSF(NTC(M)+JNIM(J, M)+NI)	
PNU(J, 1)		PNU(NTD+NJM(1)+J)		PSE(NMAX(MMAX), JMAG, MMAX)		PSE(NTC(MMAX)+JNIM(JMAG, MMAX)+NIMAX(MMAX))	
PNU(JMAG, NFI)		PNU(NTD+NJM(NFI)+JMAG)		PS(NMAX(MMAX), JMAG, MMAX)		PS(NTB(MMAX)+JNIM(JMAG, MMAX)+NIMAX(MMAX))	
FS(1, 1)		FS(NTDAA+NJM(1)+1)		PSF(NMAX(MMAX), JMAG, MMAX)		PSF(NTC(MMAX)+JNIM(JMAG, MMAX)+NIMAX(MMAX))	
FS(J, 1)		FS(NTDAA+NJM(1)+J)		PB(1, 1)		PB(NTCB(1)+1)	
FS(JMAX, 1)		FS(NTDAA+NJM(1)+JMAX)		PB(J, 1)		PB(NTCB(1)+J)	
FS(J, 1)		FS(NTDAA+NJM(1)+J-1)		PB(JMAG, 1)		PB(NTCB(1)+JMAG)	
FS(JMAX, NFI)		FS(NTDAA+NJM(NFI)+JMAX-1)		PB(J, M)		PB(NTCB(M)+J)	
P(1, 1, 1)		P(NTDA(1)+NTDB(1)+1)		PB(JMAG, MMAX)		PB(NTCB(MMAX)+JMAG)	
P(1, 2, 1)		P(NTDA(1)+NTDB(2)+1)		PS(1, 1, 1)		PS(NTCC(1)+N3J(1)+1)	
P(2, 2, 1)		P(NTDA(1)+NTDB(2)+2)		PS(2, 1, 1)		PS(NTCC(1)+N3J(1)+2)	
P(1, J, 1)		P(NTDA(1)+NTDB(J)+1)		PS(3, 1, 1)		PS(NTCC(1)+N3J(1)+3)	
P(J', J, 1)		P(NTDA(1)+NTDB(J')+1)		PS(1, J, 1)		PS(NTCC(1)+N3J(J)+1)	
P(J, J, 1)		P(NTDA(1)+NTDB(J)+J')		PS(2, J, 1)		PS(NTCC(1)+N3J(J)+2)	
P(J, JMAG, 1)		P(NTDA(1)+NTDB(JMAG)+J')		PS(3, J, 1)		PS(NTCC(1)+N3J(J)+3)	
P(JMAG, JMAG, 1)		P(NTDA(1)+NTDB(JMAG)+JMAG)		PS(1, JMAG, 1)		PS(NTCC(1)+N3J(JMAG)+1)	
P(J', J, 1)		P(NTDA(1)+NTDB(J)+J')		PS(2, JMAG, 1)		PS(NTCC(1)+N3J(JMAG)+2)	
P(JMAG, JMAG, JMAG)		P(NTDA(JMAG)+NTDB(JMAG)+JMAG)		PS(3, JMAG, 1)		PS(NTCC(1)+N3J(JMAG)+3)	
MN(1)		MN(NTC(1)+1)		PS(1, J, M)		PS(NTCC(M)+N3J(J)+1)	
NAB(1)		NAB(NTC(1)+2)		PS(2, J, M)		PS(NTCC(M)+N3J(J)+2)	
NOR(1)		NOR(NTC(1)+3)		PS(3, J, M)		PS(NTCC(M)+N3J(J)+3)	
NPPC(1)		NPPC(NTC(1)+4)		PS(1, JMAG, MMAX)		PS(NTCC(MMAX)+N3J(JMAG)+1)	
				PS(2, JMAG, MMAX)		PS(NTCC(MMAX)+N3J(JMAG)+2)	
				PS(3, JMAG, MMAX)		PS(NTCC(MMAX)+N3J(JMAG)+3)	
				PNU(1, 1)		PNU(NTD+NJM(1)+1)	

Quantity	Location in Common
ZZ(NS)	ZZ(NTF+8x(NS-1)+8)
NT(NSTOT)	NT(NTF+8x(NSTOT-1)+1)
ZZ(NSTOT)	ZZ(NTF+8x(NSTOT-1)+8)
ES(1,1)	ES(NTF+NJM(1)+1)
ES(J,1)	ES(NTG+NJM(1)+J)
ES(JMAG,1)	ES(NTG+NJM(1)+JMAG)
ES(J,M)	ES(NTG+NJM(M)+J)
ES(JMAG,MMM)	ES(NTG+NJM(MMM)+JMAG)
ES(1,1)	EIS(NTH+NJM(1)+1)
EIS(J,1)	EIS(NTH+NJM(1)+J)
EIS(JMAG,1)	EIS(NTH+NJM(1)+JMAG)
EIS(J,M)	EIS(NTH+NJM(M)+J)
EIS(JMAG,MMM)	EIS(NTH+NJM(MMM)+JMAG)
FISS(1,1)	FISS(NTI+NJM(1)+1)
FISS(J,1)	FISS(NTI+NJM(1)+J)
FISS(JMAG,1)	FISS(NTI+NJM(1)+JMAG)
FISS(J,M)	FISS(NTI+NJM(M)+J)
FISS(JMAG,MMM)	FISS(NTI+NJM(MMM)+JMAG)
FLUX(1,1)	FLUX(NTJ+NJM(1)+1)
FLUX(J,1)	FLUX(NTJ+NJM(1)+J)
FLUX(JMAG,1)	FLUX(NTJ+NJM(1)+JMAG)

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Quantity	Location in Common
AI(1,1)	AI(NTE(1)+6)
NOS(1,1)	NOS(NTE(1)+7)
MP(1,1,1)	MP(NTE(1)+8)
MP(2,1,1)	MP(NTE(1)+9)
MP(3,1,1)	MP(NTE(1)+10)
MP(4,1,1)	MP(NTE(1)+11)
AI(NJ,1)	AI(NTE(1)+6xNJ)
MP(4,NJ,1)	MP(NTE(1)+6xNJ+5)
AI(NSMAX(1),1)	AI(NTE(1)+6xNSMAX(1))
MP(4,NSMAX(1),1)	MP(NTE(1)+6xNSMAX(1)+5)
NSMAX(NR)	NSMAX(NTE(NR)+1)
NPFC(NR)	NPFC(NTE(NR)+5)
AI(1,NR)	AI(NTE(NR)+6)
MP(4,1,NR)	MP(NTE(NR)+11)
AI(NSMAX(NR),NR)	AI(NTE(NR)+6xNSMAX(NR))
MP(4,NSMAX(NR),NR)	MP(NTE(NR)+6xNSMAX(NR)+5)
NSMAX(NRMAX)	NSMAX(NTE(NRMAX)+1)
MP(4,NSMAX(NRMAX),NRMAX)	MP(NTE(NRMAX)+6xNSMAX(NRMAX)+5)
NT(1)	NT(NTE+1)
AC(1)	AC(NTE+2)
BC(1)	BC(NTE+3)
CC(1)	CC(NTE+4)
XX(1)	XX(NTE+5)
XZ(1)	XZ(NTE+6)
YZ(1)	YZ(NTE+7)
ZZ(1)	ZZ(NTE+8)
NT(NS)	NT(NTF+8x(NS-1)+1)

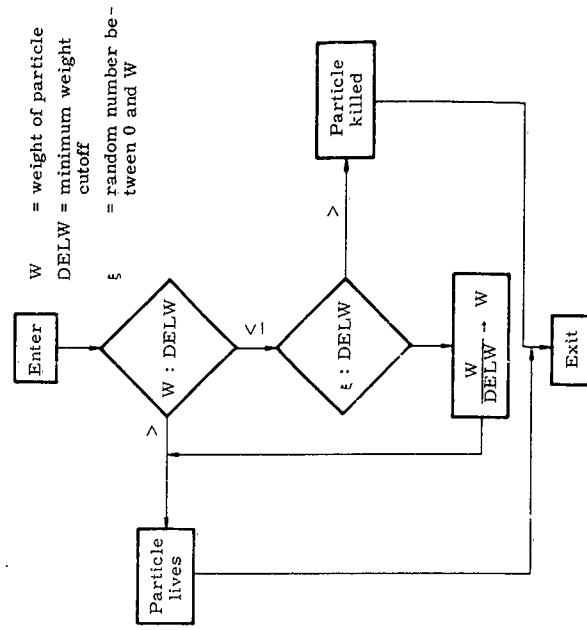
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APPENDIX I

RUSSIAN ROULETTE

Russian roulette is used in the code to ensure that the weight of the particles does not fall below a minimum weight, below which the particle contributions to the various tallies would not be significant and therefore not worth spending the calculation time to obtain the tallies.

If a particle's weight falls below a prescribed value, a game is played to determine if the particle should be "killed" and a new particle followed or if the particle should continue its "life." If the particle is allowed to "live," then it is given an extra weight to make up for the fact that some other particles may have been killed. The process is best described in a flow diagram.



APPENDIX J

STRAIGHT MONTE CARLO TALLIES

If the analytic estimation routine is not entered, the tallies described in Appendix H plus other additional tallies are made by means of straight Monte Carlo. The methods of obtaining these tallies are described below.

1. Number of Neutrons and Particles Leaving from the System

If a neutron particle escapes (leaks) from the system, 1 is added to the particle tally and W , the particle's weight, is added to the neutron tally.

2. Number of Neutrons Entering Special Tally Regions

If a particle enters a special tally region, W , the particle's weight, is added to the tally for that special tally region.

3. Estimation of Criticality

The criticality of the system for a particular time period is estimated by dividing the number of neutrons left at the end of the census period by the number for neutrons starting their life history for that census period.

4. Number of Neutrons Scattered, Elastically and Inelastically

If a particle scatters elastically or inelastically, W , the weight of the particle, is added to the respective tally.

5. Number of Neutrons Born Versus Energy

If a particle experiences a fission event, $W * \nu$ is tallied for the particular energy group the particle is in, where ν is the number of the particles emitted per fission for that particular energy group, W is the weight of the particle.

6. Number of Particles and Neutrons Starting Life Histories

One is added to the particle tally and W is added to the neutron tally of each particle starting their life history for the census period.

7. Number of Particles and Neutrons on Census Tape After Census Period

One is added to the particle tally and W is added to the neutron tally of the number of particles and neutrons on census tape immediately before the particle is written on the census tape.

8. Neutron Flux Versus Region and Energy Group

The following tally is made for the region and energy group occupied by the particle, if the region is one for which the flux is to be tallied.

$$\frac{\text{Weight of particle} \times \text{average path length through the region}}{\text{Volume of the region} \times \text{census time}} =$$

$$W \times \frac{1}{\mu} (1 - e^{-\mu x}), \text{ where}$$

x = actual distance traveled in the region

μ = macroscopic cross section in the region.

9. Number of Neutrons Crossing from Region l to Region l'

If a particle travels from Region l to Region l' (two adjacent regions), W is added to the tally of neutrons crossing from Region l to Region l' .

10. Number of Neutrons Born in Fission or Scattered Elastically or Inelastically Versus Material and Energy Group

The tally for each of the three processes is made by adding W or W* to the correct tally as the particle experiences the event for the material and energy group in which the particle resides.

11. Number of Times the Collision Routine Was Entered Versus Material and Energy Group

One is added to the tally for the particular material and energy group in which the particle resides.

12. Number of Particles and Neutrons That Have Fallen Below the Energy Cutoff

One is added to the particle tally and W to the neutron tally when the energy of the particle falls below the energy cutoff.

13. Dose Rates Versus Region and Energy Group

The doses are obtained by multiplying the neutron flux by the dose conversion factor for the particular region and energy group under consideration.

END