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A COMPUTER PROGRAM FOR EVALUATING RESONANCE ABSORPTION INCLUDING RESONANCE OVERLAP

by

C. A. Stevens and C. V. Smith

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August 24, 1965

The GAROL computer code is described herein as it existed on August 24, 1965.

General Atomic has exercised due care in preparation, but does not warrant the merchantability, accuracy, and completeness of the code or of its description contained herein. The complexity of this kind of program precludes any guarantee to that effect. Therefore, any user must make his own determination of the suitability of the code for any specific use, and of the validity of the information produced by use of the code.

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ABSTRACT

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A computer program, GAROL, has been written to study resonance absorption. The program is an improvement over other programs, presently in use, by virtue of its ability to handle overlap effects between resonances of a resonance absorber and of mixtures of resonance absorbers. In addition, a wide choice of geometry, energy mesh spacings, and cross section representation is available to the user.

Author

INTRODUCTION

Resonance absorption is a subject of considerable interest to designers of nuclear reactors. Accordingly, a considerable amount of work has been done in this area. For a good, up-to-date, summary the reader is referred to the work of Nordheim.[1]

One of the assumptions which has been included in most treatments of resonance absorption is that, in a mixture of resonance absorbers, the total absorption may be obtained by summing the absorptions in each resonance of each nuclide, each being computed as if the other resonances were not present. The GAROL computer program does not make this assumption; it explicitly takes into account those effects which arise from resonance overlap of an individual resonance absorber and of mixtures of different resonance absorbers. It is conventional to consider the problem as a lattice of absorber imbedded in a purely scattering medium in which the flux is taken to be $\frac{1}{E}$. Thus the flux dips in the scattering medium due to absorptions in the lump are neglected. For tight lattices, this approximation can be poor. The GAROL program does not make this assumption; it solves two coupled integral equations for the fluxes in each region.

It is in these respects that this work represents an improvement over other computer programs used for computing resonance absorption; see for instance reference (2).

DESCRIPTION OF THE GAROL PROGRAM

General Features

The GAROL computer program is quite versatile. It allows an unlimited number of energy points, with flexibility regarding the layout of the mesh. The mesh may be chosen at equal energy or lethargy intervals; it may be chosen to be proportional to the neutron velocity ($\Delta E \sim \sqrt{E}$), or it may be an arbitrary table of mesh points. The program allows a choice of geometries: homogeneous, cylindrical, plane, spherical, or it can accept an arbitrary table of escape probabilities. Regardless of the geometry, a Dancoff correction may be used to account for shadowing effects in a tight lattice. The program can accommodate a mixture of up to ten isotopes. A cross section tape generated in a GAROL run can be used again in subsequent runs, thus allowing a saving of computer time. Cross sections may be $\frac{1}{v}$, constant, computed from single level Breit-Wigner resonance parameters, or they may be given in tabular form.

The output includes integrated fluxes over desired energy bands, for each region and for the cell. It contains average microscopic cross sections for capture, fission, and scattering for each isotope, for each region and for the cell. At the user's option, one can obtain pointwise values for the flux, source, total cross section, and collision density $[E\Sigma_t(E)\varphi(E)]$ for each region. Also at the user's option, he may obtain graphical results, automatically generated on an electronic plotter.

Equations to be Solved

Consider a lattice of absorber lumps, denoted by the index 1, imbedded in another medium, not necessarily a pure scatterer, which is denoted by index 2. The average flux in the two media may be obtained as the solutions of the integral equation

$$\begin{aligned} V_1\Sigma_{T1}\varphi_1(E) &= (1 - P_1)V_1\sum_{i=1}^{M}\frac{N_{1i}}{1-\alpha_i}\int_E^{E/\alpha_i}\frac{\sigma_{si}(E')}{E'}\varphi_1(E')dE' \\ &+ P_2V_2\sum_{i=1}^{M}\frac{N_{2i}}{1-\alpha_i}\int_E^{E/\alpha_i}\frac{\sigma_{si}(E')}{E'}\varphi_2(E')dE' \\ &+ V_1(1 - P_1)Q_1(E) + V_2P_2Q_2(E) \end{aligned} \tag{1}$$

and another one just like it, but with the subscripts 1 and 2 reversed. The notation of Equation (1) is as follows:

V_k is the volume of region k.

$\Sigma_{tk}(E)$ is the total macroscopic cross section of region k.

$\varphi_k(E)$ is the average flux in region k.

P_k is the escape probability from region k.

N_{ki} is the number density of isotope i in region k.

$\sigma_{si}(E')$ is the microscopic scattering cross section of isotope i.

$\alpha_i = \left(\frac{A_i - 1}{A_i + 1}\right)^2$, where A_i is the atomic weight of isotope i.

$Q_k(E)$ = source in region k.

We wish to restrict the energy range of interest to the interval (E_1, E_N), with $E_1 > E_N$, such that below E_1, we may ignore such high energy processes as inelastic scattering, anisotropic scattering in the center of mass coordinate system, and birth of neutrons from fission. In fact, we would like this to be true even for an energy range above E_1 so that in the absence of absorption in that range, we would have a 1/E flux. Above E_N, we assume that the velocity of the neutrons is sufficiently large so that the scattering kernel may be obtained from the mechanics of neutrons colliding with free and stationary atoms. In other words, upscattering and binding effects may be ignored, as is already implied by Equation (1).

By use of the Heaviside function H(x), defined by

$$H(x) = 1 \quad \text{for } x \geq 0$$
$$= 0 \quad \text{for } x < 0,$$

we can rewrite Equation (1) in a more convenient form,

$$V_1\Sigma_{T1}\varphi_1(E) = (1 - P_1)V_1\sum_{i=1}^{M}\frac{N_{1i}}{1 - \alpha_i}\int_E^{E_1}\frac{\sigma_{si}(E')}{E'}H(E - \alpha_i E')\varphi_1(E')dE'$$

$$+ P_2V_2\sum_{i=1}^{M}\frac{N_{2i}}{1 - \alpha_i}\int_E^{E_1}\frac{\sigma_{si}(E')}{E'}H(E - \alpha_i E')\varphi_2(E')dE' \qquad (2)$$

$$+ V_1(1 - P_1)S_1(E) + V_2P_2S_2(E),$$

where we have removed the direct sources Q_k, and where

$$S_k(E) = \sum_{i=1}^{M}\frac{N_{ki}}{1 - \alpha_i}\int_{E_1}^{E/\alpha_i}\frac{\sigma_{si}(E')}{E'}H(E - \alpha_i E')\varphi_k(E')dE' \qquad (3)$$

If we assume that in the interval $(E_1, E_1/\alpha)$ the flux has the magnitude $1/E$, that it is spatially flat and isotropic, and that the scattering cross section is independent of energy, we can easily evaluate the integral in Equation (3) to obtain

$$S_k(E) = \sum_{i=1}^{M}\frac{N_{ki}\sigma_{si}}{1 - \alpha_i}\left(\frac{1}{E_1} - \frac{\alpha_i}{E}\right)H(E - \alpha_i E_1) \qquad (4)$$

The quantity $S_k(E)$ may now be considered as an external source which is normalized so that

$$\int_0^{E_1} S_k(E)dE = \sum_{i=1}^{M}\frac{N_{ki}\sigma_s}{1 - \alpha_i}\int_{\alpha E_1}^{E_1}\left(\frac{1}{E_1} - \frac{\alpha_i}{E}\right)dE = \sum_{i=1}^{M}N_{ki}\sigma_{si}\xi_i \qquad (5)$$

where ξ_i is the usual

$$\xi_i = 1 + \frac{\alpha_i}{1 - \alpha_i}\ln\alpha_i \qquad (6)$$

From Equation (5), we see that the integrated source from each isotope is proportional to $\sigma_s\xi$ for that isotope. In addition to this source, another source of arbitrary energy dependence may be superposed on it by the user of the GAROL program.

Collision Probabilities

The manner by which the collision probabilities ($1.0 - P_k$) are computed is based upon the frequently used assumption that they may be computed for a flat source in each region. For standard geometries, these are obtained directly from Case, de Hoffmann, and Placzek.[3] For more complicated geometries it is possible to generate collision probabilities by other means, usually with one velocity transport theory solutions, and to use these directly in the GAROL program.

The collision probabilities for the two regions are related in a very simple manner. In order to see this, let $G(x, x')$ be the flux at the point x due to a unit source at point x' in a one velocity problem. The well known reciprocity theorem[3] states that

$$G(x,x') = G(x',x) \tag{7}$$

If we consider a two region problem in which region 1 has a source $S_1(x)$, the total flux at any point x will be

$$\varphi(x) = \int_{V_1} S_1(x')G(x,x')d^3x'$$

where V_1 denotes that the integral is carried out over region 1.

The collision rate in region 2, which is equal to the escape rate from region 1 since all collisions effectively remove neutrons from the velocity of interest, is

$$\int_{V_2} \Sigma_{t2}\varphi(x)d^3x = \int_{V_2} d^3x \int_{V_1} d^3x'\Sigma_{t2}(x)S_1(x')G(x,x')$$

The escape probability is given by

$$P_1 = \frac{\int_{V_2}\Sigma_{t2}\varphi(x)d^3x}{\int_{V_1} S_1(x)d^3x} = \frac{\int_{V_2} d^3x \int_{V_1} d^3x'\Sigma_{t2}(x)S_1(x')G(x,x')}{\int_{V_1} S_1(x)d^3x} \tag{10}$$

If Σ_{t2} and S_1 are constants, the escape probability becomes

$$P_1 = \frac{\Sigma_{t2} \int_{V_2} d^3x \int_{V_1} d^3x' G(x,x')}{V_1} \tag{11}$$

or

$$\int_{V_2} d^3x \int_{V_1} d^3x' G(x,x') = \frac{P_1 V_1}{\Sigma_{t2}} \tag{12}$$

In exactly the same way, we obtain

$$\int_{V_1} d^3x \int_{V_2} d^3x' G(x,x') = \int_{V_2} d^3x \int_{V_1} d^3x' G(x',x) = \frac{P_2 V_2}{\Sigma_{t1}} \tag{13}$$

Now, by using the reciprocity relation, Equation (7), and comparing Equations (12) and (13), we obtain

$$P_1 V_1 \Sigma_{t1} = P_2 V_2 \Sigma_{t2} \tag{14}$$

So, once P_1 has been computed, P_2 may be obtained simply by use of Equation (14).

The escape probabilities in the GAROL program are computed from the flat source assumption. For the simple geometries, these have been developed by Case, et. al.[(3)] We summarize their results as they are applicable to the GAROL program.

Let $\bar{\ell}_1$ denote the mean chord length of region 1, and Σ_{t1} be the total macroscopic cross section in the region.

For a sphere of radius r:

$$r = \frac{3}{4} \bar{\ell}_1 \tag{15}$$

With $x = r\Sigma_{t1}$, we have for

$x \leq 0.02$

$$P_1(x) = 1 - \frac{3x}{4} \tag{16}$$

0.02 < x < 5.0

$$P_1(x) = \frac{3}{8x^3}\,[2x^2 - 1 + (1 + 2x)e^{-2x}] \tag{17}$$

x ≥ 5.0

$$P_1(x) = \frac{3}{4x}\,[1 - \frac{1}{2x^2}] \tag{18}$$

For an infinite cylinder with radius r:

$$r = \frac{\bar{\ell}_1}{2} \tag{19}$$

With $x = r\Sigma_{t1}$, we have for

x < 0.1

$$P_1(x) = 1 - \frac{4x}{3} + \frac{x^2}{2}\,\ell n\frac{2}{x} + \frac{x^2}{2}\,(\frac{5}{4} - \gamma) \tag{20}$$

in which Euler's constant $\gamma = 0.577216 \ldots$

0.1 ≤ x ≤ 6.0

Interpolation from tables.

x ≥ 6.0

$$P_1(x) = \frac{1}{2x} - \frac{3}{32x^3} \tag{21}$$

For a slab of half thickness a:

$$a = \frac{\bar{\ell}_1}{4} \tag{22}$$

With $x = a\Sigma_{t1}$, we have for

x < 0.05

$$P_1(x) = 1 - x\ell n\,\frac{1}{2x} - x(\frac{3}{2} - \gamma) - \frac{2x^2}{3} \tag{23}$$

again with $\gamma = 0.577216 \ldots$

$\underline{0.05 \le x \le 5.0}$

Interpolation from tables.

$\underline{x > 5.0}$

$$P_1(x) = \frac{1}{4x} \tag{24}$$

For an arbitrary geometry:

$$\text{with } x = \frac{\bar{\ell}_1 \Sigma_{t1}}{2}$$

we use for

$\underline{0.0 \le x \le 6.0}$

Interpolation from tables which are supplied by the user.

$\underline{x \ge 6.0}$

$$P_1(x) = \frac{C_1}{x} + \frac{C_2}{x^2} + \frac{C_3}{x^3} \tag{25}$$

in which the constants C_1, C_2, and C_3 are supplied by the user.

A Dancoff correction factor, C, can be applied for tight lattice calculations. It is used to modify the escape probability P_1 by the formula

$$P_1^* = P_1 \frac{1 - C}{1 - (1 - \Sigma_t \bar{\ell}_1 P_1)C} \tag{26}$$

where $\bar{\ell}_1$ is the mean chord length of region 1. Equation (26) is due to Nordheim.(4) It is a good approximation for lumps of any degree of grayness. If region 2 contains cross sections which vary with energy, the factor C depends upon energy. The GAROL program at present allows only one constant number for C, so it should be used with reservation on a tight lattice problem with a variable cross section in region 2.

<u>Cross Sections</u>

Cross sections may be used in a number of ways. These include:

1) one number, to represent a $\frac{1}{v}$ capture cross section, or a constant scattering cross section

2) a tabulated set of pointwise cross sections

3) a set of single level Breit-Wigner parameters, from which the GAROL program computes pointwise cross sections.

If it is desired to have the program compute cross sections from resonance parameters, the following computations are carried out within the computer program.

The cross sections are given by the usual formulae,

$$\sigma_a = \frac{\Gamma_\gamma}{\Gamma}\sqrt{\frac{E_o}{E}}\,\sigma_o\psi(\xi,x), \tag{27}$$

$$\sigma_f = \frac{\Gamma_f}{\Gamma}\sqrt{\frac{E_o}{E}}\,\sigma_o\psi(\xi,x), \tag{28}$$

$$\sigma_s = \frac{\Gamma_n^{\,o}\sqrt{E_o}}{\Gamma}\,\sigma_o\psi(\xi,x) + \left(\sigma_o\sigma_p g\,\frac{\Gamma_n^{\,o}\sqrt{E_o}}{\Gamma}\right)^{1/2}\chi(\xi,x) + \sigma_p \tag{29}$$

where

$$\xi = \frac{\Gamma}{\Gamma_D} = \sqrt{\frac{A\Gamma^2}{4EkT}} \tag{30}$$

is the ratio of the natural width to the Doppler width,

$$\sigma_o = \frac{2.6 \times 10^6}{\sqrt{E_o}}\,g\,\frac{\Gamma_n^{\,o}}{\Gamma} \tag{31}$$

is the value of the peak of the total cross section at zero temperature,

$$\Gamma_n = \Gamma_n^{\,o}\sqrt{E} \tag{32}$$

is the neutron width, $\Gamma_n^{\,o}$ being the reduced neutron width. Γ_γ, Γ_f, and Γ are the capture, fission and total widths, respectively. g is the statistical factor,

$$g = \frac{2J + 1}{2(2I + 1)} \tag{33}$$

where I is the nuclear spin and J is the spin of the compound nucleus. σ_p is the potential cross section and the shape functions ψ and χ are given by

$$\psi(\xi,x) = \frac{\xi}{\sqrt{4\pi}} \int_{-\infty}^{\infty} \frac{e^{-(x - y)^2\xi^2/4}}{1 + y^2} dy \tag{34}$$

and

$$\chi(\xi,x) = \frac{2\xi}{\sqrt{4\pi}} \int_{-\infty}^{\infty} \frac{y e^{-(x - y)^2\xi^2/4}}{1 + y^2} dy . \tag{35}$$

x is given by

$$x = \frac{2(E - E_o)}{\Gamma} , \tag{36}$$

E_o is the position of the center of the resonance, E is the neutron energy and T is the absolute temperature.

The method used to evaluate the shape functions is one devised by Triplett, Merrill, and Burr.[5]

Whenever accuracy permits it, five terms of an asymptotic series expansion are used to evaluate the line shapes.

The asymptotic series for ψ is

$$\psi(x,\xi) = \sum_{k=o}^{\infty} \alpha_k \left(\frac{4}{\xi^2}\right)^k (x^2 + 1)^{-\left(\frac{2k+1}{2}\right)} \sin[(2k + 1) \sin^{-1}(x^2 + 1)^{-\frac{1}{2}}] \tag{37}$$

where

$$\alpha_o = 1$$

$$\alpha_k = \frac{1.3.5 \ldots(2k-1)}{2^k} , \quad k=1,2, \ldots \tag{38}$$

From the relation,

$$\chi(x,\xi) = 2x\psi(x,\xi) + \frac{4}{\xi^2} \frac{\partial\psi}{\partial x} (x,\xi) \tag{39}$$

we obtain

$$\chi(x,\xi) = \sum_{k=o}^{\infty} 2\alpha_k \left(\frac{4}{\xi^2}\right)^k (x^2 + 1)^{-\left(\frac{2k+1}{2}\right)} \left\{ \frac{-2(2k + 1)}{\xi^2(1 + x^2)} \cos[(2k + 1)\sin^{-1}(x^2 + 1)^{-\frac{1}{2}}] \right. \tag{40}$$

$$\left. + x(1 \frac{-2(2k + 1)}{\xi^2(1 + x^2)} \sin[(2k + 1)\sin^{-1}(x^2 + 1)^{-\frac{1}{2}}] \right\}$$

If we set

$$J_k(x) = (x^2 + 1)^{-\frac{1}{2}} \sin[(2k + 1)\sin^{-1}(x^2 + 1)^{-\frac{1}{2}}] \tag{41}$$

and

$$H_k(x) = (x^2 + 1)^{-\frac{1}{2}} \cos[(2k + 1)\sin^{-1}(x^2 + 1)^{-\frac{1}{2}}], \tag{42}$$

we have

$$\psi(x,\xi) = \sum_{k=o}^{\infty} \alpha_k \left[\frac{4}{\xi^2(x^2 + 1)}\right]^k J_k(x) \tag{43}$$

and

$$\chi(x,\xi) = \sum_{k=o}^{\infty} 2\alpha_k \left[\frac{4}{\xi^2(x^2 + 1)}\right]^k xJ_k(x) - \frac{2}{\xi^2} \frac{(2k + 1)}{(1 + x^2)} (xJ_k(x) + H_k(x)) \tag{44}$$

By using elementary trigonometric formulae, it can be shown that Equations (41) and (42) are easily evaluated by the recursion equations

$$J_o(x) = \frac{1}{1 + x^2} \tag{45}$$

$$H_o(x) = \frac{x}{1 + x^2} \tag{46}$$

$$J_{k+1}(x) = \frac{x^2 - 1}{x^2 + 1} J_k(x) + \frac{2x}{x^2 + 1} H_k(x) \tag{47}$$

$$H_{k+1}(x) = \frac{x^2 - 1}{x^2 + 1} H_k(x) - \frac{2x}{x^2 + 1} J_k(x) \qquad (48)$$

In the GAROL program, the first five terms of Equations (43) and (44) are used, and Equations (45) to (48) are used to compute individual terms of the series.

When it is not sufficiently accurate to use the asymptotic series, a convergent series is used. The latter is not used for all x and ξ values because of computer time considerations.

The convergent series for ψ is

$$\psi(x,\xi) = \exp[-x^2 z] \sum_{k=o}^{\infty} \frac{1}{k!} (xz)^{2k} \Gamma_k(z) \qquad (49)$$

where

$$z = \frac{\xi^2}{4}$$

and

$$\Gamma_k(z) = \sqrt{z}\, e^z \int_z^{\infty} e^{-u} u^{-(k+\frac{1}{2})} du \qquad (50)$$

By using Equation (39), we also have

$$\chi(x,\xi) = 2xz \exp[-x^2 z] \sum_{k=o}^{\infty} \frac{1}{k!} (xz)^{2k} \Gamma_{k+1}(z) . \qquad (51)$$

$\Gamma_k(z)$ may be obtained from the recursion relation

$$\Gamma_{k+1}(z) = \frac{2}{2k+1} [(\frac{1}{z})^k - \Gamma_k(z)] \qquad (52)$$

and

$$\Gamma_o(z) = z^{\frac{1}{2}} e^z \int_z^{\infty} e^{-u} u^{-\frac{1}{2}} du \qquad (53)$$

The quantity $\Gamma_o(z)$ may also be written as

$$\Gamma_o(z) = z^{\frac{1}{2}} e^z (\sqrt{\pi} - \gamma(\tfrac{1}{2}, z)) \tag{54}$$

where

$$\gamma(a,z) = \int_0^z e^{-u} u^{a-1} du \tag{55}$$

is the incomplete gamma function, or it may be expressed in terms of the normalized error function as

$$\Gamma_o(z) = \sqrt{\pi z}\, e^z (1 - \mathrm{erf}(\sqrt{z})) \tag{56}$$

In the GAROL computer program $\Gamma_o(z)$ is computed from Equation (56) using the expansion

$$\mathrm{erf}(x) = \frac{2}{\sqrt{\pi}} \left(x - \frac{x^3}{1!3} + \frac{x^5}{2!5} - \frac{x^7}{3!7} + \ldots\right) \tag{57}$$

whenever $z \leq 8.4$.

$\Gamma_o(z)$ is computed from the continued fraction

$$\Gamma_o(z) = \cfrac{1}{1 + \cfrac{1}{2z + \cfrac{2}{z + \cfrac{3}{2z + \cfrac{4}{z + \cfrac{5}{2z + \cfrac{6}{z + \cfrac{7}{2z + 2.5}}}}}}}} \tag{58}$$

if $z > 8.4$.

When the convergent series is used for a given x and ξ, $\Gamma_o(z)$ needs to be computed only once. The remaining $\Gamma_k(z)$ are obtained rapidly from Equation (52).

The regions in the x,ξ plane for which the convergent or asymptotic series are to be used must be determined experimentally. The division which is given in Reference (5) has been found to be unsatisfactory. In the GAROL program, the convergent series is used whenever

$$
\begin{array}{lll}
0 \leq x < 1.2 & \text{and} & \frac{4}{\xi^2} \geq 0.275\ x^2 + 0.05 \\
1.2 \leq x < 10 & \text{and} & \frac{4}{\xi^2} \geq 0.12\ x^2 + 0.28 \\
10 \leq x < 100 & \text{and} & \frac{4}{\xi^2} > 0.08\ x^2 + 1.8 \\
100 \leq x < 500 & \text{and} & \frac{4}{\xi^2} > 0.0717\ x^2 + 83 \\
500 < x < 2500 & \text{and} & \frac{4}{\xi^2} > 0.0635\ x^2 + 2100 \\
x > 2500 & \text{and} & \frac{4}{\xi^2} \geq 0.111\ x^{1.93}
\end{array}
\tag{59}
$$

For other values the asymptotic series has good accuracy and is therefore used.

Cross sections are computed in this manner for a finite interval around each resonance; that is, the method just described is used whenever

$$
|x| \min(\xi,1) < 150 \tag{60}
$$

Outside of this interval, the scattering cross section is taken to be constant and equal to the potential cross sections. When computing the capture cross section for $x \min(\xi,1) < -150$ the line shape ψ is taken to be first term of its asymptotic series, or

$$
\psi(x,\xi) = \frac{1}{1 + x^2} . \tag{61}
$$

For neutron energies such that $x \min(\xi,1) > 150$, the capture cross section is assumed to be zero.

The Numerical Flux Computation

Let us first evaluate the integral

$$
\int_E^{E_1} \frac{\sigma_s(E')}{E'} H(E - \alpha E')\varphi(E')dE'
$$

numerically. This integral is typical of the type which appears in Equation (2). Break up the integral into a sum of integrals,

$$\int_{E}^{E/\alpha} \frac{\sigma_s(E')}{E'} H(E - \alpha E')\varphi(E')dE' = \sum_{j=p+1}^{i} \int_{E_j}^{E_{j-1}} \frac{\sigma_s(E')}{E'} \varphi(E')dE' + \int_{E_p}^{E_1} \frac{\sigma_s(E')}{E'} H(E_i - \alpha E')\varphi(E')dE' \tag{62}$$

where the discrete variable E_i replaces E, and E_p is the discrete energy mesh point just below E_i/α. Note that if $E_i/\alpha > E_1$, p=1, and the last integral contributes nothing. For each interval (E_j, E_{j-1}) assume that $\sigma_s(E)\varphi(E)$ is linear; that is

$$\sigma_s(E)\varphi(E) = \frac{1}{E_{j-1} - E_j} [(E - E_j)\sigma_{s,j-1}\varphi_{j-1} + (E_{j-1} - E)\sigma_{s,j}\varphi_j] \tag{63}$$

where $\sigma_{s,j}$ and φ_j are the scattering cross section and flux at the energy E_j.

For the integral whose limits are (E_p, E_1) assume that $\sigma_s\varphi$ is linear in the interval $(E_p, E_i/\alpha)$,

$$\sigma_s(E)\varphi(E) = \frac{1}{E_i/\alpha - E_p} [(E - E_p)\sigma_s(\frac{E_i}{\alpha})\varphi(\frac{E_i}{\alpha}) + (\frac{E_i}{\alpha} - E)\sigma_{s,p}\varphi_p]. \tag{64}$$

But E_i/α generally does not correspond to a mesh point and so we express $\sigma_s(\frac{E_i}{\alpha})\varphi(\frac{E_i}{\alpha}) \equiv \sigma^*_{s,p}\varphi^*_p$, by linear interpolation, in terms of its value at the two surrounding mesh points p and p-1. Then

$$\sigma^*_{s,p}\varphi^*_p = \frac{1}{E_{p-1} - E_p} [(E_{p-1} - \frac{E_i}{\alpha})\sigma_{s,p}\varphi_p + (\frac{E_i}{\alpha} - E_p)\sigma_{s,p-1}\varphi_{p-1}]. \tag{65}$$

Inserting Equations (63) and (64) into Equation (62) gives

$$\int_{E}^{E/\alpha} \frac{\sigma_s(E')}{E'} H(E - \alpha E')\varphi(E')dE' = \sigma_{s,p}\varphi_p\beta_p + \sigma_{s,i}\varphi_i\gamma_i + \sum_{j=p+1}^{i-1} \sigma_{s,j}\varphi_j\delta_j + C_p \tag{66}$$

where

$$\beta_k = 1 - \frac{E_{k+1}}{E_k - E_{k+1}} \ln \frac{E_k}{E_{k+1}} \tag{67}$$

$$\gamma_k = \frac{E_{k-1}}{E_{k-1} - E_k} \ln \frac{E_{k-1}}{E_k} - 1 \tag{68}$$

$$\delta_k = \beta_k + \gamma_k \tag{69}$$

and

$$C_p = \frac{1}{2}\left(\frac{E_i}{\alpha} - E_p\right)\left(\frac{\sigma_{s,p}\varphi_p}{E_p} + \frac{\sigma^*_{s,p}\varphi^*_p\alpha}{E_i}\right) \tag{70}$$

unless $p = 1$, in which case

$$C_p = 0 . \tag{71}$$

C_p is the evaluation of the last integral of Equation (62).

The special case for which $p=i$ corresponds to mesh points that are spaced sufficiently wide apart so that, for some isotope, $\alpha E_{i-1} > E_i$. For this case, the integral on the left hand side of Equation (62) is

$$\int_{E}^{E/\alpha} \frac{\sigma_s(E')}{E'} H(E - \alpha E')\varphi(E')dE' = C_i = \frac{1}{2}\left(\frac{1}{\alpha} - 1\right)(\sigma_{s,i}\varphi_i + \sigma^*_{s,i}\varphi^*_i\alpha) \tag{72}$$

and, from Equation (65),

$$\sigma^*_{s,i}\varphi^*_i = \frac{1}{E_{i-1} - E_i} \left[\left(E_{i-1} - \frac{E_i}{\alpha}\right)\sigma_{s,i}\varphi_i + E_i\left(\frac{1}{\alpha} - 1\right)\sigma_{s,i-1}\varphi_{i-1}\right] \tag{73}$$

Insertion of Equation (73) into Equation (72) gives, for the special case p=i,

$$\int_{E}^{E/\alpha} \frac{\sigma_s(E')}{E'} H(E - \alpha E')\varphi(E')dE' = a_i\sigma_{s,i}\varphi_i + b_i\sigma_{s,i-1}\varphi_{i-1} \tag{74}$$

where

$$a_i = \frac{1-\alpha}{2\alpha}\left[1 + \frac{\alpha E_{i-1} - E_i}{E_{i-1} - E_i}\right] \tag{75}$$

and

$$b_i = \frac{(1-\alpha)^2}{2\alpha} \frac{E_i}{E_{i-1} - E_i} . \tag{76}$$

We are now ready to write Equation (2) in its finite differenced form. The equation is

$$\begin{aligned} V_1\Sigma_{t1,i}\varphi_{1i} = {} & (1 - P_1)V_1 \sum_{k=1}^{M} \frac{N_{1k}}{1-\alpha_k}(Z_{1ki} + W_{1ki}\varphi_{1i}) \\ & + P_2V_2\sum_{k=1}^{M} \frac{N_{2k}}{1-\alpha_k}(Z_{2ki} + W_{2ki}\varphi_{2i}) \\ & + V_1(1 - P_1)S_{1i} + V_2P_2S_{2i} \end{aligned} \tag{77}$$

where

$$Z_{nki} = \sigma_{s,kp}\varphi_p\beta_p + \sum_{j=p+1}^{i-1} \sigma_{s,kj}\varphi_j\delta_j + C_{pk} \tag{78}$$

and

$$W_{nki} = \sigma_{s,ki}\gamma_i \tag{79}$$

if $p \neq i$. If $p = i$, that is if $\alpha_k E_{i-1} > E_i$, we have instead

$$Z_{nki} = b_{ik} = \frac{(1 - \alpha_k)^2}{2\alpha_k} \frac{E_i}{E_{i-1} - E_i} \tag{80}$$

and

$$W_{nki} = \frac{1 - \alpha_k}{2\alpha_k} [1 + \frac{\alpha_k E_{i-1} - E_i}{E_{i-1} - E_i}] \tag{81}$$

In Equations (78) and (81) the subscripts n and k denote the region and the isotope, respectively. With some additional abbreviated notation, we can write Equation (77) in a more compact manner. Define

$$D_{ni} = V_n \left\{ \Sigma_{tn,i} - (1 - P_n) \sum_{k=1}^{M} \frac{N_{nk}}{1 - \alpha_k} W_{nki} \right\} \tag{82}$$

$$Q_{ni} = V_n P_n \sum_{k=1}^{M} \frac{N_{nk}}{1 - \alpha_k} W_{nki} \tag{83}$$

and

$$T_{nmi} = V_n(1 - P_n) \sum_{k=1}^{M} \frac{N_{nk}}{1 - \alpha_k} Z_{nki} + V_m P_m \sum_{k=1}^{M} \frac{N_{mk}}{1 - \alpha_k} Z_{mki} \tag{84}$$

$$+ V_n(1 - P_n) S_{ni} + V_m P_m S_{mi}$$

In terms of these, Equation (77) becomes

$$D_{1i}\varphi_{1i} - Q_{2i}\varphi_{2i} = T_{12i} \tag{85}$$

As was mentioned below Equation (1), there exists another equation like it, but with the subscripts 1 and 2 reversed. In the notation of Equation (85) that second equation is

$$D_{2i}\varphi_{2i} - Q_{1i}\varphi_{1i} = T_{21i} \tag{86}$$

We may solve Equations (85) and (86) simultaneously to obtain

$$\varphi_{1i} = \frac{T_{12i}D_{2i} + Q_{2i}T_{21i}}{D_{2i}D_{1i} - Q_{1i}Q_{2i}} \tag{87}$$

and

$$\varphi_{2i} = \frac{T_{21i}D_{1i} + Q_{1i}T_{12i}}{D_{2i}D_{1i} - Q_{1i}Q_{2i}} . \tag{88}$$

The GAROL computer program evaluates Equations (87) and (88) for each i, one at a time beginning with i=1, until the complete flux solution has been obtained.

Averaging of Cross Sections

With the GAROL computer program, it is possible to obtain flux weighted cross sections over any desired energy bands. In addition a one group average, covering the entire range of the calculation, is always obtained. All of the integrals are carried out by the trapezoidal approximation. Let Σ_α denote the cross section for any reaction. This may be capture, scattering, or fission. Quite generally, a cell averaged macroscopic cross section may be defined by

$$\bar{\Sigma}_\alpha = \frac{\int dE \int dV \int d\Omega \Sigma_\alpha(r,E)\varphi(r,E,\Omega)}{\int dE \int dV \int d\Omega \varphi(r,E,\Omega)} , \tag{89}$$

where the angular integration is carried out over the full range, the volume is taken over the entire cell, and the energy integration is carried out over the energy group limits of interest.

For our two region cell, we define the integrated quantities

$$V_1\varphi_1(E) = \int_{V_1} dV \int d\Omega \varphi(r,E,\Omega) \tag{90}$$

$$V_2\varphi_2(E) = \int_{V_2} dV \int d\Omega\varphi(r,E,\Omega). \tag{91}$$

The energy dependent fluxes $\varphi_1(E)$ and $\varphi_2(E)$ are the fluxes of Equation (1). If $\Sigma_\alpha(r,E)$ has the simple form

$$\Sigma_\alpha(r,E) = N_1\sigma_\alpha(E) \tag{92}$$

in V_1 and

$$\Sigma_\alpha(r,E) = N_2\sigma_\alpha(E) \tag{93}$$

in V_2, in which the number densities of the isotopes of interest are constant in each region, Equation (89) may be greatly simplified. Usually Equations (92) and (93) are satisfied; in fact, most often $N_2 = 0$. Using Equations (90) to (93) in (89) gives

$$\bar{\Sigma}_\alpha = \frac{N_1V_1\int\sigma_\alpha(E)\varphi_1(E)dE + N_2V_2\int\sigma_\alpha(E)\varphi_2(E)dE}{V_1\int\varphi_1(E)dE + V_2\int\varphi_2(E)dE} \tag{94}$$

If we define a flux weighted cross section for each region i by

$$\bar{\sigma}_{\alpha,i} = \frac{\int\sigma_\alpha(E)\varphi_i(E)dE}{\bar{\varphi}_i} \tag{95}$$

where $\bar{\varphi}_i$ is the group integrated flux

$$\bar{\varphi}_i = \int\varphi_i(E)dE , \tag{96}$$

Equation (94) becomes

$$\bar{\Sigma}_\alpha = \frac{N_1V_1\bar{\sigma}_{\alpha,1}\bar{\varphi}_1 + N_2V_2\bar{\sigma}_{\alpha,2}\bar{\varphi}_2}{V_1\bar{\varphi}_1 + V_2\bar{\varphi}_2} \tag{97}$$

We wish to compute a cell averaged microscopic cross section such that when it is multiplied by the number density of the isotope, homogenized over the entire cell, we obtain the correct macroscopic cross section. Thus we want $\bar{\sigma}_\alpha$ to satisfy

$$\bar{\Sigma}_\alpha = \frac{N_1 V_1 + N_2 V_2}{V_1 + V_2} \bar{\sigma}_\alpha \tag{98}$$

Hence, the cell averaged microscopic cross section is

$$\bar{\sigma}_\alpha = \frac{N_1 V_1 \bar{\sigma}_{\alpha,1} \bar{\varphi}_1 + N_2 V_2 \bar{\sigma}_{\alpha,2} \bar{\varphi}_2}{V_1 \bar{\varphi}_1 + V_2 \bar{\varphi}_2} \frac{V_1 + V_2}{N_1 V_1 + N_2 V_2} \tag{99}$$

The GAROL output includes the groupwise averages of capture, scattering and, if present, fission cross sections as given by Equations (95), for each region, and by Equation (99) for the cell. In the presence of fission, the quantity α, the ratio of capture to fission cross sections is also computed. If, as is usually the case, $N_2 = 0$ (the resonance absorber is present only in region 1), Equation (99) simplifies to

$$\bar{\sigma}_\alpha = \frac{\bar{\sigma}_{\alpha,1} \bar{\varphi}_1}{\bar{\varphi}_c} \tag{100}$$

where $\bar{\varphi}_c$ is the average flux in the cell given by

$$\bar{\varphi}_c = \frac{V_1 \bar{\varphi}_1 + V_2 \bar{\varphi}_2}{V_1 + V_2} \tag{101}$$

An Application of the GAROL Program

As an application of the GAROL computer program, we include a study of the effect of overlap of the resonances of the thorium doublet on the resonance integral and on the Doppler effect for thorium and thorium oxide rods.

The two resonances which were investigated had the parameters

$E_o = 21.8$ eV $E_o = 23.47$

$\Gamma_n = 2.1$ mv $\Gamma_n = 4.0$ mv

$\Gamma_\gamma = 24.5$ mv $\Gamma_\gamma = 24.5$ mv

$g = 1.0$ $g = 1.0$

In order to compute the resonance overlap, the cross sections for three thorium "isotopes" were computed: one isotope had both resonances, another had only the 21.8 eV resonance, while the third had only the 23.47 eV resonance. Separate problems were run for each of these isotopes. The resonance integral for the first isotope was compared with the sum of the resonance integrals of the second and third isotopes. The latter corresponds to the usual methods of computation. This comparison gives a direct indication of the influence of resonance overlap.

The results are summarized in Tables I to IV. All of the total resonance integrals referred to have been evaluated by standard procedures.[4] The GAROL computer program was used only for an energy range covering the resonance doublet. It can be seen that the usual neglect of resonance overlap is justified for thin rods. But for larger rods the errors introduced can be significant.

Table I

Resonance Integral of Thorium Doublet in Th Metal Rods

	T = 300°K				T = 2000°K		
Rod Size (cm)	No Overlap	With Overlap	% Diff.	% Diff. in Total Resonance Integral	No Overlap	With Overlap	% Diff.
0.138	6.05	6.00	1	0.25	9.08	9.44	1
0.275	4.02	3.94	1.8	0.5	5.85	5.74	1.9
0.55	2.72	2.62	3.5	0.8	3.58	3.45	3.7
1.1	1.87	1.75	6.7	1.3	2.24	2.09	7.3
2.2	1.30	1.15	12.6	2	1.45	1.27	13.6

Table II

Doppler Effect in Thorium Doublet
for Th Metal Rods

Rod Size (cm)	$(\Delta I)_{2000-300}$ With No Overlap	$(\Delta I)_{2000-300}$ With Overlap	% Diff.
0.138	3.47	3.45	0.9
0.275	1.87	1.80	2
0.55	0.86	0.83	4.5
1.1	0.37	0.34	10
2.2	0.15	0.12	23

Table III

Resonance Integral of Thorium Doublet in ThO_2 Rods

	T = 300°K				T = 2000°K		
Rod Size (cm)	No Overlap	With Overlap	% Diff.	% Diff. in Total Resonance Integral	No Overlap	With Overlap	% Diff.
0.25	6.35	6.28	1	0.3	10.0	9.9	1
0.50	4.30	4.21	2	0.6	6.33	6.18	2.4
1.0	3.02	2.90	4	0.9	4.09	3.90	5
2.0	2.21	2.05	8	1.6	2.78	2.55	9

Table IV

Doppler Effect in Thorium Doublet for ThO_2 Rods

Rod Size (cm)	$(\Delta I)_{2000-300}$ With No Overlap	$(\Delta I)_{2000-300}$ With Overlap	% Diff.
0.25	3.66	3.62	1.3
0.50	2.03	1.97	3
1.0	1.07	1.00	7
2.0	0.57	0.50	14

Output from GAROL

Standard output from a GAROL problem includes a description of the nuclides present on the cross section tape, if one has been generated, and a listing of the input options and limits specified for the calculation. Further printed output is given if requested. This includes:

1. Pointwise cross-sections calculated from resonance parameters or interpolated from input cross sections, by isotope.
2. Pointwise flux, source, total macroscopic cross section, and collision density, all by region.
3. Broad group averaged cross sections.
4. Plotting description.

Output from the sample problem selects all of these options.

Two types of plotting may be done automatically from a GAROL problem. For region 1, the pointwise flux, total cross section, and collision density may be plotted. As an additional option, graphs of capture and fission rates, for each material, may be obtained. Samples of each of these are included. The plotting routines in GAROL were adapted from the two-dimensional plot routine described in reference 6.

Efficient Use of GAROL

Some hints regarding the efficient use of GAROL are included here. There are a number of ways in which the program may be used to do a homogeneous calculation. The most efficient is to choose the no geometry option, put the homogeneous mixture into region 1, and put 0.0 for the mean chord length of region 2 and for the number density of all materials in region 2. It is possible to run two homogeneous problems simultaneously by using the no geometry option, and by putting one mixture into each region. In such cases the mean chord lengths may be chosen to be equal to unity.

Generally speaking, the computer time is greatest for lighter materials. The only exception is for A=1.0 which is fastest of all because it is programmed differently. In practical applications, one frequently has a case in which he wants the flux to be $\frac{1}{E}$ in region 2. In such a case, it can be shown that the resonance integral of the isotopes in region 1 is independent of the choice of moderator in region 2. Thus, to simulate a $\frac{1}{E}$ flux in region 2, it is best to let it be a large region in which the only material present has A=1.0, a constant scattering cross section, and no capture cross section.

OPERATING INSTRUCTIONS

Computer and Tape Requirements

The GAROL program is run on the IBM 7044 (32K) computer from a program tape and a starter deck, behind which is placed punched card input describing the problem(s) to be run.

In addition to the tapes required by the GA system, GAROL makes use of three special tapes: B4 for the GAROL Program Tape, B5 for GAROL cross section storage, and C6 for plotting. The B4 and B5 tapes must be mounted in all cases, and the B5 tape may be saved for subsequent runs. Thus, the tape configuration is as follows:

GA Tape Unit	Fortran Logical Tape Number	Tape Function
C1	1	General Atomic version of the IBM 7044 IBSYS Monitor (Version 9)
C2	5	Standard input tape
C3	6	Standard output tape
B4	7	GAROL program tape
B5	9	GAROL cross section tape
C6	11	GAROL plot tape, if any

If any plotting is done, instructions for the Stromberg-Carlson S-C 4020 High Speed Microfilm Recorder are written on tape C6. The number of graphs for which instructions have been generated will be printed on the on-line printer and will be transferred by the GA computer operator to the tape label provided by the user. The tape will then be sent to the S-C 4020 for plotting.

Thus, the deck setup for a sample GAROL problem consists of a six card starter deck followed by data cards prepared according to the Input Specifications for GAROL.

INPUT SPECIFICATIONS FOR GAROL

CARD	COLUMNS	FORMAT	NAME	DESCRIPTION
1	12	I12	INDEX	Source of cross sections for this problem(s) 0 = cross sections have been calculated and written on tape during an earlier run. This tape will be mounted on unit (B5). 1 = cross-sections will be calculated and written on tape (B5). This tape may be saved and reused for future calculations, if desired.
2	1-72	12A6	TLABEL	Tape label for data tape (B5). If INDEX = 0, this card must be identical to that used when the data tape was written.

If INDEX = 0, go to card 13.

CARD	COLUMNS	FORMAT	NAME	DESCRIPTION
3	12	I12	NINDEX	Energy specification index 1 = Energies will be read from input cards (card 4A) 2 = Energies will be calculated by equal mesh spacing (card 4B) 3 = Energies will be calculated with mesh spacing proportion to velocity (card 4C) 4 = Energies will be calculated with equal lethargy mesh spacing (card 4D) 5 = Energies will be generated by a special subroutine ENRG (NPTS,E) supplied by the user (card 4E).
	13-24	I12	NPTS	Number of energy points. This value is needed for NINDEX = 1, and may be used when NINDEX = 5, if desired.

If NINDEX = 1, card 4A is needed.

CARD	COLUMNS	FORMAT	NAME	DESCRIPTION
4A		6E12.6	E(i)	Energy points, in eV, from high to low. (NPTS entries)

If NINDEX = 2, card 4B is needed.

CARD	COLUMNS	FORMAT	NAME	DESCRIPTION
4B	1-12	E12.6	EMAX	Maximum energy, eV
	13-24	E12.6	EMIN	Minimum energy, eV
	25-36	E12.6	DELTAE	ΔE, eV

INPUT SPECIFICATIONS FOR GAROL

CARD	COLUMNS	FORMAT	NAME	DESCRIPTION
If NINDEX = 3, card 4C is needed.				
4C	1-12	E12.6	EMAX	Maximum energy, eV
	13-24	E12.6	EMIN	Minimum energy, eV
	25-36	E12.6	CONST	C, where $E_{i+1} = E_i - C\sqrt{E_i}$ (equal velocity intervals)
If NINDEX = 4, card 4D is needed.				
4D	1-12	E12.6	EMAX	Maximum energy, eV
	13-24	E12.6	EMIN	Minimum energy, eV
	25-36	E12.6	DELTAU	Δu

If NINDEX = 5, the user supplies his own ENRG (NPTS,E) subroutine to compute, or read, his energy mesh. The number of energy points, NPTS, must not exceed 8000. The array E, which must be dimensioned, contains the energy points which are returned to the main program. If any input cards are required by the user's subroutine, they are inserted here (card 4E).

CARD	COLUMNS	FORMAT	NAME	DESCRIPTION
4E				Variables and formats determined by the user.
5	1-12	I12	MAT	Number of nuclides for which cross sections will be calculated and written on tape (≤ 20)
	13-24	I12	JHYD	Will an A = 1.0 isotope be included on this tape? 0 = no 1 = yes
Cards 6 to 8 are repeated for each nuclide (MAT times).				
6	1-12	F12.6	TID	Identification number of this nuclide, given by Z and A, in the form 92.235000 for uranium 235. Nuclides should be given in ascending numerical order. Different sets of data for one nuclide may be distinguished in the fourth through six decimal places.
	13-42	5A6	CNAME	Nuclide description.
7	1-12	E12.6	AMASS	Atomic mass
	13-24	E12.6	ASYMSC	Asymptotic scattering cross section, used for computing source only.

INPUT SPECIFICATIONS FOR GAROL

CARD	COLUMNS	FORMAT	NAME	DESCRIPTION
	25-36	E12.6	SCAP	Capture cross section index. If SCAP ≥ 0.0, SCAP is the value of the capture cross section at 0.0253 eV, and the cross section is 1/v. If SCAP = -1.0, pointwise capture cross sections will be calculated from resonance parameters. If SCAP = -2.0, pointwise cross sections will be read from cards (card 12).
	37-48	E12.6	SFIS	Fission cross section index. If SFIS ≥ 0.0, no fission. If SFIS = -1.0, pointwise fission will be calculated from resonance parameters. If SCAP = -2.0, this index is not used; pointwise fission cross sections will be read from cards (card 12).
	49-60	E12.6	SCAT	Scattering cross section index. If SCAT ≥ 0.0, scattering is constant at that value. If SCAT = -1.0, pointwise scattering cross sections will be calculated from resonance parameters. If SCAP = -2.0, this index is not used; pointwise scattering cross sections will be read from cards (card 12).
	61-72	E12.6	PRINT	Print index, for this nuclide. 0.0 = no printing 1.0 = the calculated or read capture, scattering, and fission (if present) cross sections for this nuclide will be printed. Up to nine sets of cross sections may be printed; if more than nine are specified, only the first nine will be printed. If any printing is done, the computer time estimate is doubled.

If SCAP = -2.0, card 8 is required.

CARD	COLUMNS	FORMAT	NAME	DESCRIPTION
8	1-12	E12.6	ENPTS	Number of energies at which cross sections will be read.

Cards 9-11 (resonance parameters) are required for each material for which any cross sections will be calculated, and in the order specified by cards 6 and 7.

INPUT SPECIFICATIONS FOR GAROL

CARD	COLUMNS	FORMAT	NAME	DESCRIPTION
9	1-12	E12.6	WGT	Atomic mass. (This number will be checked against card 7, col. 1-12, to be sure that resonance parameters are given in the order specified).
	13-24	E12.6	STAT	Statistical factor indicator. If the statistical factor, g, is to have a constant value for all resonances, then STAT is the value used for the statistical factor. If STAT $\leq$ 0.0, the statistical factor must be specified for each resonance.
	25-36	E12.6	SPCT	Potential scattering cross-section, barns.
	37-48	E12.6	TEMP	Temperature, $^{\circ}$K.
10	1-12	I12	NEZ	Number of resolved resonances (maximum = 500).
	24	I12	NFIS	Will fission widths be specified? 0 - No. 1 - Yes.
	36	I12	NGN	Γ_n form index. 0 - Neutron half-widths to be specified are standard values, not reduced. 1 - Neutron half-widths to be specified are reduced widths, Γ_n^o.

Card 11 is given for each resonance. The format of card 11 is one of four types, depending on the NFIS and STAT values.

If NFIS = 0 and STAT $\leq$ 0.0, supply one card 11A for each resonance.

CARD	COLUMNS	FORMAT	NAME	DESCRIPTION
11A	1-12	E12.6	EO	Resonance energy, eV.
	13-24	E12.6	GI	Either the spin (I) of the target nucleus, or the statistical factor, g, for this resonance, depending on the specification for GJ in the next field of this input card.
	25-36	E12.6	GJ	If GJ > 0.0, it is taken to be the spin (J) of the compound nucleus for this resonance, and the statistical factor is calculated as:

INPUT SPECIFICATIONS FOR GAROL

CARD	COLUMNS	FORMAT	NAME	DESCRIPTION
				$g = \frac{1}{2}\frac{(2J+1)}{(2I+1)}$ If GJ < 0.0, then GI in the previous field is taken to be the statistical factor, g, for this resonance.
	37-48	E12.6	GG	Γ_γ in millivolts.
	49-60	E12.6	GN	Γ_n, or Γ_n^o, mv, depending on NGN specified on card 10, Col. 36.
If NFIS = 0 and STAT > 0.0, supply one card 11B for each resonance.				
11B	1-12	E12.6	EO	Resonance energy, eV.
	13-24	E12.6	GG	Γ_γ, mv.
	25-36	E12.6	GN	Γ_n or Γ_n^o, mv.
If NFIS = 1, and STAT $\leq$ 0.0, supply one card 11C for each resonance.				
11C	1-12	E12.6	EO	Resonance energy, eV.
	13-24	E12.6	GI	As on card 11A.
	25-36	E12.6	GJ	As on card 11A.
	37-48	E12.6	GG	Γ_γ, mv.
	49-60	E12.6	GN	Γ_n or Γ_n^o, mv.
	61-72	E12.6	GF	Γ_F, mv.
If NFIS = 1 and STAT > 0.0, supply one card 11D for each resonance.				
11D	1-12	E12.6	EO	Resonance energy, eV.
	13-24	E12.6	GG	Γ_γ, mv.
	25-36	E12.6	GN	Γ_n or Γ_n^o, mv.
	37-48	E12.6	GF	Γ_F, mv.

If cross-sections will be read from cards, (SCAP = -2.0), for any nuclide, card 12, repeated at each energy, is required.

Cross sections for up to 3 nuclides may be read from cards, and must be in the order specified by cards 6 to 8.

INPUT SPECIFICATIONS FOR GAROL

CARD	COLUMNS	FORMAT	NAME	DESCRIPTION
12	1-12	E12.6	E	Energy, eV (high to low)
	13-24	E12.6	CAP	Capture cross section (barns)
	25-36	E12.6	SCAT	Scatter cross section (barns)
	37-48	E12.6	FISS	Fission cross section (barns)

Cross sections on the GAROL mesh are computed from this table by linear interpolation.

CARD	COLUMNS	FORMAT	NAME	DESCRIPTION
13	1-72	12A6	TITLE	Problem description for flux calculation.
14	1-12	E12.6	EST	Upper boundary of energy range of interest (eV). If EST = 0.0, the first energy point present on the data tape will be used.
	13-24	E12.6	EEND	Lower boundary of energy range of interest (eV). If EEND = 0.0, the last energy point present on the data tape will be used.
	25-36	F12.1	GEOM	Geometry 1.0 = none (homogeneous) 2.0 = slab 3.0 = cylinder 4.0 = sphere 5.0 = Read your own escape probability table and coefficients (cards 18 and 19). 6.0 = Use the previously read tables.
	37-48	F12.1	ELEMS	Number of nuclides.
	49-60	F12.1	PRINT	Shall pointwise flux, external source, total cross section, and collision density be printed? 0.0 = no 1.0 = yes
	61-72	F12.1	PLOT	Shall flux, total cross section and collision density be plotted? 0.0 = no 1.0 = yes

INPUT SPECIFICATIONS FOR GAROL

CARD	COLUMNS	FORMAT	NAME	DESCRIPTION
15	1-12	E12.6	ELBAR(1)	$\overline{\ell}_1$ = Mean chord length, region 1
	13-24	E12.6	ELBAR(2)	$\overline{\ell}_2$ = Mean chord length, region 2: $\overline{\ell}_2 = 4V_2/S$ where V_2 is volume and S is common surface.
	25-36	E12.6	CC	Dancoff correction factor, if any.
	37-48	E12.6	XSORC	Will extra source terms be read? 0.0 = no 1.0 = yes
16	1-12	F12.1	ENBG	Number of broad groups. If ENBG = 0.0, there is no group averaging.

If ENBG $\neq$ 0.0, card 17 is needed.

CARD	COLUMNS	FORMAT	NAME	DESCRIPTION
17		6E12.6	BEG(i)	Broad group lower boundaries in eV, from high to low.

Card 18 is repeated for each nuclide.

CARD	COLUMNS	FORMAT	NAME	DESCRIPTION
18	1-12	F12.6	TID	Tape identification number for nuclide wanted.
	13-24	E12.6	DENS(1)	Density of this nuclide in region 1.
	25-36	E12.6	DENS(2)	Density of this nuclide in region 2.
	37-48	E12.6	PLOTS	0.0 = absorption rate for this isotope will not be plotted. 1.0 = absorption rate for this isotope will be plotted.

If GEOM = 5.0, cards 19 and 20 are needed.

CARD	COLUMNS	FORMAT	NAME	DESCRIPTION
19	1-12	E12.6	C1	The constants C_1, C_2 and C_3.
	13-24	E12.6	C2	
	25-36	E12.6	C3	
		6E12.6	CYLT(i)	Special escape probability tables as a function of $\frac{\overline{\ell}_1\Sigma_{t1}}{2}$. (302 entries from $\frac{\overline{\ell}_1\Sigma_{t1}}{2}$ = 0.00 to 6.02 in steps of 0.02.)

If XSORC = 1.0, cards 21 and 22 are needed.

CARD	COLUMNS	FORMAT	NAME	DESCRIPTION
21	1-12	E12.6	ZSORC	Number of source points to be read. (ZSORC $\geq$2.0)

INPUT SPECIFICATIONS FOR GAROL

CARD	COLUMNS	FORMAT	NAME	DESCRIPTION
22	1-12	E12.6		Energy of source point
	13-24	E12.6		Source, region 1
	25-36	E12.6		Source, region 2

Repeat card 22 for each source point.

Repeat input from card 13 until all problems have been specified.

GAROL Error Table

Link No.	Error No.	Description of Error
1	1	Tape label card (input card 2) and label on data tape mounted on B5 do not agree.
1	2	Number of materials specified for data tape is not between 1 and 20.
1	3	More than 3 nuclides have been specified for the data tape with cross sections to be read from input cards.
1	7	A nuclide, other than the first, has been specified for the data tape with atomic mass A = 1.0.
1	4	Energy index (input card 3) is less than 1.
1	5	Energy index (input card 3) is greater than 5.
1	6	Number of energy points, using energy option 5, is greater than 8000, the core-contained limit.
2	1	Resonance parameters are either missing or out of order for a nuclide for which cross sections are to be calculated.
4	1	Number of materials for resonance calculation is not between 1 and 10.
4	2	Number of broad groups for averaging is not between 1 and 50.
4	3	Nuclide requested for resonance calculation is not present on data tape.

GAROL STARTER DECK AND SAMPLE PROBLEM

```
$IBJOB GAROL    NOSOURCE
$DUMP           TYPE1,00000-77777,ERROR
$*MOUNT         U07, (GAROL PROGRAM TAPE ON (B4))
$*MOUNT         U09,  (GAROL DATA TAPE ON (B5))
$*HOLD          U11, (C6)  PLOT TAPE
$RELOAD         U07,NAME=GAROL                                                   U
           1
THORIUM TAPE FOR GAROL SAMPLE PROBLEMS                                         8-65
           4
29.023214   17.603469   0.00125
           5            1
1.0         HYDROGEN
1.0         20.0        0.0         0.0         20.0        1.0
6.0         GRAPHITE
12.0        4.7102      0.0         0.0         4.7102      1.0
8.0         OXYGEN
16.0        3.7         0.0         0.0         3.7         1.0
90.232      TH232  300K, GAM=24.5, TWO RES
232.0       12.6        -1.0        0.0         -1.0        1.0
90.2321     TH232 2000K, GAM=24.5, TWO RES
232.0       12.6        -1.0        0.0         -1.0        1.0
232.0       1.0         12.6        300.0
           2            0           0
21.8        24.5        2.1
23.47       24.5        4.0
232.0       1.0         12.6        2000.0
           2            0           0
21.8        24.5        2.1
23.47       24.5        4.0
  THORIUM R=2.2     T=300
29.023214   17.603469   3.0         2.0         1.0         1.0
4.4         100000.0    0.0
2.0
22.603302   17.603469
1.0         0.0         1.0         1.0
90.2320     0.03037     0.0         1.0
```

GAROL DATA TAPE, LABELED THORIUM TAPE FOR GAROL SAMPLE PROBLEMS 8-65

NUCLIDE TABLE OF CONTENTS

NUCLIDE I.D.	NAME	A	ASYMPTOTIC SCATTERING	CAPTURE	FISSION	SCATTER	NUMBER OF ARRAYS
1.0	HYDROGEN	1.000	20.00000	0.	0.	2.00000 01	0
6.0	GRAPHITE	12.000	4.71020	0.	0.	4.71020 00	0
8.0	OXYGEN	16.000	3.70000	0.	0.	3.70000 00	0
90.232	TH232 300K, GAM=24.5, TWO RES	232.000	12.60000	COMPUTED	0.	COMPUTED	2
90.2321	TH232 2000K, GAM=24.5, TWO RES	232.000	12.60000	COMPUTED	0.	COMPUTED	2

GAROL DATA TAPE, LABELED THORIUM TAPE FOR GAROL SAMPLE PROBLEMS 8-65

DOPPLER BROADENING CALCULATIONS FOR TH232 300K, GAM=24.5, TWO RES

```
ABSORBER MASS         =  232.000
POTENTIAL SCATTERING  =   12.600 (BARNS)
TEMPERATURE           =  300.000 (K)
```

RESONANCE PARAMETER INPUT

	RESONANCE	STATISTICAL FACTORS			HALF-WIDTHS - MV		
NUMBER	ENERGY-EV	I	J	G	GAMMA N	GAMMA GAMMA	GAMMA F
1	21.800	0.0	0.0	1.000	2.1000	24.5000	0.0000
2	23.470	0.0	0.0	1.000	4.0000	24.5000	0.0000

GAROL DATA TAPE, LABELED THORIUM TAPE FOR GAROL SAMPLE PROBLEMS 8-65

DOPPLER BROADENING CALCULATIONS FOR TH232 2000K, GAM=24.5, TWO RES
ABSORBER MASS = 232.000
POTENTIAL SCATTERING = 12.600 (BARNS)
TEMPERATURE = 2000.000 (K)

RESONANCE PARAMETER INPUT

	RESONANCE	STATISTICAL FACTORS			HALF-WIDTHS - MV		
NUMBER	ENERGY-EV	I	J	G	GAMMA N	GAMMA GAMMA	GAMMA F
1	21.800	0.0	0.0	1.000	2.1000	24.5000	0.0000
2	23.470	0.0	0.0	1.000	4.0000	24.5000	0.0000

GAROL DATA TAPE, LABELED THORIUM TAPE FOR GAROL SAMPLE PROBLEMS

		TH232 300		TH232 2000	
	ENERGY-EV	CAPTURE	SCATTER	CAPTURE	SCATTER
1	2.90232 01	1.05696-01	1.38357 01	1.05968-01	1.38368 01
2	2.89870 01	1.07078-01	1.38434 01	1.07358-01	1.38445 01
3	2.89507 01	1.08485-01	1.38512 01	1.08773-01	1.38523 01
4	2.89146 01	1.09918-01	1.38590 01	1.10213-01	1.38602 01
5	2.88785 01	1.11377-01	1.38670 01	1.11680-01	1.38681 01
6	2.88424 01	1.12863-01	1.38750 01	1.13174-01	1.38762 01
7	2.88064 01	1.14377-01	1.38832 01	1.14696-01	1.38844 01
8	2.87704 01	1.15918-01	1.38914 01	1.16246-01	1.38926 01
9	2.87344 01	1.17489-01	1.38997 01	1.17826-01	1.39010 01
10	2.86985 01	1.19089-01	1.39081 01	1.19435-01	1.39094 01
11	2.86627 01	1.20719-01	1.39167 01	1.21075-01	1.39180 01
12	2.86269 01	1.22381-01	1.39253 01	1.22747-01	1.39266 01
13	2.85911 01	1.24074-01	1.39340 01	1.24450-01	1.39354 01
14	2.85554 01	1.25800-01	1.39429 01	1.26187-01	1.39442 01
15	2.85197 01	1.27559-01	1.39518 01	1.27957-01	1.39532 01
16	2.84841 01	1.29353-01	1.39609 01	1.29762-01	1.39623 01
17	2.84485 01	1.31182-01	1.39700 01	1.31603-01	1.39715 01
18	2.84130 01	1.33047-01	1.39793 01	1.33480-01	1.39808 01
19	2.83775 01	1.34949-01	1.39887 01	1.35395-01	1.39903 01
20	2.83420 01	1.36890-01	1.39983 01	1.37348-01	1.39998 01
21	2.83066 01	1.38869-01	1.40079 01	1.39341-01	1.40095 01
22	2.82713 01	1.40888-01	1.40177 01	1.41374-01	1.40193 01
23	2.82359 01	1.42949-01	1.40276 01	1.43449-01	1.40292 01
24	2.82007 01	1.45052-01	1.40376 01	1.45567-01	1.40393 01
25	2.81654 01	1.47198-01	1.40477 01	1.47729-01	1.40495 01
26	2.81303 01	1.49389-01	1.40580 01	1.49936-01	1.40598 01
27	2.80951 01	1.51625-01	1.40684 01	1.52189-01	1.40703 01
28	2.80600 01	1.53909-01	1.40790 01	1.54490-01	1.40809 01
29	2.80250 01	1.56242-01	1.40897 01	1.56840-01	1.40916 01
30	2.79900 01	1.58624-01	1.41006 01	1.59241-01	1.41025 01
31	2.79550 01	1.61057-01	1.41116 01	1.61693-01	1.41136 01
32	2.79201 01	1.63543-01	1.41227 01	1.64199-01	1.41248 01
33	2.78852 01	1.66083-01	1.41340 01	1.66760-01	1.41361 01
34	2.78504 01	1.68678-01	1.41455 01	1.69377-01	1.41476 01
35	2.78156 01	1.71331-01	1.41571 01	1.72053-01	1.41593 01
36	2.77808 01	1.74043-01	1.41689 01	1.74788-01	1.41711 01
37	2.77461 01	1.76816-01	1.41809 01	1.77585-01	1.41832 01
38	2.77115 01	1.79652-01	1.41930 01	1.80446-01	1.41953 01
39	2.76768 01	1.82552-01	1.42053 01	1.83372-01	1.42077 01
40	2.76423 01	1.85518-01	1.42178 01	1.86366-01	1.42203 01
41	2.76077 01	1.88553-01	1.42305 01	1.89429-01	1.42330 01
42	2.75732 01	1.91658-01	1.42433 01	1.92563-01	1.42459 01
43	2.75388 01	1.94836-01	1.42564 01	1.95772-01	1.42590 01
44	2.75044 01	1.98089-01	1.42696 01	1.99057-01	1.42723 01
45	2.74700 01	2.01419-01	1.42831 01	2.02421-01	1.42859 01
46	2.74357 01	2.04829-01	1.42967 01	2.05866-01	1.42996 01
47	2.74014 01	2.08321-01	1.43106 01	2.09394-01	1.43135 01
48	2.73672 01	2.11899-01	1.43247 01	2.13009-01	1.43277 01
49	2.73330 01	2.15564-01	1.43390 01	2.16714-01	1.43421 01
50	2.72989 01	2.19319-01	1.43535 01	2.20511-01	1.43567 01
51	2.72648 01	2.23168-01	1.43683 01	2.24403-01	1.43715 01

GARDL DATA TAPE, LABELED THORIUM TAPE FOR GAROL SAMPLE PROBLEMS 8-65

	ENERGY-EV	TH232 300 CAPTURE	SCATTER	TH232 2000 CAPTURE	SCATTER
52	2.72307 01	2.27114-01	1.43833 01	2.28394-01	1.43866 01
53	2.71967 01	2.31160-01	1.43985 01	2.32487-01	1.44020 01
54	2.71627 01	2.35309-01	1.44140 01	2.36685-01	1.44175 01
55	2.71288 01	2.39565-01	1.44298 01	2.40992-01	1.44334 01
56	2.70949 01	2.43932-01	1.44458 01	2.45413-01	1.44495 01
57	2.70611 01	2.48413-01	1.44621 01	2.49950-01	1.44659 01
58	2.70273 01	2.53012-01	1.44786 01	2.54608-01	1.44826 01
59	2.69935 01	2.57734-01	1.44955 01	2.59392-01	1.44995 01
60	2.69598 01	2.62583-01	1.45126 01	2.64305-01	1.45168 01
61	2.69261 01	2.67563-01	1.45300 01	2.69353-01	1.45343 01
62	2.68925 01	2.72680-01	1.45478 01	2.74540-01	1.45522 01
63	2.68589 01	2.77938-01	1.45658 01	2.79873-01	1.45704 01
64	2.68253 01	2.83342-01	1.45842 01	2.85355-01	1.45889 01
65	2.67918 01	2.88899-01	1.46029 01	2.90994-01	1.46077 01
66	2.67583 01	2.94613-01	1.46220 01	2.96794-01	1.46269 01
67	2.67249 01	3.00491-01	1.46414 01	3.02763-01	1.46465 01
68	2.66915 01	3.06539-01	1.46611 01	3.08906-01	1.46664 01
69	2.66582 01	3.12764-01	1.46813 01	3.15231-01	1.46867 01
70	2.66249 01	3.19172-01	1.47018 01	3.21744-01	1.47074 01
71	2.65916 01	3.25771-01	1.47227 01	3.28454-01	1.47285 01
72	2.65584 01	3.32569-01	1.47440 01	3.35369-01	1.47500 01
73	2.65252 01	3.39573-01	1.47658 01	3.42497-01	1.47720 01
74	2.64921 01	3.46793-01	1.47879 01	3.49846-01	1.47943 01
75	2.64590 01	3.54236-01	1.48106 01	3.57426-01	1.48172 01
76	2.64259 01	3.61913-01	1.48336 01	3.65247-01	1.48405 01
77	2.63929 01	3.69832-01	1.48572 01	3.73320-01	1.48643 01
78	2.63600 01	3.78006-01	1.48812 01	3.81655-01	1.48885 01
79	2.63270 01	3.86444-01	1.49058 01	3.90264-01	1.49133 01
80	2.62941 01	3.95157-01	1.49308 01	3.99158-01	1.49387 01
81	2.62613 01	4.04159-01	1.49564 01	4.08352-01	1.49646 01
82	2.62285 01	4.13462-01	1.49826 01	4.17858-01	1.49910 01
83	2.61957 01	4.23080-01	1.50093 01	4.27691-01	1.50180 01
84	2.61630 01	4.33027-01	1.50367 01	4.37866-01	1.50457 01
85	2.61303 01	4.43318-01	1.50646 01	4.48400-01	1.50740 01
86	2.60977 01	4.53970-01	1.50932 01	4.59309-01	1.51029 01
87	2.60651 01	4.65000-01	1.51224 01	4.70612-01	1.51325 01
88	2.60325 01	4.76425-01	1.51523 01	4.82329-01	1.51628 01
89	2.60000 01	4.88264-01	1.51829 01	4.94479-01	1.51938 01
90	2.59675 01	5.00540-01	1.52143 01	5.07085-01	1.52256 01
91	2.59351 01	5.13272-01	1.52464 01	5.20171-01	1.52582 01
92	2.59027 01	5.26484-01	1.52793 01	5.33760-01	1.52916 01
93	2.58703 01	5.40201-01	1.53130 01	5.47879-01	1.53258 01
94	2.58380 01	5.54449-01	1.53476 01	5.62558-01	1.53609 01
95	2.58057 01	5.69255-01	1.53831 01	5.77825-01	1.53970 01
96	2.57735 01	5.84650-01	1.54195 01	5.93714-01	1.54340 01
97	2.57413 01	6.00666-01	1.54568 01	6.10259-01	1.54719 01
98	2.57091 01	6.17335-01	1.54951 01	6.27497-01	1.55110 01
99	2.56770 01	6.34696-01	1.55345 01	6.45468-01	1.55510 01
100	2.56449 01	6.52785-01	1.55750 01	6.64215-01	1.55923 01
101	2.56129 01	6.71647-01	1.56166 01	6.83784-01	1.56347 01
102	2.55809 01	6.91324-01	1.56594 01	7.04224-01	1.56783 01
103	2.55489 01	7.11866-01	1.57034 01	7.25589-01	1.57232 01

GAROL DATA TAPE, LABELED THORIUM TAPE FOR GAROL SAMPLE PROBLEMS

		TH232 300		TH232 2000	
	ENERGY-EV	CAPTURE	SCATTER	CAPTURE	SCATTER
104	2.55170 01	7.33323-01	1.57487 01	7.47936-01	1.57695 01
105	2.54851 01	7.55753-01	1.57953 01	7.71328-01	1.58171 01
106	2.54533 01	7.79214-01	1.58433 01	7.95831-01	1.58663 01
107	2.54215 01	8.03772-01	1.58929 01	8.21520-01	1.59170 01
108	2.53898 01	8.29496-01	1.59440 01	8.48473-01	1.59693 01
109	2.53580 01	8.56463-01	1.59967 01	8.76776-01	1.60234 01
110	2.53264 01	8.84754-01	1.60511 01	9.06522-01	1.60792 01
111	2.52947 01	9.14459-01	1.61073 01	9.37814-01	1.61370 01
112	2.52631 01	9.45673-01	1.61653 01	9.70763-01	1.61967 01
113	2.52316 01	9.78503-01	1.62254 01	1.00549 00	1.62586 01
114	2.52000 01	1.01306 00	1.62876 01	1.04213 00	1.63227 01
115	2.51686 01	1.04948 00	1.63920 01	1.08083 00	1.63892 01
116	2.51371 01	1.08788 00	1.64187 01	1.12175 00	1.64582 01
117	2.51057 01	1.12842 00	1.64878 01	1.16506 00	1.65298 01
118	2.50744 01	1.17127 00	1.65596 01	1.21097 00	1.66042 01
119	2.50430 01	1.21661 00	1.66342 01	1.25969 00	1.66817 01
120	2.50118 01	1.26462 00	1.67117 01	1.31147 00	1.67623 01
121	2.49805 01	1.31553 00	1.67922 01	1.36656 00	1.68463 01
122	2.49493 01	1.36958 00	1.68762 01	1.42527 00	1.69340 01
123	2.49181 01	1.42704 00	1.69636 01	1.48793 00	1.70255 01
124	2.48870 01	1.48821 00	1.70548 01	1.55492 00	1.71212 01
125	2.48559 01	1.55340 00	1.71500 01	1.62666 00	1.72214 01
126	2.48249 01	1.62299 00	1.72495 01	1.70363 00	1.73264 01
127	2.47939 01	1.69739 00	1.73537 01	1.78637 00	1.74366 01
128	2.47629 01	1.77705 00	1.74628 01	1.87549 00	1.75524 01
129	2.47319 01	1.86250 00	1.75772 01	1.97169 00	1.76743 01
130	2.47010 01	1.95430 00	1.76973 01	2.07579 00	1.78028 01
131	2.46702 01	2.05312 00	1.78236 01	2.18870 00	1.79384 01
132	2.46394 01	2.15969 00	1.79567 01	2.31151 00	1.80819 01
133	2.46086 01	2.27487 00	1.80970 01	2.44546 00	1.82340 01
134	2.45779 01	2.39961 00	1.82452 01	2.59203 00	1.83956 01
135	2.45471 01	2.53501 00	1.84020 01	2.75294 00	1.85675 01
136	2.45165 01	2.68235 00	1.85682 01	2.93027 00	1.87510 01
137	2.44859 01	2.84309 00	1.87447 01	3.12646 00	1.89472 01
138	2.44553 01	3.01891 00	1.89325 01	3.34450 00	1.91578 01
139	2.44247 01	3.21181 00	1.91328 01	3.58802 00	1.93843 01
140	2.43942 01	3.42409 00	1.93469 01	3.87623 00	1.96378 01
141	2.43637 01	3.65848 00	1.95763 01	4.19731 00	1.99077 01
142	2.43333 01	3.91820 00	1.98229 01	4.57146 00	2.02039 01
143	2.43029 01	4.20710 00	2.00885 01	5.01656 00	2.05320 01
144	2.42725 01	4.52977 00	2.03757 01	5.56009 00	2.08997 01
145	2.42422 01	4.89180 00	2.06872 01	6.24473 00	2.13177 01
146	2.42119 01	5.29994 00	2.10263 01	7.13695 00	2.18018 01
147	2.41817 01	5.76253 00	2.13970 01	8.33956 00	2.23743 01
148	2.41515 01	6.28989 00	2.18041 01	1.00092 01	2.30578 01
149	2.41213 01	6.89493 00	2.22534 01	1.23799 01	2.39284 01
150	2.40912 01	7.59404 00	2.27519 01	1.57921 01	2.50206 01
151	2.40611 01	8.40827 00	2.33084 01	2.07277 01	2.64324 01
152	2.40310 01	9.36502 00	2.39342 01	2.78453 01	2.82803 01
153	2.40010 01	1.05006 01	2.46432 01	3.80137 01	3.07133 01
154	2.39710 01	1.18641 01	2.54540 01	5.23315 01	3.39142 01
155	2.39411 01	1.35234 01	2.63908 01	7.21252 01	3.80966 01

GAROL DATA TAPE, LABELED THORIUM TAPE FOR GAROL SAMPLE PROBLEMS 8-65

		TH232 300		TH232 2000	
	ENERGY-EV	CAPTURE	SCATTER	CAPTURE	SCATTER
156	2.39112 01	1.55745 01	2.74867 01	9.89104 01	4.34955 01
157	2.38813 01	1.81588 01	2.87878 01	1.34306 02	5.03507 01
158	2.38515 01	2.14914 01	3.03603 01	1.79896 02	5.88806 01
159	2.38217 01	2.60072 01	3.23372 01	2.37027 02	6.92484 01
160	2.37919 01	3.23666 01	3.48764 01	3.06578 02	8.15235 01
161	2.37622 01	4.22065 01	3.83630 01	3.88689 02	9.56407 01
162	2.37325 01	5.94243 01	4.36035 01	4.82524 02	1.11366 02
163	2.37029 01	9.33845 01	5.23653 01	5.86079 02	1.28272 02
164	2.36732 01	1.64412 02	6.82111 01	6.96111 02	1.45742 02
165	2.36437 01	3.09283 02	9.71553 01	8.08201 02	1.62984 02
166	2.36141 01	5.78375 02	1.46730 02	9.16994 02	1.79037 02
167	2.35846 01	1.01240 03	2.21695 02	1.01659 03	1.93091 02
168	2.35552 01	1.59737 03	3.16782 02	1.10107 03	2.04079 02
169	2.35258 01	2.22522 03	4.11528 02	1.16507 03	2.11271 02
170	2.34964 01	2.70816 03	4.74700 02	1.20438 03	2.14114 02
171	2.34670 01	2.86611 03	4.79882 02	1.21636 03	2.12340 02
172	2.34377 01	2.63563 03	4.22276 02	1.20027 03	2.06008 02
173	2.34084 01	2.11129 03	3.22514 02	1.15735 03	1.95494 02
174	2.33792 01	1.48296 03	2.13790 02	1.09064 03	1.81448 02
175	2.33500 01	9.25114 02	1.23392 02	1.00463 03	1.64728 02
176	2.33208 01	5.24768 02	6.25598 01	9.04771 02	1.46303 02
177	2.32917 01	2.81936 02	2.85251 01	7.96894 02	1.27162 02
178	2.32626 01	1.52558 02	1.24879 01	6.86665 02	1.08222 02
179	2.32335 01	8.89883 01	6.15007 00	5.79111 02	9.02593 01
180	2.32045 01	5.81527 01	4.18103 00	4.78292 02	7.38647 01
181	2.31755 01	4.21796 01	3.90597 00	3.87124 02	5.94256 01
182	2.31465 01	3.28713 01	4.20881 00	3.07353 02	4.71322 01
183	2.31176 01	2.67807 01	4.68304 00	2.39655 02	3.70032 01
184	2.30888 01	2.24271 01	5.19619 00	1.83823 02	2.89233 01
185	2.30599 01	1.92079 01	5.69504 00	1.38999 02	2.26845 01
186	2.30311 01	1.67115 01	6.17154 00	1.03910 02	1.80274 01
187	2.30023 01	1.47342 01	6.62188 00	7.70847 01	1.46750 01
188	2.29736 01	1.31420 01	7.04603 00	5.70209 01	1.23596 01
189	2.29449 01	1.18428 01	7.44562 00	4.23101 01	1.08396 01
190	2.29162 01	1.07717 01	7.82288 00	3.17121 01	9.90954 00
191	2.28876 01	9.88163 00	8.18025 00	2.41890 01	9.40281 00
192	2.28590 01	9.13781 00	8.52016 00	1.89093 01	9.18995 00
193	2.28305 01	8.51413 00	8.84492 00	1.52319 01	9.17446 00
194	2.28019 01	7.99071 00	9.15671 00	1.26786 01	9.28704 00
195	2.27735 01	7.55230 00	9.45758 00	1.09040 01	9.47980 00
196	2.27450 01	7.18713 00	9.74948 00	9.66538 00	9.72091 00
197	2.27166 01	6.88611 00	1.00342 01	8.79629 00	9.99013 00
198	2.26882 01	6.64232 00	1.03136 01	8.19512 00	1.02799 01
199	2.26599 01	6.45054 00	1.05894 01	7.77769 00	1.05767 01
200	2.26316 01	6.30702 00	1.08632 01	7.50635 00	1.08809 01
201	2.26033 01	6.20929 00	1.11368 01	7.35832 00	1.11924 01
202	2.25751 01	6.15603 00	1.14119 01	7.32719 00	1.15133 01
203	2.25469 01	6.14704 00	1.16905 01	7.42184 00	1.18474 01
204	2.25187 01	6.18322 00	1.19746 01	7.65912 00	1.22034 01
205	2.24906 01	6.26671 00	1.22664 01	8.10897 00	1.25820 01
206	2.24625 01	6.40096 00	1.25683 01	8.83476 00	1.29982 01
207	2.24344 01	6.59105 00	1.28832 01	9.95594 00	1.34669 01

GAROL DATA TAPE, LABELED THORIUM TAPE FOR GAROL SAMPLE PROBLEMS

		TH232 300		TH232 2000	
	ENERGY-EV	CAPTURE	SCATTER	CAPTURE	SCATTER
208	2.24064 01	6.84400 00	1.32144 01	1.16472 01	1.40080 01
209	2.23784 01	7.16928 00	1.35656 01	1.41561 01	1.46480 01
210	2.23504 01	7.57963 00	1.39417 01	1.78219 01	1.54210 01
211	2.23225 01	8.09217 00	1.43483 01	2.30940 01	1.63699 01
212	2.22946 01	8.73001 00	1.47925 01	3.05450 01	1.75466 01
213	2.22668 01	9.52492 00	1.52835 01	4.08749 01	1.90112 01
214	2.22390 01	1.05213 01	1.58333 01	5.48992 01	2.08299 01
215	2.22112 01	1.17826 01	1.64576 01	7.35151 01	2.30703 01
216	2.21834 01	1.34031 01	1.71784 01	9.76410 01	2.57952 01
217	2.21557 01	1.55276 01	1.80263 01	1.28128 02	2.90538 01
218	2.21280 01	1.84816 01	1.90701 01	1.65645 02	3.28712 01
219	2.21004 01	2.27328 01	2.03756 01	2.10543 02	3.72378 01
220	2.20728 01	2.95199 01	2.21213 01	2.62722 02	4.20987 01
221	2.20452 01	4.17359 01	2.46531 01	3.21505 02	4.73468 01
222	2.20177 01	6.60330 01	2.86704 01	3.85561 02	5.28196 01
223	2.19902 01	1.16011 02	3.54510 01	4.52881 02	5.83025 01
224	2.19627 01	2.14686 02	4.69227 01	5.20836 02	6.35392 01
225	2.19353 01	3.91327 02	6.51504 01	5.86322 02	6.82487 01
226	2.19079 01	6.66800 02	9.08689 01	6.45980 02	7.21435 01
227	2.18805 01	1.02854 03	1.21446 02	6.96479 02	7.49806 01
228	2.18532 01	1.41107 03	1.49872 02	7.34824 02	7.65377 01
229	2.18259 01	1.70616 03	1.66634 02	7.58654 02	7.66857 01
230	2.17986 01	1.81079 03	1.64424 02	7.66484 02	7.53792 01
231	2.17714 01	1.68559 03	1.42682 02	7.57862 02	7.26680 01
232	2.17442 01	1.37897 03	1.08272 02	7.33407 02	6.86926 01
233	2.17170 01	9.96761 02	7.15752 01	6.94740 02	6.36709 01
234	2.16899 01	6.43217 02	4.11197 01	6.44302 02	5.78761 01
235	2.16628 01	3.77578 02	2.05477 01	5.85101 02	5.16104 01
236	2.16357 01	2.08306 02	9.08865 00	5.20415 02	4.51775 01
237	2.16087 01	1.13667 02	3.90451 00	4.53496 02	3.88579 01
238	2.15817 01	6.53533 01	2.17366 00	3.87310 02	3.28884 01
239	2.15547 01	4.15397 01	1.99539 00	3.24340 02	2.74503 01
240	2.15278 01	2.93697 01	2.37787 00	2.66470 02	2.26629 01
241	2.15009 01	2.25062 01	2.90115 00	2.14940 02	1.85862 01
242	2.14741 01	1.81522 01	3.41934 00	1.70378 02	1.52271 01
243	2.14472 01	1.50855 01	3.89779 00	1.32881 02	1.25505 01
244	2.14204 01	1.28513 01	4.32050 00	1.02131 02	1.04916 01
245	2.13937 01	1.11161 01	4.69968 00	7.75167 01	8.96761 00
246	2.13670 01	9.73572 00	5.04069 00	5.82565 01	7.88883 00
247	2.13403 01	8.61602 00	5.34866 00	4.35014 01	7.16684 00
248	2.13136 01	7.69305 00	5.62808 00	3.24147 01	6.72052 00
249	2.12870 01	6.92179 00	5.88277 00	2.42276 01	6.47947 00
250	2.12604 01	6.26970 00	6.11596 00	1.82704 01	6.38550 00
251	2.12338 01	5.71271 00	6.33034 00	1.39860 01	6.39257 00
252	2.12073 01	5.23263 00	6.52819 00	1.09282 01	6.46566 00
253	2.11808 01	4.81553 00	6.71143 00	8.75196 00	6.57918 00
254	2.11543 01	4.45053 00	6.88172 00	7.19838 00	6.71511 00
255	2.11279 01	4.12904 00	7.04044 00	6.07856 00	6.86131 00
256	2.11015 01	3.84421 00	7.18881 00	5.25803 00	7.00995 00
257	2.10752 01	3.59050 00	7.32786 00	4.64307 00	7.15625 00
258	2.10488 01	3.36340 00	7.45850 00	4.16955 00	7.29750 00
259	2.10225 01	3.15919 00	7.58151 00	3.79420 00	7.43235 00

GAROL DATA TAPE, LABELED THORIUM TAPE FOR GAROL SAMPLE PROBLEMS 8-65

		TH232 300		TH232 2000	
	ENERGY-EV	CAPTURE	SCATTER	CAPTURE	SCATTER
260	2.09963 01	2.97481 00	7.69760 00	3.48809 00	7.56029 00
261	2.09701 01	2.80768 00	7.80736 00	3.23194 00	7.68131 00
262	2.09439 01	2.65565 00	7.91133 00	3.01287 00	7.79568 00
263	2.09177 01	2.51688 00	8.01000 00	2.82218 00	7.90379 00
264	2.08916 01	2.38982 00	8.10379 00	2.64720 00	8.00848 00
265	2.08655 01	2.27315 00	8.19306 00	2.49964 00	8.10430 00
266	2.08394 01	2.16571 00	8.27817 00	2.36602 00	8.19630 00
267	2.08134 01	2.06654 00	8.35943 00	2.24451 00	8.28336 00
268	2.07874 01	1.97475 00	8.43710 00	2.13356 00	8.36631 00
269	2.07614 01	1.88962 00	8.51144 00	2.03188 00	8.44544 00
270	2.07355 01	1.81049 00	8.58267 00	1.93840 00	8.52103 00
271	2.07096 01	1.73678 00	8.65099 00	1.85219 00	8.59333 00
272	2.06837 01	1.66798 00	8.71680 00	1.77246 00	8.66257 00
273	2.06578 01	1.60367 00	8.77966 00	1.69852 00	8.72895 00
274	2.06320 01	1.54342 00	8.84034 00	1.62979 00	8.79266 00
275	2.06063 01	1.48691 00	8.89876 00	1.56576 00	8.85388 00
276	2.05805 01	1.43380 00	8.95508 00	1.50597 00	8.91276 00
277	2.05548 01	1.38382 00	9.00940 00	1.45004 00	8.96945 00
278	2.05291 01	1.33672 00	9.06183 00	1.39761 00	9.02407 00
279	2.05035 01	1.29227 00	9.11249 00	1.34839 00	9.07674 00
280	2.04779 01	1.25026 00	9.16147 00	1.30209 00	9.12759 00
281	2.04523 01	1.21052 00	9.20885 00	1.25847 00	9.17670 00
282	2.04268 01	1.17287 00	9.25472 00	1.21732 00	9.22418 00
283	2.04012 01	1.13716 00	9.29916 00	1.17844 00	9.27011 00
284	2.03757 01	1.10326 00	9.34223 00	1.14166 00	9.31457 00
285	2.03503 01	1.07104 00	9.38400 00	1.10681 00	9.35764 00
286	2.03249 01	1.04038 00	9.42453 00	1.07376 00	9.39939 00
287	2.02995 01	1.01118 00	9.46389 00	1.04238 00	9.43988 00
288	2.02741 01	9.83343-01	9.50212 00	1.01255 00	9.47918 00
289	2.02488 01	9.56785-01	9.53928 00	9.84154-01	9.51733 00
290	2.02235 01	9.31422-01	9.57541 00	9.57107-01	9.55440 00
291	2.01982 01	9.07181-01	9.61056 00	9.31315-01	9.59343 00
292	2.01730 01	8.83993-01	9.64478 00	9.06698-01	9.62547 00
293	2.01478 01	8.61794-01	9.67809 00	8.83179-01	9.65957 00
294	2.01226 01	8.40526-01	9.71054 00	8.60692-01	9.69275 00
295	2.00975 01	8.20136-01	9.74217 00	8.39172-01	9.72507 00
296	2.00724 01	8.00572-01	9.77300 00	8.18561-01	9.75656 00
297	2.00473 01	7.81790-01	9.80307 00	7.98806-01	9.78725 00
298	2.00223 01	7.63745-01	9.83240 00	7.79857-01	9.81717 00
299	1.99973 01	7.46397-01	9.86103 00	7.61668-01	9.84636 00
300	1.99723 01	7.29709-01	9.88899 00	7.44196-01	9.87484 00
301	1.99473 01	7.13647-01	9.91629 00	7.27402-01	9.90265 00
302	1.99224 01	6.98177-01	9.94296 00	7.11249-01	9.92979 00
303	1.98975 01	6.83270-01	9.96903 00	6.95703-01	9.95631 00
304	1.98727 01	6.68897-01	9.99451 00	6.80732-01	9.98223 00
305	1.98478 01	6.55032-01	1.00194 01	6.66306-01	1.00076 01
306	1.98230 01	6.41649-01	1.00438 01	6.52397-01	1.00323 01
307	1.97983 01	6.28726-01	1.00677 01	6.38980-01	1.00565 01
308	1.97736 01	6.16240-01	1.00910 01	6.26030-01	1.00802 01
309	1.97488 01	6.04171-01	1.01139 01	6.13525-01	1.01034 01
310	1.97242 01	5.92499-01	1.01362 01	6.01442-01	1.01261 01
311	1.96995 01	5.81207-01	1.01582 01	5.89763-01	1.01484 01

GAROL DATA TAPE, LABELED THORIUM TAPE FOR GAROL SAMPLE PROBLEMS

		TH232 300		TH232 2000	
	ENERGY-EV	CAPTURE	SCATTER	CAPTURE	SCATTER
312	1.96749 01	5.70277-01	1.01796 01	5.78468-01	1.01701 01
313	1.96504 01	5.59694-01	1.02007 01	5.67539-01	1.01915 01
314	1.96258 01	5.49441-01	1.02213 01	5.56961-01	1.02124 01
315	1.96013 01	5.39505-01	1.02415 01	5.46717-01	1.02328 01
316	1.95768 01	5.29872-01	1.02614 01	5.36792-01	1.02529 01
317	1.95523 01	5.20528-01	1.02808 01	5.27173-01	1.02726 01
318	1.95279 01	5.11463-01	1.02999 01	5.17847-01	1.02919 01
319	1.95035 01	5.02665-01	1.03186 01	5.08801-01	1.03109 01
320	1.94792 01	4.94122-01	1.03370 01	5.00022-01	1.03295 01
321	1.94548 01	4.85824-01	1.03550 01	4.91502-01	1.03477 01
322	1.94305 01	4.77762-01	1.03728 01	4.83227-01	1.03656 01
323	1.94063 01	4.69926-01	1.03902 01	4.75190-01	1.03832 01
324	1.93820 01	4.62307-01	1.04072 01	4.67379-01	1.04005 01
325	1.93578 01	4.54898-01	1.04240 01	4.59787-01	1.04174 01
326	1.93336 01	4.47689-01	1.04405 01	4.52405-01	1.04341 01
327	1.93095 01	4.40674-01	1.04567 01	4.45224-01	1.04505 01
328	1.92853 01	4.33845-01	1.04727 01	4.38237-01	1.04666 01
329	1.92612 01	4.27196-01	1.04883 01	4.31437-01	1.04824 01
330	1.92372 01	4.20719-01	1.05037 01	4.24817-01	1.04979 01
331	1.92132 01	4.14409-01	1.05189 01	4.18369-01	1.05132 01
332	1.91892 01	4.08260-01	1.05338 01	4.12089-01	1.05282 01
333	1.91652 01	4.02266-01	1.05484 01	4.05969-01	1.05430 01
334	1.91412 01	3.96421-01	1.05629 01	4.00004-01	1.05576 01
335	1.91173 01	3.90721-01	1.05770 01	3.94189-01	1.05719 01
336	1.90934 01	3.85159-01	1.05910 01	3.88518-01	1.05860 01
337	1.90696 01	3.79733-01	1.06048 01	3.82986-01	1.05998 01
338	1.90458 01	3.74437-01	1.06183 01	3.77589-01	1.06135 01
339	1.90220 01	3.69266-01	1.06316 01	3.72321-01	1.06269 01
340	1.89982 01	3.64218-01	1.06447 01	3.67180-01	1.06401 01
341	1.89745 01	3.59286-01	1.06576 01	3.62160-01	1.06531 01
342	1.89508 01	3.54469-01	1.06704 01	3.57257-01	1.06659 01
343	1.89271 01	3.49762-01	1.06829 01	3.52468-01	1.06786 01
344	1.89035 01	3.45162-01	1.06952 01	3.47788-01	1.06910 01
345	1.88798 01	3.40665-01	1.07074 01	3.43216-01	1.07033 01
346	1.88563 01	3.36268-01	1.07194 01	3.38746-01	1.07153 01
347	1.88327 01	3.31968-01	1.07312 01	3.34376-01	1.07272 01
348	1.88092 01	3.27762-01	1.07429 01	3.30103-01	1.07390 01
349	1.87857 01	3.23648-01	1.07543 01	3.25923-01	1.07505 01
350	1.87622 01	3.19622-01	1.07657 01	3.21834-01	1.07619 01
351	1.87388 01	3.15682-01	1.07768 01	3.17834-01	1.07732 01
352	1.87154 01	3.11825-01	1.07878 01	3.13919-01	1.07842 01
353	1.86920 01	3.08048-01	1.07987 01	3.10087-01	1.07952 01
354	1.86686 01	3.04351-01	1.08094 01	3.06335-01	1.08059 01
355	1.86453 01	3.00729-01	1.08199 01	3.02662-01	1.08166 01
356	1.86220 01	2.97182-01	1.08304 01	2.99064-01	1.08270 01
357	1.85988 01	2.93707-01	1.08406 01	2.95540-01	1.08374 01
358	1.85755 01	2.90301-01	1.08508 01	2.92088-01	1.08476 01
359	1.85523 01	2.86964-01	1.08608 01	2.88705-01	1.08576 01
360	1.85291 01	2.83692-01	1.08707 01	2.85390-01	1.08676 01
361	1.85060 01	2.80485-01	1.08804 01	2.82141-01	1.08774 01
362	1.84829 01	2.77340-01	1.08900 01	2.78955-01	1.08871 01
363	1.84598 01	2.74257-01	1.08995 01	2.75832-01	1.08966 01

GAROL DATA TAPE, LABELED THORIUM TAPE FOR GAROL SAMPLE PROBLEMS

		TH232 300		TH232 2000	
	ENERGY-EV	CAPTURE	SCATTER	CAPTURE	SCATTER
364	1.84367 01	2.71232-01	1.09089 01	2.72769-01	1.09060 01
365	1.84137 01	2.68265-01	1.09182 01	2.69765-01	1.09153 01
366	1.83907 01	2.65354-01	1.09273 01	2.66819-01	1.09245 01
367	1.83677 01	2.62498-01	1.09363 01	2.63928-01	1.09336 01
368	1.83448 01	2.59695-01	1.09452 01	2.61091-01	1.09426 01
369	1.83219 01	2.56944-01	1.09541 01	2.58308-01	1.09514 01
370	1.82990 01	2.54243-01	1.09627 01	2.55576-01	1.09602 01
371	1.82761 01	2.51591-01	1.09713 01	2.52894-01	1.09688 01
372	1.82533 01	2.48988-01	1.09798 01	2.50261-01	1.09773 01
373	1.82305 01	2.46431-01	1.09882 01	2.47675-01	1.09858 01
374	1.82077 01	2.43920-01	1.09965 01	2.45136-01	1.09941 01
375	1.81850 01	2.41454-01	1.10047 01	2.42643-01	1.10023 01
376	1.81622 01	2.39030-01	1.10128 01	2.40194-01	1.10105 01
377	1.81396 01	2.36649-01	1.10208 01	2.37787-01	1.10185 01
378	1.81169 01	2.34310-01	1.10287 01	2.35423-01	1.10264 01
379	1.80943 01	2.32011-01	1.10365 01	2.33100-01	1.10343 01
380	1.80717 01	2.29751-01	1.10442 01	2.30817-01	1.10420 01
381	1.80491 01	2.27529-01	1.10519 01	2.28573-01	1.10497 01
382	1.80265 01	2.25345-01	1.10594 01	2.26367-01	1.10573 01
383	1.80040 01	2.23198-01	1.10669 01	2.24199-01	1.10648 01
384	1.79815 01	2.21086-01	1.10743 01	2.22066-01	1.10722 01
385	1.79591 01	2.19010-01	1.10816 01	2.19970-01	1.10795 01
386	1.79366 01	2.16968-01	1.10888 01	2.17908-01	1.10868 01
387	1.79142 01	2.14959-01	1.10959 01	2.15880-01	1.10940 01
388	1.78918 01	2.12982-01	1.11030 01	2.13885-01	1.11011 01
389	1.78695 01	2.11038-01	1.11100 01	2.11923-01	1.11081 01
390	1.78472 01	2.09124-01	1.11169 01	2.09992-01	1.11150 01
391	1.78249 01	2.07242-01	1.11237 01	2.08092-01	1.11219 01
392	1.78026 01	2.05389-01	1.11305 01	2.06223-01	1.11286 01
393	1.77804 01	2.03565-01	1.11372 01	2.04383-01	1.11354 01
394	1.77582 01	2.01770-01	1.11438 01	2.02572-01	1.11420 01
395	1.77360 01	2.00002-01	1.11503 01	2.00789-01	1.11486 01
396	1.77138 01	1.98262-01	1.11568 01	1.99034-01	1.11551 01
397	1.76917 01	1.96549-01	1.11632 01	1.97306-01	1.11615 01
398	1.76696 01	1.94862-01	1.11696 01	1.95605-01	1.11679 01
399	1.76475 01	1.93200-01	1.11759 01	1.93930-01	1.11742 01
400	1.76255 01	1.91564-01	1.11821 01	1.92280-01	1.11804 01
401	1.76035 01	1.89953-01	1.11882 01	1.90656-01	1.11866 01

TAPE COMPLETE. TIME = 7.403 MH

```
GAROL PROBLEM    1.      THORIUM R=2.2      T=300

GEOMETRY  =  CYLIN.

MEAN CHORD LENGTH OF REGION  1  =      4.400000 00

                     REGION  2  =      1.000000 05

DANCOFF CORRECTION  =      0.

PLOTTING OF THE RESULTS OF THIS PROBLEM HAS BEEN REQUESTED.

UPPER ENERGY LIMIT  =      2.902321 01  EV

LOWER ENERGY LIMIT  =      1.760347 01  EV

NUMBER OF BROAD GROUPS  =   2

       BROAD GROUP BOUNDARIES (EV)

    1   2.902321 01  TO   2.260330 01
    2   2.260330 01  TO   1.760347 01

NUMBER OF MATERIALS  =   2

 MATERIAL I.D.    DESCRIPTION                              D E N S I T Y
                                                        REGION  1      REGION  2

 1       1.0      HYDROGEN                            0.              1.000000 00
 2      90.232    TH232  300K, GAM=24.5, TWO RES      3.037000-02     0.
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GAROL PROBLEM 1, THORIUM R=2.2 T=300

POINT	ENERGY-EV	FLUX REGION 1	FLUX REGION 2	SOURCE REGION 1	SOURCE REGION 2	TOTAL CROSS SECTION REGION 1	TOTAL CROSS SECTION REGION 2	COLLISION DENSITY REGION 1	COLLISION DENSITY REGION 2
1	2.902321 01	3.255428-02	3.445518-02	1.318468-02	1.566144 04	4.234015-01	2.000000 01	4.000473-01	2.000000 01
2	2.898696 01	3.263290-02	3.449827-02	1.223643-02	1.566144 04	4.236767-01	2.000000 01	4.007679-01	2.000000 01
3	2.895075 01	3.271380-02	3.454142-02	1.128698-02	1.566144 04	4.239553-01	2.000000 01	4.015234-01	2.000000 01
4	2.891458 01	3.279707-02	3.458462-02	1.033635-02	1.566144 04	4.242374-01	2.000000 01	4.023100-01	2.000000 01
5	2.887846 01	3.288283-02	3.462788-02	9.384524-03	1.566144 04	4.245230-01	2.000000 01	4.031294-01	2.000000 01
6	2.884238 01	3.297119-02	3.467119-02	8.431509-03	1.566144 04	4.248123-01	2.000000 01	4.039828-01	2.000000 01
7	2.880635 01	3.306227-02	3.471456-02	7.477305-03	1.566144 04	4.251052-01	2.000000 01	4.048718-01	2.000000 01
8	2.877037 01	3.315620-02	3.475798-02	6.521903-03	1.566144 04	4.254020-01	2.000000 01	4.057977-01	2.000000 01
9	2.873443 01	3.325308-02	3.480145-02	5.565312-03	1.566144 04	4.257025-01	2.000000 01	4.067623-01	2.000000 01
10	2.869853 01	3.335307-02	3.484498-02	4.607522-03	1.566144 04	4.260070-01	2.000000 01	4.077671-01	2.000000 01
11	2.866268 01	3.345628-02	3.488856-02	3.648534-03	1.566144 04	4.263154-01	2.000000 01	4.088137-01	1.999999 01
12	2.862688 01	3.356286-02	3.493220-02	2.681347-03	1.566144 04	4.266279-01	2.000000 01	4.099040-01	1.999999 01
13	2.859111 01	3.367294-02	3.497589-02	1.726950-03	1.566144 04	4.269445-01	2.000000 01	4.110395-01	1.999999 01
14	2.855540 01	3.378672-02	3.501964-02	7.643657-04	1.566144 04	4.272654-01	2.000000 01	4.122227-01	1.999999 01
15	2.851973 01	3.389401-02	3.506344-02	0.	1.566144 04	4.275906-01	2.000000 01	4.133295-01	1.999999 01
16	2.848410 01	3.396379-02	3.510729-02	0.	1.566144 04	4.279201-01	2.000000 01	4.139819-01	1.999999 01
17	2.844852 01	3.403308-02	3.515121-02	0.	1.566144 04	4.282542-01	2.000000 01	4.146317-01	1.999999 01
18	2.841298 01	3.410176-02	3.519517-02	0.	1.566144 04	4.285929-01	2.000000 01	4.152776-01	1.999999 01
19	2.837748 01	3.416970-02	3.523919-02	0.	1.566144 04	4.289362-01	2.000000 01	4.159180-01	1.999999 01
20	2.834203 01	3.423676-02	3.528327-02	0.	1.566144 04	4.292843-01	2.000000 01	4.165515-01	1.999999 01
21	2.830663 01	3.430277-02	3.532740-02	0.	1.566144 04	4.296373-01	2.000000 01	4.171759-01	1.999999 01
22	2.827127 01	3.436757-02	3.537159-02	0.	1.566144 04	4.299952-01	2.000000 01	4.177897-01	1.999999 01
23	2.823595 01	3.443098-02	3.541583-02	0.	1.566144 04	4.303583-01	2.000000 01	4.183907-01	1.999999 01
24	2.820068 01	3.449282-02	3.546012-02	0.	1.566144 04	4.307265-01	2.000000 01	4.189767-01	1.999999 01
25	2.816545 01	3.455286-02	3.550448-02	0.	1.566144 04	4.311001-01	2.000000 01	4.195453-01	1.999999 01
26	2.813026 01	3.461094-02	3.554888-02	0.	1.566144 04	4.314791-01	2.000000 01	4.200945-01	1.999999 01
27	2.809512 01	3.466676-02	3.559335-02	0.	1.566144 04	4.318636-01	2.000000 01	4.206208-01	1.999999 01
28	2.806002 01	3.472009-02	3.563787-02	0.	1.566144 04	4.322538-01	2.000000 01	4.211218-01	1.999999 01
29	2.802497 01	3.477100-02	3.568244-02	0.	1.566144 04	4.326498-01	2.000000 01	4.215982-01	1.999999 01
30	2.798996 01	3.482055-02	3.572707-02	0.	1.566144 04	4.330517-01	2.000000 01	4.220634-01	1.999999 01
31	2.795500 01	3.486915-02	3.577176-02	0.	1.566144 04	4.334597-01	2.000000 01	4.225222-01	1.999999 01
32	2.792007 01	3.491682-02	3.581650-02	0.	1.566144 04	4.338738-01	2.000000 01	4.229751-01	1.999999 01
33	2.788520 01	3.496352-02	3.586130-02	0.	1.566144 04	4.342944-01	2.000000 01	4.234217-01	1.999999 01
34	2.785036 01	3.500924-02	3.590615-02	0.	1.566144 04	4.347214-01	2.000000 01	4.238671-01	1.999998 01
35	2.781557 01	3.505402-02	3.595106-02	0.	1.566144 04	4.351550-01	2.000000 01	4.242968-01	1.999998 01
36	2.778082 01	3.509779-02	3.599602-02	0.	1.566144 04	4.355955-01	2.000000 01	4.247254-01	1.999998 01
37	2.774612 01	3.514062-02	3.604105-02	0.	1.566144 04	4.360429-01	2.000000 01	4.251487-01	1.999998 01
38	2.771146 01	3.518253-02	3.608613-02	0.	1.566144 04	4.364974-01	2.000000 01	4.255672-01	1.999998 01
39	2.767684 01	3.522353-02	3.613126-02	0.	1.566144 04	4.369593-01	2.000000 01	4.259811-01	1.999998 01
40	2.764226 01	3.526366-02	3.617645-02	0.	1.566144 04	4.374286-01	2.000000 01	4.263912-01	1.999998 01
41	2.760773 01	3.530298-02	3.622170-02	0.	1.566144 04	4.379056-01	2.000000 01	4.267982-01	1.999998 01
42	2.757325 01	3.534154-02	3.626701-02	0.	1.566144 04	4.383904-01	2.000000 01	4.272031-01	1.999998 01
43	2.753880 01	3.537943-02	3.631237-02	0.	1.566144 04	4.388833-01	2.000000 01	4.276071-01	1.999998 01
44	2.750440 01	3.541663-02	3.635778-02	0.	1.566144 04	4.393845-01	2.000000 01	4.280102-01	1.999998 01
45	2.747004 01	3.545323-02	3.640326-02	0.	1.566144 04	4.398941-01	2.000000 01	4.284135-01	1.999998 01
46	2.743572 01	3.548919-02	3.644879-02	0.	1.566144 04	4.404124-01	2.000000 01	4.288170-01	1.999998 01
47	2.740145 01	3.552451-02	3.649438-02	0.	1.566144 04	4.409396-01	2.000000 01	4.292208-01	1.999998 01
48	2.736722 01	3.555922-02	3.654003-02	0.	1.566144 04	4.414759-01	2.000000 01	4.296253-01	1.999998 01
49	2.733303 01	3.559332-02	3.658573-02	0.	1.566144 04	4.420216-01	2.000000 01	4.300310-01	1.999998 01
50	2.729889 01	3.562686-02	3.663149-02	0.	1.566144 04	4.425769-01	2.000000 01	4.304387-01	1.999998 01
51	2.726478 01	3.565978-02	3.667731-02	0.	1.566144 04	4.431422-01	2.000000 01	4.308478-01	1.999998 01
52	2.723072 01	3.569215-02	3.672318-02	0.	1.566144 04	4.437176-01	2.000000 01	4.312593-01	1.999998 01

GAROL PROBLEM 1. THORIUM R=2.2 T=300

POINT	ENERGY-EV	FLUX REGION 1	FLUX REGION 2	SOURCE REGION 1	SOURCE REGION 2	TOTAL CROSS SECTION REGION 1	TOTAL CROSS SECTION REGION 2	COLLISION DENSITY REGION 1	COLLISION DENSITY REGION 2
53	2.719671 01	3.572395-02	3.676911-02	0.	1.566144 04	4.443034-01	2.000000 01	4.316735-01	1.999998 01
54	2.716273 01	3.575519-02	3.681510-02	0.	1.566144 04	4.449000-01	2.000000 01	4.320907-01	1.999997 01
55	2.712880 01	3.578588-02	3.686115-02	0.	1.566144 04	4.455075-01	2.000000 01	4.325111-01	1.999997 01
56	2.709491 01	3.581601-02	3.690725-02	0.	1.566144 04	4.461264-01	2.000000 01	4.329351-01	1.999997 01
57	2.706106 01	3.584558-02	3.695341-02	0.	1.566144 04	4.467570-01	2.000000 01	4.333629-01	1.999997 01
58	2.702726 01	3.587457-02	3.699963-02	0.	1.566144 04	4.473995-01	2.000000 01	4.337947-01	1.999997 01
59	2.699349 01	3.590301-02	3.704591-02	0.	1.566144 04	4.480544-01	2.000000 01	4.342309-01	1.999997 01
60	2.695977 01	3.593090-02	3.709225-02	0.	1.566144 04	4.487220-01	2.000000 01	4.346720-01	1.999997 01
61	2.692610 01	3.595819-02	3.713864-02	0.	1.566144 04	4.494026-01	2.000000 01	4.351177-01	1.999997 01
62	2.689246 01	3.598490-02	3.718509-02	0.	1.566144 04	4.500967-01	2.000000 01	4.355687-01	1.999997 01
63	2.685886 01	3.601101-02	3.723160-02	0.	1.566144 04	4.508047-01	2.000000 01	4.360249-01	1.999997 01
64	2.682531 01	3.603652-02	3.727817-02	0.	1.566144 04	4.515269-01	2.000000 01	4.364869-01	1.999997 01
65	2.679180 01	3.606139-02	3.732480-02	0.	1.566144 04	4.522639-01	2.000000 01	4.369546-01	1.999997 01
66	2.675833 01	3.608563-02	3.737148-02	0.	1.566144 04	4.530161-01	2.000000 01	4.374283-01	1.999997 01
67	2.672490 01	3.610925-02	3.741822-02	0.	1.566144 04	4.537839-01	2.000000 01	4.379088-01	1.999997 01
68	2.669152 01	3.613218-02	3.746502-02	0.	1.566144 04	4.545679-01	2.000000 01	4.383957-01	1.999997 01
69	2.665818 01	3.615444-02	3.751188-02	0.	1.566144 04	4.553686-01	2.000000 01	4.388895-01	1.999997 01
70	2.662487 01	3.617600-02	3.755880-02	0.	1.566144 04	4.561865-01	2.000000 01	4.393904-01	1.999997 01
71	2.659161 01	3.619685-02	3.760578-02	0.	1.566144 04	4.570222-01	2.000000 01	4.398987-01	1.999997 01
72	2.655839 01	3.621693-02	3.765282-02	0.	1.566144 04	4.578762-01	2.000000 01	4.404145-01	1.999997 01
73	2.652522 01	3.623625-02	3.769991-02	0.	1.566144 04	4.587493-01	2.000000 01	4.409381-01	1.999997 01
74	2.649208 01	3.625480-02	3.774706-02	0.	1.566144 04	4.596420-01	2.000000 01	4.414701-01	1.999997 01
75	2.645899 01	3.627254-02	3.779428-02	0.	1.566144 04	4.605550-01	2.000000 01	4.420106-01	1.999997 01
76	2.642593 01	3.628944-02	3.784155-02	0.	1.566144 04	4.614890-01	2.000000 01	4.425597-01	1.999996 01
77	2.639292 01	3.630544-02	3.788888-02	0.	1.566144 04	4.624448-01	2.000000 01	4.431177-01	1.999996 01
78	2.635995 01	3.632056-02	3.793627-02	0.	1.566144 04	4.634231-01	2.000000 01	4.436850-01	1.999996 01
79	2.632702 01	3.633474-02	3.798372-02	0.	1.566144 04	4.644247-01	2.000000 01	4.442619-01	1.999996 01
80	2.629413 01	3.634794-02	3.803123-02	0.	1.566144 04	4.654505-01	2.000000 01	4.448485-01	1.999996 01
81	2.626129 01	3.636013-02	3.807879-02	0.	1.566144 04	4.665014-01	2.000000 01	4.454453-01	1.999996 01
82	2.622848 01	3.637126-02	3.812642-02	0.	1.566144 04	4.675783-01	2.000000 01	4.460524-01	1.999996 01
83	2.619571 01	3.638134-02	3.817411-02	0.	1.566144 04	4.686822-01	2.000000 01	4.466707-01	1.999996 01
84	2.616299 01	3.639028-02	3.822186-02	0.	1.566144 04	4.698141-01	2.000000 01	4.473000-01	1.999996 01
85	2.613031 01	3.639803-02	3.826966-02	0.	1.566144 04	4.709752-01	2.000000 01	4.479406-01	1.999995 01
86	2.609766 01	3.640458-02	3.831753-02	0.	1.566144 04	4.721665-01	2.000000 01	4.485934-01	1.999996 01
87	2.606506 01	3.640981-02	3.836545-02	0.	1.566144 04	4.733893-01	2.000000 01	4.492579-01	1.999996 01
88	2.603250 01	3.641372-02	3.841344-02	0.	1.566144 04	4.746448-01	2.000000 01	4.499349-01	1.999996 01
89	2.599998 01	3.641624-02	3.846149-02	0.	1.566144 04	4.759344-01	2.000000 01	4.506250-01	1.999996 01
90	2.596750 01	3.641732-02	3.850959-02	0.	1.566144 04	4.772595-01	2.000000 01	4.513285-01	1.999996 01
91	2.593506 01	3.641687-02	3.855776-02	0.	1.566144 04	4.786216-01	2.000000 01	4.520456-01	1.999996 01
92	2.590266 01	3.641486-02	3.860598-02	0.	1.566144 04	4.800222-01	2.000000 01	4.527770-01	1.999996 01
93	2.587031 01	3.641116-02	3.865427-02	0.	1.566144 04	4.814630-01	2.000000 01	4.535227-01	1.999996 01
94	2.583799 01	3.640578-02	3.870262-02	0.	1.566144 04	4.829459-01	2.000000 01	4.542840-01	1.999996 01
95	2.580571 01	3.639858-02	3.875102-02	0.	1.566144 04	4.844725-01	2.000000 01	4.550609-01	1.999995 01
96	2.577347 01	3.638947-02	3.879949-02	0.	1.566144 04	4.860451-01	2.000000 01	4.558534-01	1.999995 01
97	2.574128 01	3.637837-02	3.884802-02	0.	1.566144 04	4.876655-01	2.000000 01	4.566625-01	1.999995 01
98	2.570912 01	3.636522-02	3.889661-02	0.	1.566144 04	4.893361-01	2.000000 01	4.574890-01	1.999995 01
99	2.567700 01	3.634986-02	3.894526-02	0.	1.566144 04	4.910593-01	2.000000 01	4.583329-01	1.999995 01
100	2.564493 01	3.633224-02	3.899397-02	0.	1.566144 04	4.928375-01	2.000000 01	4.591953-01	1.999995 01
101	2.561289 01	3.631220-02	3.904274-02	0.	1.566144 04	4.946735-01	2.000000 01	4.600762-01	1.999995 01
102	2.558090 01	3.628964-02	3.909158-02	0.	1.566144 04	4.965701-01	2.000000 01	4.609767-01	1.999995 01
103	2.554894 01	3.626446-02	3.914047-02	0.	1.566144 04	4.985304-01	2.000000 01	4.618976-01	1.999995 01
104	2.551702 01	3.623648-02	3.918943-02	0.	1.566144 04	5.005576-01	2.000000 01	4.628391-01	1.999995 01

GAROL PROBLEM 1, THORIUM R=2.2 T=300

POINT	ENERGY-EV	FLUX REGION 1	FLUX REGION 2	SOURCE REGION 1	SOURCE REGION 2	TOTAL CROSS SECTION REGION 1	TOTAL CROSS SECTION REGION 2	COLLISION DENSITY REGION 1	COLLISION DENSITY REGION 2
105	2.548515 01	3.620560-02	3.923844-02	0.	1.566144 04	5.026553-01	2.000000 01	4.638026-01	1.999995 01
106	2.545331 01	3.617164-02	3.928752-02	0.	1.566144 04	5.048271-01	2.000000 01	4.647883-01	1.999995 01
107	2.542151 01	3.613439-02	3.933666-02	0.	1.566144 04	5.070771-01	2.000000 01	4.657964-01	1.999995 01
108	2.538976 01	3.609375-02	3.938586-02	0.	1.566144 04	5.094096-01	2.000000 01	4.668288-01	1.999995 01
109	2.535804 01	3.604949-02	3.943512-02	0.	1.566144 04	5.118291-01	2.000000 01	4.678857-01	1.999995 01
110	2.532636 01	3.600144-02	3.948445-02	0.	1.566144 04	5.143407-01	2.000000 01	4.689684-01	1.999995 01
111	2.529472 01	3.594938-02	3.953383-02	0.	1.566144 04	5.169496-01	2.000000 01	4.700776-01	1.999995 01
112	2.526312 01	3.589308-02	3.958328-02	0.	1.566144 04	5.196617-01	2.000000 01	4.712144-01	1.999995 01
113	2.523156 01	3.583233-02	3.963279-02	0.	1.566144 04	5.224832-01	2.000000 01	4.723801-01	1.999995 01
114	2.520004 01	3.576681-02	3.968236-02	0.	1.566144 04	5.254208-01	2.000000 01	4.735750-01	1.999994 01
115	2.516856 01	3.569629-02	3.973199-02	0.	1.566144 04	5.284817-01	2.000000 01	4.748009-01	1.999994 01
116	2.513712 01	3.562040-02	3.978169-02	0.	1.566144 04	5.316740-01	2.000000 01	4.760579-01	1.999994 01
117	2.510572 01	3.553890-02	3.983144-02	0.	1.566144 04	5.350061-01	2.000000 01	4.773483-01	1.999994 01
118	2.507436 01	3.545140-02	3.988126-02	0.	1.566144 04	5.384874-01	2.000000 01	4.786727-01	1.999994 01
119	2.504303 01	3.535753-02	3.993115-02	0.	1.566144 04	5.421281-01	2.000000 01	4.800327-01	1.999994 01
120	2.501175 01	3.525693-02	3.998109-02	0.	1.566144 04	5.459393-01	2.000000 01	4.814298-01	1.999994 01
121	2.498051 01	3.514917-02	4.003110-02	0.	1.566144 04	5.499331-01	2.000000 01	4.828655-01	1.999994 01
122	2.494930 01	3.503376-02	4.008117-02	0.	1.566144 04	5.541230-01	2.000000 01	4.843410-01	1.999994 01
123	2.491813 01	3.491015-02	4.013130-02	0.	1.566144 04	5.585236-01	2.000000 01	4.858573-01	1.999994 01
124	2.488700 01	3.477785-02	4.018149-02	0.	1.566144 04	5.631508-01	2.000000 01	4.874163-01	1.999994 01
125	2.485591 01	3.463629-02	4.023175-02	0.	1.566144 04	5.680227-01	2.000000 01	4.890202-01	1.999994 01
126	2.482486 01	3.448483-02	4.028207-02	0.	1.566144 04	5.731587-01	2.000000 01	4.906703-01	1.999994 01
127	2.479385 01	3.432278-02	4.033245-02	0.	1.566144 04	5.785808-01	2.000000 01	4.923687-01	1.999994 01
128	2.476288 01	3.414935-02	4.038290-02	0.	1.566144 04	5.843130-01	2.000000 01	4.941163-01	1.999994 01
129	2.473195 01	3.396379-02	4.043341-02	0.	1.566144 04	5.903825-01	2.000000 01	4.959157-01	1.999994 01
130	2.470105 01	3.376517-02	4.048398-02	0.	1.566144 04	5.968193-01	2.000000 01	4.977682-01	1.999994 01
131	2.467019 01	3.355250-02	4.053462-02	0.	1.566144 04	6.036572-01	2.000000 01	4.996752-01	1.999994 01
132	2.463937 01	3.332480-02	4.058531-02	0.	1.566144 04	6.109341-01	2.000000 01	5.016392-01	1.999993 01
133	2.460859 01	3.308101-02	4.063608-02	0.	1.566144 04	6.186928-01	2.000000 01	5.036637-01	1.999993 01
134	2.457785 01	3.281975-02	4.068690-02	0.	1.566144 04	6.269819-01	2.000000 01	5.057481-01	1.999993 01
135	2.454715 01	3.253968-02	4.073779-02	0.	1.566144 04	6.358561-01	2.000000 01	5.078942-01	1.999993 01
136	2.451648 01	3.223947-02	4.078875-02	0.	1.566144 04	6.453784-01	2.000000 01	5.101062-01	1.999993 01
137	2.448586 01	3.191728-02	4.083976-02	0.	1.566144 04	6.556203-01	2.000000 01	5.123816-01	1.999993 01
138	2.445527 01	3.157144-02	4.089084-02	0.	1.566144 04	6.666643-01	2.000000 01	5.147236-01	1.999993 01
139	2.442472 01	3.120001-02	4.094199-02	0.	1.566144 04	6.786057-01	2.000000 01	5.171325-01	1.999993 01
140	2.439421 01	3.080090-02	4.099320-02	0.	1.566144 04	6.915551-01	2.000000 01	5.196094-01	1.999993 01
141	2.436373 01	3.037173-02	4.104447-02	0.	1.566144 04	7.056415-01	2.000000 01	5.221526-01	1.999993 01
142	2.433330 01	2.991006-02	4.109581-02	0.	1.566144 04	7.210162-01	2.000000 01	5.247631-01	1.999993 01
143	2.430290 01	2.941297-02	4.114720-02	0.	1.566144 04	7.378579-01	2.000000 01	5.274360-01	1.999993 01
144	2.427254 01	2.887745-02	4.119867-02	0.	1.566144 04	7.563790-01	2.000000 01	5.301681-01	1.999993 01
145	2.424222 01	2.830029-02	4.125020-02	0.	1.566144 04	7.768337-01	2.000000 01	5.329560-01	1.999993 01
146	2.421193 01	2.767771-02	4.130179-02	0.	1.566144 04	7.995285-01	2.000000 01	5.357887-01	1.999993 01
147	2.418169 01	2.700594-02	4.135345-02	0.	1.566144 04	8.248364-01	2.000000 01	5.386587-01	1.999993 01
148	2.415148 01	2.628073-02	4.140517-02	0.	1.566144 04	8.532156-01	2.000000 01	5.415517-01	1.999993 01
149	2.412131 01	2.549742-02	4.145696-02	0.	1.566144 04	8.852341-01	2.000000 01	5.444465-01	1.999992 01
150	2.409118 01	2.465129-02	4.150882-02	0.	1.566144 04	9.216055-01	2.000000 01	5.473217-01	1.999992 01
151	2.406108 01	2.373707-02	4.156073-02	0.	1.566144 04	9.632362-01	2.000000 01	5.501422-01	1.999992 01
152	2.403102 01	2.274987-02	4.161271-02	0.	1.566144 04	1.011296 00	2.000000 01	5.528783-01	1.999992 01
153	2.400100 01	2.168397-02	4.166476-02	0.	1.566144 04	1.067318 00	2.000000 01	5.554715-01	1.999992 01
154	2.397102 01	2.053394-02	4.171687-02	0.	1.566144 04	1.133350 00	2.000000 01	5.578571-01	1.999992 01
155	2.394108 01	1.929513-02	4.176905-02	0.	1.566144 04	1.212193 00	2.000000 01	5.599678-01	1.999992 01
156	2.391117 01	1.796262-02	4.182129-02	0.	1.566144 04	1.307771 00	2.000000 01	5.616974-01	1.999992 01

GAROL PROBLEM 1, THORIUM R=2.2 T=300

POINT	ENERGY-EV	FLUX REGION 1	FLUX REGION 2	SOURCE REGION 1	SOURCE REGION 2	TOTAL CROSS SECTION REGION 1	TOTAL CROSS SECTION REGION 2	COLLISION DENSITY REGION 1	COLLISION DENSITY REGION 2
157	2.388130 01	1.653285-02	4.187360-02	0.	1.566144 04	1.425768 00	2.000000 01	5.629304-01	1.999992 01
158	2.385147 01	1.500319-02	4.192597-02	0.	1.566144 04	1.574737 00	2.000000 01	5.635165-01	1.999992 01
159	2.382167 01	1.334777-02	4.197841-02	0.	1.566144 04	1.771920 00	2.000000 01	5.634107-01	1.999992 01
160	2.379191 01	1.157358-02	4.203091-02	0.	1.566144 04	2.042169 00	2.000000 01	5.623268-01	1.999992 01
161	2.376219 01	9.634381-03	4.208349-02	0.	1.566144 04	2.445896 00	2.000000 01	5.601776-01	1.999992 01
162	2.373251 01	7.496224-03	4.213612-02	0.	1.566144 04	3.128956 00	2.000000 01	5.566543-01	1.999992 01
163	2.370286 01	5.249934-03	4.218882-02	0.	1.566144 04	4.426420 00	2.000000 01	5.508168-01	1.999991 01
164	2.367325 01	3.235904-03	4.224159-02	0.	1.566144 04	7.064778 00	2.000000 01	5.411927-01	1.999991 01
165	2.364368 01	1.805631-03	4.229442-02	0.	1.566144 04	1.234352 01	2.000000 01	5.269666-01	1.999991 01
166	2.361414 01	9.788079-04	4.234732-02	0.	1.566144 04	2.202142 01	2.000000 01	5.089966-01	1.999991 01
167	2.358464 01	5.530087-04	4.240029-02	0.	1.566144 04	3.747956 01	2.000000 01	4.888276-01	1.999991 01
168	2.355518 01	3.415327-04	4.245332-02	0.	1.566144 04	5.813277 01	2.000000 01	4.676701-01	1.999991 01
169	2.352575 01	2.368779-04	4.250642-02	0.	1.566144 04	8.007792 01	2.000000 01	4.462527-01	1.999991 01
170	2.349636 01	1.871217-04	4.255958-02	0.	1.566144 04	9.666346 01	2.000000 01	4.249982-01	1.999991 01
171	2.346701 01	1.694894-04	4.261282-02	0.	1.566144 04	1.016178 02	2.000000 01	4.041755-01	1.999991 01
172	2.343770 01	1.764206-04	4.266611-02	0.	1.566144 04	9.286864 01	2.000000 01	3.840017-01	1.999991 01
173	2.340842 01	2.107620-04	4.271948-02	0.	1.566144 04	7.391452 01	2.000000 01	3.646650-01	1.999991 01
174	2.337917 01	2.875044-04	4.277291-02	0.	1.566144 04	5.153019 01	2.000000 01	3.463662-01	1.999991 01
175	2.334997 01	4.429184-04	4.282641-02	0.	1.566144 04	3.184314 01	2.000000 01	3.293259-01	1.999991 01
176	2.332080 01	7.544975-04	4.287998-02	0.	1.566144 04	1.783715 01	2.000000 01	3.138533-01	1.999991 01
177	2.329167 01	1.366933-03	4.293361-02	0.	1.566144 04	9.428705 00	2.000000 01	3.001925-01	1.999991 01
178	2.326257 01	2.472445-03	4.298731-02	0.	1.566144 04	5.012454 00	2.000000 01	2.882934-01	1.999991 01
179	2.323351 01	4.137257-03	4.304108-02	0.	1.566144 04	2.889351 00	2.000000 01	2.777331-01	1.999991 01
180	2.320449 01	6.102974-03	4.309491-02	0.	1.566144 04	1.893075 00	2.000000 01	2.680904-01	1.999990 01
181	2.317550 01	7.996345-03	4.314881-02	0.	1.566144 04	1.399618 00	2.000000 01	2.593761-01	1.999990 01
182	2.314655 01	9.654020-03	4.320278-02	0.	1.566144 04	1.126122 00	2.000000 01	2.516401-01	1.999990 01
183	2.311763 01	1.108658-02	4.325682-02	0.	1.566144 04	9.555544-01	2.000000 01	2.449043-01	1.999990 01
184	2.308875 01	1.234768-02	4.331092-02	0.	1.566144 04	8.389201-01	2.000000 01	2.391699-01	1.999990 01
185	2.305991 01	1.344748-02	4.336509-02	0.	1.566144 04	7.563022-01	2.000000 01	2.345275-01	1.999990 01
186	2.303110 01	1.442793-02	4.341933-02	0.	1.566144 04	6.949570-01	2.000000 01	2.309280-01	1.999990 01
187	2.300233 01	1.530807-02	4.347364-02	0.	1.566144 04	6.485855-01	2.000000 01	2.283808-01	1.999990 01
188	2.297360 01	1.610617-02	4.352802-02	0.	1.566144 04	6.131110-01	2.000000 01	2.268613-01	1.999990 01
189	2.294490 01	1.684101-02	4.358246-02	0.	1.566144 04	5.857898-01	2.000000 01	2.263581-01	1.999990 01
190	2.291623 01	1.752846-02	4.363697-02	0.	1.566144 04	5.647175-01	2.000000 01	2.268393-01	1.999990 01
191	2.288761 01	1.818389-02	4.369155-02	0.	1.566144 04	5.485393-01	2.000000 01	2.282942-01	1.999990 01
192	2.285902 01	1.881844-02	4.374620-02	0.	1.566144 04	5.362725-01	2.000000 01	2.306889-01	1.999990 01
193	2.283046 01	1.943636-02	4.380091-02	0.	1.566144 04	5.271942-01	2.000000 01	2.339377-01	1.999990 01
194	2.280194 01	2.003135-02	4.385570-02	0.	1.566144 04	5.207671-01	2.000000 01	2.378623-01	1.999990 01
195	2.277346 01	2.059365-02	4.391055-02	0.	1.566144 04	5.165903-01	2.000000 01	2.422750-01	1.999990 01
196	2.274501 01	2.111445-02	4.396547-02	0.	1.566144 04	5.143649-01	2.000000 01	2.470228-01	1.999990 01
197	2.271659 01	2.158875-02	4.402047-02	0.	1.566144 04	5.138712-01	2.000000 01	2.520142-01	1.999990 01
198	2.268821 01	2.201423-02	4.407552-02	0.	1.566144 04	5.149520-01	2.000000 01	2.571998-01	1.999990 01
199	2.265987 01	2.238990-02	4.413066-02	0.	1.566144 04	5.175018-01	2.000000 01	2.625556-01	1.999990 01
200	2.263156 01	2.271469-02	4.418585-02	0.	1.566144 04	5.214584-01	2.000000 01	2.680656-01	1.999990 01
201	2.260329 01	2.298764-02	4.424112-02	0.	1.566144 04	5.267994-01	2.000000 01	2.737230-01	1.999990 01
202	2.257506 01	2.320770-02	4.429645-02	0.	1.566144 04	5.335387-01	2.000000 01	2.795290-01	1.999990 01
203	2.254685 01	2.337247-02	4.435186-02	0.	1.566144 04	5.417272-01	2.000000 01	2.854770-01	1.999990 01
204	2.251869 01	2.348005-02	4.440733-02	0.	1.566144 04	5.514540-01	2.000000 01	2.915758-01	1.999990 01
205	2.249056 01	2.352658-02	4.446287-02	0.	1.566144 04	5.628505-01	2.000000 01	2.978187-01	1.999990 01
206	2.246246 01	2.350782-02	4.451849-02	0.	1.566144 04	5.760973-01	2.000000 01	3.042044-01	1.999990 01
207	2.243440 01	2.341887-02	4.457417-02	0.	1.566144 04	5.914338-01	2.000000 01	3.107324-01	1.999990 01
208	2.240638 01	2.325311-02	4.462992-02	0.	1.566144 04	6.091725-01	2.000000 01	3.173898-01	1.999990 01

GAROL PROBLEM 1. THORIUM R=2.2 T=300

POINT	ENERGY-EV	FLUX REGION 1	FLUX REGION 2	SOURCE REGION 1	SOURCE REGION 2	TOTAL CROSS SECTION REGION 1	TOTAL CROSS SECTION REGION 2	COLLISION DENSITY REGION 1	COLLISION DENSITY REGION 2
209	2.237839 01	2.300486-02	4.468574-02	0.	1.566144 04	6.297194-01	2.000000 01	3.241868-01	1.999989 01
210	2.235043 01	2.266626-02	4.474163-02	0.	1.566144 04	6.536027-01	2.000000 01	3.311156-01	1.999989 01
211	2.232251 01	2.222870-02	4.479759-02	0.	1.566144 04	6.815159-01	2.000000 01	3.381685-01	1.999989 01
212	2.229462 01	2.168299-02	4.485362-02	0.	1.566144 04	7.143789-01	2.000000 01	3.453409-01	1.999989 01
213	2.226677 01	2.101837-02	4.490972-02	0.	1.566144 04	7.534331-01	2.000000 01	3.526152-01	1.999989 01
214	2.223896 01	2.022313-02	4.496590-02	0.	1.566144 04	8.003874-01	2.000000 01	3.599673-01	1.999989 01
215	2.221117 01	1.928330-02	4.502214-02	0.	1.566144 04	8.576563-01	2.000000 01	3.673383-01	1.999989 01
216	2.218343 01	1.818534-02	4.507845-02	0.	1.566144 04	9.287586-01	2.000000 01	3.746735-01	1.999989 01
217	2.215572 01	1.691333-02	4.513483-02	0.	1.566144 04	1.019033 00	2.000000 01	3.818591-01	1.999989 01
218	2.212804 01	1.541093-02	4.519128-02	0.	1.566144 04	1.140444 00	2.000000 01	3.889069-01	1.999989 01
219	2.210040 01	1.367080-02	4.524781-02	0.	1.566144 04	1.309202 00	2.000000 01	3.955491-01	1.999989 01
220	2.207279 01	1.160309-02	4.530440-02	0.	1.566144 04	1.568343 00	2.000000 01	4.016723-01	1.999989 01
221	2.204521 01	9.154517-03	4.536106-02	0.	1.566144 04	2.016235 00	2.000000 01	4.069031-01	1.999989 01
222	2.201767 01	6.476127-03	4.541780-02	0.	1.566144 04	2.876144 00	2.000000 01	4.101073-01	1.999989 01
223	2.199017 01	4.049387-03	4.547460-02	0.	1.566144 04	4.599888 00	2.000000 01	4.096050-01	1.999989 01
224	2.196270 01	2.319311-03	4.553148-02	0.	1.566144 04	7.945043 00	2.000000 01	4.047071-01	1.999988 01
225	2.193526 01	1.302934-03	4.558843-02	0.	1.566144 04	1.386323 01	2.000000 01	3.962139-01	1.999988 01
226	2.190786 01	7.646107-04	4.564545-02	0.	1.566144 04	2.301040 01	2.000000 01	3.854468-01	1.999988 01
227	2.188049 01	4.886406-04	4.570254-02	0.	1.566144 04	3.492521 01	2.000000 01	3.734098-01	1.999988 01
228	2.185316 01	3.481765-04	4.575971-02	0.	1.566144 04	4.740572 01	2.000000 01	3.606986-01	1.999988 01
229	2.182586 01	2.800635-04	4.581694-02	0.	1.566144 04	5.687682 01	2.000000 01	3.476668-01	1.999988 01
230	2.179859 01	2.558397-04	4.587425-02	0.	1.566144 04	5.998726 01	2.000000 01	3.345458-01	1.999988 01
231	2.177136 01	2.659727-04	4.593162-02	0.	1.566144 04	5.552468 01	2.000000 01	3.215206-01	1.999988 01
232	2.174417 01	3.143874-04	4.598907-02	0.	1.566144 04	4.516739 01	2.000000 01	3.087684-01	1.999988 01
233	2.171700 01	4.207815-04	4.604659-02	0.	1.566144 04	3.244537 01	2.000000 01	2.964894-01	1.999988 01
234	2.168987 01	6.320492-04	4.610419-02	0.	1.566144 04	2.078331 01	2.000000 01	2.849198-01	1.999988 01
235	2.166278 01	1.047590-03	4.616186-02	0.	1.566144 04	1.209109 01	2.000000 01	2.743915-01	1.999988 01
236	2.163572 01	1.856327-03	4.621959-02	0.	1.566144 04	6.602263 00	2.000000 01	2.651665-01	1.999988 01
237	2.160869 01	3.332613-03	4.627740-02	0.	1.566144 04	3.570642 00	2.000000 01	2.571340-01	1.999988 01
238	2.158169 01	5.638109-03	4.633528-02	0.	1.566144 04	2.050795 00	2.000000 01	2.495406-01	1.999988 01
239	2.155473 01	8.472858-03	4.639324-02	0.	1.566144 04	1.322159 00	2.000000 01	2.414662-01	1.999988 01
240	2.152781 01	1.121553-02	4.645127-02	0.	1.566144 04	9.641735-01	2.000000 01	2.327955-01	1.999988 01
241	2.150091 01	1.353289-02	4.650937-02	0.	1.566144 04	7.716197-01	2.000000 01	2.245178-01	1.999988 01
242	2.147406 01	1.544531-02	4.656754-02	0.	1.566144 04	6.551269-01	2.000000 01	2.172882-01	1.999988 01
243	2.144723 01	1.707918-02	4.662579-02	0.	1.566144 04	5.765215-01	2.000000 01	2.111805-01	1.999988 01
244	2.142044 01	1.847226-02	4.668410-02	0.	1.566144 04	5.215086-01	2.000000 01	2.063526-01	1.999988 01
245	2.139368 01	1.971553-02	4.674250-02	0.	1.566144 04	4.803265-01	2.000000 01	2.025958-01	1.999988 01
246	2.136695 01	2.084236-02	4.680096-02	0.	1.566144 04	4.487598-01	2.000000 01	1.998496-01	1.999988 01
247	2.134026 01	2.188195-02	4.685950-02	0.	1.566144 04	4.241074-01	2.000000 01	1.980440-01	1.999988 01
248	2.131360 01	2.285908-02	4.691811-02	0.	1.566144 04	4.045625-01	2.000000 01	1.971066-01	1.999988 01
249	2.128698 01	2.379390-02	4.697679-02	0.	1.566144 04	3.888745-01	2.000000 01	1.969650-01	1.999988 01
250	2.126038 01	2.470379-02	4.703555-02	0.	1.566144 04	3.761524-01	2.000000 01	1.975597-01	1.999988 01
251	2.123382 01	2.559994-02	4.709438-02	0.	1.566144 04	3.657472-01	2.000000 01	1.988146-01	1.999988 01
252	2.120730 01	2.648520-02	4.715328-02	0.	1.566144 04	3.571761-01	2.000000 01	2.006185-01	1.999988 01
253	2.118081 01	2.735229-02	4.721226-02	0.	1.566144 04	3.500739-01	2.000000 01	2.028131-01	1.999988 01
254	2.115435 01	2.819047-02	4.727131-02	0.	1.566144 04	3.441603-01	2.000000 01	2.052403-01	1.999987 01
255	2.112792 01	2.899184-02	4.733044-02	0.	1.566144 04	3.392171-01	2.000000 01	2.077831-01	1.999987 01
256	2.110153 01	2.975522-02	4.738964-02	0.	1.566144 04	3.350727-01	2.000000 01	2.103856-01	1.999987 01
257	2.107517 01	3.048088-02	4.744891-02	0.	1.566144 04	3.315905-01	2.000000 01	2.130103-01	1.999987 01
258	2.104884 01	3.117193-02	4.750826-02	0.	1.566144 04	3.286610-01	2.000000 01	2.156453-01	1.999987 01
259	2.102254 01	3.183131-02	4.756768-02	0.	1.566144 04	3.251953-01	2.000000 01	2.182817-01	1.999987 01
260	2.099628 01	3.246164-02	4.762718-02	0.	1.566144 04	3.241211-01	2.000000 01	2.209125-01	1.999987 01

GAROL PROBLEM 1, THORIUM R=2.2 T=300

POINT	ENERGY-EV	FLUX REGION 1	FLUX REGION 2	SOURCE REGION 1	SOURCE REGION 2	TOTAL CROSS SECTION REGION 1	TOTAL CROSS SECTION REGION 2	COLLISION DENSITY REGION 1	COLLISION DENSITY REGION 2
261	2.097005 01	3.306532-02	4.768675-02	0.	1.566144 04	3.223788-01	2.000000 01	2.235315-01	1.999987 01
262	2.094386 01	3.364414-02	4.774639-02	0.	1.566144 04	3.209192-01	2.000000 01	2.261319-01	1.999987 01
263	2.091769 01	3.419965-02	4.780611-02	0.	1.566144 04	3.197013-01	2.000000 01	2.287072-01	1.999987 01
264	2.089156 01	3.473349-02	4.786591-02	0.	1.566144 04	3.186907-01	2.000000 01	2.312538-01	1.999987 01
265	2.086546 01	3.524641-02	4.792577-02	0.	1.566144 04	3.178587-01	2.000000 01	2.337637-01	1.999987 01
266	2.083940 01	3.573898-02	4.798572-02	0.	1.566144 04	3.171809-01	2.000000 01	2.362297-01	1.999987 01
267	2.081337 01	3.621180-02	4.804574-02	0.	1.566144 04	3.166365-01	2.000000 01	2.386457-01	1.999987 01
268	2.078737 01	3.666567-02	4.810583-02	0.	1.566144 04	3.162080-01	2.000000 01	2.410083-01	1.999987 01
269	2.076140 01	3.710125-02	4.816600-02	0.	1.566144 04	3.158801-01	2.000000 01	2.433142-01	1.999987 01
270	2.073546 01	3.751974-02	4.822625-02	0.	1.566144 04	3.156400-01	2.000000 01	2.455645-01	1.999987 01
271	2.070956 01	3.792213-02	4.828656-02	0.	1.566144 04	3.154765-01	2.000000 01	2.477596-01	1.999987 01
272	2.068369 01	3.830930-02	4.834696-02	0.	1.566144 04	3.153798-01	2.000000 01	2.498999-01	1.999987 01
273	2.065785 01	3.868214-02	4.840743-02	0.	1.566144 04	3.153417-01	2.000000 01	2.519864-01	1.999987 01
274	2.063204 01	3.904118-02	4.846798-02	0.	1.566144 04	3.153548-01	2.000000 01	2.540181-01	1.999987 01
275	2.060627 01	3.938740-02	4.852860-02	0.	1.566144 04	3.154128-01	2.000000 01	2.559977-01	1.999987 01
276	2.058053 01	3.972142-02	4.858930-02	0.	1.566144 04	3.155102-01	2.000000 01	2.579258-01	1.999987 01
277	2.055482 01	4.004384-02	4.865007-02	0.	1.566144 04	3.156421-01	2.000000 01	2.598030-01	1.999987 01
278	2.052914 01	4.035523-02	4.871092-02	0.	1.566144 04	3.158041-01	2.000000 01	2.616305-01	1.999987 01
279	2.050349 01	4.065597-02	4.877185-02	0.	1.566144 04	3.159927-01	2.000000 01	2.634081-01	1.999987 01
280	2.047788 01	4.094667-02	4.883285-02	0.	1.566144 04	3.162044-01	2.000000 01	2.651377-01	1.999987 01
281	2.045230 01	4.122793-02	4.889393-02	0.	1.566144 04	3.164363-01	2.000000 01	2.668210-01	1.999986 01
282	2.042675 01	4.150016-02	4.895508-02	0.	1.566144 04	3.166860-01	2.000000 01	2.684589-01	1.999985 01
283	2.040123 01	4.176384-02	4.901631-02	0.	1.566144 04	3.169510-01	2.000000 01	2.700529-01	1.999986 01
284	2.037575 01	4.201942-02	4.907762-02	0.	1.566144 04	3.172294-01	2.000000 01	2.716045-01	1.999985 01
285	2.035029 01	4.226715-02	4.913900-02	0.	1.566144 04	3.175193-01	2.000000 01	2.731139-01	1.999986 01
286	2.032487 01	4.250736-02	4.920047-02	0.	1.566144 04	3.178193-01	2.000000 01	2.745820-01	1.999986 01
287	2.029948 01	4.274081-02	4.926201-02	0.	1.566144 04	3.181277-01	2.000000 01	2.760128-01	1.999986 01
288	2.027412 01	4.296764-02	4.932362-02	0.	1.566144 04	3.184435-01	2.000000 01	2.774061-01	1.999986 01
289	2.024880 01	4.318815-02	4.938532-02	0.	1.566144 04	3.187655-01	2.000000 01	2.787630-01	1.999986 01
290	2.022350 01	4.340252-02	4.944708-02	0.	1.566144 04	3.190926-01	2.000000 01	2.800838-01	1.999986 01
291	2.019824 01	4.361115-02	4.950893-02	0.	1.566144 04	3.194239-01	2.000000 01	2.813704-01	1.999986 01
292	2.017300 01	4.381437-02	4.957085-02	0.	1.566144 04	3.197587-01	2.000000 01	2.826243-01	1.999986 01
293	2.014780 01	4.401228-02	4.963286-02	0.	1.566144 04	3.200963-01	2.000000 01	2.838456-01	1.999986 01
294	2.012263 01	4.420523-02	4.969493-02	0.	1.566144 04	3.204359-01	2.000000 01	2.850360-01	1.999986 01
295	2.009750 01	4.439350-02	4.975709-02	0.	1.566144 04	3.207771-01	2.000000 01	2.861968-01	1.999986 01
296	2.007239 01	4.457728-02	4.981933-02	0.	1.566144 04	3.211193-01	2.000000 01	2.873287-01	1.999986 01
297	2.004732 01	4.475675-02	4.988164-02	0.	1.566144 04	3.214621-01	2.000000 01	2.884327-01	1.999986 01
298	2.002227 01	4.493216-02	4.994403-02	0.	1.566144 04	3.218050-01	2.000000 01	2.895099-01	1.999986 01
299	1.999726 01	4.510368-02	5.000650-02	0.	1.566144 04	3.221477-01	2.000000 01	2.905611-01	1.999986 01
300	1.997228 01	4.527135-02	5.006904-02	0.	1.566144 04	3.224898-01	2.000000 01	2.915863-01	1.999986 01
301	1.994733 01	4.543548-02	5.013167-02	0.	1.566144 04	3.228312-01	2.000000 01	2.925872-01	1.999986 01
302	1.992241 01	4.559623-02	5.019437-02	0.	1.566144 04	3.231714-01	2.000000 01	2.935647-01	1.999986 01
303	1.989752 01	4.575378-02	5.025715-02	0.	1.566144 04	3.235104-01	2.000000 01	2.945196-01	1.999986 01
304	1.987267 01	4.590824-02	5.032001-02	0.	1.566144 04	3.238478-01	2.000000 01	2.954525-01	1.999986 01
305	1.984784 01	4.605973-02	5.038295-02	0.	1.566144 04	3.241835-01	2.000000 01	2.963641-01	1.999986 01
306	1.982305 01	4.620841-02	5.044596-02	0.	1.566144 04	3.245174-01	2.000000 01	2.972552-01	1.999986 01
307	1.979828 01	4.635438-02	5.050906-02	0.	1.566144 04	3.248492-01	2.000000 01	2.981263-01	1.999985 01
308	1.977355 01	4.649777-02	5.057224-02	0.	1.566144 04	3.251790-01	2.000000 01	2.989780-01	1.999985 01
309	1.974885 01	4.663862-02	5.063549-02	0.	1.566144 04	3.255065-01	2.000000 01	2.998107-01	1.999985 01
310	1.972418 01	4.677707-02	5.069882-02	0.	1.566144 04	3.258316-01	2.000000 01	3.006250-01	1.999985 01
311	1.969954 01	4.691329-02	5.076223-02	0.	1.566144 04	3.261543-01	2.000000 01	3.014221-01	1.999985 01
312	1.967493 01	4.704735-02	5.082573-02	0.	1.566144 04	3.264746-01	2.000000 01	3.022023-01	1.999985 01

GAROL PROBLEM 1, THORIUM R=2.2 T=300

POINT	ENERGY-EV	FLUX REGION 1	FLUX REGION 2	SOURCE REGION 1	SOURCE REGION 2	TOTAL CROSS SECTION REGION 1	TOTAL CROSS SECTION REGION 2	COLLISION DENSITY REGION 1	COLLISION DENSITY REGION 2
313	1.965035 01	4.717932-02	5.088930-02	0.	1.566144 04	3.267923-01	2.000000 01	3.029659-01	1.999985 01
314	1.962580 01	4.730930-02	5.095295-02	0.	1.566144 04	3.271074-01	2.000000 01	3.037136-01	1.999985 01
315	1.960129 01	4.743731-02	5.101668-02	0.	1.566144 04	3.274198-01	2.000000 01	3.044455-01	1.999985 01
316	1.957680 01	4.756356-02	5.108049-02	0.	1.566144 04	3.277295-01	2.000000 01	3.051629-01	1.999985 01
317	1.955235 01	4.768798-02	5.114437-02	0.	1.566144 04	3.280366-01	2.000000 01	3.058652-01	1.999985 01
318	1.952792 01	4.781073-02	5.120834-02	0.	1.566144 04	3.283409-01	2.000000 01	3.065535-01	1.999985 01
319	1.950353 01	4.793188-02	5.127239-02	0.	1.566144 04	3.286424-01	2.000000 01	3.072282-01	1.999985 01
320	1.947916 01	4.805147-02	5.133652-02	0.	1.566144 04	3.289411-01	2.000000 01	3.078897-01	1.999985 01
321	1.945483 01	4.816957-02	5.140073-02	0.	1.566144 04	3.292371-01	2.000000 01	3.085382-01	1.999985 01
322	1.943052 01	4.828624-02	5.146502-02	0.	1.566144 04	3.295303-01	2.000000 01	3.091742-01	1.999985 01
323	1.940625 01	4.840156-02	5.152939-02	0.	1.566144 04	3.298207-01	2.000000 01	3.097982-01	1.999985 01
324	1.938201 01	4.851555-02	5.159384-02	0.	1.566144 04	3.301083-01	2.000000 01	3.104103-01	1.999985 01
325	1.935780 01	4.862829-02	5.165838-02	0.	1.566144 04	3.303931-01	2.000000 01	3.110111-01	1.999985 01
326	1.933361 01	4.873981-02	5.172299-02	0.	1.566144 04	3.306751-01	2.000000 01	3.116007-01	1.999985 01
327	1.930946 01	4.885009-02	5.178768-02	0.	1.566144 04	3.309544-01	2.000000 01	3.121791-01	1.999984 01
328	1.928534 01	4.895933-02	5.185246-02	0.	1.566144 04	3.312309-01	2.000000 01	3.127474-01	1.999984 01
329	1.926125 01	4.906741-02	5.191731-02	0.	1.566144 04	3.315047-01	2.000000 01	3.133050-01	1.999984 01
330	1.923719 01	4.917453-02	5.198225-02	0.	1.566144 04	3.317758-01	2.000000 01	3.138532-01	1.999984 01
331	1.921315 01	4.928066-02	5.204727-02	0.	1.566144 04	3.320442-01	2.000000 01	3.143917-01	1.999984 01
332	1.918915 01	4.938583-02	5.211237-02	0.	1.566144 04	3.323099-01	2.000000 01	3.149208-01	1.999984 01
333	1.916518 01	4.948999-02	5.217755-02	0.	1.566144 04	3.325729-01	2.000000 01	3.154403-01	1.999984 01
334	1.914124 01	4.959328-02	5.224281-02	0.	1.566144 04	3.328333-01	2.000000 01	3.159509-01	1.999984 01
335	1.911733 01	4.969568-02	5.230815-02	0.	1.566144 04	3.330910-01	2.000000 01	3.164527-01	1.999984 01
336	1.909345 01	4.979727-02	5.237358-02	0.	1.566144 04	3.333462-01	2.000000 01	3.169460-01	1.999984 01
337	1.906959 01	4.989806-02	5.243908-02	0.	1.566144 04	3.335988-01	2.000000 01	3.174312-01	1.999984 01
338	1.904577 01	4.999807-02	5.250467-02	0.	1.566144 04	3.338488-01	2.000000 01	3.179081-01	1.999984 01
339	1.902198 01	5.009736-02	5.257034-02	0.	1.566144 04	3.340963-01	2.000000 01	3.183774-01	1.999984 01
340	1.899822 01	5.019594-02	5.263610-02	0.	1.566144 04	3.343413-01	2.000000 01	3.188390-01	1.999984 01
341	1.897448 01	5.029383-02	5.270193-02	0.	1.566144 04	3.345839-01	2.000000 01	3.192932-01	1.999984 01
342	1.895078 01	5.039105-02	5.276785-02	0.	1.566144 04	3.348239-01	2.000000 01	3.197400-01	1.999984 01
343	1.892711 01	5.048756-02	5.283385-02	0.	1.566144 04	3.350616-01	2.000000 01	3.201794-01	1.999984 01
344	1.890346 01	5.058345-02	5.289993-02	0.	1.566144 04	3.352969-01	2.000000 01	3.206117-01	1.999984 01
345	1.887985 01	5.067875-02	5.296610-02	0.	1.566144 04	3.355298-01	2.000000 01	3.210373-01	1.999984 01
346	1.885626 01	5.077354-02	5.303234-02	0.	1.566144 04	3.357604-01	2.000000 01	3.214567-01	1.999984 01
347	1.883271 01	5.086777-02	5.309868-02	0.	1.566144 04	3.359886-01	2.000000 01	3.218697-01	1.999984 01
348	1.880918 01	5.096148-02	5.316509-02	0.	1.566144 04	3.362146-01	2.000000 01	3.222764-01	1.999984 01
349	1.878568 01	5.105461-02	5.323159-02	0.	1.566144 04	3.364383-01	2.000000 01	3.226766-01	1.999984 01
350	1.876222 01	5.114727-02	5.329817-02	0.	1.566144 04	3.366598-01	2.000000 01	3.230709-01	1.999984 01
351	1.873878 01	5.123943-02	5.336483-02	0.	1.566144 04	3.368790-01	2.000000 01	3.234593-01	1.999983 01
352	1.871537 01	5.133110-02	5.343158-02	0.	1.566144 04	3.370961-01	2.000000 01	3.238417-01	1.999983 01
353	1.869199 01	5.142240-02	5.349840-02	0.	1.566144 04	3.373111-01	2.000000 01	3.242190-01	1.999983 01
354	1.866864 01	5.151322-02	5.356532-02	0.	1.566144 04	3.375239-01	2.000000 01	3.245905-01	1.999983 01
355	1.864532 01	5.160370-02	5.363232-02	0.	1.566144 04	3.377346-01	2.000000 01	3.249572-01	1.999983 01
356	1.862203 01	5.169374-02	5.369940-02	0.	1.566144 04	3.379432-01	2.000000 01	3.253184-01	1.999983 01
357	1.859876 01	5.178339-02	5.376656-02	0.	1.566144 04	3.381498-01	2.000000 01	3.256744-01	1.999983 01
358	1.857553 01	5.187268-02	5.383381-02	0.	1.566144 04	3.383543-01	2.000000 01	3.260255-01	1.999983 01
359	1.855232 01	5.196162-02	5.390115-02	0.	1.566144 04	3.385569-01	2.000000 01	3.263718-01	1.999983 01
360	1.852915 01	5.205015-02	5.396856-02	0.	1.566144 04	3.387575-01	2.000000 01	3.267129-01	1.999983 01
361	1.850600 01	5.213839-02	5.403607-02	0.	1.566144 04	3.389561-01	2.000000 01	3.270496-01	1.999983 01
362	1.848288 01	5.222631-02	5.410365-02	0.	1.566144 04	3.391528-01	2.000000 01	3.273818-01	1.999983 01
363	1.845979 01	5.231391-02	5.417132-02	0.	1.566144 04	3.393476-01	2.000000 01	3.277094-01	1.999983 01
364	1.843673 01	5.240123-02	5.423908-02	0.	1.566144 04	3.395405-01	2.000000 01	3.280327-01	1.999983 01

GAROL PROBLEM 1. THORIUM R=2.2 T=300

POINT	ENERGY-EV	FLUX REGION 1	FLUX REGION 2	SOURCE REGION 1	SOURCE REGION 2	TOTAL CROSS SECTION REGION 1	TOTAL CROSS SECTION REGION 2	COLLISION DENSITY REGION 1	COLLISION DENSITY REGION 2
365	1.841370 01	5.248824-02	5.430692-02	0.	1.566144 04	3.397316-01	2.000000 01	3.283516-01	1.999983 01
366	1.839070 01	5.257491-02	5.437484-02	0.	1.566144 04	3.399209-01	2.000000 01	3.286659-01	1.999983 01
367	1.836773 01	5.266136-02	5.444285-02	0.	1.566144 04	3.401083-01	2.000000 01	3.289764-01	1.999983 01
368	1.834478 01	5.274748-02	5.451095-02	0.	1.566144 04	3.402940-01	2.000000 01	3.292824-01	1.999983 01
369	1.832136 01	5.283343-02	5.457913-02	0.	1.566144 04	3.404779-01	2.000000 01	3.295849-01	1.999983 01
370	1.829898 01	5.291912-02	5.464740-02	0.	1.566144 04	3.406601-01	2.000000 01	3.298835-01	1.999983 01
371	1.827612 01	5.300459-02	5.471575-02	0.	1.566144 04	3.408405-01	2.000000 01	3.301784-01	1.999983 01
372	1.825328 01	5.308974-02	5.478418-02	0.	1.566144 04	3.410193-01	2.000000 01	3.304689-01	1.999983 01
373	1.823048 01	5.317473-02	5.485271-02	0.	1.566144 04	3.411964-01	2.000000 01	3.307561-01	1.999983 01
374	1.820771 01	5.325945-02	5.492131-02	0.	1.566144 04	3.413718-01	2.000000 01	3.310394-01	1.999983 01
375	1.818496 01	5.334402-02	5.499001-02	0.	1.566144 04	3.415456-01	2.000000 01	3.313194-01	1.999983 01
376	1.816225 01	5.342838-02	5.505879-02	0.	1.566144 04	3.417178-01	2.000000 01	3.315960-01	1.999982 01
377	1.813956 01	5.351254-02	5.512765-02	0.	1.566144 04	3.418884-01	2.000000 01	3.318690-01	1.999982 01
378	1.811690 01	5.359653-02	5.519660-02	0.	1.566144 04	3.420575-01	2.000000 01	3.321388-01	1.999982 01
379	1.809427 01	5.368041-02	5.526564-02	0.	1.566144 04	3.422250-01	2.000000 01	3.324057-01	1.999982 01
380	1.807166 01	5.376403-02	5.533477-02	0.	1.566144 04	3.423910-01	2.000000 01	3.326689-01	1.999982 01
381	1.804909 01	5.384758-02	5.540398-02	0.	1.566144 04	3.425554-01	2.000000 01	3.329294-01	1.999982 01
382	1.802654 01	5.393037-02	5.547328-02	0.	1.566144 04	3.427184-01	2.000000 01	3.331864-01	1.999982 01
383	1.800402 01	5.401400-02	5.554266-02	0.	1.566144 04	3.428799-01	2.000000 01	3.334401-01	1.999982 01
384	1.798153 01	5.409700-02	5.561213-02	0.	1.566144 04	3.430399-01	2.000000 01	3.336910-01	1.999982 01
385	1.795907 01	5.417988-02	5.568169-02	0.	1.566144 04	3.431956-01	2.000000 01	3.339391-01	1.999982 01
386	1.793663 01	5.426265-02	5.575133-02	0.	1.566144 04	3.433557-01	2.000000 01	3.341844-01	1.999982 01
387	1.791422 01	5.434526-02	5.582106-02	0.	1.566144 04	3.435115-01	2.000000 01	3.344267-01	1.999982 01
388	1.789184 01	5.442779-02	5.589088-02	0.	1.566144 04	3.436660-01	2.000000 01	3.346666-01	1.999982 01
389	1.786949 01	5.451018-02	5.596079-02	0.	1.566144 04	3.438190-01	2.000000 01	3.349035-01	1.999982 01
390	1.784717 01	5.459242-02	5.603078-02	0.	1.566144 04	3.439707-01	2.000000 01	3.351376-01	1.999982 01
391	1.782488 01	5.467456-02	5.610087-02	0.	1.566144 04	3.441211-01	2.000000 01	3.353691-01	1.999982 01
392	1.780261 01	5.475658-02	5.617104-02	0.	1.566144 04	3.442701-01	2.000000 01	3.355980-01	1.999982 01
393	1.778037 01	5.483849-02	5.624129-02	0.	1.566144 04	3.444179-01	2.000000 01	3.358242-01	1.999982 01
394	1.775816 01	5.492029-02	5.631164-02	0.	1.566144 04	3.445644-01	2.000000 01	3.360479-01	1.999982 01
395	1.773597 01	5.500200-02	5.638207-02	0.	1.566144 04	3.447096-01	2.000000 01	3.362690-01	1.999982 01
396	1.771382 01	5.508363-02	5.645259-02	0.	1.566144 04	3.448536-01	2.000000 01	3.364879-01	1.999982 01
397	1.769169 01	5.516522-02	5.652320-02	0.	1.566144 04	3.449963-01	2.000000 01	3.367046-01	1.999982 01
398	1.766959 01	5.524673-02	5.659390-02	0.	1.566144 04	3.451378-01	2.000000 01	3.369190-01	1.999982 01
399	1.764752 01	5.532808-02	5.666463-02	0.	1.566144 04	3.452781-01	2.000000 01	3.371306-01	1.999982 01
400	1.762547 01	5.540944-02	5.673556-02	0.	1.566144 04	3.454172-01	2.000000 01	3.373405-01	1.999982 01

GAROL PROBLEM 1, THORIUM R=2.2 T=300

GROUP FLUXES

GROUP	ENERGY-EV LOWER LIMIT	REGION 1	REGION 2	CELL AVERAGE
1	2.260329 01	1.883591-01	2.499997-01	2.499970-01
2	1.762547 01	1.864222-01	2.493729-01	2.493701-01
ONE GROUP FLUX		3.747813-01	4.993726-01	4.993671-01

GAROL PROBLEM 1, THORIUM R=2.2 T=300

BROAD GROUP AVERAGED CROSS SECTIONS

MATERIAL 1 1.0 HYDROGEN

GROUP	ENERGY-EV LOWER LIMIT	REGION 1 CAPTURE	REGION 1 SCATTER	REGION 2 CAPTURE	REGION 2 SCATTER	CELL AVERAGE CAPTURE	CELL AVERAGE SCATTER
1	2.260329 01	0.	2.000000 01	0.	2.000000 01	0.	2.000021 01
2	1.762547 01	0.	2.000000 01	0.	2.000000 01	0.	2.000022 01
ONE GROUP AVERAGE		0.	2.000000 01	0.	2.000000 01	0.	2.000022 01

GAROL PROBLEM 1, THORIUM R=2.2 T=300

BROAD GROUP AVERAGED CROSS SECTIONS

MATERIAL 2 90.232 TH232 300K, GAM=24.5, TWO RES

GROUP	ENERGY-EV LOWER LIMIT	REGION 1 CAPTURE	REGION 1 SCATTER	REGION 2 CAPTURE	REGION 2 SCATTER	CELL AVERAGE CAPTURE	CELL AVERAGE SCATTER
1	2.260329 01	3.265843 00	1.563582 01	1.025817 02	3.157013 01	2.460635 00	1.178074 01
2	1.762547 01	2.858973 00	1.035968 01	6.745096 01	1.574598 01	2.137289 00	7.744608 00
ONE GROUP AVERAGE		3.063460 00	1.301138 01	8.503838 01	2.366799 01	2.299165 00	9.765205 00

```
GAROL PROBLEM     1.      THORIUM R=2.2      T=300

                          GENERAL ATOMIC, TPLOT,091565, S01   SMITH    -GAROL

     FRAME NO.    1     SERIES IDENTIFICATION
                                                                             BEGIN PLOT SETUP    15.5926 MH
                                                                               BEGIN PLOTTING    15.7269 MH
                                                                                 END PLOTTING    16.0694 MH

     FRAME NO.    2      THORIUM R=2.2      T=300
                                                  FLUX         IN        REGION 1
                                                                             BEGIN PLOT SETUP    16.0741 MH
                                                                               BEGIN PLOTTING    16.2083 MH
                                                                                 END PLOTTING    16.5417 MH

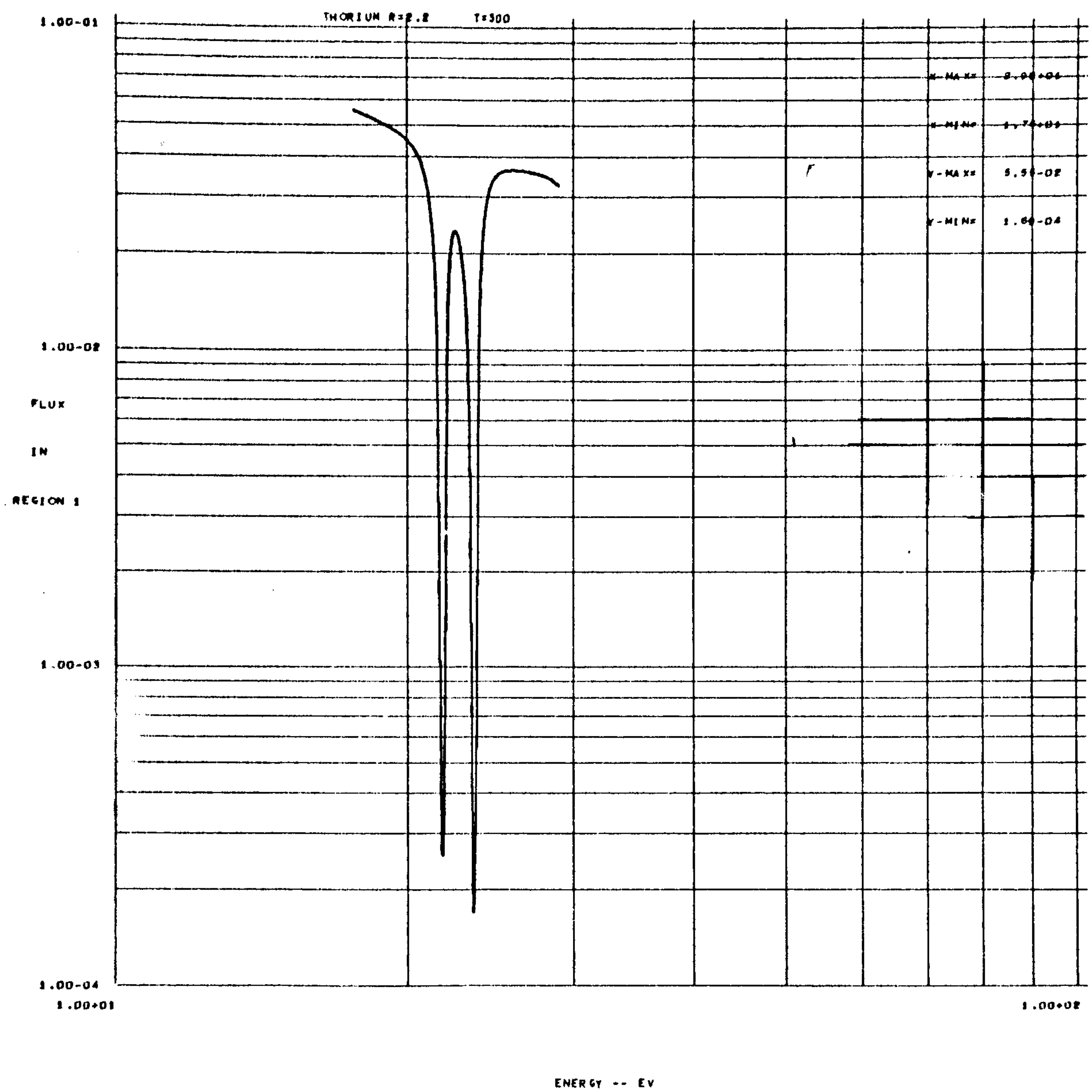
     FRAME NO.    3      THORIUM R=2.2      T=300
                       TOTAL      CROSS-      SECTION      IN        REGION 1
                                                                             BEGIN PLOT SETUP    16.5463 MH
                                                                               BEGIN PLOTTING    16.6204 MH
                                                                                 END PLOTTING    16.9769 MH

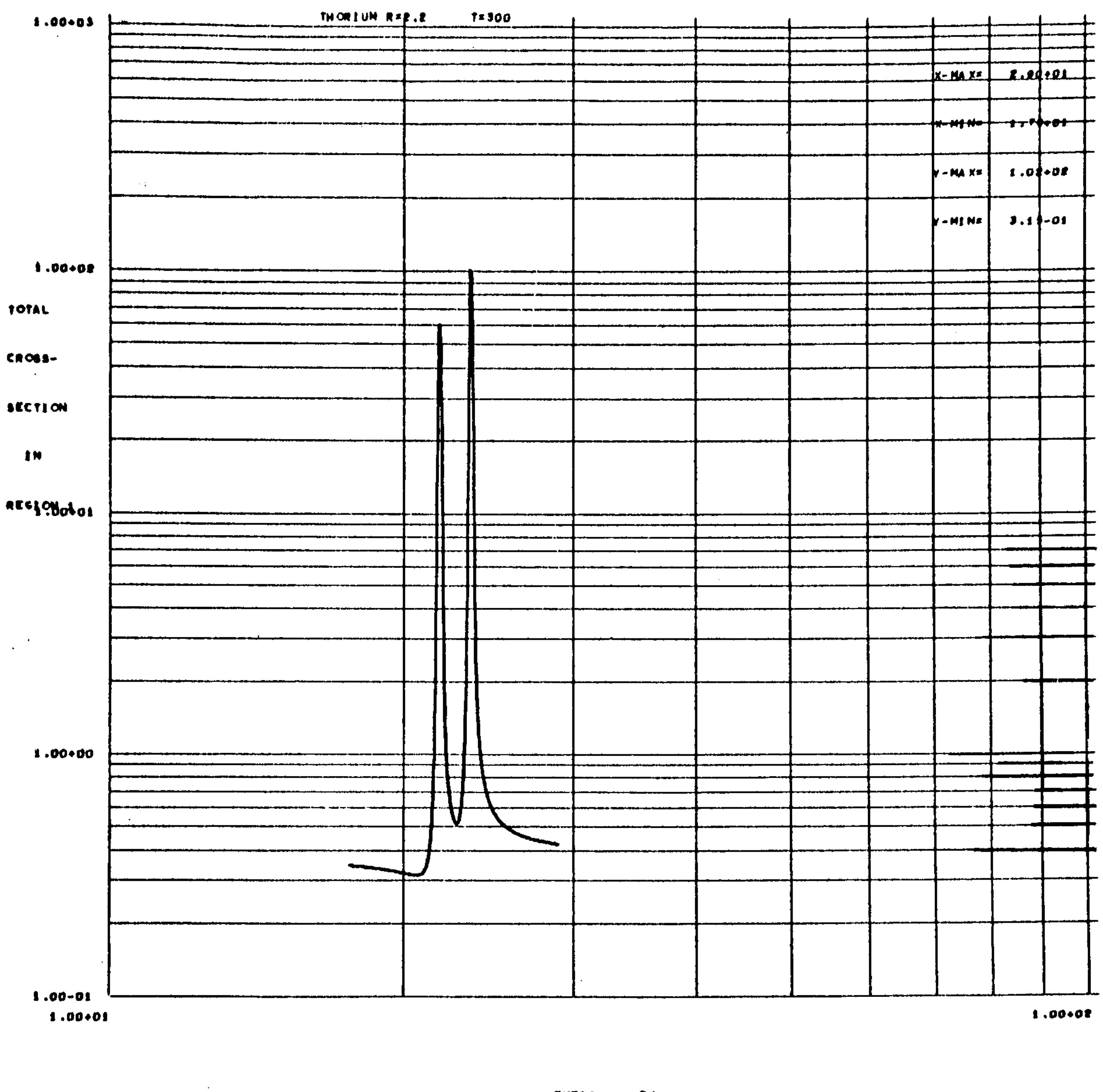
     FRAME NO.    4      THORIUM R=2.2      T=300
                                  COLLISION   DENSITY      IN        REGION 1

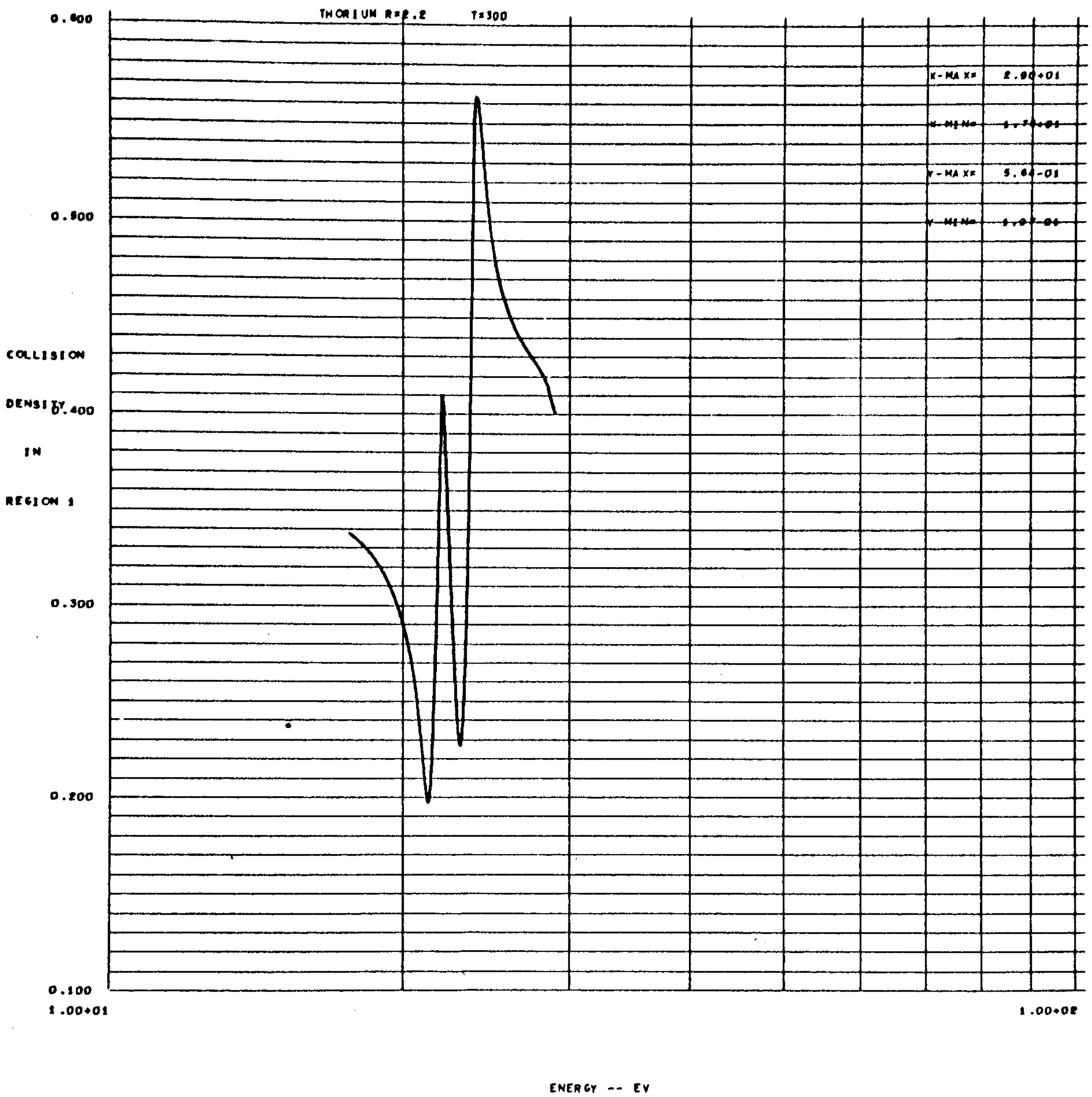
NO PLOTTING FOR THIS FRAME.  Y IS CONSTANT FOR ALL X  AT  0.
                         THORIUM R=2.2      T=300
                                            CAPTURE      RATE
                                                                             BEGIN PLOT SETUP    18.0231 MH
                                                                               BEGIN PLOTTING    18.0972 MH
                                                                                 END PLOTTING    18.4398 MH

     FRAME NO.    5      THORIUM R=2.2      T=300
                                            CAPTURE      RATE

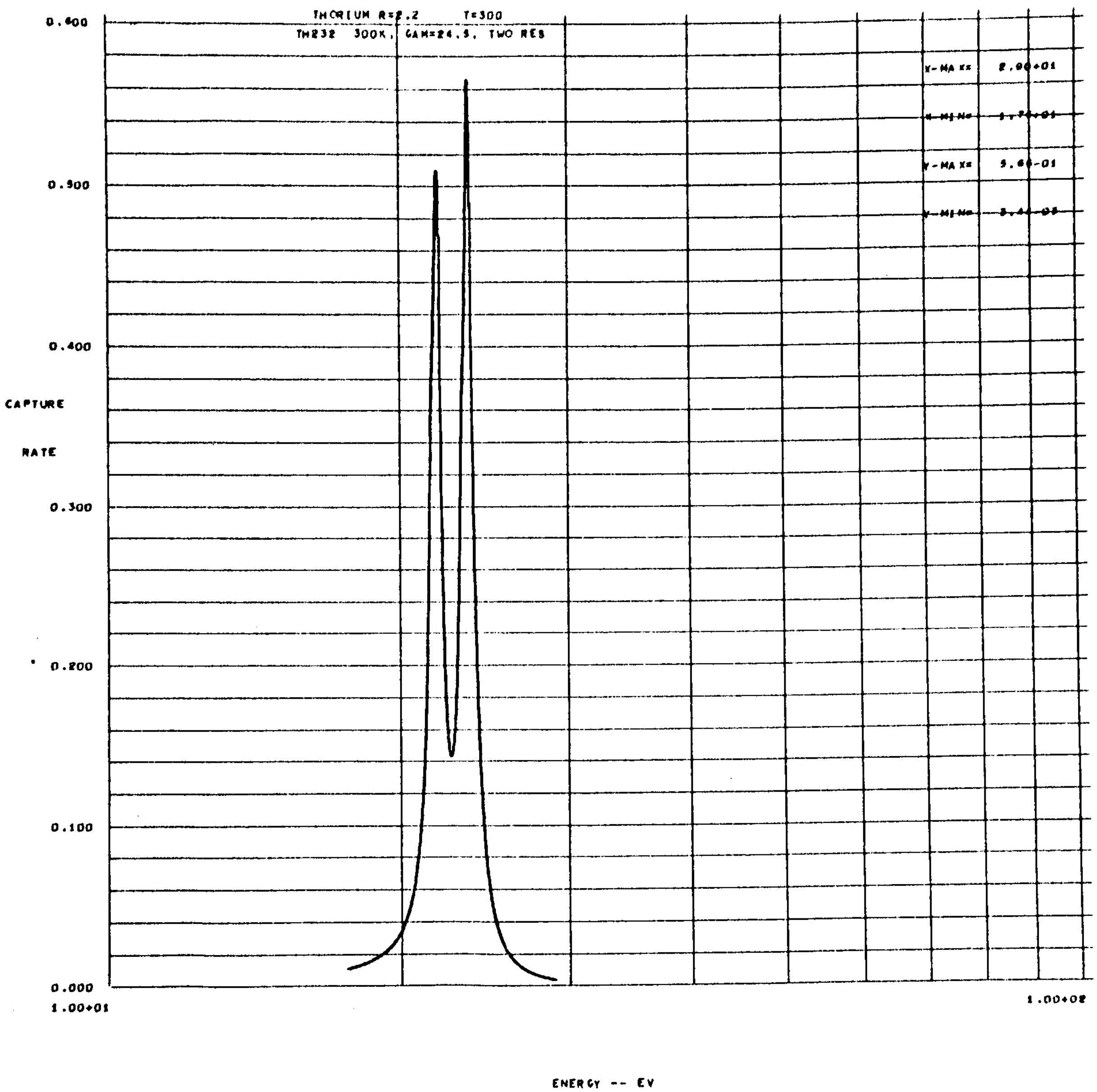
END-OF-DATA
```


THORIUM R=2.2 T=300
X-MAX= 9.00+01
X-MIN= 1.70+01
Y-MAX= 5.50-02
Y-MIN= 1.60-04
1.00-01
1.00-02
1.00-03
1.00-04
FLUX
IN
REGION 1
1.00+01
1.00+02
ENERGY -- EV


THORIUM R=2.2 T=300
1.00+03
1.00+02
TOTAL
CROSS-
SECTION
IN
REGION 1
1.00+01
1.00+00
1.00-01
1.00+01
1.00+02
X-MAX=
X-MIN=
Y-MAX=
Y-MIN=
ENERGY -- EV



THORIUM R=2.2 T=300
X-MAX= 2.90+01
X-MIN=
Y-MAX= 5.64-01
Y-MIN=
0.600
0.500
0.400
0.300
0.200
0.100
COLLISION DENSITY IN REGION 1
1.00+01
1.00+02
ENERGY -- EV


THORIUM R=2.2 T=300
TH232 300K, GAM=24.5, TWO RES
X-MAX=
Y-MAX=
CAPTURE
RATE
0.600
0.500
0.400
0.300
0.200
0.100
0.000
1.00+01
1.00+02
ENERGY -- EV

LISTING OF THE GAROL PROGRAM

```
$IBFTC GAROL    LIST,DECK,REF                                         08-09-65MAIN0000
C                              MAIN LINK FOR GAROL                            MAIN0010
C                               7-15-65   C V SMITH                           MAIN0020
C                                                                             MAIN0030
      COMMON /ALL/  NIN,NOUT,NDATA,NIN1,NIN3,JHYD,NEL,NARRAY,NPAGE,LINESMAIN0040
     1,NPROB,NPTS,INDEX,NPLOT,TITLE(12),TID(10,20),CNAME(5,20),LINEPP   MAIN0050
     2 ,MAT,MFRAME                                                      MAIN0060
      COMMON /TABLES/ CS1,CS2,CS3,SLABT(505),CYLT(305)                  MAIN0070
      COMMON /PLOTT/ TLABEL(12),XLABEL(12),YLABEL(12),TT2(12),NFRAME    MAIN0080
      CALL CHAIN(1)                                                     MAIN0090
      END                                                               MAIN0100
```

```
$IBMAP DUMFIL  LIST,DECK,REF                                          08-09-65DUMF0000
       EXTERN  UTVAR.                                                   DUMF0010
       ENTRY   FIL04.                                                   DUMF0020
       ENTRY   FIL07.                                                   DUMF0030
       ENTRY   FIL10.                                                   DUMF0040
       ENTRY   FIL11.                                                   DUMF0050
       ENTRY   FIL13.                                                   DUMF0060
       ENTRY   FIL14.                                                   DUMF0070
       ENTRY   FIL15.                                                   DUMF0080
       ENTRY   FIL16.                                                   DUMF0090
FIL04. EQU     *                                                        DUMF0100
FIL07. EQU     *                                                        DUMF0110
FIL10. EQU     *                                                        DUMF0120
FIL11. EQU     *                                                        DUMF0130
FIL13. EQU     *                                                        DUMF0140
FIL14. EQU     *                                                        DUMF0150
FIL15. EQU     *                                                        DUMF0160
FIL16. EQU     *                                                        DUMF0170
       BSS     1                                                        DUMF0180
       END                                                              DUMF0190
```

```
$IBFTC ERRORS  LIST,DECK,REF                                          08-09-65ERRS0000
      SUBROUTINE ERRORS(N1,N2)                                          ERRS0010
      WRITE (6,601) N1,N2                                               ERRS0020
      PRINT 601, N1,N2                                                  ERRS0030
  601 FORMAT (22H0ERROR IN GAROL, LINK I2,14H, ERROR NUMBER I4,1H. )    ERRS0040
      CALL EXIT                                                         ERRS0050
      END                                                               ERRS0060
```

```
$IBFTC BOOLER  LIST,REF                                                 BOOL0000
      SUBROUTINE BOOLER(A1,A2)                                          BOOL0010
      A2=A1                                                             BOOL0020
      RETURN                                                            BOOL0030
      END                                                               BOOL0040
```

```
$IBFTC TABSET  LIST,REF                                            08-09-65
C
C                 SETS UP SLAB AND CYLINDER TABLES
C           DATA FROM CASE, K., F. DE HOFFMANN, AND G. PLACZEK (1953)
C
      BLOCK DATA
      COMMON /TABLES/ CS1,CS2,CS3,SLABT(505),CYLT(305)
      DIMENSION  B1(89), B2(88), B3(88), B4(88), B5(88), B6(61)
      DIMENSION  C1(79), C2(78), C3(78), C4(67)
      EQUIVALENCE (B1(1),SLABT(1)), (B2(1),SLABT(90)),
     1 (B3(1),SLABT(178)), (B4(1),SLABT(266)), (B5(1),SLABT(354)),
     2 (B6(1),SLABT(442))
      EQUIVALENCE (C1(1),CYLT(1)), (C2(1),CYLT(80)), (C3(1),CYLT(158)),
     1 (C4(1),CYLT(236))
      DATA     B1/0.0,0.04840,0.0831,0.1127,0.1390,0.1629,0.1849,0.2054,
     1 0.2246,0.2427,0.2597,0.2759,0.2913,0.3060,0.3200,0.3335,0.3464,
     2 0.3588,0.3707,0.3821,0.3932,0.4039,0.4142,0.4242,0.4339,0.4432,
     3 0.4523,0.4611,0.4696,0.4779,0.4859,0.4937,0.5013,0.5087,0.5159,
     4 0.5229,0.5298,0.5364,0.5429,0.5492,0.5554,0.5614,0.5673,0.5730,
     5 0.5786,0.5841,0.5895,0.5947,0.5998,0.6048,0.6097,0.6145,0.6192,
     6 0.6237,0.6282,0.6326,0.6369,0.6411,0.6453,0.6493,0.6533,0.6572,
     7 0.6610,0.6647,0.6684,0.6720,0.6755,0.6790,0.6824,0.6857,0.6890,
     8 0.6922,0.6954,0.6985,0.7015,0.7045,0.7074,0.7103,0.7132,0.7159,
     9 0.7187,0.7214,0.7240,0.7266,0.7292,0.7317,0.7342,0.7366,0.7390/
      DATA          B2/0.7414,0.7437,0.7460,0.7483,0.7505,0.7527,0.7548,
     1 0.7569,0.7590,0.7611,0.7631,0.7651,0.7670,0.7690,0.7709,0.7727,
     2 0.7746,0.7764,0.7782,0.7800,0.7817,0.7834,0.7851,0.7868,0.7884,
     3 0.7901,0.7917,0.7932,0.7948,0.7963,0.7978,0.7993,0.8008,0.8023,
     4 0.8037,0.8051,0.8065,0.8079,0.8093,0.8106,0.8119,0.8132,0.8145,
     5 0.8158,0.8171,0.8183,0.8196,0.8202,0.8220,0.8232,0.8243,0.8255,
     6 0.8266,0.8278,0.8289,0.8300,0.8311,0.8321,0.8332,0.8342,0.8353,
     7 0.8363,0.8373,0.8383,0.8393,0.8403,0.8413,0.8422,0.8432,0.8441,
     8 0.8450,0.8460,0.8469,0.8478,0.8486,0.8495,0.8504,0.8512,0.8521,
     9 0.8529,0.8538,0.8546,0.8554,0.8562,0.8570,0.8578,0.8586,0.8593/
      DATA          B3/0.8601,0.8608,0.8616,0.8623,0.8631,0.8638,0.8645,
     1 0.8652,0.8659,0.8666,0.8673,0.8680,0.8687,0.8693,0.8700,0.8707,
     2 0.8713,0.8720,0.8726,0.8732,0.8738,0.8745,0.8751,0.8757,0.8763,
     3 0.8769,0.8775,0.8781,0.8786,0.8792,0.8798,0.8804,0.8809,0.8815,
     4 0.8820,0.8826,0.8831,0.8836,0.8842,0.8847,0.8852,0.8857,0.8863,
     5 0.8868,0.8873,0.8878,0.8883,0.8887,0.8892,0.8897,0.8902,0.8907,
     6 0.8911,0.8916,0.8921,0.8925,0.8930,0.8934,0.8939,0.8943,0.8948,
     7 0.8952,0.8956,0.8961,0.8965,0.8969,0.8973,0.8977,0.8982,0.8986,
     8 0.8990,0.8994,0.8998,0.9002,0.9006,0.9010,0.9013,0.9017,0.9021,
     9 0.9025,0.9029,0.9032,0.9036,0.9040,0.9043,0.9047,0.9051,0.9054/
      DATA          B4/0.9058,0.9061,0.9065,0.9068,0.9072,0.9075,0.9078,
     1 0.9082,0.9085,0.9089,0.9092,0.9095,0.9098,0.9102,0.9105,0.9108,
     2 0.9111,0.9114,0.9117,0.9120,0.9124,0.9127,0.9130,0.9133,0.9136,
     3 0.9139,0.9141,0.9144,0.9147,0.9150,0.9153,0.9156,0.9159,0.9162,
     4 0.9164,0.9167,0.9170,0.9173,0.9175,0.9178,0.9181,0.9183,0.9186,
     5 0.9189,0.9191,0.9194,0.9196,0.9199,0.9202,0.9204,0.9207,0.9209,
     6 0.9212,0.9214,0.9217,0.9219,0.9221,0.9224,0.9226,0.9229,0.9231,
```

```
7 0.9233,0.9236,0.9238,0.9240,0.9243,0.9245,0.9247,0.9249,0.9252,   TABS0510
8 0.9254,0.9256,0.9258,0.9261,0.9263,0.9265,0.9267,0.9269,0.9271,   TABS0520
9 0.9273,0.9276,0.9278,0.9280,0.9282,0.9284,0.9286,0.9288,0.9290/   TABS0530
 DATA        B5/0.9292,0.9294,0.9296,0.9298,0.9300,0.9302,0.9304,   TABS0540
1 0.9306,0.9308,0.9309,0.9311,0.9313,0.9315,0.9317,0.9319,0.9321,   TABS0550
2 0.9323,0.9324,0.9326,0.9328,0.9330,0.9332,0.9333,0.9335,0.9337,   TABS0560
3 0.9339,0.9340,0.9342,0.9344,0.9346,0.9347,0.9349,0.9351,0.9352,   TABS0570
4 0.9354,0.9356,0.9357,0.9359,0.9361,0.9362,0.9364,0.9366,0.9367,   TABS0580
5 0.9369,0.9370,0.9372,0.9373,0.9375,0.9377,0.9378,0.9380,0.9381,   TABS0590
6 0.9383,0.9384,0.9386,0.9387,0.9389,0.9390,0.9392,0.9393,0.9395,   TABS0600
7 0.9396,0.9398,0.9399,0.9401,0.9402,0.9403,0.9405,0.9406,0.9408,   TABS0610
8 0.9409,0.9410,0.9412,0.9413,0.9415,0.9416,0.9417,0.9419,0.9420,   TABS0620
9 0.9421,0.9423,0.9424,0.9425,0.9427,0.9428,0.9429,0.9431,0.9432/   TABS0630
 DATA        B6/0.9433,0.9434,0.9436,0.9437,0.9438,0.9439,0.9441,   TABS0640
1 0.9442, 0.9443,0.9444,0.9446,0.9447,0.9448,0.9449,0.9451,0.9452,  TABS0650
2 0.9453,0.9454,0.9455,0.9457,0.9458,0.9459,0.9460,0.9461,0.9462,   TABS0660
3 0.9464,0.9465,0.9466,0.9467,0.9468,0.9469,0.9470,0.9471,0.9473,   TABS0670
4 0.9474,0.9475,0.9476,0.9477,0.9478,0.9479,0.9480,0.9481,0.9482,   TABS0680
5 0.9483,0.9485,0.9486,0.9487,0.9488,0.9489,0.9490,0.9491,0.9492,   TABS0690
6 0.9493,0.9494,0.9495,0.9496,0.9497,0.9498,0.9499,0.9500,0.9501/   TABS0700
 DATA   C1/0.0,0.2561,0.04967,0.07248,0.09421,0.11498,0.13487,      TABS0710
10.15396,0.17231,0.18996,0.20697,0.22336,0.23918,0.25446,0.26923,   TABS0720
20.28351,0.29733,0.31070,0.32366,0.33621,0.34838,0.36019,0.37164,   TABS0730
30.38276,0.39356,0.40405,0.41424,0.42414,0.43377,0.44314,0.45225,   TABS0740
40.46112,0.46975,0.47816,0.48634,0.49432,0.50209,0.50966,0.51704,   TABS0750
50.52424,0.53126,0.53811,0.54479,0.55131,0.55767,0.56389,0.56996,   TABS0760
60.57588,0.58167,0.58733,0.59285,0.59826,0.60354,0.60870,0.61375,   TABS0770
70.61869,0.62352,0.62825,0.63287,0.63740,0.64183,0.64616,0.65041,   TABS0780
80.65457,0.65864,0.66263,0.66654,0.67038,0.67413,0.67781,0.68142,   TABS0790
90.68495,0.68842,0.69182,0.69516,0.69843,0.70164,0.70479,0.70788/   TABS0800
 DATA       C2/0.71091,0.71389,0.71681,0.71968,0.72250,0.72526,     TABS0810
10.72798,0.73065,0.73327,0.73585,0.73833,0.74087,0.74331,0.74572,   TABS0820
20.74808,0.75040,0.75269,0.75493,0.75714,0.75931,0.76145,0.76355,   TABS0830
30.76562,0.76765,0.76966,0.77163,0.77357,0.77548,0.77736,0.77921,   TABS0840
40.78103,0.78282,0.78459,0.78633,0.78805,0.78974,0.79140,0.79304,   TABS0850
50.79465,0.79624,0.79781,0.79936,0.80088,0.80239,0.80387,0.80532,   TABS0860
60.80677,0.80818,0.80958,0.81096,0.81233,0.81367,0.81500,0.81630,   TABS0870
70.81759,0.81886,0.82012,0.82136,0.82258,0.82379,0.82498,0.82616,   TABS0880
80.82732,0.82847,0.82960,0.83071,0.83182,0.83291,0.83399,0.83505,   TABS0890
90.83610,0.83714,0.83816,0.83917,0.84017,0.84116,0.84214,0.84310/   TABS0900
 DATA        C3/0.84405,0.84500,0.84593,0.84685,0.84776,0.84866,    TABS0910
10.84955,0.85043,0.85130,0.85216,0.85301,0.85385,0.85468,0.85550,   TABS0920
20.85632,0.85712,0.85792,0.85870,0.85948,0.86025,0.86101,0.86177,   TABS0930
30.86251,0.86325,0.86398,0.86471,0.86542,0.86613,0.86683,0.86752,   TABS0940
40.86821,0.86889,0.86956,0.87023,0.87089,0.87154,0.87219,0.87283,   TABS0950
50.87346,0.87409,0.87471,0.87533,0.87594,0.87654,0.87714,0.87773,   TABS0960
60.87832,0.87890,0.87947,0.88004,0.88061,0.88117,0.88173,0.88228,   TABS0970
70.88282,0.88336,0.88389,0.88443,0.88495,0.88547,0.88598,0.88650,   TABS0980
80.88701,0.88751,0.88801,0.88850,0.88899,0.88948,0.88996,0.89044,   TABS0990
90.89091,0.89138,0.89184,0.89230,0.89276,0.89321,0.89366,0.89411/   TABS1000
```

```
      DATA         C4/0.89455,0.89499,0.89542,0.89585,0.89628,0.89671,  TABS1010
     10.89713,0.89755,0.89796,0.89837,0.89878,0.89919,0.89959,0.89999,  TABS1020
     20.90038,0.90077,0.90116,0.90155,0.90193,0.90231,0.90268,0.90306,  TABS1030
     30.90343,0.90381,0.90417,0.90453,0.90489,0.90525,0.90560,0.90595,  TABS1040
     40.90631,0.90665,0.90700,0.90734,0.90768,0.90802,0.90835,0.90868,  TABS1050
     50.90902,0.90934,0.90967,0.90999,0.91031,0.91063,0.91095,0.91126,  TABS1060
     60.91157,0.91188,0.91219,0.91250,0.91280,0.91310,0.91340,0.91369,  TABS1070
     70.91399,0.91429,0.91457,0.91487,0.91515,0.91544,0.91572,0.91600,  TABS1080
     80.91628,0.91656,0.91684,0.91711,0.91738/                          TABS1090
      END                                                               TABS1100
```

```
$IBMAP TIDCO   LIST,DECK,REF                                              08-09-65TIDC0000
*                                                                                 TIDC0010
*                     CALLING SEQUENCE -                                          TIDC0020
*                                                                                 TIDC0030
*                        CALL TIDCO(TID(1))                                       TIDC0040
*                                                                                 TIDC0050
        ENTRY    TIDCO                                                            TIDC0060
*                                                                                 TIDC0070
        EXTERN   ERROR                                                            TIDC0080
        EXTERN   EXIT                                                             TIDC0090
*                                                                                 TIDC0100
*                                                                                 TIDC0110
*                     CONSTANTS NEEDED                                            TIDC0120
 ZERO   OCT      0                                                                TIDC0130
 NERR   OCT      3                                                                TIDC0140
 TEN    OCT      12                                                               TIDC0150
*                                                                                 TIDC0160
*                     TEST SYMBOLS                                                TIDC0170
 B6     OCT      60                                                               TIDC0180
 BB     OCT      606060606060                                                     TIDC0190
 BO     OCT      006060606060                                                     TIDC0200
*                                                                                 TIDC0210
*                     INDEX REGISTER AND INTERIM STORAGE                          TIDC0220
 XX4    BSS      1                                                                TIDC0230
 T1     BSS      1                                                                TIDC0240
 T2     BSS      1                                                                TIDC0250
 T3     BSS      1                                                                TIDC0260
 T4     BSS      1                                                                TIDC0270
 F1     BSS      1                                                                TIDC0280
 F2     BSS      1                                                                TIDC0290
 Y1     TRA      **                                                               TIDC0300
 Y2     TRA      **                                                               TIDC0310
 Y3     TRA      **                                                               TIDC0320
*                                                                                 TIDC0330
 PT1    PZE      **                                                               TIDC0340
*                     ENTRY FOR ID CONVERSION                                     TIDC0350
 TIDCO  SAVE     1,2,4                                                            TIDC0360
        STZ      T1                                                               TIDC0370
        STZ      T2                                                               TIDC0380
        STZ      T3                                                               TIDC0390
        STZ      T4                                                               TIDC0400
        CAL      BB                                                               TIDC0410
        SLW      F1                                                               TIDC0420
        CAL      3,4                                                              TIDC0430
        STA      PC1                                                              TIDC0440
        STA      A1                                                               TIDC0450
        ADD      =1                                                               TIDC0460
        STA      A2                                                               TIDC0470
        ADD      =1                                                               TIDC0480
        STA      B1                                                               TIDC0490
        LXA      NUMB-1,1                                                         TIDC0500
```

```
         SXA     Y2,1                          TIDC0510
         SXA     Y3,1                          TIDC0520
         TXI     *+1,1,5                       TIDC0530
         SXA     Y1,1                          TIDC0540
         LXA     ZERO,2                        TIDC0550
LP2      LXA     ZERO,1                        TIDC0560
LP1      PXA     ,1                            TIDC0570
         SAC     PC1,,2                        TIDC0580
         PXA     ,0                            TIDC0590
PC1      PCS     **,2,0                        TIDC0600
         PAX     ,4                            TIDC0610
         TXL     NUMB,4,9                      TIDC0620
         TXH     MISP,4,48                     TIDC0630
         TXH     Y3,4,47                       TIDC0640
         TXH     MISP,4,27                     TIDC0650
         TXH     Y1,4,26                       TIDC0660
         TXH     MISP,4,16                     TIDC0670
         TXH     Y2,4,15                       TIDC0680
         TRA     MISP                          TIDC0690
CONT     TXI     *+1,1,1                       TIDC0700
         TXL     LP1,1,5                       TIDC0710
         TXI     *+1,2,-1                      TIDC0720
         TXH     LP2,2,-2                      TIDC0730
         TRA     FINAL                         TIDC0740
DEC      STO     T1                            TIDC0750
         STO     T2                            TIDC0760
         TSX     SET,4                         TIDC0770
         STZ     T3                            TIDC0780
         CAL     PC1+3                         TIDC0790
         STA     Y1                            TIDC0800
         CAL     DEC-1                         TIDC0810
         STA     Y3                            TIDC0820
         CAL     F1                            TIDC0830
         SLW     F2                            TIDC0840
         CAL     BB                            TIDC0850
         SLW     F1                            TIDC0860
         TRA     CONT                          TIDC0870
NUMB     STO     T1                            TIDC0880
         TSX     MPLY,4                        TIDC0890
         TSX     SET,4                         TIDC0900
         CLA     T2                            TIDC0910
         TNZ     CONT                          TIDC0920
         CAL     PC1+2                         TIDC0930
         STA     Y2                            TIDC0940
         STA     Y3                            TIDC0950
         TRA     CONT                          TIDC0960
MPLY     LDQ     T4                            TIDC0970
         MPY     TEN                           TIDC0980
         STQ     T4                            TIDC0990
         CLA     T4                            TIDC1000
```

```
        ADD     T1                                  TIDC1010
        STO     T4                                  TIDC1020
        TRA     1,4                                 TIDC1030
SET     CLA     T3                                  TIDC1040
        ADD     =1                                  TIDC1050
        STO     T3                                  TIDC1060
        CAL     F1                                  TIDC1070
        ALS     6                                   TIDC1080
        ADD     T1                                  TIDC1090
        SLW     F1                                  TIDC1100
        TOV     *+1                                 TIDC1110
        TRA     1,4                                 TIDC1120
FINAL   LXA     T3,1                                TIDC1130
        TXH     FIX,1,5                             TIDC1140
        STZ     T1                                  TIDC1150
        CLA     =6                                  TIDC1160
        SUB     T3                                  TIDC1170
        PAX     ,1                                  TIDC1180
        SXA     PT1,1                               TIDC1190
        TSX     MPLY,4                              TIDC1200
        TIX     *-1,1,1                             TIDC1210
        CAL     B6                                  TIDC1220
        SLW     T1                                  TIDC1230
        LXA     PT1,1                               TIDC1240
        TXH     REPL,1,5                            TIDC1250
        TSX     SET,4                               TIDC1260
        TIX     *-1,1,1                             TIDC1270
        TRA     FIX                                 TIDC1280
REPL    CAL     B0                                  TIDC1290
        SLW     F1                                  TIDC1300
        TRA     OUT                                 TIDC1310
FIX     CLA     =5                                  TIDC1320
        PAX     ,1                                  TIDC1330
LP4     PXA     ,1                                  TIDC1340
        SAC     PT2,,2                              TIDC1350
        SAC     PT3,,2                              TIDC1360
        SAC     PT4,,2                              TIDC1370
        CAL     B6                                  TIDC1380
PT2     CCS     F1,,5                               TIDC1390
        TRA     *+2                                 TIDC1400
        TRA     CC2                                 TIDC1410
        PXA     ,0                                  TIDC1420
PT3     PCS     F1,,5                               TIDC1430
        TNZ     OUT                                 TIDC1440
        CAL     B6                                  TIDC1450
PT4     SAC     F1,,5                               TIDC1460
CC2     TIX     LP4,1,1                             TIDC1470
OUT     CAL     F1                                  TIDC1480
A2      SLW     **                                  TIDC1490
        CAL     F2                                  TIDC1500
```

```
A1      SLW      **                                                    TIDC1510
        CLA      T4                                                    TIDC1520
B1      STO      **                                                    TIDC1530
        RETURN   TIDCO                                                 TIDC1540
MISP    CALL     ERROR(NERR)                                           TIDC1550
        CALL     EXIT                                                  TIDC1560
        END                                                            TIDC1570
```

```
$IBFTC ERROR    LIST,DECK,REF                                  08-09-65ERR 0000
      SUBROUTINE ERROR(N)                                              ERR 0010
C                ERROR SUBROUTINE FOR TIDCO                            ERR 0020
      WRITE (6,1)                                                      ERR 0030
    1 FORMAT (1HO///34HOERROR STOP---MISPUNCHED ID NUMBER  )           ERR 0040
      CALL EXIT                                                        ERR 0050
      END                                                              ERR 0060
```

```
                         * * * * * * * * * *
                          G A R O L   L I N K   1
                         * * * * * * * * * *
$IBMAP COMSET  LIST,REF                                                08-09-651COM0000
 B     BOOL    37333                                                            1COM0010
 BSET  CONTRL  A,C                                                              1COM0020
 A     BSS     B                                                                1COM0030
 C     EQU     *                                                                1COM0040
       END                                                                      1COM0050


$IBFTC LINK1   LIST,DECK,REF                                           08-09-651LNK0000
C                                                                               1LNK0010
C                            LINK  1                                            1LNK0020
C                 SET UP CONSTANTS AND INITIALIZE DATA TAPE                     1LNK0030
C                                                                               1LNK0040
      COMMON /ALL/  NIN,NOUT,NDATA,NIN1,NIN3,JHYD,NEL,NARRAY,NPAGE,LINES1LNK0050
     1,NPROB,NPTS,INDEX,NPLOT,TITLE(12),TID(10,20),CNAME(5,20),LINEPP   1LNK0060
     2 ,MAT,MFRAME                                                      1LNK0070
      COMMON /TABLES/ CS1,CS2,CS3,SLABT(505),CYLT(305)                  1LNK0080
      COMMON /BSET/ LIMST,LIM1,LIM2,NPRINT,JPRINT(10),DUM(200),DE1,DE2  1LNK0090
     1 ,DE3,EEZERO,E(8000),SCAP(20),SF(20),SSC(20),SA(20),ALPHA(20)     1LNK0100
     2 ,KTAPE(3),KPTS(10)                                               1LNK0110
     3              ,NORES(20),LLIM(20),SPO(20),EZERO(600),RHGT(600)    1LNK0120
     4 ,FACT1(600),FACT2(600),FACT3(600),FRAT(600),XI(600)              1LNK0130
     5              ,GI(500),GJ(500),GF(500),E0(500),GG(500),GN(500)    1LNK0140
     6 ,SPIN(500)                                                       1LNK0150
      COMMON /PLOTT/ TLABEL(12),XLABEL(12),YLABEL(12),TT2(12),NFRAME    1LNK0160
      EQUIVALENCE (TID,NTID),(DUM,LIM),(NPT,NPTS),(NDATA,NDATA1)        1LNK0170
      DIMENSION NTID(10,20), LIM(200)                                   1LNK0180
      DIMENSION  KT(3)                                                  1LNK0190
      DIMENSION  FMT(12)                                                1LNK0200
C                                                                       1LNK0210
C                   SET CONSTANTS                                       1LNK0220
      NIN=5                                                             1LNK0230
      NOUT=6                                                            1LNK0240
      LIMST=8000                                                        1LNK0250
      NPROB=0                                                           1LNK0260
      CS1=0.5                                                           1LNK0270
      CS2=0.0                                                           1LNK0280
      CS3=-0.09375                                                      1LNK0290
      MFRAME=0                                                          1LNK0300
      NPAGE=0                                                           1LNK0310
      LINEPP=52                                                         1LNK0320
      NKT=0                                                             1LNK0330
      KT(1)=NIN                                                         1LNK0340
      KT(2)=3                                                           1LNK0350
      KT(3)=2                                                           1LNK0360
      NDATA1=9                                                          1LNK0370
      READ (NIN,902) INDEX                                              1LNK0380
```

```
      REWIND NDATA1
      READ (5,901)(TLABEL(I),I=1,12)
  901 FORMAT (12A6)
      IF (INDEX.LE.0) GO TO 710
C                START PREPARING A NEW DATA TAPE
      READ (NIN,902) NINDEX,NPTS
      CALL ENERGY(NINDEX)
      CALL BOOLER(6H(2A6, ,FMT(1))
      CALL BOOLER(6H2X5A6,,FMT(2))
      CALL BOOLER(6H0PF10.,FMT(3))
      CALL BOOLER(6H3,F12.,FMT(4))
      CALL BOOLER(6H5,2X1P,FMT(5))
      CALL BOOLER(6HI10)  ,FMT(12))
      CALL BOOLER(6HE13.5,,EFMT)
      CALL BOOLER(6H1X    ,XFMT1)
      CALL BOOLER(6H2X    ,XFMT2)
      CALL BOOLER(6H2A6,  ,AFMT)
      CALL BOOLER(6H    CO,C1)
      CALL BOOLER(6HMPUTED,C2)
      CALL BOOLER(6H INPUT,C3)
      CALL BOOLER(6H CARDS,C4)
      CALL HEAD
      READ (NIN,902) MAT,JHYD
  902 FORMAT (6I12)
      IF (MAT.LT.1.OR.MAT.GT.20) CALL ERRORS(1,2)
      NEL=MAT
      NSUM=0
      NPRINT=0
      DO 10 K=1,NEL
      KPTS(K)=0
      READ (5,903) TID(1,K),TID(2,K),(CNAME(I,K),I=1,5),(TID(J,K),J=4,8)
     1 ,TID(10,K)
      CALL TIDCO(TID(1,K))
  903 FORMAT (2A6,5A6/6E12.6)
      IF (TID(6,K).GT.-2.0) GO TO 5
      TID(7,K)=-2.0
      TID(8,K)=-2.0
      NKT=NKT+1
      READ (NIN,902) KPTS(NKT)
      NT=3
      GO TO 6
    5 NT=0
      IF (TID(6,K).LT.0.0) NT=NT+1
      IF (TID(7,K).LT.0.0) NT=NT+1
      IF (TID(8,K).LT.0.0) NT=NT+1
    6 NTID(9,K)=NT
      NSUM=NSUM+NT
      IF (TID(10,K).LE.0.0) GO TO 10
      IF (NT.LE.0) GO TO 10
      NPRINT=NPRINT+1
```

```
      JPRINT(NPRINT)=K
   10 CONTINUE
      IF (NKT.LE.0) GO TO 12
      IF (NKT.GT.3) CALL ERRORS(1,3)
      DO 8 K=2,NEL
      IF (TID(4,K).EQ.1.0) CALL ERRORS(1,7)
    8 CONTINUE
      N=1
      DO 11 K=1,NEL
      IF (TID(6,K).GT.-2.0) GO TO 11
      KTAPE(N)=KT(NKT)
      MTAPE=KTAPE(N)
      IF (NKT.GT.1) REWIND MTAPE
      N=N+1
      NKT=NKT-1
   11 CONTINUE
   12 CONTINUE
      NARRAY=NSUM
      WRITE (6,904)
  904 FORMAT (26H0NUCLIDE TABLE OF CONTENTS/13H0NUCLIDE I.D. 7X,4HNAME
     1 26X 1HA 5X 10HASYMPTOTIC 7X 7HCAPTURE 7X 7HFISSION 7X 7HSCATTER
     2 5X 9HNUMBER OF/56X 10HSCATTERING 48X 6HARRAYS/)
      DO 30 K=1,NEL
      N=0
      L=6
      DO 35 JK=6,8
      IF (TID(JK,K).LT.0.0) GO TO 31
      N=N+1
      DUM(N)=TID(JK,K)
      FMT(L)=EFMT
      FMT(L+1)=XFMT1
      GO TO 34
   31 FMT(L)=AFMT
      FMT(L+1)=XFMT2
      IF (TID(JK,K).LT.-1.0) GO TO 32
      DUM(N+1)=C1
      DUM(N+2)=C2
      GO TO 33
   32 DUM(N+1)=C3
      DUM(N+2)=C4
      DUM(N+3)=C3
      DUM(N+4)=C4
      DUM(N+5)=C3
      N=N+6
      DUM(N)=C4
      FMT(L+2)=AFMT
      FMT(L+3)=XFMT2
      FMT(L+4)=AFMT
      FMT(L+5)=XFMT2
      GO TO 36
```

```
   33 N=N+2
   34 L=L+2
   35 CONTINUE
   36 NO=N
      WRITE (6,FMT) TID(1,K),TID(2,K),(CNAME(I,K),I=1,5),TID(4,K),
     1 TID(5,K),(DUM(N),N=1,NO),NTID(9,K)
   30 CONTINUE
C
C
   40 IF (INDEX.GT.1) GO TO 50
      WRITE (NDATA)(TLABEL(I),I=1,12)
      WRITE (NDATA1) NPT,NEL,NARRAY,JHYD
      WRITE (NDATA1)((TID(I,K),I=1,10),(CNAME(J,K),J=1,5),K=1,NEL)
      WRITE (NDATA)(SLABT(I),I=1,505),(CYLT(J),J=1,305)
      GO TO 100
   50 READ  (NDATA) (DUM(I),I=1,12)
      DO 60 I=1,12
      IF (TLABEL(I).NE.DUM(I)) CALL ERRORS(1,8)
   60 CONTINUE
      DO 70 I=1,3
   70 READ (NDATA) DUM1
      READ (NIN,902) JPT
      JHYD=JPT
      DO 80 J=1,JPT
   80 READ (NDATA) DUM1
      READ (10,500)(DUM2,J=1,JPT)
  500 FORMAT (E12.6)
      IF (ABS(DUM1-DUM2).GT.1.0E-5*DUM1) CALL ERRORS(1,9)
  100 CALL CHAIN(2)
C                READ FROM A DATA TAPE PREVIOUSLY PREPARED
  710 NERR=1
C                CHECK LABEL ON A DATA TAPE WRITTEN ON AN EARLIER RUN
      READ (NDATA)(DUM(I),I=1,12)
      DO 720 I=1,12
      IF (DUM(I).NE.TLABEL(I)) CALL ERRORS(1,1)
  720 CONTINUE
      NERR=2
C                   STORE -TABLE OF CONTENTS- AND OTHER DATA FROM
C                   BEGINNING OF DATA TAPE
      READ (NDATA1) NPT,NEL,NARRAY,JHYD
      READ (NDATA1) ((TID(J,K),J=1,10),(CNAME(I,K),I=1,5),K=1,NEL)
      DO 730 K=1,NEL
      IF (TID(6,K).GT.0.0)  TID(6,K)=TID(6,K)*0.159
      IF (TID(6,K).GT.-2.0) GO TO 730
      TID(7,K)=-2.0
      TID(8,K)=-2.0
  730 CONTINUE
      READ (NDATA1) DUMMY
      CALL CHAIN(4)
      END
```

```
$IBFTC ENERGY  LIST,DECK,REF                                            08-09-65
      SUBROUTINE ENERGY(NINDEX)
C
C                SET UP ENERGY MESH
C
      COMMON /ALL/  NIN,NOUT,NDATA,NIN1,NIN3,JHYD,NEL,NARRAY,NPAGE,LINES
     1,NPROB,NPTS,INDEX,NPLOT,TITLE(12),TID(10,20),CNAME(5,20),LINEPP
     2 ,MAT,MFRAME
      COMMON /TABLES/ CS1,CS2,CS3,SLABT(505),CYLT(305)
      COMMON /BSET/ LIMST,LIM1,LIM2,NPRINT,JPRINT(10),DUM(200),DE1,DE2
     1 ,DE3,EEZERO,E(8000),SCAP(20),SF(20),SSC(20),SA(20),ALPHA(20)
     2 ,KTAPE(3),KPTS(10)
     3                ,NORES(20),LLIM(20),SP0(20),EZERO(600),RHGT(600)
     4 ,FACT1(600),FACT2(600),FACT3(600),FRAT(600),XI(600)
     5                ,GI(500),GJ(500),GF(500),E0(500),GG(500),GN(500)
     6 ,SPIN(500)
      COMMON /PLOTT/ TLABEL(12),XLABEL(12),YLABEL(12),TT2(12),NFRAME
      EQUIVALENCE (TID,NTID),(DUM,LIM),(NPT,NPTS),(NDATA,NDATA1)
      DIMENSION NTID(10,20), LIM(200)
C
      IF (NINDEX.LT.1) CALL ERRORS(1,4)
      IF (NINDEX.GT.5) CALL ERRORS(1,5)
      LIMST=7998
      M2=LIMST
      NT=1
      LIM1=M2
C               INTERMEDIATE STORAGE OF ENERGIES ON INTERMEDIARY TAPE 8
      NIN1=8
      REWIND NIN1
  100 GO TO (1,2,3,4,5,5),NINDEX
C               READ ENERGIES FROM INPUT CARDS
    1 M2=MINO(NPTS,LIMST)
      LIM2=NPTS
      READ (NIN,901)(E(I),I=1,M2)
  901 FORMAT (6E12.6)
      IF (M2.GE.NPTS) GO TO 10
      WRITE (NIN1)(E(I),I=1,M2)
  101 NT=NT+1
      M2=MINO(NPTS-(NT-1)*LIMST,LIMST)
      READ (NIN,901)(E(I),I=1,M2)
      DO 102 I=1,M2
      WRITE (NIN1) E(I)
  102 CONTINUE
      IF (M2.LT.NPTS-NT*LIMST) GO TO 101
      GO TO 8
C               EQUAL ENERGY SPACING
C               READ E-MAX AND DELTA-E
    2 READ (NIN,901) EMAX,EMIN,DELTAE
      E(1)=EMAX
      DO 201 I=2,M2
      E(I)=E(I-1)-DELTAE
```

```
      IF (E(I).GT.EMIN) GO TO 201
      NPTS=I
      IF (E(I).LT.EMIN) E(I)=EMIN
      GO TO 10
  201 CONTINUE
      WRITE (NIN1)(E(I),I=1,M2)
      ENEXT=E(M2)
      M3=20000
      DO 202 I=1,M3
      ENEXT=ENEXT-DELTAE
      IF (ENEXT.GT.EMIN) GO TO 202
      NPTS=M2+I
      IF (ENEXT.LT.EMIN) ENEXT=EMIN
      WRITE (NIN1) ENEXT
      GO TO 7
  202 WRITE (NIN1) ENEXT
      CALL ERRORS(1,7)
C                 EQUAL VELOCITY SPACING
C                 READ EMAX AND CONSTANT
    3 READ (NIN,901) EMAX,EMIN,CONST
      E(1)=EMAX
      DO 301 I=2,M2
      E(I)=E(I-1)-CONST*SQRT(E(N-1))
      IF (E(I).GT.EMIN) GO TO 301
      NPTS=I
      IF (E(I).LT.EMIN) E(I)=EMIN
      GO TO 10
  301 CONTINUE
      WRITE (NIN1)(E(I),I=1,M2)
      M3=20000
      ENEXT=E(M2)
      DO 302 I=1,M3
      ENEXT=ENEXT-CONST*SQRT(ENEXT)
      IF (ENEXT.GT.EMIN) GO TO 302
      NPTS=M2+I
      IF (ENEXT.LT.EMIN) ENEXT=EMIN
      WRITE (NIN1) ENEXT
      GO TO 7
  302 WRITE (NIN1) ENEXT
      CALL ERRORS(1,7)
C                 EQUAL LETHARGY SPACING
C                 READ  EZERO AND DELTA-U
    4 READ (NIN,901) EMAX,EMIN,DELTAU
      E(1)=EMAX
      EDU=EXP(-DELTAU)
      DO 401 I=2,M2
      E(I)=E(I-1)*EDU
      IF (E(I).GT.EMIN) GO TO 401
      NPTS=I
      IF (E(I).LT.EMIN) E(I)=EMIN
```

```
      GO TO 10                                                          ENER1010
  401 CONTINUE                                                          ENER1020
      WRITE (NIN1)(E(I),I=1,M2)                                         ENER1030
      M3=20000                                                          ENER1040
      ENEXT=E(M2)                                                       ENER1050
      DO 402 I=1,M3                                                     ENER1060
      ENEXT=ENEXT*EDU                                                   ENER1070
      IF (ENEXT.GT.EMIN) GO TO 402                                      ENER1080
      NPTS=M2+I                                                         ENER1090
      IF (ENEXT.LT.EMIN) ENEXT=EMIN                                     ENER1100
      WRITE (NIN1) ENEXT                                                ENER1110
      GO TO 7                                                           ENER1120
  402 WRITE (NIN1) ENEXT                                                ENER1130
      CALL ERRORS(1,7)                                                  ENER1140
C              USE YOUR OWN SUBROUTINE ENRG TO GENERATE ENERGY POINTS   ENER1150
C         WHERE NPTS IS LESS THAN 8001 AND ENERGIES ARE CORE CONTAINED ENER1160
    5 CALL ENRG(NPTS,E)                                                 ENER1170
      LIM1=NPTS                                                         ENER1180
      LIM2=NPTS                                                         ENER1190
      IF (NPTS.GT.8000) CALL ERRORS(1,6)                                ENER1200
      GO TO 10                                                          ENER1210
    7 REWIND NIN1                                                       ENER1220
      READ (NIN1) DUMMY                                                 ENER1230
      GO TO 10                                                          ENER1240
    8 REWIND NIN1                                                       ENER1250
    9 READ (NIN1)(E(I),I=1,LIM1)                                        ENER1260
   10 RETURN                                                            ENER1270
      END                                                               ENER1280

$IBFTC ENRG    LIST,DECK,REF                                   08-09-65ENRG0000
      SUBROUTINE ENRG(NPTS,E)                                           ENRG0010
      DIMENSION E(8000)                                                 ENRG0020
      WRITE (6,601)                                                     ENRG0030
  601 FORMAT (39HODUMMY SUBROUTINE ENRG HAS BEEN ENTERED/113HOIN ORDER TENRG0040
     1O USE THE OPTION OF GENERATING YOUR OWN ENERGIES, PLEASE REPLACE TENRG0050
     2HIS SUBROUTINE WITH ONE OF YOUR OWN. )                            ENRG0060
      CALL ERRORS(1,6)                                                  ENRG0070
      END                                                               ENRG0080

$IBFTC HEAD    LIST,DECK,REF                                   08-09-65HEAD0000
      SUBROUTINE HEAD                                                   HEAD0010
      COMMON /ALL/  NIN,NOUT,NDATA,NIN1,NIN3,JHYD,NEL,NARRAY,NPAGE,LINESHEAD0020
     1,NPROB,NPTS,INDEX,NPLOT,TITLE(12),TID(10,20),CNAME(5,20),LINEPP   HEAD0030
     2 ,MAT,MFRAME                                                      HEAD0040
      COMMON /PLOTT/ TLABEL(12),XLABEL(12),YLABEL(12),T2(12)            HEAD0050
      NPAGE=NPAGE+1                                                     HEAD0060
      WRITE (6,601)(TLABEL(I),I=1,12),NPAGE                             HEAD0070
  601 FORMAT(26H1GAROL DATA TAPE, LABELED 12A6, 22X 4HPAGE I6)          HEAD0080
      RETURN                                                            HEAD0090
      END                                                               HEAD0100
```

```
                            *  *  *  *  *  *  *  *  *  *
                              G A R O L   L I N K   2
                            *  *  *  *  *  *  *  *  *  *
$IBMAP COMSET  LIST,REF                                          08-09-652COM0000
 B      BOOL    37333                                                    2COM0010
 BSET   CONTRL  A,C                                                      2COM0020
 A      BSS     B                                                        2COM0030
 C      EQU     *                                                        2COM0040
        END                                                              2COM0050


$IBFTC LINK2   LIST,DECK,REF                                     08-09-652LNK0000
C                         LINK  2                                        2LNK0010
C                READ RESONANCE PARAMETERS                               2LNK0020
C                COMPUTE RESONANCE VARIABLES AND INDICES                 2LNK0030
C                FOR CALCULATING CROSS SECTIONS                          2LNK0040
C                                                                        2LNK0050
      COMMON /ALL/  NIN,NOUT,NDATA,NIN1,NIN3,JHYD,NEL,NARRAY,NPAGE,LINES2LNK0060
     1,NPROB,NPTS,INDEX,NPLOT,TITLE(12),TID(10,20),CNAME(5,20),LINEPP    2LNK0070
     2 ,MAT,MFRAME                                                       2LNK0080
      COMMON /TABLES/ CS1,CS2,CS3,SLABT(505),CYLT(305)                   2LNK0090
      COMMON /BSET/ LIMST,LIM1,LIM2,NPRINT,JPRINT(10),DUM(200),DE1,DE2   2LNK0100
     1 ,DE3,EEZERO,E(8000),SCAP(20),SF(20),SSC(20),SA(20),ALPHA(20)      2LNK0110
     2 ,KTAPE(3),KPTS(10)                                                2LNK0120
     3              ,NORES(20),LLIM(20),SPO(20),EZERO(600),RHGT(600)     2LNK0130
     4 ,FACT1(600),FACT2(600),FACT3(600),FRAT(600),XI(600)               2LNK0140
     5              ,GI(500),GJ(500),GF(500),E0(500),GG(500),GN(500)     2LNK0150
     6 ,SPIN(500)                                                        2LNK0160
      COMMON /PLOTT/ TLABEL(12),XLABEL(12),YLABEL(12),TT2(12),NFRAME     2LNK0170
      EQUIVALENCE (TID,NTID),(DUM,LIM),(NPT,NPTS),(NDATA,NDATA1)         2LNK0180
      DIMENSION NTID(10,20), LIM(200)                                    2LNK0190
C                                                                        2LNK0200
      LIM3=LIM1                                                          2LNK0210
      LIM1=0                                                             2LNK0220
      NKT=0                                                              2LNK0230
      DO 10 K=1,MAT                                                      2LNK0240
      IF (TID(6,K).GE.0.0.AND.TID(7,K).GE.0.0.AND.TID(8,K).GE.0.0)       2LNK0250
     1 GO TO 10                                                          2LNK0260
      IF (TID(6,K).EQ.-1.0) GO TO 5                                      2LNK0270
      IF (TID(8,K).EQ.-1.0) GO TO 5                                      2LNK0280
      IF (TID(7,K).EQ.-1.0) GO TO 5                                      2LNK0290
      NKT=NKT+1                                                          2LNK0300
      GO TO 10                                                           2LNK0310
    5 CALL DSET(K)                                                       2LNK0320
      LIM1=234                                                           2LNK0330
   10 CONTINUE                                                           2LNK0340
      LIM1=LIM3                                                          2LNK0350
      IF (NKT.LE.1) GO TO 30                                             2LNK0360
      NKTM1=NKT-1                                                        2LNK0370
      DO 25 J=1,NKTM1                                                    2LNK0380
      JTAPE=KTAPE(J)                                                     2LNK0390
      KTO=KPTS(J)                                                        2LNK0400
```

```
      DO 20 I=1,KTO
      READ (NIN,500)EE, CAP, SCAT, FIS
      WRITE (JTAPE,500)EE, CAP, SCAT, FIS
  500 FORMAT (4E12.6)
   20 CONTINUE
      REWIND JTAPE
   25 CONTINUE
   30 CALL CHAIN(3)
      END
```

```
$IBFTC DSET    LIST,DECK,REF                                          08-09-65
      SUBROUTINE DSET(NMAT)
C
C                 READ AND SET UP RESONANCE PARAMETERS AND CONSTANTS
C                 FOR DOPPLER BROADENING CALCULATION
C     ADAPTED FOR GAROL FROM THE FASDOP PROGRAM (GAMD-6562)
C
      COMMON /ALL/  NIN,NOUT,NDATA,NIN1,NIN3,JHYD,NEL,NARRAY,NPAGE,LINES
     1,NPROB,NPTS,INDEX,NPLOT,TITLE(12),TID(10,20),CNAME(5,20),LINEPP
     2 ,MAT,MFRAME
      COMMON /TABLES/ CS1,CS2,CS3,SLABT(505),CYLT(305)
      COMMON /BSET/ LIMST,LIM1,LIM2,NPRINT,JPRINT(10),DUM(200),DE1,DE2
     1 ,DE3,EEZERO,E(8000),SCAP(20),SF(20),SSC(20),SA(20),ALPHA(20)
     2 ,KTAPE(3),KPTS(10)
     3               ,NORES(20),LLIM(20),SPO(20),EZERO(600),RHGT(600)
     4 ,FACT1(600),FACT2(600),FACT3(600),FRAT(600),XI(600)
     5               ,GI(500),GJ(500),GF(500),E0(500),GG(500),GN(500)
     6 ,SPIN(500)
      COMMON /PLOTT/ TLABEL(12),XLABEL(12),YLABEL(12),TT2(12),NFRAME
      EQUIVALENCE (TID,NTID),(DUM,LIM),(NPT,NPTS),(NDATA,NDATA1)
      DIMENSION NTID(10,20), LIM(200)
      INTEGER   GAMN
      DIMENSION GAMN(1)
      IF (LIM1.EQ.234) GO TO 2
      KST=1
      GO TO 3
    2 KST=KEND+1
    3 CONTINUE
   20 READ (5,510) WGT,STAT,SPOT,TEMP
      IF (WGT.NE.TID(4,NMAT)) CALL ERRORS(2,1)
      READ (5,520) NEZ,NFIS,NGN
      NRR=NEZ
      NORES(NMAT)=NRR
      LLIM(NMAT)=KST
      KEND=KST+NRR-1
      AMASS=WGT
      SPO(NMAT)=SPOT
```

```
      CALL HEAD
      WRITE (6,602) (CNAME(I,NMAT),I=1,5),AMASS,SPOT,TEMP
  602 FORMAT (1H08X,37H DOPPLER BROADENING CALCULATIONS FOR  5A6/
     118X,24H ABSORBER MASS          = F8.3/
     318X,24H POTENTIAL  SCATTERING = F8.3,8H (BARNS)/
     418X,24H TEMPERATURE            = F8.3,4H (K)//)
      DO 30 K=1,NRR
      GI(K)=0.0
      GJ(K)=0.0
   30 GF(K)=0.0
      IF (NFIS.GT.0) GO TO 80
      IF (STAT.GT.0.0) GO TO 70
      READ (5,530) (E0(J),GI(J),GJ(J),GG(J),GN(J),J=1,NRR)
   40 DO 60 K=1,NRR
      IF (GJ(K).GE.0.0) GO TO 50
      SPIN(K)=GI(K)
      GO TO 60
   50 SPIN(K)=(2.0*GJ(K)+1.0)/(2.0*GI(K)+1.0)*0.5
   60 CONTINUE
      GO TO 120
   70 READ (5,540) (E0(J),GG(J),GN(J),J=1,NRR)
      GO TO 100
   80 IF (STAT.GT.0.0) GO TO 90
      READ (5,510) (E0(J),GI(J),GG(J),GN(J),GF(J),J=1,NRR)
      GO TO 40
   90 READ (5,550) (E0(J),GG(J),GN(J),GF(J),J=1,NRR)
  100 DO 110 K=1,NRR
  110 SPIN(K)=STAT
  120 IF (NGN.GT.0) GO TO 302
  301 GAMN(1)=- 4903602544
      GO TO 303
  302 GAMN(1)=- 4903602496
  303 CONTINUE
  304 WRITE(6,305) GAMN(1)
  305 FORMAT(39X,26H RESONANCE PARAMETER INPUT//17X,11H RESONANCE 5X,21H
     1 STATISTICAL FACTORS 12X,17H HALF-WIDTHS - MV/11X,49H NUMBER     EN
     2ERGY-EV       I      J       G         GA  A6,27H    GAMMA GAMMA    GA
     3MMA F//)
      WRITE(6,306) (K,E0(K),GI(K),GJ(K),SPIN(K),GN(K),GG(K),GF(K)
     1,K=1,NEZ)
  306 FORMAT(I16,F13.3,F10.1,F6.1,F8.3,2F13.4,F14.4)
      IF (NGN.LE.0) GO TO 142
      DO 141 K=1,NRR
  141 GN(K)=GN(K)*SQRT(E0(K))
  142 DO 143 K=1,NRR
      GG(K)=GG(K)*0.001
      GN(K)=GN(K)*0.001
  143 GF(K)=GF(K)*0.001
      RAKT=SQRT(AMASS/(8.6167E-05*TEMP))
      CON1=((AMASS+1.0)/AMASS)**2
      CON2=2.6029E+06*CON1
```

```
      CON3=1.6133505E+03*CON1                                           DSET0880
      RSPO=SQRT(SPOT)                                                   DSET0890
      DO 200 J=1,NRR                                                    DSET0900
      JJ=KST+J-1                                                        DSET0910
      EZERO(JJ)=EO(J)                                                   DSET0920
      GPF=GG(J)+GF(J)                                                   DSET0930
      REO=1.0/EO(J)                                                     DSET0940
      GT=1.0/(GN(J)+GPF)                                                DSET0950
      RREO=SQRT(REO)                                                    DSET0960
      GNGT=GN(J)*GT                                                     DSET0970
      FACT=GNGT*RREO*SPIN(J)                                            DSET0980
      FACT1(JJ)=FACT*RSPO*CON3                                          DSET0990
      FACT2(JJ)=FACT*GPF*GT*CON2                                        DSET1000
      FACT3(JJ)=GNGT*GNGT*SPIN(J)*REO*CON2                              DSET1010
      FRAT(JJ)=GF(J)/GPF                                                DSET1020
      HGT=0.5/GT                                                        DSET1030
      RHGT(JJ)=2.0*GT                                                   DSET1040
      XI(JJ)=HGT*RREO*RAKT                                              DSET1050
  200 CONTINUE                                                          DSET1060
      RETURN                                                            DSET1070
  160 WRITE (6,560)                                                     DSET1080
      CALL EXIT                                                         DSET1090
  510 FORMAT(6E12.6)                                                    DSET1100
  520 FORMAT(6I12)                                                      DSET1110
  530 FORMAT(5E12.6)                                                    DSET1120
  540 FORMAT(3E12.6)                                                    DSET1130
  550 FORMAT(4E12.6)                                                    DSET1140
  560 FORMAT(1H1///10X,54H * * * * * ERROR STOP - INPUT LIST TOO LARGE *DSET1150
     1 * * * *)                                                         DSET1160
      END                                                               DSET1170

$IBFTC HEAD    LIST,DECK,REF                                    08-09-65HEAD0000
      SUBROUTINE HEAD                                                   HEAD0010
      COMMON /ALL/  NIN,NOUT,NDATA,NIN1,NIN3,JHYD,NEL,NARRAY,NPAGE,LINESHEAD0020
     1,NPROB,NPTS,INDEX,NPLOT,TITLE(12),TID(10,20),CNAME(5,20),LINEPP   HEAD0030
     2 ,MAT,MFRAME                                                      HEAD0040
      COMMON /PLOTT/ TLABEL(12),XLABEL(12),YLABEL(12),T2(12)            HEAD0050
      NPAGE=NPAGE+1                                                     HEAD0060
      WRITE (6,601)(TLABEL(I),I=1,12),NPAGE                             HEAD0070
  601 FORMAT(26H1GAROL DATA TAPE, LABELED 12A6, 22X 4HPAGE I6)          HEAD0080
      RETURN                                                            HEAD0090
      END                                                               HEAD0100
```

```
                         * * * * * * * * * *
                          G A R O L   L I N K  3
                         * * * * * * * * * *
$IBMAP COMSET  LIST,REF                                          08-09-653COM0000
 B     BOOL    37333                                                     3COM0010
 BSET  CONTRL  A,C                                                       3COM0020
 A     BSS     B                                                         3COM0030
 C     EQU     *                                                         3COM0040
       END                                                               3COM0050


$IBFTC LINK3   LIST,DECK,REF                                     08-09-653LNK0000
C                        LINK  3                                         3LNK0010
C               CALCULATE CROSS SECTIONS                                 3LNK0020
C               AND WRITE DATA TAPE ON (B5)                              3LNK0030
C                                                                        3LNK0040
      COMMON /ALL/  NIN,NOUT,NDATA,NIN1,NIN3,JHYD,NEL,NARRAY,NPAGE,LINES3LNK0050
     1,NPROB,NPTS,INDEX,NPLOT,TITLE(12),TID(10,20),CNAME(5,20),LINEPP   3LNK0060
     2 ,MAT,MFRAME                                                      3LNK0070
      COMMON /TABLES/ CS1,CS2,CS3,SLABT(505),CYLT(305)                  3LNK0080
      COMMON /BSET/ LIMST,LIM1,LIM2,NPRINT,JPRINT(10),DUM(200),DE1,DE2  3LNK0090
     1 ,DE3,EEZERO,E(8000),SCAP(20),SF(20),SSC(20),SA(20),ALPHA(20)     3LNK0100
     2 ,KTAPE(3),KPTS(10)                                               3LNK0110
     3              ,NORES(20),LLIM(20),SPO(20),EZERO(600),RHGT(600)    3LNK0120
     4 ,FACT1(600),FACT2(600),FACT3(600),FRAT(600),XI(600)              3LNK0130
     5              ,GI(500),GJ(500),GF(500),EO(500),GG(500),GN(500)    3LNK0140
     6 ,SPIN(500)                                                       3LNK0150
      COMMON /PLOTT/ TLABEL(12),XLABEL(12),YLABEL(12),TT2(12),NFRAME    3LNK0160
      EQUIVALENCE (TID,NTID),(DUM,LIM),(NPT,NPTS),(NDATA,NDATA1)        3LNK0170
      DIMENSION NTID(10,20), LIM(200)                                   3LNK0180
      DO 20 JK=1,50                                                     3LNK0190
      GI(JK)=0.0                                                        3LNK0200
      GJ(JK)=0.0                                                        3LNK0210
   20 CONTINUE                                                          3LNK0220
      IF (NPRINT.GT.0) GO TO 21                                         3LNK0230
      ASSIGN  4 TO NGO                                                  3LNK0240
      GO TO 22                                                          3LNK0250
   21 ASSIGN 10 TO NGO                                                  3LNK0260
      CALL HEAD                                                         3LNK0270
   22 CONTINUE                                                          3LNK0280
      IF (JHYD.LE.1) GO TO 23                                           3LNK0290
      JST=JHYD                                                          3LNK0300
      JHYD=1                                                            3LNK0310
   24 IF (JST.LE.LIMST) GO TO 25                                        3LNK0320
      JST=JST-LIMST                                                     3LNK0330
      NT=NT+1                                                           3LNK0340
      GO TO 24                                                          3LNK0350
   23 JST=1                                                             3LNK0360
```

```
   25 I=JST
      JEND1=MINO(NPTS,LIMST)
      NT=1
      NTLIM=0
      NTLIMP=LIMST
      DO 1 K=1,MAT
      ALPHA(K)=((TID(4,K)-1.0)/(TID(4,K)+1.0))**2
    1 CONTINUE
      IF (JEND1.LT.NPTS) GO TO 2
      ASSIGN 6 TO NP1
      ASSIGN 8 TO NP2
      GO TO 3
    2 ASSIGN 5 TO NP1
      ASSIGN 9 TO NP2
      EEZERO=E(LIMST)
    3 CONTINUE
      IF (JST.GT.1) GO TO 4
      DE1=0.0
      DE2=E(2)/(E(1)-E(2))*ALOG(E(1)/E(2))
      DE3=(E(1)-E(2))*.5
      ND=1
      CALL FASDOP(1)
      DO 40 K=1,NEL
      ETO=E(I)*ALPHA(K)
      DO 30 J=I,NPT
      IF (E(J).GT.ETO) GO TO 30
      LIM(ND)=J-I-1
      JJ=J-1
      GO TO 31
   30 CONTINUE
      LIM(ND)=NPT-I
      JJ=NPT
   31 ND=ND+1
      NCORT=0
   33 LIM(ND)=NCORT
      ND=ND+NCORT+1
      IF (TID(6,K).GE.0.0) GO TO 34
      DUM(ND)=SCAP(K)
      ND=ND+1
   34 IF (TID(7,K).GE.0.0) GO TO 35
      DUM(ND)=SF(K)
      ND=ND+1
   35 IF (TID(8,K).GE.0.0) GO TO 40
      DUM(ND)=SSC(K)
      ND=ND+1
   40 CONTINUE
      ND=ND-1
      WRITE (NDATA1) E(I),DE1,DE2,DE3,ND,(DUM(J),J=1,ND)
      IF (NPRINT.GT.0) CALL PRINT(JST,E(JST))
    4 JST=JST+1
```

```
      I=JST
      GO TO NP2,(8,9)
    9 IF (JST.LE.LIMST) GO TO 8
      JST=1
      I=JST
      NT=NT+1
      NTLIM=(NT-1)*LIMST
      NTLIMP=NTLIM+LIMST
    8 CONTINUE
      IF (JST+NTLIM.GE.NPTS) GO TO 11
      DE1=E(I-1)/(E(I-1)-E(I))*ALOG(E(I-1)/E(I))
      DE2=E(I+1)/(E(I)-E(I+1))*ALOG(E(I)/E(I+1))
      DE3=(E(I)-E(I+1))*0.5
      CALL FASDOP(JST)
      CALL NUTZ(JST,NT)
      GO TO NP1,(5,6)
    5 IF (NTLIMP+JST-1.GE.NPTS) ASSIGN 6 TO NP1
      READ (NIN1) E(JST-1)
      IF (JST.EQ.1) E(LIMST)=EEZERO
      IF (JST.EQ.2) E(LIMST+1)=E(1)
    6 CONTINUE
      GO TO NGO,(4,10)
   10 CALL PRINT(JST,E(JST))
      GO TO 4
   11 CONTINUE
      DE1=E(I-1)/(E(I-1)-E(I))*ALOG(E(I-1)/E(I))
      DE2=0.0
      DE3=0.0
      CALL FASDOP(JST)
      CALL NUTZ(JST,NT)
      IF (NPRINT.GT.0) CALL PRINT(JST,E(JST))
      EE=0.0
      ND=1
      WRITE (NDATA) EE,DE1,DE1,DE3,ND,EE
      END FILE NDATA
      CALL TICKER(TIME)
      TIME=TIME/216.0
      PRINT  601, TIME
  601 FORMAT (1H0/15H0TAPE COMPLETE.  15X,6HTIME = F10.3,3H MH )
      REWIND NDATA
      DO 12 I=1,4
   12 READ (NDATA) DUMMY
      CALL CHAIN(4)
      END
```

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$IBFTC FASDOP  LIST,DECK,REF                                        08-09-65FASD0000
      SUBROUTINE FASDOP(JK)                                                 FASD0010
C                                                                           FASD0020
C     FAST AND EPITHERMAL ENERGY RANGE DOPPLER BROADENING CALCULATION       FASD0030
C     ADAPTED FOR GAROL FROM THE FASDOP PROGRAM (GAMD-6562)                 FASD0040
C          'FASDOP' COMPUTES THE TOTAL CONTRIBUTION FROM ALL RESOLVED       FASD0050
C          RESONANCES TO THE ABSORPTION, FISSION, AND SCATTERING            FASD0060
C          CROSS-SECTIONS AT SPECIFIED ENERGIES.                            FASD0070
C     OR CALCULATES CROSS-SECTIONS BY INTERPOLATION FROM INPUT              FASD0080
C                                                                           FASD0090
      COMMON /ALL/  NIN,NOUT,NDATA,NIN1,NIN3,JHYD,NEL,NARRAY,NPAGE,LINESFASD0100
     1,NPROB,NPTS,INDEX,NPLOT,TITLE(12),TID(10,20),CNAME(5,20),LINEPP    FASD0110
     2 ,MAT,MFRAME                                                          FASD0120
      COMMON /TABLES/ CS1,CS2,CS3,SLABT(505),CYLT(305)                      FASD0130
      COMMON /BSET/ LIMST,LIM1,LIM2,NPRINT,JPRINT(10),DUM(200),DE1,DE2    FASD0140
     1 ,DE3,EEZERO,E(8000),SCAP(20),SF(20),SSC(20),SA(20),ALPHA(20)       FASD0150
     2 ,KTAPE(3),KPTS(10)                                                   FASD0160
     3            ,NORES(20),LLIM(20),SPO(20),EZERO(600),RHGT(600)        FASD0170
     4 ,FACT1(600),FACT2(600),FACT3(600),FRAT(600),XI(600)                FASD0180
     5            ,GI(500),GJ(500),GF(500),E0(500),GG(500),GN(500)        FASD0190
     6 ,SPIN(500)                                                           FASD0200
      EQUIVALENCE (TID,NTID),(DUM,LIM),(NPT,NPTS),(NDATA,NDATA1)            FASD0210
      DIMENSION NTID(10,20), LIM(200)                                       FASD0220
      DIMENSION A(4)                                                        FASD0230
      EQUIVALENCE (GI(1),ELAST(1)), (GI(11),SCAPL(1)), (GI(21),SSCL(1)) FASD0240
     1 , (GI(31),SFL(1)), (GI(41),JPTS(1))                                  FASD0250
      EQUIVALENCE (GJ(1),ENEXT(1)), (GJ(11),SCAPN(1)), (GJ(21),SSCN(1)) FASD0260
     1 , (GJ(31),SFN(1))                                                    FASD0270
      DIMENSION  ELAST(10), SCAPL(10), SSCL(10), SFL(10), JPTS(10)          FASD0280
      DIMENSION  ENEXT(10), SCAPN(10), SSCN(10), SFN(10)                    FASD0290
C                                                                           FASD0300
      RE=SQRT(1.0/E(JK))                                                    FASD0310
      N=0                                                                   FASD0320
      DO 300 I=1,MAT                                                        FASD0330
      IF (TID(6,I).LE.-2.0) GO TO 245                                       FASD0340
      SA(I)=0.0                                                             FASD0350
      SF(I)=0.0                                                             FASD0360
      SSC(I)=SPO(I)                                                         FASD0370
      IF (TID(6,I).GE.0.0.AND.TID(7,I).GE.0.0.AND.TID(8,I).GE.0.0)          FASD0380
     1 GO TO 300                                                            FASD0390
      JST=LLIM(I)                                                           FASD0400
      JEND=JST+NORES(I)-1                                                   FASD0410
      DO 240 J=JST,JEND                                                     FASD0420
      X=RHGT(J)*(E(JK)-EZERO(J))                                            FASD0430
      XTEST=ABS(X)                                                          FASD0440
      IF (XI(J).LT.1.0) XTEST=XTEST*XI(J)                                   FASD0450
      IF (XTEST.LE.150.0) GO TO 220                                         FASD0460
      IF (X.GT.0.0) GO TO 240                                               FASD0470
      PSI=1.0/(1.0+X*X)                                                     FASD0480
      GO TO 230                                                             FASD0490
```

```
C      CALCULATE PSI(X,XI) AND CHI(X,XI)                                FASD0500
C      SHALL WE USE ASYMPTOTIC OR CONVERGENT SERIES                     FASD0510
  220 THE=4.0/(XI(J)*XI(J))                                             FASD0520
      AXI=ABS(X     )                                                   FASD0530
      IF(AXI-1.2)21,12,12                                               FASD0540
   12 IF(AXI-10.0)23,14,14                                              FASD0550
   14 IF(AXI-100.0)25,16,16                                             FASD0560
   16 IF (AXI-500.0) 27,18,18                                           FASD0570
   18 IF (AXI-2500.0) 29,29,31                                          FASD0580
   21 IF(0.275*AXI*AXI+0.05-THE   )78,78,59                             FASD0590
   23 IF(0.12*AXI*AXI +0.28-THE   )78,78,59                             FASD0600
   25 IF (0.08*AXI*AXI+1.8-THE) 78,78,59                                FASD0610
   27 IF (0.0717*AXI*AXI+83.0-THE) 78,78,59                             FASD0620
   29 IF (0.0635*AXI*AXI+2100.0-THE) 78,78,59                            FASD0630
   31 IF (0.111*AXI**1.93-THE) 78,78,59                                 FASD0640
C      TO 59 FOR ASYMPTOTIC SERIES                                      FASD0650
   59 SQ = X*X+1.0                                                      FASD0660
      AJ=1.0/SQ                                                         FASD0670
      BB=THE*AJ                                                         FASD0680
      A(1)=0.5                                                          FASD0690
      A(2)=0.75                                                         FASD0700
      A(3)=1.875                                                        FASD0710
      A(4)=6.5625                                                       FASD0720
      AH=X*AJ                                                           FASD0730
      T1=(SQ-2.0)*AJ                                                    FASD0740
      T2=2.0*AH                                                         FASD0750
      PSI=AJ                                                            FASD0760
      CHI=(1.0-BB)*AH                                                   FASD0770
      B=1.0                                                             FASD0780
      DO 10 K=1,4                                                       FASD0790
      B=B*BB                                                            FASD0800
      AB=A(K)*B                                                         FASD0810
      AT=T2*AJ                                                          FASD0820
      AJ=AJ*T1+T2*AH                                                    FASD0830
      AH=T1*AH-AT                                                       FASD0840
      PSI=PSI+AB*AJ                                                     FASD0850
      S1=2*K+1                                                          FASD0860
      XAJ=X*AJ                                                          FASD0870
      CHI=CHI+AB*(XAJ-0.5*S1*BB*(XAJ+AH))                               FASD0880
   10 CONTINUE                                                          FASD0890
      CHI=CHI*2.0                                                       FASD0900
      GO TO 230                                                         FASD0910
C      TO 78 FOR CONVERGENT SERIES                                      FASD0920
C      CALCULATE GAMMA INCOMPLETE(0)                                    FASD0930
   78 TT=1.0/THE                                                        FASD0940
      IF(TT-8.4)81,81,82                                                FASD0950
   81 CALL GAMINC(TT,FR)                                                FASD0960
      G1C=FR*EXP(TT)*SQRT(TT)                                           FASD0970
      GO TO 83                                                          FASD0980
   82 V=0.5*XI(J)                                                       FASD0990
```

```
      TWOV=XI(J)                                                        FASD1000
      G1C=V/(V+1.0/(TWOV+2.0/(V+3.0/(TWOV+4.0/(V+5.0/(TWOV+6.0/         FASD1010
     1 (V+7.0/(TWOV+2.5)))))))))                                        FASD1020
   83 RAT=X*X                                                           FASD1030
      G2C= 2.0*(1.0-G1C)                                                FASD1040
      C1=RAT*TT                                                         FASD1050
      C11=C1                                                            FASD1060
      TEP=G1C+C1*TT*G2C                                                 FASD1070
      TEC=G2C                                                           FASD1080
      FQ1=1.0                                                           FASD1090
      C2=X     /THE                                                     FASD1100
      C3=EXP(-X     *C2)                                                FASD1110
      T9=1.0                                                            FASD1120
       DO 91 KZ=1,100                                                   FASD1130
      FQ1=FQ1+1.0                                                       FASD1140
      T9=T9+2.0                                                         FASD1150
      G2C=2.0/T9*(1.0-TT*G2C)                                           FASD1160
      TR=C11*G2C                                                        FASD1170
      C11=C1*C11/FQ1                                                    FASD1180
      TR1=C11*TT*G2C                                                    FASD1190
      TEP=TEP+TR1                                                       FASD1200
      TEC=TEC+TR                                                        FASD1210
      IF(ABS(TR/TEC)-0.00001)93,93,91                                   FASD1220
   91 CONTINUE                                                          FASD1230
      WRITE (6,603)                                                     FASD1240
  603 FORMAT (83H0IN CALCULATION OF PSI AND CHI, CONVERGENT SERIES UNCONFASD1250
     1VERGED AFTER 100 ITERATIONS.     )                                FASD1260
   93 PSI     =C3*TEP                                                   FASD1270
      CHI     =C2*C3*TEC*2.0                                            FASD1280
  230 Y=FACT2(J)*PSI*RE                                                 FASD1290
      SA(I)=SA(I)+Y                                                     FASD1300
      SF(I)=SF(I)+FRAT(J)*Y                                             FASD1310
      IF (XTEST.GT.150.0) GO TO 240                                     FASD1320
      SSC(I)=SSC(I)+FACT3(J)*PSI+FACT1(J)*CHI                           FASD1330
  240 CONTINUE                                                          FASD1340
      SCAP(I)=SA(I)-SF(I)                                               FASD1350
      IF (SSC(I).LT.0.0) SSC(I)=0.0                                     FASD1360
      GO TO 300                                                         FASD1370
C                                                                       FASD1380
C                    READ CROSS-SECTIONS FROM CARDS AND INTERPOLATE     FASD1390
  245 CONTINUE                                                          FASD1400
      N=N+1                                                             FASD1410
      JTAPE=KTAPE(N)                                                    FASD1420
      IF (ELAST(I).GT.0.0) GO TO 248                                    FASD1430
  246 READ (JTAPE,500) ELAST(I),SCAPL(I),SSCL(I),SFL(I)                 FASD1440
  500 FORMAT (4E12.6)                                                   FASD1450
      JPTS(I)=JPTS(I)+1                                                 FASD1460
  247 READ (JTAPE,500) ENEXT(I),SCAPN(I),SSCN(I),SFN(I)                 FASD1470
      JPTS(I)=JPTS(I)+1                                                 FASD1480
  248 IF (ENEXT(I).GT.E(JK)) GO TO 250                                  FASD1490
```

```
      IF (ABS(ELAST(I)-E(JK)).LE.1.0E-5*ELAST(I)) GO TO 252            FASD1500
  249 IF (ELAST(I).GT.E(JK))GO TO 251                                  FASD1510
      GO TO 252                                                        FASD1520
  250 ELAST(I)=ENEXT(I)                                                FASD1530
      SCAPL(I)=SCAPN(I)                                                FASD1540
      SSCL(I) = SSCN(I)                                                FASD1550
      SFL(I)  =  SFN(I)                                                FASD1560
      IF (JPTS(I).LT.KPTS(N)) GO TO 247                                FASD1570
      GO TO 252                                                        FASD1580
  251 ERATIO = (E(JK)-ENEXT(I))/(ELAST(I)-ENEXT(I))                    FASD1590
      SCAP(I)=SCAPN(I) + ERATIO*(SCAPL(I)-SCAPN(I))                    FASD1600
      SSC(I) = SSCN(I) + ERATIO*(SSCL(I)-SSCN(I))                      FASD1610
      SF(I)  =  SFN(I) + ERATIO*(SFL(I)-SFN(I))                        FASD1620
      GO TO 253                                                        FASD1630
  252 SCAP(I)=SCAPL(I)                                                 FASD1640
      SSC(I) = SSCL(I)                                                 FASD1650
      SF(I)  =  SFL(I)                                                 FASD1660
  253 IF (JK.LT.NPTS) GO TO 300                                        FASD1670
      IF (JPTS(I).GE.KPTS(N)) GO TO 300                                FASD1680
      J1=JPTS(I)+1                                                     FASD1690
      J2=KPTS(N)                                                       FASD1700
      DO 254 K=J1,J2                                                   FASD1710
  254 READ (JTAPE) DUMMY                                               FASD1720
  300 CONTINUE                                                         FASD1730
      RETURN                                                           FASD1740
      END                                                              FASD1750
```

```
$IBFTC NUTZ     LIST,DECK,REF                                      08-09-65
      SUBROUTINE NUTZ(I,MT)
C
C                COMPUTE NUMBER OF DOWNSCATTERINGS
C                AND WRITE DATA ON CROSS SECTION TAPE (NDATA)
C
      COMMON /ALL/  NIN,NOUT,NDATA,NIN1,NIN3,JHYD,NEL,NARRAY,NPAGE,LINES
     1,NPROB,NPTS,INDEX,NPLOT,TITLE(12),TID(10,20),CNAME(5,20),LINEPP
     2 ,MAT,MFRAME
      COMMON /TABLES/ CS1,CS2,CS3,SLABT(505),CYLT(305)
      COMMON /BSET/ LIMST,LIM1,LIM2,NPRINT,JPRINT(10),DUM(200),DE1,DE2
     1 ,DE3,EEZERO,E(8000),SCAP(20),SF(20),SSC(20),SA(20),ALPHA(20)
     2 ,KTAPE(3),KPTS(10)
     3             ,NORES(20),LLIM(20),SPO(20),EZERO(600),RHGT(600)
     4 ,FACT1(600),FACT2(600),FACT3(600),FRAT(600),XI(600)
     5             ,GI(500),GJ(500),GF(500),EO(500),GG(500),GN(500)
     6 ,SPIN(500)
      EQUIVALENCE (TID,NTID),(DUM,LIM),(NPT,NPTS),(NDATA,NDATA1)
      DIMENSION NTID(10,20), LIM(200)
      ND=1
      NT=MT
      LIMM1=LIMST*(NT-1)
      DO 40 K=1,NEL
      ETO=E(I)*ALPHA(K)
      ETL=E(I-1)*ALPHA(K)
      NST=I
      NEND=MINO(LIMST,NPTS-LIMM1)
   20 DO 30 J=NST,NEND
      IF (E(J).GT.ETO) GO TO 30
      LIM(ND)=J-I-1
      IF (LIM(ND).LT.0) LIM(ND)=LIM(ND)+LIMM1
      JJ=J-1
      GO TO 31
   30 CONTINUE
      IF (NEND.GE.NPTS-LIMM1) GO TO 25
      IF (NEND.EQ.I-1) GO TO 25
      NST=1
      LIMM1=LIMST*NT
      NEND=MINO(I-1,NPTS-LIMM1)
      NT=NT+1
      GO TO 20
   25 LIM(ND)=NEND-I
      IF (LIM(ND).LT.0) LIM(ND)=LIM(ND)+LIMM1
      JJ=NEND
   31 ND=ND+1
      NCORT=0
  320 IF (JJ.GE.1) GO TO 32
      JJ=LIMST
   32 IF (ETL.LT.E(JJ))GO TO 33
```

```
      NCORT=NCORT+1                                                     NUTZ0490
      NDC=NCORT+ND                                                      NUTZ0500
      DUM(NDC)=E(JJ)                                                    NUTZ0510
      JJ=JJ-1                                                           NUTZ0520
      GO TO 320                                                         NUTZ0530
   33 LIM(ND)=NCORT                                                     NUTZ0540
      ND=ND+NCORT+1                                                     NUTZ0550
      IF (TID(6,K).GE.0.0) GO TO 34                                     NUTZ0560
      DUM(ND)=SCAP(K)                                                   NUTZ0570
      ND=ND+1                                                           NUTZ0580
   34 IF (TID(7,K).GE.0.0) GO TO 35                                     NUTZ0590
      DUM(ND)=SF(K)                                                     NUTZ0600
      ND=ND+1                                                           NUTZ0610
   35 IF (TID(8,K).GE.0.0) GO TO 40                                     NUTZ0620
      DUM(ND)=SSC(K)                                                    NUTZ0630
      ND=ND+1                                                           NUTZ0640
   40 CONTINUE                                                          NUTZ0650
      ND=ND-1                                                           NUTZ0660
      WRITE (NDATA1) E(I),DE1,DE2,DE3,ND,(DUM(J),J=1,ND)                NUTZ0670
      RETURN                                                            NUTZ0680
      END                                                               NUTZ0690
```

```
$IBFTC PRINT   LIST,DECK,REF                                       08-09-65
      SUBROUTINE PRINT(JST,EE)
C
C                 PRINT ROUTINE FOR GAROL DATA
C
      COMMON /ALL/  NIN,NOUT,NDATA,NIN1,NIN3,JHYD,NEL,NARRAY,NPAGE,LINES
     1,NPROB,NPTS,INDEX,NPLOT,TITLE(12),TID(10,20),CNAME(5,20),LINEPP
     2 ,MAT,MFRAME
      COMMON /TABLES/ CS1,CS2,CS3,SLABT(505),CYLT(305)
      COMMON /BSET/ LIMST,LIM1,LIM2,NPRINT,JPRINT(10),DUM(200),DE1,DE2
     1 ,DE3,EEZERO,E(8000),SCAP(20),SF(20),SSC(20),SA(20),ALPHA(20)
     2 ,KTAPE(3),KPTS(10)
     3                 ,NORES(20),LLIM(20),SP0(20),EZERO(600),RHGT(600)
     4 ,FACT1(600),FACT2(600),FACT3(600),FRAT(600),XI(600)
     5                 ,GI(500),GJ(500),GF(500),E0(500),GG(500),GN(500)
     6 ,SPIN(500)
      EQUIVALENCE (TID,NTID),(DUM,LIM),(NPT,NPTS),(NDATA,NDATA1)
      DIMENSION NTID(10,20), LIM(200)
      DIMENSION  FMT(24), DUM1(9), DUM2(9), NSUB(9), NFMT(1)
     1 , T(20)
      EQUIVALENCE (FMT,NFMT)
      IF (NCODE.EQ.2345) GO TO 100
      CALL BOOLER(6HCAPTUR,CAP)
      CALL BOOLER(6HE     ,TURE)
      CALL BOOLER(6HFISSIO,FIS)
      CALL BOOLER(6HN     ,SION)
      CALL BOOLER(6HSCATTE,SCAT)
      CALL BOOLER(6HR     ,TER)
      CALL BOOLER(6H(20X, ,FMT(1))
      CALL BOOLER(6HA6,A4,,A6A4)
      CALL BOOLER(6H      ,BLANK)
      CALL BOOLER(6H2X    ,TWOX)
      CALL BOOLER(6H X    ,X)
      CALL BOOLER(6H )    ,ENDFMT)
      NCODE=2345
      N=1
      NF=2
      ND=0
      L=0
      DO 50 K=1,MAT
      IF (K.NE.JPRINT(N)) GO TO 50
      FMT(NF)=A6A4
      FMT(NF+1)=TWOX
      NF=NF+2
      NSPACE=(NTID(9,K)-1)*12
      NS=NSPACE/10
      NFMT(NF)=NS*64+NSPACE-NS*10
      IF (NFMT(NF).EQ.0) GO TO 10
      FMT(NF+1)=X
      NF=NF+2
```

```
 10 IF (TID(6,K).GE.0.0) GO TO 20
    ND=ND+1
    NSUB(ND)=K
    T(L+1)=CAP
    T(L+2)=TURE
    L=L+2
    IF (ND.GE.9) GO TO 60
    IF (TID(6,K).LE.-2.0) GO TO 21
 20 IF (TID(7,K).GE.0.0) GO TO 30
 21 ND=ND+1
    NSUB(ND)=K+20
    T(L+1)=FIS
    T(L+2)=SION
    L=L+2
    IF (ND.GE.9) GO TO 60
    IF (TID(6,K).LE.-2.0) GO TO 31
 30 IF (TID(8,K).GE.0.0) GO TO 40
 31 ND=ND+1
    NSUB(ND)=K+40
    T(L+1)=SCAT
    T(L+2)=TER
    L=L+2
    IF (ND.GE.9) GO TO 60
 40 CONTINUE
    N=N+1
    IF (N.GT.NPRINT) GO TO 60
 50 CONTINUE
 60 IF (FMT(NF-1).EQ.X) NF=NF-2
    FMT(NF)=ENDFMT
    IF(NF.GE.24) GO TO 80
    NF=NF+1
    DO 70 NJ=NF,24
 70 FMT(NJ)=BLANK
 80 CONTINUE
    GO TO 105
100 IF (MOD(JST,52).GT.0) GO TO 115
    CALL HEAD
105 DO 110 I=1,NPRINT
    J=JPRINT(I)
    DUM1(I)=CNAME(1,J)
    DUM2(I)=CNAME(2,J)
110 CONTINUE
    WRITE (6,FMT)(DUM1(I),DUM2(I),I=1,NPRINT)
    WRITE (6,601)(T(I),I=1,L)
601 FORMAT (8X,9HENERGY-EV 3X 18A6)
115 WRITE (6,600)
600 FORMAT (1X)
    DO 120 I=1,ND
    J=NSUB(I)
120 DUM1(I)=SCAP(J)
```

```
      WRITE (6,602) JST,EE,(DUM1(LL),LL=1,ND)                           PRIN1000
  602 FORMAT (I6,1P10E12.5)                                             PRIN1010
      RETURN                                                            PRIN1020
      END                                                               PRIN1030
```

```
$IBFTC GAMINC  LIST,DECK,REF                                    08-09-65GAMI0000
      SUBROUTINE GAMINC(X1,FR)                                          GAMI0010
C                                                                       GAMI0020
C     CALCULATE INCOMPLETE GAMMA-FUNCTION , G(A,X)  FOR A=0.5)          GAMI0030
C     ADAPTED FOR GAROL FROM THE ZUT PROGRAM (GA-2525)                  GAMI0040
C                                                                       GAMI0050
      C=0.0                                                             GAMI0060
      EX=1.0                                                            GAMI0070
      SUM=1.0                                                           GAMI0080
      DO 20 K=1,20                                                      GAMI0090
      DO 15 J=1,5                                                       GAMI0100
      C=C+1.0                                                           GAMI0110
      EX=-X1*EX/C                                                       GAMI0120
      TERM=EX/(2.0*C+1.0)                                               GAMI0130
   15 SUM=SUM+TERM                                                      GAMI0140
      IF(ABS(TERM/SUM)-1.0E-5)22,22,20                                  GAMI0150
   20 CONTINUE                                                          GAMI0160
   22 FR=2.0*SQRT(X1)*SUM                                               GAMI0170
      FR=1.7724539-FR                                                   GAMI0180
      RETURN                                                            GAMI0190
      END                                                               GAMI0200
```

```
$IBFTC HEAD    LIST,DECK,REF                                    08-09-65HEAD0000
      SUBROUTINE HEAD                                                   HEAD0010
      COMMON /ALL/  NIN,NOUT,NDATA,NIN1,NIN3,JHYD,NEL,NARRAY,NPAGE,LINESHEAD0020
     1,NPROB,NPTS,INDEX,NPLOT,TITLE(12),TID(10,20),CNAME(5,20),LINEPP   HEAD0030
     2 ,MAT,MFRAME                                                      HEAD0040
      COMMON /PLOTT/ TLABEL(12),XLABEL(12),YLABEL(12),T2(12)            HEAD0050
      NPAGE=NPAGE+1                                                     HEAD0060
      WRITE (6,601)(TLABEL(I),I=1,12),NPAGE                             HEAD0070
  601 FORMAT(26H1GAROL DATA TAPE, LABELED 12A6, 22X 4HPAGE I6)          HEAD0080
      RETURN                                                            HEAD0090
      END                                                               HEAD0100
```

* * * * * * * * * *
G A R O L   L I N K   4
* * * * * * * * * *

```
$IBMAP COMSET  LIST,REF                                                08-09-654COM0000
 B     BOOL    7022                                                             4COM0010
 BSET  CONTRL  A,C                                                              4COM0020
 A     BSS     8                                                                4COM0030
 C     EQU     *                                                                4COM0040
       END                                                                      4COM0050
```

```
$IBFTC LINK4   LIST,DECK,REF                                           08-09-654LNK0000
C                                                                               4LNK0010
C                               LINK  4                                         4LNK0020
C                    RESONANCE OVERLAP CALCULATION                              4LNK0030
C                                                                               4LNK0040
      COMMON /ALL/  NIN,NOUT,NDATA,NIN1,NIN3,JHYD,NEL,NARRAY,NPAGE,LINES4LNK0050
     1,NPROB,NPTS,INDEX,NPLOT,TITLE(12),TID(10,20),CNAME(5,20),LINEPP   4LNK0060
     2 ,MAT,MFRAME                                                      4LNK0070
      COMMON /BSET/ V(2), R, IGEOM, EC, EST, EEND, NHYD, HYD(2)         4LNK0080
     1 , E, DE1, DE2, DE3, DE4, SUM(2), SUMA, SUMB, T(2), S(2)          4LNK0090
     2 , TERM, CC, MORDER(10), ELBAR(2)                                 4LNK0100
     3 , ZID(10,10), CAP(10), SCAT(10), FIS(10), LIM(10), DENS(10,2)    4LNK0110
     4 , DENSTY(10,2), ALPHA(10), TOTAL(2), P(2), D(2), Q(2), DDQQ      4LNK0120
     5 , PHI(2), SORC(2)                                                4LNK0130
     6 , NBG, BEG(50), BPHI(50,2), BCAP(50,10,2), BSCAT(50,10,2)        4LNK0140
     7 , BFIS(50,10,2), CELLS(50), CELLC(50), CELLF(50), OGPHI(2)       4LNK0150
     8 , OGSCAT(3), OGCAP(3), OGFIS(3)                                  4LNK0160
     9 ,TNAME(5,10)                                                     4LNK0170
      COMMON /PLOTT/ TLABEL(12),XLABEL(12),YLABEL(12),TT2(12),NFRAME    4LNK0180
      EQUIVALENCE (TID,NID), (ZID,ID), (DUM,NDUM), (NDATA,NDATA1)       4LNK0190
      DIMENSION DUM(100)                                                4LNK0200
      DIMENSION   NID(10,50), ID(10,10), NDUM(1)                        4LNK0210
      DIMENSION EJ(5,10), NCORT(10),PHIL(2), SCATL(10), LIML(10)        4LNK0220
     1 ,DETP(2), TA(8000,2)                                             4LNK0230
      DIMENSION XS(2)                                                   4LNK0240
C                                                                       4LNK0250
C                     READ PROBLEM INPUT CARDS                          4LNK0260
      LIMST=8000                                                        4LNK0270
  100 CALL INPUT                                                        4LNK0280
      NPRINT=INDEX                                                      4LNK0290
      NXSORC=NHYD                                                       4LNK0300
      IF (NXSORC.GE.1) CALL XSORC(1,DA,DA)                              4LNK0310
      IF (NPLOT.LT.1) GO TO 160                                         4LNK0320
      NIN3=3                                                            4LNK0330
      REWIND NIN3                                                       4LNK0340
      WRITE (NIN3)((TNAME(I,K),I=1,5),K=1,MAT)                          4LNK0350
      NIN1=2                                                            4LNK0360
      REWIND NIN1                                                       4LNK0370
```

```
      ASSIGN 321 TO NGOP
      ASSIGN 400 TO NGOQ
      GO TO 170
  160 ASSIGN 326 TO NGOP
      ASSIGN 500 TO NGOQ
  170 NERR=4
      NHYD=0
      ASSIGN 771 TO JGO
      DO 180 N=1,LIMST
      DO 180 NR=1,2
  180 TA(N,NR)=0.0
      DE4=0.0
      DEC=1.0/EC
      DO 185 NG=1,NBG
      DO 185 NR=1,2
      BPHI(NG,NR)=0.0
      DO 185 K=1,MAT
      BCAP(NG,K,NR)=0.0
      BFIS(NG,K,NR)=0.0
      BSCAT(NG,K,NR)=0.0
  185 CONTINUE
      IF (JHYD.GT.0.AND.MORDER(1).EQ.1) GO TO 190
      GO TO 195
  190 NHYD=1
      HYD(1)=0.0
      HYD(2)=0.0
C         READ THROUGH DATA TAPE UNTIL STARTING ENERGY (EST) IS FOUND
  195 IF (EST.GT.0.0) GO TO 201
      READ (NDATA1) E,DE1,DE2,DE3,NENTRY,(DUM(J),J=1,NENTRY)
      EST=E
      EC=E
      DEC=1.0/E
      GO TO 203
  201 READ (NDATA1) E,DE1,DE2,DE3,NENTRY,(DUM(J),J=1,NENTRY)
  202 IF (E.GT.EST) GO TO 201
  203 JST=0
      EC=E
      DEC=1.0/EC
      JPRINT=0
      NG=1
      DE12=1.0-DE2
      DO 204 K=1,MAT
  204 LIML(K)=1
      CALL TICKER(TIME)
      TIME=TIME/216.0
      WRITE (6,3001) TIME,NHYD
 3001 FORMAT (90X 26HSTART SPECTRUM CALCULATION F8.3,3H MH/ 90X
     1 6HNHYD = I3)
      ASSIGN 221 TO NGO1
      ASSIGN 231 TO NGO2
```

```
      ASSIGN 2481 TO NG05
 2049 ASSIGN 291  TO NG06
  205 DO 206 NR=1,2
      SUM(NR)=0.0
  206 TOTAL(NR)=0.0
      JST=JST+1
      IF (JST.GT.LIMST) JST=1
C                  READ MICROSCOPIC DATA
      NN=0
      M=1
      DO 220 K=1,MAT
      MO=MORDER(K)
  210 NN=NN+1
      LIM(K)=NDUM(M)
      M=M+1
      NCORT(K)=NDUM(M)
      M=M+1
      IF (NCORT(K).LE.0) GO TO 212
      NC=NCORT(K)
      DO 211 J=1,NC
      EJ(J,K)=DUM(M)
      M=M+1
  211 CONTINUE
  212 IF (MO.LE.1) GO TO 213
      MO=MO-1
      M=M+NID(9,NN)
      GO TO 210
  213 IF (ZID(6,K).GE.0.0) GO TO 214
      CAP(K)=DUM(M)
      M=M+1
      GO TO 215
  214 CAP(K)=ZID(6,K)/SQRT(E)
  215 IF (ZID(7,K).GE.0.0) GO TO 216
      FIS(K)=DUM(M)
      M=M+1
      GO TO 217
  216 FIS(K)=0.0
  217 IF (ZID(8,K).GE.0.0) GO TO 218
      SCAT(K)=DUM(M)
      M=M+1
      GO TO 219
  218 SCAT(K)=ZID(8,K)
C                  COMPUTE TOTAL CROSS SECTION FOR REGIONS 1 AND 2
  219 S1=CAP(K)+FIS(K)+SCAT(K)
      IF (LIML(K).LE.0) GO TO 2191
      SS=SCAT(K)*(DE1-1.0)
      GO TO 2193
 2191 AA=1.0-ALPHA(K)
      SS=(SCAT(K)*AA*(ELAST*(1.0+ALPHA(K))-2.0*E))/(2.0*ALPHA(K)*(ELAST-
     1 E))
```

```
      BB=0.5*(E/(ELAST-E))*AA**2/ALPHA(K)*SCATL(K)
      DO 2192 NR=1,2
      IF (DENS(K,NR).LE.0.0) GO TO 2192
      TA(JST,NR)=TA(JST,NR)+BB*PHIL(NR)*DENSTY(K,NR)
 2192 CONTINUE
 2193 DO 220 NR=1,2
      IF (DENS(K,NR).LE.0.0) GO TO 220
      TOTAL(NR)=TOTAL(NR)+S1*DENS(K,NR)
      SUM(NR)=SUM(NR)+SS*DENSTY(K,NR)
  220 CONTINUE
      ARG=ELBAR(1)*TOTAL(1)
C                    COMPUTE ESCAPE PROBABILITY FOR REGIONS 1 AND 2
      GO TO (4,6,1,2,1,1,222),IGEOM
    6 ARG1=ARG*0.25
      GO TO 3
    1 ARG1=ARG*.5
      GO TO 3
    2 ARG1=ARG*.75
    3 CALL PROB(ARG1,IGEOM,P(1))
C          APPLY DANCOFF CORRECTION, IF ANY, TO ESCAPE PROBABILITY TERM
      IF (CC.GT.0.0) P(1)=P(1)*(1.0-CC)/(1.0-CC*(1.0-ARG*P(1)))
      P(2)=P(1)*ARG/(TOTAL(2)*ELBAR(2))
      GO TO 5
    4 P(1)=0.0
      P(2)=0.0
      ASSIGN 772 TO JGO
      IGEOM=7
    5 GO TO NGO1,(221,222)
  221 IF (MORDER(1).GT.1.AND.LIM(1).GT.LIMST) GO TO 350
      ASSIGN 222 TO NGO1
C                    COMPUTE FLUXES FOR REGIONS 1 AND 2
  222 DO 223 NR=1,2
      MR=3-NR
      D(NR)=V(MR)*(TOTAL(MR)-(1.0-P(MR))*SUM(MR))
      Q(NR)=V(MR)*SUM(MR)*P(MR)
      SORC(NR)=0.0
  223 CONTINUE
      DDQQ=1.0/(D(1)*D(2)-Q(1)*Q(2))
      DO 230 K=1,MAT
      DO 230 NT=1,2
      IF (DENS(K,NT).LE.0.0) GO TO 230
      IF (E.LT.ALPHA(K)*EC) GO TO 230
      SORC(NT)=SORC(NT)+DENSTY(K,NT)*ZID(5,K)*(DEC-ALPHA(K)/E)
  230 CONTINUE
      IF (NXSORC.NE.1) GO TO 2300
      CALL XSORC(2,E,XS)
      SORC(1)= SORC(1)+XS(1)
      SORC(2)= SORC(2)+XS(2)
 2300 SORC(1)=SORC(1)*V(1)
      SORC(2)=SORC(2)*V(2)
```

```
      SPD=SORC(1)*P(1)-SORC(2)*P(2)
      GO TO NGO2,(231,233,234)
  231 T(1)=SORC(2)+SPD
      T(2)=SORC(1)-SPD
      DO 2310 NR=1,2
      MR=3-NR
      D(NR)=TOTAL(MR)*V(MR)
      PHI(MR)=T(NR)/D(NR)
      S(MR)=E*PHI(MR)*TOTAL(MR)
      DETP(MR)=DE12*PHI(MR)
 2310 CONTINUE
      LINES=60
      IF (NHYD.GT.0) GO TO 232
      ASSIGN 234 TO NGO2
      GO TO 2401
  232 ASSIGN 233 TO NGO2
      ASSIGN 244 TO NGO4
      GO TO 2401
  233 DO 2330 NR=1,2
 2330 TA(JST,NR)=TA(JST,NR)+HYD(NR)
      ASSIGN 244 TO NGO4
  234 T(1)=TA(JST,2)*V(2)*(1.0-P(2))+TA(JST,1)*V(1)*P(1)+SORC(2)+SPD
      T(2)=TA(JST,1)*V(1)*(1.0-P(1))+TA(JST,2)*V(2)*P(2)+SORC(1)-SPD
      TA(JST,1)=0.0
      TA(JST,2)=0.0
  240 DO 2400 NR=1,2
      MR=3-NR
      GO TO JGO,(771,772)
  772 PHI(NR)=T(MR)/D(MR)
      GO TO 773
  771 PHI(NR)=(Q(NR)*T(NR)+T(MR)*D(NR))*DDQQ
  773 S(NR)=E*PHI(NR)*TOTAL(NR)
      DETP(NR)=DE12*PHI(NR)
 2400 CONTINUE
C                    PRINT FLUXES FOR REGIONS 1 AND 2
 2401 IF (NPRINT.LE.0) GO TO 242
      LINES=LINES+1
      JPRINT=JPRINT+1
      IF (LINES.GT.LINEPP) CALL HEAD
      WRITE (NOUT,603) JPRINT,E,PHI(1),PHI(2),SORC(1),SORC(2),TOTAL(1),
     1 TOTAL(2),S(1),S(2)
  603 FORMAT (I5,1P9E14.6)
C                    COMPUTE SOURCES FROM THIS ENERGY TO ALL SUCCEEDING
C                    ENERGIES FOR THIS MATERIAL
  242 DO 250 K=1,MAT
      GO TO NGO4,(243,244)
  244 ASSIGN 243 TO NGO4
      DO 2440 NR=1,2
 2440 HYD(NR)=HYD(NR)+SCAT(K)*DETP(NR)*DENSTY(K,NR)
      GO TO 250
```

```
  243 IF (LIM(K).LE.0) GO TO 250
      DO 2500 NR=1,2
      IF (DENS(K,NR).LE.0.0) GO TO 2500
      SUMA=SCAT(K)*DETP(NR)*DENSTY(K,NR)
  245 NST=JST+1
      IF (NST.GT.LIMST) NST=1
      NEND=NST+LIM(K)-1
      IF (NEND.LE.LIMST) GO TO 247
      DO 246 N=NST,LIMST
      TA(N,NR)=TA(N,NR)+SUMA
  246 CONTINUE
      NST=1
      NEND=NEND-LIMST
  247 DO 248 N=NST,NEND
      TA(N,NR)=TA(N,NR)+SUMA
  248 CONTINUE
      JJ=0
      NC=NCORT(K)
      GO TO NGO5,(2481,249)
 2481 ASSIGN 249 TO NGO5
      GO TO 2500
C                    COMPUTE CORRECTION TERMS, IF ANY, AND ADD THEM IN
  249 IF (NC.LE.0) GO TO 2500
C                    COMPUTE CAROL-S CORRECTION
      R1=(1.0-DE1)*SCAT(K)
      TA(NEND,NR)=TA(NEND,NR)+R1*PHI(NR)*DENSTY(K,NR)
      JJ=JJ+1
C                    COMPUTE CHARLIE-S CORRECTION
      EBAR=EJ(JJ,K)/ALPHA(K)
      FLAST=SCATL(K)*PHIL(NR)
      F=SCAT(K)*PHI(NR)
      FBAR=((EBAR-E)*FLAST+(ELAST-EBAR)*F)/(ELAST-E)
      CTERM=(EBAR-E)*0.5*(FBAR/EBAR+F/E)
      TA(NEND,NR)=TA(NEND,NR)+CTERM*DENSTY(K,NR)
      NC=NC-1
      NEND=NEND-1
      IF (NEND.LE.0) NEND=LIMST
      GO TO 249
 2500 CONTINUE
  250 CONTINUE
C                    ADD TERMS FOR THIS ENERGY INTO SUMMATIONS FOR
C                    BROAD GROUP AVERAGES
      DE=DE3+DE4
      IF (E.GT.BEG(NG)) GO TO 280
      IF (E.EQ.BEG(NG)) GO TO 270
  260 NG=NG+1
      IF (NG.GT.NBG) GO TO 290
      IF (E.LT.BEG(NG)) GO TO 260
      DO 255 NT=1,2
      DETPX=PHI(NT)*DE3
```

```
      BPHI(NG,NT)=DETPX                                                 4LNK2880
      DO 255 K=1,MAT                                                    4LNK2890
      BSCAT(NG,K,NT)=SCAT(K)*DETPX                                      4LNK2900
      BCAP(NG,K,NT)=CAP(K)*DETPX                                        4LNK2910
      IF (ZID(7,K).LT.0.0) BFIS(NG,K,NT)=FIS(K)*DETPX                   4LNK2920
  255 CONTINUE                                                          4LNK2930
      GO TO 290                                                         4LNK2940
  270 DE=DE4                                                            4LNK2950
  280 DO 285 NT=1,2                                                     4LNK2960
      DETPX=PHI(NT)*DE                                                  4LNK2970
      BPHI(NG,NT)=BPHI(NG,NT)+DETPX                                     4LNK2980
      DO 285 K=1,MAT                                                    4LNK2990
      BSCAT(NG,K,NT)=BSCAT(NG,K,NT)+SCAT(K)*DETPX                       4LNK3000
      BCAP(NG,K,NT)=BCAP(NG,K,NT)+CAP(K)*DETPX                          4LNK3010
      IF (ZID(7,K).LT.0.0) BFIS(NG,K,NT)=BFIS(NG,K,NT)+FIS(K)*DETPX     4LNK3020
  285 CONTINUE                                                          4LNK3030
      IF (E.EQ.BEG(NG)) GO TO 260                                       4LNK3040
C                 STORE ENERGY, FLUXES, AND SCATTERING TERMS FOR USE    4LNK3050
C                 AT NEXT ENERGY                                        4LNK3060
  290 GO TO NGO6,(291,2049,329)                                         4LNK3070
  291 DE4=DE3                                                           4LNK3080
      ELAST=E                                                           4LNK3090
      DO 310 NR=1,2                                                     4LNK3100
  310 PHIL(NR)=PHI(NR)                                                  4LNK3110
      DO 320 K=1,MAT                                                    4LNK3120
      LIML(K)=LIM(K)                                                    4LNK3130
  320 SCATL(K)=SCAT(K)                                                  4LNK3140
      GO TO NGOP,(321,326)                                              4LNK3150
  321 DO 325 K=1,MAT                                                    4LNK3160
      CAP(K)=CAP(K)*PHI(1)                                              4LNK3170
      FIS(K)=FIS(K)*PHI(1)                                              4LNK3180
  325 CONTINUE                                                          4LNK3190
      WRITE (NIN3) E,PHI(1),TOTAL(1)                                    4LNK3200
      WRITE (NIN1)(CAP(K),FIS(K),K=1,MAT)                               4LNK3210
  326 CONTINUE                                                          4LNK3220
      READ (NDATA1) E,DE1,DE2,DE3,NENTRY,(DUM(J),J=1,NENTRY)            4LNK3230
      DE12=DE1-DE2                                                      4LNK3240
      IF (E.LE.EEND) GO TO 327                                          4LNK3250
      IF (E.GT.BEG(NG)) GO TO 205                                       4LNK3260
      IF (ELAST-BEG(NG).GT.BEG(NG)-E) GO TO 341                         4LNK3270
      ASSIGN 2049 TO NGO6                                               4LNK3280
      GO TO 328                                                         4LNK3290
  327 ASSIGN 329 TO NGO6                                                4LNK3300
  328 BEG(NG)=ELAST                                                     4LNK3310
      GO TO 260                                                         4LNK3320
  341 BEG(NG)=E                                                         4LNK3330
      GO TO 205                                                         4LNK3340
C           FINISH COMPUTING BROAD GROUP AVERAGES AND PRINT RESULTS     4LNK3350
  329 CONTINUE                                                          4LNK3360
      CALL TICKER(TIME)                                                 4LNK3370
```

```
      TIME=TIME/216.0                                                   4LNK3380
      WRITE (6,3002) TIME                                               4LNK3390
 3002 FORMAT (90X 26H  END SPECTRUM CALCULATION F8.3,3H MH)             4LNK3400
      IF (NG.GE.NBG) GO TO 300                                          4LNK3410
      NGP1=NG+1                                                         4LNK3420
      DO 330 N=NGP1,NBG                                                 4LNK3430
      DO 330 NT=1,2                                                     4LNK3440
      BPHI(N,NT)=0.0                                                    4LNK3450
      DO 330 K=1,MAT                                                    4LNK3460
      BCAP(N,K,NT)=0.0                                                  4LNK3470
      BSCAT(N,K,NT)=0.0                                                 4LNK3480
      BFIS(N,K,NT)=0.0                                                  4LNK3490
  330 CONTINUE                                                          4LNK3500
  300 IF (NXSORC.GE.1) CALL XSORC(3,DA,DA)                              4LNK3510
      GO TO NGOQ,(400,500)                                              4LNK3520
  400 REWIND NIN3                                                       4LNK3530
      NPTS=JPRINT                                                       4LNK3540
      IF (NBG.LE.0) CALL CHAIN(6)                                       4LNK3550
  500 IF (NBG.LE.0) GO TO 100                                           4LNK3560
      CALL CHAIN(5)                                                     4LNK3570
  350 WRITE (6,600) LIM(1)                                              4LNK3580
  600 FORMAT(113HOCHAIN 3 IS NOT YET AVAILABLE.  PROBLEMS ARE LIMITED, T4LNK3590
     1HEREFORE, TO MATERIALS FOR WHICH SOURCES AFFECT LESS THAN/        4LNK3600
     2 62H08000 SUCCEEDING ENERGIES.  FOR MATERIAL 1, THESE TERMS AFFECT4LNK3610
     3  I8, 8HENERGIES)                                                 4LNK3620
      CALL EXIT                                                         4LNK3630
      END                                                               4LNK3640
```

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$IBFTC INPUT   LIST,DECK,REF                                           08-09-65INPT0000
      SUBROUTINE INPUT                                                  INPT0010
C                                                                       INPT0020
C             READ PROBLEM INPUT CARDS AND PRINT PROBLEM SPECIFICATIONS INPT0030
C                   CHECK SOME OF THE INPUT AGAINST DIMENSIONED LIMITS  INPT0040
C                                                                       INPT0050
      COMMON /ALL/  NIN,NOUT,NDATA,NIN1,NIN3,JHYD,NEL,NARRAY,NPAGE,LINESINPT0060
     1,NPROB,NPTS,INDEX,NPLOT,TITLE(12),TID(10,20),CNAME(5,20),LINEPP   INPT0070
     2 ,MAT,MFRAME                                                      INPT0080
      COMMON /TABLES/ CS1,CS2,CS3,SLABT(505),CYLT(305)                  INPT0090
      COMMON /BSET/ V(2), R, IGEOM, EC, EST, EEND, NHYD, HYD(2)         INPT0100
     1 , E, DE1, DE2, DE3, DE4, SUM(2), SUMA, SUMB, T(2), S(2)          INPT0110
     2 , TERM, CC, MORDER(10), ELBAR(2)                                 INPT0120
     3 , ZID(10,10), CAP(10), SCAT(10), FIS(10), LIM(10), DENS(10,2)    INPT0130
     4 , DENSTY(10,2), ALPHA(10), TOTAL(2), P(2), D(2), Q(2), DDQQ      INPT0140
     5 , PHI(2), SORC(2)                                                INPT0150
     6 , NBG, BEG(50), BPHI(50,2), BCAP(50,10,2), BSCAT(50,10,2)        INPT0160
     7 , BFIS(50,10,2), CELLS(50), CELLC(50), CELLF(50), OGPHI(2)       INPT0170
     8 , OGSCAT(3), OGCAP(3), OGFIS(3)                                  INPT0180
     9 ,TNAME(5,10)                                                     INPT0190
      COMMON /PLOTT/ TLABEL(12),XLABEL(12),YLABEL(12),TT2(12),NFRAME    INPT0200
      EQUIVALENCE (TID,NID), (ZID,ID), (DUM,NDUM), (NDATA,NDATA1)       INPT0210
      DIMENSION   NID(10,50), ID(10,10)                                 INPT0220
C                                                                       INPT0230
    1 READ (NIN,901)(TITLE(I),I=1,12)                                   INPT0240
  901 FORMAT (12A6)                                                     INPT0250
      NPROB=NPROB+1                                                     INPT0260
      NCT=0                                                             INPT0270
      IF (NPROB.EQ.1) GO TO 3                                           INPT0280
      REWIND NDATA1                                                     INPT0290
      DO 2 J=1,3                                                        INPT0300
    2 READ (NDATA1) DUMMY                                               INPT0310
      IF (GEOM.GE.5.0) NCT=1                                            INPT0320
    3 READ (NIN,902) EST,EEND,GEOM,ELEMS,PRINT,PLOTTZ                   INPT0330
      INDEX=PRINT+.1                                                    INPT0340
      NPLOT=PLOTTZ+.1                                                   INPT0350
      IF (NPLOT.GT.0) NPLOT=10                                          INPT0360
  902 FORMAT (6E12.6)                                                   INPT0370
      MAT=ELEMS+.1                                                      INPT0380
      IGEOM=GEOM+.1                                                     INPT0390
      NERR=1                                                            INPT0400
      IF (MAT.GT.10.OR.MAT.LT.1) GO TO 420                              INPT0410
      READ (NIN,902) (ELBAR(L),L=1,2),CC,ZXSORC                         INPT0420
      NHYD=ZXSORC+.1                                                    INPT0430
      V(1)=1.0                                                          INPT0440
      V(2)=ELBAR(2)/ELBAR(1)                                            INPT0450
      R=V(2)                                                            INPT0460
      READ (NIN,902) ENBG                                               INPT0470
      NBG=ENBG+.1                                                       INPT0480
      NERR=NERR+1                                                       INPT0490
```

```
      IF (NBG.LE.0) GO TO 14
      IF (NBG.GT.50) GO TO 420
      READ (NIN,902)(BEG(I),I=1,NBG)
      GO TO 15
   14 BEG(1)=0.0
   15 CONTINUE
      READ (NIN,903)((ZID(N,K),N=1,2),(DENS(K,NT),NT=1,2),TT2(K),
     1 K=1,MAT)
  903 FORMAT (2A6,3E12.6)
      PL=0.0
      DO 4 K=1,MAT
    4 PL=PL+TT2(K)
      NPL=PL+.1
      IF (NPL.GT.0) NPLOT=NPLOT+1
      NERR=NERR+1
      J=1
      NSP=1
      DO 150 K=1,MAT
      CALL TIDCO(ZID(1,K))
  110 IF (NID(3,J)-ID(3,K)) 120,130,420
  120 J=J+1
      NSP=NSP+1
      IF (J.GT.NEL) GO TO 420
      GO TO 110
  130 MORDER(K)=NSP
      DO 140 I=4,10
      ZID(I,K)=TID(I,J)
  140 CONTINUE
      DO 145 I=1,5
  145 TNAME(I,K)=CNAME(I,J)
      J=J+1
      NSP=1
      ALPHA(K)=((ZID(4,K)-1.0)/(ZID(4,K)+1.0))**2
      DO 150 NT=1,2
      DENSTY(K,NT)=DENS(K,NT)/(1.0-ALPHA(K))
  150 CONTINUE
      NPAGE=NPAGE+1
      WRITE (NOUT,611) NPROB,(TITLE(I),I=1,12),NPAGE
  611 FORMAT (15H1GAROL PROBLEM I4,1H,3X 12A6,27X 4HPAGE I6)
      IF (IGEOM.GT.4) GO TO 175
      IF (IGEOM.GE.3) GO TO 160
      IF (IGEOM.GT.1) GO TO 155
      CALL BOOLER(6HNONE  ,A1)
      GO TO 170
  155 CALL BOOLER(6HSLAB  ,A1)
      GO TO 170
  160 IF (IGEOM.GT.3) GO TO 165
      CALL BOOLER(6HCYLIN.,A1)
      GO TO 170
  165 CALL BOOLER(6HSPHERE,A1)
```

```
 170 WRITE (NOUT,612) A1                                                 INPT1000
 612 FORMAT (14HOGEOMETRY  =  A6)                                        INPT1010
 175 WRITE (NOUT,6121) ELBAR(1),ELBAR(2),CC                              INPT1020
6121 FORMAT (36HOMEAN CHORD LENGTH OF REGION  1  =  1PE14.6/             INPT1030
   1 1HO 21X 14HREGION  2  =  1PE14.6/                                   INPT1040
   2 24HODANCOFF CORRECTION  =  1PE14.6)                                 INPT1050
     IF (NHYD.EQ.1) WRITE (NOUT,701)                                     INPT1060
 701 FORMAT        (108HOEXTRA SOURCE TERMS WILL BE READ FROM INPUT CARDINPT1070
   1S, INTERPOLATED WHERE NEEDED, AND ADDED TO COMPUTED SOURCES.  )      INPT1080
     IF (NPLOT.GT.0) WRITE (NOUT,702)                                    INPT1090
 702 FORMAT        (61HOPLOTTING OF THE RESULTS OF THIS PROBLEM HAS BEENINPT1100
   1 REQUESTED.  )                                                       INPT1110
     IF (EST.LE.0.0) GO TO 210                                           INPT1120
     WRITE (NOUT,613) EST                                                INPT1130
 613 FORMAT        (24HOUPPER ENERGY LIMIT  =  1PE14.6,4H  EV)           INPT1140
     GO TO 220                                                           INPT1150
 210 WRITE (NOUT,211)                                                    INPT1160
 211 FORMAT        (62HOUPPER ENERGY LIMIT WILL BE THE FIRST ENERGY ON TINPT1170
   1HE DATA TAPE. )                                                      INPT1180
 220 IF (EEND.LE.0.0) GO TO 230                                          INPT1190
     WRITE (NOUT,221) EEND                                               INPT1200
 221 FORMAT        (24HOLOWER ENERGY LIMIT  =  1PE14.6,4H  EV)           INPT1210
     GO TO 240                                                           INPT1220
 230 WRITE (NOUT,231)                                                    INPT1230
 231 FORMAT        (61HOLOWER ENERGY LIMIT WILL BE THE LAST ENERGY ON THINPT1240
   1E DATA TAPE. )                                                       INPT1250
 240 IF (NBG.GT.0) GO TO 250                                             INPT1260
     WRITE (NOUT,245)                                                    INPT1270
 245 FORMAT        (60HOBROAD GROUP AVERAGED CROSS SECTIONS WILL NOT BE INPT1280
   1CALCULATED. )                                                        INPT1290
     GO TO 260                                                           INPT1300
 250 J=1                                                                 INPT1310
     IF (NBG.GT.1) GO TO 255                                             INPT1320
     WRITE (NOUT,615) NBG,J,EST,BEG(1)                                   INPT1330
     GO TO 260                                                           INPT1340
 255 CONTINUE                                                            INPT1350
     WRITE (6,615) NBG,J,EST,BEG(1),(I,BEG(I-1),BEG(I),I=2,NBG)          INPT1360
 615 FORMAT      (26HONUMBER OF BROAD GROUPS  = I4/1HO 7X 27HBROAD GROUINPT1370
   1P BOUNDARIES (EV)//( I6,1PE14.6,4H  TO 1PE14.6))                     INPT1380
 260 CONTINUE                                                            INPT1390
     WRITE (NOUT,614) MAT,(K,ZID(1,K),ZID(2,K),(TNAME(I,K),I=1,5),       INPT1400
   1 DENS(K,1),DENS(K,2),K=1,MAT)                                        INPT1410
 614 FORMAT(1HO    22HNUMBER OF MATERIALS  =  I4/1HO 1X13HMATERIAL I.D.INPT1420
   1 5X 11HDESCRIPTION 27X 13HD E N S I T Y /55X 9HREGION  1 6X 9HREGIINPT1430
   2ON  2//(I3,2X,2A6,2X,5A6,1P2E15.6))                                  INPT1440
     IF (IGEOM.LE.4) GO TO 180                                           INPT1450
     IF (IGEOM.GE.6) GO TO 185                                           INPT1460
     READ (NIN,902) CS1,CS2,CS3                                          INPT1470
     READ (NIN,902)(CYLT(I),I=2,305)                                     INPT1480
     CYLT(1)= 0.0                                                        INPT1490
```

```
      NPAGE=NPAGE+1
      WRITE (NOUT,611) NPROB,(TITLE(I),I=1,12),NPAGE
      WRITE (NOUT,616)
  616 FORMAT(47H0SPECIAL ESCAPE PROBABILITY TABLES WILL BE USED /)
      DO 176 I=1,50
      I2=I+50
      I3=I2+50
      I4=I3+50
      I5=I4+50
      I6=I5+50
      WRITE (NOUT,617)I,CYLT(I),I2,CYLT(I2),I3,CYLT(I3),I4,CYLT(I4),I5,
     1CYLT(I5),I6,CYLT(I6)
  617 FORMAT (I5,F10.5,5(I6,F10.5))
  176 CONTINUE
      I=301
      I2=302
      WRITE (NOUT,618) I,CYLT(I),CS1,CS2,CS3,I2,CYLT(I2)
  618 FORMAT (79X,I6,F10.5/22H COEFFICIENTS--  CS1 = E12.6,3X 5HCS2 =
     1E12.6,3X 5HCS3 =E12.6,5X,I6,F10.5)
      IF (NPROB.GT.1) GO TO 190
      GO TO 200
  180 IF (NPROB.LE.1) GO TO 200
      IF (NCT.LE.0) GO TO 190
      READ (NDATA1)(SLABT(I),I=1,505),(CYLT(J),J=1,305)
      CS1=0.5
      CS2=0.0
      CS3=-0.09375
      GO TO 200
  185 WRITE (NOUT,186)
  186 FORMAT (71H0SPECIAL ESCAPE PROBABILITY TABLES FROM PRECEDING PROBL
     1EM WILL BE USED.  )
  190 READ (NDATA1) DUMMY
  200 RETURN
  420 CALL ERRORS(4,NERR)
      END
```

```
$IBFTC XSORC    LIST,DECK,REF                                         08-09-65XSOR0000
      SUBROUTINE XSORC(N,E,XS)                                                XSOR0010
C                                                                             XSOR0020
C                READ AND INTERPOLATE BACKGROUND SOURCE FROM INPUT CARDS     XSOR0030
      DIMENSION XS(2)                                                         XSOR0040
      NIN=5                                                                   XSOR0050
      GO TO (10,20,30),N                                                      XSOR0060
   10 READ (NIN,500) SORCES                                                   XSOR0070
  500 FORMAT (6E12.6)                                                         XSOR0080
      KPTS=SORCES+.1                                                          XSOR0090
      READ (NIN,500) E1,SA1,SB1                                               XSOR0100
      READ (NIN,500) E2,SA2,SB2                                               XSOR0110
      JPTS=2                                                                  XSOR0120
      GO TO 40                                                                XSOR0130
   15 READ (NIN,500) E2,SA2,SB2                                               XSOR0140
      JPTS=JPTS+1                                                             XSOR0150
   20 IF (E2.GT.E) GO TO 22                                                   XSOR0160
      IF (ABS(E1-E).LE.1.0E-5*E1) GO TO 24                                    XSOR0170
   21 IF (E1.GT.E) GO TO 23                                                   XSOR0180
      GO TO 24                                                                XSOR0190
   22 E1=E2                                                                   XSOR0200
      SA1=SA2                                                                 XSOR0210
      SB1=SB2                                                                 XSOR0220
      IF (JPTS.LT.KPTS) GO TO 15                                              XSOR0230
      GO TO 24                                                                XSOR0240
   23 ERATIO=(E-E2)/(E1-E2)                                                   XSOR0250
      XS(1)=SA2+ERATIO*(SA1-SA2)                                              XSOR0260
      XS(2)=SB2+ERATIO*(SB1-SB2)                                              XSOR0270
      GO TO 40                                                                XSOR0280
   24 XS(1)=SA1                                                               XSOR0290
      XS(2)=SB1                                                               XSOR0300
      GO TO 40                                                                XSOR0310
   30 IF (JPTS.GE.KPTS) GO TO 40                                              XSOR0320
      J1=JPTS+1                                                               XSOR0330
      DO 31 J=J1,KPTS                                                         XSOR0340
   31 READ (NIN,500) DA                                                       XSOR0350
   40 RETURN                                                                  XSOR0360
      END                                                                     XSOR0370
```

```
-$IBFTC PROB    LIST,DECK,REF                                          08-09-65
      SUBROUTINE PROB(ARG,IGEOM,PZERO)
C
C                    COMPUTE ESCAPE PROBABILITIES FOR REGION 1
C     ADAPTED FOR GAROL FROM THE ZUT PROGRAM (GA-2525)
C       THE CONSTANT 0.577216 DEFINES EULERS NUMBER
C
      COMMON /TABLES/ CS1,CS2,CS3,SLABT(505),CYLT(305)
C
      GO TO (940,720,620,820,640,640,640), IGEOM
C
C                    CYLINDRICAL GEOMETRY
  620 IF (ARG-0.1) 660,680,640
  640 IF (ARG-6.0) 680,680,700
C     /ARG LESS THAN 0.1/
  660 PZERO=1.0-1.3333333*ARG+0.5*(-ALOG(ARG)+1.3659312)*ARG*ARG
      GO TO 920
C     /ARG GREATER THAN OR EQUAL TO 0.1, LESS THAN OR EQUAL TO 6.0/
  680 CALL NEWCYL(ARG,PC)
      PZERO=1.0-PC
      GO TO 920
C     /ARG GREATER THAN 6.0/
  700 PZERO=(CS1+CS2/ARG+CS3/(ARG*ARG))/ARG
      GO TO 920
C
C                    SLAB GEOMETRY
  720 IF (ARG-0.05) 760,780,740
  740 IF (ARG-5.0) 780,780,800
C     /ARG LESS THAN 0.05/
  760 PZERO=1.0+ARG*(+ALOG(ARG)-0.66666667*ARG-0.2296368)
      GO TO 920
C     /ARG GREATER THAN OR EQUAL TO 0.05, LESS THAN OR EQUAL TO 5.0/
  780 CALL NEWSLB(ARG,PC)
      PZERO=1.0-PC
      GO TO 920
C     /ARG GREATER THAN 5.0/
  800 PZERO=0.25/ARG
      GO TO 920
C
C                    SPHERICAL GEOMETRY
  820 IF (ARG-0.02) 860,860,840
  840 IF (ARG-5.0) 880,900,900
C     /ARG LESS THAN OR EQUAL TO 0.02/
  860 PZERO=1.0-0.75*ARG
      GO TO 920
C     /ARG GREATER THAN 0.02, LESS THAN 5.0/
  880 PZERO=3.0*((2.0*ARG)*ARG-1.0+(1.0+(2.0*ARG))*EXP(-(2.0*ARG)))
     1       /(2.0*ARG)**3
      GO TO 920
```

```
C     /ARG GREATER THAN OR EQUAL TO 5.0/                                PROB0490
  900 PZERO=3.0*((2.0*ARG)*ARG-1.0)/(2.0*ARG)**3                        PROB0500
C                                                                       PROB0510
  920 RETURN                                                            PROB0520
C                                                                       PROB0530
C                  NO GEOMETRY                                          PROB0540
  940 PZERO=0.0                                                         PROB0550
      GO TO 920                                                         PROB0560
      END                                                               PROB0570
```

```
$IBFTC HEAD    LIST,DECK,REF                                         08-09-65HEAD0000
      SUBROUTINE HEAD                                                    HEAD0010
      COMMON /ALL/  NIN,NOUT,NDATA,NIN1,NIN3,JHYD,NEL,NARRAY,NPAGE,LINESHEAD0020
     1,NPROB,NPTS,INDEX,NPLOT,TITLE(12),TID(10,20),CNAME(5,20),LINEPP   HEAD0030
     2 ,MAT                                                              HEAD0040
C                    PAGE HEADING ROUTINE                                HEAD0050
      NPAGE=NPAGE+1                                                      HEAD0060
      WRITE (NOUT,601) NPROB,(TITLE(I),I=1,12),NPAGE                     HEAD0070
  601 FORMAT (15H1GAROL PROBLEM I4,1H,3X 12A6, 27X 4HPAGE I6/            HEAD0080
     1 6HOPOINT 4X 9HENERGY-EV 8X 4HFLUX 10X 4HFLUX 8X 6HSOURCE 8X       HEAD0090
     2 6HSOURCE 9X 19HTOTAL CROSS SECTION 9X 18HCOLLISION  DENSITY/      HEAD0100
     3 24X 9HREGION  1 5X 9HREGION  2  5X 9HREGION  1 5X 9HREGION  2 5X HEAD0110
     4 9HREGION  1 5X 9HREGION  2 5X 9HREGION  1 5X 9HREGION  2/)        HEAD0120
      LINES=1                                                            HEAD0130
      RETURN                                                             HEAD0140
      END                                                                HEAD0150

$IBFTC NEWCYL  LIST,DECK,REF                                         08-09-65NEWC0000
      SUBROUTINE NEWCYL(ARG,FARG)                                        NEWC0010
C     ADAPTED FOR GAROL FROM THE ZUT PROGRAM (GA-2525)                   NEWC0020
      COMMON /TABLES/ CS1,CS2,CS3,SLABT(505),CYLT(305)                   NEWC0030
       DEL=0.02                                                          NEWC0040
      RINK=ARG/DEL                                                       NEWC0050
       IN=RINK                                                           NEWC0060
      FIN=IN                                                             NEWC0070
       RINK=RINK-FIN                                                     NEWC0080
      FARG=CYLT(IN+1)+RINK*(CYLT(IN+2)-CYLT(IN+1))-RINK*(RINK-1.0)/4.0  NEWC0090
     1*(CYLT(IN+2)+CYLT(IN+1)-CYLT(IN)-CYLT(IN+3))                       NEWC0100
  220 RETURN                                                             NEWC0110
      END                                                                NEWC0120

$IBFTC NEWSLB  LIST,DECK,REF                                         08-09-65NEWS0000
      SUBROUTINE NEWSLB(ARG,FARG)                                        NEWS0010
C                                                                        NEWS0020
C     ADAPTED FOR GAROL FROM THE ZUT PROGRAM (GA-2525)                   NEWS0030
      COMMON /TABLES/ CS1,CS2,CS3,SLABT(505),CYLT(305)                   NEWS0040
      DEL=0.01                                                           NEWS0050
      RINK=ARG/DEL                                                       NEWS0060
       IN=RINK                                                           NEWS0070
      FIN=IN                                                             NEWS0080
       RINK=RINK-FIN                                                     NEWS0090
      FARG=SLABT(IN+1)+RINK*(SLABT(IN+2)-SLABT(IN+1))-RINK*(RINK-1.0)/4.NEWS0100
     10*(SLABT(IN+2)+SLABT(IN+1)-SLABT(IN)-SLABT(IN+3))                  NEWS0110
  220 RETURN                                                             NEWS0120
      END                                                                NEWS0130
```

```
                  * * * * * * * * * *
                   G A R O L   L I N K   5
                  * * * * * * * * * *
$IBMAP COMSET  LIST,REF                                         08-09-655COM0000
 B      BOOL    7022                                                     5COM0010
 BSET   CONTRL  A,C                                                      5COM0020
 A      BSS     B                                                        5COM0030
 C      EQU     *                                                        5COM0040
        END                                                              5COM0050
```

```
$IBFTC LINK5   LIST,REF                                         08-09-655LNK0000
      COMMON /ALL/  NIN,NOUT,NDATA,NIN1,NIN3,JHYD,NEL,NARRAY,NPAGE,LINES5LNK0010
     1,NPROB,NPTS,INDEX,NPLOT,TITLE(12),TID(10,20),CNAME(5,20),LINEPP   5LNK0020
     2 ,MAT,MFRAME                                                      5LNK0030
      CALL AVRG                                                         5LNK0040
      IF (NPLOT.LE.0) CALL CHAIN (4)                                    5LNK0050
C                TRANSFER TO PLOT ROUTINES  (LINK 6)                    5LNK0060
      CALL CHAIN (6)                                                    5LNK0070
      END                                                               5LNK0080
```

```
$IBFTC AVRG    LIST,DECK,REF                                          08-09-65
      SUBROUTINE AVRG
C
C
C             COMPLETE BROAD GROUP AVERAGES, COMPUTE CELL AND ONE-GROUP
C                     AVERAGES, AND PRINT RESULTS
C
      COMMON /ALL/  NIN,NOUT,NDATA,NIN1,NIN3,JHYD,NEL,NARRAY,NPAGE,LINES
     1,NPROB,NPTS,INDEX,NPLOT,TITLE(12),TID(10,20),CNAME(5,20),LINEPP
     2 ,MAT,MFRAME
      COMMON /TABLES/ CS1,CS2,CS3,SLABT(505),CYLT(305)
      COMMON /BSET/ V(2), R, IGEOM, EC, EST, EEND, NHYD, HYD(2)
     1 , E, DE1, DE2, DE3, DE4, SUM(2), SUMA, SUMB, T(2), S(2)
     2 , TERM, CC, MORDER(10), ELBAR(2)
     3 , ZID(10,10), CAP(10), SCAT(10), FIS(10), LIM(10), DENS(10,2)
     4 , DENSTY(10,2), ALPHA(10), TOTAL(2), P(2), D(2), Q(2), DDQQ
     5 , PHI(2), SORC(2)
     6 , NBG, BEG(50), BPHI(50,2), BCAP(50,10,2), BSCAT(50,10,2)
     7 , BFIS(50,10,2), CELLS(50), CELLC(50), CELLF(50), OGPHI(2)
     8 , OGSCAT(3), OGCAP(3), OGFIS(3)
     9 ,TNAME(5,10)
      COMMON /PLOTT/ TLABEL(12),XLABEL(12),YLABEL(12),TT2(12),NFRAME
      EQUIVALENCE (TID,NID), (ZID,ID)
      DIMENSION   NID(10,50),   ID(10,10)
      DIMENSION  CPHI(50)
      NPAGE=NPAGE+1
      VA=V(1)
      VB=V(2)
      WRITE (6,601) NPROB,(TITLE(I),I=1,12),NPAGE
  601 FORMAT (15H1GAROL PROBLEM I4,1H, 3X 12A6,27X 4HPAGE I6)
      DO 300 NT=1,2
      OGPHI(NT)=0.0
      DO 300 N=1,NBG
      OGPHI(NT)=OGPHI(NT)+BPHI(N,NT)
  300 CONTINUE
      AK=1.0/(VA+VB)
      OGPHI3=0.0
      DO 301 N=1,NBG
      CPHI(N)=(BPHI(N,1)*VA+BPHI(N,2)*VB)*AK
      OGPHI3=OGPHI3+CPHI(N)
  301 CONTINUE
      WRITE (6,602)
  602 FORMAT (13H0GROUP FLUXES/6H0GROUP 3X 9HENERGY-EV 5X 9HREGION  1
     1 5X 9HREGION  2 4X 12HCELL AVERAGE/8X 11HLOWER LIMIT/)
      WRITE (6,603)(I,BEG(I),BPHI(I,1),BPHI(I,2),CPHI(I),I=1,NBG)
  603 FORMAT (I4,1X,1P4E14.6)
      WRITE (6,604)(OGPHI(I),I=1,2),OGPHI3
  604 FORMAT (15H0ONE GROUP FLUX  1PE18.6,2E14.6)
      DO 400 K=1,MAT
      NPAGE=NPAGE+1
```

```
      WRITE (6,601) NPROB,(TITLE(I),I=1,12),NPAGE
      RR=DENS(K,2)*R
      TERM=(1.0+R)/(DENS(K,1)+RR)
      DO 305 NT=1,3
      OGSCAT(NT)=0.0
      OGCAP(NT)=0.0
      OGFIS(NT)=0.0
  305 CONTINUE
      DO 310 N=1,NBG
      BBR=1.0/(BPHI(N,1)+BPHI(N,2)*R)
      CELLS(N)=(DENS(K,1)*BSCAT(N,K,1)+RR*BSCAT(N,K,2))*TERM*BBR
      CELLC(N)=(DENS(K,1)*BCAP(N,K,1)+RR*BCAP(N,K,2))*TERM*BBR
      DO 310 NT=1,2
      OGSCAT(NT)=OGSCAT(NT)+BSCAT(N,K,NT)
      OGCAP(NT)=OGCAP(NT)+BCAP(N,K,NT)
      BSCAT(N,K,NT)=BSCAT(N,K,NT)/BPHI(N,NT)
      BCAP(N,K,NT)=BCAP(N,K,NT)/BPHI(N,NT)
  310 CONTINUE
      BBR=1.0/(OGPHI(1)+OGPHI(2)*R)
      OGSCAT(3)=(DENS(K,1)*OGSCAT(1)+RR*OGSCAT(2))*TERM*BBR
      OGCAP(3)=(DENS(K,1)*OGCAP(1)+RR*OGCAP(2))*TERM*BBR
      DO 315 NT=1,2
      OGCAP(NT)=OGCAP(NT)/OGPHI(NT)
      OGSCAT(NT)=OGSCAT(NT)/OGPHI(NT)
  315 CONTINUE
      IF (ZID(7,K).GE.0.0) GO TO 350
      IF (ZID(7,K).EQ.-1.0) GO TO 319
      DO 316 NT=1,2
      DO 316 N=1,NBG
      IF (BFIS(N,K,NT).NE.0.0) GO TO 319
  316 CONTINUE
      GO TO 350
  319 DO 320 N=1,NBG
      BBR=1.0/(BPHI(N,1)+BPHI(N,2)*R)
      CELLF(N)=(DENS(K,1)*BFIS(N,K,1)+RR*BFIS(N,K,2))*TERM*BBR
      DO 320 NT=1,2
      OGFIS(NT)=OGFIS(NT)+BFIS(N,K,NT)
      BFIS(N,K,NT)=BFIS(N,K,NT)/BPHI(N,NT)
  320 CONTINUE
      BBR=1.0/(OGPHI(1)+OGPHI(2)*R)
      OGFIS(3)=(DENS(K,1)*OGFIS(1)+RR*OGFIS(2))*TERM*BBR
      DO 325 NT=1,2
      OGFIS(NT)=OGFIS(NT)/OGPHI(NT)
  325 CONTINUE
      WRITE (NOUT,701) K,ZID(1,K),ZID(2,K),(TNAME(JKL,K),JKL=1,5)
  701 FORMAT (36H0BROAD GROUP AVERAGED CROSS SECTIONS /10H0MATERIAL I2,
     1 2X,2A6,5X,5A6)
      WRITE (NOUT,702)
```

```
702 FORMAT (6H0GROUP 3X 9HENERGY-EV 18X 22HR   E   G   I   O   N      1 34X AVRG0980
   1 22HR   E   G   I   O   N      2 /8X 11HLOWER LIMIT 5X 7HCAPTURE 7X     AVRG0990
   2 7HSCATTER 7X 7HFISSION 8X 5HALPHA 8X 7HCAPTURE 7X 7HSCATTER 7X        AVRG1000
   3 7HFISSION 8X 5HALPHA /)                                              AVRG1010
    DO 330 N=1,NBG                                                        AVRG1020
    A1=BCAP(N,K,1)/BFIS(N,K,1)                                            AVRG1030
    A2=BCAP(N,K,2)/BFIS(N,K,2)                                            AVRG1040
    WRITE (NOUT,703) N,BEG(N),BCAP(N,K,1),BSCAT(N,K,1),BFIS(N,K,1),A1,AVRG1050
   1 BCAP(N,K,2),BSCAT(N,K,2),BFIS(N,K,2),A2                              AVRG1060
703 FORMAT (I4,1X,1P9E14.6)                                               AVRG1070
330 CONTINUE                                                              AVRG1080
    A1=OGCAP(1)/OGFIS(1)                                                  AVRG1090
    A2=OGCAP(2)/OGFIS(2)                                                  AVRG1100
    WRITE (NOUT,704) OGCAP(1),OGSCAT(1),OGFIS(1),A1,OGCAP(2),OGSCAT(2)AVRG1110
   1 ,OGFIS(2),A2                                                         AVRG1120
704 FORMAT (19H0ONE GROUP AVERAGE 1P8E14.6)                               AVRG1130
    WRITE (NOUT,705)                                                      AVRG1140
705 FORMAT (6H0GROUP 3X 9HENERGY-EV 18X 25HC E L L      A V E R A G E/ AVRG1150
   1 8X 11HLOWER LIMIT 5X 7HCAPTURE 7X 7HSCATTER 7X 7HFISSION 8X          AVRG1160
   2 5HALPHA/ )                                                           AVRG1170
    DO 340 N=1,NBG                                                        AVRG1180
    A1=CELLC(N)/CELLF(N)                                                  AVRG1190
    WRITE (NOUT,703) N,BEG(N),CELLC(N),CELLS(N),CELLF(N),A1               AVRG1200
340 CONTINUE                                                              AVRG1210
    A1=OGCAP(3)/OGFIS(3)                                                  AVRG1220
    WRITE (NOUT,704) OGCAP(3),OGSCAT(3),OGFIS(3),A1                       AVRG1230
    GO TO 400                                                             AVRG1240
350 CONTINUE                                                              AVRG1250
    WRITE (NOUT,701) K,ZID(1,K),ZID(2,K),(TNAME(JKL,K),JKL=1,5)           AVRG1260
    WRITE (NOUT,706)                                                      AVRG1270
706 FORMAT (6H0GROUP 3X 9HENERGY-EV 9X 15HR E G I O N   1 13X 15HR E GAVRG1280
   1 I O N   2 14X 13HCELL   AVERAGE /8X 11HLOWER LIMIT 5X 7HCAPTURE 7XAVRG1290
   2 7HSCATTER 7X 7HCAPTURE 7X 7HSCATTER 7X 7HCAPTURE 7X 7HSCATTER /) AVRG1300
    DO 360 N=1,NBG                                                        AVRG1310
    WRITE (NOUT,703) N,BEG(N),(BCAP(N,K,NT),BSCAT(N,K,NT),NT=1,2),        AVRG1320
   1 CELLC(N),CELLS(N)                                                    AVRG1330
360 CONTINUE                                                              AVRG1340
    WRITE (NOUT,704) (OGCAP(NT),OGSCAT(NT),NT=1,3)                        AVRG1350
400 CONTINUE                                                              AVRG1360
    RETURN                                                                AVRG1370
    END                                                                   AVRG1380
```

```
                        * * * * * * * * * *
                         G A R O L   L I N K  6
                        * * * * * * * * * *
$IBMAP CCMSET  LIST,REF                                            08-09-656COM0000
 BSET  CONTRL  A,C                                                         6COM0010
 A     BSS     18050                                                       6COM0020
 C     EQU     *                                                           6COM0030
       END                                                                 6COM0040


$IBFTC LINK6   LIST,REF                                            08-09-656LNK0000
C                         LINK  6                                          6LNK0010
C                      PLCT  ROUTINES                                      6LNK0020
C                                                                          6LNK0030
      COMMON /ALL/  NIN,NOUT,NDATA,NIN1,NIN3,JHYD,NEL,NARRAY,NPAGE,LINES6LNK0040
     1,NPROB,NPTS,INDEX,NPLOT,TITLE(12),TID(10,20),CNAME(5,20),LINEPP   6LNK0050
     2 ,MAT,MFRAME                                                         6LNK0060
      COMMON /PLOTT/ TLABEL(12),XLABEL(12),YLABEL(12), T2(12),NFRAME      6LNK0070
      COMMON /BSET/ TNAME(5,10),E(1000),CAP(1000,8),FIS(1000,8)            6LNK0080
      EQUIVALENCE (PHI(1),CAP(1,1)),(TOTAL(1),CAP(1,2)),(CD(1),CAP(1,3))6LNK0090
      DIMENSICN  PHI(1000),TOTAL(1000),CD(1000)                           6LNK0100
      DIMENSION   KPLOT(10)                                                6LNK0110
C                                                                          6LNK0120
      REWIND NIN1                                                          6LNK0130
      NTWO=2                                                               6LNK0140
      DO 5 K=1,MAT                                                         6LNK0150
    5 KPLOT(K)=T2(K)+.1                                                    6LNK0160
      READ  (NIN3)((TNAME(I,K),I=1,5),K=1,MAT)                             6LNK0170
      CALL TPLOT(1,N,N,N,D,D,D)                                            6LNK0180
      CALL BCDLER(6H      ,BLANK)                                          6LNK0190
      NXSCL=2                                                              6LNK0200
      NYSCL=1                                                              6LNK0210
      MPTS=NPTS                                                            6LNK0220
      KMAT=MINO(MAT,8)                                                     6LNK0230
   10 JEND=MPTS                                                            6LNK0240
      IF (JEND.GT.1000) JEND=1000                                          6LNK0250
      DO 30 J=1,12                                                         6LNK0260
      TLABEL(J)=TITLE(J)                                                   6LNK0270
      T2(J)=BLANK                                                          6LNK0280
      XLABEL(J)=BLANK                                                      6LNK0290
      YLABEL(J)=BLANK                                                      6LNK0300
   30 CONTINUE                                                             6LNK0310
      CALL BCDLER(6HENERGY,XLABEL(6))                                      6LNK0320
      CALL BCDLER(6H -- EV,XLABEL(7))                                      6LNK0330
      IF (NPLOT.EQ.1)GO TO 49                                              6LNK0340
      DO 20 I=1,JEND                                                       6LNK0350
      READ  (NIN3) E(I),PHI(I),TOTAL(I)                                    6LNK0360
      CD(I)=E(I)*PHI(I)*TOTAL(I)                                           6LNK0370
   20 CONTINUE                                                             6LNK0380
```

```
      CALL BCCLER(6H  FLUX,YLABEL(5))
      CALL BCCLER(6H  IN  ,YLABEL(7))
      CALL BCCLER(6HREGION,YLABEL(9))
      CALL BCCLER(6H 1    ,YLABEL(10))
      CALL TPLOT(2,NXSCL,NTWC,JEND,E,PHI,PHI)
      CALL BCCLER(6HTOTAL ,YLABEL(1))
      CALL BCCLER(6HCROSS-,YLABEL(3))
      CALL BCCLER(6HSECTIC,YLABEL(5))
      CALL BCCLER(6HN     ,YLABEL(6))
      CALL TPLOT(2,NXSCL,NTWO,JEND,E,TOTAL,PHI)
      CALL BCCLER(6HCOLLIS,YLABEL(3))
      CALL BCCLER(6HION   ,YLABEL(4))
      CALL BCCLER(6HDENSIT,YLABEL(5))
      CALL BCCLER(6HY     ,YLABEL(6))
      YLABEL(1)=BLANK
      CALL TPLOT(2,NXSCL,NYSCL,JEND,E,CD,PHI)
      DC 40 J=1,12
      YLABEL(J)=BLANK
   40 CCNTINUE
      IF (NPLCT-10.LE.0) GC TO 70
   49 DO 50 I=1,JEND
   50 READ (NIN1)(CAP(I,K),FIS(I,K),K=1,KMAT)
      CALL BCCLER(6HCAPTUR,YLABEL(5))
      CALL BCCLER(6HE     ,YLABEL(6))
      CALL BCCLER(6H  RATE,YLABEL(7))
      DC 100 K=1,MAT
      IF (KPLCT(K).LE.0) GO TO 100
      DO 60 J=1,5
   60 T2(J)=TNAME(J,K)
      CALL TPLOT(2,NXSCL,NYSCL,JEND,E,CAP(1,K),PHI)
      IF (TID(7,K).GE.0.0) GO TO 100
      CALL BCCLER(6HFISSIC,YLABEL(5))
      CALL BCCLER(6HN     ,YLABEL(6))
      CALL TPLOT(2,NXSCL,NYSCL,JEND,E,FIS(1,K),PHI)
      CALL BCCLER(6HCAPTUR,YLABEL(5))
      CALL BCCLER(6HE     ,YLABEL(6))
  100 CONTINUE
   70 IF (JEND.GE.MPTS) GO TO 200
      MPTS=MPTS-1000
      GC TO 10
  200 CALL END(1)
      CALL BACK
      MFRAME=NFRAME
      PRINT 908,MFRAME
  908 FORMAT (1HO I6,26H FRAMES HAVE BEEN PLOTTED. )
      CALL CHAIN(4)
      END
```

```
$IBFTC TPLOT   LIST,DECK,REF                                        08-10-65
      SUBROUTINE TPLOT(NNNN,NXSCL,NYSCL,NPT,XQX,YQY,Y)
C
C     ADAPTED FOR GARCL FROM THE TPLOT PROGRAM (GAMD-4346 REVISED)
C
      COMMON /PLOTT/  TITLE(12),XLABEL(12),YLABEL(12),T2(12),MFRAME
      DIMENSION  X(1000), Y(1000), A(682), CHR(3), HEAD(10)
     1,XQX(1000), YQY(1000)
      DIMENSION ZNAME(5)
      DIMENSION  TYP(2)
C
      GO TO (1000,2000),NNNN
 1000 CF=0.43429448
      NTAPE=6
      IF (MFRAME.GT.1) NTAPE=-6
      CALL BCDLER (6HX-MAX=,BXMAX)
      CALL BCDLER (6HY-MAX=,BYMAX)
      CALL BCDLER (6HX-MIN=,BXMIN)
      CALL BCDLER (6HY-MIN=,BYMIN)
      CALL BCDLER (6H     X,BXXX)
      CALL BCDLER (6H     Y,BYYY)
      NCHRS=8
      INDEX=4
      INTENS=3
      AKAR=BXXX
      ICHAR=55
      CALL SETUP(A,682,NTAPE)
      CALL RST
      CALL SC1
      CALL HEADER
      IF (MFRAME.GT.1) GO TO 101
      MFRAME=1
      CALL BIGBEN(DATE,ZNAME)
      CALL BCDCON(HEAD)
      WRITE (0,205) DATE,(ZNAME(I),I=1,4)
  205 FORMAT (23H GENERAL ATOMIC, TPLOT, A6,2H, 4A6)
      CALL FRAME(0.0,5.0,5.0,0.0)
      CALL TSP(1.0,2.5,HEAD(1),60)
      WRITE (6,902)(HEAD(I),I=1,10)
      WRITE (6,910)MFRAME
      CALL ADF
  101 RETURN
C
 2000 CALL TICKER(TIME)
      TIME=TIME/216.0
      MFRAME=MFRAME+1
      NPTS=NPT
      DO 116 I=1,NPT
      X(I)=XQX(I)
      Y(I)=YQY(I)
```

```
 116 CONTINUE
 117 XMAXX=-1.E+35
     XMINN=1.E+35
     YMAXX=-1.E+35
     YMINN=1.E+35
     DO 118 IJ=1,NPTS
     XMAXX=AMAX1(XMAXX,X(IJ))
     XMINN=AMIN1(XMINN,X(IJ))
     YMAXX=AMAX1(YMAXX,Y(IJ))
     YMINN=AMIN1(YMINN,Y(IJ))
 118 CONTINUE
     IF (XMAXX-XMINN) 120,120,121
 120 WRITE (6,941)XMAXX
 941 FORMAT(58HONO PLOTTING FOR THIS FRAME.  X IS CONSTANT FOR ALL Y
    1AT  1PE12.6)
     GO TO 100
 121 IF (YMAXX-YMINN) 122,122,130
 122 WRITE (6,942)YMAXX
 942 FORMAT (58HONO PLOTTING FOR THIS FRAME.  Y IS CONSTANT FOR ALL X
    1AT  1PE12.6)
     GO TO 100
 130 X1PR=XMAXX
     X2PR=XMINN
     Y1PR=YMAXX
     Y2PR=YMINN
 132 GO TO (11,21),NXSCL
  11 Z1=ABS(XMINN)
     Z2=ABS(XMAXX)
     Z=ALOG10(AMAX1(Z1,Z2))
     N=-Z
     IF (N) 15,13,14
  13 IF (Z) 14,16,15
  14 N=N+1
  15 SCFX=10.0**N
     IF (XMAXX.LE.0.0) GO TO 1511
     LX2=XMAXX*SCFX+.999
     GO TO 1512
1511 LX2=XMAXX*SCFX
1512 X2=FLOAT(LX2)
     GO TO 17
  16 SCFX=10.0**N
     X2=XMAXX*SCFX
     LX2=X2+.999
  17 DO 18 J=1,NPT
  18 X(J)=X(J)*SCFX
     IF (XMINN) 1811,1810,1812
1810 LXMIN=0
     XX=0.0
     GO TO 1813
1811 LXMIN=XMINN*SCFX-.999
```

```
      XX=FLOAT(LXMIN)-.2E-6
      GO TO 1813
 1812 LXMIN=XMINN*SCFX
      XX=FLOAT(LXMIN)+.2E-6
 1813 X10=ABS(X2-XX)
      X1=XX-0.1*X10
      X1TYP=XX-0.08*X10
      NDIST=LX2-LXMIN
      IF (NDIST-5) 19,20,20
   19 NX=NDIST*10+1
      SX=0.1
      GO TO 30
   20 NX=NDIST*5+1
      SX=0.2
      GO TO 30
   21 IF (XMINN) 210,210,212
  210 WRITE (6,211)BXXX,BXXX
      GO TO 101
  212 DO 22 J=1,NPT
   22 X(J)=ALOG10(X(J))
      XMAXX=ALOG10(XMAXX)
      XMINN=ALOG10(XMINN)
      IF (XMINN)24,23,23
   23 NX1=XMINN
      GO TO 25
   24 NX1=XMINN-1.0
      IF (XMAXX) 26,25,25
   25 NX2=XMAXX+1.0
      GO TO 27
   26 NX2=XMAXX
   27 NXC=NX2-NX1
      XX=FLOAT(NX1)
      X2=FLOAT(NX2)
      X10=X2-XX
      X1=XX-0.1*X10
      X1TYP=XX-0.08*X10
   30 GO TO (31,41),NYSCL
   31 Z1=ABS(YMINN)
      Z2=ABS(YMAXX)
      ZY=ALOG10(AMAX1(Z1,Z2))
      NY=-ZY
      IF (NY) 35,33,34
   33 IF (ZY) 34,36,35
   34 NY=NY+1
   35 SCFY=10.0**NY
      IF (YMAXX.LE.0.) GO TO 3511
      LY1=YMAXX*SCFY+.999
      GO TO 3512
 3511 LY1=YMAXX*SCFY
 3512 Y1=FLOAT(LY1)
```

```
      GO TO 37
   36 SCFY=10.0**NY
      Y1=YMAXX*SCFY
      LY1=Y1+.999
   37 DO 38 J=1,NPT
   38 Y(J)=Y(J)*SCFY
      IF (YMINN) 381,380,382
  380 LYMIN=0
      YY=0.0
      GO TO 383
  381 LYMIN=YMINN*SCFY-.999
      YY=FLOAT(LYMIN)-.2E-6
      GO TO 383
  382 LYMIN=YMINN*SCFY
      YY=FLOAT(LYMIN) +.2E-06
  383 Y10=ABS(Y1-YY)
      Y22=YY-0.1*Y10
      Y2TYP=YY-0.02*Y10
      MDIST=LY1-LYMIN
      IF (MDIST-5) 39,39,40
   39 NY=MDIST*10+1
      SY=0.1
      GO TO 60
   40 NY=MDIST*5+1
      SY=0.2
      GO TO 60
   41 IF (YMINN) 410,410,412
  410 WRITE (6,211)BYYY,BYYY
      GO TO 101
  412 DO 42 J=1,NPT
   42 Y(J)=ALOG10(Y(J))
      YMAXX=ALOG10(YMAXX)
      YMINN=ALOG10(YMINN)
      IF (YMINN) 44,43,43
   43 NY2=YMINN
      GO TO 45
   44 NY2=YMINN-1.0
      IF (YMAXX) 46,45,45
   45 NY1=YMAXX+1.0
      GO TO 47
   46 NY1=YMAXX
   47 NYC=NY1-NY2
      Y1=FLOAT(NY1)
      YY=FLOAT(NY2)
      Y10=Y1-YY
      Y22=YY-0.1*Y10
      Y2TYP=YY-0.02*Y10
   60 Y1T=0.01*Y10+Y1
      XRSIDE=X2+0.01*X10
      WRITE (6,922)TIME
```

```
      CALL TICKER (TIME)
      TIME=TIME/216.0
      WRITE (6,923)TIME
  603 CALL FRAME (X1,Y1T,XRSIDE,Y22)
      GO TO (61,62),NYSCL
   61 CALL GXA (NY,XX,YY,SY)
      GO TO 70
   62 SY=Y10/FLOAT(NYC)
      IF (NYC-5) 64,64,63
   63 NY=NYC+1
      CALL GXA (NY,XX,YY,SY)
      GO TO 70
   64 NY=NYC+1
      VY=YY
      DO 65 J=1,9
      CALL GXA (NY,XX,VY,SY)
      NY=NYC
      AK=J+1
   65 VY=YY+ALOG(AK)*CF*SY
   70 GO TO (71,72),NXSCL
   71 CALL GYA (NX,XX,YY,SX)
      GO TO 76
   72 SX=X10/FLOAT(NXC)
      IF (NXC-5) 74,74,73
   73 NX=NXC+1
      CALL GYA (NX,XX,YY,SX)
      GO TO 76
   74 NX=NXC+1
      VX=XX
      DO 75 J=1,9
      CALL GYA (NX,VX,YY,SX)
      NX=NXC
      AK=J+1
   75 VX=XX+ALOG(AK)*CF*SX
   76 XCENT=XX+0.2*X10
      CALL TSP(XCENT,Y1T,TITLE(1),72)
      XL=X1
      Y11=Y1T-0.02*(Y1T-YY)
      CALL TSP(XCENT,Y11,T2(1),72)
      Y11=0.05*(Y1T-YY)
      YL=Y1T-Y11*5.0
      CALL TSP(XCENT,Y22,XLABEL(1),72)
      DO 1235 J=1,12,2
      YL=YL-Y11
 1235 CALL TSP(XL,YL,YLABEL(J),12)
      XPT=XX+0.85*X10
      YPT=Y1-0.05*Y10
      CALL BCDCON(CHR)
      WRITE (0,911) BXMAX,X1PR
      CALL TSP(XPT,YPT,CHR(1),18)
```

```
      WRITE (0,911) BXMIN,X2PR
      YPT=YPT-0.05*Y10
      CALL TSP(XPT,YPT,CHR(1),18)
      WRITE (0,911) BYMAX,Y1PR
      YPT=YPT-0.05*Y10
      CALL TSP(XPT,YPT,CHR(1),18)
      WRITE (0,911) BYMIN,Y2PR
      YPT=YPT-0.05*Y10
      CALL TSP(XPT,YPT,CHR(1),18)
   80 CALL BCDCON(TYP)
      GO TO (82,81),NXSCL
   82 IF (NX-10) 821,821,822
  821 NQXJ=2
      GO TO 825
  822 IF (NX-40) 823,823,824
  823 NQXJ=5
      GO TO 825
  824 NQXJ=10
  825 DO 83 IK=1,NX,NQXJ
      QX    =XX+SX*FLOAT(IK)-SX
      X2TYP=QX-X10/16.0
      QX=QX/SCFX
      IF (ABS(QX)-999.0) 827,827,826
  826 WRITE (0,1006) QX
      GO TO 83
  827 IF (ABS(QX)-.1) 830,829,829
  830 TTX=ABS(QX)*SCFX
      IF (TTX-.2E-6) 829,829,826
  829 WRITE (0,1008) QX
   83 CALL TSP (X2TYP,Y2TYP,TYP,NCHRS)
      GO TO 90
   81 JNX=NXC+1
      DO 183 IK=1,JNX
      X2TYP=XX+SX*FLOAT(IK)-SX
      IX=(X2TYP)/SX
      XLX=10.0**IX
      X2TYP=X2TYP-X10/16.0
      WRITE (0,1006) XLX
  183 CALL TSP (X2TYP,Y2TYP,TYP,NCHRS)
   90 GO TO (92,91),NYSCL
   92 IF(NY-10)1921,1921,1922
 1921 NQYJ=2
      GO TO 1925
 1922 IF(NY-40)1923,1923,1924
 1923 NQYJ=5
      GO TO 1925
 1924 NQYJ=10
 1925 DO 93 IJ=1,NY,NQYJ
      Y1TYP=YY+SY*FLOAT(IJ)-SY
      QY=Y1TYP
```

```
      QY=QY/SCFY
      IF (ABS(QY)-999.0) 1927,1927,1926
 1926 WRITE (0,1006) QY
      GO TO 93
 1927 IF (ABS(QY)-.1) 1930,1929,1929
 1930 TTY=ABS(QY)*SCFY
      IF (TTY-.1E-3) 1929,1929,1926
 1929 WRITE (0,1008) QY
   93 CALL TSP (X1TYP,Y1TYP,TYP,NCHRS)
      GO TO 889
   91 JNY=NYC+1
      DO 193 IJ=1,JNY
      Y1TYP=YY+SY*FLOAT(IJ)-SY
      IY=(Y1TYP)/SY
      YLY=10.0**IY
      WRITE (0,1006) YLY
  193 CALL TSP (X1TYP,Y1TYP,TYP,NCHRS)
  889 CONTINUE
      NVRS=NPTS-1
      DO 98 JKL=1,INTENS
   98 CALL DVR(NVRS,1,X,Y,1)
      CALL END
      CALL ADF
      CALL TICKER (TIME)
      TIME=TIME/216.0
      WRITE (6,924)TIME
      WRITE (6,909)MFRAME,(TITLE(I),I=1,12)
      GO TO 99
  100 MFRAME=MFRAME-1
      WRITE (6,600)(TITLE(I),I=1,12)
   99 CONTINUE
      WRITE (6,600)(YLABEL(I),I=1,12)
  600 FORMAT (22X 12A6)
      GO TO 101


  901 FORMAT(12A6)
  902 FORMAT (1H0 20X 12A6)
  909 FORMAT (1H04X,10H FRAME NO. I4,3X,12A6)
  910 FORMAT (1H04X,10H FRAME NO. I4,3X,22H SERIES IDENTIFICATION   )
  911 FORMAT (A6,1PE10.2,2X)
  922 FORMAT(80X,17H BEGIN PLOT SETUP F10.4,3H MH)
  923 FORMAT(80X,17H   BEGIN PLOTTING F10.4,3H MH)
  924 FORMAT(80X,17H     END PLOTTING F10.4,3H MH)
 1001 FORMAT (I6)
 1002 FORMAT (A6)
 1006 FORMAT (1PE8.2,4X)
 1008 FORMAT (F8.3,4X)
  211 FORMAT (1H0/1H019X,20H * * *  ERROR  * * * //20X,16H THE LOGARITHM
     11C A6,31H-SCALE OPTION HAS BEEN SELECTED//20X,15H BUT A VALUE OF
```

```
      2 A6,49H LESS THAN OR EQUAL TO ZERO HAS BEEN ENCOUNTERED.//20X,       TPL03500
     332H THIS GRAPH CANNOT BE CONTINUED.)                                   TPL03510
      END                                                                    TPL03520

$IBFTC HEADER  LIST,DECK,REF                                        08-09-65HEAD0000
      SUBROUTINE HEADER                                                      HEAD0010
      COMMON /ALL/  NIN,NOUT,NDATA,NIN1,NIN3,JHYD,NEL,NARRAY,NPAGE,LINESHEAD0020
     1,NPROB,NPTS,INDEX,NPLOT,TITLE(12),TID(10,20),CNAME(5,20),LINEPP       HEAD0030
     2 ,MAT,MFRAME                                                          HEAD0040
      NPAGE=NPAGE+1                                                         HEAD0050
      WRITE (6,601) NPROB,(TITLE(I),I=1,12),NPAGE                           HEAD0060
  601 FORMAT (15H1GAROL PROBLEM I4,1H, 3X 12A6, 27X 4HPAGE I6)              HEAD0070
      RETURN                                                                HEAD0080
      END                                                                   HEAD0090

$IBMAP BACKUP  LIST,DECK,REF                                        08-11-65BACK0000
       ENTRY   BACK                                                         BACK0010
BACK   TXI     **,0,0                                                       BACK0020
       SXA     AXT,4                                                        BACK0030
       TSX     S.IOOP,4                                                     BACK0040
       IOSKP   B1                                                           BACK0050
       PZE     S.SU11                                                       BACK0060
 AXT   AXT     **,4                                                         BACK0070
       TRA*    BACK                                                         BACK0080
 B1    MZE     1                                                            BACK0090
       END                                                                  BACK0100
```

A number of routines which are used in GAROL are not included in the listing. These are machine language subroutines which are part of the General Atomic Plot Package.(7) These routines are:

ADF	advances film
DVR	draw vector
END	writes end of file on plot tape
FRAME	establishes frame limits
GXA	generates x-axes
GYA	generates y-axes
RST	reset
SCI	select camera 1
SETUP	sets up plot buffer storage
TSP	types information on frame.

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