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A ONE-DIMENSIONAL DIFFUSION CODE FOR GENERATING EFFECTIVE NUCLEAR CROSS SECTIONS

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1DX, A ONE-DIMENSIONAL DIFFUSION CODE FOR GENERATING EFFECTIVE NUCLEAR CROSS SECTIONS

By

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1DX, A ONE-DIMENSIONAL DIFFUSION CODE FOR GENERATING EFFECTIVE NUCLEAR CROSS SECTIONS

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ABSTRACT

1DX is a multipurpose, one-dimensional (plane, cylinder, sphere) diffusion theory code for use in fast reactor analysis. The code is designed to:

- Compute k_{eff} and perform criticality searches on time absorption (α), reactor composition, reactor dimensions, and buckling by means of either a flux or an adjoint model
- Compute and punch collapsed microscopic and macroscopic cross sections averaged over the spectrum in any specified zone
- Compute and punch resonance shielded cross sections using data in the "Russian" format.

All programming is in FORTRAN-IV. Since variable dimensioning is employed, no simple restrictions on problem complexity can be stated. In a 65K memory, 100-group problems are feasible for a moderate number of mesh intervals ($\sim$30). A representative 26-group k_{eff} calculation with 30 spatial intervals using data in the "Russian" format requires about 40 seconds on a UNIVAC 1108. If the cross section data is in the "DTF" format, the same problem would require about 5 seconds.

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1DX, A ONE-DIMENSIONAL DIFFUSION CODE FOR GENERATING EFFECTIVE NUCLEAR CROSS SECTIONS

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I. INTRODUCTION

1DX is a one-dimensional diffusion theory program designed to compute resonance shielded and collapsed group cross sections. Resonance shielded cross sections are calculated using data (infinite dilution cross sections and resonance shielding factors) in the "Russian" format.(1) Interpolation schemes are used to compute shielding factors applicable to specific compositions. Collapsed group cross sections by reactor zone are calculated using flux-weighting.

The one-dimensional flux profiles and eigenvalue are computed by standard source-iteration techniques. Convergence is accelerated using fission source over-relaxation. Adjoint calculations are performed by transposing the scattering matrix and fission source and then inverting the group order of the input data.

Criticality searches can be performed on time absorption (α), material concentrations, region dimensions, and buckling. Alpha and k_{eff} can be used as parametric eigenvalues.

The format of the input data (e.g., cross sections, flux dumps, geometry, and composition specifications) is compatible with the Los Alamos one- and two-dimensional transport codes DTF-IV(2) and 2DF,(3) the BNW two-dimensional diffusion theory code 2DB,(4) and the BNW perturbation code PERT-IV.(5) All five codes use the same input module.

All programming is in Fortran-IV. Variable dimensioning is employed to make maximum use of the available fast memory.

A general description of the mathematical models used in 1DX is given in Chapters II-V. The appendices are devoted to details of code operation.

II. CALCULATION OF FLUX AND EFFECTIVE MULTIPLICATION CONSTANT

Formulation of Difference Equations

The multigroup diffusion equations can be written in the form

$$D_i \nabla^2 \phi_i - \Sigma_r^i \phi_i + S_i = 0, \quad i = 1, 2, \ldots, IGM \tag{2.1}$$

where

$$S_i = \frac{\chi_i}{k_{eff}} \sum_{j=1}^{IGM} (\nu\Sigma_f)^j \phi_j + \sum_{j=1}^{i-1} \Sigma(j\rightarrow i) \phi_j \tag{2.2}$$

and

IGM = number of energy groups,

i = energy group index,

ϕ_i = flux in group i,

S_i = source in group i,

D_i = diffusion constant for group i ($= 1/3\ \Sigma_{tr}^i$),

$(\nu\Sigma_f)^i$ = fission source cross section for group i,

$\Sigma(j\rightarrow i)$ = downscattering cross section from group j to i,

Σ_r^i = removal cross section for group i

$$\left[= \Sigma_a^i + \sum_{j=i+1}^{IGM} \Sigma(i\rightarrow j)\right],$$

χ_i = fission source fraction in group i,

k_{eff} = effective multiplication constant.

The spatial difference equations in 1DX are set up such that the mesh point is placed in the center of the homogeneous mesh interval. Equations (2.1) and (2.2) are then integrated over the volume associated with each mesh point. For example, for mesh point k, the integration would be from $[r_k - (\delta r_k/2)]$ to $[r_k + (\delta r_k/2)]$.

The leakage terms are obtained by transforming the volume integral over the Laplacian to a surface integral using Green's theorem,

$$\int D\nabla^2 \phi \, dV = \int D\overrightarrow{\nabla\phi} \cdot d\vec{A} \quad . \tag{2.3}$$

The flux gradients at the mesh boundary are obtained by interpolating the two contiguous flux values. Thus, volume integration of Equation (2.1) for mesh point k leads to the expression

$$\overline{D}_{k,k-1} A_{k,k-1} \frac{\phi_{k-1} - \phi_k}{r_k - r_{k-1}} + \overline{D}_{k+1,k} A_{k+1,k} \frac{\phi_{k+1} - \phi_k}{r_{k+1} - r_k}$$

$$- \Sigma_r^k \phi_k V_k + S_k V_k = 0, \quad k = 1, 2, \ldots, IM \tag{2.4}$$

where, for simplicity, the group indices have been omitted, and

- IM = number of mesh intervals,
- ϕ_k = flux associated with mesh point k,
- r_k = radial position of mesh point k,
- V_k = volume associated with mesh point k,
- S_k = source rate associated with mesh point k,
- Σ_r^k = removal cross section associated with mesh point k,
- $A_{k,k-1}$ = area of boundary between mesh point k and mesh point k-1,
- $\overline{D}_{k,k-1}$ = effective diffusion constant between mesh point k and mesh point k-1

$$\left[\overline{D}_{k,k-1} = \frac{D_k D_{k-1} (\delta r_k + \delta r_{k-1})}{D_k \delta r_{k-1} + D_{k-1} \delta r_k}\right] .$$

Note that if the mesh boundary is not a zone boundary, the expression for $\overline{D}_{k,k-1}$ reduces to D_k.

If we let

$$\alpha_k = \frac{\bar{D}_{k,k-1} A_{k,k-1}}{r_k - r_{k-1}} \tag{2.5}$$

and

$$\beta_k = \alpha_k + \alpha_{k+1} + \Sigma_r^k V_k \quad , \tag{2.6}$$

Equation (2.4) can be recast into the convenient form

$$-\alpha_k \phi_{k-1} + \beta_k \phi_k - \alpha_{k+1} \phi_{k+1} = S_k V_k,$$

$$k = 1, 2, \ldots, IM \quad . \tag{2.7}$$

Discussion of Boundary Conditions

Three boundary conditions are available in 1DX: reflective ($\overrightarrow{\nabla\phi} = 0$), vacuum ($\phi = 0$ at $0.71\ \lambda_{tr}$), and periodic.

Reflective

Imagine that a pseudo mesh interval (interval 0) with the same composition and thickness of Interval 1 is added on the left side of the left boundary. See Figure 1. If $\overrightarrow{\nabla\phi} = 0$ at the boundary, then $\phi_0 = \phi_1$. Since $(\phi_0 - \phi_1)$ vanishes, the coefficient of $\phi_0 - \phi_1$ [see Equation (2.4)] is immaterial, and thus α_1 can be set equal to zero.

Vacuum

Again, imagine that a pseudo mesh interval (interval IM+1) with the same composition as interval IM is added to the right side of the right boundary. Since the flux vanishes at $0.71\ \lambda_{tr}$, from Equation (2.5) we see that the appropriate coefficient of $\phi_{IM} - \phi_{IM+1}$ (where $\phi_{IM+1} = 0$) is

$$\alpha_{IM+1} = \frac{D_{IM} A_{IM+1,IM}}{0.5\ \delta r_{IM} + 0.71\ \lambda_{tr}} \quad . \tag{2.8}$$

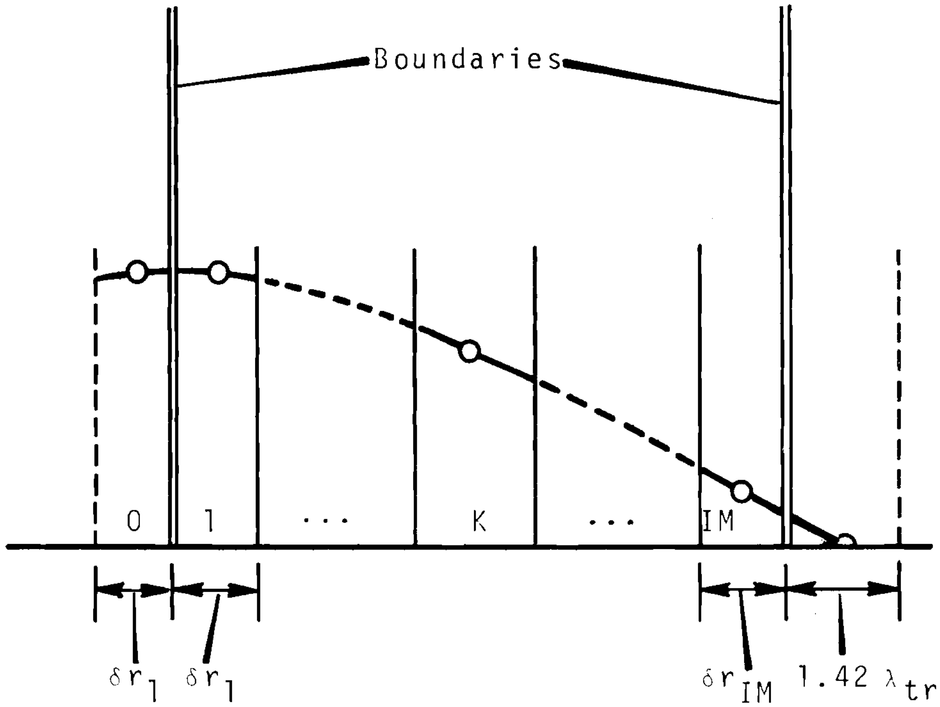

FIGURE 1. *Schematic Diagram of Reactor with Reflective Left Boundary and Vacuum Right Boundary*

Note that, as in the reflective case, there is no contribution of the pseudo flux in Equation (2.4); i.e., for $\vec{\nabla}\phi = 0$, $\alpha_1 = 0$, and for $\phi = 0$ at 0.71 λ_{tr}, $\phi_{IM+1} = 0$.

Periodic Flux

In the periodic boundary condition option,

$$\phi_0 \equiv \phi_{IM}$$

and

$$\phi_{IM+1} \equiv \phi_1 \quad .$$

From Equation (2.5), we see that

$$\alpha_1 = \alpha_{IM+1} = \frac{\overline{D}_{IM,1}\, A_{IM+1,IM}}{0.5(\delta r_1 + \delta r_{IM})} \quad . \tag{2.9}$$

It should be stressed that the pseudo mesh intervals discussed above are not in any way a part of the code. They are mentioned here only for heuristic purposes.

Solution of Difference Equations

The eigenvalue and spatial flux profiles are computed by standard source-iteration techniques; i.e., by using an initial fission source distribution, the flux profiles in each group are sequentially calculated beginning in the top (highest energy) group. The flux profiles in each group are computed by directly inverting Equation (2.7). After the new fluxes in all groups have been calculated, a new fission source distribution is computed. The multiplication ratio, λ, is then obtained by taking the ratio of the new fission source rate to the old (previous iteration) fission source rate. The above sequence of events is called an outer iteration.

Before each new outer iteration, the fission spectrum is multiplied by $1/\lambda$, so that λ approaches unity as the iteration proceeds. The effective multiplication constant is simply the product of the successive λ's. Convergence is assumed when $|1 - \lambda| < \varepsilon$, where ε, the eigenvalue convergence criterion, is an input parameter.

Fission source over-relaxation is employed in 1DX to accelerate convergence. The procedure is as follows: After the new fission source rate profile, $F_1^{\nu+1}$, is calculated, a second "new" value, $F_2^{\nu+1}$, is computed by magnifying the difference between the new fission source rate and the old fission source rate, F^ν, by a factor of β, the over-relaxation factor. Thus,

$$F_2^{\nu+1} = F^\nu + \beta(F_1^{\nu+1} - F^\nu) \quad . \tag{2.10}$$

$F_2^{\nu+1}$ is then normalized to give the same total source as $F_1^{\nu+1}$.

The adjoint form of Equation (2.1) is solved by transposing (in energy) the scattering matrix, interchanging the role of χ_i and $(\nu\Sigma_f)^i$, and inverting the group order of the cross sections, fission spectrum, and velocities. The calculation then proceeds as in a flux calculation. Thus, in an adjoint calculation, the group indices in the output are inverted, and the balance tables lack a direct physical significance.

III. DISCUSSION OF SEARCH OPTIONS

The 1DX code computes implicit eigenvalue searches on time absorption, material composition, zone thickness, and material buckling. In contrast to a k_{eff} calculation, the fission spectrum is not multiplied by $1/\lambda$ after each outer iteration. Instead, after a converged λ has been obtained ($|\lambda^{\nu+1} - \lambda^{\nu}| < \varepsilon'$, where ε' is the parametric eigenvalue convergence criterion) by a sequence of outer iterations, the desired parameter is perturbed to make λ approach unity. That is, first a converged λ is calculated for the initial system. The system is then altered by an amount specified in the input (the eigenvalue modifier) and a second converged λ is calculated. Subsequent parameter changes are determined using either linear or parabolic interpolation procedures. The iteration is continued until $|1 - \lambda| < \varepsilon$.

Time Absorption (α calculation)

For simplicity, let us consider the one-group, time dependent diffusion equation

$$\frac{1}{v}\frac{\partial \phi(\vec{r},t)}{\partial t} = D\nabla^2\phi(\vec{r},t) - \Sigma_a\phi(\vec{r},t) + \nu\Sigma_f\phi(\vec{r},t) \quad . \tag{3.1}$$

If we now assume that

$$\phi(\vec{r},t) = \phi(\vec{r})e^{\alpha t} \quad , \tag{3.2}$$

we can obviously rewrite Equation (3.1) in the form

$$D\nabla^2\phi(\vec{r}) - (\Sigma_a + \frac{\alpha}{v})\ \phi(r) + \nu\Sigma_f\phi(\vec{r}) = 0 \quad . \tag{3.3}$$

In a time absorption calculation, the parameter, α, as defined and used in Equations (3.2) and (3.3), is computed as the eigenvalue. Note that α/v is effectively an absorption cross section--hence the name "time absorption."

Material Concentration (C calculation)

1DX can perform a flexible and comprehensive criticality search on material composition. Any number of materials can simultaneously be added, depleted, or interchanged in any number of zones.

The format for specifying concentration searches can best be described by a simple example. Let us suppose that a zone mixture, say Mix 10, is to be composed of two materials mixed at full density, Materials 8 and 9. Let us further assume that Materials 8 and 9 are to be simultaneously interchanged such that they occupy a fixed volume fraction, β, of the zone mixture. The I0, I1, and I2 vectors could then be set up as shown in the following tabulation.

Mix Number (I0)	Material Number (I1)	Material Density (I2)
10	0	0
10	8	1.0
10	9	-1.0
10	10	0
10	8	α - 1.0
10	9	β - α + 1.0

The first row (10,0,0) instructs the code to clear the storage area for Mix 10. The second row (10,8,1.0) and third row (10,9,-1.0) cause Material 8 and Material 9 to be added to Mix 10 with densities of 1.0 and -1.0, respectively. The fourth row (10,10,0) causes the current contents of Mix 10 to be multiplied by the eigenvalue. Finally, rows five (10,8, α - 1.0) and six (10,9,β - α + 1.0) instruct the code to add Materials 8 and 9 to Mix 10 with densities of α - 1.0 and β - α + 1.0, respectively.

All of the foregoing can be summarized by the expression

$$\Sigma_{10} = 1.0 \cdot \Sigma_8 \cdot EV - 1.0 \cdot \Sigma_9 \cdot EV + (\alpha - 1.0)\Sigma_8 + (\beta - \alpha + 1.0)\Sigma_9 \quad (3.4)$$

where

Σ_{10} = macroscopic cross section for Mix 10,

Σ_8 = full density cross section for Material 8,

Σ_9 = full density cross section for Material 9,

EV = eigenvalue.

Note that for an initial eigenvalue guess of 1.0, Equation (3.4) reduces to $\Sigma_{10} = \alpha \cdot \Sigma_8 + (\beta - \alpha)\Sigma_9$. Therefore, α and $\beta - \alpha$ are simply the initial volume fractions of Materials 8 and 9, respectively.

Zone Dimensions (δ calculation)

1DX searches on reactor dimensions by varying the dimensions of each mesh interval. Each mesh width, δr_k, is computed from the expression

$$\delta r_k = \delta r_k^o \, [1 + (\text{dimensional modifier})_k \, \text{EV}] \quad , \tag{3.5}$$

where δr_k^o is the initial mesh spacing and EV is the eigenvalue. Different dimensional modifiers can be specified for each zone.

Buckling (B^2 calculation)

In a buckling search, the quantity $D_i \gamma B^2$ (where D_i is the zone dependent diffusion constant for group i and γ is the zone dependent buckling modifier) is added to the i^{th} group absorption cross section. The in-group scattering cross section, σ_{gg}^i, is reduced by the same amount so that the calculated total cross section remains equal to the input total. cross section. The buckling is then computed as the eigenvalue.

IV. CALCULATION OF COLLAPSED CROSS SECTIONS

1DX will collapse any IGM group cross section set (microscopic or macroscopic) to a NCR group set (IGM > NCR $\geq$ 1) using the fluxes from any specified zone. The regrouping is determined by simply specifying the number of fine groups in each collapsed group. Thus, the energy bounds of the collapsed groups correspond to those in the original group structure. The collapsing scheme is as follows:

Let

I = collapsed energy group index,

ϕ_I = total flux in collapsed group I,

$\bar{\sigma}^I$ = average microscopic cross section for the Ith collapsed group,

$\bar{\sigma}(I \rightarrow J)$ = scattering cross section from group I to group J.

For simplicity, the zone indices have been omitted. We now define ϕ_I by the equation

$$\phi_I = \sum^{I} \phi_i \quad , \tag{4.1}$$

where the symbol $\sum^{I}$ denotes a sum over the initial energy groups comprising the Ith collapsed group.

The fission, absorption, and neutron emission cross sections are calculated such that reaction rates are unaltered by the averaging procedure. Therefore, for $\bar{\sigma}_f$, $\bar{\sigma}_a$, and $\overline{\nu\sigma}_f$,

$$\bar{\sigma}^I = \frac{\sum \sigma^i \phi_i}{\phi_I} \quad . \tag{4.2}$$

Since the leakage rate in group I is given by $\sum^{I} \frac{\nabla^2 \phi_i}{3\Sigma^i_{tr}}$, the formulation for calculating the transport cross section is not as obvious. Two options, normalized weighting and reciprocal weighting, are available in 1DX to calculate the transport cross section. Normalized weighting is given by

$$\bar{\sigma}_{tr}^{I} = \frac{\sum^{I} \sigma_{tr}^{i} \frac{\phi_i}{\Sigma_{tr}^{i}}}{\sum^{I} \frac{\phi_i}{\Sigma_{tr}^{i}}} \tag{4.3}$$

and reciprocal weighting by

$$\bar{\sigma}_{tr}^{I} = \frac{\phi_I}{\sum^{I} \frac{\phi_i}{\sigma_{tr}^{i}}} \tag{4.4}$$

where Σ_{tr}^{i} is the macroscopic cross section for the specified zone.

The collapsed downscattering cross sections are calculated by matching the slowing down rates. Thus,

$$\bar{\sigma}(I\rightarrow J) = \frac{\sum^{I}\sum^{J} \sigma(i\rightarrow j)\ \phi_i}{\phi_I} \quad . \tag{4.5}$$

Finally, the in-group scattering cross section is calculated from the identity

$$\bar{\sigma}_{gg}^{I} = \bar{\sigma}_{tr}^{I} - \bar{\sigma}_{a}^{I} - \sum_{J=I+1}^{NCR} \bar{\sigma}(I\rightarrow J) \quad . \tag{4.6}$$

V. CALCULATION OF RESONANCE SHIELDED CROSS SECTIONS USING DATA IN THE RUSSIAN FORMAT

Cross section data in the "Russian" format is given in three sections: infinite dilution cross sections, inelastic scattering matrices, and resonance self-shielding factors. A brief description of the format and treatment of this data is given in the following paragraphs. For a more complete description, the reader is referred to the Russian text.[1]

Infinite Dilution Cross Sections and Inelastic Scattering Matrices

For each energy group of each isotope, nine parameters are given. These are defined below.

σ_t = total cross section ($\sigma_f + \sigma_c + \sigma_e + \sigma_{in}$),

σ_f = fission cross section,

ν = neutrons released per fission,

σ_c = capture cross section,

σ_{in} = total inelastic scattering cross section (including $\sigma_{n,2n}$ reaction),

σ_e = total elastic scattering cross section,

μ_e = average cosine of elastic scattering angle,

ξ = average lethargy change by elastic scattering,

$\sigma_{d,e}$ = elastic slowing-down cross section (in 1DX, elastic removal is always to next energy group).

The second data block contains the inelastic scattering matrix, $\sigma_{in}(i\rightarrow j)$. This matrix contains NXCM +1 terms (where NXCM is the number of downscattering terms) for each energy group--one for in-group scattering and NXCM for scattering to the first NXCM lower groups.

The code cross-checks a substantial portion of the above input data using the equations

$$\sigma_t = \sigma_f + \sigma_c + \sigma_e + \sigma_{in} \quad , \tag{5.1}$$

$$\sigma_{in,\ i} = \sum_j \sigma_{in}(i \rightarrow j) \quad (\text{if } \sigma_{n,2n} = 0) \quad , \qquad (5.2)$$

and

$$\sigma_{d,e} = \frac{\xi \sigma_e}{\delta u} \quad , \qquad (5.3)$$

where δu is the lethargy width of the group in question.

Resonance Self-Shielding Factors

Self-shielding factors are used to account for flux depression in the vicinity of large resonances. For each energy group of each isotope, self-shielding factors are listed for fission, capture, total, and elastic scattering. In crude terms,

$$\bar{\sigma} = f(T,\sigma_o)\ \sigma \qquad (5.4)$$

where

$\bar{\sigma}$ = resonance shielded cross section,
σ = infinite dilution cross section,
f = resonance self-shielding factor,
T = temperature,
σ_o = sum of total cross sections of all other elements in the medium per atom of the isotope under discussion.

The resonance self-shielding factors are compiled for discrete values of σ_o and temperature. The format of the input data (for a temperature dependent isotope) is pictured in Table 1. Although three rows of shielding factors are always given (if the f factors are temperature dependent), the number of columns (discrete σ_o values) can vary from 1 to 6.

The next two sections describe the interpolation equations employed to compute shielding factors for any temperature and total cross section.

TABLE 1. Format for Resonance Self-Shielding Factors

Temperature, °K	σ_o^1	σ_o^2	σ_o^3
T_a*	${}^1f_a$	${}^2f_a$	${}^3f_a$
T_b	${}^1f_b$	${}^2f_b$	${}^3f_b$
T_c	${}^1f_c$	${}^2f_c$	${}^3f_c$

* $T_a < T_b < T_c$

Temperature Interpolation Equation

For each σ_o column, the shielding factor corresponding to the current temperature is computed by the equation[6]

$$f(T) = \alpha + \beta \ln T \quad , \tag{5.5}$$

where

β is determined using the two end points, f_a and f_c,
α is chosen so that $F(T_b) = f_b$.

Although other interpolation schemes may be preferable in some instances, Equation (5.5) appears to be satisfactory for most FBR analyses.

σ_o Interpolation Equation

If σ_o, the total cross section per atom of all other isotopes, lies between any two tabulated total cross sections, say σ_o^1 and σ_o^2, the shielding factor is computed from the expression

$$f(\sigma_o) = {}^1f + \frac{{}^2f - {}^1f}{\ln(\sigma_o^2/\sigma_o^1)} \ln(\sigma_o/\sigma_o^1) \quad . \tag{5.6}$$

If σ_o is greater than the largest tabulated total cross section, σ_o^L, or less than the smallest cross section, σ_o^S, the following approximations are employed:

1) $\sigma_o \geq 10^7$, $f = 1.0,$ (5.7)

2) $10^7 > \sigma_o > \sigma_o^L$, $f = 1.0 + \frac{{}^L f - 1.0}{\ln(\sigma_o^L/10^7)} \ln(\sigma_o/10^7),$

(5.8)

3) $\sigma_o < \sigma_o^S$, $f = {}^S f.$ (5.9)

Iteration to Obtain Total Cross Sections

Since σ_o of each isotope cannot be obtained until the total cross section of all other isotopes is known, one must iterate to obtain both the shielding factors and the total cross sections.

An initial estimate of σ_o for each energy group of the k^{th} isotope is

$$\sigma_{o,k}^1 = \frac{1}{N_k} \sum_{j \neq k} N_j \sigma_{t,j} \quad , \tag{5.10}$$

where:

$\sigma_{o,k}$ = total cross section (excluding itself) per atom of the k^{th} isotope,

$\sigma_{t,j}$ = total cross section of j^{th} isotope,

N_k = atom density of k^{th} isotope.

For simplicity, the group index is suppressed.

Subsequent approximations to the total cross section are obtained using the algorithm

$$\sigma_{o,k}^{\nu+1} = \frac{1}{N_k} \sum_{j \neq k} N_j \left(f_{c,j}^{\nu} \sigma_{c,j} + f_{f,j}^{\nu} \sigma_{f,j} + f_{e,j}^{\nu} \sigma_{e,j} + \sigma_{in,j} \right) \tag{5.11}$$

where ν is the iteration index. The symbol f^{ν} indicates that f has been evaluated using the ν^{th} value of σ_o. It has been found that typical problems converge very well in four or five iterations; hence the number of iterations on $\sigma_{o,k}$ has been set equal to five.

Heterogeneity Correction to σ_o

If desired, 1DX will compute the total cross section for each fuel isotope using the Bell modification[7] to the rational approximation. That is,

$$\sigma_{o,k} = \frac{\Sigma_t^{(f)}}{N_k} + \frac{\Sigma_t^{(m)} V_m}{N_k \; V_f} \cdot \frac{1}{1 + \frac{4V_m}{S_f} \Sigma_t^{(m)}} \quad , \qquad (5.12)$$

or

$$\sigma_{o,k} = \frac{\Sigma_t^{(f)}}{N_k} + \frac{\Sigma_t^{(m)} V_m}{N_k \; V_f} \cdot \frac{1}{1 + X \; \Sigma_t^{(m)\prime}} \qquad (5.13)$$

where

$\Sigma_t^{(f)}$ = macroscopic total cross section in fuel excluding isotope k,
$\Sigma_t^{(m)}$ = macroscopic total cross section in moderator region,
N_k = atom density of isotope k in fuel region,
V_f = volume of fuel region,
V_m = volume of moderator region,
S_f = area of fuel region,
$X = 4(V_f + V_m)/S_f$,
$\Sigma_t^{(m)\prime} = V_m \Sigma_t^{(m)} / (V_f + V_m)$.

The heterogeneity constant, X (in units of centimeters), is the only input parameter. Note that X = 0 corresponds to a homogeneous mixture of fuel and moderator.

Correction to Elastic Removal Using Current Flux Spectrum

By necessity, the infinite dilution cross sections and shielding factors were formulated without reference to a particular reactor system. Consequently, group cross sections were calculated using an assumed in-group flux spectrum. The Bondarenko[1] cross sections, for example, were computed using a fission spectrum weighting in the top 3 groups, and a constant flux [$\emptyset(u) = C$] weighting in the remaining groups.

For most cross sections, the above procedure is probably adequate. For elastic moderation, however, appreciable errors can be encountered if the flux that contributes to elastic moderation departs significantly from the group averaged flux.

Since elastic moderation (group transfer) usually originates near the lower group boundary ($\xi << \delta u$), it is clearly more logical to use the lower boundary flux than the group averaged flux for computing elastic moderation.

As an option, after calculating a converged eigenvalue and fluxes, 1DX will recompute the elastic moderation cross section, $\bar{\sigma}_{d,e}$, using the multigroup fluxes from any specified zone. For group i (except for i = 1), the elastic moderation rate for each isotope is computed using the flux at lethargy point u_i' where

$$u_i' = u_i - 0.66\ \xi \quad . \tag{5.14}$$

Using linear interpolation on $\xi\bar{\sigma}_e\emptyset(u)$, $\bar{\sigma}_{d,e}$ is then computed using the expression

$$\bar{\sigma}^i_{d,e} = \frac{1}{\delta u_i}\left\{(\xi\bar{\sigma}_e)^i + \frac{u_i' - \bar{u}_i}{\bar{u}_{i+1} - \bar{u}_i}\left[\frac{\emptyset(\bar{u}_{i+1})}{\emptyset(\bar{u}_i)}(\xi\bar{\sigma}_e)^{i+1} - (\xi\bar{\sigma}_e)^i\right]\right\} \tag{5.15}$$

for i = 2, . . ., IGM (see Figure 2). Although any number of iterations on $\bar{\sigma}_{d,e}$ (i.e., spectrum recalculations) can be made, it has been found that $\bar{\sigma}_{d,e}$ converges well in a few iterations ($\leq$5).

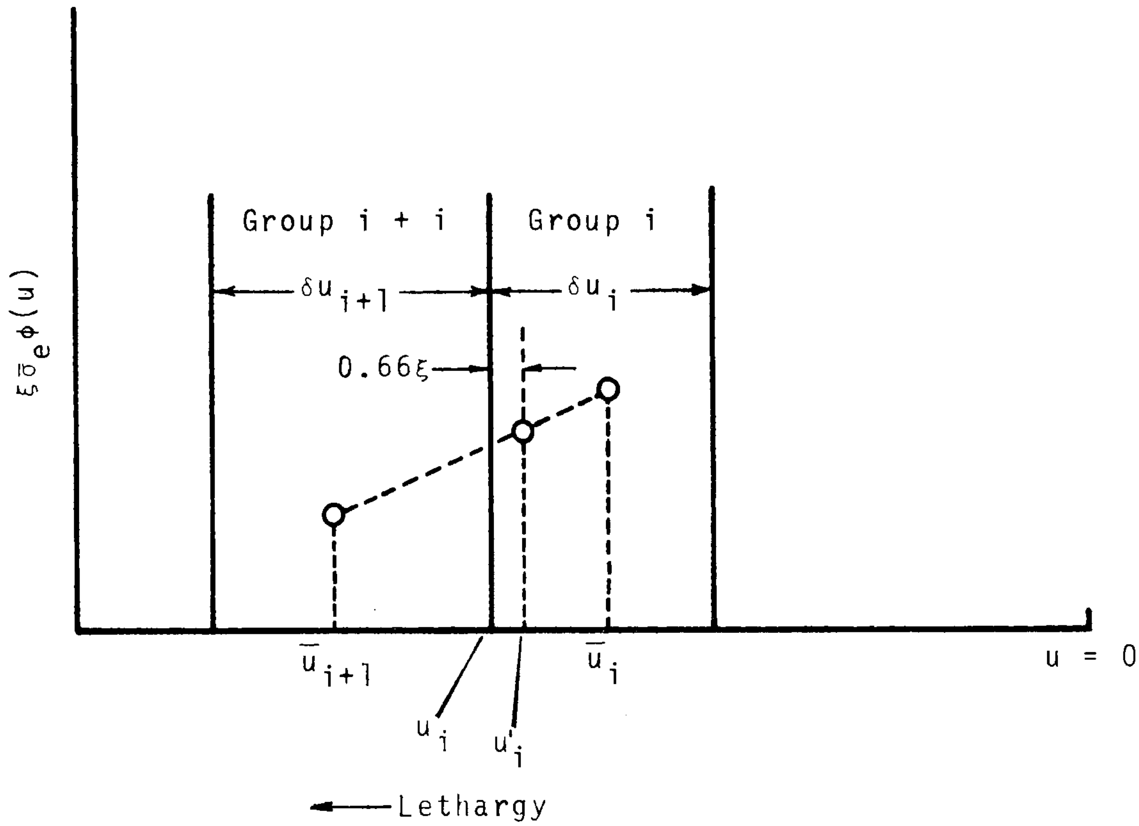

FIGURE 2. Schematic Diagram of Elastic Removal Model

Equations for Multigroup Cross Sections

The 1DX code uses and punches cross sections in the "DTF" format:

$$\bar{\sigma}_f^i \quad \bar{\sigma}_a^i \quad \overline{\nu\sigma}_f^i \quad \bar{\sigma}_{tr}^i \quad \bar{\sigma}(i\rightarrow i) \quad \bar{\sigma}(i-1\rightarrow i) \; . \; . \; .$$

The bar indicates that the cross sections include resonance self-shielding.

The above cross sections are computed from data in the "Russian" format using the following equations:

$$\bar{\sigma}_f^i = f_f^i \sigma_f^i \quad , \tag{5.16}$$

$$\bar{\sigma}_a^i = f_f^i \sigma_f^i + f_c^i \sigma_c^i - \left[\sum_j \sigma_{in}(i \rightarrow j) - \sigma_{in}^i \right] \quad , \tag{5.17}$$

$$(\overline{\nu\sigma}_f)^i = \nu^i f_f^i \sigma_f^i \quad , \tag{5.18}$$

$$\bar{\sigma}_{tr}^i = \left[f_t^i \sigma_t^i - \left(f_f^i \sigma_f^i + f_c^i \sigma_c^i + \sigma_{in}^i \right) \right] (1 - \mu_e^i) + f_f^i \sigma_f^i + f_c^i \sigma_c^i + \sigma_{in}^i \quad , \tag{5.19}$$

$$\bar{\sigma}(i-1 \rightarrow i) = \bar{\sigma}_{d,e}^{i-1} + \sigma_{in} \, (i-1 \rightarrow i) \quad , \tag{5.20}$$

$$\bar{\sigma}(i-2 \rightarrow i) = \sigma_{in} \, (i-2 \rightarrow i) \quad , \tag{5.21}$$

$$\bar{\sigma}(i-3 \rightarrow i) = \sigma_{in} \, (i-3 \rightarrow i) \quad , \tag{5.22}$$

. . .

$$\bar{\sigma}(i \rightarrow i) = \bar{\sigma}_{tr}^i - \bar{\sigma}_a^i - \sum_{j \neq 1} \bar{\sigma}(i \rightarrow j) \quad . \tag{5.23}$$

A few words should be given to the treatment of $\sigma_{n,2n}$. Since most codes do not handle $\sigma_{n,2n}$ directly, it must be incorporated in the above cross section format. This is accomplished by adding $2 \times \sigma_{n,2n}$ to the inelastic scattering matrix and subtracting $\sigma_{n,2n}$ from the capture cross section.

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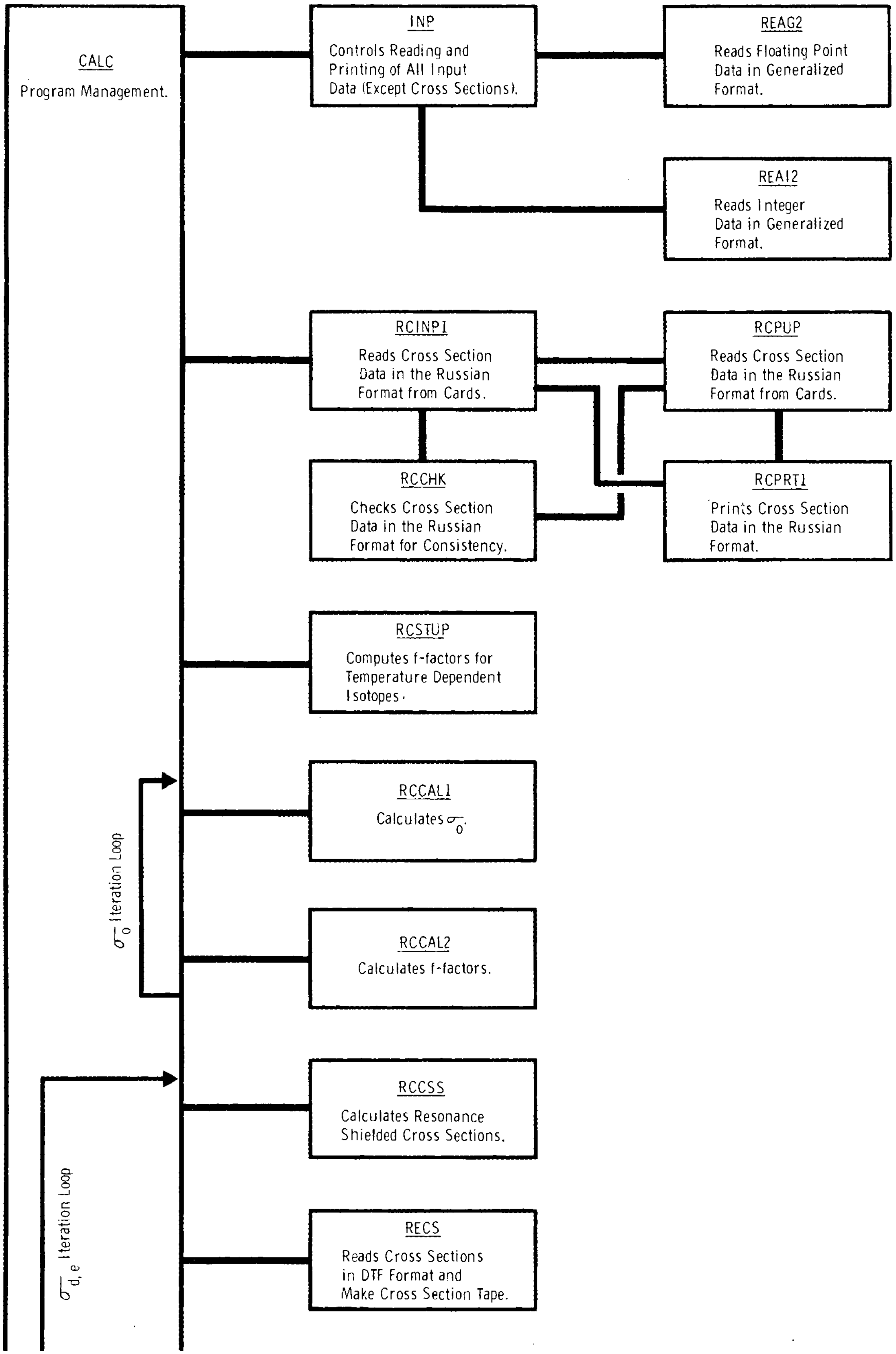
APPENDIX A

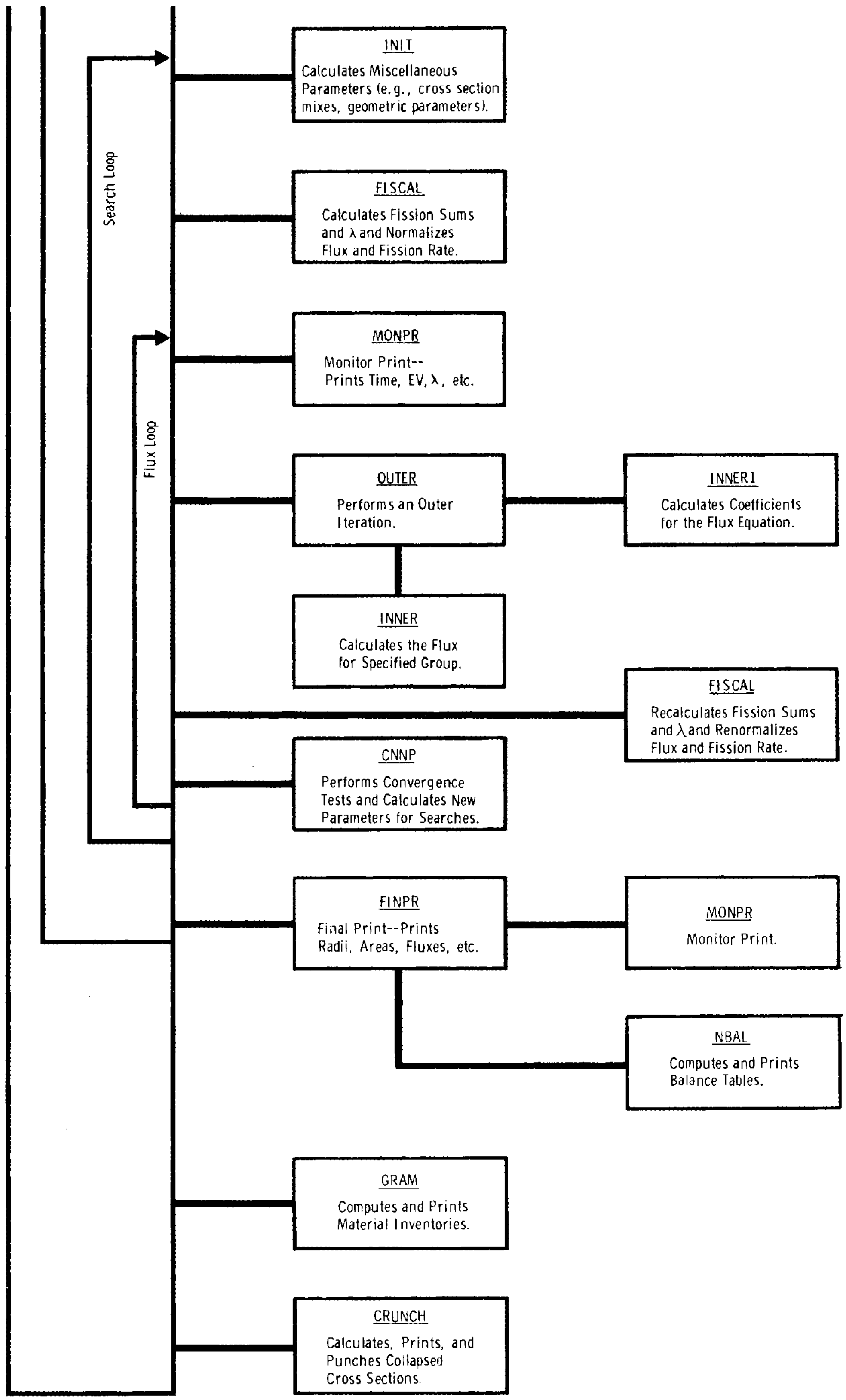
SIMPLIFIED LOGICAL FLOW DIAGRAM

APPENDIX A

SIMPLIFIED LOGICAL FLOW DIAGRAM

A simplified logical flow chart is given on the following two pages. With the exception of two minor subroutines, CLEAR (sets an array equal to a specified constant) and ERRO2 (prints error messages), all subroutines and their functions are shown in the flow diagram.


CALC
Program Management.
INP
Controls Reading and Printing of All Input Data (Except Cross Sections).
REAG2
Reads Floating Point Data in Generalized Format.
REAI2
Reads Integer Data in Generalized Format.
RCINP1
Reads Cross Section Data in the Russian Format from Cards.
RCPUP
Reads Cross Section Data in the Russian Format from Cards.
RCCHK
Checks Cross Section Data in the Russian Format for Consistency.
RCPRT1
Prints Cross Section Data in the Russian Format.
RCSTUP
Computes f-factors for Temperature Dependent Isotopes.
RCCAL1
Calculates σ_0.
σ_0 Iteration Loop
RCCAL2
Calculates f-factors.
RCCSS
Calculates Resonance Shielded Cross Sections.
$\sigma_{d,e}$ Iteration Loop
RECS
Reads Cross Sections in DTF Format and Make Cross Section Tape.


INIT
Calculates Miscellaneous Parameters (e.g., cross section mixes, geometric parameters).
Search Loop
FISCAL
Calculates Fission Sums and λ and Normalizes Flux and Fission Rate.
MONPR
Monitor Print-- Prints Time, EV, λ, etc.
Flux Loop
OUTER
Performs an Outer Iteration.
INNER1
Calculates Coefficients for the Flux Equation.
INNER
Calculates the Flux for Specified Group.
FISCAL
Recalculates Fission Sums and λ and Renormalizes Flux and Fission Rate.
CNNP
Performs Convergence Tests and Calculates New Parameters for Searches.
FINPR
Final Print--Prints Radii, Areas, Fluxes, etc.
MONPR
Monitor Print.
NBAL
Computes and Prints Balance Tables.
GRAM
Computes and Prints Material Inventories.
CRUNCH
Calculates, Prints, and Punches Collapsed Cross Sections.

APPENDIX B

INPUT INSTRUCTIONS

APPENDIX B

INPUT INSTRUCTIONS

The following pages describe the input data for 1DX. Most input is read in via generalized input subroutines. The format for data read in through the generalized input subroutines must adhere to the following form: All cards must contain six data fields of 12 columns each, either 6(I1,I2,I9) for integer data or 6(I1,I2,E9.4) for floating point data. The last nine columns of each field contain the data associated with the particular field; columns 2-3 contain an integer, N, from 0 to 99. The first column of each field must contain:

0 - no effect (N = 0),

1 - repeat associated entry N times,

2 - do N linear interpolations between associated data entry and succeeding data entry,

3 - terminate reading of this array with previous data entry.

Variable	Columns	Description
CARD 1: FORMAT (11A6,I6)		
To run a series of cases, repeat from this card.		
ID(11)	1-66	Identification card.
MAXT	67-72	Maximum running time (minutes). Not used if zero.
CARD 2: FORMAT (12I6)		
A02	1-6	Problem type: = 0, regular calculation, = 1, adjoint calculation.
I04	7-12	Eigenvalue type: = 1, k_{eff}, = 2, time absorption (α), = 3, concentration (C), = 4, zone thickness (δ), = 5, buckling (B^2).

Variable	Columns	Description
S02	13-18	Parametric eigenvalue type: = 0, none, = 1, k_{eff}, = 2, α.
IGM	19-24	Number of energy groups.
NXCM	25-30	Number of downscattering terms.
ML	31-36	= -N, N input cross section materials from tape on logical unit 15, = +N, N input cross section materials from cards.
M07	37-42	Initial flux guess option: = 0, none, = 1, fluxes from cards.
NPRT	43-48	Print option: = 0, delete printing of cross section data and fluxes (mini), = 1, delete printing of input cross sections in the Russian format (midi), = 2, full print (maxi).
NPUN	49-54	Flux dump option: = 0, no punch, = 1, punch fluxes.
NRCF	55-60	Number of mixes used in generating resonance shielded cross sections. If NRCF = 0, cross section data is in DTF format.
NIFF	61-66	Number of spectrum recalculation iterations in the calculation of $\tilde{\sigma}_{d,e}$. (See Equation 5.15.) Not used if NRCF = 0.
MM01	67-72	Number of mixture specifications for generating resonance shielded cross sections. (See Appendix D for sample problem.)

CARD 3: FORMAT (12I6)

Variable	Columns	Description
IGE	1-6	Geometry: = 0, plane, = 1, cylinder, = 2, sphere.
IM	7-12	Number of space intervals ($\geq$3).
IZM	13-18	Number of material zones.
MT	19-24	Total number of materials, including mixes.
M01	25-30	Number of mixture specifications.

Variable	Columns	Description
B01	31-36	Left boundary condition: = 0, vacuum, = 1, reflective, = 2, periodic.
B02	37-42	Right boundary condition.
NCR	43-48	Number of collapsed groups. If NCR $\geq$ IGM, no group collapsing calculation is done.
NXINP	49-54	Number of collapsed downscattering terms. 1DX also calculates this quantity, NXCMP. If NXINP = 0, NXCMP is used. If 0 < NXINP < NXCMP, $\bar{\sigma}(I \rightarrow I + NXINP \equiv \sum_{J=NXINP}^{NXCMP} \bar{\sigma}(I \rightarrow J)$.
NTR	55-60	Type weighting for collapsed σ_{tr}: = 0, normalized [Equation (4.3)], = 1, reciprocal [Equation (4.4)].
NFGM	61-66	Number of collapsed materials.
IPUN	67-72	= 0, print collapsed cross section data, = 1, punch collapsed cross section data, = 2, write collapsed cross section data to tape on logical unit 16, put end of file (EOF) mark after last material, and rewind tape. = 3, write collapsed cross section data to tape on logical unit 16 (an EOF mark is not put on tape and tape is not rewound). If IGM group data is desired as output, set NCR equal to IGM and continue as in a group collapsing calculation.

CARD 4: FORMAT (6E12.6)

EV	1-12	Initial eigenvalue guess. (Used only in search calculations.)

Variable	Columns	Description
EVM	12-24	Initial eigenvalue modifier. This value should decrease k_{eff}--i.e., EV + EVM should produce a lower k_{eff} than EV. Since EV and EVM are completely problem dependent, no representative values can be given. However, these parameters are important so some thought should be given to estimating a reasonable value. (Used only in search calculations.)
S03	25-36	Parametric eigenvalue (see third word on Card 2).
BUCK	37-48	Buckling (cm^{-2}). Caution--search calculations that include a buckling term cannot be performed using input cross sections (mixes) directly in zones. Furthermore, a given input mix cannot be used directly in two or more zones in k_{eff} or search problems that have a buckling term. These problems can be avoided by mixing with a density of 1.0. If searching on buckling, BUCK should be zero.
LAL	49-60	Lower limit on $\|\lambda - 1\|$, where $\lambda - 1$ is, in essence, the predicted change in the current reactivity. After LAL is reached, the eigenvalue slope is no longer altered. LAL is used only in search calculations. Recommended value $\approx$0.005.
LAH	61-72	Upper limit on $\|\lambda - 1\|$. If $\|\lambda - 1\|$ is greater than LAH, LAH rather than $\|\lambda - 1\|$ is used in predicting the new eigenvalue. LAH is used only in search calculations. Recommended value $\approx$0.5.

CARD 5: FORMAT (6E12.6)

Variable	Columns	Description
EPS	1-12	Convergence criterion on the total fission source rate. The problem is automatically terminated after 100 iterations.
EPSA	13-24	Parametric eigenvalue convergence criterion. The eigenvalue is recalculated when $\|\lambda^{\nu+1} - \lambda^{\nu}\|$ is less than EPSA. EPSA is only used in search calculations. Recommended value $\approx$10 × EPS.

Variable	Columns	Description
POD	25-36	Parameter oscillation damper. Ratio of the computed eigenvalue change to the predicted eigenvalue change. POD can be used to accelerate convergence or damp out oscillations. (Used only in search calculations.)
ORF	37-48	Over-relaxation factor. If instabilities arise, reduce ORF. Recommended value $\approx$1.4.
S01	49-60	If X is negative, the total power is normalized to $\lvert X \rvert$ Mwt using the conversion factor of 215 MeV/fission. If positive, X = total source/k_{eff}.

CARD 6: FORMAT [6(I1,I2,E9.4)]*

Optional--required if M07=1.

N0(IM,IGM)	1-12	Initial flux guess for first mesh point in first group.
N0(IM,IGM)	13-24	Initial flux guess for second mesh point in first group. Continue for all mesh points and all energy groups. The flux guess for each group does not start on a new card.

. . .

CARD 7: FORMAT [6(I1,I2,E9.4)]

R0(IM+1)	1-12	Spatial position (cm) of first mesh boundary (0.0).
R0(IM+1)	13-24	Spatial position of second mesh boundary.

. . .

CARD 8: FORMAT [6(I1,I2,I9)]

M0(IM)	1-12	Zone number for first mesh interval.
M0(IM)	13-24	Zone number for second mesh interval.

. . .

* *Generalized input format (see page B-1).*

Variable	Columns	Description
CARD 9: FORMAT [6(I1,I2,I9)]		
M2(IZM)	1-12	Material number for first zone.
M2(IZM)	13-24	Material number for second zone.
. . .		
CARD 10: FORMAT [6(II,I2,E9.4)]		
Optional--required if BUCK≠0 or if I04=5.		
GAM(IZM)	1-12	Buckling modifier for first zone.
GAM(IZN)	13-24	Buckling modifier for second zone.
. . .		
CARD 11: FORMAT [6(I1,I2,E9.4)]		
K7(IGM)	1-12	Fission fraction (spectrum) in first energy group.
K7(IGM)	13-24	Fission fraction in second energy group.
. . .		
CARD 12: FORMAT [6(I1,I2,E9.4)]		
V7(IGM)	1-12	Neutron velocity for first energy group (cm/sec). Not used if I04≠2 and S02≠2.
V7(IGM)	13-24	Neutron velocity for second energy group.
. . .		
CARD 13: FORMAT [6(I1,I2,I9)]		
Optional--required if M01>0. For instructions in setting up the I0, I1, and I2 cards for a "C" search and for a sample problem using data in the Russian format, see Chapter III and Appendix D, respectively.		
I0(M01)	1-12	Material number of Mix 1.
I0(M01)	13-24	Material number of Mix 1.
. . .		
I0(M01)	N-(N+12)	Material number of Mix 2.
. . .		
CARD 14: FORMAT [6(I1,I2,I9)]		
Optional--required if M01>0.		
I1(M01)	1-12	0.
I1(M01)	13-24	Material number of first material in Mix 1.
I1(M01)	25-36	Material number of second material in Mix 1.
. . .		
I1(M01)	N-(N+12)	0.

Variable	Columns	Description
I1(M01)	(N+13) -(N+24)	Number of first material in Mix 2.
. . .		

CARD 15: FORMAT [6(I1,I2,E9.4)]

Optional--required if M01>0.

Variable	Columns	Description
I2(M01)	1-12	0 (to clear storage area for Mix 1).
I2(M01)	13-24	Concentration of first material in Mix 1 (atoms/barn-cm).
I2(M01)	25-36	Concentration of second material in Mix 1.
. . .		
I2(M01)	N-(N+12)	0 (to clear storage area for Mix 2).
I2(M01)	(N+13) -(N+24)	Concentration of first material in Mix 2.
. . .		

CARD 16: FORMAT [6(I1,I2,E9.4)]

Optional--required if I04=4.

Variable	Columns	Description
R3(IZM)	1-12	Dimensional modifier for first zone (if zero, zone width is held constant).
R3(IZM)	13-24	Dimensional modifier for second zone.
. . .		

CARD 17: FORMAT [6(I1,I2,I9)]

Optional--required if NCR≤IGM.

Variable	Columns	Description
NPN(NCR)	1-12	Number of original groups in first collapsed group.
NPN(NCR)	13-24	Number of original groups in second collapsed group.
. . .		

CARD 18: FORMAT [6(I1,I2,I9)]

Optional--required if NCR≤IGM.

Variable	Columns	Description
NFP(NFGM)	1-12	Material number of first material to be collapsed.
NFP(NFGM)	13-24	Material number of second material to be collapsed.
. . .		

Variable	Columns	Description
CARD 19: FORMAT [6(I1,I2,I9)]		
Optional--required if NCR≤IGM.		
NZN(NFGM)	1-12	Zone number of fluxes used for first collapsed material.
NZN(NFGM)	13-24	Zone number of fluxes used for second collapsed material.
. . .		
CARD 20: FORMAT [6(I1,I2,I9)]		
Optional--required if NRCF>0.		
ZN(NRCF)	1-12	Zone number of fluxes used in $\sigma_{d,e}$ iteration for first cross section mix.
ZN(NRCF)	13-24	Zone number of fluxes used in $\sigma_{d,e}$ iteration for second cross section mix.
. . .		
CARD 21: FORMAT [6(I1,I2,I9)]		
Optional--required NRCF>0.		
HETC(NRCF)	1-12	Heterogeneity constant (cm) for first cross section mix. See Equation (5.13).
HETC(NRCF)	13-24	Heterogeneity constant for second cross section mix.
. . .		
CARD 22: FORMAT [6(I1,I2,I9)]		
Optional--required if NRCF>0.		
J1(MM01)	1-12	Not used.
J1(MM01)	13-24	Number of first input isotope in first cross section mix(≤ML).
J1(MM01)	25-36	Number of second input isotope in second cross section mix.
. . .		
J1(MM01)	N-(N+12)	Not used.
J1(MM01)	(N+13) -(N+24)	Number of first input isotope in second cross section mix (≤ML).
. . .		

Variable	Columns	Description
CARD 23: FORMAT [6(I1,I2,E9.4)]		
Optional--required if NRCF>0.		
ATEM(MM01)	1-12	Not used.
ATEM(MM01)	13-24	Temperature of first input isotope in first cross section mix.
ATEM(MM01)	25-36	Temperature of second input isotope in first cross section mix.
. . .		
CARD 24: FORMAT [6(I1,I2,I9)]		
Optional--required if NRCF>0.		
MF(MM01)	1-12	Not used.
MF(MM01)	13-24	Fuel or moderator designation (0/1 = fuel/moderator) of first input isotope in first cross section mix.
MF(MM01)	25-36	Fuel or moderator designation of second input isotope in first cross section mix.
. . .		
CARD 25: FORMAT [6(I1,I2,E9.4)]		
Optional--required if NRCF>0.		
U7(IGM)	1-12	Lethargy width (δu) for first energy group.
U7(IGM)	13-24	Lethargy width for second energy group.
. . .		
CARD 26: FORMAT [6(I1,I2,I9)]		
Optional--required if NRCF>0 and ML<0.		
NUT(|ML|)	1-12	Sequence number on cross section tape (generated by PUPX) of first input isotope.
NUT(|ML|)	13-24	Sequence number on cross section tape of second input isotope.
. . .		
CARD 27: FORMAT (A6,E6.2,7I6,3E6.0)		
Optional--required if NRCF>0 and ML>0.		
HOLN(ML)	1-6	Name (of first input isotope).

Variable	Columns	Description
ATW(ML)	7-12	Atomic weight (used in calculating material inventories). Caution--if NRCF>0 and the same input isotope is in more than one mix used in generating resonance shielded cross sections, the material inventory table is frequently in error.
NT(ML)	13-18	= 0, isotope is not temperature dependent, = 1, isotope is temperature dependent.
NGB(ML)	19-24	Group number where f-factors start.
NGE(ML)	25-30	Group number where f-factors end.
NPFF(4,ML)	31-36	Number of discrete σ_0 values for fission f-factors.
NPFF(4,ML)	37-42	Number of discrete σ_0 values for capture f-factors.
NPFF(4,ML)	43-48	Number of discrete σ_0 values for total f-factors.
NPFF(4,ML)	49-54	Number of discrete σ_0 values for elastic scattering f-factors.
TEM(3,ML)	55-60	First temperature f-factors are given for.
TEM(3,ML)	61-66	Second temperature f-factors are given for.
TEM(3,ML)	67-72	Third temperature f-factors are given for.

CARD 28: FORMAT (12E6.3)

Optional--required if NRCF>0, ML>0, and NPFF(1,ML)>0.

SF(4,ML,6)	1-6	First discrete σ_0 value for fission f-factors.
SF(4,ML,6)	7-12	Second discrete σ_0 value for fission f-factors.

. . .

CARD 29: FORMAT (12E6.3)

Optional--required if NRCF>0, ML>0, NPFF(1,ML)>0, and NT(ML) = 0.

FF(4, 3xIGM,6)	1-6	First fission f-factor for group NGB(ML).
FF(4, 3xIGM,6)	7-12	Second fission f-factor for group NGB(ML).

. . .

Variable	Columns	Description
FF(4,3xIGM,6)	N-(N+6)	First fission f-factor for group NGB(ML)+1.

. . .

Continue through group NGB(ML); then repeat cards 28 and 29 for capture, total, and elastic scattering if NPFF(2,ML), NPFF(3,ML) and NPFF(4,ML) are not equal to zero respectively.

CARD 30: FORMAT (12E6.3)

Optional--required if NRCF>0, ML>0, NPFF(1,ML)>0, and NT(ML) = 1.

FF(4,3xIGM,6)	1-6	First fission f-factor for group NGB(ML) at temperature TEM(1,ML).
FF(4,3xIGM,6)	7-12	Second fission f-factor for group NGB(ML) at temperature TEM(1,ML).
. . .		
FF(4,3xIGM,6)	N-(N+6)	First fission f-factor for group NGB(ML) at temperature TEM(2,ML).
FF(4,3xIGM,6)	(N+7) -(N+12)	Second fission f-factor for group NGB(ML) at temperature TEM(2,ML).

. . .

Continue for TEM(3,ML) and through group NGB(ML); then repeat cards 28 and 30 for capture, total, and elastic scattering if NPFF(2,ML), NPFF(3,ML), and NPFF(4,ML) are not equal to zero respectively.

CARD 31: FORMAT(I3,F10.4,F9.4,F5.3,F10.4,F6.4,F9.4,F6.4, F6.4,F8.4)

Optional--required if NRCF>0 and ML>0.

Group index	1-3	Group number.
SR(9,IGM)	4-13	σ_t (for first group).
SR(9,IGM)	14-22	σ_f.
SR(9,IGM)	23-27	ν.
SR(9,IGM)	28-37	σ_c.
SR(9,IGM)	38-43	σ_{in}.
SR(9,IGM)	44-52	σ_e.
SR(9,IGM)	53-58	μ_e.

Variable	Columns	Description
SR(9,IGM)	59-64	ξ.
SR(9,IGM)	65-72	$\sigma_{d,e}$.

Repeat through group IGM.

CARD 32: FORMAT [I3,E7.4,10E6.4/(12E6.4)]

Optional--required if NRCF>0 and ML>0.

Variable	Columns	Description
Group index	1-3	Group number.
SM(IGM,NXCM+1)	4-10	$\sigma_{in}(i \to i)$--for first group.
SM(IGM,NXCM+1)	11-16	$\sigma_{in}(i \to i+1)$.
SM(IGM,NXCM+1)	17-22	$\sigma_{in}(i \to i+2)$.

. . .

Continue through $\sigma_{in}(i \to i+NXCM)$. Repeat through group IGM. Repeat from card 27 for ML isotopes.

CARD 33: FORMAT (A6,E6.2,10A6)

Optional--required if NRCF=0.

Variable	Columns	Description
HOLN(ML)	1-6	Name (of first input isotope).
ATW(ML)	7-12	Atomic weight.
AA(10)	13-72	Miscellaneous information.

CARD 34: FORMAT (6E12.5)

Optional--required if NRCF=0 and ML>0. Punched cross section data from 1DX is also in this format.

Variable	Columns	Description
C(ITL,IGM,ML)	1-12	σ_f (barns)--for first group of first isotope.
C(ITL,IGM,ML)	13-24	σ_a.
C(ITL,IGM,ML)	25-36	$\nu\sigma_f$.
C(ITL,IGM,ML)	37-48	σ_{tr}.
C(ITL,IGM,ML)	49-60	$\sigma(i \to i)$.
C(ITL,IGM,ML)	61-72	$\sigma(i-1 \to i)$.

. . .

Continue through $\sigma(i-NXCM \to i)$. Repeat through group IGM. Repeat from card 33 for ML isotopes (if ML<0, simply repeat card 33 for each input isotope).

1DX

ID(11) Identification Card (columns 1–66)	MAXT Max. Running Time (min) (columns 67–72)	(columns 73–80)

AO2	IO4	SO2	IGM	NXCM	ML
Problem Type: = 0, Regular = 1, Adjoint	Eigenvalue Type: = 1, k_{eff} = 2, Absorption (α) = 3, Concentration (C) = 4, Zone Thickness (δ) = 5, Buckling (B^2)	Parametric Eigenvalue Type: = 0, None = 1, k_{eff} = 2, α	No. of Energy Groups	No. of Down-Scattering Terms	= -N, N Input Materials From Tape = +N, N Input Materials From Cards

MO7	NPRT	NPUN	NRCF	NIFF	MMO1
Initial Flux Guess Option: = 0, None = 1, Fluxes From Cards	Print Option: = 0, Mini = 1, Midi = 2, Maxi	Flux Punch Option: = 0, No Punch = 1, Punch Fluxes on Cards	No. of Mixes Used in Generating Resonance Shielded Cross Sections (If NRCF = 0, XS Data is in DTF Format)	No. of Spectrum Recalculation Iterations in the Calculation of $\sigma_{\ell,e}$	No. of Mix Specifications for Generating Shielded Cross Sections

IGE	IM	IZM	MT	MO1	BO1
Geometry: = 0, Plane = 1, Cylinder = 2, Sphere	No. of Space Intervals	No. of Material Zones	Total No. of Materials Including Mixes	No. of Mixture Specifications	Left Boundary Condition: = 0, Vacuum = 1, Reflective = 2, Periodic

BO2	NCR	NXINP	NTR	NFGM	IPUN
Right Boundary Condition	No. of Collapsed Groups (If NCR ≥ IGM No Group Collapsing)	No. of Collapsed Down-scattering terms (If NXINP = 0, Calculated by Code)	Type Weighting for Collapsed σ_{tr} = 0, Normalized = 1, Reciprocal	No. of Collapsed Materials	= 0, Print Collapsed Cross Section Data = 1, Punch Collapsed Data = 2, Write Collapsed Data on Tape, EOF, and Rewind Tape = 3, Write Collapsed Data on Tape

Condition	Cols 1–12	Cols 13–24	Cols 25–36	Cols 37–48	Cols 49–60	Cols 61–72	Cols 73–80
●	EV Initial Eigenvalue Guess	EVM Initial Eigenvalue Modifier	SO3 Parametric Eigenvalue	BUCK Buckling (cm^{-2})	LAL Lambda Lower	LAH Lambda Upper	
●	EPS Eigenvalue Convergence Criterion	EPSA Parametric Eigenvalue Convergence Criterion	POD Parameter Oscillation Damper	ORF Over-relaxation Factor	SO1 - Negative, Power (Mwt) + Positive, Neutron Source Rate		
IF (MO7) = 1 ●	Flux Guess for First Mesh Point in First Group	Flux Guess for Second Mesh Point in First Group	● ● ●	Flux Guess for IMth Mesh Point in First Group	Flux Guess for First Mesh Point in Second Group	● ● ●	NO(IM, IGM)
●	Spatial Position of First Mesh Boundary (0.0)	Spatial Position of Second Mesh Boundary (cm)	● ● ●				RO(IM+1)
●	Zone No. for First Mesh Interval	Zone No. for Second Mesh Interval	● ● ●				MO(IM)
●	Material No. for First Zone	Material No. for Second Zone	● ● ●				M2(IZM)
IF(BUCK) ≠ 0 or IF(I04) = 5 ●	Buckling Modifier for First Zone	Buckling Modifier for Second Zone	● ● ●				GAM(IZM)

Condition	Columns 1–12	Columns 13–24	Columns 25–36	Columns 37–48	Columns 49–60	Columns 61–72	Columns 73–80
	Fission Fraction in First Energy Group	Fission Fraction in Second Energy Group	● ● ●				K7(IGM)
	Neutron Velocity for First Energy Group	Neutron Velocity for Second Energy Group	● ● ●				V7(IGM)
IF(MO1)>0	Material No. of Mix 1	Material No. of Mix 1	● ● ●	Material No. of Mix 2	Material No. of Mix 2	● ● ●	IO(MO1)
IF(MO1)>0	0	Material No. of First Material in Mix 1	Material No. of Second Material in Mix 1	● ● ●	0	● ● ●	I1(MO1)
IF(MO1)>0	0	Concentration of First Material in Mix 1	Concentration of Second Material in Mix 1	● ● ●	0	● ● ●	I2(MO1)
IF(IO4) = 4	Dimensional Modifier for First Zone	Dimensional Modifier for Second Zone	● ● ●				R3(IZM)
	No. of Original Groups in First Collapsed Group	No. of Original Groups in Second Collapsed Group	● ● ●				NPN(NCR)

IF(NCR) ≤ IGM	Material No. of First Material to be Collapsed	Material No. of Second Material to be Collapsed	• • •				NFP(NFGM)
IF(NCR) ≤ IGM	Zone No. of Fluxes Used for First Collapsed Material	Zone No. of Fluxes Used for Second Collapsed Material	• • •				NZN(NFGM)
IF (NRCF)>0	Zone No. of Fluxes Used in $\sigma_{d,e}$ Iteration for First Cross Section Mix	Zone No. of Fluxes Used in $\sigma_{d,e}$ Iteration for Second Cross Section Mix	• • •				ZN(NRCF)
IF (NRCF)>0	Heterogeneity Constant for First Cross Section Mix	Heterogeneity Constant for Second Cross Section Mix	• • •				HETC(NRCF)
IF (NRCF)>0	0	Number of First Input Isotope in First Cross Section Mix	Number of Second Input Isotope in First Cross Section Mix	• • •	0	• • •	J1(MMO1)
IF (NRCF)>0	0	Temperature of First Input Isotope in First Cross Section Mix	Temperature of Second Input Isotope in First Cross Section Mix	• • •	0	• • •	ATEM(MMO1)

1–12	13–24	25–36	37–48	49–60	61–72	73–80
0	Fuel or Moderator (0/1 = Fuel/Moderator) Designation of First Isotope in First Cross Section Mix	Fuel or Moderator Designation of Second Isotope in First Cross Section Mix	● ● ●	0	● ● ●	MF(MM01)
Lethargy Width for First Energy Group	Lethargy Width for Second Energy Group	● ● ●				U7(IGM)
Cross Section Data						

APPENDIX C

STORAGE REQUIREMENTS

APPENDIX C

STORAGE REQUIREMENTS

1DX uses variable dimensioning by storing the subscripted variables in one array, A(35000). The variable dimensioned arrays require N storage locations ($N \leq 35000$), where

$N = MAX\ (N_1, N_2)$

$$
\begin{aligned}
N_1 = {} & IGM\ (13 + 5 \cdot MM01^{\dagger} - 4 \cdot NRCF^{\dagger} + NXCM^{\dagger} + 83^{\dagger} + 1^{\times}) \\
& + IZM(ML + IGM + 4 + 2 \cdot NCR^{\times} + 2 \cdot IGM^{\times} + 1^{*}) \\
& + IM(4 \cdot IGM + 12) \\
& + ML(4 + 34^{\dagger}) \\
& + 4 \cdot M01 \\
& + 3 \cdot MM01^{\dagger} \\
& + 3 \cdot NRCF^{\dagger} \\
& + NCR^{\times} \\
& + MT(NXCM + 5) \\
& + 2 \cdot NFGM^{\times} \\
& + 12
\end{aligned}
$$

and

$$
\begin{aligned}
N_2 = {} & IGM(2 + 5 \cdot MM01^{\dagger} - 4 \cdot NRCF^{\dagger} + NXCM^{\dagger} + 83^{\dagger} + 1^{\times}) \\
& + IZM(IGM + 3 + 2 \cdot NCR^{\times} + 2 \cdot IGM^{\times} + 1^{*}) \\
& + MT(NXCM + 5)(IGM + 1) \\
& + IM(IGM + 7) \\
& + ML(4 + 34^{\dagger}) \\
& + 3 \cdot M01 \\
& + 3 \cdot MM01^{\dagger} \\
& + 3 \cdot NRCF^{\dagger} \\
& + NCR^{\times} \\
& + 2 \cdot NFGM^{\times} \\
& + 4
\end{aligned}
$$

All of the above variables are input to 1DX on cards 1 and 2.

† *resonance shielding calculation*

× *group collapsing calculation*

* *delta (δ) eigenvalue calculation*

APPENDIX D
SAMPLE PROBLEM

APPENDIX D

SAMPLE PROBLEM

This section demonstrates the procedure used in setting up a 1DX input deck for a problem using cross section data in the Russian format. The problem is a 26 group k_{eff} calculation for a two-zone spherical reactor (see Figure D.1). The number of mesh intervals (IM) is 30 (20 for core and 10 for blanket); each interval is equal to 2 cm. The number of mixes used in generating resonance shielded cross sections (NRCF) is two, one mix for the core and one for the reflector.

Isotope	Atom Densities Core	Blanket
1 Pu^{239}	0.0020	0.0000
2 U^{238}	0.0080	0.0150
3 O	0.0192	0.0300
4 Fe	0.0120	0.0200
ML=5 Na	0.0110	0.0050

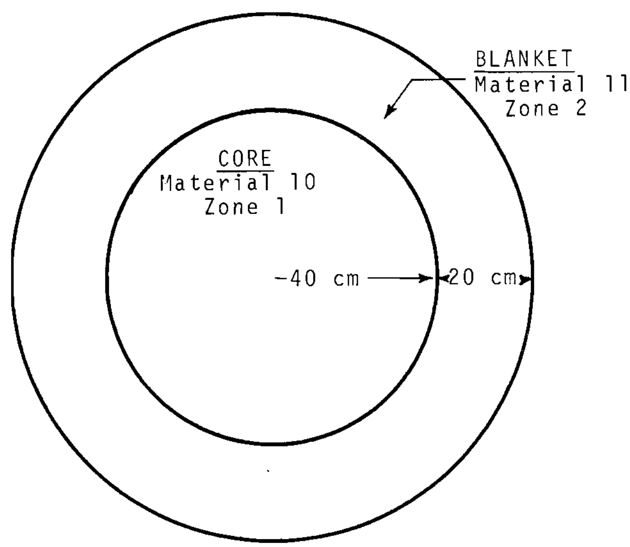


FIGURE D-1. Schematic Diagram of Reactor Considered in Sample Problem

The input is self-explanatory, except perhaps, for the I0, I1, I2, and J1 arrays (see Table D.1). If the cross section data is in the DTF format, the I1 array gives the material number (macroscopic or microscopic) of the cross section to be added to material I0 at density I2. However, for cross section data in the Russian format, the array J1 is the number of the input isotope and I1 is the resulting material number of the shielded cross section set. In the sample problem, for example, U^{238}, the second input isotope, is designated material 2 (in the core) and material 6 (in the reflector). Because of resonance shielding, it is necessary to give the same isotope a different material number whenever it is used in a cross section mix. From MM01 (the number of cross section mix specifications) + 1 to M01, the I1 vector has the same meaning as when the data is in the DTF format. Thus, in our example, rows 12, 13, and 14 result in a macroscopic $U^{238}O_2$ cross section set calculated in the reflector mix environment.

TABLE D-1. Material Specifications for Sample Problem

	I0	I1	I2	J1
1	10	0	0	0
2	10	1	0.0020	1
3	10	2	0.0080	2
4	10	3	0.0192	3
5	10	4	0.0120	4
6	10	5	0.0110	5
7	11	0	0	0
8	11	6	0.0150	2
9	11	7	0.0300	3
10	11	8	0.0200	4
11 (MM01)	11	9	0.0050	5
12	12	0	0	
13	12	6	0.0244	
14 (M01)	12	7	0.0488	

```
 1DX SAMPLE PROBLEM                                                    2
     0     1     0    26    10    -5     0     1     0     2     5    11
     2    30     2    12    14     1     0     4     0     1    11     0
         0.0         0.0          .0         0.0        .001          .5
       1.0-6       1.0-5         1.0         1.3      -400.0
219   0.02 9        40.0        60.03                                         R0
120        1110        23                                                     M0
          10          113                                                     M2
       0.020       0.098       0.190       0.268       0.196       0.135      K7
       0.058       0.022       0.009       0.003    0.001115         0.0      K7
3                                                                             K7
126       1.03                                                                V7
1 6        101 5       111 3       123                                        I0
           0           1           2           3           4           5      I1
           0           6           7           8           9           0      I1
           6           73                                                     I1
           0       .0020       .  80       .0192       .0120       .0110      I2
           0       .0150       . 300       .0200       .0050           0      I2
       .0244       .04883                                                     I2
           4           4           6            123                          NPN
           1           2           3           4           5          10     NFP
           6           7           8           9          113                NFP
1 6        11 5        23                                                    NZN
           1           23                                                     ZN
1 2       1.03                                                              HETC
                       1           2           3           4           5      J1
           0           2           3           4          53                  J1
1 6     900.01 5     800.03                                                 ATEM
1 4         1 2         11 3        01 2        13                            MF
1 3       .481 2      .571 3      .69117      .77         1.03                U7
           1           4           6           8          103                NUT
```

* * * * 1DX * * * *

1DX SAMPLE PROBLEM 2

A02	0/1=REGULAR CALCULATION/ADJOINT CALCULATION	0
I04	EIGENVALUE TYPE (1/2/3/4/5=KEFF/ALPHA/CONCENTRATION/DELTA/BUCKLING)	1
S02	PARAMETRIC EIGENVALUE TYPE (0/1/2=NONE/KEFF/ALPHA)	0
IGM	NUMBER OF ENERGY GROUPS	26
NXCM	NUMBER OF DOWNSCATTERING TERMS	10
ML	NEGATIVE/POSITIVE=NUMBER OF MATERIALS FROM TAPE/CARDS	-5
M07	FLUX GUESS (0/1=NONE/CARDS)	0
NPRT	PRINT OPTION (0/1/2=MINI/MIDI/MAXI)	0
NPUN	FLUX DUMP (0/1=NO/YES)	0
NRCF	NO. OF MIXES USED IN GENERATING XS DATA (IF 0, DATA IS IN DTF FORMAT)	2
NIFF	NUMBER OF ITERATIONS IN CALCULATION OF SIGE	5
MM01	NUMBER OF MIX SPECIF. FOR GENERATING SHIELDED XS	11
IGE	GEOMETRY (0/1/2=PLANE/CYLINDER/SPHERE)	2
IM	NUMBER OF SPACE INTERVALS	30
IZM	NUMBER OF MATERIAL ZONES	2
MT	TOTAL NUMBER OF MATERIALS INCLUDING MIXES	12
M01	NUMBER OF MIXTURE SPECIFICATIONS	14
B01	LEFT BOUNDARY CONDITION (0/1/2=VACUUM/REFLECTIVE/PERIODIC)	1
B02	RIGHT BOUNDARY CONDITION (0/1/2=VACUUM/REFLECTIVE/PERIODIC)	0
NCR	NUMBER OF COLLAPSED GROUPS (IF NCR>IGM, NO EFFECT)	4
NXINP	NUMBER OF COLLAPSED DOWNSCATTERING TERMS (IF 0, CALCULATED BY 1DX)	0
NTR	TYPE WEIGHTING FOR COLLAPSED SIGTR (0/1=NORMALIZED/RECIPROCAL)	1
NFGM	NUMBER OF COLLAPSED MATERIALS	5
IPUN	COLLAPSED CROSS SECTION OUTPUT (0/1/2/3=PRINT/PUNCH/TAPE+EOF/TAPE)	0
EV	FIRST EIGENVALUE GUESS	0.0000
EVM	EIGENVALUE MODIFIER	0.0000
S03	PARAMETRIC EIGENVALUE	0.0000
BUCK	BUCKLING (CM-2)	0.0000
LAL	LAMBDA LOWER	1.0000-03
LAH	LAMBDA UPPER	5.0000-01
EPS	EIGENVALUE CONVERGENCE CRITERION	1.0000-06
EPSA	PARAMETER CONVERGENCE CRITERION	1.0000-05
POD	PARAMETER OSCILLATION DAMPER	1.0000+00
ORF	OVER-RELAXATION FACTOR	1.3000+00
S01	NEGATIVE/POSITIVE=POWER (MWT)/NEUTRON SOURCE RATE	-4.0000+02

LAST 10035

```
MESH POINTS
        R0      31
 -.00000   .20000+01  .40000+01  .60000+01  .80000+01  .10000+02  .12000+02  .14000+02  .16000+02  .18000+02
 .20000+02  .22000+02  .24000+02  .26000+02  .28000+02  .30000+02  .32000+02  .34000+02  .36000+02  .38000+02
 .40000+02  .42000+02  .44000+02  .46000+02  .48000+02  .50000+02  .52000+02  .54000+02  .56000+02  .58000+02
 .60000+02

ZONE NUMBERS BY MESH INTERVAL
        M0      30
         1          1          1          1          1          1          1          1          1          1
         1          1          1          1          1          1          1          1          1          1
         2          2          2          2          2          2          2          2          2          2

MATERIAL NUMBERS BY ZONE
        M2       2
        10         11

FISSION FRACTIONS
        K7      26
 .20000-01  .98000-01  .19000-00  .26800-00  .19600-00  .13500-00  .58000-01  .22000-01  .90000-02  .30000-02
 .10000-02  .00000     .00000     .00000     .00000     .00000     .00000     .00000     .00000     .00000
 .00000     .00000     .00000     .00000     .00000     .00000

NEUTRON VELOCITY
        V7      26
 .10000+01  .10000+01  .10000+01  .10000+01  .10000+01  .10000+01  .10000+01  .10000+01  .10000+01  .10000+01
 .10000+01  .10000+01  .10000+01  .10000+01  .10000+01  .10000+01  .10000+01  .10000+01  .10000+01  .10000+01
 .10000+01  .10000+01  .10000+01  .10000+01  .10000+01  .10000+01

MIXTURE SPECIFICATIONS (I0/I1/I2=MIX NUMBER/MAT. NUMBER FOR MIX/MATERIAL DENSITY)
        I0      14
        10         10         10         10         10         10         11         11         11         11
        11         12         12         12
        I1      14
         0          1          2          3          4          5          0          6          7          8
         9          0          6          7
        I2      14
 .00000     .20000-02  .80000-02  .19200-01  .12000-01  .11000-01  .00000     .15000-01  .30000-01  .20000-01
 .50000-02  .00000     .24400-01  .48800-01

NUMBER OF GROUPS PER CRUNCHED GROUP
       NPN       4
         4          4          6         12

NUMBERS OF MATERIALS TO BE CRUNCHED
       NFP       5
         1          2         10         11         12
```

```
ZONE NUMBERS OF FLUXES USED FOR CRUNCH CALCULATION
       NZN     5
         1           1           1           2           2

ZONE NUMBERS FOR EACH CROSS SECTION MIX
        ZN     2
         1           2

HETEROGENEITY CONSTANT FOR EACH CROSS SECTION MIX
      HETC     2
  .10000+01   .10000+01

ISOTOPE NUMBER FOR EACH TERM IN XS MIX VECTOR
        J1    11
         0           1           2           3           4           5           0           2           3           4
         5

TEMPERATURES FOR EACH TERM IN XS MIX VECTOR
      ATEM    11
  .90000+03   .90000+03   .90000+03   .90000+03   .90000+03   .90000+03   .80000+03   .80000+03   .80000+03   .80000+03
  .80000+03

FUEL OR MODERATOR DESIGNATION FOR EACH TERM IN XS MIX VECTOR  (0/1=FUEL/MODERATOR)
        MF    11
         0           0           0           0           1           1           0           0           0           1
         1

LETHARGY WIDTHS
        U7    26
  .48000-00   .48000-00   .48000-00   .57000-00   .57000-00   .69000-00   .69000-00   .69000-00   .77000-00   .77000-00
  .77000-00   .77000-00   .77000-00   .77000-00   .77000-00   .77000-00   .77000-00   .77000-00   .77000-00   .77000-00
  .77000-00   .77000-00   .77000-00   .77000-00   .77000-00   .10000+01

SEQUENCE NUMBERS ON TAPE FOR CROSS SECTION DATA IN THE RUSSIAN FORMAT
       NUT     5
         1           4           6           8          10

  1 CHECK M3PU49   GROUP  1      PRESUMABLY SIGMA(N,2N) =  4.200000-01

  2 CHECK M1U238   GROUP  1      PRESUMABLY SIGMA(N,2N) =  8.019999-01
```

CROSS SECTION DATA FOR THE FOLLOWING ISOTOPES WAS GIVEN IN THE RUSSIAN FORMAT

ISOTOPE NUMBER	ISOTOPE	NUMBER ON TAPE
1	M3PU49	1
2	M1U238	4
3	O	6
4	M2 FE	8
5	NA	10

MIXTURE SPECIFICATIONS FOR CALCULATING SHIELDED CROSS SECTIONS

MIXTURE NUMBER	MIX COMMAND	MATERIAL DENSITY	ISOTOPE NUMBER	TEMPERATURE (DEG K)	0/1=FUEL/MOD
10	0	.00000000	0	.90000000+03	0
10	1	.20000000-02	1	.90000000+03	0
10	2	.79999999-02	2	.90000000+03	0
10	3	.19200000-01	3	.90000000+03	0
10	4	.12000000-01	4	.90000000+03	1
10	5	.11000000-01	5	.90000000+03	1
11	0	.00000000	0	.80000000+03	0
11	6	.15000000-01	2	.80000000+03	0
11	7	.30000000-01	3	.80000000+03	0
11	8	.20000000-01	4	.80000000+03	1
11	9	.49999999-02	5	.80000000+03	1

	CROSS SECTION MIX NUMBER	ZONE FLUXES FOR XS MIX	HETC. CONST. FOR XS MIX
1	10	1	.10000000+01
2	11	2	.10000000+01

MIXTURE SPECIFICATIONS

	MIXTURE NUMBER	MIX COMMAND	MATERIAL DENSITY
1	10	0	.00000000
2	10	1	.20000000-02
3	10	2	.79999999-02
4	10	3	.19200000-01
5	10	4	.12000000-01
6	10	5	.11000000-01
7	11	0	.00000000
8	11	6	.15000000-01
9	11	7	.30000000-01
10	11	8	.20000000-01
11	11	9	.49999999-02
12	12	0	.00000000
13	12	6	.24400000-01
14	12	7	.48800000-01

1DX SAMPLE PROBLEM

TIME (MINUTES)	SIGE ITERATIONS	OUTER ITERATIONS	EIGENVALUE SLOPE	EIGENVALUE	LAMBDA
.16	0	0	.00000000	.00000000	.00000000
.18	0	1	.00000000	.98287991-00	.98287988-00
.18	0	2	.00000000	.10072591+01	.10248039+01
.19	0	3	.00000000	.10163560+01	.10090313+01
.20	0	4	.00000000	.10179630+01	.10015812+01
.21	0	5	.00000000	.10183523+01	.10003824+01
.22	0	6	.00000000	.10184363+01	.10000826+01
.23	0	7	.00000000	.10184537+01	.10000170+01
.24	0	8	.00000000	.10184575+01	.10000038+01
.24	0	9	.00000000	.10184584+01	.10000008+01
.27	1	10	.00000000	.10184584+01	.00000000
.28	1	11	.00000000	.10097408+01	.10097408+01
.29	1	12	.00000000	.10124162+01	.10026496+01
.30	1	13	.00000000	.10123253+01	.99991015-00
.31	1	14	.00000000	.10123755+01	.10000496+01
.32	1	15	.00000000	.10123785+01	.10000029+01
.33	1	16	.00000000	.10123799+01	.10000014+01
.33	1	17	.00000000	.10123802+01	.10000002+01
.36	2	18	.00000000	.10123802+01	.00000000
.37	2	19	.00000000	.10116640+01	.10116640+01
.38	2	20	.00000000	.10115890+01	.99992584-00
.39	2	21	.00000000	.10116042+01	.10000150+01
.39	2	22	.00000000	.10116036+01	.99999944-00
.42	3	23	.00000000	.10116036+01	.00000000
.43	3	24	.00000000	.10115381+01	.10115381+01
.44	3	25	.00000000	.10114366+01	.99989972-00
.45	3	26	.00000000	.10114443+01	.10000076+01
.45	3	27	.00000000	.10114427+01	.99999841-00
.46	3	28	.00000000	.10114427+01	.10000000+01
.49	4	29	.00000000	.10114427+01	.00000000
.50	4	30	.00000000	.10114083+01	.10114082+01
.51	4	31	.00000000	.10113741+01	.99996619-00
.51	4	32	.00000000	.10113764+01	.10000023+01
.52	4	33	.00000000	.10113758+01	.99999938-00
.55	5	34	.00000000	.10113758+01	.00000000
.56	5	35	.00000000	.10113455+01	.10113455+01
.56	5	36	.00000000	.10113393+01	.99999379-00
.57	5	37	.00000000	.10113397+01	.10000004+01

FINAL NEUTRON BALANCE TABLE

GROUP	FISS. SOURCE	FISSIONS	IN-SCATTER	OUT-SCATTER	ABSORPTION	LEFT LEAK.	RIGHT LEAK.	TOTAL LEAKAGE
1	6.718+17	1.141+17	-8.590+09	5.716+17	9.391+16	0.000	6.274+15	6.274+15
2	3.292+18	3.877+17	9.134+16	2.875+18	4.820+17	0.000	2.650+16	2.650+16
3	6.382+18	9.575+17	9.794+17	6.293+18	1.005+18	0.000	6.341+16	6.341+16
4	9.002+18	1.449+18	3.475+18	1.081+19	1.569+18	0.000	1.027+17	1.027+17
5	6.584+18	6.913+17	7.720+18	1.318+19	1.002+18	0.000	1.191+17	1.191+17
6	4.535+18	1.306+18	1.540+19	1.728+19	2.119+18	0.000	5.348+17	5.348+17
7	1.948+18	1.525+18	2.079+19	1.907+19	2.736+18	0.000	9.315+17	9.315+17
8	7.390+17	1.462+18	2.068+19	1.736+19	2.950+18	0.000	1.106+18	1.106+18
9	3.023+17	1.278+18	1.807+19	1.386+19	3.343+18	0.000	1.164+18	1.164+18
10	1.008+17	9.130+17	1.374+19	9.035+18	3.820+18	0.000	9.842+17	9.842+17
11	3.359+16	5.648+17	9.321+18	5.448+18	3.258+18	0.000	6.485+17	6.485+17
12	0.000	3.173+17	5.512+18	3.621+18	1.610+18	0.000	2.815+17	2.815+17
13	0.000	1.440+17	3.634+18	2.720+18	8.122+17	0.000	1.021+17	1.021+17
14	0.000	2.514+17	2.720+18	1.280+18	1.292+18	0.000	1.480+17	1.480+17
15	0.000	1.520+17	1.280+18	5.370+17	6.742+17	0.000	6.923+16	6.923+16
16	0.000	6.950+16	5.370+17	2.272+17	2.698+17	0.000	3.995+16	3.995+16
17	0.000	2.188+16	2.272+17	8.702+16	1.242+17	0.000	1.604+16	1.604+16
18	0.000	7.721+15	8.702+16	3.612+16	4.207+16	0.000	8.831+15	8.831+15
19	0.000	1.078+15	3.612+16	1.158+16	2.154+16	0.000	2.999+15	2.999+15
20	0.000	6.092+14	1.158+16	2.578+15	8.200+15	0.000	7.972+14	7.972+14
21	0.000	3.274+13	2.578+15	3.614+14	2.134+15	0.000	8.262+13	8.262+13
22	0.000	1.982+13	3.614+14	1.933+14	1.201+14	0.000	4.803+13	4.803+13
23	0.000	1.748+13	1.933+14	9.332+13	7.492+13	0.000	2.502+13	2.502+13
24	0.000	7.830+12	9.332+13	3.834+13	4.375+13	0.000	1.123+13	1.123+13
25	0.000	1.552+12	3.834+13	1.272+13	2.123+13	0.000	4.386+12	4.386+12
26	0.000	2.703+11	1.272+13	-8.033+05	1.195+13	0.000	7.668+11	7.668+11
27	3.359+19	1.161+19	1.243+20	1.243+20	2.723+19	0.000	6.356+18	6.356+18

	ZONE	RADIUS (CM)	AVG RADIUS (CM)	AREA (CM2)	VOLUME (CM3)	TOTAL FLUX (N/CM2-SEC)	POWER (MWT/LITER)	FISSION SOURCE
1	1	-0.00000	1.00000+00	0.00000	3.35103+01	1.74422+16	2.45974+00	2.09526+14
2	1	2.00000+00	3.00000+00	5.02654+01	2.34572+02	1.73668+16	2.44919+00	2.08627+14
3	1	4.00000+00	5.00000+00	2.01062+02	6.36696+02	1.72167+16	2.42816+00	2.06835+14
4	1	6.00000+00	7.00000+00	4.52389+02	1.23988+03	1.69932+16	2.39685+00	2.04165+14
5	1	8.00000+00	9.00000+00	8.04247+02	2.04413+03	1.66980+16	2.35550+00	2.00641+14
6	1	1.00000+01	1.10000+01	1.25664+03	3.04944+03	1.63336+16	2.30446+00	1.96290+14
7	1	1.20000+01	1.30000+01	1.80956+03	4.25581+03	1.59032+16	2.24415+00	1.91149+14
8	1	1.40000+01	1.50000+01	2.46301+03	5.66324+03	1.54103+16	2.17508+00	1.85260+14
9	1	1.60000+01	1.70000+01	3.21699+03	7.27173+03	1.48591+16	2.09781+00	1.78671+14
10	1	1.80000+01	1.90000+01	4.07150+03	9.08129+03	1.42542+16	2.01299+00	1.71438+14
11	1	2.00000+01	2.10000+01	5.02654+03	1.10919+04	1.36009+16	1.92132+00	1.63619+14
12	1	2.20000+01	2.30000+01	6.08212+03	1.33036+04	1.29047+16	1.82357+00	1.55280+14
13	1	2.40000+01	2.50000+01	7.23822+03	1.57163+04	1.21718+16	1.72054+00	1.46489+14
14	1	2.60000+01	2.70000+01	8.49486+03	1.83301+04	1.14085+16	1.61312+00	1.37319+14
15	1	2.80000+01	2.90000+01	9.85203+03	2.11450+04	1.06218+16	1.50221+00	1.27849+14
16	1	3.00000+01	3.10000+01	1.13097+04	2.41609+04	9.81890+15	1.38879+00	1.18158+14
17	1	3.20000+01	3.30000+01	1.28680+04	2.73779+04	9.00742+15	1.27387+00	1.08334+14
18	1	3.40000+01	3.50000+01	1.45267+04	3.07960+04	8.19547+15	1.15857+00	9.84687+13
19	1	3.60000+01	3.70000+01	1.62860+04	3.44151+04	7.39169+15	1.04415+00	8.86670+13
20	1	3.80000+01	3.90000+01	1.81458+04	3.82352+04	6.60545+15	9.32118-01	7.90539+13
21	2	4.00000+01	4.10000+01	2.01062+04	4.22565+04	5.71045+15	1.16288-01	9.54698+12
22	2	4.20000+01	4.30000+01	2.21671+04	4.64788+04	4.78247+15	7.86473-02	6.45536+12
23	2	4.40000+01	4.50000+01	2.43285+04	5.09021+04	3.95988+15	5.32829-02	4.37264+12
24	2	4.60000+01	4.70000+01	2.65904+04	5.55266+04	3.23770+15	3.61502-02	2.96619+12
25	2	4.80000+01	4.90000+01	2.89529+04	6.03520+04	2.60730+15	2.45502-02	2.01414+12
26	2	5.00000+01	5.10000+01	3.14159+04	6.53786+04	2.05818+15	1.66757-02	1.36802+12
27	2	5.20000+01	5.30000+01	3.39794+04	7.06062+04	1.57913+15	1.13128-02	9.28116+11
28	2	5.40000+01	5.50000+01	3.66435+04	7.60349+04	1.15891+15	7.64313-03	6.27210+11
29	2	5.60000+01	5.70000+01	3.94081+04	8.16646+04	7.86697+14	5.11190-03	4.19787+11
30	2	5.80000+01	5.90000+01	4.22732+04	8.74954+04	4.52293+14	3.34048-03	2.74791+11
31		6.00000+01		4.52389+04				

1DX SAMPLE PROBLEM

MATERIAL INVENTORY (KILOGRAMS) FOR EACH ZONE

	MATERIAL	ATOMIC WT.	ZONE 1 2.681+02 LITERS	ZONE 2 6.367+02 LITERS
1	M3PU49	239.050	2.128+02	0.000
2	M1U238	238.050	8.476+02	3.775+03
3	O	16.000	1.367+02	5.074+02
4	M2 FE	55.850	2.983+02	1.181+03
5	NA	22.990	1.126+02	1.215+02

ZONE AVERAGED FLUXES

ZONE	FLUX (N/CM2-SEC)	VOLUME (LITERS)
1	1.00857+16	2.68082+02
2	2.26212+15	6.36096+02

COLLAPSED FISSION FRACTIONS AND ZONE AVERAGED FLUXES BY GROUP

GROUP	FISS. FRACT.	ZONE 1	ZONE 2
1	5.76000-01	1.07719+15	9.79983+13
2	4.11000-01	5.54458+15	1.00094+15
3	1.30000-02	3.40588+15	1.11941+15
4	0.00000	5.80837+13	4.37702+13

COLLAPSED CROSS SECTIONS

GROUP 1	SIGF	SIGA	NUSIGF	SIGTR	GXG	G-1XG	G-2XG	. . .
MAT 1 ZONE 1	.19824+01	.20060+01	.64166+01	.47172+01	.16430+01	.00000	.00000	.00000
MAT 2 ZONE 1	.54311-00	.56218-00	.15391+01	.48499+01	.17153+01	.00000	.00000	.00000
MAT 10 ZONE 1	.83097-02	.89441-02	.25146-01	.12166+00	.71173-01	.00000	.00000	.00000
MAT 11 ZONE 2	.81467-02	.90855-02	.23081-01	.16666-00	.93433-01	.00000	.00000	.00000
MAT 12 ZONE 2	.13252-01	.14480-01	.37545-01	.17977-00	.86639-01	.00000	.00000	.00000

GROUP 2	SIGF	SIGA	NUSIGF	SIGTR	GXG	G-1XG	G-2XG	. . .
MAT 1 ZONE 1	.16623+01	.18210+01	.48668+01	.75511+01	.56343+01	.10229+01	.00000	.00000
MAT 2 ZONE 1	.24943-02	.14847-00	.64354-02	.73530+01	.70309+01	.24990+01	.00000	.00000
MAT 10 ZONE 1	.33445-02	.49037-02	.97851-02	.21271-00	.20101-00	.40850-01	.00000	.00000
MAT 11 ZONE 2	.20165-04	.23834-02	.52024-04	.29508-00	.28025-00	.63009-01	.00000	.00000
MAT 12 ZONE 2	.32801-04	.36821-02	.84626-04	.36255-00	.34253-00	.76853-01	.00000	.00000

GROUP 3	SIGF	SIGA	NUSIGF	SIGTR	GXG	G-1XG	G-2XG	. . .
MAT 1 ZONE 1	.18994+01	.25344+01	.54582+01	.12894+02	.10356+02	.95812-01	.45270-01	.00000
MAT 2 ZONE 1	.00000	.49021-00	.00000	.12751+02	.12258+02	.17361-00	.73426-01	.00000
MAT 10 ZONE 1	.37987-02	.92252-02	.10916-01	.30036-00	.29054-00	.67968-02	.69665-03	.00000
MAT 11 ZONE 2	.00000	.80140-02	.00000	.41401-00	.40496-00	.12447-01	.11342-02	.00000
MAT 12 ZONE 2	.00000	.12405-01	.00000	.48102-00	.46751-00	.16337-01	.17952-02	.00000

GROUP 4	SIGF	SIGA	NUSIGF	SIGTR	GXG	G-1XG	G-2XG	. . .
MAT 1 ZONE 1	.81188+01	.13437+02	.23301+02	.23952+02	.10516+02	.29637-02	.00000	.00000
MAT 2 ZONE 1	.00000	.14359+01	.00000	.12756+02	.11321+02	.33372-02	.00000	.00000
MAT 10 ZONE 1	.16238-01	.38757-01	.46602-01	.37768-00	.33892-00	.59797-03	.00000	.00000
MAT 11 ZONE 2	.00000	.19338-01	.00000	.51202-00	.49269-00	.10305-02	.00000	.00000
MAT 12 ZONE 2	.00000	.30407-01	.00000	.46603-00	.43563-00	.11066-02	.00000	.00000

APPENDIX E

SOURCE DECK LISTING

```
-IL PDP INCL                                                                     IDX 0001
ABC* FCOPY                                                                       IDX 0002
      COMMON       NCR1,     NFF,     NINP,     NOUT, NSCRAT,   NSCR1,   NSCR2,  IDX 0003
     1              NSM,     NSR,      ALA,      B07,    CNT,     CVT,     E01,  IDX 0004
     2              E02,     E03,       EQ,      EVP,   EVPP,     FEF,    GBAR,  IDX 0005
     3              GLH,   ICARD,     IGEP,     IGM3,    IGP,     IGV,     IHS,  IDX 0006
     4              IHT,      IP,     IRED,    ITEMP, ITEMP1,  ITEMP2,     ITL,  IDX 0007
     5             ITLP,   KPAGE,      LAP,     LAPP,    LAR,      ME,     MMT,  IDX 0008
     6               NB,   NCRUN,       NE,    NGOTO,   NP02,    NRED,   NSIGO,  IDX 0009
     7            NXCMP,   NXCMR,      P02,     PBAR,    PI2,     R02,    SBAR,  IDX 0010
     8              SK7,     T06,       T7,      T11,   TEMP,   TEMP1,   TEMP2,  IDX 0011
     9            TEMP3,   TEMP4,       TI,      TSD,    V11                    IDX 0012
      COMMON     ID(11),    MAXT,      A02,      I04,    S02,     IGM,    NXCM,  IDX 0013
     1               ML,     M07,     NPRT,     NPUN,   NRCF,    NIFF,    MM01,  IDX 0014
     2              IGE,      IM,      IZM,       MT,    M01,     B01,     B02,  IDX 0015
     3              NCR,   NXINP,      NTR,     NFGM,   IPUN,      EV,     EVM,  IDX 0016
     4              S03,    BUCK,      LAL,      LAH,    EPS,    EPSA,     POD,  IDX 0017
     5              ORF,     S01                                                 IDX 0018
      COMMON        LR0,     LM0,      LM2,     LGAM,    LK7,     LV7,     LI0,  IDX 0019
     1              LI1,     LI2,      LR3,      LN0,   LATW,   LHOLN,    LNUT,  IDX 0020
     2            LMPUP,     LNT,     LNGB,     LNGE,  LNPFF,     LFF,     LSF,  IDX 0021
     3              LSR,     LSM,      LZN,    LHETC,    LJ1,   LATEM,     LMF,  IDX 0022
     4              LU7,    LTEM,      LAG,     LNXS,   LFSS,   LSIGO,    LNPN,  IDX 0023
     5             LNFP,    LNZN,      LNV,      LC2,  LALPH,   LALPS,    LPHJ,  IDX 0024
     6             LPHI,     LC0,      LA0,      LR1,    LR4,     LR5,     LV0,  IDX 0025
     7              LN2,     LF0,      LF2,      LI3,    LK6,     LS2,    LCXS,  IDX 0026
     8             LVOL,   LMASS,      LHA,      LPA,    LEB,    LAST            IDX 0027
      INTEGER       A02,     B01,      B02,      B07,    CNT,     CVT     P02,   IDX 0028
     1              R02,     S02,      T06,       ZN                             IDX 0029
      REAL           I2,      I3,       K6,       K7,    LAH,     LAL,     LAP,  IDX 0030
     1             LAPP,     LAR,     MASS,       N0,     N2                     IDX 0031
      END                                                                        IDX 0032
```

```
-ITC FOR CALC,CALC
C
C     * * * * *  DESCRIPTION OF SUBROUTINES  * * * * *
C
C   CALC        MAIN PROGRAM.
C
C   INP         CONTROLS READING AND PRINTING OF ALL INPUT DATA (EXCEPT
C               CROSS SECTION DATA).
C
C   ERRO2       PRINTS ERROR MESSAGES.
C
C   CLEAR       SETS AN ARRAY OF A GIVEN LENGTH EQUAL TO A SPECIFIED
C               CONSTANT.
C   REAG2       READS FLOATING POINT DATA IN GENERALIZED FORMAT.
C
C   REAI2       READS INTEGER DATA IN GENERALIZED FORMAT.
C
C   RCINP1      READS CROSS SECTION DATA IN THE RUSSIAN FORMAT FROM
C               CARDS.
C
C   RCPUP       READS CROSS SECTION DATA IN THE RUSSIAN FORMAT FROM TAPE.
C
C   RCPRT1      PRINTS CROSS SECTION DATA IN THE RUSSIAN FORMAT.
C
C   RCCHK       CHECKS CROSS SECTION DATA IN THE RUSSIAN FORMAT FOR
C               CONSISTENCY.
C
C   RCSTUP      COMPUTES F-FACTORS FOR TEMPERATURE DEPENDENT ISOTOPES
C               AND WRITES THE CROSS SECTION DATA ON TAPE IN THE PROPER
C               ORDER.
C
C   RCCAL1      CALCULATES SIGO.
C
C   RCCAL2      CALCULATES F-FACTORS.
C
C   RCCSS       CALCULATES RESONANCE SHIELDED CROSS SECTIONS.
C
C   RECS        READS CROSS SECTIONS, PERFORMS ADJOINT REVERSALS IF
C               REQUIRED, AND WRITES CROSS SECTION TAPE.
C
C   INIT        PERFORMS ADJOINT REVERSALS ON V7 AND K7, MIXES AND PRINTS
C               CROSS SECTIONS, MODIFIES GEOMETRY, AND CALCULATES AREAS,
C               VOLUMES, EFFECTIVE FISSION SPECTRUM AND FISSION RATE.
C
C   FISCAL      CALCULATES FISSION SUMS AND LAMBDA AND NORMALIZES FLUX
C               AND FISSION SOURCE RATE.
C
C   MONPR       MONITOR PRINT--PRINTS TIME, ITERATION NUMBER, EIGENVALUE
C               SLOPE, EIGENVALUE, AND LAMBDA AFTER EACH OUTER ITERATION.
C
C   OUTER       PERFORMS AN OUTER ITERATION--CALCULATES THE SOURCE INTO
C               EACH GROUP AND THE NEW FISSION AND FISSION SOURCE RATE.
C
C   INNER1      CALCULATES COEFFICIENTS FOR THE FLUX EQUATION.
C
C   INNER       CALCULATES THE FLUX FOR SPECIFIED GROUP.
C
C   CNNP        PERFORMS CONVERGENCE TESTS AND CALCULATES NEW PARAMETERS
C               FOR SEARCH OPTIONS.
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C                                                                       1DX 0092
C   FINPR       FINAL PRINT--PRINTS RADII, AREAS, VOLUMES, FLUXES,      1DX 0093
C               POWER, AND FISSION SOURCE RATE.                         1DX 0094
C                                                                       1DX 0095
C   NBAL        COMPUTES AND PRINTS BALANCE TABLES.                     1DX 0096
C                                                                       1DX 0097
C   GRAM        CALCULATES AND PRINTS MATERIAL INVENTORIES FOR EACH     1DX 0098
C               ZONE.                                                   1DX 0099
C                                                                       1DX 0100
C   CRUNCH      CALCULATES, PRINTS, AND PUNCHES COLLAPSED CROSS SECTIONS.1DX 0101
C                                                                       1DX 0102
C                                                                       1DX 0103
C     * * * * *  INTERNAL VARIABLES  * * * * *                          1DX 0104
C                                                                       1DX 0105
C     NCR1            CROSS SECTION TAPE                                1DX 0106
C     NFF             RESONANCE SHIELDING FACTOR TAPE                   1DX 0107
C     NINP            INPUT TAPE                                        1DX 0108
C     NOUT            OUTPUT TAPE                                       1DX 0109
C     NSCRAT          SCRATCH TAPE                                      1DX 0110
C     NSCR1           SCRATCH TAPE                                      1DX 0111
C     NSCR2           SCRATCH TAPE                                      1DX 0112
C     NSM             INELASTIC SCATTERING MATRIX TAPE                  1DX 0113
C     NSR             INFINITE DILUTION CROSS SECTION TAPE              1DX 0114
C     ALA             LAMBDA                                            1DX 0115
C     B07             USED FOR INTERNAL COMPUTATION IN FISCAL AND INIT  1DX 0116
C     CNT             CONVERGENCE TRIGGER FOR LAMBDA                    1DX 0117
C     CVT             CONVERGENCE TRIGGER                               1DX 0118
C     E01             TEMPORARY                                         1DX 0119
C     E02             TEMPORARY                                         1DX 0120
C     E03             TEMPORARY                                         1DX 0121
C     EQ              EIGENVALUE SLOPE                                  1DX 0122
C     EVP             PREVIOUS EIGENVALUE                               1DX 0123
C     EVPP            EIGENVALUE FOR TWO ITERATIONS BACK                1DX 0124
C     FEF             ENERGY RELEASED PER FISSION (=215 MEV)            1DX 0125
C     GBAR            GROUP INDICATOR FOR TAPE MOTION IN OUTER          1DX 0126
C     GLH             MAXIMUM TIME IN SECONDS                           1DX 0127
C     ICARD           NEGATIVE/POSITIVE=XS DATA FROM TAPE/CARDS         1DX 0128
C     IGEP            IGE + 1                                           1DX 0129
C     IGM3            IGM*3                                             1DX 0130
C     IGP             IGM + 1                                           1DX 0131
C     IGV             GROUP INDICATOR FOR INNER AND OUTER               1DX 0132
C     IHS             POSITION OF SIGMA SELF SCATTER                    1DX 0133
C     IHT             POSITION OF SIGMA TRANSPORT                       1DX 0134
C     IP              IM + 1                                            1DX 0135
C     IRED            FIRST PASS THROUGH RCCAL1  (1/2=YES/NO)           1DX 0136
C     ITEMP           TEMPORARY                                         1DX 0137
C     ITEMP1          TEMPORARY                                         1DX 0138
C     ITEMP2          TEMPORARY                                         1DX 0139
C     ITL             CROSS SECTION TABLE LENGTH                        1DX 0140
C     ITLP            CRUNCHED CROSS SECTION TABLE LENGTH               1DX 0141
C     KPAGE           PAGE COUNTER FOR MONITOR PRINT                    1DX 0142
C     LAP             LAMBDA FOR PREVIOUS EIGENVALUE                    1DX 0143
C     LAPP            LAMBDA FOR TWO ITERATIONS BACK                    1DX 0144
C     LAR             LAMBDA FOR PREVIOUS ITERATION                     1DX 0145
C     ME              CROSS SECTION DATA INCONSISTENCY COUNT            1DX 0146
C     MMT             MM01 - NRCF                                       1DX 0147
C     NB              TEMPORARY                                         1DX 0148
C     NCRUN           CRUNCH CALCULATION  (0/1=NO/YES)                  1DX 0149
C     NE              TEMPORARY                                         1DX 0150
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C       NGOTO          FLAG SET EQUAL TO ONE IF PROBLEM IS FINISHED          1DX 0151
C       NP02           TOTAL ITERATION COUNT                                 1DX 0152
C       NRED           PERFORM ANOTHER ITERATION ON SIGE (0/1=NO/YES)        1DX 0153
C       NSIGO          SIGO ITERATION COUNT                                  1DX 0154
C       NXCMP          NUMBER OF DOWNSCATTERING TERMS FOR CRUNCHED GROUPS    1DX 0155
C       NXCMR          NXCM + 1                                              1DX 0156
C       P02            OUTER ITERATION COUNT                                 1DX 0157
C       PBAR           TEMPORARY                                             1DX 0158
C       PI2            6.28318                                               1DX 0159
C       R02            SIGE ITERATION COUNT                                  1DX 0160
C       SBAR           TEMPORARY                                             1DX 0161
C       SK7            SUM OF K7 OVER ALL GROUPS                             1DX 0162
C       T06            0/1=NOT DELTA/DELTA CALCULATION                       1DX 0163
C       T7             ALPHA/VELOCITY                                        1DX 0164
C       T11            PREVIOUS FISSION TOTAL                                1DX 0165
C       TEMP           TEMPORARY                                             1DX 0166
C       TEMP1          TEMPORARY                                             1DX 0167
C       TEMP2          TEMPORARY                                             1DX 0168
C       TEMP3          TEMPORARY                                             1DX 0169
C       TEMP4          TEMPORARY                                             1DX 0170
C       TI             TIME                                                  1DX 0171
C       TSD            (MW-SEC)/(FISSIONS)                                   1DX 0172
C       V11            TOTAL SOURCE FOR THE GROUP                            1DX 0173
C                                                                            1DX 0174
C       * * * * *  INPUT VARIABLES (CARDS 1-5)  * * * * *                    1DX 0175
C                                                                            1DX 0176
C       ID(11)         IDENTIFICATION CARD                                   1DX 0177
C       MAXT           MAXIMUM TIME IN MINUTES                               1DX 0178
C       A02            0/1=FLUX CALCULATION/ADJOINT CALCULATION              1DX 0179
C       I04            EIGENVALUE TYPE (1/2/3/4/5=KEFF/ALPHA/CONCENTRATION/1DX 0180
C                      DELTA/BUCKLING)                                       1DX 0181
C       S02            PARAMETRIC EIGENVALUE TYPE  (0/1/2=NONE/KEFF/ALPHA) 1DX 0182
C       IGM            NUMBER OF GROUPS                                      1DX 0183
C       NXCM           NUMBER OF DOWNSCATTERING TERMS                        1DX 0184
C       ML             NEG/POS=NUMBER OF MATERIALS FROM TAPE/CARDS           1DX 0185
C       M07            FLUX GUESS  (0/1=NONE/CARDS)                          1DX 0186
C       NPRT           PRINT OPTION  (0/1/2=MINI/MIDI/MAXI)                  1DX 0187
C       NPUN           FLUX DUMP  (0/1=NO/YES)                               1DX 0188
C       NRCF           NO. MIXES USED IN GENERATING SHIELDED XS  (IF 0,      1DX 0189
C                      DATA IS IN DTF FORMAT)                                1DX 0190
C       NIFF           NUMBER OF ITERATIONS IN CALCULATION OF SIGE           1DX 0191
C       MM01           NO. MIX SPECIF. FOR GENERATING SHIELDED XS            1DX 0192
C       IGE            GEOMETRY  (0/1/2=PLANE/CYLINDER/SPHERE)               1DX 0193
C       IM             NUMBER OF SPACE INTERVALS                             1DX 0194
C       IZM            NUMBER OF MATERIAL ZONES                              1DX 0195
C       MT             TOTAL NUMBER OF MATERIALS INCLUDING MIXES             1DX 0196
C       M01            NUMBER OF MIXTURE SPECIFICATIONS                      1DX 0197
C       B01            LEFT BOUNDARY CONDITION  (0/1/2=VACUUM/REFL/PER)      1DX 0198
C       B02            RIGHT BOUNDARY CONDITION  (0/1/2=VACUUM/REFL/PER)     1DX 0199
C       NCR            NUMBER OF CRUNCHED GROUPS                             1DX 0200
C       NXINP          NO. COLLAPS. DOWNSCAT. TERMS  (IF 0, CALC. BY 1DX)    1DX 0201
C       NTR            TYPE WEIGHTING FOR SIGMA TRANSPORT  (0/1=NW/RW)       1DX 0202
C       NFGM           NO. COLLAPSED MATERIALS                               1DX 0203
C       IPUN           COLLAPS. XS OUTPUT  (0/1/2/3=PRINT/PUNCH/TAPE+EOF/    1DX 0204
C                      TAPE)                                                 1DX 0205
C       EV             FIRST EIGENVALUE GUESS                                1DX 0206
C       EVM            EIGENVALUE MODIFIER                                   1DX 0207
C       S03            PARAMETRIC EIGENVALUE                                 1DX 0208
C       BUCK           BUCKLING                                              1DX 0209
```

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C       LAL              LAMBDA LOWER                                         1DX 0210
C       LAH              LAMBDA UPPER                                         1DX 0211
C       EPS              EIGENVALUE CONVERGENCE CRITERION                     1DX 0212
C       EPSA             PARAMETRIC EIGENVALUE CONVERGENCE CRITERION          1DX 0213
C       POD              PARAMETER OSCILLATION DAMPER                         1DX 0214
C       ORF              FISSION SOURCE OVER-RELAXATION FACTOR                1DX 0215
C       S01              NEG/POS=POWER (MWT)/NEUTRON SOURCE RATE              1DX 0216
C                                                                             1DX 0217
C       * * * * *  SUBSCRIPTED VARIABLES  * * * * *                           1DX 0218
C                                                                             1DX 0219
C       RO(IP)           INITIAL RADII                                        1DX 0220
C       MO(IM)           ZONE NUMBERS                                         1DX 0221
C       M2(IZM)          MATERIAL NUMBERS BY ZONE                             1DX 0222
C       K7(IGM)          FISSION SPECTRUM  (INPUT)                            1DX 0223
C       V7(IGM)          NEUTRON VELOCITIES                                   1DX 0224
C       IO(MO1)          MIX NUMBER                                           1DX 0225
C       I1(MO1)          MATERIAL NUMBER FOR MIX                              1DX 0226
C       I2(MO1)          MATERIAL DENSITY                                     1DX 0227
C       R3(IZM)          RADIAL ZONE NUMBERS  (DELTA CALCULATION ONLY)        1DX 0228
C       NO(IM,IGM)       FLUX  (OLD)                                          1DX 0229
C       ATW(ML)          MATERIAL ATOMIC WEIGHT                               1DX 0230
C       HOLN(ML)         MATERIAL NAME                                        1DX 0231
C       NUT(ML)          SEQUENCE NUMBER ON TAPE FOR DATA IN RUSSIAN FORMAT   1DX 0232
C       MPUP(ML)         ISOTOPE NOS. OF MATERIALS IN ORDER READ FROM TAPE    1DX 0233
C       NT(ML)           ISOTOPE IS TEMPERATURE DEPENDENT  (0/1=NO/YES)       1DX 0234
C       NGB(ML)          GROUP NUMBER F-FACTORS BEGIN AT                      1DX 0235
C       NGE(ML)          GROUP NUMBER F-FACTORS END AT                        1DX 0236
C       NPFF(4,ML)       NO. OF SIGO COLUMNS FOR 1/2/3/4=FISSION/CAPTURE/     1DX 0237
C                        TOTAL/ELASTIC F-FACTORS                              1DX 0238
C       FF(4,IGM3,6)     INPUT SELF-SHIELDING FACTORS                         1DX 0239
C       SF(4,ML,6)       DISCRETE SIGO VALUES FOR INPUT F-FACTORS             1DX 0240
C       SR(9,IGM)        INFINITE DILUTION CROSS SECTIONS                     1DX 0241
C       SM(IGM,NXCMR)    INELASTIC SCATTERING MATRIX                          1DX 0242
C       ZN(NRCF)         ZONE NOS. OF FLUXES TO BE USED IN SIGE CALCULATION   1DX 0243
C       HETC(NRCF)       HETEROGENEITY CONSTANTS                              1DX 0244
C       J1(MMO1)         ISOTOPE NUMBER IN XS MIX VECTOR                      1DX 0245
C       ATEM(MMO1)       ISOTOPE TEMPERATURE IN XS MIX VECTOR                 1DX 0246
C       MF(MMO1)         ISOTOPE IS 0/1=FUEL/MODERATOR                        1DX 0247
C       U7(IGM)          LETHARGY WIDTHS                                      1DX 0248
C       TEM(3,ML)        DISCRETE TEMPERATURE VALUES FOR INPUT F-FACTORS      1DX 0249
C       AG(NRCF,IGM)     USED IN HETEROGENEITY CALCULATION                    1DX 0250
C       NXS(NRCF)        NO. OF MIX SPECIFICATIONS IN EACH XS MIX .           1DX 0251
C       FSS(4,MMT,IGM)CALCULATED SELF-SHIELDING FACTORS                       1DX 0252
C       SIGO(MMT,IGM) CALCULATED SIGO VALUES                                  1DX 0253
C       NPN(NCR)         NUMBER OF GROUPS PER CRUNCHED GROUP                  1DX 0254
C       NFP(NFGM)        MATERIAL NUMBERS TO BE CRUNCHED                      1DX 0255
C       NZN(NFGM)        ZONE NUMBERS OF FLUXES USED FOR CRUNCH CALCULATION   1DX 0256
C       NV(IGM)          COLLAPSED GROUP NO. FOR EACH FINE GROUP              1DX 0257
C       C2(IZM,IGM)      ZONE MACROSCOPIC TRANSPORT CROSS SECTIONS            1DX 0258
C       ALPH(IZM,IGM) FINE-GROUP TRANSPORT CROSS SECTION WEIGHTING COEFF.     1DX 0259
C       ALPS(IZM,NCR) ALPH(IZM,IGM) SUMMED OVER A COLLAPSED GROUP             1DX 0260
C       PHJ(IZM,NCR)     ZONE FLUXES FOR EACH COLLAPSED GROUP                 1DX 0261
C       PHI(IZM,IGP)     ZONE FLUXES FOR EACH FINE GROUP (AND TOTAL)          1DX 0262
C       CO(ITL,MT)       CROSS SECTION ARRAY FOR CURRENT GROUP                1DX 0263
C       AO(IP)           AREA ELEMENTS                                        1DX 0264
C       R1(IP)           CURRENT RADII                                        1DX 0265
C       R4(IM)           AVERAGE RADII                                        1DX 0266
C       R5(IM)           DELTA-R                                              1DX 0267
C       VO(IM)           VOLUME ELEMENTS                                      1DX 0268
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C      N2(IM,IGM)      FLUX  (NEW)
C      F0(IM)          FISSION SOURCE (OLD)
C      F2(IM)          FISSION SOURCE (NEW)
C      I3(M01)         MATERIAL DENSITIES USED IN GRAM
C      K6(IGM)         FISSION SPECTRUM  (EFFECTIVE)
C      S2(IM)          SOURCE
C      CXS(IP,IGM,2) CONSTANTS INVOLVING CROSS SECTIONS FOR FLUX CALC.
C      VOL(IZM)        ZONE VOLUME (LITERS)
C      MASS(ML,IZM)    MATERIAL INVENTORY IN EACH ZONE
C      HA(IM)          TEMP STORAGE FOR FLUX CALCULATION
C      PA(IM)          TEMP STORAGE FOR FLUX CALCULATION
C      EB(8,IGP)       1/2/3/4/5/6/7/8=FISSION SOURCE/IN-SCATTER/
C                      OUT-SCATTER/ABSORPTIONS/LEFT LEAK./RIGHT LEAK./
C                      TOTAL LEAK./FISSION RATE
C      GAM(IZM)        BUCKLING MODIFIERS FOR EACH ZONE
C
       INCLUDE ABC
       COMMON A(35000)
1      CALL ETIME
C      READ INPUT DATA
       CALL INP
       IF(NRCF)    20,20,10
C      CROSS SECTION DATA IS IN RUSSIAN FORMAT
10     CALL RCINP1(A(LHOLN),A(LATW),A(LNT),A(LNGB),A(LNGE),A(LNPFF),
      1            A(LFF),IGM3,ML,A(LSF),A(LSR),A(LSM),IGM,A(LU7),
      2            A(LTEM),A(LATEM),A(LI0),A(LI1),A(LI2),A(LJ1),
      3            A(LMF),A(LZN),A(LHETC),A(LNUT),A(LMPUP),A(LNXS))
       CALL RCSTUP(A(LNPFF),A(LNT),A(LFF),A(LTEM),A(LATEM),IGM3,A(LNGB),
      1            A(LNGE),A(LJ1),A(LSR),A(LSM),IGM,A(LMPUP))
       DO 15  NSIGO = 1,5
       CALL RCCAL1(A(LAG),A(LNXS),A(LI1),A(LSR),A(LMF),A(LI2),A(LFSS),
      1            A(LSIGO),A(LHETC),NRCF,MMT)
15     CALL RCCAL2(A(LNXS), A(LI1), A(LJ1), A(LNGB), A(LNGE), A(LNPFF),
      1            A(LFF), A(LSIGO),A(LSF), A(LFSS),IGM3,MMT,ML,A(LHOLN),
      2            A(LI2))
16     R02 = R02 + 1
       IF(R02 - NIFF)  18,17,17
17     NRED = 0
18     CALL RCCSS(A(LZN),A(LNXS),A(LI1),A(LSR),A(LSM),A(LN2),A(LFSS),
      1           A(LU7),A(LPHI),IGM,ITL,MMT,IZM)
C      READ DATA IN DTF FORMAT, PERFORM ADJ REVERSALS, AND MAKE XS TAPE
20     CALL RECS (A(LN2),ITL,IGM,MT,A(LATW),A(LHOLN))
       DO 25  I=LN2, LAST
25     A(I) = 0.0
102    CALL INIT(A(LK6), A(LK7), A(LI0), A(LI1), A(LI2), A(LM0), A(LM2),
      1         A(LN0), A(LR0), A(LR1), A(LR3), A(LR4), A(LR5), A(LA0),
      2                 A(LF0), A(LC0), A(LV0),ITL,IM, A(LV7),MT,A(LEB),
      3                 A(LGAM))
C      PERFORM FISSION CALCULATION
       CALL FISCAL (A(LN0),A(LF0) ,A(LV0) ,A(LC0) ,A(LK6) ,
      2             A(LM0) ,A(LM2),ITL,MT, IM, A(LEB))
C      CALL MONITOR PRINT
101    CALL MONPR
       GO TO (100, 107, 107, 107), NGOTO
C      PERFORM AN OUTER ITERATION
107    CALL OUTER( A(LA0), A(LC0), A(LF0), A(LK6),  A(LM0), A(LM2),
      1            A(LN0), A(LN2), A(LS2), A(LV0), A(LV7), A(LF2), ITL,
      2            MT, A(LCXS), IM, A(LR5), A(LR4), A(LHA), A(LPA),
      3            A(LEB), IP, IGM)
```

```
C       PERFORM FISSION CALCULATION
        CALL FISCAL (A(LN0),A(LF0) ,A(LV0) ,A(LC0) ,A(LK6) ,
       2            A(LM0) ,A(LM2),ITL,MT, IM, A(LEB))
C       PERFORM CONVERGENCE AND NEW PARAMETER CALCULATIONS
        CALL CNNP(A(LF2),A(LK6),A(LEB))
        GO TO (100, 101, 102), NGOTO
C       100/101/102=FINAL PRINT/MONITOR PRINT/SEARCH CALCULATION
C       FINAL PRINT
100     CALL FINPR(A(LF2),A(LPA),A(LC0),A(LM0),A(LM2),A(LN2),A(LR1),
       1           A(LR4),A(LA0),A(LV0),A(LF0),ITL,IM,A(LEB),A(LCXS),
       2           IP,IGM,A(LPHI),IZM,A(LC2),IGM,A(LGAM))
        IF(NRED)  150,150,16
C       CALCULATE MATERIAL INVENTORY
150     CALL GRAM(A(LMASS),A(LVOL),A(LATW),A(LHOLN),IM,A(LM0),A(LM2),
       1          A(LV0),A(LI0),A(LI1),A(LI2),ML,A(LI3),A(LJ1))
        IF(NCRUN)  240,240,210
C       COLLAPSE CROSS SECTIONS
210     CALL CRUNCH(A(LPHI),A(LN2),A(LV0),A(LV7),A(LPHJ),A(LNPN),A(LK7),
       1           A(LN2),A(LC0),A(LNFP),A(LNZN),A(LM0),A(LHOLN),
       2           A(LATW),IZM,ITLP,A(LNV),NCR,ITL,IM,A(LVOL),A(LC2),
       3           IGM,A(LK6),A(LALPH),A(LALPS))
240     GO TO 1
        END
```

```
-ITC FOR INP,INP
      SUBROUTINE INP
      INCLUDE ABC
      COMMON A(35000)
C     THIS SUBROUTINE CONTROLS THE READING OF INPUT DATA EXCEPT XS DATA
C     SET UP DRUM UNITS
      DIMENSION  JLPTAB(49)
      CALL  SETDR(3,150000,200000,JLPTAB)
      CALL  SETDR(4,350000,200000,JLPTAB(8))
      CALL  SETDR(8,550000,100000,JLPTAB(15))
      CALL  SETDR(9,650000,100000,JLPTAB(22))
      CALL  SETDR(10,750000,350000,JLPTAB(29))
      CALL  SETDR(11,1100000,100000,JLPTAB(36))
      CALL  SETDR(12,1200000,100000,JLPTAB(43))
      NCR1 = 3
      NSCRAT = 4
      NINP = 5
      NOUT = 6
      NFF = 8
      NSR = 9
      NSM = 10
      NSCR1 = 11
      NSCR2 = 12
      REWIND NCR1
      REWIND NSCRAT
      REWIND NFF
      REWIND NSR
      REWIND NSM
      REWIND NSCR1
      REWIND NSCR2
      WRITE(NOUT,10)
10    FORMAT(1H1,41X,35H  *  *  *  *    1 D X    *  *  *  *   ///)
      READ(NINP,20) (ID(I),I=1,11), MAXT
20    FORMAT(11A6,I6)
      WRITE(NOUT,30) (ID(I),I=1,11), MAXT
30    FORMAT(10X,1H ,11A6,I6/)
      READ(NINP,40) A02, I04, S02, IGM, NXCM, ML, M07, NPRT, NPUN, NRCF,
     1 NIFF, MM01, IGE, IM, IZM, MT, M01, B01, B02, NCR, NXINP, NTR,
     2 NFGM, IPUN
40    FORMAT(12I6)
      READ(NINP,50) EV, EVM, S03, BUCK, LAL, LAH, EPS, EPSA, POD, ORF,
     1 S01
50    FORMAT(6E12.6)
      WRITE(NOUT,60) A02, I04, S02, IGM, NXCM, ML
60    FORMAT(
     192H   A02       0/1=REGULAR CALCULATION/ADJOINT CALCULATION
     2                           I9/
     392H   I04       EIGENVALUE TYPE  (1/2/3/4/5=KEFF/ALPHA/CONCENTRATIO
     4N/DELTA/BUCKLING)           I9/
     592H   S02       PARAMETRIC EIGENVALUE TYPE  (0/1/2=NONE/KEFF/ALPHA)
     6                           I9/
     992H   IGM       NUMBER OF ENERGY GROUPS
     1                           I9/
     292H  NXCM       NUMBER OF DOWNSCATTERING TERMS
     3                           I9/
     192H    ML       NEGATIVE/POSITIVE=NUMBER OF MATERIALS FROM TAPE/CAR
     2DS                         I9)
      WRITE(NOUT,70) M07, NPRT, NPUN, NRCF, NIFF, MM01
70    FORMAT(
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     392H   MO7      FLUX GUESS  (0/1=NONE/CARDS)                        1DX 0410
     4                                I9/                                1DX 0411
     592H  NPRT      PRINT OPTION  (0/1/2=MINI/MIDI/MAXI)                1DX 0412
     6                                I9/                                1DX 0413
     792H  NPUN      FLUX DUMP  (0/1=NO/YES)                             1DX 0414
     8                                I9/                                1DX 0415
     792H  NRCF      NO. OF MIXES USED IN GENERATING XS DATA  (IF 0, DAT1DX 0416
     8A IS IN DTF FORMAT)             I9/                                1DX 0417
     992H  NIFF      NUMBER OF ITERATIONS IN CALCULATION OF SIGE         1DX 0418
     1                                I9/                                1DX 0419
     292H  MM01      NUMBER OF MIX SPECIF. FOR GENERATING SHIELDED XS    1DX 0420
     3                                I9/)                               1DX 0421
      WRITE(NOUT,80) IGE, IM, IZM, MT, MO1, BO1                          1DX 0422
80    FORMAT(                                                            1DX 0423
     192H   IGE      GEOMETRY  (0/1/2=PLANE/CYLINDER/SPHERE)             1DX 0424
     2                                I9/                                1DX 0425
     392H    IM      NUMBER OF SPACE INTERVALS                           1DX 0426
     4                                I9/                                1DX 0427
     592H   IZM      NUMBER OF MATERIAL ZONES                            1DX 0428
     6                                I9/                                1DX 0429
     792H    MT      TOTAL NUMBER OF MATERIALS INCLUDING MIXES           1DX 0430
     8                                I9/                                1DX 0431
     992H   MO1      NUMBER OF MIXTURE SPECIFICATIONS                    1DX 0432
     1                                I9/                                1DX 0433
     292H   BO1      LEFT  BOUNDARY CONDITION  (0/1/2=VACUUM/REFLECTIVE/1DX 0434
     3PERIODIC)                       I9)                                1DX 0435
      WRITE(NOUT,90)  BO2, NCR, NXINP, NTR, NFGM, IPUN                   1DX 0436
90    FORMAT(                                                            1DX 0437
     192H   BO2      RIGHT BOUNDARY CONDITION  (0/1/2=VACUUM/REFLECTIVE/1DX 0438
     2PERIODIC)                       I9/                                1DX 0439
     392H   NCR      NUMBER OF COLLAPSED GROUPS  (IF NCR=IGM, NO EFFECT)1DX 0440
     4                                I9/                                1DX 0441
     592H NXINP      NUMBER OF COLLAPSED DOWNSCATTERING TERMS  (IF 0, CA1DX 0442
     6LCULATED BY 1DX)                I9/                                1DX 0443
     592H   NTR      TYPE WEIGHTING FOR COLLAPSED SIGTR  (0/1=NORMALIZED1DX 0444
     6/RECIPROCAL)                    I9/                                1DX 0445
     792H  NFGM      NUMBER OF COLLAPSED MATERIALS                       1DX 0446
     8                                I9/                                1DX 0447
     992H  IPUN      COLLAPSED CROSS SECTION OUTPUT  (0/1/2/3=PRINT/PUNC1DX 0448
     1H/TAPE+EOF/TAPE)                I9/)                               1DX 0449
      WRITE(NOUT,100) EV, EVM, S03, BUCK, LAL, LAH                       1DX 0450
100   FORMAT(                                                            1DX 0451
     191H    EV      FIRST EIGENVALUE GUESS                              1DX 0452
     2                              1PE10.4/                             1DX 0453
     391H   EVM      EIGENVALUE MODIFIER                                 1DX 0454
     4                              1PE10.4/                             1DX 0455
     591H   S03      PARAMETRIC EIGENVALUE                               1DX 0456
     6                              1PE10.4/                             1DX 0457
     791H  BUCK      BUCKLING (CM-2)                                     1DX 0458
     8                              1PE10.4/                             1DX 0459
     991H   LAL      LAMBDA LOWER                                        1DX 0460
     1                              1PE10.4/                             1DX 0461
     291H   LAH      LAMBDA UPPER                                        1DX 0462
     3                              1PE10.4/)                            1DX 0463
      WRITE(NOUT,120) EPS, EPSA, POD, ORF, S01                           1DX 0464
120   FORMAT(                                                            1DX 0465
     191H   EPS      EIGENVALUE CONVERGENCE CRITERION                    1DX 0466
     2                              1PE10.4/                             1DX 0467
     391H  EPSA      PARAMETER CONVERGENCE CRITERION                     1DX 0468
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     4                             1PE10.4/                               1DX 0469
     591H    POD       PARAMETER OSCILLATION DAMPER                       1DX 0470
     6                             1PE10.4/                               1DX 0471
     791H    ORF       OVER-RELAXATION FACTOR                             1DX 0472
     8                             1PE10.4/                               1DX 0473
     991H    S01       NEGATIVE/POSITIVE=POWER (MWT)/NEUTRON SOURCE RATE  1DX 0474
     1                             1PE10.4/                               1DX 0475
     291H                                                                 1DX 0476
     3                             1PE10.4/)                              1DX 0477
      IF(A02)  230,230,210                                                1DX 0478
210   IF(NIFF)  230,230,220                                               1DX 0479
220   CALL ERRO2(6H   INP,220,1)                                          1DX 0480
230   IF(S02) 240, 260, 240                                               1DX 0481
240   IF(S03) 260, 250, 260                                               1DX 0482
250   CALL ERRO2(6H   INP,250,1)                                          1DX 0483
260   FEF = 215.0                                                         1DX 0484
      TSD = FEF*1.602*10.**(-19)                                          1DX 0485
      GLH = MAXT*60                                                       1DX 0486
      IGMIM = IGM*IM                                                      1DX 0487
      KPAGE =100                                                          1DX 0488
      ME = 0                                                              1DX 0489
      IHS = 5                                                             1DX 0490
      ITL = NXCM + 5                                                      1DX 0491
      IHT = 4                                                             1DX 0492
      IP = IM + 1                                                         1DX 0493
      IGP = IGM + 1                                                       1DX 0494
      IGEP = IGE + 1                                                      1DX 0495
      EQ = .0                                                             1DX 0496
      LAP = .0                                                            1DX 0497
      LAPP = .0                                                           1DX 0498
      LAR = .0                                                            1DX 0499
      ALA = .0                                                            1DX 0500
      P02 = 0                                                             1DX 0501
      NP02 = 0                                                            1DX 0502
      CVT = 0                                                             1DX 0503
      CNT = 0                                                             1DX 0504
      NXCMP = NXCM                                                        1DX 0505
      IF(NXCM - NCR + 1)  275,275,270                                     1DX 0506
270   NXCMP = NCR - 1                                                     1DX 0507
275   ITLP = NXCMP + 5                                                    1DX 0508
      NCRUN = 0                                                           1DX 0509
      IF(NCR-IGM)  280,280,290                                            1DX 0510
280   NCRUN = 1                                                           1DX 0511
290   T06 = 0                                                             1DX 0512
      IF(I04-4)  310, 300, 310                                            1DX 0513
300   T06 = 1                                                             1DX 0514
310   R02 = 0                                                             1DX 0515
      MMT = MM01 - NRCF                                                   1DX 0516
      ICARD = ML                                                          1DX 0517
      ML = IABS(ML)                                                       1DX 0518
      IRED = 1                                                            1DX 0519
      NRED = 0                                                            1DX 0520
      IF(NRCF) 316, 316, 314                                              1DX 0521
314   NRED = 1                                                            1DX 0522
      R02 = -1                                                            1DX 0523
316   IGM3 = IGM*3                                                        1DX 0524
      NXCMR = NXCM + 1                                                    1DX 0525
C     COMPUTE DIMENSION POINTERS                                          1DX 0526
      LR0 = 1                                                             1DX 0527
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LM0 = LR0 + IP                                                          1DX 0528
LM2 = LM0 + IM                                                          1DX 0529
LGAM = LM2 + IZM                                                        1DX 0530
LK7 = LGAM + IZM                                                        1DX 0531
LV7 = LK7 + IGM                                                         1DX 0532
LI0 = LV7 + IGM                                                         1DX 0533
LI1 = LI0 + M01                                                         1DX 0534
LI2 = LI1 + M01                                                         1DX 0535
LR3 = LI2 + M01                                                         1DX 0536
LN0 = LR3 + IZM*T06                                                     1DX 0537
LATW = LN0 + IM*IGM                                                     1DX 0538
LHOLN = LATW + ML                                                       1DX 0539
LNUT = LHOLN + ML                                                       1DX 0540
LMPUP = LNUT + ML                                                       1DX 0541
LNT = LMPUP + ML                                                        1DX 0542
LNGB = LNT + ML*NRED                                                    1DX 0543
LNGE = LNGB + ML*NRED                                                   1DX 0544
LNPFF = LNGE + ML*NRED                                                  1DX 0545
LFF = LNPFF + 4*ML*NRED                                                 1DX 0546
LSF = LFF + 4*IGM3*6*NRED                                               1DX 0547
LSR = LSF + 4*ML*6*NRED                                                 1DX 0548
LSM = LSR + 9*IGM*NRED                                                  1DX 0549
LZN = LSM + IGM*NXCMR*NRED                                              1DX 0550
LHETC = LZN + NRCF*NRED                                                 1DX 0551
LJ1 = LHETC + NRCF*NRED                                                 1DX 0552
LATEM = LJ1 + MM01*NRED                                                 1DX 0553
LMF = LATEM + MM01*NRED                                                 1DX 0554
LU7 = LMF + MM01*NRED                                                   1DX 0555
LTEM = LU7 + IGM*NRED                                                   1DX 0556
LAG = LTEM + 3*ML*NRED                                                  1DX 0557
LNXS = LAG + NRCF*IGM*NRED                                              1DX 0558
LFSS = LNXS + NRCF*NRED                                                 1DX 0559
LSIGO = LFSS + 4*MMT*IGM*NRED                                           1DX 0560
LNPN = LSIGO + MMT*IGM*NRED                                             1DX 0561
LNFP = LNPN + NCR*NCRUN                                                 1DX 0562
LNZN = LNFP + NFGM*NCRUN                                                1DX 0563
LNV = LNZN + NFGM*NCRUN                                                 1DX 0564
LC2 = LNV + IGM*NCRUN                                                   1DX 0565
LALPH = LC2 + IZM*IGM*NCRUN                                             1DX 0566
LALPS = LALPH + IZM*IGM*NCRUN                                           1DX 0567
LPHJ = LALPS + IZM*NCR*NCRUN                                            1DX 0568
LPHI = LPHJ + IZM*NCR*NCRUN                                             1DX 0569
LC0 = LPHI + IZM*IGP                                                    1DX 0570
LA0 = LC0 + ITL*MT                                                      1DX 0571
LR1 = LA0 + IP                                                          1DX 0572
LR4 = LR1 + IP                                                          1DX 0573
LR5 = LR4 + IM                                                          1DX 0574
LV0 = LR5 + IM                                                          1DX 0575
LN2 = LV0 + IM                                                          1DX 0576
LF0 = LN2 + IM*IGM                                                      1DX 0577
LF2 = LF0 + IM                                                          1DX 0578
LI3 = LF2 + IM                                                          1DX 0579
LK6 = LI3 + M01                                                         1DX 0580
LS2 = LK6 + IGM                                                         1DX 0581
LCXS = LS2 + IM                                                         1DX 0582
LVOL = LCXS + IP*IGM*2                                                  1DX 0583
LMASS = LVOL + IZM                                                      1DX 0584
LHA = LMASS + ML*IZM                                                    1DX 0585
LPA = LHA + IM                                                          1DX 0586
```

```
      LFB = LPA + IM
      LAST = LEB + 8*IGP
      ITEMP = LN2 + ITL*IGM*MT
      LAST = MAX0(LAST,ITEMP)
      WRITE(NOUT, 320) LAST
320   FORMAT(5H LAST,I6///)
      DO 325  I=1,LAST
325   A(I) = 0.0
C     READ FLUXES
      IF(M07-1)  330, 350, 350
330   ITEMP = LN0 + IGMIM - 1
      DO 340  I=LN0,ITEMP
340   A(I) = 1.0
      GO TO 370
350   WRITE(NOUT,360)
360   FORMAT(11H0FLUX GUESS)
      CALL REAG2(6H    N0,A(LN0),IGMIM)
C     READ MESH POINTS
370   WRITE(NOUT,380)
380   FORMAT(12H0MESH POINTS)
      CALL REAG2(6H    R0,A(LR0),IP)
C     READ ZONE NUMBERS
      WRITE(NOUT,390)
390   FORMAT(30H0ZONE NUMBERS BY MESH INTERVAL)
      CALL REAI2(6H    M0,A(LM0),IM)
C     READ MATERIAL NUMBERS
      WRITE(NOUT,400)
400   FORMAT(25H0MATERIAL NUMBERS BY ZONE)
      CALL REAI2(6H    M2,A(LM2),IZM)
C     READ BUCKLING MODIFIERS
      IF(I04 - 5)  401,402,401
401   IF(BUCK)  402,408,402
402   WRITE(NOUT,404)
404   FORMAT(27H0BUCKLING MODIFIERS BY ZONE)
      CALL REAG2(6H   GAM,A(LGAM),IZM)
C     READ FISSION FRACTIONS
408   WRITE(NOUT,410)
410   FORMAT(18H0FISSION FRACTIONS)
      CALL REAG2(6H    K7,A(LK7),IGM)
C     READ VELOCITIES
      WRITE(NOUT,420)
420   FORMAT(17H0NEUTRON VELOCITY)
      CALL REAG2(6H    V7,A(LV7),IGM)
C     READ MIXTURE SPECIFICATIONS
      IF(M01)  440,440,430
430   WRITE(NOUT,445)
445   FORMAT(82H0MIXTURE SPECIFICATIONS (I0/I1/I2=MIX NUMBER/MAT. NUMBER
     1 FOR MIX/MATERIAL DENSITY))
      CALL REAI2(6H    I0,A(LI0),M01)
      CALL REAI2(6H    I1,A(LI1),M01)
      CALL REAG2(6H    I2,A(LI2),M01)
C     READ ZONE MODIFIERS IF DELTA CALCULATION
440   IF(I04-4)  500,450,500
450   WRITE(NOUT,460)
460   FORMAT(32H0ZONE MODIFIERS FOR DELTA OPTION)
      CALL REAG2(6H    R3,A(LR3),IZM)
C     READ NUMBERS OF MATERIALS TO BE PUNCHED
C     READ NUMBER OF GROUPS FOR EACH CRUNCHED GROUP
500   IF(NCRUN)  575,575,540
```

```
540     WRITE(NOUT,550)                                                   1DX 0646
550     FORMAT(36H0NUMBER OF GROUPS PER CRUNCHED GROUP)                   1DX 0647
        CALL REAI2(6H   NPN,A(LNPN),NCR)                                  1DX 0648
C       READ NUMBERS OF MATERIALS TO BE CRUNCHED                          1DX 0649
        WRITE(NOUT,560)                                                   1DX 0650
560     FORMAT(36H0NUMBERS OF MATERIALS TO BE CRUNCHED)                   1DX 0651
        CALL REAI2(6H   NFP,A(LNFP),NFGM)                                 1DX 0652
C       READ ZONE NUMBERS OF FLUXES USED FOR CRUNCH CALCULATION           1DX 0653
        WRITE(NOUT,570)                                                   1DX 0654
570     FORMAT(51H0ZONE NUMBERS OF FLUXES USED FOR CRUNCH CALCULATION)    1DX 0655
        CALL REAI2(6H   NZN,A(LNZN),NFGM)                                 1DX 0656
575     IF(NRCF) 670, 670, 580                                            1DX 0657
C       READ ZONE NUMBERS FOR EACH CROSS SECTION MIX                      1DX 0658
580     WRITE(NOUT,590)                                                   1DX 0659
590     FORMAT(40H0ZONE NUMBERS FOR EACH CROSS SECTION MIX)               1DX 0660
        CALL REAI2(6H    ZN,A(LZN),NRCF)                                  1DX 0661
C       READ HETEROGENEITY CONSTANT FOR EACH CROSS SECTION MIX            1DX 0662
        WRITE(NOUT,600)                                                   1DX 0663
600     FORMAT(50H0HETEROGENEITY CONSTANT FOR EACH CROSS SECTION MIX)     1DX 0664
        CALL REAG2(6H  HETC,A(LHETC),NRCF)                                1DX 0665
C       READ ISOTOPE NUMBER FOR EACH TERM IN XS MIX VECTOR                1DX 0666
        WRITE(NOUT,610)                                                   1DX 0667
610     FORMAT(46H0ISOTOPE NUMBER FOR EACH TERM IN XS MIX VECTOR)         1DX 0668
        CALL REAI2(6H    J1,A(LJ1),MM01)                                  1DX 0669
C       READ TEMPERATURE FOR EACH TERM IN XS MIX VECTOR                   1DX 0670
        WRITE(NOUT,620)                                                   1DX 0671
620     FORMAT(44H0TEMPERATURES FOR EACH TERM IN XS MIX VECTOR)           1DX 0672
        CALL REAG2(6H  ATEM,A(LATEM),MM01)                                1DX 0673
C       READ FUEL OR MODERATOR DESIGNATION FOR EACH TERM IN XS MIX VECTOR 1DX 0674
        WRITE(NOUT,630)                                                   1DX 0675
630     FORMAT(83H0FUEL OR MODERATOR DESIGNATION FOR EACH TERM IN XS MIX V1DX 0676
       1ECTOR  (0/1=FUEL/MODERATOR))                                      1DX 0677
        CALL REAI2(6H    MF,A(LMF),MM01)                                  1DX 0678
C       READ LETHARGY WIDTHS                                              1DX 0679
        WRITE(NOUT,640)                                                   1DX 0680
640     FORMAT(16H0LETHARGY WIDTHS)                                       1DX 0681
        CALL REAG2(6H    U7,A(LU7),IGM)                                   1DX 0682
        IF(ICARD)  650,670,670                                            1DX 0683
C       READ SEQUENCE NUMBERS ON TAPE FOR INPUT CROSS SECTIONS            1DX 0684
650     WRITE(NOUT,660)                                                   1DX 0685
660     FORMAT(70H0SEQUENCE NUMBERS ON TAPE FOR CROSS SECTION DATA IN THE 1DX 0686
       1RUSSIAN FORMAT)                                                   1DX 0687
        CALL REAI2(6H   NUT,A(LNUT),ML)                                   1DX 0688
C       END OF INPUT DATA  (EXCEPT CROSS SECTION DATA)                    1DX 0689
670     IF(LAST - 35000)  700, 700, 680                                   1DX 0690
680     WRITE(NOUT,690)                                                   1DX 0691
690     FORMAT(26H PROGRAM CAPACITY EXCEEDED)                             1DX 0692
        STOP                                                              1DX 0693
700     RETURN                                                            1DX 0694
        END                                                               1DX 0695
```

```
-IT FOR  ERRO2,ERRO2
      SUBROUTINE ERRO2( HOL,JSUBR,I)
      COMMON      NCR1,    NFF,    NINP,    NOUT, NSCRAT,   NSCR1,   NSCR2
      WRITE (NOUT,1)          HOL,JSUBR
1     FORMAT(2H */9H ERROR IN,A6,3H AT,I6/2H */2H *)
      GO TO (3,4),I
3     STOP
4     RETURN
      END
```

```
-IT FOR  CLEAR,CLEAR
      SUBROUTINE CLEAR (X,Y,N)
      DIMENSION Y(1)
      DO 1 I=1,N
1     Y(I)=X
      RETURN
      END
```

```
-IT  FOR REAG2,REAG2                                                   1DX 0712
      SUBROUTINE REAG2(HOLL,ARRAY,NCOUNT)                              1DX 0713
      DIMENSION ARRAY(1),V(12),K(12),IN(12)                            1DX 0714
      COMMON     NCR1,    NFF,    NINP,    NOUT, NSCRAT,  NSCR1,  NSCR2 1DX 0715
      JFLAG=0                                                          1DX 0716
      J=1                                                              1DX 0717
10    IF(JFLAG)20,40,20                                                1DX 0718
20    DO 30 JJ=1,6                                                     1DX 0719
      K(JJ)=K(JJ+6)                                                    1DX 0720
      IN(JJ)=IN(JJ+6)                                                  1DX 0721
30    V(JJ)=V(JJ+6)                                                    1DX 0722
      JFLAG=0                                                          1DX 0723
      GO TO 60                                                         1DX 0724
40    READ (NINP,50)      (K(I),IN(I),V(I),I=1,6)                      1DX 0725
50    FORMAT(6(I1,I2,E9.4))                                            1DX 0726
60    DO 140 I=1,6                                                     1DX 0727
      L=K(I)+1                                                         1DX 0728
      GO TO (70,80,100,150),L                                          1DX 0729
C     NO MODIFICATION                                                  1DX 0730
70    ARRAY(J)=V(I)                                                    1DX 0731
      J=J+1                                                            1DX 0732
      GO TO 140                                                        1DX 0733
C     REPEAT                                                           1DX 0734
80    L=IN(I)                                                          1DX 0735
      DO 90 M=1,L                                                      1DX 0736
      ARRAY(J)=V(I)                                                    1DX 0737
90    J=J+1                                                            1DX 0738
      GO TO 140                                                        1DX 0739
C     INTERPOLATE                                                      1DX 0740
100   IF(I-6) 120,110,110                                              1DX 0741
110   READ (NINP,50)        (K(JJ),IN(JJ),V(JJ),JJ=7,12)               1DX 0742
      JFLAG=1                                                          1DX 0743
120   L=IN(I)+1                                                        1DX 0744
      DEL=(V(I+1)-V(I))/FLOAT (L)                                      1DX 0745
      DO 130 M=1,L                                                     1DX 0746
      ARRAY(J)=V(I)+DEL*FLOAT (M-1)                                    1DX 0747
130   J=J+1                                                            1DX 0748
140   CONTINUE                                                         1DX 0749
      GO TO 10                                                         1DX 0750
C     TERMINATE                                                        1DX 0751
150   J=J-1                                                            1DX 0752
      WRITE (NOUT,160)        HOLL,J      ,( ARRAY(I),I=1,J)           1DX 0753
      IF(J  -NCOUNT)170,180,170                                        1DX 0754
160   FORMAT(6X,A6,I6/(10E12.5))                                       1DX 0755
170   CALL ERRO2( 6H REAG2,170,1)                                      1DX 0756
180   RETURN                                                           1DX 0757
      END                                                              1DX 0758
```

```
-IT   FOR REAI2,REAI2
      SUBROUTINE REAI2(HOLL,IARRAY,NCOUNT)
      DIMENSION IARRAY(1),IV(6),K(6),IN(6)
      COMMON       NCR1,     NFF,    NINP,     NOUT, NSCRAT,   NSCR1,   NSCR2
      J=1
10    READ(NINP,20)        (K(I),IN(I),IV(I),I=1,6)
20    FORMAT(6(I1,I2,I9))
      DO 70I=1,6
      L=K(I)+1
      GO TO (30,40,60,80 ),L
C     NO MODIFICATION
30    IARRAY(J)=IV(I)
      J=J+1
      GO TO 70
C     REPEAT
40    L=IN(I)
      DO 50 M=1,L
      IARRAY(J)=IV(I)
50    J=J+1
      GO TO 70
C     INTERPOLATE
60    CALL ERRO2(6H  REAI,60,1)
70    CONTINUE
      GO TO 10
C     TERMINATE
80    J=J-1
      WRITE (NOUT,90)        HOLL,J      ,(IARRAY(I),I=1,J)
      IF(J  -NCOUNT)100,110,100
90    FORMAT(6X,A6,I6/(10I12))
100   CALL ERRO2( 6H REAI2,100,1)
110   RETURN
      END
```

```
-ITC  FOR RCINP1,RCINP1
      SUBROUTINE RCINP1(HOLN,ATW,NT,NGB,NGE,NPFF,FF,JGM3,JML,SF,
     1                  SR, SM, JGM, U7, TEM, ATEM, I0, I1, I2, J1, MF,
     2                  ZN, HETC,NUT,MPUP,NXS)
      DIMENSION  HOLN(1), ATW(1), NT(1), NGB(1), NGE(1), NPFF(4,1),
     1           FF(4,JGM3,1), SF(4,JML,1), SR(    9,1), SM(    JGM,1),
     2           U7(1), TEM(3,1), ATEM(1), I0(1), I1(1), I2(1), J1(1),
     3           MF(1),  ZN(1), HETC(1), NUT(1), MPUP(1), NXS(1)
      INCLUDE ABC
C     READ CROSS SECTION DATA IN THE RUSSIAN FORMAT
      ITEMP = 0
      ITEMP1 = 1
      DO 7  J=2,MM01
      IF(I0(J) - I0(J-1))  3, 7, 3
3     ITEMP = ITEMP + 1
      ITEMP2 = J
      NXS(ITEMP) = ITEMP2 - ITEMP1
      ITEMP1 = ITEMP2
7     CONTINUE
      NXS(NRCF) = MM01 + 1 - ITEMP1
      IF(ICARD)  10,20,20
10    CALL RCPUP(HOLN,ATW,NT,NGB,NGE,NPFF,FF,JGM3,JML,SF,
     1                  SR, SM, JGM, U7, TEM, ATEM, I0, I1, I2, J1, MF,
     2                  ZN, HETC,NUT,MPUP)
      GO TO 640
20    DO 600  M=1,ML
      READ(NINP,30)  HOLN(M), ATW(M), NT(M), NGB(M), NGE(M),
     1               (NPFF(K,M), K=1,4), (TEM(K,M),K=1,3)
30    FORMAT(A6,E6.2,7I6,3E6.0)
      IF(NT(M)) 40, 40, 50
40    NB = NGB(M)
      NE = NGE(M)
      GO TO 60
50    NB = 3*NGB(M) - 2
      NE = 3*NGE(M)
60    DO 100  K=1,4
      NF = NPFF(K,M)
      IF(NF)  100,100,62
62    READ(NINP,80)  (SF(K,M,N),N=1,NF)
      READ(NINP,80)  ((FF(K,J,N), N=1,NF), J=NB,NE)
      WRITE(NFF)     ((FF(K,J,N), N=1,NF), J=NB,NE)
80    FORMAT(12E6.3)
100   CONTINUE
      DO 200  IIG=1,IGM
      READ(NINP,160)  L, (SR(  K,IIG), K=1,9)
160   FORMAT(I3, F10.4, F9.4, F5.3, F10.4, F6.4, F9.4, F6.4, F6.4, F8.4)
      IF(L-IIG)  170, 200, 170
170   WRITE(NOUT,180)   HOLN(M),IIG
180   FORMAT(32H CHECK CROSS SECTION SEQUENCE    ,A6,6H GROUP I3///)
200   CONTINUE
      WRITE(NSR)  ((SR(K,IIG), K=1,9), IIG=1,IGM)
      DO 300  IIG=1,IGM
      IF(NXCMR - 11)  230,230,250
230   READ(NINP,240) L, (SM(  IIG,K),K=1,NXCMR)
240   FORMAT(I3, E7.4, 10E6.4)
      GO TO 265
250   READ(NINP,260) L, (SM(  IIG,K),K=1,NXCMR)
260   FORMAT(I3, E7.4, 10E6.4/(12E6.4))
265   IF(L-IIG)  270, 300, 270
```

```
270    WRITE(NOUT,280)    HOLN(M),IIG                                         1DX 0850
280    FORMAT(36H CHECK SCATTERING MATRIX SEQUENCE    ,A6,6H GROUP I3///) 1DX 0851
300    CONTINUE                                                               1DX 0852
       WRITE(NSM)   ((SM(IIG,K), K=1,NXCMR), IIG=1,IGM)                       1DX 0853
       NB = NGB(M)                                                            1DX 0854
       NE = NGE(M)                                                            1DX 0855
       IF(NPRT - 1)  600,600,320                                              1DX 0856
320    CALL RCPRT1(HOLN, SR, SM, NPFF, SF, FF, NT, M, JML, JGM, JGM3,         1DX 0857
      1            NGB, NGE, TEM)                                             1DX 0858
600    CALL RCCHK(M, SR, HOLN, U7, SM, NT, NPFF, FF, NGB, NGE, JML,           1DX 0859
      1            JGM, JGM3)                                                 1DX 0860
       IF(NPRT - 1)  610,610,640                                              1DX 0861
610    WRITE(NOUT,620)  (M,HOLN(M), M=1,ML)                                   1DX 0862
620    FORMAT(79H1 CROSS SECTION DATA FOR THE FOLLOWING ISOTOPES WAS GIVE1DX 0863
      1N IN THE RUSSIAN FORMAT// 30H  ISOTOPE              ISOTOPE /          1DX 0864
      3                            8H  NUMBER// (I6,17X,A6))                  1DX 0865
640    WRITE(NOUT,650) (I0(J),I1(J),I2(J),J1(J),ATEM(J),MF(J),J=1,MM01)  1DX 0866
650    FORMAT(63H1MIXTURE SPECIFICATIONS FOR CALCULATING SHIELDED CROSS S1DX 0867
      1ECTIONS// 118H        MIXTURE             MIX                 MATERI1DX 0868
      2AL            ISOTOPE           TEMPERATURE        0/1=FUEL/MOD  1DX 0869
      3/           96H        NUMBER              COMMAND              DENSI1DX 0870
      4TY                  NUMBER              (DEG K)   //(I10, I21, E25.8,  1DX 0871
      5  I15, E25.8, I14))                                                    1DX 0872
       WRITE(NOUT,660)                                                        1DX 0873
660    FORMAT(/////8X,                                                        1DX 0874
      156H     CROSS SECTION          ZONE FLUXES         HETC. CONST./  8X, 1DX 0875
      256H       MIX NUMBER           FOR XS MIX            FOR XS MIX /)     1DX 0876
       ITEMP1 = 1                                                             1DX 0877
       DO 670   J=1,NRCF                                                      1DX 0878
       ITEMP = I0(ITEMP1)                                                     1DX 0879
       ITEMP1 = ITEMP1 + NXS(J)                                               1DX 0880
670    WRITE(NOUT,680)  J, ITEMP, ZN(J), HETC(J)                              1DX 0881
680    FORMAT( I5, I14, I20, E25.8)                                           1DX 0882
       REWIND NFF                                                             1DX 0883
       REWIND NSR                                                             1DX 0884
       REWIND NSM                                                             1DX 0885
       RETURN                                                                 1DX 0886
       END                                                                    1DX 0887
```

```
-ITC  FOR RCPUP,RCPUP
      SUBROUTINE RCPUP(HOLN,ATW,NT,NGB,NGE,NPFF,FF,JGM3,JML,SF,
     1                 SR, SM, JGM, U7, TEM, ATEM, I0, I1, I2, J1, MF,
     2                  ZN, HETC,NUT,MPUP)
      DIMENSION  HOLN(1), ATW(1), NT(1), NGB(1), NGE(1), NPFF(4,1),
     1           FF(4,JGM3,1), SF(4,JML,1), SR(    9,1), SM(     JGM,1),
     2           U7(1), TEM(3,1), ATEM(1), I0(1), I1(1), I2(1), J1(1),
     3           MF(1),  ZN(1), HETC(1), NUT(1), MPUP(1)
      INCLUDE ABC
C     THIS SUBROUTINE READS DATA IN THE RUSSIAN FORMAT FROM TAPE
      NLAST = NUT(1)
      DO 30  M=2,ML
      IF(NUT(M) - NLAST)  30,30,20
20    NLAST = NUT(M)
30    CONTINUE
      REWIND 15
      MTEMP = 0
      DO 600  NN=1,NLAST
      DO 34  M=1,ML
      IF(NUT(M) - NN)  34,35,34
34    CONTINUE
      GO TO 600
35    MTEMP = MTEMP + 1
      MPUP(MTEMP) = M
      READ(15)        HOLN(M), ATW(M), NT(M), NGB(M), NGE(M),
     1                (NPFF(K,M), K=1,4), (TEM(K,M),K=1,3)
      IF(NT(M)) 40, 40, 50
40    NB = NGB(M)
      NE = NGE(M)
      GO TO 60
50    NB = 3*NGB(M) - 2
      NE = 3*NGE(M)
60    DO 100  K=1,4
      NF = NPFF(K,M)
      IF(NF)  100,100,62
62    READ(15)        (SF(K,M,N),N=1,NF)
      READ(15)        ((FF(K,J,N), N=1,NF), J=NB,NE)
      WRITE(NFF)      ((FF(K,J,N), N=1,NF), J=NB,NE)
100   CONTINUE
      READ(15)     ((SR(K,IIG), K=1,9), IIG=1,IGM)
      WRITE(NSR)   ((SR(K,IIG), K=1,9), IIG=1,IGM)
      READ(15)     ((SM(IIG,K), K=1,NXCMR), IIG=1,IGM)
      WRITE(NSM)   ((SM(IIG,K), K=1,NXCMR), IIG=1,IGM)
      NB = NGB(M)
      NE = NGE(M)
      IF(NPRT - 1)  380,380,320
320   CALL RCPRT1(HOLN, SR, SM, NPFF, SF, FF, NT, M, JML, JGM, JGM3,
     1            NGB, NGE, TEM)
380   CALL RCCHK(M, SR, HOLN, U7, SM, NT, NPFF, FF, NGB, NGE, JML,
     1           JGM, JGM3)
600   CALL NTRAN(15,8,1)
      REWIND 15
      IF(NPRT - 1)  610,610,640
610   WRITE(NOUT,620)  (M,HOLN(M), NUT(M), M=1,ML)
620   FORMAT(79H1 CROSS SECTION DATA FOR THE FOLLOWING ISOTOPES WAS GIVE
     1N IN THE RUSSIAN FORMAT//
     251H  ISOTOPE             ISOTOPE                  NUMBER   /
     351H   NUMBER                                      ON TAPE //
     4   (I6, 17X, A6, 14X, I4))
640   RETURN
      END
```

```
-ITC FOR RCPRT1,RCPRT1                                                   1DX 0949
      SUBROUTINE RCPRT1(HOLN, SR, SM, NPFF, SF, FF, NT, M, JML, JGM,     1DX 0950
     1                  JGM3, NGB, NGE, TEM)                             1DX 0951
      DIMENSION  HOLN(1), SR(    9,1), SM(    JGM,1), NPFF(4,1),         1DX 0952
     1           SF(4,JML,1), FF(4,JGM3,1), NT(1), NGB(1), NGE(1),       1DX 0953
     2           TEM(3,1)                                                1DX 0954
      INCLUDE ABC                                                        1DX 0955
C     PRINT DATA IN THE RUSSIAN FORMAT                                   1DX 0956
      WRITE(NOUT,40)  M, HOLN(M)                                         1DX 0957
40    FORMAT(1H1,I4,5X,24H CROSS SECTION DATA FOR ,A6//)                 1DX 0958
      WRITE(NOUT,50)                                                     1DX 0959
50    FORMAT( 93H GROUP   SIGT       SIGF       NU       SIGC     SIGIN  1DX 0960
     1   SIGEL      MUEL       XI       SIGDEL/)                         1DX 0961
      DO 60  IIG=1,IGM                                                   1DX 0962
60    WRITE(NOUT,70)   IIG, (SR(  K,IIG),K=1,9)                          1DX 0963
70    FORMAT(I4, F9.3, 8F10.3)                                           1DX 0964
      WRITE(NOUT,80)  HOLN(M)                                            1DX 0965
80    FORMAT(///33H INELASTIC SCATTERING MATRIX FOR A6,//                1DX 0966
     144H GROUP    GXG      GXG+1      GXG+2       . . ./)               1DX 0967
      DO 100  IIG=1,IGM                                                  1DX 0968
90    FORMAT(I4, F9.3, 10F10.3, ( F13.3,10F10.3))                        1DX 0969
100   WRITE(NOUT,90)  IIG, (SM(  IIG,K), K=1,NXCMR)                      1DX 0970
      DIMENSION  HF(2,4)                                                 1DX 0971
      DATA    ((HF(I,J), I=1,2), J=1,4)/7HFISSION,7HCAPTURE,7H  TOTAL,   1DX 0972
     1        7HELASTIC/                                                 1DX 0973
      DO 300  K=1,4                                                      1DX 0974
      NF = NPFF(K,M)                                                     1DX 0975
      IF(NF)  300, 300, 110                                              1DX 0976
110   IF(NT(M))  120, 120, 220                                           1DX 0977
120   WRITE(NOUT,130)  (HF(KI,K),KI=1,2),    HOLN(M)                     1DX 0978
130   FORMAT(/1H0,A6,A1,28H SELF-SHIELDING FACTORS FOR A6,26H (TEMPERATU1DX 0979
     1RE INDEPENDENT)/)                                                  1DX 0980
150   WRITE(NOUT,160)     (SF(K,M,N), N=1,NF)                            1DX 0981
160   FORMAT(6H SIGO , 1P18E7.1)                                         1DX 0982
      WRITE(NOUT,170)                                                    1DX 0983
170   FORMAT(  6H GROUP/)                                                1DX 0984
      DO 180  J=NB,NE                                                    1DX 0985
180   WRITE(NOUT,190)    J, (FF(K,J,N), N=1,NF)                          1DX 0986
190   FORMAT(I4,  F9.3, 17F7.3)                                          1DX 0987
      GO TO 300                                                          1DX 0988
220   WRITE(NOUT,230)  (HF(KI,K),KI=1,2), HOLN(M), (TEM(KI,M),KI=1,3)    1DX 0989
230   FORMAT(/1H0,A6,A1,28H SELF-SHIELDING FACTORS FOR A6,17H ARE GIVEN  1DX 0990
     1AT T =,F5.0,1H,,F5.0,6H, AND ,F5.0,15H DEGREES KELVIN/)            1DX 0991
      WRITE(NOUT,160)     (SF(K,M,N),N=1,NF),  (SF(K,M,N),N=1,NF),       1DX 0992
     1                    (SF(K,M,N),N=1,NF)                             1DX 0993
      WRITE(NOUT,170)                                                    1DX 0994
      DO 280  IIG=NB,NE                                                  1DX 0995
      J = 3*IIG - 2                                                      1DX 0996
280   WRITE(NOUT,190) IIG, (FF(K,J,N),N=1,NF),  (FF(K,J+1,N), N=1,NF),   1DX 0997
     1                      (FF(K,J+2,N),N=1,NF)                         1DX 0998
300   CONTINUE                                                           1DX 0999
      RETURN                                                             1DX 1000
      END                                                                1DX 1001
```

```
-ITC FOR RCCHK,RCCHK
      SUBROUTINE RCCHK(M, SR, HOLN, U7, SM, NT, NPFF, FF, NGB, NGE,
     1                 JML, JGM, JGM3)
      DIMENSION  SR(     9,1), HOLN(1), U7(1), SM(     JGM,1), NT(1),
     1           NPFF(4,1), FF(4,JGM3,1), NGB(1), NGE(1)
      INCLUDE ABC
C     THIS SUBROUTINE CHECKS THE RUSSIAN DATA FOR CONSISTENCY
      DO 300    IIG = 1,IGM
      TEMP =  (SR(   1,IIG) - (SR(   2,IIG) + SR(   4,IIG) +SR(   5,IIG) +
     1          SR(   6,IIG)))/SR(   1,IIG)
      IF(ABS(TEMP) - .005)   70, 40, 40
40    ME = ME + 1
      WRITE(NOUT,50) ME, HOLN(M), IIG
50    FORMAT(/I4,7H CHECK A6,7H  GROUP I3)
70    IF(IIG - 3)  120, 120, 80
80    IF(IIG - IGM) 90, 120, 120
90    TEMP = (SR(   9,IIG) - (SR(   8,IIG)*SR(   6,IIG)/U7(IIG)))/
     1       SR(   9,IIG)
      IF(ABS(TEMP) - .03)  120, 100, 100
100   ME = ME + 1
      WRITE(NOUT,110)  ME, HOLN(M), IIG
110   FORMAT(/I4,7H CHECK A6,7H  GROUP I3,19H SIGMADEL LOOKS BAD)
120   TEMP = .0
      DO 130  K=1,NXCMR
130   TEMP = TEMP + SM(   IIG,K)
      IF(ABS(TEMP - SR(   5,IIG)) - .005)  300, 140, 140
140   TEMP = TEMP - SR(   5,IIG)
      ME = ME + 1
      WRITE(NOUT,150)  ME, HOLN(M), IIG, TEMP
150   FORMAT(/I4,7H CHECK A6,7H  GROUP I3,5X,26H PRESUMABLY SIGMA(N,2N)
     1= 1PE12.6)
300   CONTINUE
      IF(NT(M))  310, 310, 320
310   ITEMP1 = NGB(M)
      ITEMP2 = NGE(M)
      GO TO 330
320   ITEMP1 = 3*NGB(M) - 2
      ITEMP2 = 3*NGE(M)
330   DO 505  K=1,4
      NF = NPFF(K,M)
      IF(NF)  505,505,340
340   DO 500  N=1,NF
      DO 500  J=ITEMP1,ITEMP2
      IF(N-1)  430, 430, 370
370   IF(FF(K,J,N) - FF(K,J,N-1) - .00001)    430, 410, 410
410   ME = ME + 1
      WRITE(NOUT,420)  ME, HOLN(M)
420   FORMAT(/I4, 7H CHECK ,A6,10H F FACTORS)
430   IF(FF(K,J,N) - 1.00001)    500, 480, 480
480   ME = ME + 1
      WRITE(NOUT,490)    ME, HOLN(M)
490   FORMAT(/I4,14H F FACTORS IN ,A6,23H ARE GREATER THAN UNITY)
500   CONTINUE
505   CONTINUE
      IF(NT(M))  900, 900, 510
510   DO 560  K=1,4
      NF = NPFF(K,M)
      IF(NF)  560,560,515
515   DO 540  N=1,NF
```

```
      DO 540  IIG=NB,NE
      J = 3*IIG - 2
      IF(FF(K,J,N) - FF(K,J+1,N) - .00001)  520, 525, 525
520   IF(FF(K,J+1,N) - FF(K,J+2,N) - .00001)  540, 525, 525
525   ME = ME + 1
      WRITE(NOUT,420) ME, HOLN(M)
540   CONTINUE
560   CONTINUE
900   RETURN
      END
```

```
-ITC FOR RCSTUP,RCSTUP
      SUBROUTINE RCSTUP(NPFF,NT,FF,TEM,ATEM,JGM3,NGB,NGE,J1,SR,SM,JGM,
     1                 MPUP)
      DIMENSION  NPFF(4,1), NT(1), FF(4,JGM3,1), TEM(3,1), ATEM(1),
     1            NGB(1), NGE(1), J1(1), SR(9,1), SM(JGM,1), MPUP(1)
      INCLUDE ABC
C     THIS SUBROUTINE COMPUTES F-FACTORS FOR TEMP. DEPENDENT MATERIALS
C     AND PUTS THE CROSS SECTION DATA ON TAPE IN THE PROPER ORDER
      DO 200    J=1,MM01
      IF(J1(J))  200, 200, 30
30    MM = J1(J)
      DO 85  MK=1,ML
      IF(ICARD)  34,36,36
34    M = MPUP(MK)
      GO TO 38
36    M = MK
38    DO 80  K=1,4
      NF = NPFF(K,M)
      IF(NF)  80, 80, 40
40    IF(NT(M))  50, 50, 60
50    ITEMP1 = NGB(M)
      ITEMP2 = NGE(M)
      GO TO 70
60    ITEMP1 = 3*NGB(M) - 2
      ITEMP2 = 3*NGE(M)
70    READ(NFF)  ((FF(K,JJ,N), N=1,NF), JJ = ITEMP1,ITEMP2)
80    CONTINUE
      READ(NSR)  ((SR(K,IIG), K=1,9), IIG=1,IGM)
      READ(NSM)  ((SM(IIG,K), K=1,NXCMR), IIG=1,IGM)
      IF(M-MM)   85, 90, 85
85    CONTINUE
90    NB = NGB(M)
      NE = NGE(M)
      DO 150  K=1,4
      NF = NPFF(K,M)
      IF(NF)  150, 150, 95
95    IF(NT(M))  120,120,98
98    DO 100  IIG=NB,NE
      JJ = 3*IIG - 2
      DO 100  N=1,NF
      AA = FF(K,JJ,N)
      BB = FF(K,JJ+1,N)
      CC = FF(K,JJ+2,N)
      DD = TEM(3,M)/TEM(1,M)
      EE = ATEM(J)/TEM(2,M)
      Y = (CC-AA)/ALOG(DD)
100   FF(K,IIG,N) = BB + Y*ALOG(EE)
120   WRITE(NSCRAT)  ((FF(K,IIG,N), N=1,NF), IIG=NB,NE)
150   CONTINUE
      WRITE(NSCR1) ((SR(K,IIG), K=1,9), IIG=1,IGM)
      WRITE(NSCR2)  ((SM(IIG,K), K=1,NXCMR), IIG=1,IGM)
      REWIND NFF
      REWIND NSR
      REWIND NSM
200   CONTINUE
      REWIND NSCRAT
      REWIND NSCR1
      REWIND NSCR2
C     SWITCH TAPE DESIGNATIONS
```

```
ITEMP = NFF
ITEMP1 = NSR
ITEMP2 = NSM
NFF = NSCRAT
NSR = NSCR1
NSM = NSCR2
NSCRAT = ITEMP
NSCR1 = ITEMP1
NSCR2 = ITEMP2
RETURN
END
```

```
-ITC    FOR RCCAL1,RCCAL1
        SUBROUTINE RCCAL1(AG,NXS,I1,SR,MF,I2,FSS,SIGO,HETC,MRCF,JMT)
        DIMENSION   AG(MRCF,1), NXS(1), I1(1), SR(9,1), MF(1), I2(1),
       1            FSS(4,JMT,1), SIGO(JMT,1), HETC(1)
        INCLUDE ABC
C       THIS SUBROUTINE CALCULATES SIGO
        ITEMP = 0
        DO 6  L=1,NRCF
        IF(HETC(L))  4,6,4
4       ITEMP = 1
        GO TO 8
6       CONTINUE
8       IF(ITEMP)  9,60,9
9       ITEMP2 = 0
        DO 50  L=1,NRCF
        DO 10  IIG=1,IGM
10      AG(L,IIG) = 0.0
        ITEMP1 = ITEMP2 + 2
        ITEMP2 = ITEMP2 + NXS(L)
        DO 50  J=ITEMP1,ITEMP2
        M = I1(J)
        READ(NSR)  ((SR(K,IIG), K=1,9), IIG=1,IGM)
        IF(MF(J))  50, 50, 20
20      GO TO (30,40), IRED
30      DO 35  IIG=1,IGM
35      AG(L,IIG) = AG(L,IIG) + I2(J)*SR(1,IIG)
        GO TO 50
40      DO 45  IIG=1,IGM
45      AG(L,IIG) = AG(L,IIG) + I2(J)*SR(1,IIG)*FSS(3,M,IIG)
50      CONTINUE
        REWIND NSR
60      DO 70  M=1,MMT
        DO 70  IIG=1,IGM
70      SIGO(M,IIG) = 0.0
        ITEMP2 = 0
        DO 180  L=1,NRCF
        ITEMP1 = ITEMP2 + 2
        ITEMP2 = ITEMP2 + NXS(L)
        DO 180  J=ITEMP1,ITEMP2
        M = I1(J)
        READ(NSR)  ((SR(K,IIG), K=1,9), IIG=1,IGM)
100     DO 180  JJ=ITEMP1,ITEMP2
        MM = I1(JJ)
        IF(M-MM)  105, 180, 105
105     DO 170  IIG=1,IGM
        IF(MF(J))  140,140,110
110     IF(MF(JJ))  120,120,140
120     GO TO (130,135), IRED
130     SIGO(MM,IIG) = SIGO(MM,IIG) + I2(J)*SR(1,IIG)/(I2(JJ)*
       1              (1.+HETC(L)*AG(L,IIG)))
        GO TO 170
135     SIGO(MM,IIG) = SIGO(MM,IIG) + I2(J)*(FSS(2,M,IIG)*SR(4,IIG) +
       1 FSS(1,M,IIG)*SR(2,IIG) + FSS(4,M,IIG)*SR(6,IIG) + SR(5,IIG))/
       2 (I2(JJ)*(1.+HETC(L)*AG(L,IIG)))
        GO TO 170
140     GO TO (150,155), IRED
150     SIGO(MM,IIG) = SIGO(MM,IIG) + I2(J)*SR(1,IIG)/I2(JJ)
        GO TO 170
155     SIGO(MM,IIG) = SIGO(MM,IIG) + I2(J)*(FSS(2,M,IIG)*SR(4,IIG) +
```

```
     1  FSS(1,M,IIG)*SR(2,IIG) + FSS(4,M,IIG)*SR(6,IIG) + SR(5,IIG))/     1DX 1200
     2    I2(JJ)                                                         1DX 1201
 170  CONTINUE                                                           1DX 1202
 180  CONTINUE                                                           1DX 1203
      IRED = 2                                                           1DX 1204
      REWIND NSR                                                         1DX 1205
      RETURN                                                             1DX 1206
      END                                                                1DX 1207
```

```
-ITC  FOR    RCCAL2,RCCAL2
      SUBROUTINE RCCAL2(NXS,I1,J1,NGB,NGE,NPFF,FF,SIGO,SF,FSS,JGM3,JMT,
     1                  JML,HOLN,I2)
      DIMENSION  NXS(1), I1(1), J1(1), NGB(1), NGE(1), NPFF(4,1),
     1           FF(4,JGM3,1), SIGO(JMT,1), SF(4,JML,1), FSS(4,JMT,1),
     2           HOLN(1), I2(1)
      INCLUDE ABC
C     THIS SUBROUTINE CALCULATES F FACTORS
      ITEMP2 = 0
      DO 400  L=1,NRCF
      ITEMP1 = ITEMP2 + 2
      ITEMP2 = ITEMP2 + NXS(L)
      DO 400  J=ITEMP1,ITEMP2
      M = I1(J)
      ITEMP = J1(J)
      NB = NGB(ITEMP)
      NE = NGE(ITEMP)
      DO 300  K=1,4
      DO 10  IIG=1,IGM
10    FSS(K,M,IIG)= 1.0
      NF = NPFF(K,ITEMP)
      IF(NF)  300, 300, 20
20    READ(NFF)  ((FF(K,IIG,N), N=1,NF), IIG=NB,NE)
      IF(I2(J))  25, 300, 25
25    DO 250  IIG=NB,NE
      IF(SIGO(M,IIG) - 9.99E6)  30, 30, 250
30    IF(SIGO(M,IIG) - SF(K,ITEMP,1))  60, 40, 40
40    AA = 1.0
      BB = FF(K,IIG,1)
      CC = 1.0E7
      DD = SF(K,ITEMP,1)
      GO TO 230
60    DO 80  NN=2,NF
      N = NN
      IF(SIGO(M,IIG) - SF(K,ITEMP,N))  80, 80, 100
80    CONTINUE
      FSS(K,M,IIG) = FF(K,IIG,NF)
      GO TO 250
100   AA = FF(K,IIG,N-1)
      BB = FF(K,IIG,N)
      CC = SF(K,ITEMP,N-1)
      IF(N-NF)  160, 120, 120
120   IF(SF(K,ITEMP,NF) - .0001)  130, 130, 160
130   DD = .0001
      GO TO 230
160   DD = SF(K,ITEMP,N)
230   FSS(K,M,IIG) = AA + (BB-AA)*(ALOG(SIGO(M,IIG)/CC)/ALOG(DD/CC))
250   CONTINUE
300   CONTINUE
      IF(NSIGO-5)  400,310,310
310   IF(NPRT - 1)  400,400,320
320   WRITE(NOUT,330)  HOLN(ITEMP), M, (IIG, SIGO(M,IIG),
     1                 (FSS(K,M,IIG), K=1,4), IIG=1,IGM)
330   FORMAT(///23H1SHIELDING FACTORS FOR A6,10H, MATERIALI3,//
     1      84H  GROUP            SIGO             FF              FC
     2     FT               FE       / (I5,    E17.5, F13.5, 3F15.5))
400   CONTINUE
      REWIND NFF
      RETURN
      END
```

```
-ITC FOR   RCCSS,RCCSS
      SUBROUTINE RCCSS(ZN,NXS,I1,SR,SM,C,FSS,U7,PHI,JGM,JTL,JMT,JZM)
      DIMENSION  ZN(1), NXS(1), I1(1), SR(9,1), SM(JGM,1), C(JTL,JGM,1),
     1 FSS(4,JMT,1), U7(1), PHI(JZM,1)
      INCLUDE ABC
C     THIS SUBROUTINE CALCULATES RESONANCE SHIELDED CROSS SECTIONS
      LAP = .0
      LAPP = .0
      LAR = .0
      ALA = .0
      P02 = 0
      CVT = 0
      CNT = 0
      IF(R02)  20,20,5
5     DO 10  IIG=1,IGM
10    READ(NCR1)  ((C(L,IIG,M), L=1,ITL), M=1,MT)
      REWIND NCR1
20    ITEMP2 = 0
      DO 400  L=1,NRCF
      KZ = ZN(L)
      ITEMP1 = ITEMP2 + 2
      ITEMP2 = ITEMP2 + NXS(L)
      DO 400  J=ITEMP1,ITEMP2
      M = I1(J)
      READ(NSR)  ((SR(K,IIG), K=1,9), IIG=1,IGM)
      READ(NSM)  ((SM(IIG,K), K=1,NXCMR), IIG=1,IGM)
      U0 = 0.0
      DO 400  IIG=1,IGM
      TEMP = 0.0
      DO 30 K=1,NXCMR
30    TEMP = TEMP + SM(IIG,K)
      IF(R02)  40, 40, 140
40    C(1,IIG,M) = FSS(1,M,IIG)*SR(2,IIG)
      C(2,IIG,M) = C(1,IIG,M) + FSS(2,M,IIG)*SR(4,IIG) -
     1             (TEMP - SR(5,IIG))
      C(3,IIG,M) = SR(3,IIG)*C(1,IIG,M)
      C(4,IIG,M) = (FSS(3,M,IIG)*SR(1,IIG) - C(2,IIG,M) - TEMP)
     1             *(1. - SR(7,IIG)) + C(2,IIG,M) + TEMP
      C(5,IIG,M) = C(4,IIG,M) - C(2,IIG,M) - TEMP + SM(IIG,1)
     1             - FSS(4,M,IIG)*SR(9,IIG)
      IF(IIG - 1)  50, 50, 60
50    C(6,IIG,M) = .0
      GO TO 80
60    C(6,IIG,M) = FSS(4,M,IIG-1)*SR(9,IIG-1) + SM(IIG-1,2)
80    DO 100  KK=7,ITL
      K = KK-5
      C(KK,IIG,M) = 0.0
      JJG = IIG - K
      IF(JJG)  100, 100, 90
90    C(KK,IIG,M) = SM(JJG,K+1)
100   CONTINUE
      GO TO 400
C     ITERATE ON ELASTIC DOWNSCATTERING CROSS SECTION
140   IF(IIG - IGM)  150, 145, 145
145   SCDP = SCD
      SCD = 0.0
      GO TO 210
150   U0 = U0 + U7(IIG)
      U1 = U0 - .5*U7(IIG)
```

```
      U2 = U0 + .5*U7(IIG+1)
      UX = U0 - .66*SR(8,IIG)
      TEMP1 = PHI(KZ,IIG+1)*U7(IIG)/(PHI(KZ,IIG)*U7(IIG+1))
      TEMP2 = (UX - U1)/(U2 - U1)
      TEMP3 = SR(8,IIG)*FSS(4,M,IIG)*SR(6,IIG)
      TEMP4 = SR(8,IIG+1)*FSS(4,M,IIG+1)*SR(6,IIG+1)
200   SCDP = SCD
      SCD = (TEMP3 + TEMP2*(TEMP4*TEMP1 - TEMP3))/U7(IIG)
      IF(IIG - 1)  205,205,210
205   SCD = SR(9,IIG)*FSS(4,M,IIG)
      GO TO 400
210   C(6,IIG,M) = SCDP + SM(IIG-1,2)
      C(5,IIG,M) = C(4,IIG,M) - C(2,IIG,M) - TEMP + SM(IIG,1) - SCD
400   CONTINUE
      REWIND NSR
      REWIND NSM
      RETURN
      END
```

```
-ITC FOR  RECS,RECS
      SUBROUTINE RECS (C,JTL,JGM,JMT,ATW,HOLN)
      INCLUDE ABC
      DIMENSION C(JTL,JGM,JMT),  ATW(1), HOLN(1)
C     C(ITL,IGM,MT) CROSS SECTION ARRAY--STARTS AT A(LN2)
      DIMENSION AA(10)
C     READ AND CHECK CROSS SECTIONS, PERFORM ADJOINT REVERSALS IF
C     REQUIRED, AND WRITE CROSS SECTION TAPE
      IF(NRCF)  1,1,160
1     WRITE(NOUT,5)  (ID(I), I=1,11)
5     FORMAT(1H1,11A6,///)
      WRITE(NOUT,10)
10    FORMAT(45H THE FOLLOWING NUCLIDES ARE IN THE DTF FORMAT/)
      DO 50  I=1,ML
      READ(NINP, 20)  HOLN(I), ATW(I), (AA(J), J=1,10)
20    FORMAT(A6, E6.2, 10A6)
      IF(ICARD)  25,25,30
25    READ(15)  ((C(L,IIG,I), L=1,ITL), IIG=1,IGM)
      GO TO 50
30    DO 35  IIG=1,IGM
35    READ(NINP,40)    (C(L,IIG,I), L=1,ITL)
40    FORMAT(6E12.5)
50    WRITE(NOUT, 60)  I, HOLN(I), (AA(J), J=2,10)
60    FORMAT(I3, 6X, A6, 6X, 10A6)
C     CHECK ON CROSS SECTION CONSISTENCY AND ORDER
      ITEMP = 0
      DO 140  J=1,ML
      DO 140  I=1,IGM
      G = C(2,I,J) + C(5,I,J)
      DO 110  K = 1, NXCM
      KK = I + K
      M = 5 + K
      IF(KK - IGM)  100, 100, 110
100   G = G + C(M,KK,J)
110   CONTINUE
      IF(ABS((G - C(4,I,J))/C(4,I,J)) - .01)  135, 120, 120
120   ITEMP = 1
130   FORMAT(1H /,16H CHECK MATERIAL I2,5X, 7H GROUP I2)
135   IF(ABS((G - C(4,I,J))/C(4,I,J)) - .0001)  140, 138, 138
138   WRITE(NOUT,130)  J, I
140   CONTINUE
      IF (ITEMP) 160,160,150
150   CALL EXIT
C     A02=0/1=FLUX CALCULATION/ADJOINT CALCULATION
160   IF(A02)  170, 280, 170
170   DO 190  IIG=1,IGM
      IGBAR=IGM-IIG+1
      DO 180  M=1,MT
      DO 180  L = 1,IHS
      TEMP=C(L,IIG,M)
      C(L,IIG,M)=C(L,IGBAR,M)
180   C(L,IGBAR,M)=TEMP
      IF (IGBAR - IIG -1) 200, 200, 190
190   CONTINUE
200   CONTINUE
      KK = ITL - IHS
      IF (KK) 280, 280, 210
210   DO 240  M = 1,MT
      DO 240  IIG = 1,IGM
```

```
      IGBAR = IGM - IIG + 1
      DO 240  L = 1,KK
      IF (L - IIG) 220, 240, 240
220   I = L + IHS
      ITEMP = IGBAR + L
      IF (IIG - ITEMP) 230, 230, 240
230   TEMP = C(I, IIG, M)
      C(I,IIG,M) = C(I,ITEMP,M)
      C(I,ITEMP,M) = TEMP
240   CONTINUE
C     WRITE CROSS SECTION TAPE
280   DO 300  IIG=1,IGM
300   WRITE(NCR1)  ((C(L,IIG,M), L=1,ITL), M=1,MT)
      REWIND NCR1
      RETURN
      END
```

```
-ITC FOR  INIT,INIT
      SUBROUTINE INIT (K6, K7, I0, I1, I2, M0, M2, N0, R0, R1, R3, R4,
     1                 R5, A0, F0, C0, V0, JTL, JIM, V7, JMT, EB, GAM)
      INCLUDE ABC
      DIMENSION  K6(1), K7(1), I0(1), I1(1), I2(1), R0(1), R1(1),
     1                 R3(1), R4(1), R5(1), A0(1), C0(JTL,JMT),
     2           V0(1), M0(1), M2(1), N0(JIM,1), F0(1), V7(1), EB(8,1),
     3           GAM(1)
C     PERFORM ADJOINT REVERSALS ON V7 AND K7
      IF(A02)  10, 40, 10
10    IF(P02)  40, 20, 40
20    IF(R02)  25,25,40
25    IIG = 1
      IGBAR=IGM
30    TEMP=K7(IIG)
      K7(IIG)=K7(IGBAR)
      K7(IGBAR)=TEMP
      TEMP=V7(IIG)
      V7(IIG)=V7(IGBAR)
      V7(IGBAR)=TEMP
      IIG=IIG+1
      IGBAR=IGBAR-1
      IF(IIG-IGBAR)  30, 40, 40
C
C     MIX CROSS SECTIONS
40    B07=1
      IF(P02)  50, 60, 50
50    GO TO (430,430,120,430,320),  I04
60    IF(M01)  90, 90, 70
70    IF(R02)  75,75,90
75    WRITE(NOUT, 80 )  (J, I0(J), I1(J), I2(J), J = 1, M01)
80    FORMAT(28H1MIXTURE SPECIFICATIONS      //
     1           3X, 16H MIXTURE NUMBER ,18H   MIX COMMAND         ,
     124H       MATERIAL DENSITY  //(I4,1X,I8,8X,I8,8X,E20.8))
90    IF(NPRT)  120, 120, 100
100   IF(NRED)  105,105,120
105   KPAGE = 100
      WRITE(NOUT,110)
110   FORMAT(24H1SHIELDED CROSS SECTIONS)
120   REWIND NCR1
      DO 310  IIG=1,IGM
      READ (NCR1)     ((C0(I,J),I=1,ITL),J=1,MT)
      IF(M01) 130, 240, 130
130   DO 230  M=1,M01
      IF(I0(M)-MT) 150, 150, 140
140   CALL ERRO2(6H  INIT,140,1)
150   IF(I1(M)-MT) 160, 160, 140
160   N=I0(M)
      L=I1(M)
      E01=I2(M)
      IF(L) 200, 200, 170
170   IF(E01) 200, 180, 200
180   IF (N-L) 200, 190, 200
190   E01 = EV
      L = 0
200   DO 230  I=1,ITL
      IF (L) 210, 220, 210
210   C0(I,N)=C0(I,N)+C0(I,L)*E01
      GO TO 230
```

```
220   CO(I,N)=CO(I,N)*E01
230   CONTINUE
240   IF(PO2) 300, 250, 300
250   IF(NPRT)  300, 300, 260
260   IF(NRED)  265,265,300
265   WRITE (NOUT, 270)  IIG
270   FORMAT(6H0GROUP,I3,  84H   SIGF        SIGA       NUSIGF       SIGTR
     1     GXG        G-1XG       G-2XG        . . .)
      DO 280  N=1,MT
280   WRITE (NOUT, 290)            N,(CO(I,N),I=1,ITL)
290   FORMAT(4H MAT,I3,10E11.5/(7X,10E11.5))
300   WRITE (NSCRAT)   ((CO(I,J),I=1,ITL),J=1,MT)
310   CONTINUE
      REWIND NCR1
      REWIND NSCRAT
C     SWITCH TAPE DESIGNATIONS
      ITEMP=NSCRAT
      NSCRAT=NCR1
      NCR1=ITEMP
320   IF(I04-5)  330, 350, 330
330   IF(BUCK)  340, 430, 340
340   TEMP = BUCK
      GO TO 380
350   IF(PO2)  360, 360, 370
360   BUCK = 0.
370   TEMP = EV - BUCK
      BUCK = EV
380   DO 420   IIG=1,IGM
      READ(NCR1)  ((CO(I,J), I=1,ITL),J=1,MT)
      DO 410  MTZ = 1,MT
      DO 400   KZ=1,IZM
      IF(M2(KZ) - MTZ)  400, 390, 400
390   TEMP1 = (TEMP*GAM(KZ))/(3.*CO(4,MTZ))
      CO(2,MTZ) = CO(2,MTZ) + TEMP1
      CO(5,MTZ) = CO(5,MTZ) - TEMP1
      GO TO 410
400   CONTINUE
410   CONTINUE
      WRITE(NSCRAT)  ((CO(I,J), I=1,ITL),J=1,MT)
420   CONTINUE
      REWIND NCR1
      REWIND NSCRAT
C     SWITCH TAPE DESIGNATIONS
      ITEMP = NSCRAT
      NSCRAT = NCR1
      NCR1 = ITEMP
C
C     MODIFY GEOMETRY
430   IF(PO2) 460, 440, 460
440   IF(RO2)  445, 445, 620
445   DO 450  I=1,IP
450   R1(I)=RO(I)
460   IF(I04-4)  490, 470, 490
470   DO 480 I=1,IM
      K=MO(I)
480   R1(I+1)=R1(I)+(RO(I+1)-RO(I))*(1.0+ EV*R3(K))
C
C     CALCULATE AREAS AND VOLUMES
490   PI2=6.28318
```

```
      IF(P02) 500, 510, 500
500   IF(I04 - 4)  620, 510, 620
510   DO 570 I=1,IM
      R4(I)=(R1(I+1)+R1(I))*0.5
      R5(I)=R1(I+1)-R1(I)
      IF( R5(I) ) 520, 520, 530
520   CALL ERRO2 (6H  INIT,520,1)
530   GO TO (540,550,560),IGEP
540   A0(I)=1.0
      A0(IP)=1.0
      V0(I) = R5(I)
      GO TO 570
550   A0(I)=PI2*R1(I)
      A0(IP)=PI2*R1(IP)
      V0(I) = PI2*R5(I)*R4(I)
      GO TO 570
560   A0(I) = 2.*PI2*R1(I)*R1(I)
      A0(IP) = 2.*PI2*R1(IP)*R1(IP)
      V0(I) = (2.0*PI2*(R1(I+1)**3 - R1(I)**3))/3.0
570   CONTINUE
C
C     CALCULATE EFFECTIVE FISSION SPECTRUM
620   IF(P02) 680, 640, 680
640   SK7=0.
      DO 670 IIG=1,IGM
      IF(S02-1) 660, 650, 660
650   K6(IIG)=K7(IIG)/S03
      GO TO 670
660   K6(IIG)=K7(IIG)
670   SK7=SK7+K7(IIG)
680   CONTINUE
C
C     CALCULATE FISSION RATE
      T11 = EB(1,IGP)
690   CALL CLEAR(0.0,F0,IM)
      DO 720 IIG=1,IGM
      EB(8,IIG) = .0
      READ (NCR1)     ((C0(I,J),I=1,ITL),J=1,MT)
      DO 720  I = 1, IM
      ITEMP=M0(I)
      ITEMP=M2(ITEMP)
      EB(8,IIG) = EB(8,IIG) + V0(I)*NU(I,IIG)*C0(1,ITEMP)
      IF(A02) 700, 710, 700
700   F0(I)=F0(I)+K7(IIG)*NU(I,IIG)
      GO TO 720
710   F0(I)=F0(I)+C0(IHT-1,ITEMP)*NU(I,IIG)
720   CONTINUE
      REWIND NCR1
      RETURN
      END
```

```
-ITC FOR  FISCAL,FISCAL
      SUBROUTINE FISCAL  (NO, FO, VO, CO, K6, MO, M2, JTL,JMT,JIM, EB)
      INCLUDE ABC
      DIMENSION FO(1), VO(1), CO(JTL,JMT),K6(1), MO(1), M2(1), NO(JIM,1)
     1         , EB(8,1)
      LAR = ALA
C     FISSION SUMS
      IF(B07)  90,90,10
10    IF(A02) 20, 40, 20
20    DO 30  IIG=1,IGM
      READ (NCR1)     ((CO(I,J),I=1,ITL),J=1,MT)
      EB(1,IIG) = .0
      DO 30  I=1,IM
      ITEMP=MO(I)
      ITEMP=M2(ITEMP)
30    EB(1,IIG) = EB(1,IIG) + CO(IHT-1,ITEMP)*FO(I)*VO(I)
      REWIND NCR1
      GO TO 70
40    E01=0.
      DO 50  I=1,IM
50    E01=E01+VO(I)*FO(I)
      DO 60  IIG=1,IGM
60    EB(1,IIG) = K6(IIG)*E01
70    EB(1,IGP) = .0
      EB(8,IGP) = .0
      DO 80  IIG=1,IGM
      EB(8,IGP) = EB(8,IGP) + EB(8,IIG)
80    EB(1,IGP) = EB(1,IGP) + EB(1,IIG)
C     CALCULATE LAMBDA
      IF(B07) 140, 90, 140
90    ALA = EB(1,IGP)/T11
      TEMP=1.0/ALA
      IF(I04-1) 140, 100, 140
100   DO 110  IIG=1,IGM
      EB(1,IIG) = EB(1,IIG)*TEMP
110   K6(IIG)=K6(IIG)*TEMP
      EB(1,IGP) = EB(1,IGP)*TEMP
      IF(A02) 120, 140, 120
120   DO 130  I=1,IM
130   FO(I)=FO(I)*TEMP
C
C     NORMALIZATION
140   B07=0
150   IF(S01)  160, 220, 170
160   E01 = ABS(S01)/(EB(8,IGP)*TSD)
      GO TO 180
170   E01 = S01/EB(1,IGP)
180   DO 190 IIG=1,IGP
190   EB(1,IIG) = E01*EB(1,IIG)
      DO 200 I=1,IM
200   FO(I)=E01*FO(I)
220   RETURN
      END
```

```
-ITC FOR  MONPR,MONPR
      SUBROUTINE MONPR
      INCLUDE ABC
C     MONITOR PRINT
      CALL ETIMEF(TI)
      TI = TI/60.
      KPAGE = KPAGE + 1
      IF(KPAGE - 40)  40, 10, 10
10    KPAGE = 0
      WRITE(NOUT,20 )  (ID(I), I=1,11)
20    FORMAT(1H1,11A6//)
      WRITE(NOUT, 30 )
30    FORMAT(5X,117H          TIME                  SIGE              OUTER
     1             EIGENVALUE          EIGENVALUE          LAMBDA     /
     2       5X, 73H     (MINUTES)            ITERATIONS             ITERATI
     3ONS             SLOPE /)
40    WRITE(NOUT,50)  TI, R02, NP02, EQ, EV, ALA
50    FORMAT(F17.2, I18, I20, E26.8, 2E20.8)
60    P02=P02+1
      NP02 = NP02 + 1
      IF(NP02-100) 80, 80, 70
70    NGOTO = 1
      NRED = 0
      GO TO 90
80    NGOTO = 4
90    RETURN
      END
```

```
-ITC FOR  OUTER,OUTER
      SUBROUTINE OUTER( A0, C0, F0, K6, M0, M2, N0, N2, S2, V0, V7, F2,
     1                  JTL,JMT,CXS,JIM, R5, R4, HA, PA, EB,JIP,JIGM)
      DIMENSION A0(1), F0(1), K6(1), M0(1), M2(1), N0(JIM,1), N2(JIM,1),
     1          S2(1), V0(1), V7(1), F2(1), C0(JTL,JMT), HA(1), PA(1),
     2          CXS(JIP,JIGM,1),R5(1), R4(1), EB(8,1)
      INTEGER        GBAR, PBAR, SBAR
      INCLUDE ABC
      IGV=1
C     SOURCE CALCULATION
20    READ(NCR1)      ((C0(I,M),I=1,ITL),M=1,MT)
      DO 30  I=1,IM
30    S2(I)=0.
40    IF(A02) 70, 50, 70
50    DO 60  I=1,IM
60    S2(I)=S2(I)+K6(IGV)*F0(I)
      GO TO 90
70    DO 80   I=1,IM
      ITEMP1=M0(I)
      ITEMP1=M2(ITEMP1)
80    S2(I)=S2(I)+C0(IHT-1,ITEMP1)*F0(I)
90    GBAR=IGV+IHS-ITL
      IF(GBAR-1) 100, 110, 110
100   GBAR=1
110   PBAR = IHS + IGV - 1
      IF(PBAR - ITL)  115, 115, 112
112   PBAR = ITL
115   IF(GBAR - IGV)  120, 140, 140
120   DO 130  I=1,IM
      ITEMP1=M0(I)
      ITEMP1=M2(ITEMP1)
      ITEMP=ITEMP1
      TEMP=C0(PBAR,ITEMP)
130   S2(I)=S2(I)+N2(I,GBAR)*TEMP
140   GBAR=GBAR+1
      PBAR=PBAR-1
      IF(GBAR - IGV)  120, 140, 150
150   IF(IGV - IGM)  170, 160, 170
160   REWIND NCR1
170   V11 = 0.
      DO 180  I=1,IM
      S2(I)=S2(I)*V0(I)
180   V11=V11+S2(I)
      EB(2,IGV) = V11 - EB(1,IGV)
C     SOURCE ALPHA
190   IF(I04 - 2)  200, 230, 200
200   IF(S02 - 2)  220, 210, 220
210   T7 = S03/V7(IGV)
      GO TO 240
220   T7 = 0.0
      GO TO 260
230   T7 = EV/V7(IGV)
240   DO 250  K = 1, IZM
      ITEMP1 = M2(K)
250   C0(IHS, ITEMP1) = C0(IHS,ITEMP1) - T7
260   CONTINUE
C     GROUP FLUX CALCULATION
270   IF(V11) 280, 300, 280
280   IF(P02 - 1)  284, 284, 282
```

```
282   IF(I04-1)  284, 286, 284
284   CALL INNER1(M0,M2,CXS,V0,C0,A0,R5,R4,JIM,JTL,JIP,JIGM)
286   CALL INNER(N0,N2,CXS,S2,HA,PA,JIP,JIGM,JTL,JIM,EB,C0,V0,M0,M2)
      DO 290  K = 1,IZM
      ITEMP1 = M2(K)
290   C0(IHS,ITEMP1) = C0(IHS,ITEMP1) + T7
      GO TO 320
300   DO 310 I=1,IM
      N2(I,IGV) = .0
310   N0(I,IGV) = .0
C     CALCULATE FISSION RATE AND FISSION SOURCE RATE
320   IF(V11) 330, 380, 330
330   IF(A02) 340, 360, 340
340   EB(8,IGV) = .0
      DO 350  I=1,IM
      ITEMP1=M0(I)
      ITEMP1=M2(ITEMP1)
      EB(8,IGV) = EB(8,IGV) + C0(1,ITEMP1)*N2(I,IGV)*V0(I)
350   F2(I)=F2(I)+K6(IGV)*N2(I,IGV)
      GO TO 380
360   EB(8,IGV) = .0
      DO 370  I=1,IM
      ITEMP1=M0(I)
      ITEMP1=M2(ITEMP1)
      EB(8,IGV) = EB(8,IGV) + C0(1,ITEMP1)*N2(I,IGV)*V0(I)
370   F2(I)=F2(I)+C0(IHT-1,ITEMP1)*N2(I,IGV)
380   IGV=IGV+1
      IF(IGV-IGM) 20, 20, 390
390   T11 = EB(1,IGP)
      REWIND NCR1
C
C     OVER-RELAX FISSION SOURCE
      E01 = .0
      E02 = .0
      EB(1,IGP) = .0
      IF(A02) 520, 580, 520
C     FOR ADJOINT CALCULATION, S2(I) WILL STORE ORFED F2(I)
520   DO 522  I=1,IM
522   S2(I) = F0(I) + ORF*(F2(I) - F0(I))
      DO 540  IIG=1,IGM
      READ(NCR1)  ((C0(I,J),I=1,ITL), J=1,MT)
      EB(1,IIG) = .0
      DO 530  I=1,IM
      ITEMP = M0(I)
      ITEMP = M2(ITEMP)
      EB(1,IIG) = EB(1,IIG) + C0(IHT-1,ITEMP)*F2(I)*V0(I)
530   E02 = E02 + C0(IHT-1,ITEMP)*S2(I)*V0(I)
540   EB(1,IGP) = EB(1,IGP) + EB(1,IIG)
      TEMP1 = EB(1,IGP)/E02
      DO 550  I=1,IM
550   F0(I) = TEMP1*S2(I)
      REWIND NCR1
      GO TO 620
580   DO 590  I=1,IM
      E01 = E01 + V0(I)*F2(I)
      F2(I) = F0(I) + ORF*(F2(I) - F0(I))
590   E02 = E02 + V0(I)*F2(I)
      TEMP1 = E01/E02
      DO 600  I=1,IM
```

```
600   FO(I) = TEMP1*F2(I)                                    1DX 1786
      DO 610  IIG=1,IGM                                      1DX 1787
610   EB(1,IIG) = K6(IIG)*E01                                1DX 1788
620   EB(1,IGP) = .0                                         1DX 1789
      EB(8,IGP) = .0                                         1DX 1790
      DO 640  IIG=1,IGM                                      1DX 1791
      EB(8,IGP) = EB(8,IGP) + EB(8,IIG)                      1DX 1792
640   EB(1,IGP) = EB(1,IGP) + EB(1,IIG)                      1DX 1793
      RETURN                                                 1DX 1794
      END                                                    1DX 1795
```

```
-ITC FOR INNER1,INNER1
      SUBROUTINE INNER1(MO,M2,CXS,VO,CO,AO,R5,R4,JIM,JTL,JIP,JIGM)
      DIMENSION  MO(1), M2(1), CXS(JIP,JIGM,2), VO(1), CO(JTL,1),
     1          AO(1), R5(1), R4(1)
      INCLUDE ABC
C     THIS SUBROUTINE CALCULATES COEFFICIENTS FOR THE FLUX EQUATION
      DO 30  I=1,IM
      ITEMP = MO(I)
      ITEMP = M2(ITEMP)
      ITEMP1 = MO(I-1)
      ITEMP1 = M2(ITEMP1)
      CXS(I,IGV,2) = VO(I)*(CO(IHT,ITEMP) - CO(IHS,ITEMP))
      IF(ITEMP - ITEMP1)  20,10,20
10    CXS(I,IGV,1) = AO(I)/(3.*CO(IHT,ITEMP)*(R4(I) - R4(I-1)))
      GO TO 30
20    CXS(I,IGV,1) = AO(I)*(R5(I-1) + R5(I))/((R4(I) - R4(I-1))*
     1  (3.*(R5(I-1)*CO(IHT,ITEMP1) + R5(I)*CO(IHT,ITEMP))))
30    CONTINUE
      DO 200  I=1,IM
      ITEMP = MO(I)
      ITEMP = M2(ITEMP)
      IF(I-1)  40, 40, 80
40    IF(BO1 - 1)  50, 60, 70
50    CXS(I,IGV,1) = AO(I)/(3.*CO(IHT,ITEMP)*(.5*R5(I) + .71/
     1  CO(IHT,ITEMP)))
      GO TO 200
60    CXS(I,IGV,1) = .0
      GO TO 200
70    ITEMP3 = MO(IM)
      ITEMP3 = M2(ITEMP3)
      CXS(I,IGV,1) = 2.*AO(I)/(3.*(R5(IM)*CO(IHT,ITEMP3) +
     1   R5(I)*CO(IHT,ITEMP)))
      GO TO 200
80    IF(I - IM)  200, 90, 90
90    IF(BO2 - 1)  100, 110, 120
100   CXS(I+1,IGV,1) = AO(I+1)/(3.*CO(IHT,ITEMP)*(.5*R5(I) +
     1  .71/CO(IHT,ITEMP)))
      GO TO 200
110   CXS(I+1,IGV,1) = .0
      GO TO 200
120   CXS(I+1,IGV,1) = CXS(1,IGV,1)
200   CXS(I,IGV,2) = CXS(I,IGV,2) + CXS(I,IGV,1) + CXS(I+1,IGV,1)
      RETURN
      END
```

```
-ITC FOR INNER,INNER
      SUBROUTINE INNER(NO,N2,CXS,S2,HA,PA,JIP,JIGM,JTL,JIM,EB,CO,
     1                 VO,MO,M2)
      INCLUDE ABC
      DIMENSION  NO(JIM,1), N2(JIM,1), CXS(JIP,JIGM,1), S2(1), HA(1),
     1           PA(1), EB(8,1), CO(JTL,1), VO(1), MO(1), M2(1)
      IF(PO2 - 1)  12, 12, 5
5     DO 10  I=1,IM
10    NO(I,IGV) = N2(I,IGV)
12    I=1
C     FLUX CALCULATION FOR VACUUM AND REFLECTIVE BOUNDARY CONDITIONS
      IF(BO1-1)  15,15,40
15    HA(I) = CXS(I+1,IGV,1)/CXS(I,IGV,2)
      PA(I) = S2(I)/CXS(I,IGV,2)
      DO 20  I=2,IM
      HA(I) = CXS(I+1,IGV,1)/(CXS(I,IGV,2) - CXS(I,IGV,1)*HA(I-1))
20    PA(I) = (S2(I) + CXS(I,IGV,1)*PA(I-1))/(CXS(I,IGV,2) -
     1        CXS(I,IGV,1)*HA(I-1))
      N2(IM,IGV) = PA(IM)
      DO 30  KI=2,IM
      I = IM + 1 - KI
30    N2(I,IGV) = PA(I) + HA(I)*N2(I+1,IGV)
      GO TO 110
C     FLUX CALCULATION FOR PERIODIC BOUNDARY CONDITIONS
40    HA(I) = CXS(I+1,IGV,1)/CXS(I,IGV,2)
      N2(I,IGV) = CXS(1,IGV,1)/CXS(I,IGV,2)
      PA(I) = S2(I)/CXS(I,IGV,2)
      TEMP1 = N2(I,IGV)
      TEMP = HA(I)
      TEMP2 = PA(I)
      IKB = IM - 1
      DO 50  I=2,IKB
      HA(I) = CXS(I+1,IGV,1)/(CXS(I,IGV,2) - CXS(I,IGV,1)*HA(I-1))
      N2(I,IGV) = CXS(I,IGV,1)*N2(I-1,IGV)/(CXS(I,IGV,2) -
     1            CXS(I,IGV,1)*HA(I-1))
      PA(I) = (S2(I) + CXS(I,IGV,1)*PA(I-1))/(CXS(I,IGV,2) -
     1        CXS(I,IGV,1)*HA(I-1))
      TEMP1 = TEMP1 + TEMP*N2(I,IGV)
      TEMP2 = TEMP2 + TEMP*PA(I)
50    TEMP = TEMP*HA(I)
      I = IM
      TEMP1 = (TEMP1 + TEMP)*CXS(1,IGV,1) + CXS(I,IGV,1)*N2(I-1,IGV)
      N2(I,IGV) = (S2(I) + CXS(I,IGV,1)*PA(I-1) + CXS(1,IGV,1)*TEMP2)/
     1           (CXS(I,IGV,2) - CXS(I,IGV,1)*HA(I-1) - TEMP1)
      DO 60  KI=2,IM
      I = IM + 1 - KI
60    N2(I,IGV) = HA(I)*N2(I+1,IGV) + N2(I,IGV)*N2(IM,IGV) + PA(I)
110   RETURN
      END
```

```
-ITC FOR  CNNP,CNNP
      SUBROUTINE CNNP (F2,K6,EB)
      DIMENSION F2(1), K6(1), EB(8,1)
      INCLUDE ABC
C     CONVERGENCE TESTS
      IF(MAXT)  25, 25, 10
10    CALL ETIMEF(TEMP)
      IF(TEMP - GLH)  25, 15, 15
15    NGOTO = 1
      NRED = 0
      WRITE(NOUT,20)
20    FORMAT(53H1 * *  RUNNING TIME EXCEEDED--FORCED CONVERGENCE  * *//)
      GO TO 135
25    E01=1.0-ALA
      E02=ABS(E01)
50    IF(EB(1,IGP))  55,130,55
55    IF (E02 - EPS)  60, 60, 70
60    CVT=1
70    CALL CLEAR (0.0, F2, IM)
      GO TO 105
80    EV=EV+POD*EQ*E01
      GO TO 170
C     FINAL PRINT
90    NGOTO=1
      IF (I04 - 1)   95,  95,  80
95    EV=0.0
      DO 100   I=1,IGM
100   EV=EV+K6(I)
      EV=SK7/EV
      GO TO 135
105   IF(CVT-1) 110, 90, 110
110   IF(I04-1) 115, 120, 140
C     MONITOR PRINT
115   NGOTO=2
      GO TO 135
120   EV=0.
      DO 125 I=1,IGM
125   EV=EV+K6(I)
      EV=SK7/EV
      GO TO 115
130   CALL ERRO2(6H  CNNP,130,1)
135   RETURN
140   CONTINUE
C
C     CALCULATE NEW PARAMETERS FOR SEARCH CALCULATIONS
145   E03=ABS (ALA-LAR)
      IF (LAPP)  270, 150, 270
150   IF (LAP)  230, 155, 230
155   IF (EQ) 200, 160, 200
160   IF (E03-EPSA) 175, 175, 165
C     MONITOR PRINT.
165   NGOTO=2
      RETURN
C     FINAL PRINT EXIT.
170   NGOTO=1
      RETURN
175   LAP=ALA
      EVP=EV
      IF (E01) 185,185,180
```

```
180   EV=EV-EVM
      GO TO 190
185   EV=EV+EVM
190   IF (I04-2)   195,  165,  195
C     MIX X-SECS.
195   NGOTO=3
      RETURN
200   IF (CVT) 170, 205,170
205   EV=EV+POD*EQ*E01
210   IF ((LAPP-1.0)/(LAP-1.0))  215, 190, 190
215   TEMP1=AMIN1(EVP,EVPP)
      IF (EV-TEMP1)  220, 225, 225
220   EV=(EVPP+EVP)/2.
      GO TO 190
225   TEMP1=AMAX1(EVP,EVPP)
      IF (EV-TEMP1)  190, 220, 220
230   IF (E03-EPSA)  235, 235, 165
235   EQ=(EVP-EV)/(LAP-ALA)
240   IF (CNT)  260, 245, 260
245   IF (E02-LAL)  265, 265, 250
250   IF (E02-LAH)  260, 260, 255
255   E01=SIGN (LAH,E01)
260   LAPP=LAP
      LAP=ALA
      EVPP=EVP
      EVP=EV
      GO TO 205
265   CNT=1
      LAP=0.0
      LAPP=0.0
      GO TO 205
270   IF (E03-EPSA) 275, 275, 165
C     CALCULATE QUADRATIC COEFFICIENTS.
275   TEMP1=EVP-EV
      TEMP2=EVPP-EV
      TEMP3=EVPP-EVP
      TEMP4=TEMP1*(EVP+EV)
      TEMP5=-TEMP2*(EV+EVPP)
      TEMP6=TEMP3*(EVPP+EVP)
      DENOM=TEMP3*TEMP2*TEMP1
      EQA=((LAPP-1.0)*TEMP1*EVP*EV-(LAP-1.0)*TEMP2
     1*EV*EVPP+(ALA-1.0)*TEMP3*EVPP*EVP)/DENOM
      EQB=-(LAPP*TEMP4+LAP*TEMP5+ALA*TEMP6)/DENOM
      EQC=(LAPP*TEMP1-LAP*TEMP2+ALA*TEMP3)/DENOM
      DISCR=EQB*EQB-4.0*EQA*EQC
      IF (DISCR)  235, 280, 280
280   IF (E02-LAL)  265, 265, 285
285   TEMP1=EQC+EQC
      TEMP=SQRT (DISCR)
      EQ=1.0/(EQB+EV*TEMP1)
      LAPP=LAP
      LAP=ALA
      EVPP=EVP
      EVP=EV
      EV1=(TEMP-EQB)/TEMP1
      EV2=-(TEMP+EQB)/TEMP1
      EVA=ABS (EV-EV1)
      EVB=ABS (EV-EV2)
      IF (EVA-EVB)  290, 290, 295
```

```
290    EV=EV1                                   1DX 2007
       GO TO 210                                1DX 2008
295    EV=EV2                                   1DX 2009
       GO TO 210                                1DX 2010
       END                                      1DX 2011
```

```
-ITC FOR FINPR,FINPR
      SUBROUTINE FINPR(F2,PA,CO,MO,M2,N2,R1,R4,AO,VO,FO,JTL,JIM,EB,CXS,
     1                   JIP,JIGM,PHI,JZM,C2,JGM,GAM)
      DIMENSION  F2(1), PA(1), CO(JTL,1), MO(1), M2(1), N2(JIM,1),
     1           R1(1), R4(1), AO(1), VO(1), FO(1), EB(8,1)
     2         , CXS(JIP,JIGM,1), PHI(JZM,1), C2(JZM,1), GAM(1)
      INCLUDE ABC
C     FINAL PRINT
      CALL MONPR
C     COMPUTE ZONE FLUXES
      DO 10  IIG=1,IGM
      DO 5  KZ=1,IZM
5     PHI(KZ,IIG) = 0.0
      DO 10  I=1,IM
      KZ = MO(I)
10    PHI(KZ,IIG) = PHI(KZ,IIG) + N2(I,IIG)*VO(I)
      IF(NRED)  20,20,999
C     BALANCE TABLES
20    CALL NBAL(N2,CO,VO,CXS,MO,M2,EB,JTL,JIM,JIP,JIGM)
      DO 21  I=1,IM
      F2(I) = .0
21    PA(I) = .0
      TEMP = 0.0
      IF(I04 - 5)  23,25,23
23    IF(BUCK)  24,26,24
24    TEMP = BUCK
      GO TO 26
25    TEMP = EV
26    DO 38  IIG=1,IGM
      READ(NCR1)  ((CO(II,J), II=1,ITL), J=1,MT)
      IF(NCRUN)  37,37,27
27    IF(TEMP)  29,355,29
29    DO 35  MTZ =1,MT
      DO 34  KZ=1,IZM
      IF(M2(KZ) - MTZ)  34,30,34
30    TEMP1 = (TEMP*GAM(KZ))/(3.*CO(4,MTZ))
      CO(2,MTZ) = CO(2,MTZ) - TEMP1
      CO(5,MTZ) = CO(5,MTZ) + TEMP1
      GO TO 35
34    CONTINUE
35    CONTINUE
      WRITE(NSCRAT)  ((CO(I,J), I=1,ITL), J=1,MT)
355   DO 36  KZ=1,IZM
      ITEMP = M2(KZ)
36    C2(KZ,IIG) = CO(4,ITEMP)
37    DO 38  I=1,IM
      ITEMP = MO(I)
      ITEMP = M2(ITEMP)
C     POWER
      F2(I) = F2(I) + CO(1,ITEMP)*N2(I,IIG)*1000.*TSD
C     TOTAL FLUX
38    PA(I) = PA(I) + N2(I,IIG)
      IF(NCRUN)  42, 42, 39
39    IF(TEMP)  40, 42, 40
40    REWIND NCR1
      REWIND NSCRAT
      ITEMP1 = NSCRAT
      NSCRAT = NCR1
      NCR1 = ITEMP1
```

```
42    WRITE(NOUT,45)                                                      1DX 2071
45    FORMAT(132H1          ZONE          RADIUS          AVG RADIUS      AR1DX 2072
     1EA           VOLUME          TOTAL FLUX          POWER          FISSI1DX 2073
     2ON SOURCE  /                                                        1DX 2074
     3       132H                      (CM)               (CM)         (CM1DX 2075
     42)           (CM3)          (N/CM2-SEC)       (MWT/LITER)           1DX 2076
     5              /)                                                    1DX 2077
      DO 50  I=1,IM                                                       1DX 2078
      ITEMP = MO(I)                                                       1DX 2079
50    WRITE(NOUT,60)  I,ITEMP,R1(I),R4(I), AO(I),VO(I),PA(I),F2(I),FO(I)1DX 2080
60    FORMAT(I4,I6,1PE16.5,1P6E17.5)                                      1DX 2081
      WRITE(NOUT,70)  IP, R1(IP), AO(IP)                                  1DX 2082
70    FORMAT(I4,10X,1PE12.5,20X,1PE14.5)                                  1DX 2083
      IF(NPRT-1) 160, 75, 75                                              1DX 2084
75    WRITE(NOUT,80)                                                      1DX 2085
80    FORMAT(30H1FLUX BY GROUP AND SPACE POINT//)                         1DX 2086
      DATA  GROUP/6H GROUP/                                               1DX 2087
      DO 150  IIG=1,IGM,6                                                 1DX 2088
      LL = IIG + 5                                                        1DX 2089
      IF(LL - IGM)  100,100,90                                            1DX 2090
90    LL = IGM                                                            1DX 2091
100   WRITE(NOUT,110)  ((GROUP,K), K=IIG,LL)                              1DX 2092
110   FORMAT(26H0        ZONE        AVG RAD ,    6(7X,A6,I4))            1DX 2093
      WRITE(NOUT,125)                                                     1DX 2094
125   FORMAT(1H )                                                         1DX 2095
      DO 130  I=1,IM                                                      1DX 2096
      ITEMP = MO(I)                                                       1DX 2097
130   WRITE(NOUT,60)  I, ITEMP, R4(I), (N2(I,K), K=IIG,LL)                1DX 2098
      IF(LL - IGM)  150,160,160                                           1DX 2099
150   CONTINUE                                                            1DX 2100
160   IF(NPUN)  200,200,170                                               1DX 2101
170   PUNCH 180,  ((N2(I,IIG), I=1,IM), IIG=1,IGM)                        1DX 2102
180   FORMAT(6(3X,E9.4))                                                  1DX 2103
200   REWIND NCR1                                                         1DX 2104
999   RETURN                                                              1DX 2105
      END                                                                 1DX 2106
```

```
-ITC FOR NBAL,NBAL                                                      1DX 2107
      SUBROUTINE NBAL(N2,CO,VO,CXS,MO,M2,EB,JTL,JIM,JIP,JIGM)           1DX 2108
      DIMENSION  N2(JIM,1), CO(JTL,1), VO(1), CXS(JIP,JIGM,1),          1DX 2109
     1           MO(1), M2(1), EB(8,1)                                  1DX 2110
      INCLUDE ABC                                                       1DX 2111
C     COMPUTE AND PRINT BALANCE TABLES                                  1DX 2112
      DO 80  IGV = 1,IGM                                                1DX 2113
      READ(NCR1)  ((CO(I,J), I=1,ITL), J=1,MT)                          1DX 2114
      DO 10  K=3,7                                                      1DX 2115
10    EB(K,IGV) = 0.0                                                   1DX 2116
      DO 20  I=1,IM                                                     1DX 2117
      TEMP = VO(I)*N2(I,IGV)                                            1DX 2118
      ITEMP = MO(I)                                                     1DX 2119
      ITEMP = M2(ITEMP)                                                 1DX 2120
C     OUT-SCATTER                                                       1DX 2121
      EB(3,IGV) = EB(3,IGV) + (CO(4,ITEMP) - CO(5,ITEMP) - CO(2,ITEMP)) 1DX 2122
     1            *TEMP                                                 1DX 2123
C     ABSORPTION                                                        1DX 2124
20    EB(4,IGV) = EB(4,IGV) + CO(2,ITEMP)*TEMP                          1DX 2125
C     LEFT LEAKAGE                                                      1DX 2126
      IF(BO1 - 1)  30, 50, 40                                           1DX 2127
30    EB(5,IGV) = CXS(1,IGV,1)*N2(1,IGV)                                1DX 2128
      GO TO 50                                                          1DX 2129
40    EB(5,IGV) = CXS(1,IGV,1)*(N2(1,IGV) - N2(IM,IGV))                 1DX 2130
50    IF(BO2 - 1)  60, 80, 70                                           1DX 2131
60    EB(6,IGV) = CXS(IM+1,IGV,1)*N2(IM,IGV)                            1DX 2132
      GO TO 80                                                          1DX 2133
70    EB(6,IGV) = -EB(5,IGV)                                            1DX 2134
80    EB(7,IGV) = EB(5,IGV) + EB(6,IGV)                                 1DX 2135
      REWIND NCR1                                                       1DX 2136
      DO 110  K=2,7                                                     1DX 2137
110   EB(K,IGP) = 0.0                                                   1DX 2138
      DO 120  IIG=1,IGM                                                 1DX 2139
      DO 120  K=2,7                                                     1DX 2140
120   EB(K,IGP) = EB(K,IGP) + EB(K,IIG)                                 1DX 2141
      WRITE(NOUT,130)                                                   1DX 2142
130   FORMAT(28H1FINAL NEUTRON BALANCE TABLE///     127H GROUP  FISS. SO1DX 2143
     1URCE      FISSIONS      IN-SCATTER    OUT-SCATTER     ABSORPTION  1DX 2144
     2 LEFT LEAK.    RIGHT LEAK.   TOTAL LEAKAGE    /)                  1DX 2145
      DO 140  IIG=1,IGM                                                 1DX 2146
140   WRITE(NOUT,150)  IIG, EB(1,IIG), EB(8,IIG), (EB(K,IIG), K=2,7)    1DX 2147
150   FORMAT(I5,1PE13.3,1P7E15.3)                                       1DX 2148
      WRITE(NOUT,155)                                                   1DX 2149
155   FORMAT(1H )                                                       1DX 2150
      IIG = IGP                                                         1DX 2151
      WRITE(NOUT,150)  IIG, EB(1,IIG), EB(8,IIG), (EB(K,IIG), K=2,7)    1DX 2152
      RETURN                                                            1DX 2153
      END                                                               1DX 2154
```

```
-ITC  FOR  GRAM,GRAM
      SUBROUTINE GRAM(MASS, VOL,  ATW, HOLN,JIM, M0, M2, V0,
     1                I0, I1, I2,JML,I3,J1)
      INCLUDE ABC
      DIMENSION MASS(JML,1), VOL(1), ATW(1), HOLN(1), M0(1),
     1          M2(1), V0(1), I0(1), I1(1), I2(1), I3(1), J1(1)
C     CALCULATE MATERIAL INVENTORIES
      WRITE(NOUT,10) (ID(I), I=1,11)
10    FORMAT(1H1,11A6///)
      WRITE(NOUT,20)
20    FORMAT(45H MATERIAL INVENTORY (KILOGRAMS) FOR EACH ZONE /   )
      CALL CLEAR(0.0,VOL,IZM)
      ITEMP = ML*IZM
      CALL CLEAR(0.0,MASS,ITEMP)
      DO 30  I = 1, IM
      K = M0(I)
30    VOL(K) = VOL(K) + V0(I)*.001
      DO 39  M=1,M01
      I3(M) = I2(M)
      IF(I0(M) - I1(M))  39,35,39
35    IF(I2(M))  39,36,39
36    DO 38  MM=1,M
      IF(I0(M) - I0(MM))  38,37,38
37    I3(MM) = I2(MM)*FV
38    CONTINUE
39    CONTINUE
      DO 190 N =1, IZM
      NN = M2(N)
      DO 190 M = 1,M01
      IF(I0(M) - NN)  190, 40, 190
40    IF(M - MM01)  42,42,44
42    L = J1(M)
      GO TO 48
44    L = I1(M)
48    IF(L - ML)  170, 170, 50
50    NNAA = L
      IF(L - I0(M))  130,190, 130
130   DO 160 MAA = 1, M01
      IF(I0(MAA) - NNAA)  160, 140, 160
140   IF(MAA - MM01)  142,142,144
142   L = J1(MAA)
      GO TO 148
144   L = I1(MAA)
148   IF(L)  160, 160, 150
150   E01 = I3(MAA)*I3(M)
      MASS(L,N) = ((E01*ATW(L)*VOL(N))/.6023) + MASS(L,N)
160   CONTINUE
      GO TO 190
170   IF(L)  190, 190, 180
180   E01 = I3(M)
      MASS(L,N) = ((E01*ATW(L)*VOL(N))/.6023) + MASS(L,N)
190   CONTINUE
      DATA   ZONE/6H ZONE /
      DO 270 L = 1, IZM, 5
      LL = L + 4
      IF(LL - IZM) 210, 210, 200
200   LL = IZM
210   WRITE(NOUT,220)  ((ZONE, K), K=L, LL)
220   FORMAT(//28H     MATERIAL   ATOMIC WT.   ,3X, 5(A6,I2,12X))
```

```
      WRITE(NOUT,230)  (VOL(K), K = L, LL)
230   FORMAT(28X, 5(1PE8.3 , 7H LITERS, 5X))
      WRITE(NOUT,240)
240   FORMAT(1H )
      DO 250 K = 1, ML
250   WRITE(NOUT,260)  K, HOLN(K), ATW(K), (MASS(K, I), I = L, LL)
260   FORMAT( I3,3X, A6, F13.3, 1X, 1PE13.3, 1P4E20.3)
      IF(LL - IZM)  270, 280, 280
270   CONTINUE
280   RETURN
      END
```

```
-ITC  FOR  CRUNCH,CRUNCH                                                  1DX 2225
      SUBROUTINE CRUNCH(PHI,N2,V0,K8,PHJ,NPN,K7,C1,C0,NFP,NZN,M0,HOLN,    1DX 2226
     1                  ATW,JZM,JTLP,NV,KCR,JTL,JIM,VOL,C2,JGM,K6,        1DX 2227
     2                  ALPH,ALPS)                                        1DX 2228
      DIMENSION PHI(JZM,1), N2(JIM,1), V0(1), K8(1), PHJ(JZM,1), NPN(1),1DX 2229
     1K7(1), C1(JTLP,KCR,1), C0(JTL,1), NFP(1), NZN(1), M0(1), HOLN(1),  1DX 2230
     2ATW(1), NV(1), VOL(1), C2(JZM,1),      K6(1), ALPH(JZM,1),         1DX 2231
     3ALPS(JZM,1)                                                         1DX 2232
      REAL  K8                                                            1DX 2233
C     C1(ITLP,NCR,MT) COLLAPSED CROSS SECTION ARRAY--STARTS AT A(LN2)     1DX 2234
C     K8(NCR)       COLLAPSED FISSION SPECTRUM--STARTS AT A(LV7)          1DX 2235
      INCLUDE ABC                                                         1DX 2236
C     CRUNCH CALCULATES, PRINTS, AND PUNCHES COLLAPSED CROSS SECTIONS     1DX 2237
C     CALCULATE ZONE AVERAGED FLUXES FOR EACH FINE GROUP                  1DX 2238
      DO 30  KZ=1,IZM                                                     1DX 2239
      PHI(KZ,IGP) = 0.0                                                   1DX 2240
      DO 30  IIG=1,IGM                                                    1DX 2241
      PHI(KZ,IIG) = PHI(KZ,IIG)*.001/VOL(KZ)                              1DX 2242
30    PHI(KZ,IGP) = PHI(KZ,IGP) + PHI(KZ,IIG)                             1DX 2243
C     CALC. FISS. SPECTRUM AND ZONE AV. FLUXES FOR EACH COLLAPSED GROUP 1DX 2244
      DO 50  JJG=1,NCR                                                    1DX 2245
      K8(JJG) = 0.0                                                       1DX 2246
      DO 50  KZ=1,IZM                                                     1DX 2247
50    PHJ(KZ,JJG) = 0.0                                                   1DX 2248
      IIG = 0                                                             1DX 2249
      DO 100  JJG=1,NCR                                                   1DX 2250
      ITEMP = NPN(JJG)                                                    1DX 2251
      DO 100  K=1,ITEMP                                                   1DX 2252
      IIG = IIG + 1                                                       1DX 2253
      K8(JJG) = K8(JJG) + K7(IIG)                                         1DX 2254
      NV(IIG) = JJG                                                       1DX 2255
      DO 100  KZ=1,IZM                                                    1DX 2256
100   PHJ(KZ,JJG) = PHJ(KZ,JJG) + PHI(KZ,IIG)                             1DX 2257
      WRITE(NOUT,110)  (KZ,PHI(KZ,IGP),VOL(KZ),KZ=1,IZM)                  1DX 2258
110   FORMAT(21H1ZONE AVERAGED FLUXES//                                   1DX 2259
     1       40H0ZONE           FLUX             VOLUME    /              1DX 2260
     2       40H             (N/CM2-SEC)         (LITERS) //(I4,1P2E18.5))1DX 2261
115   WRITE(NOUT,120)                                                     1DX 2262
120   FORMAT(////62H COLLAPSED FISSION FRACTIONS AND ZONE AVERAGED FLUXE1DX 2263
     1S BY GROUP/)                                                        1DX 2264
      DATA  ZONE/6H  ZONE/                                                1DX 2265
      DO 180  KZ=1,IZM,6                                                  1DX 2266
      ITEMP = KZ + 5                                                      1DX 2267
      IF(ITEMP - IZM)  140,140,130                                        1DX 2268
130   ITEMP = IZM                                                         1DX 2269
140   WRITE(NOUT,150)  ((ZONE, K), K=KZ,ITEMP)                            1DX 2270
150   FORMAT(30H GROUP     FISS. FRACT.        , 6(A6, I3, 9X))           1DX 2271
      WRITE(NOUT,160)                                                     1DX 2272
160   FORMAT(1H )                                                         1DX 2273
170   FORMAT(I4, 1P7E18.5)                                                1DX 2274
      DO 180  JJG=1,NCR                                                   1DX 2275
180   WRITE(NOUT,170)   JJG,K8(JJG),(PHJ(K,JJG), K=KZ,ITEMP)              1DX 2276
C     CALCULATION OF COLLAPSED SIGF, SIGA, NUSIGF, AND SIGTR              1DX 2277
190   IF(NCR - IGM)   195, 192, 192                                       1DX 2278
192   DO 194  IIG=1,IGM                                                   1DX 2279
      READ(NCR1)  ((C0(I,J),I=1,ITL),J=1,MT)                              1DX 2280
      DO 194  M=1,NFGM                                                    1DX 2281
      ITEMP1 = NFP(M)                                                     1DX 2282
      DO 194  I=1,ITL                                                     1DX 2283
```

```
194     C1(I,IIG,M) = C0(I,ITEMP1)
        GO TO 955
195     DO 200  JJG=1,NCR
        DO 200  KZ=1,IZM
200     ALPS(KZ,JJG) = 0.0
        IIG = 0
        DO 235  JJG = 1, NCR
        ITEMP = NPN(JJG)
        DO 235  K=1,ITEMP
        IIG = IIG + 1
        DO 235  KZ=1,IZM
        ALPH(KZ,IIG) = PHI(KZ,IIG)/C2(KZ,IIG)
235     ALPS(KZ,JJG) = ALPS(KZ,JJG) + ALPH(KZ,IIG)
        IIG = 0
        DO 290  JJG=1,NCR
        DO 240  JT=1,ITLP
        DO 240  M=1,NFGM
240     C1(JT,JJG,M) = 0.0
        ITEMP = NPN(JJG)
        DO 290  K=1,ITEMP
        IIG = IIG + 1
        READ(NCR1)    ((C0(I,J),I=1,ITL),J=1,MT)
        DO 290  M=1,NFGM
        ITEMP1 = NFP(M)
        KZ = NZN(M)
        DO 250  JT=1,3
250     C1(JT,JJG,M) = C1(JT,JJG,M) + C0(JT,ITEMP1)*PHI(KZ,IIG)/
       1               PHJ(KZ,JJG)
        IF(NTR)  280, 280, 260
260     C1(4,JJG,M) =  C1(4,JJG,M) + PHI(KZ,IIG)/C0(4,ITEMP1)
        GO TO 290
280     C1(4,JJG,M) = C1(4,JJG,M) + C0(4,ITEMP1)*ALPH(KZ,IIG)/ALPS(KZ,JJG)
290     CONTINUE
        IF(NTR)  310, 310, 295
295     DO 300  JJG=1,NCR
        DO 300  M=1,NFGM
        KZ = NZN(M)
        ITEMP = NPN(JJG)
300     C1(4,JJG,M) =  PHJ(KZ,JJG)/C1(4,JJG,M)
310     REWIND NCR1
C       CALCULATION OF SCATTERING MATRIX
        IF(NXCMP)  900, 900, 330
330     IIG = 0
        DO 500  JJG=1,NCR
        ITEMP = NPN(JJG)
        DO 500  K=1,ITEMP
        READ(NCR1)    ((C0(I,J),I=1,ITL),J=1,MT)
        IIG = IIG + 1
        DO 500  M=1,NFGM
        ITEMP1 = NFP(M)
        KZ = NZN(M)
        DO 500  LT=1,NXCM
        IT = LT + 5
        ING = IIG - LT
        JNG = NV(ING)
        JT = JJG + 5 - JNG
        IF(JT-5)  500, 500, 480
480     IF(ING)  500, 500, 490
490     C1(JT,JJG,M) = C1(JT,JJG,M) + C0(IT,ITEMP1)*PHI(KZ,ING)/
```

```
     1                PHJ(KZ,JNG)
500   CONTINUE
      IF(NXINP)  900, 900, 530
530   IF(NXCMP - NXINP)  900, 900, 540
540   ITEMP = NXINP + 5
      ITEMP1 = NXINP + 6
      DO 570  M=1,NFGM
      DO 570  JJG=1,NCR
      DO 570  JT=ITEMP1,ITLP
      KKG = JJG + JT + 1 - ITEMP1
      IF(KKG - NCR)  550, 550, 570
550   C1(ITEMP,JJG,M) = C1(ITEMP,JJG,M) + C1(JT,KKG,M)
570   CONTINUE
      ITLP = NXINP + 5
      NXCMP = NXINP
C     CALCULATION OF SIGG
900   DO 950  JJG=1,NCR
      DO 950  M=1,NFGM
      TEMP = .0
      DO 930  L=1,NXCMP
      JT = L + 5
      J = JJG + L
      IF(J - NCR)  930, 930, 950
930   TEMP = TEMP + C1(JT,J,M)
950   C1(5,JJG,M) = C1(4,JJG,M) - C1(2,JJG,M) - TEMP
C     PRINT COLLAPSED CROSS SECTIONS
955   WRITE(NOUT,960)
960   FORMAT(/25H1COLLAPSED CROSS SECTIONS)
      DO 980 JJG=1,NCR
      WRITE(NOUT,970) JJG
970   FORMAT(6H0GROUP,I3,11X,82H SIGF       SIGA      NUSIGF      SIGTR
     1      GXG          G-1XG        G-2XG        . . .)
      DO 980  M=1,NFGM
      ITEMP1 = NFP(M)
      KZ = NZN(M)
980   WRITE(NOUT,990)  ITEMP1, KZ, (C1(JT,JJG,M),JT=1,ITLP)
990   FORMAT( 4H MAT,I3,1X,5H ZONE,I3,10E11.5/ (16X,10E11.5))
      IF(IPUN )  1100, 1100, 1000
C     PUNCH COLLAPSED CROSS SECTIONS
1000  DO 1070   M=1,NFGM
      Z=1.0
      PUNCH 1040,NFP(M), Z, NCR
1040  FORMAT(3HMAT,I3,F6.2,10X,I3,7H GROUPS)
1045  IF(IPUN - 1)  1050,1050,1060
1050  DO 1055  JJG=1,NCR
1055  PUNCH 1080, (C1(JT,JJG,M),JT=1,ITLP)
      GO TO 1070
1060  WRITE(16)  ((C1(JT,JJG,M), JT=1,ITLP), JJG=1,NCR)
1070  CONTINUE
1080  FORMAT(6E12.6)
      IF(IPUN-2)  1100,1090,1100
1090  CALL NTRAN(16,9,11)
1100  REWIND NCR1
      RETURN
      END
```

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