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SYN3D: A SINGLE-CHANNEL, SPATIAL FLUX SYNTHESIS CODE FOR DIFFUSION THEORY CALCULATIONS

by

C. H. Adams

BASE TECHNOLOGY

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ARGONNE NATIONAL LABORATORY, ARGONNE, ILLINOIS

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Applied Physics Division

July 1976

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ABSTRACT

This report is a user's manual for SYN3D, a computer code which uses single-channel, spatial flux synthesis to calculate approximate solutions to two- and three-dimensional, finite-difference, multigroup neutron diffusion theory equations. SYN3D is designed to run in conjunction with any one of several one- and two-dimensional, finite-difference codes (required to generate the synthesis expansion functions) currently being used in the fast reactor community. The report describes the theory and equations, the use of the code, and the implementation on the IBM 370/195 and CDC 7600 of the version of SYN3D available through the Argonne Code Center.

I. INTRODUCTION

This report is a user's manual for SYN3D, a computer code which uses single-channel, spatial flux synthesis to calculate approximate solutions to two- and three-dimensional, finite-difference, multigroup neutron diffusion theory equations.

SYN3D is designed to run in conjunction with any one of several one- and two-dimensional finite-difference codes (required to generate the synthesis expansion functions) currently being used in the fast reactor community. Most of the data for a calculation must be supplied in the formats of the Standard Interface Files defined by the Committee on Computer Code Coordination (CCCC). Appendix A of this report is the computer code abstract for SYN3D.

SYN3D is operational at Argonne National Laboratory within the ARC System of reactor analysis codes and has been sent, in stand-alone form, to the Argonne Code Center for distribution to other laboratories. Sections II, III and IV of this report cover material of interest to users of both the ARC System and Code Center versions of the code; Section V deals with the Code Center version only. Users who have just received SYN3D from the Code Center and who are faced with the task of bringing the code up on their machine should read Section V first; it describes the contents of the Code Center tapes and outlines the steps necessary to implement SYN3D in stand-alone form on the IBM 370/195 and CDC 7600.

II. SYNTHESIS THEORY AND EQUATIONS

In this section we develop the synthesis approximation used in SYN3D from the mesh-box-centered, diffusion theory, finite-difference equations and describe the solution of the resulting synthesis equations.

A. Diffusion Theory Difference Equations

There are two finite-difference forms of the neutron diffusion equations currently used in reactor analysis. In the derivation of the first, the fluxes in the differential equations are expanded in Taylor series about the mesh points (i.e. the intersections of the mesh lines in two dimensions and mesh planes in three). The PDQ code contains this formulation.[1,2] The other difference equations are derived by expanding the fluxes about a point at the center of a mesh block. The codes 2DB, 3DB, DIF2D, CITATION and VENTURE use this approach.[3-6] SYN3D is designed to calculate an approximate solution for the second type of difference equation, which is the form most frequently used in fast reactor analysis.

In x-y-z geometry the three-dimensional, finite-difference equations associated with the mesh block defined by x mesh interval i, y mesh interval j, and z mesh interval k in energy group g can be written:

$$
\begin{aligned}
&- d^{xg}_{i+1jk}\left[\phi^g_{i+1jk} - \phi^g_{ijk}\right]\Delta y_j \Delta z_k + d^{xg}_{ijk}\left[\phi^g_{ijk} - \phi^g_{i-1jk}\right]\Delta y_j \Delta z_k \\
&- d^{yg}_{ij+1k}\left[\phi^g_{ij+1k} - \phi^g_{ijk}\right]\Delta x_i \Delta z_k + d^{yg}_{ijk}\left[\phi^g_{ijk} - \phi^g_{ij-1k}\right]\Delta x_i \Delta z_k \qquad (1) \\
&- d^{zg}_{ijk+1}\left[\phi^g_{ijk+1} - \phi^g_{ijk}\right]\Delta x_i \Delta y_j + d^{zg}_{ijk}\left[\phi^g_{ijk} - \phi^g_{ijk-1}\right]\Delta x_i \Delta y_j \\
&+ \sum_{g'} v_{ijk}\, r^{gg'}_{ijk}\, \phi^g_{ijk} - v_{ijk}\, s^g_{ijk} = 0,
\end{aligned}
$$

$$i = 1 \ldots I, \quad j = 1 \ldots J, \quad k = 1 \ldots K, \quad g = 1 \ldots G.$$

I is the number of x mesh intervals, J is the number of y mesh intervals, and K is the number of axial mesh intervals. G is the number of energy groups. No equations are written for those mesh blocks which contain a blackness theory material.

ϕ^g_{ijk} is the discrete group flux associated with mesh block (i,j,k). ϕ^g_{ijk} is identically zero if mesh block (i,j,k) is in a blackness theory region. If i = 0 or I + 1, j = 0 or J + 1, or k = 0 or K + 1 the ϕ^g_{ijk}'s are exterior fluxes and their definition depends on the boundary conditions at the corresponding boundary of the model. For homogeneous boundary conditions of the form

$$C_1^g D^g \hat{n} \cdot \nabla\phi^g + C_2^g \phi^g = 0 \tag{2}$$

where $\hat{n}$ is the outward normal unit vector, the exterior fluxes for the boundary are identically zero; the boundary condition is specified by the definition of the d's (see below). Equation (2) includes the cases of zero flux $[C_1^g = 0]$, zero current $[C_1^g = 0]$ and logarithmic (or extrapolated) conditions. The exterior fluxes at a boundary with periodic conditions are identically equal to the first interior fluxes on one of the other boundary surfaces of the model.

The three types of d's $[d_{ijk}^{xg}, d_{ijk}^{yg}, d_{ijk}^{zg}]$ are defined similarly, and so it is necessary to discuss only one of them $[d_{ijk}^{xg}]$. If the mesh blocks (i,j,k) and (i-1,j,k) are within the boundaries of the model, and neither contains a blackness theory material,

$$d_{ijk}^{xg} = \frac{2D_{i-ijk}^g \, D_{ijk}^g}{\Delta x_i \, D_{i-1jk}^g + \Delta x_{i-1} \, D_{ijk}^g} , \tag{3}$$

$$i = 1 \ldots I, \quad j = 1 \ldots J, \quad k = 1 \ldots K, \quad g = 1 \ldots G.$$

D_{ijk}^g is the group g diffusion coefficient for mesh block (i,j,k) and Δx_i, Δy_i, and Δz_k define its size. If one of the mesh blocks is outside the boundary of the model (the cases i = 1 and i = I + 1), but that boundary surface has a periodic boundary condition, then Eq. (3) still holds if it is understood that the exterior mesh block is identical to a corresponding interior mesh block on some other boundary.

SYN3D permits anisotropic diffusion coefficients. The value of D_{ijk}^g appearing in the expression for d_{ijk}^{xg} may be different from the value of D_{ijk}^g appearing in d_{ijk}^{yg}.

For the homogeneous boundary condition given by Eq. (2) at i = 1 as well as when there is an internal interface between a blackness theory material in mesh block (i - 1,j,k) and an ordinary material in (i,j,k),

$$d_{ijk}^{xg} = \frac{D_{ijk}^g \, C_2^g}{D_{ijk}^g \, C_1^g + \frac{1}{2} \Delta x_i C_2^g} . \tag{4}$$

In the case of a blackness theory boundary, $\hat{n}$ in Eq. (2) is the unit normal into the blackness region at the interface. When Eq. (2) is the boundary condition at i = I, and for an internal interface between a blackness theory material in mesh block (i,j,k) and an ordinary material in (i - 1,j,k),

$$d_{ijk}^{xg} = \frac{D_{i-1jk}^g \, C_2^g}{D_{i-1jk}^g \, C_1^g + \frac{1}{2} \Delta x_{i-1} \, C_2^g} . \tag{5}$$

If both (i - 1,j,k) and (i,j,k) contain blackness theory material d^{xg}_{ijk} is not defined, because the only two equations in which it could appear are never written.

The remaining notation in Eq. (1) is simpler to define. v_{ijk} is the volume of mesh block (i,j,k). $r^{gg'}_{ijk}$ is basically the combination of macroscopic cross sections representing absorption, scattering, and fission. s^{g}_{ijk} is an inhomogeneous source. With the proper definitions of $r^{gg'}_{ijk}$ and s^{g}_{ijk}, Eq. (1) becomes the statement of an eigenvalue problem, an outer iteration of an eigenvalue problem, a distributed source problem, or even one time step of an implicit space-time calculation. To cast Eq. (1) in the form of the eigenvalue problem, for example,

$$s^{g}_{ijk} = 0,$$

$$r^{gg'}_{ijk} = \Sigma^{g}_{R}\delta_{gg'} + \Sigma^{g\leftarrow g'}_{s} - \lambda\chi^{g}\nu\Sigma^{g'}_{f} , \tag{6}$$

where Σ^{g}_{R} is the total macroscopic cross section for removal from group g, $\Sigma^{g\leftarrow g'}_{s}$ is the cross section for scattering into group g from g', χ^{g} is the fission spectrum and $\nu\Sigma^{g'}_{f}$ is the cross section for neutron production by fission. λ is the eigenvalue, and $\delta_{gg'}$ is the Kronecker delta.

In r-z and triangular geometries the finite-difference equations are similar to Eq. (1) if one alters some definitions. In r-z geometry the "x" dimension is the radial dimension, and the leakage finite-difference coefficient away from external boundaries and blackness regions becomes

$$d^{xg}_{ijk} = \frac{2D^{g}_{i-1jk}\ D^{g}_{ijk}}{\Delta x_i\ D^{g}_{i-1jk} + \Delta x_{i-1}\ D^{g}_{ijk}}\ (2\Pi\ x_i) \tag{7}$$

where x_i is the radial position of the interface between mesh interval i-1 and i. The leakage coefficients at boundaries (Eqs. (4) and (5)) are also multiplied by $2\Pi\ x_i$. Now v_i is the volume of an annulus.

For geometries which have triangular mesh in the plane, each mesh cell couples to 3 other cells in the plane rather than to 4. The coupling between internal mesh triangles (i-1,j,k) and (i,j,k) is

$$d^{xg}_{ijk} = \frac{2\sqrt{3}\ D^{g}_{i-1jk}\ D^{g}_{ijk}}{D^{g}_{i-1jk} + D^{g}_{ijk}} \tag{8}$$

and no Δy_i appears multiplying the term (as in Eq. (1)). When one side of a triangle is an exterior (or blackness region) boundary the coefficient is given by

$$d^{xg}_{ijk} = \frac{D^g_{ijk}\ C^g_2}{2\sqrt{3}\ D^g_{ijk}\ C^g_1 + \Delta x\ C^g_2}\ (2\sqrt{3}\ \Delta x)\ . \tag{9}$$

Δx is not subscripted since in regular triangular mesh there is only one characteristic length, the side of a triangle. When the triangular mesh is bisected by a boundary, and the flux, therefore, is defined for a point on the boundary,

$$d^{xg}_{ijk} = \frac{C^g_2}{4\ C^g_1\ D_{ijk}}\ (2\sqrt{3}\ \Delta x)\ . \tag{10}$$

B. The Single-Channel Synthesis Approximation

The equations and capabilities of SYN3D are based on Kaplan's blending method.[7] Kaplan suggested that the three-dimensional neutron flux can often be approximated by the trial function

$$\phi^g_{ijk} = \sum_{n=1}^{N} a^g_{nk}\ H^g_{nij}\ . \tag{11}$$

The planar expansion functions, H^g_{nij}, are known functions, precalculated by the user. They should be the best practical estimates of the planar flux distributions encountered at various axial positions. The combining coefficients, a^g_{nk}, are the unknowns of the synthesis calculation. Equation (11) states the basic, single-channel synthesis approximation; a more elaborate approximation, multichannel synthesis, is discussed briefly in a later section of this report.

The literature already contains a number of derivations of synthesis difference equations.[8-14] The derivations shown later in this report borrow features of a number of them and are built around the premise that synthesis should be viewed as an approximate method of solving the finite-difference equations; nowhere in this report do we use the differential form of the diffusion equation. This is a realistic approach, since we know that expansion functions must come from finite-difference calculations, and it avoids the problem of trial function discontinuities which arises when one starts from the differential form.[9,12,15-17]

The discrete combining coefficients in Eq. (11) represent a potentially large number (N x K x G) of unknowns, and SYN3D offers two ways to reduce that number. First, if one of the expansion functions, H_n, is characteristic of a limited axial zone of the model, and there is no reason to think its

presence may help the solution away from that zone, one can simply set the corresponding combining coefficients, a^g_{nk}, equal to zero for ranges of values of k. This is the discrete analog to the treatment of the continuous equations suggested in Ref. 18 and has the effect of excluding particular expansion functions from the trial function in particular axial zones. Carried to the extreme that only one combining coefficient in each group remains unknown for each mesh interval, Eq. (11) reduces to the one-function-per-zone synthesis form proposed by Meyer.[19] In a variation of this procedure, setting to zero all those combining coefficients associated with a particular n and g offers a mechanism for specifying different numbers of expansion functions for each energy group.

The second way to reduce the number of unknowns is by group collapsing.[20] Group-collapsed synthesis is not to be confused with group collapsed cross section; it simply means that the user specifies some prescription for expressing the G combining coefficients for the G group fluxes of one expansion function in terms of a smaller number, G′, of unknowns. In this work we will allow linear transformations of the form

$$a^g_{nk} = \sum_{b=1}^{G'} u^{gb}\, a^b_{nk} \quad . \tag{12}$$

Note that we have limited ourselves to one collapsing scheme for all expansion functions and regions of the model. To see how group collapsing might be applied, consider the example of a four-group model collapsed to two groups. If the matrix u was given by

$$u = \begin{pmatrix} 1 & 0 \\ 1 & 0 \\ 0 & 1 \\ 0 & 1 \end{pmatrix} , \tag{13}$$

then the synthesis trial functions [Eq. (11)] for each group flux become

$$\phi^1_{ijk} = \sum_{n=1}^{N} a^1_{nk}\, H^1_{nij} \quad , \quad \phi^2_{ijk} = \sum_{n=1}^{N} a^1_{nk}\, H^2_{nij}$$

$$\phi^3_{ijk} = \sum_{n=1}^{N} a^2_{nk}\, H^3_{nij} \quad , \quad \phi^4_{ijk} = \sum_{n=1}^{N} a^2_{nk}\, H^4_{nij} \tag{14}$$

A single set of combining coefficients, a^1, is used for both the group 1 and group 2 trial functions. Another set, a^2, is used with groups 3 and 4. In this example the number of unknowns has been reduced by a factor of 2.

One constraint should be applied to the definition of the matrix elements, u^{gb}, to assure that the individual expansion function spectra

are recoverable from the group-collapsed synthesis trial function [Eq. (11)], and that is

$$\sum_{b=1}^{G'} u^{gb} = \text{the same value for all g.} \tag{15}$$

This constraint is desirable since the user has supplied expansion functions which should have spectra characteristic of the various regions of the model.

With the group-collapsing option added, the synthesis trial function becomes

$$\phi_{ijk}^{g} = \sum_{b=1}^{G'} u^{gb} \sum_{n=1}^{N} a_{nk}^{b} H_{nij}^{g} \ . \tag{16}$$

Note that Eq. (16) reduces to the statement of group-dependent synthesis (Eq. (11)) when u^{gb} is the unit matrix.

So far we have discussed only the trial function for the direct flux. For a variational derivation of the synthesis equations and for perturbation theory, an adjoint flux is required.

$$\phi_{ijk}^{*g} = \sum_{b=1}^{G'} u^{*gb} \sum_{n=1}^{N} a_{nk}^{*b} H_{nij}^{*g} \tag{17}$$

u^* is the adjoint group-collapsing scheme, which does not have to be the same as the direct group-collapsing matrix, u. a^* is the adjoint combining coefficient. H_n^* is a user-supplied expansion function for the adjoint trial function and is usually called a weighting function. In order to keep the synthesis equations in a form convenient to solve, there must be the same number of nonzero adjoint combining coefficients, a_{nk}^{*b}, as there are direct, a_{nk}^{b}, at each axial mesh interval, k.

C. Derivation of the Synthesis Equations

There are two methods commonly used to derive synthesis equations. We first outline the most straightforward of them, the weighted residuals (or weight-and-integrate) approach, and next show a derivation from a variational principle.

Weighted Residuals

For the weighted residuals method, start by substiuting the synthesis trial function (Eq. (16)) into the finite-difference equation (Eq. (1)). Then multiply each equation for a particular axial mesh interval (i.e. each combination of i,j,g for one k) by the factor

$$u^{*gb'}\ H^{*g}_{n'ij}\ , \tag{18}$$

and sum the weighted equations over the indices i, j and g. Repeat this procedure for a total number of multipliers (Eq. (18)) equal to the number of combining coefficients for a single value of k, making sure that each time the combination of collapsed group (b') and expansion function (n') for the multiplier is unique. We shall account later for the fact that some of the combining coefficients may be zero (i.e. that certain expansion functions have been dropped where it is felt that they are not needed). For now we will treat the calculation as if all expansion functions are used everywhere.

When the dust settles, the synthesis equations are:

$$\begin{aligned}
&\sum_{b=1}^{G}\sum_{n=1}^{N} a^{b}_{nk}\left[\sum_{g=1}^{G} u^{*gb'}\sum_{g'=1}^{G} u^{g'b}\sum_{i=1}^{I}\sum_{j=1}^{J} H^{*g}_{n'ij}\ v_{ijk}\ r^{gg'}_{ijk}\ H^{g'}_{nij}\right]\\
&+\sum_{b=1}^{G}\sum_{n=1}^{N} a^{b}_{nk}\ \Delta z_k\left[\sum_{g=1}^{G} u^{*gb'}\ u^{gb}\left\{\sum_{j=1}^{J} H^{*g}_{n'1j}\ d^{xg}_{1jk}\ \Delta y_j\left(H^{g}_{n1j}-H^{g}_{n0j}\right)\right.\right.\\
&+\sum_{i=2}^{I}\sum_{j=1}^{J}\left(H^{*g}_{n'ij}-H^{*g}_{ni-1j}\right)\ d^{xg}_{ijk}\ \Delta y_j\left(H^{g}_{nij}-H^{g}_{ni-1j}\right)\\
&-\sum_{j=1}^{J} H^{*g}_{n'I+1j}\ d^{xg}_{I+1jk}\ \Delta y_j\left(H^{g}_{nI+1j}-H^{g}_{nIj}\right)\\
&+\sum_{i=1}^{I} H^{*g}_{n'i1}\ d^{yg}_{i1k}\ \Delta x_i\left(H^{g}_{ni1}-H^{g}_{ni0}\right)\\
&+\sum_{i=1}^{I}\sum_{j=2}^{J}\left(H^{*g}_{n'ij}-H^{*g}_{n'ij-1}\right)\ d^{yg}_{ijk}\ \Delta x_i\left(H^{g}_{nij}-H^{g}_{nij-1}\right)\\
&\left.\left.-\sum_{i=1}^{I} H^{*g}_{n'iJ+1}\ d^{yg}_{iJ+1k}\ \Delta x_i\left(H^{g}_{niJ+1}-H^{g}_{niJ}\right)\right\}\right]\\
&-\sum_{b=1}^{G'}\sum_{n=1}^{N}\left(a^{b}_{nk+1}-a^{b}_{nk}\right)\left[\sum_{g=1}^{G} u^{*gb'}\ u^{gb}\left\{\sum_{i=1}^{I}\sum_{j=1}^{J} H^{*g}_{n'ij}\ d^{zg}_{ijk+1}\ \Delta x_i\ \Delta y_j\ H^{g}_{nij}\right\}\right]\\
&+\sum_{b=1}^{G'}\sum_{n=1}^{N}\left(a^{b}_{nk}-a^{b}_{nk-1}\right)\left[\sum_{g=1}^{G} u^{*gb'}\ u^{gb}\left\{\sum_{i=1}^{I}\sum_{j=1}^{J} H^{*g}_{n'ij}\ d^{zg}_{ijk}\ \Delta x_i\ \Delta y_j\ H^{g}_{nij}\right\}\right]\\
&-\sum_{g=1}^{G} u^{*gb'}\left\{\sum_{i=1}^{I}\sum_{j=1}^{J} H^{*g}_{n'ij}\ v_{ijk}\ s^{g}_{ijk}\right\} = 0
\end{aligned} \tag{19}$$

for each combination of k, b′ and n′ for which a weighting was performed.

To reduce Eq. (19) to a form which is a convenient basis for a practical computer code we will restrict the axial boundary conditions to the form given in Eq. (2) (zero flux, zero current or extrapolated boundary conditions) and introduce new notation. Periodic conditions will not be allowed at the top and bottom of the model, which means that

$$a^{b}_{n0} = a^{b}_{nK+1} = 0 \tag{20}$$

for all n and b in Eq. (19).

We introduce a new subscript, m, which identifies a unique combination of collapsed group (b) and expansion function (n).

$$a_{mk} = a^{b}_{nk} \ . \tag{21}$$

The maximum value of m, which is the maximum number of combining coefficients associated with a single mesh interval, is M.

$$M = G' \times N. \tag{22}$$

There is a comparable index, m′, associated with the weighting functions. By redefining some of the multiple summations in Eq. (19) we can write the synthesis equations.

$$0 = - \sum_{m=1}^{M} \frac{1}{\Delta z_k} D_{m'mk}\, a_{mk-1} - \sum_{m=1}^{M} \frac{1}{\Delta z_{k+1}} D_{m'mk+1}\, a_{mk+1}$$

$$+ \sum_{m=1}^{M} \left[\frac{1}{\Delta z_k} D_{m'mk} + \frac{1}{\Delta z_{k+1}} D_{m'mk+1} + \Delta z_k R_{m'mk} \right] a_{mk} - \Delta z_k S_{m'k} \ , \tag{23}$$

$$m' = 1 \ldots M, \qquad K = 1 \ldots K \ ,$$

subject to the condition given by Eq. (20). The definitions of the matrices $D_{m'mk}$ and $R_{m'mk}$ and the vector $S_{m'k}$ are:

$$R_{m'mk} = \sum_{g=1}^{G} u^{*gb'} \sum_{g'=1}^{G} u^{g'b} \sum_{i=1}^{I} \sum_{j=1}^{J} H^{*g}_{n'ij}\, \Delta x_i\, \Delta y_j\, r^{gg'}_{ijk}\, H^{g'}_{nij}$$

$$+ \sum_{g=1}^{G} u^{*gb'} u^{gb} \left\{ \sum_{j=1}^{J} H^{*g}_{n1k}\, d^{xg}_{1jk}\, \Delta y_j \left(H^{g}_{n1j} - H^{g}_{n0j} \right) \right.$$

$$+ \sum_{i=2}^{I} \sum_{j=1}^{J} \left(H^{*g}_{n'ij} - H^{*g}_{n'i-1j} \right) d^{xg}_{ijk} \, \Delta y_j \left(H^{g}_{nij} - H^{g}_{ni-1j} \right)$$

$$- \sum_{j=1}^{J} H^{*g}_{n'I+1j} \, d^{xg}_{I+1jk} \, \Delta y_j \left(H^{g}_{nI+1j} - H^{g}_{nIj} \right)$$

$$+ \sum_{i=1}^{I} H^{*g}_{n'i1} \, d^{yg}_{i1k} \, \Delta x_i \left(H^{g}_{ni1} - H^{g}_{ni0} \right)$$

$$+ \sum_{i=1}^{I} \sum_{j=2}^{J} \left(H^{*g}_{n'ij} - H^{*g}_{n'ij-1} \right) d^{yg}_{ijk} \, \Delta x_i \left(H^{g}_{nij} - H^{g}_{nij-1} \right)$$

$$\left. - \sum_{i=1}^{I} H^{*g}_{n'iJ+1} \, d^{yg}_{iJ+1k} \, \Delta x_i \left(H^{g}_{niJ+1} - H^{g}_{niJ} \right) \right\} \tag{24}$$

$$D_{m'mk} = \sum_{g=1}^{G} u^{*gb'} \, u^{gb} \sum_{i=1}^{I} \sum_{j=1}^{J} H^{*g}_{n'ij} \, d^{zg}_{ijk} \, \Delta x_i \, \Delta y_j \, \Delta z_k \, H^{g}_{nij} \tag{25}$$

$$S_{m'k} = \sum_{g=1}^{G} u^{*gb'} \sum_{i=1}^{I} \sum_{j=1}^{J} H^{*g}_{n'ij} \, \Delta x_i \, \Delta y_j \, s^{g}_{ijk} \quad . \tag{26}$$

In order to define $D_{m'mk}$ by a single expression it is necessary to define Δz_{K+1} in $D_{m'mK+1}$. The definition is arbitraty, since it is cancelled by the inverse mesh spacing when $D_{m'mK+1}$ is used in Eq. (23).

We pointed out earlier that expansion functions can be eliminated from the trial function over ranges of axial mesh intervals by setting their combining coefficients identically equal to zero. We can modify Eq. (23) to imply this if we define the symbol

$$\sum_{\substack{m \text{ at} \\ k}} \tag{27}$$

to mean the sum over only those values of m at axial mesh interval k which correspond to nonzero combining coefficients, a_{mk}. When the number of unknowns is reduced in this way it becomes necessary to reduce the number of equations. In order that the reduced set of synthesis equations remains in a block-tridiagonal form which is convenient for numerical inversions, we will require that when a combining coefficients is eliminated the corresponding equation that must be dropped be one associated with the same mesh point. Therefore, the "m′ = 1 ... M" in Eq. (23) is replaced by "m′ at k", implying that Eq. (23) is written only for certain values of m′ at each mesh interval.

The final form of the synthesis equations can now be written,

$$0 = - \sum_{\substack{m \text{ at} \\ k-1}} \frac{1}{\Delta z_k} D_{m'mk}\, a_{mk-1} - \sum_{\substack{m \text{ at} \\ k+1}} \frac{1}{\Delta z_{k+1}} D_{m'mk+1}\, a_{mk+1}$$

$$+ \sum_{\substack{m \text{ at} \\ k}} \left[\frac{1}{\Delta z_k} D_{m'mk} + \frac{1}{\Delta z_{k+1}} D_{m'mk+1} + \Delta z_k\, R_{m'mk} \right] a_{mk}$$

$$- \Delta z_k\, S_{m'k}, \qquad m' \text{ at } k, \qquad k = 1 \ldots K \tag{28}$$

<u>A Variational Derivation</u>

Consider the following functional:

$$\sum_{g=1}^{G} \sum_{j=1}^{J} \sum_{k=1}^{K} \Delta y_j\, \Delta z_k \left\{ \phi^{*g}_{1jk}\, d^{xg}_{1jk} \left(\phi^{g}_{1jk} - \phi^{g}_{0jk} \right) - \phi^{*g}_{Ijk}\, d^{xg}_{I+1jk} \left(\phi^{g}_{I+1jk} - \phi^{g}_{Ijk} \right) \right.$$

$$\left. + \sum_{i=2}^{I} \left(\phi^{*g}_{ijk} = \phi^{*g}_{i-1jk} \right) d^{xg}_{ijk} \left(\phi^{g}_{ijk} - \phi^{g}_{i-1jk} \right) \right\}$$

$$+ \sum_{g=1}^{G} \sum_{i=1}^{I} \sum_{k=1}^{K} \Delta x_i\, \Delta z_k \left\{ \phi^{*g}_{i1k}\, d^{yg}_{i1k} \left(\phi^{g}_{i1k} - \phi^{g}_{i0k} \right) - \phi^{*g}_{iJk}\, d^{yg}_{iJ+1k} \left(\phi^{g}_{iJ+1k} - \phi^{g}_{iJk} \right) \right.$$

$$\left. + \sum_{j=2}^{J} \left(\phi^{*g}_{ijk} - \phi^{*g}_{ij-1k} \right) d^{yg}_{ijk} \left(\phi^{g}_{ijk} - \phi^{g}_{ij-1k} \right) \right\}$$

$$+ \sum_{g=1}^{G} \sum_{i=1}^{I} \sum_{j=1}^{J} \Delta x_i\, \Delta y_j \left\{ \phi^{*}_{ij1}\, d^{zg}_{ij1} \left(\phi_{ij1} - \phi_{ij0} \right) - \phi^{*}_{ijK}\, d^{zg}_{ijK+1} \left(\phi_{ijK+1} - \phi_{ijK} \right) \right.$$

$$\left. + \sum_{k=2}^{K} \left(\phi^{*g}_{ijk} - \phi^{*g}_{ijk-1} \right) d^{zg}_{ijk} \left(\phi^{g}_{ijk} - \phi^{g}_{ijk-1} \right) \right\}$$

$$+ \sum_{g=1}^{G} \sum_{g'=1}^{G} \sum_{i=1}^{I} \sum_{j=1}^{J} \sum_{k=1}^{K} \phi^{*g}_{ijk}\, v_{ijk}\, r^{gg'}_{ijk}\, \phi^{g'}_{ijk}$$

$$- \sum_{g=1}^{G} \sum_{i=1}^{I} \sum_{j=1}^{J} \sum_{k=1}^{K} v_{ijk} \left(\phi^{*g}_{ijk}\, S^{g}_{ijk} + S^{*g}_{ijk}\, \phi^{g}_{ijk} \right) . \tag{29}$$

ϕ^{*g}_{ijk} is the discrete adjoint group flux and s^{*g}_{ijk} an adjoint source for mesh block (i,j,k). The other quantities were defined when they appeared earlier in Eq. (1). It is straightforward to show that requiring the functional to

be stationary with respect to arbitrary variations of the discrete adjoint fluxes leads to the set of difference equations given in Eq. (1) for any of the allowed types of boundary conditions.

For boundary conditions in the form of Eq. (2) recall that the exterior fluxes (ϕ^g_{0jk}, ϕ^g_{I+1jk}, ϕ^g_{i0k}, etc.) are identically zero. When those terms are dropped from Eq. (29) the symmetry of the remaining expression should make it clear that requiring variations with respect to the direct flux be zero leads to the usual adjoint difference equations. To show that the same is true when there are periodic boundary conditions one must replace the exterior discrete fluxes in Eq. (29) by the appropriate internal fluxes before calculating-the variations. For example, if an x-y-z geometry model has quarter-core symmetry the boundary conditions are periodic at the surfaces i = 1 and j = 1. The external fluxes are redefined by

$$\phi^g_{0jk} = \phi^g_{j1k} \ , \quad \phi^g_{i0k} = \phi^g_{1ik} \ ,$$

$$\phi^{*g}_{0jk} = \phi^{*g}_{j1k} \ , \quad \phi^{*g}_{i0k} = \phi^{*g}_{1ik} \ , \tag{30}$$

There are also identities relating the coefficients in the leakage terms at the periodic boundary.

$$\Delta x_i = \Delta y_i \qquad i = 1 \ldots I, \qquad \Delta x_0 = \Delta y_1 = \Delta x_2 = \Delta y_0$$

$$d^{xg}_{1jk} = \frac{2D^g_{0jk}\ D^g_{1jk}}{\Delta x_1\ D^g_{0jk} + \Delta x_0\ D^g_{jk}} = \frac{2D^g_{j1k}\ D^g_{1jk}}{\Delta x_1\ D^g_{j1k} + \Delta y_1\ D^g_{1jk}} = d^{yg}_{j1k} \ . \tag{31}$$

With the identities shown in Eqs. (30) and (31), one can show that adjoint equations with periodic boundary conditions can be derived from the functional given by Eq. (29).

To derive the synthesis equations, first substitute the trial functions for the direct flux [Eq. (16)] and adjoint flux [Eq. (17)] into the functional [Eq. (29)]. One can reduce the result to

$$\begin{aligned}
&\sum_{k=1}^{K+1} \sum_{m'=1}^{M} \sum_{m=1}^{M} \frac{1}{\Delta z_k} \left(a^*_{m'k} - a^*_{m'k-1}\right) D_{m'mk} \left(a_{mk} - a_{mk-1}\right) \\
&+ \sum_{k=1}^{K} \sum_{m'=1}^{M} \sum_{m=1}^{M} \Delta z_k\ a^*_{m'k}\ R_{m'mk}\ a_{mk} \\
&- \sum_{k=1}^{K} \sum_{m'=1}^{M} \Delta z_k\ a^*_{m'k}\ S_{m'k} - \sum_{k=1}^{K} \sum_{m=1}^{M} \Delta z_k\ a_{mk}\ S^*_{mk}
\end{aligned} \tag{32}$$

by using the definitions given in Eqs. (24) - (26) and

$$S^*_{mk} = \sum_{g=1}^{G} u^{gb} \sum_{i=1}^{I} \sum_{j=1}^{J} H^g_{nij} \, \Delta x_i \, \Delta y_j \, s^{*g}_{ijk} \quad . \tag{33}$$

Setting the variations of this functional with respect to nonzero, adjoint combining coefficients equal to zero leads directly to the direct synthesis equations derived in the last section [Eq. (28)]. Following the same procedure with the direct combining coefficients leads to a set of adjoint synthesis equations.

$$0 = - \sum_{\substack{m' \text{at} \\ k-1}} \frac{1}{\Delta z_k} D_{m'mk} \, a^*_{m'k-1} - \sum_{\substack{m' \text{at} \\ k+1}} \frac{1}{\Delta z_{k+1}} D_{m'mk+1} \, a^*_{m'k+1}$$

$$+ \sum_{\substack{m' \text{at} \\ k}} \left[\frac{1}{\Delta z_k} D_{m'mk} + \frac{1}{\Delta z_{k+1}} D_{m'mk+1} + \Delta z_k \, R_{m'mk} \right] a^*_{m'k} - \Delta z_k \, S^*_{mk},$$

$$m \text{ at } k, \quad k = 1 \ldots K \, . \tag{34}$$

It should be emphasized that the adjoint variables in a synthesis calculation are combining coefficients, a^*_{mk}, and not fluxes. Whether or not the adjoint trial function [Eq. (17)] is a good approximation to the adjoint flux depends on the user's choice of weighting function. It is very common in practical calculations to use the expansion functions for weighting functions also, and this might be a poor choice in situations where the adjoint is required. In particular, when sodium void reactivity distributions are to be calculated by perturbation theory it may be necessary to generate weighting functions from two-dimensional adjoint calculations.

When the groups are not collasped in a synthesis calculation the adjoint combining coefficients will, as best they can, reproduce the adjoint spectrum. If the groups are partially collapsed and direct flux weighting is used, however, it will be virtually impossible for the adjoint trial function to yield reasonable spectra. It has been found that results can be improved if the direct flux expansion coefficients are scaled before being used as weighting functions.[20,21]

$$H^{*g}_{nij} = w^g \, H^g_{nij} \quad . \tag{35}$$

D. The Solution of the Synthesis Eigenvalue Equations

Equation (28) can be written in the form of an eigenvalue problem if we drop the inhomogeneous source and break up $R_{m'mk}$ into its fission and non-fission components.

$$R_{m'mk} = E_{m'mk} - \lambda F_{m'mk} \tag{36}$$

$$m' \text{ at } k, \quad k = 1 \ldots K$$

$E_{m'mk}$ includes the planar leakage, scattering and absorption components of Equation (24). $F_{m'mk}$ is the fission part of Eq. (24). λ is the eigenvalue (1/k).

Fission Source Iteration with Wielandt Acceleration

SYN3D solves Eq. (28), modified by the Eq. (36), by the fission source iteration method with the convergence accelerated by Wielandt (or fractional) iteration.[22] The statement of one iteration of the solution can be written as a matrix equation,

$$- A_k^- a_{k-1} - A_k^+ a_{k+1} + A_k^o a_k = S_k, \qquad k = 1 \ldots K, \tag{37}$$

where a_k is the unknown vector of combining coefficients (a_{mk}, m at k) associated with mesh interval k and A_k^-, A_k^+, A_k^o and S_k are defined by

$$(A_k^-)_{m'm} = \frac{1}{\Delta z_k} D_{m'mk} \quad , \tag{38}$$

$$(A_k^+)_{m'm} = \frac{1}{\Delta z_{k+1}} D_{m'mk+1} \quad , \tag{39}$$

$$(S_k)_{m'} = \sum_{\substack{m \text{ at} \\ k}} \Delta z_k \, (\lambda - \lambda_e) \, F_{m'mk} \, a'_{mk} \quad , \tag{40}$$

$$(A_k^o)_{m'm} = \frac{1}{\Delta z_k} D_{m'mk} + \frac{1}{\Delta z_{k+1}} D_{m'mk+1} + \Delta z_k \left(E_{m'mk} - \lambda_e F_{m'mk} \right) . \tag{41}$$

a'_{mk} is the combining coefficient from the previous iteration. λ_e is an estimate of the eigenvalue. When λ_e is a few percent less than the fundamental eigenvalue (the estimated k is greater than the fundamental k) most problems converge in a very few iterations. An estimate of k is one of the input parameters to the code; when none is provided SYN3D falls back on a straight fission source iteration ($\lambda_e = 0$).

SYN3D requires that for each axial mesh interval the number of group-weighting functions used (i.e. the number of equations) be the same as the number of combining coefficients. This means that the matrix A^o is square. However, since the number of combining coefficients may change from one mesh interval to the next the matrices A_k^- and A_k^+ may be non-square. Note that, because of Eq. (20), the first term of Eq. (37) vanishes for k = 1, and the second term vanishes for k = K.

The convergence criterion used in SYN3D is that the eigenvalue, λ, not change by more than an input criterion on two successive iterations.

Solution by Forward Elimination, Backward Substitution

The solution of the block-tridiagonal source problem (Eq. (37)) is performed by the forward elimination, backward substitution technique (a specialization of Gauss reduction).[23] The first step is to sweep through the axial mesh generating the following set of matrices, H_k, and vectors, Q_k.

$$\text{at } k = 1, \qquad \begin{aligned} H_1 &= \left[A_1^o\right]^{-1} A_1^+ \\ Q_1 &= \left[A_1^o\right]^{-1} S_1 \end{aligned} \tag{42}$$

$$\text{at } k = 2 \ldots K - 1, \qquad \begin{aligned} H_k &= \left[A_k^o - A_k^- H_{k-1}\right]^{-1} A_k^+ \\ Q_k &= \left[A_k^o - A_k^- H_{k-1}\right]^{-1} \left[A_k^- Q_{k-1} + S_k\right] \end{aligned} \tag{43}$$

$$\text{at } k = K, \qquad Q_k = \left[A_k^o - A_k^- H_{k-1}\right]^{-1} \left[A_k^- Q_{k-1} + S_k\right] \tag{44}$$

The second step, the backward substitution, is

$$\text{at } k = K, \qquad a_k = Q_k \tag{45}$$

$$\text{at } k = K - 1 \ldots 1, \qquad a_k = Q_k + H_k a_{k+1} \quad . \tag{46}$$

Scaling and Differencing

The realities of computer arithmetic can lead to two problems with the synthesis equations. The first occurs when numbers generated during the calculation exceed the maximum or minimum magnitudes allowed by the computer. This can happen during the inversion of Eq. (37) when the normalizations of the expansion functions are unusually large (or small) and/or when the spectra of the expansion functions span too many orders of magnitude. Matrix inversion routines which calculate the determinant are especially vulnerable. This is simply a problem with normalization; when it occurs there is probably nothing fundamentally wrong with the synthesis calculation.

The second problem, linear dependence, was very early recognized as a potential nuisance,[7] but to our knowledge it has never caused much difficulty. If a set of expansion functions in one group is "almost" linearly dependent the inversion of Eq. (37) will fail. The best defense against this, of course, is to know enough about the expansion functions to avoid this situation by dropping superfluous group fluxes from one or more expansion functions (an option available in SYN3D).

As insurance against either of these two problems arising, a transformation is performed on Eq. (37) during its solution. The transformation has the effect of a change of variables from the original synthesis approximation

$$\phi^g_{ijk} = \sum_{n=1}^{N} a^g_{nk} H^g_{nij} \quad , \tag{47}$$

where H^g_n is the input expansion function, to

$$\phi^g_{ijk} = \sum_{n=1}^{N} b^g_{nk} G^g_{nij} \quad , \tag{48}$$

where the transformed expansion functions, G^g_n, are defined

$$G^g_{1ij} = H^g_{1ij} / s^g_1 \quad , \tag{49}$$

$$G^g_{nij} = (H^g_{nij} / s^g_n) - (H^g_{1ij} / s^g_1) \quad , n = 2 \ldots N \quad . \tag{50}$$

s^g_n is a scaling factor used to change the normalization. At each axial mesh interval and in each group this transformation has the effect of: (1) renormalizing whichever expansion function has been designated n = 1 (Eq. (49)), and (2) renormalizing and differencing the other functions with respect to the first (Eq. (50)). This differencing scheme is a sort of poor man's orthogonalization.

The relationships between the original and transformed combining coefficients are

$$b^g_1 = s^g_1 a^g_1 + \sum_{n=2}^{N} b^g_n \tag{51}$$

$$b^g_n = s^g_n a^g_n \ , n = 2 \ldots N \quad , \tag{52}$$

$$a^g_1 = (b^g_1 - \sum_{n=2}^{N} b^g_n) / s^g_1 \quad , \tag{53}$$

$$a^g_n = b^g_n / s^g_n \quad , \quad n = 2 \ldots N \quad . \tag{54}$$

The transformation of the matrices in Eq. (37) is governed by

$$\sum_{g=1}^{G} \sum_{n=1}^{N} A_{mn}^{g'g} a_n^g = \sum_{g=1}^{G} \sum_{n=1}^{N} B_{mn}^{g'g} b_n^g \tag{55}$$

where A represents any of the matrices (A^-, A^+ or A^o) operating on the combining coefficients and B represents a transformed matrix. The relationships between A and B are

$$B_{m1}^{g'g} = A_{m1}^{g'g} / s_1^g \quad , \tag{56}$$

$$B_{mn}^{g'g} = (A_{mn}^{g'g} / s_n^g) - (A_{m1}^{g'g} / s_1^g) \quad , n = 2 \ldots N \quad , \tag{57}$$

$$A_{m1}^{g'g} = s_1^g B_{m1}^{g'g} \quad , \tag{58}$$

$$A_{mn}^{g'g} = s_n^g (B_{mn}^{g'g} + (A_{m1}^{g'g} / s_1^g)) \quad , n = 2 \ldots N \quad . \tag{59}$$

The scaling factors, s_n^g, used were taken from the set of axial leakage integrals, Eq. (25).

$$s_n^g = D_{m'mk} \tag{60}$$

where m' is the composite index for the appropriate group and "first" weighting function, H_1^{*g}, and m is the composite index for the same group and n'th function. This choice was made because (1) the integrals $D_{m'mk}$ were available and (2) the elements of the transformed matrices in the synthesis equations were on the order of unity.

E. Other Calculations

Multichannel Synthesis

Multichannel synthesis is an extension of the single-channel approximation in which different combining coefficients are assigned to an expansion function in separate regions of the x-y plane.[15] The multichannel trial function can be written,

$$\phi_{ijk}^g = \sum_{n=1}^{N} \sum_{c=1}^{C_n} a_{nck}^g f_{ncij}^g H_{nij}^g \quad . \tag{61}$$

Equation (61) differs from Eq. (11) by the additional summation over the index c (for "channel") and the multichannel basis functions f_{nc}^g. Note that Eq. (61) permits the number and definitions of the sets of basis functions to differ from one expansion function to another.

Two constraints should be placed on the choice of basis functions. The first is that the expression on the right in Eq. (61) must be single-valued for each (i, j). The second is the spatial analog to the restriction placed on the group-collapsing matrix (Eq. (15)). Because it is desirable that the planar flux shape of each expansion function, H_n^g, be recoverable from the synthesis trial function for the three-dimensional flux, ϕ^g,

$$\sum_{c=1}^{C_n} f_{ncij}^g = \text{the same value for all g, i and j.} \tag{62}$$

Our original intention was to offer multichannel synthesis as an option in SYN3D. After some experience with small test problems and large, fast-critical models we concluded that the advantage of improved accuracy was outweighed by the disadvantage of longer running times and more complex trial functions, and SYN3D was not carried beyond the single-channel stage. For experimental purposes and for special applications it is possible to perform multichannel calculations with SYN3D by factoring in the multichannel basis functions outside the code,

$$H_{nij}^g \rightarrow f_{ncij}^g \, H_{nij}^g \quad , \qquad c = 1 \ldots C_n \quad , \tag{63}$$

and treating each product, $f_{nc}^g \, H_n^g$, as a separate expansion function.

Perturbation Theory

The derivation of a perturbation theory expression for the change in an eigenvalue due to a change in the model, carried out within the framework of single-channel flux synthesis, leads to the same result one obtains with derivations based on the original difference equations. Therefore, any perturbation theory code which is based on the finite-difference equations in Eq. (1) can be used with fluxes and adjoints calculated with SYN3D. It is important to remember, however, that a different interpretation must be given the results. A perturbation theory calculation based on synthesis fluxes and adjoints answers the question "what happens to the synthesis calculation when one perturbs the model?" and not necessarily "what happens to the finite-difference calculation?"

III. USER CONSIDERATIONS

This section is a discussion of the mechanics of running SYN3D from a user's standpoint. It is mostly directed towards the ARC System SYN3D (as opposed to the stand-alone version available through the Argonne Code Center). Users who have the Code Center version should read Section V before Section III.

A. CCCC Standards and the ARC System

A number of features of SYN3D will seem strange unless one is aware of the ground rules under which the code was written. In recent years

code development supported by the Division of Reactor Research and Development of ERDA has been subject to a set of standards defined by the Committee on Computer Code Coordination (CCCC).[24] A major part of these standards is a set of definitions of a number of binary files, called standard interface files, which contain most of the data required for neutronics calculations. The ARC System of reactor analysis codes developed at Argonne has its own set of standard binary files.[25] SYN3D was written to conform to the CCCC standards but, at the same time, to be compatible with ARC System modules required in synthesis calculations at Argonne.

Table III-I lists both the ARC System and CCCC input files used by SYN3D. The ARC System SYN3D user should be aware of both sets of interface files; users of the Code Center version of SYN3D need only be concerned with the CCCC files.

The ARC System SYN3D is really the Code Center SYN3D prefaced by a translator (TRANSL) which reads ARC System files and writes the corresponding CCCC standard interface files. Output files generated by both versions of SYN3D are all in the CCCC formats.

B. Basic Input Requirements

Expansion Functions

The expansion functions, H_n^g, in Eq. (11), used in each synthesis calculation must be calculated in separate jobs; SYN3D does not compute expansion functions. Some suggestions of guidelines for choosing expansion functions based on Argonne's experience with LMFBR calculations are given in Section III-H.

The ARC System SYN3D user supplies a number of expansion functions in either ARC System form (FR.D1, FR.D2, FA.D1 and/or FA.D2), CCCC form (RTFLUX and/or ATFLUX) or a mix of the two. The several functions are differentiated by the CCCC device of a file version number. The current ARC System Standard Path for SYN3D (STP018) permits up to 10 flux files in the ARC System format (FR.D1, etc.). The ARC System SYN3D and Standard Path does not distinguish between flux and adjoint files (e.g. FR.D2 vs. FA.D2). The Code Center SYN3D permits 10 flux (RTFLUX) files and five adjoint (ATFLUX) files.

The user controls the version number of the expansion and weighting functions by his assignment of each file to a logical unit number. In the SYN3D input (SYNFIL) he/she refers to a particular expansion or weighting function by its CCCC designation (e.g. RTFLUX, version number five), even though he/she may have supplied the file in an ARC System format (FR.D2, version number five).

Cross Sections

SYN3D follows the practice of most ARC System neutronics calculations of permitting cross section input in either microscopic or macroscopic form. Microscopic cross sections in the ARC System Standard Path STP018 are in XS.ISO files, and the compositions are defined by the type 13 and 14 cards of the BCD file A.NIP.[25]

TABLE III-1. ARC System and CCCC Input Files for SYN3D. These are not all required; some are generated by SYN3D or its ARC System Standard Path, and others may never be needed at all

ARC System BCD	ARC System Binary	CCCC Binary	Contents
	GEOM	GEODST	Model Geometry
A.NIP	BC		
	B.HOMOG	NDXSRF ZNATDN	Composition Definitions
	XS.ISO	ISOTXS	Microscopic Cross Sections
	XS.C.MIN COMPXS*	COMPXS*	Macroscopic Cross Sections
SYNFIL	SYNCON*	SYNCON*	SYN3D Control Data
	FR.D1 FR.D2	RTFLUX	Flux Files
	FA.D1 FA.D2	ATFLUX	Adjoint Flux Files

*COMPXS and SYNCON are code-dependent, binary files which are not officially part of either the ARC or CCCC Systems.

STP018 uses the module HOMOG to create the macroscopic cross section file XS.C.MIN, and the ARC System-to-CCCC translator in SYN3D, TRANSL, converts XS.C.MIN to COMPXS. Either XS.C.MIN or COMPXS can be input directly, in which case the preceding steps in the cross section generation procedure will be skipped. COMPXS can accommodate directional diffusion coefficients and "power" cross sections; otherwise it is similar to XS.C.MIN.

The Code Center version of SYN3D can run either from the CCCC microscopic cross section and composition files ISOTXS, NDXSRF and ZNATDN or from the macroscopic cross section file COMPXS. In the first case the SYN3D overlay HMG4C will create a COMPXS file.

Geometry

SYN3D builds up a three-dimensional model of a reactor by stacking user-supplied two-dimensional planes. This approach was chosen for two reasons:

(1) At the time SYN3D was started, Argonne had no user-oriented, three-dimensional geometry input processor. We did have a well established, one- and two-dimensional input processor in the ARC System module GNIP.[26]

(2) The user was going to have to set up two-dimensional geometries for the expansion function calculations anyway, and it would be convenient if he/she could simply reuse that data without changes.

The ARC System input procedure is particularly suited to generating a series of two-dimensional geometry descriptions. STP018 looks for a BLOCK=GEOM card. If it finds one it expects there to be an A.NIP data set specified for a plane. GNIP processes the A.NIP data to a pair of GEOM and BC files (version number 1) and TRANSL converts them to a GEODST file (again, version number 1). STP018 then looks for another BLOCK=GEOM and a corresponding A.NIP for the next planar geometry description (this time producing a GEODST, version number 2). This procedure continues until all the BLOCK=GEOM data blocks are processed. What makes this scheme convenient is that while the first BLOCK=GEOM must contain a complete A.NIP (DATASET=A.NIP), subsequent blocks need only contain the type 15 cards unique to that plane (MODIFY=A.NIP). The manner in which the two-dimensional planes are stacked to form a three-dimensional model is specified in the SYN3D BCD input file SYNFIL.

It is possible to input a three-dimensional GEODST instead of several two-dimensional files. If the SYN3D BCD file SYNFIL does not specify an axial mesh or a stacking of planes (card types 4 and 5) the code interprets the version 1 GEODST to be a description of the full model and breaks it up into a number of two-dimensional GEODST's (version numbers 2, 3, etc.). This will only work when the expansion functions are also input in CCCC formats (RTFLUX and ATFLUX). This restriction is due to the translator TRANSL, and this mode of input only works when there is no geometry or flux file translation required.

In describing the geometry input we have been using the example of three-dimensional models. The same input procedure works for two-dimensional models built up from one-dimensional "planes".

Code Dependent Input - SYNFIL

The special BCD input required by SYN3D is defined by the BCD file SYNFIL. Appendix D is a file description for SYNFIL. SYNFIL must be included in the ARC System input in a data block BLOCK=SYN3D.

C. Running the ARC System SYN3D - ARCP018

The catalogued procedure for SYN3D on the Argonne 370/195 is ARCP018. The procedure is listed in Appendix C. ARCSP018 executes the synthesis Standard Path STP018, which is listed in Appendix B and discussed briefly in Section IV.

Input and Output Data Sets

Table III-2 lists all the input and output data sets that are of interest to users. Besides the files already mentioned in Section III-B the list includes the direct and adjoint combining coefficient files DCCOEF and ACCOEF, the pointwise power density PWDINT, the composition-averaged flux file RZFLUX and the synthesis integral library files INTTOC, VOLINT and DIFINT. Scratch data sets are discussed in Section IV.

File descriptions for the data sets listed in Table III-2 can be found in one of three places:

For the following ARC System Files see ANL-7711 (Ref. 25)
GEOM, BC, FR.D1, FR.D2, FA.D1, FA.D2, XS.C.MIN, A.NIP, XS.ISO

For the following CCCC Standard Interface Files see Appendix I.
GEODST, RTFLUX, ATFLUX, PWDINT, RZFLUX

For the following code-dependent files see Appendices D and E.
SYNFIL, COMPXS, INTTOC, VOLINT, DIFINT, DCCOEF, ACCOEF

Job Control and Symbolic Parameters

The SYN3D catalogued procedure ARCSP018 (see Appendix C for listing) is designed for the convenience of users operating from ARC System data sets. Table III-2 lists the symbolic parameters available and their default values.

Sample Input

Figure III-1 is a listing of an input deck. The problem it represents is Sample Problem 3 of the Code Center SYN3D package (see Section V-E), a three-dimensional model with control rods. There are six BLOCK=GEOM data blocks defining rodded and unrodded core, blanket and reflector planes. The four expansion functions are in the FR.D2 format, and the cross sections are generated from an XS.ISO file.

TABLE III-2. ARC SYN3D Input and Output Data Set Names and Job Control Substitution Symbolic Parameters

			Job Control Substitution					
			Symbolic Parameter			Default		
Logical Unit Number	Data Set Name, Version Number	DATASET*	Data Set Name	Disposition	Volume	Data Set Name	Disposition	Volume****
11	GEOM, 1	GEOM01	GEOM01	GEDSP01	GEVOL01	&GEOM01	(NEW, DELETE)	
12	GEOM, 2	GEOM02	GEOM02	GEDSP02	GEVOL02	&GEOM02	(NEW, DELETE)	
.	.	.	.	.	.	.	.	
.	.	.	.	.	.	.	.	
.	.	.	.	.	.	.	.	
20	GEOM, 10	GEOM10	GEOM10	GEDSP10	GEVOL10	&GEOM10	(NEW, DELETE)	
21	GEODST, 1	GEOD01						
.	.	.						
.	.	.						
30	GEODST, 10	GEOD10						
31	BC, 1	BC01	BC01	BCDSP01	BCVOL01	&BC01	(NEW, DELETE)	
.	.	.	.	.	.	.	.	
.	.	.	.	.	.	.	.	
40	BC, 10	BC10	BC10	BCDSP10	BCVOL10	&BC10	(NEW, DELETE)	
41	FR.D2, 1**	FLUX01	FLUX01	FLDSP01	FLVOL01	NULLFILE	(OLD, KEEP)	
.	.	.	.	.	.	.	.	
.	.	.	.	.	.	.	.	
50	FR.D2, 10**	FLUX10	FLUX10	FLDSP10	FLVOL10	NULLFILE	(OLD, KEEP)	
51	RTFLUX, 1	RTFL01						
.	.	.						
.	.	.						
60	RTFLUX, 10	RTFL10						
61	SYNFIL, 1	SYNFIL						
62	COMPXS, 1	COMPXS						
65	INTTOC, 1	INITC1	INTTOC1	TOCDSP1	TOCVOL1	NULLFILE	(OLD, KEEP)	
66	INITOC, 2	INITC2	INITOC2	TOCDSP2	TOCVOL2	&INTTOC2	(NEW, DELETE)	
67 (file 1)	XS.C.MIN, 1***	XS.C.MIN	COMPXS1	CXSDISP	CXSVOLM	&XSCMIN1	(NEW, DELETE)	
67 (file 2)	"	"	COMPXS2	"	"	&XSCMIN2	"	
68	VOLINT, 1	VOLIN1	VOLINT1	VNTDSP1	VNTVOL1	NULLFILE	(OLD, KEEP)	
69	VOLINT, 2***	VOLIN2	VOLINT2	VNTDSP2	VNTVOL2	&VOLINT2	(NEW, DELETE)	
70	DIFINT, 1	DIFIN1	DIFINT1	DNTDSP1	DNTVOL1	NULLFILE	(OLD, KEEP)	
71	DIFINT, 2***	DIFIN2	DIFINT2	DNTDSP2	DNTVOL2	&DIFINT2	(NEW, DELETE)	
74	DCCOEF, 1	DCCOEF	DCCOEF	DCCDSP	DCCVOL	&DCCOEF	(NEW, DELETE)	
75	ACCOEF, 1	ACCOEF	ACCOEF	ACCDSP	ACCVOL	&ACCOEF	(NEW, DELETE)	
77	A.NIP, 1	A.NIP						
79 (file 1)	XS.ISO, 1	XS.ISO	MICRXS1		MICRVOL	NULLFILE	(OLD, KEEP)	
79 (file 2)	"	"	MICRXS2		"	NULLFILE	"	
91	ATFLUX, 1	ATFLUX						
92	PWDINT, 1	PWDINT						
93	RZFLUX, 1	RZFLUX						

*"DATASET" is the name of the file as it should be spelled when specified under BLOCK=OLD, BLOCK=GEOM or BLOCK=SYN3D.

**FLUX01 through FLUX10 can also be used for FR.D1, FA.D1 and FA.D2 files. FR.D2 is shown above only as an example

***The following symbolic parameters are associated with certain of the above files. They did not fit conveniently into the table and are included here.

Logical Unit Number	Data Set Name, Version Number	Symbolic Parameter	Default	Description
67 (file 1)	XS.C.MIN, 1	CXSBLK1	1028	BLKSIZE
67 (file 2)	"	CXSBLK2	6136	BLKSIZE
69	VOLINT, 2	LIBBLK2	12280	BLKSIZE
71	DIFINT, 2	"	"	"
		HALFBLK	6136	Half Track BLKSIZE
		QRTRBLK	3064	Quarter Track BLKSIZE
		UNITS	BATCKDSK	Units Parameter

****All default volume designations are blank, implying old data set on

FIGURE III-1. ARC SYSTEM SYN3D INPUT DECK. THE THREE-DIMENSIONAL MODEL IS BUILT UP FROM TWO-DIMENSIONAL A.NIP DATA SETS.

```
//SYN3D EXEC ARCSP018,
//      FLUX01='C116.B21006.TEST3D.FRD2.COREU',
//      FLUX02='C116.B21006.TEST3D.FRD2.COREB',
//      FLUX03='C116.B21006.TEST3D.FRD2.BLANU',
//      FLUX04='C116.B21006.TEST3D.FRD2.BLANB',
//      FLVOL01=DISK98,FLVOL02=DISK98,FLVOL03=DISK98,FLVOL04=DISK98,
//      MICRXS1='C116.B21006.XSISO1.THRGRP',
//      MICRXS2='C116.B21006.XSISO.THRGRPF2'
//SYSIN DD *
BLOCK=OLD
DATASET=XS.ISO
DATASET=FLUX01
DATASET=FLUX02
DATASET=FLUX03
DATASET=FLUX04
BLOCK=GEOM
DATASET=A.NIP
01          TEST3D, UNRODDED REFLECTOR PLANE
02              0      0  3000    -1  3000    -1      0      1
03             40
04              3      2      3      2
06    REFL            0.0        115.0                        0.0        115.0
06    BLAN            0.0         95.0                        0.0         95.0
06    CORE2           0.0         75.0                        0.0         75.0
06    CORE1           0.0         55.0                        0.0         55.0
06    ROD1            0.0          5.0                        0.0          5.0
06    ROD2            0.0          5.0                       65.0         75.0
06    ROD3           65.0         75.0                       65.0         75.0
06    ROD4           45.0         55.0                       45.0         55.0
06    ROD5           65.0         75.0                        0.0          5.0
09         Y      1           5.     11        115.
09         Y      1           5.     11        115.
14          C1     PU239       0.0011U 238       0.0064NA 23       0.0104
14          C1     FE          0.01810  16       0.0149
14          C2     PU239       0.0015U 238       0.0054NA 23       0.0110
14          C2     FE          0.01810  16       0.0139
14          AB     U 238       0.0080NA 23       0.0088FE          0.0244
14          AB     O  16       0.0160
14          RB     U 238       0.0145NA 23       0.0066FE          0.0173
14          RB     O  16       0.0290
14          RE     NA 23       0.0044FE          0.0691
14          RD     NA 23       0.0104FE          0.01810  16       0.0149
14          RD     B10I        0.0090C12I        0.0412
14          RC     NA 23       0.0220
15    RC    ROD1   ROD2  ROD3  ROD4  ROD5
15    RE    REFL   BLAN  CORE1  CORE2
BLOCK=GEOM
MODIFY=A.NIP
01          TEST3D, UNRODDED BLANKET PLANE
15    RC    ROD1   ROD2  ROD3  ROD4  ROD5
15    RE    REFL
15    AB    BLAN   CORE1  CORE2
```

FIGURE III-1. ARC SYSTEM SYN3D INPUT DECK. CONTINUED.

```
BLOCK=GEOM
MODIFY=A.NIP
01            TEST3D, UNRODDED CORE PLANE
15     RC     ROD1  ROD2  ROD3  ROD4  ROD5
15     RE     REFL
15     RB     BLAN
15     C1     CORE1
15     C2     CORE2
BLOCK=GEOM
MODIFY=A.NIP
01            TEST3D, RODDED CORE PLANE
15     RD     ROD1  ROD2  ROD3  ROD4  ROD5
15     RE     REFL
15     RB     BLAN
15     C1     CORE1
15     C2     CORE2
BLOCK=GEOM
MODIFY=A.NIP
01            TEST3D, RODDED BLANKET PLANE
15     RD     ROD1  ROD2  ROD3  ROD4  ROD5
15     RE     REFL
15     AB     BLAN  CORE1  CORE2
BLOCK=GEOM
MODIFY=A.NIP
01            TEST3D, RODDED REFLECTOR PLANE
15     RD     ROD1  ROD2  ROD3  ROD4  ROD5
15     RE     REFL  BLAN  CORE1  CORE2
BLOCK=SYN3D
DATASET=SYNFIL
01     3 GROUP, 3-DIMENSIONAL MODEL, FLUX WEIGHTED SYNTHESIS
01          BLANKET FUNCTIONS (3 AND 4) NOT USED EVERYWHERE
01          3D GEOMETRY BUILT UP FROM 2D GEODST FILES
02         10     1    20                                1     1
03                   1.00                        10.0
04               20        200.0
05                1                  0.          20.
05                2                 20.          60.
05                3                 60.         100.
05                4                100.         140.
05                5                140.         180.
05                6                180.         200.
07     RTFLUX     1                 0.0        200.0
07     RTFLUX     2                 0.0        200.0
07     RTFLUX     3                  0.          80.
07     RTFLUX     4                120.         200.
16                                                 1
17          1     2     3
19          1    10     2    10     3    10
21         10
/*
```

D. Multiple Problems and Restarts

For most problems the most expensive part of a SYN3D calculation is generating the integrals (Eqs. (24) and (25)) which form the coefficients of the synthesis equations. If the same integrals can be used for a number of synthesis calculations the user can save a significant amount of time.

Mutliple Problems

The simplest way to reuse integrals is to run several problems in a single job. The ARC System SYN3D does this automatically by looping on BLOCK=SYN3D data blocks. A problem defined by a second BLOCK=SYN3D uses integrals generated under the first BLOCK=SYN3D, calculating additional integrals if required. The output flux file from each loop can be saved by specifying different version numbers for the output RTFLUX (see SYNFIL card type 16). Only the last set of combining coefficients can be saved, however, since SYN3D always writes them to DCCOEF version number 1.

This multiple pass feature is not available in the Code Center SYN3D. Code Center SYN3D users will have to use the more formal restart procedure described in the next paragraph.

Restarts - INTTOC, VOLINT and DIFINT

The integrals SYN3D calculates are stored in a library consisting of three files: INTTOC, VOLINT and DIFINT. SYN3D always writes these files with a version number of 2. If these files are input with a version number of 1 the code will merge the old integrals with whatever integrals it still must calculate before writing the output libraries. The version 1 files are not changed.

File descriptions for the library files are in Appendix E. INTTOC is a short file containing the table of contents for VOLINT and DIFINT as well as the general problem data. DIFINT contains the integrals associated with the axial leakage, $D_{m'mk}$ (Eq. (25)). VOLINT contains four types of integrals which are referred to in the coding and in the SYN3D output as REM, FIS, POW and FLUX. REM and FIS are, respectively, the removal and fission components of $R_{m'mk}$ (see Eqs. (24) and (36)). POW is the planar power integral,

$$POW^b_{nk} = \sum_{g=1}^{G} u^{gb} \sum_{i=1}^{I} \sum_{j=1}^{J} \Delta x_i \, \Delta y_i \, p^g_{ijk} \, H^g_{nij} \quad . \tag{64}$$

where p^g_{ijk} is a "power" cross section supplied in the COMPXS file. Eq. (64) is written for an x-y plane; one can obtain the expression for other geometries by replacing $\Delta x_i \, \Delta y_j$ by the appropriate volume element. The FLUX integral is, as one might guess,

$$FLUX^b_n = \sum_{g=1}^{G} u^{bg} \sum_{i=1}^{I} \sum_{j=1}^{J} \Delta x_i \, \Delta y_j \, H^g_{nij} \quad . \tag{65}$$

The index b refers to a collapsed group. Recall that when group collapsing is not used u^{gb} is the Kronecker delta (u^{gb} = 1 when g = b, = 0 otherwise).

One can restart SYN3D to do another synthesis calculation or simply to obtain further edits for a problem run previously. In the latter case DCCOEF and/or ACCOEF must be among the input data sets.

SYN3D cannot be restarted in the middle of the synthesis integral calculation or the middle of the solution routine. If the job terminates before completing one of those two stages, that particular stage must be repeated.

E. Edits and Output Options

SYN3D has some standard edits, over which the user has no control, and some optional edits. Appendix H contains output from the sample problems in the Code Center package (Section V-E).

Standard Output

SYN3D always lists the SYNFIL input data and two pages describing the model and synthesis trial function (in terms of CCCC files). When logarithmic boundary conditions are used the constants C_1 and C_2 listed in the edits refer to Eq. (2) in Section II.

$$C_1^g D^g \hat{n} \cdot \nabla \phi^g + C_2^g \phi^g = 0. \tag{2}$$

In addition, SYN3D edits the integral tables of contents, the eigenvalue and the combining coefficients (a_{nk}^g).

The standard output files are:

INTTOC, 2
DIFINT, 2
VOLINT, 2
DCCOEF, 1 (for a direct solution)
ACCOEF, 1 (for an adjoint solution)

Optional Output

SYNFIL card type 16 through 21 specify output options. Flux and adjoint edits may be specified by group and plane. Pointwise power density edits may be requested by plane. SYN3D will also edit the composition-averaged group fluxes (the contents of the RZFLUX file) and the perturbation theory denominator,

$$\sum_{g=1}^{G} \sum_{g'=1}^{G} \sum_{i=1}^{I} \sum_{j=1}^{J} \sum_{k=1}^{K} \phi_{ijk}^{*g} \chi^g \nu\Sigma_f^{g'} \phi_{ijk}^{g'} V_{ijk}. \tag{66}$$

where the symbols were defined for Eqs. (1) and (6).

The optional output files are:

RTFLUX, N	(N specified by user)
ATFLUX, N	(N specified by user)
PWDINT, N	(N specified by user)
RZFLUX, N	(N specified by user)
GEODST, N	(N specified by user)

The output, three-dimensional (or two-dimensional) GEODST file may be useful when the input geometry has been specified by a set of two-dimensional (or one-dimensional) GEODST files.

Combining Coefficient Plots

SYN3D will edit printer plots of the axial power distribution,

$$(\text{power})_k = \sum_{n=1}^{N} \sum_{b=1}^{G'} POW_{nk}^{b} \, a_{nk}^{b} \quad , \tag{67}$$

and the axial group fluxes (after group collapsing)

$$(\text{flux})_k^b = \sum_{n=1}^{N} FLUX_n^b \, a_{nk}^b \quad . \tag{68}$$

POW_{nk}^b and $FLUX_n^b$ are defined by Eqs. (64) and (65). The plots show the totals (Eqs. (67) and (68)) as well as the modal components (for each n). The output from Sample Problem 3 in Appendix H shows one of these plots.

F. Error Messages

Errors caught by SYN3D during execution are identified by subroutine name and an error number. Appendix F is a complete list. Non-fatal errors (positive error numbers) are flagged but never cause the termination of a run; they are frequently anomalies in the input which suggest user errors. Fatal errors will not cause the job to terminate immediately; SYN3D will continue as far as it can before forcing an abnormal termination through subroutine ERROR.

G. Storage Requirements and Running times

Data storage during a SYN3D calculation is managed dynamically through the BPOINTER routines (see Section IV-C for a description of BPOINTER). The BPOINTER storage container size required on input card type 3 of data set SYNFIL should be set as large as practical for models of any significant size. SYN3D keeps in-core as much data as it can in order to minimize I/O time and makes use of all the container it is given. A very rough guess at the minimum size required is the largest of the three expressions given below:

$$5000 + 70 \cdot G + 7 \cdot G^2, \qquad 2 \cdot I \cdot J,$$

$$\text{or } 5000 + 7 \cdot (N \cdot G)^2 \quad . \tag{69}$$

G is the number of groups, I is the number of first-dimension mesh intervals, J is the number of second-dimension mesh intervals, and N is the maximum number of expansion functions used simultaneously at any one axial mesh interval. Users of the CDC version of the Code Center SYN3D may run into trouble at about $N \cdot G = 50$. Some coding changes are suggested in Section V-F which will alleviate the problem.

Running time can vary dramatically, depending on the complexity of the model and the synthesis scheme used. The time required to do the integrals is proportional to the square of the number of groups (before group collapsing), the number of planar mesh points, the number of different axial zones, and the square of the number of expansion functions. The time for the solution of the synthesis equations is proportional to the number of iterations, the number of axial mesh intervals, the cube of the number of groups (after group collapsing) and the cube of the number of expansion functions.

Table III-3 shows running times for two fast critical assembly models.

H. Applications of Synthesis

Choosing Expansion Functions

The choice of expansion functions is very important to the success of the synthesis approximation, but we will touch on that subject only very briefly in this report. The experiences of many users can be found in the Refs. 7, 9, 16, 19, 20, 27-30. We will summarize here some of Argonne's recent experience with SYN3D calculations of fast critical assemblies.[27-29]

We have settled on different prescriptions for high-reactivity (core) and low-reactivity (blanket and reflector) planes of a model. For high-reactivity planes the best choices are critically buckled, eigenvalue calculations. It is not necessary to fine-tune the buckling to force the two-dimensional eigenvalue to be exactly that expected for the three-dimensional model; 1% or 2% differences are probably close enough. We have tried expansion functions which are calculated with group- and region-dependent bucklings determined from an r-z model; synthesis calculations based on these expansion functions give better results than calculations based on uniformly buckled expansion functions, but the advantages are probably outweighted by the nuisance of setting up the extra r-z model. Our current practice is to choose a single, constant buckling,

$$B^2 = (\pi/L)^2 \quad , \tag{70}$$

based on an effective unreflected core height, L, which is within 10 cm. of the value that would be required to get the expected critical eigenvalue.

TABLE III-3. ARC System SYN3D Running Times and Storage Requirements for Two Fast Critical Assembly Models on the IBM 370/195. The GCFR Model was Run at Two Different Container Sizes

Model	GCFR		ZPPR3
Groups	11		28
Spatial Mesh (x-y-z)	25 x 27 x 18		54 x 25 x 22
Axial Zones	4		3
Expansion Functions	2		3
Iterations	5		4
BPOINTER Container	40,000	8,000*	60,000
REGION Size (K-bytes)	650	375	800
CP Time (min)	0.9	0.9	8.9
WAIT Time (min)	1.7	2.4	3.3
Total Time (min)	2.6	3.3	12.2

*This was the minimum container size, rounded to the next 1000 words, for which the GCFR model would run.

For low-reactivity planes such as a blanket zone, or no-reactivity planes like a reflector, an eigenvalue calculation is a poor (or even impossible) way to generate characteristic planar shapes. Our current practice is to obtain expansion functions from inhomogeneous calculations in which the fixed source is the product of the diffusion coefficient in the zone of interest times the expansion function characteristic of the adjacent, higher-reactivity plane. The philosophy behind this choice is that the most important source of neutrons in a low-reactivity plane is the leakage from a high-reactivity plane, and that leakage source is roughly proportional to:

(1) the neutron distribution in the high-reactivity plane, and

(2) the ability of neutrons to diffuse into the low-reactivity plane.

We have applied this prescription almost entirely to axial blankets; we are not usually so interested in reflector zones that it is necessary to supply a reflector expansion function.

Blanket Functions - STP016, AJC10 and ARCSP016

An ARC System Catalogued Procedure, ARCSP016, and Standard Path, STP016, have been written to set up a fixed source for a subsequent DIF1D or DIF2D calculation of a low-reactivity expansion function. ARCSP016 is listed in Appendix J, and STP016 is listed in Appendix K. Basically, STP016 calls the usual ARC System geometry and cross section processing modules to generate GEOM and XS.C.MIN files and then calls the module AJC010. AJC010 multiplies an input flux distribution (FR.D1 or FR.D2) by the local diffusion coefficients and writes a fixed source file (ES.D1D or ES.D2D). The symbolic parameters for ARCSP016 are listed in Appendix J.

An ARCSP016 job step is usually followed immediately by an ARCSP001 (DIF1D) or ARCSP003 (DIF2D) job step. Figure III-2 shows an input deck for calculating a blanket function for the sample problems described in Section V-E. Quirks in the DIF2D Standard Path make it necessary to include a type 19 card in A.NIP (even though the data on that card is not used) and to include DATASET=ES.D2SH in the DIF2D BLOCK=OLD (even though no such data set exists). Note that the A.NIP created in the first step is passed to the second.

IV. CODE STRUCTURE AND PROGRAMMING CONSIDERATIONS

This section describes the structure of SYN3D from a programmer's standpoint. It is a survey of the several distinct code blocks making up SYN3D and is intended as an aid to users who wish to make changes to the code or who wish to understand the flow of the calculation.

A. The ARC System SYN3D

The differences between the Code Center SYN3D and the ARC System SYN3D are in operating environment; the bulk of the coding (specifically,

FIGURE III-2. INPUT FOR A BLANKET EXPANSION FUNCTION CALCULATION USING ARCSP016 AND ARCSP03 (DIF2D).

```
//STEP2 EXEC ARCSP016,
//      COMPXS1='C116.B21006.TEST3D.XSCMIN.F1',
//      COMPXS2='C116.B21006.TEST3D.XSCMIN.F2',
//      CXSDISP='(OLD,KEEP)',CXSVOLM=DISK98,
//      FLUX2D='C116.B21006.TEST3D.FRD2.CORFU',FLUXVOL=DISK98
//SYSIN DD *
BLOCK=OLD
DATASET=FR.D2
DATASET=XS.C.MIN
BLOCK=STP016
DATASET=A.NIP
01          TEST3D, UNRODDED BLANKET PLANE
02               0      0  3000    -1  3000    -1      0      1
                            .
                            .
                            .
                            .
15    AB     BLAN  CORE1  CORE2
15    BC     ROD1  ROD2  ROD3  ROD4  ROD5
19         0REFL                              1.0
/*
//STEP3 EXEC ARCSP003,
//      COMPXS1='C116.B21006.TEST3D.XSCMIN.F1',
//      COMPXS2='C116.B21006.TEST3D.XSCMIN.F2',
//      CXSDISP='(OLD,KEEP)',CXSVOLM=DISK98,
//      MICRXS1=NULLFILE,
//      MICRXS2=NULLFILE,
//      REALFLX='C116.B21006.TEST3D.FRD2.BLANU',
//      REALVOL=DISK98,
//      REALDSP='(OLD,KEEP)'
//FT19F001 DD DSN=&ANIP,UNIT=SASCR,DISP=(OLD,DELETE)
//FT36F001 DD DSN=&ESD2D,DISP=(OLD,DELETE),VOL=SER=SCR001
//FT54F001 DD DISP=(OLD,DELETE),UNIT=3330,VOL=SER=SCR001
//SYSIN DD *
BLOCK=OLD
DATASET=A.NIP
DATASET=XS.C.MIN
DATASET=ES.D2D
DATASET=ES.D2SH
BLOCK=STP003
DATASET=A.DIF2D
01          TEST3D, UNRODDED BLANKET PLANE
01               0      0      0      3      1      5      0      1
01                                             1      1             1
02
03                     1      3      3      8      3  30000      0
04               1.0E-5       1.0E-5       1.0E-5          0.0          0.0
05            300      1      3      3      8      3
06               1.0E-8          0.0          0.0
DATASET=A.PDIF2D
01         4      0            0
/*
```

the overlays CARDS, INTEG, SOLVE and EDITS) is identical. The ARC System synthesis Standard Path, STP018, calls a number of modules (among them SYN3D) in performing a synthesis calculation; the Standard Path and associated, additional ARC System modules have not been included in the Code Center SYN3D package.

STP018

Appendix B is a listing of the ARC System synthesis Standard Path, STP018. In addition to the SYN3D module, which is designated NUC012 in the ARC System, STP018 may execute one or more of the following modules:

NUI001	The cross section homogenization input processor.
NUC001	Cross section homogenization.
NUI004	Triangular mesh geometry input processor.
NUI002	General geometry input processor.

File Definitions

The ARC System SYN3D uses ARC System files, Version III CCCC files and a number of scratch files. The ARC System and CCCC files are discussed in Section III of this report. The official definitions of the required Version III CCCC files are given in Appendix I along with a discussion of the one instance (in a triangular mesh GEODST file) where the SYN3D requirements and the official definitions differ. Scratch files are defined in Appendix E.

B. Overlay Structure

Figure IV-1 is a diagram of the SYN3D module indicating the calling sequences of the overlays and subroutines. The Code Center version of the code does not include the TRANSL branch. The ARC System SYN3D does not contain the HMG4C branch. The functions of the main driver and each of the six primary overlays are discussed below. Table IV-1 lists each subroutine and common block and includes a brief description of functions performed.

Main Driver

The main drivers of the Code Center and ARC System versions of SYN3D differ somewhat in form but are similar in function. Each is a short routine which sets the values of a number of code dependent parameters and then calls the primary overlays which perform the synthesis calculation. In the Code Center version the main driver handles the SEEK initialization; in the ARC System this function is accomplished in the Standard Path.

TRANSL

TRANSL is a code block required in the ARC System SYN3D as an interface between ARC System files and the CCCC files that SYN3D works with.

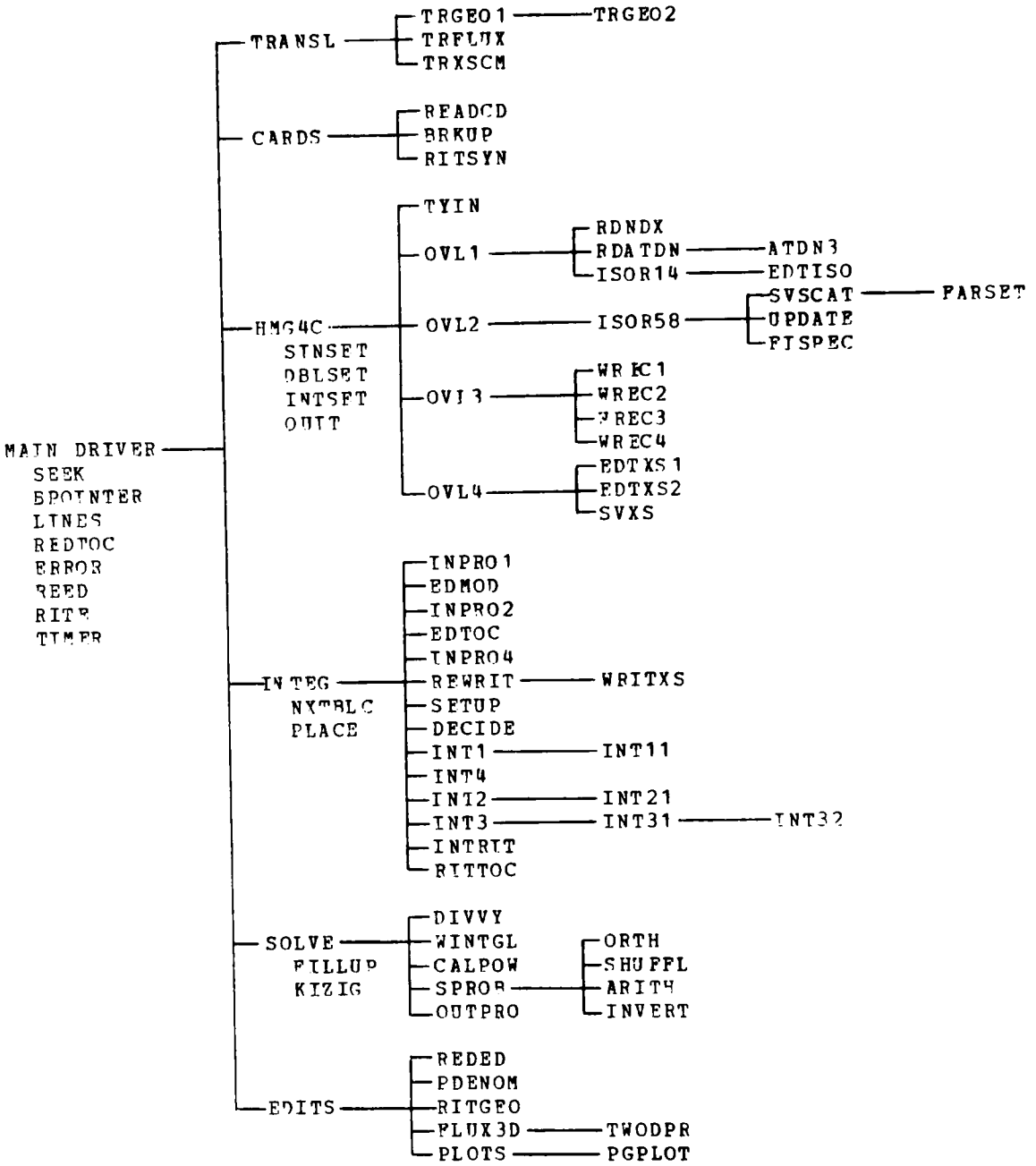


FIGURE IV-1. SYN3D PROGRAM STRUCTURE SHOWING SUBROUTINE CALLING SEQUENCES. TRANSL IS USED ONLY IN THE ARC SYN3D, HMG4C IS USED ONLY IN THE CODE CENTER VERSION. ROUTINES CALLED BY SEVERAL SUBROUTINES IN A BRANCH ARE LISTED UNDER THE BRANCH NAME. FOR EXAMPLE, SEEK IS USED THROUGHOUT THE CODE, QUIT IS CALLED BY SEVERAL SUBROUTINES IN HMG4C, ETC.

TABLE IV-1. SYN3D SUBROUTINES AND COMMON BLOCKS.

ROUTINES USED THROUGHOUT SYN3D.

BULK	BPOINTER ROUTINE, INITIALIZES BULK STORAGE (LCM).
CLEAR	BPOINTER ROUTINE, ZEROES ZRRAY.
ERROR	ERROR ROUTINE.
FREE	BPOINTER ROUTINE, RELEASES BPOINTER CONTAINER.
IPT2	BPOINTER ROUTINE, RETURNS POINTER FOR SUBARRAY.
IPTERR	BPOINTER ROUTINE, RETURNS NUMBER OF BPOINTER ERRORS.
IGET	BPOINTER ROUTINE, RETURN POINTER FOR ARRAY.
LINES	PAGE HEADINGS.
POINTR	BPOINTER ROUTINE, INITIALIZATION.
PURGE	BPOINTER ROUTINE, SHIFTS ARRAY STORAGE TO SQUEEZE OUT BLANKS.
PUTM	BPOINTER ROUTINE, RESERVES STORAGE FOR ARRAY.
REDEFM	BPOINTER ROUTINE, CHANGES STORAGE FOR ARRAY.
REDTOC	READS INTTOC FILE.
REED	READS BINARY FILES.
RITE	WRITES BINARY FILES.
SEEK	CCCC FILE MANAGER.
TIMER	RETURNS TIME, DATE, ETC.
WIPOUT	BPOINTER ROUTINE, RELEASES STORAGE FOR ARRAY.

COMMON BLOCKS.

ARRAY	REFERENCE POINT FOR BPOINTER CONTAINER.
HMGPTR	BPOINTER POINTERS FOR HMG4C.
HOWIN	IO PARAMETERS.
LINK	DATA FOR LINES.
LOCATE	BPOINTER PARAMETERS.
MASTER	GENERAL SYN3D DATA.
OUTPUT	IO PARAMETER.
POINT	BPOINTER POINTERS FOR INTEG.
POINTC	BPOINTER POINTERS FOR CARDS.
POINTE	BPOINTER POINTERS FOR EDITS.
POINTS	BPOINTER POINTERS FOR SOLVE.
REF	GENERAL HMG4C DATA.
SCAT	SCATTERING CROSS SECTION PARAMETERS FOR HMG4C.
TRAN	DATA FOR TRANSL.

TABLE IV-1. SYN3D SUBROUTINES AND COMMON BLOCKS. CONTINUED.

TRANSL - ARC TO CCCC CONVERSION (ARC SYSTEM ONLY).

TRFLUX	READS FR.D1, FR.D2, FA.D1, FA.D2, WRITES RTFLUX.
TRGEO1	READS GEOM AND BC, WRITES GEODST.
TRGEO2	TRANSLATES BOUNDARY CONDITIONS.
TRXSCM	READS 2-FILE XS.C.MIN, WRITES COMPXS.

CARDS - PROCESSES CODE-DEPENDENT, BCD DATA.

BRKUP	BREAKS 3D MODEL GEOMETRY INTO SEVERAL 2D GEODST FILES.
READCD	READS BCD CARD INPUT.
RITSYN	WRITES SYNCON FILE.

HMG4C - CREATES MACROSCOPIC CROSS SECTION FILE, COMPXS (CODE CENTER SYN3D ONLY).

ATDN3	READS ZONE ATOM DENSITIES.
DBLSET	MOVES DOUBLE-PRECISION DATA.
EDTISO	EDITS RECORDS 2 AND 3 OF ISOTXS FILE.
EDTXS1	EDITS RECORDS 1 AND 2 OF COMPXS.
EDTXS2	EDITS RECORDS 3 AND 4 OF COMPXS FOR A SINGLE COMPOSITION.
FARSET	REVERSE ORDER AND MOVE SINGLE-PRECISION DATA.
FISPEC	COMPUTES PROMPT FISSION SPECTRUM.
INTSET	MOVES INTEGER DATA.
ISOR14	READS RECORDS 1-4 OF ISOTXS FILE.
ISOR58	READS ISOTOPE-DEPENDENT ISOTXS RECORDS.
OVL1	DRIVER FOR INITIAL CROSS SECTION INPUT PROCESSING.
OVL2	DRIVER FOR MICROSCOPIC DATA PROCESSING.
OVL3	WRITES COMPXS FILE.
OVL4	EDITS COMPXS FILE.
QUIT	FATAL ERROR MESSAGE.
RDNDX	READS NDXSRF FILE.
RDATDN	READS ZNATDN FILE.
SINSET	MOVES SINGLE-PRECISION DATA.
SVSCAT	SCATTERING CROSS SECTION PROCESSING.
SVXS	PICKS UP MACROSCOPIC DATA.
TYIN	COMMUNICATION WITH THE REST OF SYN3D.
UPDATE	BUILDS UP MACROSCOPIC DATA.
WREC1	WRITES RECORD TYPE 1 OF COMPXS FILE.
WREC2	WRITES RECORD TYPE 2 OF COMPXS FILE.
WREC3	WRITES RECORD TYPE 3 OF COMPXS FILE.
WREC4	WRITES RECORD TYPE 4 OF COMPXS FILE.

TABLE IV-1. SYN3D SUBROUTINES AND COMMON BLOCKS. CONTINUED.

INTEG - CALCULATES SYNTHESIS INTEGRALS.

DECIDE	CHOOSES INTEGRALS TO BE DONE ON EACH PASS THROUGH INTEG.
EDMOD	EDITS MODEL DESCRIPTION.
EDTOC	EDITS INTEGRAL TABLE OF CONTENTS.
INPRO1	PROCESSES CODE-DEPENDENT INPUT FROM SYNCON.
INPRO2	DETERMINES WHAT INTEGRALS MUST BE CALCULATED.
INPRO4	MAKES DATA MANAGEMENT DECISIONS.
INTRIT	WRITES RECORDS OF OUTPUT INTEGRAL FILE.
INT1	CALCULATION OF SCATTERING, ABSORPTION AND FISSION INTEGRALS.
INT11	CALCULATION OF SCATTERING, ABSORPTION AND FISSION INTEGRALS.
INT2	CALCULATION OF PLANAR LEAKAGE INTEGRALS.
INT21	CALCULATION OF PLANAR LEAKAGE INTEGRALS.
INT3	CALCULATION OF AXIAL LEAKAGE INTEGRALS.
INT31	CALCULATION OF AXIAL LEAKAGE INTEGRALS.
INT32	CALCULATION OF AXIAL LEAKAGE INTEGRALS.
INT4	CALCULATION OF FLUX AND POWER INTEGRALS.
NXTBLC	RETURNS DATA REWRITE PARAMETERS.
PLACE	STORES INTEGRALS IN OUTPUT ARRAYS.
REWRIT	REWRITES FLUXES, GEOMETRY DATA AND CROSS SECTIONS.
RITTOC	WRITES INTTOC FILE.
SETUP	OPENS OUTPUT INTEGRAL FILES.
WRITXS	PROCESSES CROSS SECTIONS FOR REWRIT.

SOLVE - SETS UP AND SOLVES SYNTHESIS EQUATIONS.

ARITH	MATRIX ARITHMETIC.
CALPOW	CALCULATES TOTAL POWER.
DIVVY	MAKES DATA MANAGEMENT DECISIONS.
FILLUP	BUILD EQUATION COEFFICIENT MATRICES FROM INTGLS FILE.
INVERT	MATRIX INVERSION.
KIZIG	RETURNS AXIAL MESH DATA.
ORTH	CHANGE OF VARIABLE TRANSFORMATION OF SYNTHESIS EQUATIONS.
OUTPRO	EDITS, WRITES COMBINING COEFFICIENT FILE.
SHUFFL	SHIFTS INTEGRALS IN EQUATION COEFFICIENT MATRICES.
SPROB	DIRECTS SOLUTION OF SOURCE PROBLEM.
WINTGL	REWRITES INTEGRALS TO INTGLS FILE.

EDITS - EDIT PACKAGE.

FLUX3D	RTFLUX, ATFLUX, PWDINT AND RZFLUX EDITS AND OUTPUT FILES.
PDENOM	PERTURBATION DENOMINATOR.
PGPLOT	PRINTER PLOTTER.
PLOTS	SETS UP COMBINING COEFFICIENT PLOTS.
REDED	INPUT PROCESSOR FOR EDITS.
RITGEO	WRITES GEODST.
TWODPR	TABLE EDITS.

When there are input GEOM and BC files TRANSL translates the data into corresponding GEODST files. When there are input FR.D2 (or FR.D1) files TRANSL creates the corresponding RTFLUX files. It distinguishes between FR.D2 and FR.D1 by checking the dimensionality of the GEODST files. Finally, TRANSL rewrites the data in an input XS.C.MIN file into the COMPXS format.

CARDS

The main purpose of CARDS is to read BCD data and write the binary file SYNCON. The value of the integer variable IWHERE (defined in the main driver and transmitted to CARDS through the common block HOWIN) identifies the operating environment (ARC System or Code Center) and determines where the BCD data comes from.

In the Code Center version (IWHERE = 1) the SYN3D input, starting with the cards-per-card-type data (see section V of this report), is read from the card input file. The logical unit number of the card input file, NFLIN, is set in the main driver and transmitted to CARDS through the common block HOWIN. In the ARC System SYN3D (IWHERE = 2) the BCD input is contained in the ARC System BCD file SYNFIL. In this case the logical unit number is determined through a call to SEEK.

The subroutine READCD reads and stores all the BCD data. The subroutine RITSYN writes the SYNCON file, which is essentially a binary version of SYNFIL (see Appendix E). The first record contains a single number, the largest card type number. The second record contains the number of input cards for each card type. Each subsequent record contains the data on an input card, with the card type number (columns 1-2) omitted.

If the user wishes to install some other input procedure, CARDS can be eliminated entirely, just so long as it is replaced with some other method of generating SYNCON.

CARDS performs one other function. SYN3D normally operates with separate GEODST files for each of the planes of a model plus additional data in SYNCON specifying how the planes are to be stacked together. When a single GEODST file is input, and the "stacking" instructions (card types 4 and 5) are omitted, subroutine BRKUP converts the single input GEODST to a number of GEODST files of lower dimensionality and constructs the necessary card type 4 and 5 data before writing SYNCON.

HMG4C

HMG4C is used in the Code Center version of SYN3D to create macroscopic cross sections from input microscopic data; in the ARC System environment this calculation is performed outside the SYN3D module by the ARC System modules NUI001 and NUC001, and HMG4C is not used. HMG4C reads the three CCCC files NDXSRF, ZNATDN and ISOTXS and writes the macroscopic cross section file COMPXS (see Appendix E). When a COMPXS file is input to the code, the main driver recognizes the fact and omits the call to HMG4C.

After reading ZNATDN, NDXSRF and the isotope independent data of ISOTXS, into core HMG4C attempts to hold all the macroscopic arrays which

are to be computed in the remaining BPOINTER container space. If this is possible a single pass is made through the ISOTXS file and the contribution of each isotope is added to each macroscopic cross section of each composition containing that isotope. If all the macroscopic data will not fit in the available core, the code determines the maximum number of compositions which will fit in a single pass. As many passes through ISOTXS are then made as are required to process all the data. The results of each pass are written to a scratch file (HFILE) for temporary storage before being written to the output COMPXS.

The COMPXS file has provision for directional diffusion coefficient data. HMG4C only supplies default values for this data - unity for the multipliers and zero for the additive terms (see Appendix E). To use directional diffusion coefficients in SYN3D the user must supply an appropriate COMPXS file from outside the code.

INTEG

The integrals required for the synthesis equations (see Section II of this report) are calculated by the INTEG overlay. These integrals are written into the library files VOLINT and DIFINT, with a table of contents and supporting data for the model written to the INTTOC file (see Appendix E).

Subroutine INPRO1 reads input data from SYNCON and checks it for errors. Subroutines INPRO2 and INPRO4 inspect the model, determine what integrals are required and make data management decisions for the calculation of the integrals.

REWRIT rewrites the expansion and weighting function fluxes and the planar geometry descriptions into the REQFLX file (see Appendix E) and rewrites the required macroscopic cross sections into REQXST (see Appendix E). All the point group fluxes and mesh interval data associated with a number of adjacent rows of mesh intervals are combined into each record of REQFLX. The size of the records and, therefore, the number of rows represented in each record are determined at run time and depend on the available BPOINTER container space. The macroscopic cross sections are rewritten with the diffusion coefficients segregrated (in separate records) from the removal and fission data. Again, the REQXST record size is determined at run time. Each record of removal/fission data contains cross sections for all groups for as many compositions as the record size allows. Each record of diffusion coefficient data contains coefficients for all compositions for as many groups as the record size allows.

The integrals are calculated inside a nest of loops over records of REQFLX and REQXST. Space is reserved for as many output records of integral library files (VOLINT and DIFINT) as can fit in core with one record of REQFLX and one record of REQXST. The integrals to be saved in those output records are built up during loops over REQFLX records (the inner loop) and REQXST records (the outer loop). The order in which the integrals are to be done is determined in subroutine DECIDE; in an effort to minimize arithmetic, integrals requiring the same two functions are done simultaneously.

The manner in which the input fluxes, geometries and cross section data are rewritten for a particular job is described in the SYN3D output under the heading "DATA MANAGEMENT PARAMETERS FOR INTEGRAL CALCULATION". The table of contents of the output DIFINT and VOLINT files is also edited.

Although the exact size of each VOLINT and DIFINT record depends on the integrals contained, a maximum record size, LENINT, is set in the main driver. The current value of LENINT has been arbitrarily set at 2000 words (REAL*8 words on IBM machines).

SOLVE

Overlay SOLVE sets up and solves the synthesis eigenvalue problem. In a series of calls to subroutine FILLUP the code determines the order in which integrals are going to be needed during the sweep through the axial mesh (see section II-D for the solution algorithm). Whenever possible, integrals required to set up equations at one mesh interval are saved and reused at the next. The required integrals from VOLINT and DIFINT are rewritten to a scratch file INTGLS in the order in which they are to be needed. Data management decisions required to set up the integral rewriting and later solution are made in subroutine DIVVY. The integrals are rewritten in WINTGL.

The inhomogeneous problem solution which is the basis of the eigenvalue calculation (see Section II-D) is carried out in subroutine SPROB. SPROB sets up the synthesis equations with the aid of subroutine FILLUP, now operating in a mode in which it retrieves integrals from the INTGLS file, and subroutine SHUFFL, which rearranges elements of the equation matrices in order to reuse integrals during the sweep of the axial mesh. During the forward-elimination part of the sweep the H matrices (see Eqs. 42 and 43) are stored in the file HFILE.

After the eigenvalue iterations subroutine OUTPRO edits the combining coefficients and writes the combining coefficient files, DCCOEF and ACCOEF.

EDITS

The EDITS overlay handles all the optional output edits and files.

C. BPOINTER, A Dynamic Storage Allocation Subprogram Package

BPOINTER is a general, FORTRAN subprogram package which was developed to alleviate bookkeeping chores associated with the use of dynamic storage allocation techniques.[25]

Programs which use BPOINTER tend to be structured in subroutine form. A control routine is used to define one or two large blocks of storage (called the container array) and to make the appropriate calls to BPOINTER to control the allocation of storage within the block(s). Calls to calculational subroutines transmit pointers corresponding to appropriate array locations through the calling sequences. All BPOINTER capabilities are accessed through an appropriate call to an entry point, subroutine or function subprogram. The following capabilities are available in the BPOINTER system:

(a) Storage of data in and retrieval of data from the container array, via user defined variable arrays.

(b) Purge of variable arrays stored in the container array.

(c) Automatic "cleanup" of the container array when more storage is required.

(d) Re-definition of array sizes without loss of data already stored in the array.

(e) Array dump of selected integer, floating point or BCD arrays in a prescribed format.

(f) Trace dumps of BPOINTER activities.

(g) Status reports of the BPOINTER tables.

Detailed program documentation including flow charts, common block information and subprogram descriptions is available in Ref. 25. This section is intended to provide a brief description of how the program package operates. The major differences between the IBM and CDC stand-alone versions of the program package are also noted.

The short example listed in Fig. IV-2 is intended to illustrate the structure of a program using the BPOINTER package. This example shows the manner in which a container is allocated, pointers defined and used, and the container released.

Brief descriptions of all the BPOINTER entry points, subroutines and functions are given in Table IV-2.

All dynamically allocated arrays are addressed relative to the common block /ARRAY/ which contains a single array element, BLK(1). In the IBM version of the code the element must be declared DOUBLE PRECISION. In some versions of the CDC BPOINTER (not the version accompanying the Code Center SYN3D, which does not use LCM) a second common block /ARRAY2/ is used to address arrays allocated to a large core memory container. In versions of BPOINTER which use LCM this common block also contains a single array element, BLKECS(1), which must be declared a LEVEL 2 variable. In the SYN3D BPOINTER package BLKECS appears in the coding but is equivalenced with BLK. The equivalent of the large core memory container on IBM equipment is a second container which may be given a HIARCHY 1 location but is addressed in precisely the same manner as the first (SCM) container. The one word assigned to the container by the source language program provides a reference address. At execution time machine language routines (ALLOC1, ALLOC2 on IBM, MEMGET1, MEMGET2 on CDC) are used to obtain the addresses of core which are available to the program for the allocation of data arrays. These blocks of core are allocated in the following manner:

FIGURE IV-2. EXAMPLE OF BPOINTER USE.

```
C  BPOINTER EXAMPLE
C  DEFINE CONTAINER COMMON BLOCK
C
      REAL*8 BLK, FLUX, POWER
      COMMON/ARRAY/BLK(1)
      DIMENSION BLK4(1)
      EQUIVALENCE (BLK(1),BLK4(1))
      DATA FLUX/6HFLUX  /, POWER/6HPOWER /, MAXSIZ/10000/
      DATA I4/4/, I8/8/, I0/0/, NG/27/
C
C  ALLOCATE CONTAINER WITH MAXSIZ WORDS OF SCM AND NO LCM
C
      CALL BULK(I0)
      CALL POINTR(BLK,MAXSIZ,I0)
C
C  ALLOCATE SPACE FOR ARRAYS POWER, FLUX AND CURRENT
C
      CALL PUTM(POWER,I8,NG,IPOWR)
      CALL PUTM(FLUX,I4,2*NG,IFLUX)
C
C  DETERMINE POINTER FOR SUB-ARRAY CURRENT WHICH FOLLOWS THE
C  NG SINGLE PRECISION WORDS FOR THE ARRAY FLUX
C
      ICURNT=IPT2(IFLUX,NG,I0)
C
C  CHECK ON BPOINTER ERROR
C
      IF( IPTERR(DUM).GT.0 ) PRINT 500
  500 FORMAT(1H0,14HBPOINTER ERROR)
C
C  CALL SUBROUTINE INIT TO USE THESE ARRAYS
C
      CALL INIT(BLK(IFLUX),BLK(IPOWR),BLK4(ICURNT),NG)
C
C  FREE CONTAINER AND RETURN
C
      CALL FREE
      RETURN
      END
      SUBROUTINE INIT(PHI,POWER,CURENT,NG)
C
C  USE BPOINTER ARRAYS JUST AS ANY OTHER VARIABLES
C
      REAL*8 POWER
      DIMENSION PHI(1),POWER(1),CURENT(1)
      DO 10 I=1,NG
      PHI(I)=1.0
      POWER(I)=3.1E+06
      CURENT(I)=.333
   10 CONTINUE
      RETURN
      END
```

TABLE IV-2. BPOINTER Subprogram Descriptions

POINTR	Initializes tables of dynamic allocation program package and calls ALLOC1 and ALLOC2 to allocate container(s) for variably dimensioned arrays.
PUTPNT/PUTBLK	Dummy routine calls PUTM to allocate array storage.
BULK	Sets number of words of BULK(LCM) core to be allocated.
FREE	Calls FREE1 and FREE2 to release container allocated by calls from subroutine POINTR.
WIPOUT/CLEAR	Deletes a named array from BPOINTER tables; zeroes all locations assigned to a named array.
GETPNT/GETN/DUMP	Returns pointer for a named array; returns index in BPOINTER tables of a named array; controls printing of a named array.
IGET	Returns pointer for a named array.
IPT2	Returns pointer to a sub-array relative to a single precision word length container.
PUTM/PUTB	Enters named arrays into fast and BULK(LCM) containers respectively.
IPTERR/NNAMSF	Returns number of BPOINTER errors; returns number of named arrays in BPOINTER tables.
ILAST/ILASTB	Returns word number of first available word in SCM/LCM container.
REDEF	Dummy routine calls REDEFM to redefine size and/or location of named array.
REDEFM/REDEFB	Redefine the size and/or location of named array within BPOINTER tables and containers.
PURGE/PURGEB	Sift storage in SCM/LCM containers to eliminate unused blocks created by WIPOUT calls.
STATUS	Edits status of BPOINTER tables.
PRTI1	Prints half word integer array from SCM container.
PRTI1E	Prints half word integer array from LCM container.
PRTI2	Prints full word integer array from SCM container.
PRTI2E	Prints full word integer array from LCM container.
PRTR1/PRTA1	Prints full word real array from SCM container.
PRTR1E/PRTA1E	Prints full word real array from LCM container.
PRTR2/PRTA2	Prints double word real array from SCM container.
PRTR2E/PRTA2E	Prints double word real array from LCM container.

IBM Allocation

The standard IBM macro instructions GETMAIN and FREEMAIN are used to allocate and free consecutive words of core which are available to the program. The designations subpool 1 and 2 are assigned to the bulk (LCM) and fast (SCM) containers, respectively. Since allocations are performed in units of 256 (eight byte) words, it is most efficient to request blocks of core in such multiples.

CDC Allocation

The COMPASS routine MEMGET uses the standard CDC macro instruction MEMORY to determine the job's SCM and LCM field lengths. The top of the user's SCM field length is used for the BPOINTER SCM container. The user is responsible for providing enough SCM memory to accommodate both the program and the BPOINTER container; there is currently no effective check to make sure that data stored in the BPOINTER container does not overlap code. It is assumed by the CDC version of BPOINTER that the level 2 common block /ARRAY2/ is addressed as the first word of LCM and the entire LCM field length is assumed to be available to BPOINTER for its LCM container.

The letters M and B are used as neumonics within BPOINTER to designate routines which operate on the SCM and LCM containers, respectively. Thus PUTM allocates an array in the SCM container while PUTB (which is not used in SYN3D) allocates an array which must be referenced on CDC equipment as a LEVEL 2 array. On IBM equipment without HIARCHY support (e.g. 370/195) the two containers are equivalent. The distinctions noted above between the two dynamic containers are important on CDC equipment where the containers are addressed quite differently and on IBM equipment with HIARCHY support where access to the BULK container (HIARCHY 1, subpool 1) is significantly slower than access to the MAIN core container (HIARCHY 0, subpool 2).

V. THE ARGONNE CODE CENTER VERSIONS OF SYN3D

SYN3D is available on magnetic tape through the Argonne Code Center for both IBM and CDC machines. This section describes the contents of the tapes and outlines the steps necessary to implement the code in stand-alone form (without understanding very much about synthesis or the code itself). The Code Center package includes several test problems; this section also contains descriptions and the solutions of these test problems.

A. The SYN3D Package

The Code Center SYN3D package consists of this memo and a magnetic tape containing four BCD files. There are separate tapes for IBM and CDC versions; Table V-1 describes the format of each tape and the contents and length of each BCD file.

TABLE V-1. Description of SYN3D Tapes and the BCD Files they Contain

	IBM Tape	CDC Tape
Type	9 trk.	7 trk.
Density	800 bpi	556 bpi
Character Code	EBCDIC (029 keypunch)	BCD (026 keypunch)

In both cases there are no internal labels, there are 80 characters per card image and and the blocking is 3200 (Forty cards per block).

File Number	Contents	Number of Card Images	
		IBM Tape	CDC Tape
1	SYN3D FORTRAN source code	19163	19163
2	Additional BPOINTER routines	501	130
3	CDFILE FORTRAN source code	665	665
5	Interface files in CDFILE format	1418	1418

TABLE V-2. SYN3D Segments

Overlay Name	Card Numbers
MAIN	1-2154
CARDS	2155-2971
HMG4C	2972-6278
INTEG	6279-12981
SOLVE	12982-16363
EDITS	16364-19163

SYN3D

The first two files combine to form the SYN3D code. The first file is SYN3D proper. The IBM and CDC versions are derived from the same source code. Statements that are unique to IBM computers (e.g. REAL*8) are surrounded by pairs of comment cards starting with the characters "CIBM" in columns 1-4 and are commented out in the CDC version. Statements that are unique to CDC computers (e.g. OVERLAY) are surrounded by "CDC*" comment cards and are commented out in the IBM version.

The card number (columns 73-80) of a particular FORTRAN instruction in the IBM version is the same in the CDC version. This was done to avoid the nuisance of maintaining entirely separate versions of the code. Future corrections to the code will be specified in terms of this numbering system.

ADDITIONAL BPOINTER ROUTINES

BPOINTER is a set of dynamic storage allocation subroutines used in SYN3D to manage fast memory. The bulk of the coding is in FORTRAN, is common to both IBM and CDC versions of SYN3D, and is included in the SYN3D source file (cards 902-2154).

A few of the BPOINTER routines, however, are machine dependent, and these are included in file 2 of the Code Center tape. For the IBM version these additional routines are all in assembler language. For the CDC version they are partly FORTRAN (the first 108 cards of file 2) and partly COMPASS (the last 22 cards).

The additional BPOINTER routines can be assembled (and for the CDC version compiled) separately and included in the main overlay of SYN3D (cards 1-2154 of file 1) at load time.

CDFILE

CDFILE (file 3) is a short, stand-alone, FORTRAN code which provides a crude way of generating CCCC binary interface files from BCD card input. File 4 contains the CDFILE BCD input file needed to produce binary interface files for a number of sample problems. If the user has other means of writing CCCC interface files he/she may choose to ignore files 3 and 4.

B. Code Structure

The discussion of the structure of SYN3D included here will just cover those aspects which affect the linking and execution of the code in a straightforward, stand-alone form. The functions of the several overlays of the program are covered in more detail in Section IV.

The simplest overlay scheme (other than none at all) is a division into a main overlay and five primary overlays. The names of the overlays and the corresponding card numbers in the source coding (file 1 of the Code Center tape), are given in Table V-2. The additional BPOINTER routines (file 2) should be included in the main overlay.

The CDC version of SYN3D includes OVERLAY cards at the beginning of each of the segments listed in Table V-2 and, therefore, can be complied directly from tape to a load file. For those compilers which permit a mix of FORTRAN and assembler language it may be convenient to splice the additional BPOINTER routines (file 2 on the Code Center tape) into the SYN3D source file after card 2154. Alternatively, one can compile SYN3D and the additional BPOINTER routines separately and merge the two either by inserting the additional BPOINTER relocatable object code at the proper place in the SYN3D load file or, for loaders that permit it, by providing the additional routines through a user library.

The IBM version of SYN3D has been run at Argonne by compiling the segments listed in Table V-2 and assembling the additional BPOINTER routines to a partitioned data set and then overlaying at load time.

C. File Number Assignments

All binary files (input and output interface files and scratch files) used by SYN3D are handled through the CCCC standard subroutines SEEK, REED and RITE. The assignment of file numbers to file names and the initialization of the SEEK tables is done from the SYN3D driver routine (cards 1-170 of the source code).

The file assignments in the Code Center version of SYN3D are listed in Table V-3. Multiple versions of some files are required. Printer output is written to file 6; BCD input (if required) is read from file 5. File assignments can be easily rearranged by changing the coding in the main driver; no other routines need be modified.

All files are written sequentially. All but one file (HFILE) is read sequentially. At different stages of the calculation HFILE is read both forwards and backwards. SYN3D does not require direct access files.

D. Running the Code Center SYN3D as a Stand-alone Program

The Code Center version of SYN3D is set up to execute in environments that may never have heard of the CCCC standards. Most of the input data are contained in CCCC standard interface binary files, and a small program, CDFILE, is provided (file 4 of the Code Center tape) to convert input from BCD cards or a card image file to the necessary binary files. Those installations which already can write CCCC files can ignore CDFILE. A small amount of data specifying input binary file numbers and additional, code-dependent data are read from cards. Even these BCD data can be eliminated if desired (see section V-F).

CDFILE

This utility program was written largely as a crude input processor for the Code Center version of SYN3D. It only processes the six CCCC files RTFLUX, ATFLUX, GEODST, ISOTXS, NDXSRF and ZNATDN.

CDFILE operates in two modes. In the first (MODE=1) it will read a number of CCCC binary files (those types listed above) and write the data in BCD card image form to a single BCD file. In the second (MODE=2) it

TABLE V-3. Files Required by the Code Center Version of SYN3D

(GEODST through ZNATDN are CCCC files. The rest may be treated as scratch files.)

File Name	File Version Nos.	Use	Logical Unit No.*
GEODST	1-10	These are the several two-dimensional GEODST files required to describe a three-dimensional model. GEODST,1 can be a three-dimensional file, in which case the code will write two-dimensional files GEODST,2...GEODST,N.	11-21
RTFLUX	1-11	RTFLUX files containing expansion and/or weighting functions.	21-31
ATFLUX	1-5	ATFLUX files containing expansion and/or weighting functions.	32-36
PWDINT	1	Output power density, by mesh volume.	37
RZFLUX	1	Zone average fluxes.	38
ISOTXS	1	Input microscopic cross sections.	39
NDXSRF	1	Cross-section reference.	40
ZNATDN	1	Zone atom densities.	41
INTTOC	1	Input synthesis integral table of contents (optional).	42
INTTOC	2	Output synthesis integral table of contents.	43
VOLINT	1	Input synthesis VOLINT integrals (optional).	44
VOLINT	2	Output synthesis VOLINT integrals.	45
DIFINT	1	Input synthesis DIFINT integrals (optional).	46
DIFINT	2	Output synthesis DIFINT integrals.	47
DCCOEF	1	Direct synthesis combining coefficients.	48
ACCOEF	1	Adjoint synthesis combining coefficients.	49
COMPXS	1	Macroscopic cross sections.	50

TABLE V-3. Contd.

File Name	File Version Nos.	Use	Logical Unit No.
REQFLX	1	Rewritten fluxes.	51
REQXST	1	Rewritten macroscopic cross sections.	52
INTGLS	1	Rewritten synthesis integrals.	53
HFILE	1	Scratch file used during solution. (Also used by HMG4C if multipass mode is used.	54
SYNCON	1	The input data in binary form.	55
SYNFIL	1	The input data in BCD card images (used with ARC System input routines).	56

*These are the file number assignments made in the main overlay of the Code Center version of SYN3D by the initialization call to SEEK. Since the rest of the code always uses SEEK to determine file numbers, it is a relatively simple job to assign entirely different file numbers by defining new SEEK tables.

will read BCD card images from a single BCD file and write a number of binary files. File 4 of the Code Center tape is a BCD file written by CDFILE in the first mode and represents the binary files necessary for several test calculations. Section V-E describes these test calculations run by first executing CDFILE with MODE=2 and file 4 of the Code Center tape as input and then executing SYN3D with the resulting binary files as input. Table V-4 describes the contents of the two input cards, and Table V-5 shows examples of the modes in which CDFILE can be run.

CDFILE can process any number of files. The BCD file (LUNBCD) contains blocks (decks) of card images stacked in the order indicated by (LUN(I),I=1,NFILES). There is no form of separator between blocks.

Installations with any sort of a network of reactor analysis codes can find a more efficient procedure for generating CCCC binary interface files than the CDFILE program. We will not encourage the general use of CDFILE by listing in this report the card image formats for those CCCC files the code can handle. Users who have no other way to generate interface files are referred to the CCCC standard file descriptions (see Appendix I) and to the FORTRAN source coding of CDFILE. It suffices to say that the program sweeps sequentially through a binary file reading and writing integer and floating point data as they are encountered.

It is suggested that CDFILE and the test problems supplied in the Code Center SYN3D package be used as a preliminary check of the code when it is initially implemented at any installation. Examples of the use of CDFILE on the ANL IBM-370 and the Lawrence Berkeley Laboratory CDC 7600 are included later in this section.

SEEK Table Initialization

SYN3D determines file numbers for all files (except card input and printer output) by calls to the CCCC standard subroutine SEEK. Among its several functions SEEK returns an "existence flag" which specifies whether or not a file "exists" (i.e. has been previously written). Files can exist because they are input to the code or because SYN3D writes them itself. There must be some mechanism, therefore, to flag an input file as "existing" in the tables kept by SEEK.

The Code Center version of SYN3D does this with a single input card, read by the main driver (at card number 134 in the SYN3D source code). Each column of this card represents a logical unit number, and a non-zero integer in a particular column means that the corresponding file is an existing, input file. SYN3D then sets the existence flag for that file through a call to SEEK with an operation code of 1. This SEEK initialization card is the first card read by SEEK.

The SYN3D BCD Control Data

Obviously, there is input required by SYN3D that cannot be accommodated by the CCCC standard interface files alone. The Code Center version of SYN3D is set up to read a certain amount of data from cards placed after the SEEK initialization card.

TABLE V-4. CDFILE Input Data

Card	Contents	Format
1	NFILES, LUNBCD, MODE	3I3
2	(LUN(I),I=1,NFILES)	24I3

NFILES = The number of CCCC binary interface files to be processed.

LUNBCD = The logical unit number of the BCD file to which BCD card images are to be written (MODE=1) or from which BCD card images are to be read (MODE=2).

MODE = 1, data from binary files is written to the BCD card image file (file number LUNBCD). 2, data from the BCD card image file is written to binary files.

LUN(I) = The logical unit number of the CCCC binary interface file from which (MODE=1) or to which (MODE=2) the Ith block of data on the BCD file number LUNBCD is to be transferred.

TABLE V-5. Examples of CDFILE Modes of Operation. These Examples Assume File 5 is Card Input, File 6 is Printer Output and File 7 is Punch Output

Mode	LUNBCD	CDFILE Function
1	6	Reads binary files and prints contents.
1	7	Reads binary files and punches contents.
2	5	Reads cards punched by a previous CDFILE run (MODE=1, LUNBCD=7) and writes binary files. The card deck should be placed immediately after the two cards described in Table V-4.
2	10	Reads card images from the file on logical unit 10 (e.g. the fourth file on the Code Center tape) and writes binary files.

These data are provided on cards which have numbers in columns 1-2 which identify a particular card type. In many cases several cards of the same type may be required. The cards must be arranged in order of ascending card type number. Immediately after the SEEK initialization card, and before the first numbered card, a card must be provided which defines (with format 24I3) the number of cards included for each card type. The number of type 1 cards is punched in columns 1-3, the number of type 2 cards in columns 4-6, etc.

The contents and formats of the numbered cards are given in the file description of the BCD file SYNFIL (see Appendix D). The user is also referred to the sample problem input shown later in this section.

Examples of Input Decks with Control Cards

Figures V-1 and V-2 show input decks set up to execute CDFILE and SYN3D. Figure V-1 is a job run on Argonne's IBM 370/195 which link edits SYN3D from a partitioned data set (C116.B21006.EXPORT.SEGLIB) containing the segments listed in Table V-2 and BPOINTER. The member ASSEM contains the additional BPOINTER routines. Figure V-2 is a job run on Berkeley's CDC 7600 which loads SYN3D from a load file (PROG) complied by FTN4.5.

BPOINTER

Storage for almost all the dimensioned arrays used in SYN3D is managed through the dynamic storage allocation routine BPOINTER. At run time BPOINTER reserves a section of memory, called the "container", the length of which is specified in the input (card type 2). On the IBM 370/195 BPOINTER actually requests space from the system, and if the REGION size is too small to hold both the program and the container an error message is printed. On CDC systems error messages may not occur when there is insufficient field length for the container until the code tries to store data outside the designated field length for the job.

The version of BPOINTER included in the CDC package can be used to allocate storage only in SCM; at present SYN3D only uses SCM.

E. Sample Problems

Model Descriptions

The test calculations included in the Code Center SYN3D package are based on the three-dimensional, simplified LMFBR model shown in Fig. V-3. A set of three-energy group cross sections is supplied, as are geometry and expansion function files required for several SYN3D calculations. The model includes rods which are banked at the midplane. The cross section data files contain microscopic cross sections for seven isotopes and number densities for seven compositions. Table V-6 defines the compositions.

File 4 of the Code Center Tape

The card images supplied in file 4 of the Code Center tape represent the CDFILE input "deck" required to generate 17 separate binary interface files. A description of each file is given in Table V-7. The "sequence

FIGURE V-1. INPUT DECK WITH CONTROL CARDS FOR THE IBM 370/195. EXECUTE CDFILE TO GENERATE INTERFACE FILES, LINK EDIT SYN3D AND EXECUTE SAMPLE PROBLEM 4. THE SOURCE CODE FOR CDFILE IS IN THE FILE &CDFILE AND THE CDFILE INPUT IS IN THE FILE &DATA. INTERFACE FILES NOT NEEDED IN THIS JOB ARE COPIED TO THE FILE &DUMP.

```
// EXEC FTHCLG
//FTH.SYSIN DD DSN=&CDFILE,DISP=(OLD,PASS),UNIT=SASCR
//GO.FT09F001 DD DSN=&DUMP,DISP=(NEW,PASS),UNIT=SASCR,
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=6136)
//GO.FT10F001 DD DSN=&DATA,DISP=(OLD,PASS),UNIT=SASCR
//GO.FT11F001 DD DSN=&GEODST1,DISP=(NEW,PASS),UNIT=SASCR,
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=6136)
//GO.FT22F001 DD DSN=&RTFLUX1,DISP=(NEW,PASS),UNIT=SASCR,
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=6136)
//GO.FT23F001 DD DSN=&RTFLUX2,DISP=(NEW,PASS),UNIT=SASCR,
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=6136)
//GO.FT24F001 DD DSN=&RTFLUX3,DISP=(NEW,PASS),UNIT=SASCR,
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=6136)
//GO.FT25F001 DD DSN=&RTFLUX4,DISP=(NEW,PASS),UNIT=SASCR,
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=6136)
//GO.FT32F001 DD DSN=&ATFLUX1,DISP=(NEW,PASS),UNIT=SASCR,
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=6136)
//GO.FT33F001 DD DSN=&ATFLUX2,DISP=(NEW,PASS),UNIT=SASCR,
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=6136)
//GO.FT39F001 DD DSN=&ISOTXS,DISP=(NEW,PASS),UNIT=SASCR,
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=6136)
//GO.FT40F001 DD DSN=&NDXSRF,DISP=(NEW,PASS),UNIT=SASCR,
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=6136)
//GO.FT41F001 DD DSN=&ZNATDN,DISP=(NEW,PASS),UNIT=SASCR,
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=6136)
//GO.SYSIN DD *
 17 10  2
 22 23 24 25 32 33 11  9  9  9  9  9  9  9 40 41 39
/*
// EXEC FTXEP,EDTOPTS='OVLY'
//EDT.SYSLMOD DD DSN=&MODLIB(SYN3D),DISP=(NEW,PASS),UNIT=SASCR,
//      SPACE=(TRK,(40,5,1),RLSE),DCB=BLKSIZE=6144
//EDT.SEGLIB DD DSN=C116.B21006.EXPORT.SEGLIB,DISP=(OLD,KEEP)
//EDT.SYSIN DD *
 ENTRY MAIN
 INCLUDE SEGLIB(MAIN,ASSEM)
 OVERLAY LEVEL1
 INCLUDE SEGLIB(CARDS)
 OVERLAY LEVEL1
 INCLUDE SEGLIB(HMG4C)
 OVERLAY LEVEL1
 INCLUDE SEGLIB(INTEG)
 OVERLAY LEVEL1
 INCLUDE SEGLIB(SOLVE)
 OVERLAY LEVEL1
 INCLUDE SEGLIB(EDITS)
/*
```

FIGURE V-1. INPUT DECK WITH CONTROL CARDS FOR THE IBM 370/195. (CONTD.)

```
// EXEC PGM=SYN3D
//STEPLIB DD DSN=&MODLIB,DISP=(OLD,PASS),UNIT=SASCR
//FT05F001 DD DDNAME=SYSIN
//FT06F001 DD SYSOUT=A
//FT11F001 DD DSN=&GEODST1,DISP=(OLD,PASS),UNIT=SASCR
//FT12F001 DD DISP=(NEW,DELETE),UNIT=SASCR,SPACE=(TRK,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=6136)
//FT13F001 DD DISP=(NEW,DELETE),UNIT=SASCR,SPACE=(TRK,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=6136)
//FT14F001 DD DISP=(NEW,DELETE),UNIT=SASCR,SPACE=(TRK,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=6136)
//FT15F001 DD DISP=(NEW,DELETE),UNIT=SASCR,SPACE=(TRK,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=6136)
//FT16F001 DD DISP=(NEW,DELETE),UNIT=SASCR,SPACE=(TRK,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=6136)
//FT17F001 DD DISP=(NEW,DELETE),UNIT=SASCR,SPACE=(TRK,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=6136)
//FT22F001 DD DSN=&RTFLUX1,DISP=(OLD,PASS),UNIT=SASCR
//FT23F001 DD DSN=&RTFLUX2,DISP=(OLD,PASS),UNIT=SASCR
//FT24F001 DD DSN=&RTFLUX3,DISP=(OLD,PASS),UNIT=SASCR
//FT25F001 DD DSN=&RTFLUX4,DISP=(OLD,PASS),UNIT=SASCR
//FT26F001 DD DSN=&RTFLUX5,UNIT=SASCR,DISP=(NEW,PASS),
//      SPACE=(TRK,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=6136)
//FT32F001 DD DSN=&ATFLUX1,DISP=(OLD,PASS),UNIT=SASCR
//FT33F001 DD DSN=&ATFLUX2,DISP=(OLD,PASS),UNIT=SASCR
//FT34F001 DD DSN=&ATFLUX3,DISP=(NEW,PASS),
//      UNIT=SASCR,SPACE=(TRK,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=6136)
//FT37F001 DD DSN=&PWDINT,UNIT=SASCR,DISP=(NEW,DELETE),
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=6136)
//FT38F001 DD DSN=&RZFLUX,UNIT=SASCR,DISP=(NEW,DELETE),
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=6136)
//FT39F001 DD DSN=&ISOTXS,DISP=(OLD,PASS),UNIT=SASCR
//FT40F001 DD DSN=&NDXSRF,DISP=(OLD,PASS),UNIT=SASCR
//FT41F001 DD DSN=&ZNATDN,DISP=(OLD,PASS),UNIT=SASCR
//FT43F001 DD DSN=&INTTOC2,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(TRK,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=3156)
//FT45F001 DD DSN=&VOLINT2,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(CYL,(2,1),RLSE),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=13030)
//FT47F001 DD DSN=&DIFINT2,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(TRK,(5,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=13030)
//FT48F001 DD DSN=&DCCOEF,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=6136)
```

FIGURE V-1. INPUT DECK WITH CONTROL CARDS FOR THE IBM 370/195. (CONTD.)

```
//FT49F001 DD DSN=&ACCOEF,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=6136)
//FT50F001 DD DSN=&COMPXS,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=6136)
//FT51F001 DD DSN=&REQFLX,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(CYL,(2,1),RLSE),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=13030)
//FT52F001 DD DSN=&REQXST,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(CYL,(2,1),RLSE),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=13030)
//FT53F001 DD DSN=&INTGLS,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(CYL,(2,1),RLSE),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=13030)
//FT54F001 DD DSN=&HFILE,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(CYL,(2,1),RLSE),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=13030)
//FT55F001 DD DSN=&SYNCON,DISP=(NEW,DELETE),UNIT=SASCR,
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=304),SPACE=(TRK,(1,1))
//SYSIN DD *
          1           1111       11      111
  4  1  1  0  0  2  4  4  0  0  0  0  2  0  0  1  1  1  1  1  1
01     3 GROUP, 3-DIMENSIONAL MODEL, MIXED FLUX AND ADJOINT WEIGHTING
01          BLANKET FUNCTIONS (3 AND 4) NOT USED EVERYWHERE
01          GROUP 3 OF BLANKET FUNCTIONS NOT USED AT ALL
01          INPUT 3D GEODST FILE
02         15     2    20                                3     3           1
03                   1.00                      10.0
06         ZL     1     3        2.13
06         ZU     1     3        2.13
07     RTFLUX     1               0.0        200.0
07     RTFLUX     2               0.0        200.0
07     RTFLUX     3               0.0        100.0
07     RTFLUX     4             100.0        200.0
08     ATFLUX     1               0.0        200.0
08     ATFLUX     2               0.0        200.0
08     RTFLUX     3               0.0        100.0
08     RTFLUX     4             100.0        200.0
13     RTFLUX     3     3     3
13     RTFLUX     4     3     3
16                5     3     1     1           1
17          1     2     3
18          1     2     3
19          1     5     1     8     1    11     2     8     3     8
20          1     5     1     8     1    11     2     8     3     8
21          3     6     9    12    15    18
/*
```

FIGURE V-2. INPUT DECK WITH CONTROL CARDS FOR THE CDC 7600. EXECUTE CDFILE TO GENERATE INTERFACE FILES, LOAD SYN3D AND EXECUTE SAMPLE PROBLEM 4. THE RELOCATABLE OBJECT CODE FOR CDFILE IS IN THE FILE "CDFILE" AND THE CDFILE INPUT IS IN THE FILE "DATA". THE FILE "PROG" CONTAINS THE RELOCATABLE OBJECT CODE FOR SYN3D. INTERFACE FILES NOT NEEDED IN THIS JOB ARE COPIED TO THE FILE "TAPE9".

```
COPYBF(DATA,TAPE10,1)
REWIND(DATA,TAPE10)
RFL,150000,500000.
LINK(X,F=CDFILE,P=FTN4LIB)
REWIND(TAPE10)
LINK(X,F=PROG,P=FTN4LIB,FL=150000)

789 CARD

 17 10  2
 22 23 24 25 32 33 11  9  9  9  9  9  9  9 40 41 39

789 CARD

          1           1111       11      111
  4  1  1  0  0  2  4  4  0  0  0  0  2  0  0  1  1  1  1  1  1
01     3 GROUP, 3-DIMENSIONAL MODEL, MIXED FLUX AND ADJOINT WEIGHTING
01          BLANKET FUNCTIONS (3 AND 4) NOT USED EVERYWHERE
01          GROUP 3 OF BLANKET FUNCTIONS NOT USED AT ALL
01          INPUT 3D GEODST FILE
02         15     2    20                                3     3            1
03                   1.00                       10.0
06         ZL     1     3         2.13
06         ZU     1     3         2.13
07     RTFLUX     1                 0.0        200.0
07     RTFLUX     2                 0.0        200.0
07     RTFLUX     3                 0.0        100.0
07     RTFLUX     4               100.0        200.0
08     ATFLUX     1                 0.0        200.0
08     ATFLUX     2                 0.0        200.0
08     RTFLUX     3                 0.0        100.0
08     RTFLUX     4               100.0        200.0
13     RTFLUX     3     3     3
13     RTFLUX     4     3     3
16                5     3     1     1            1
17          1     2     3
18          1     2     3
19          1     5     1     8     1    11     2     8     3     8
20          1     5     1     8     1    11     2     8     3     8
21          3     6     9    12    15    18

6789 CARD
```

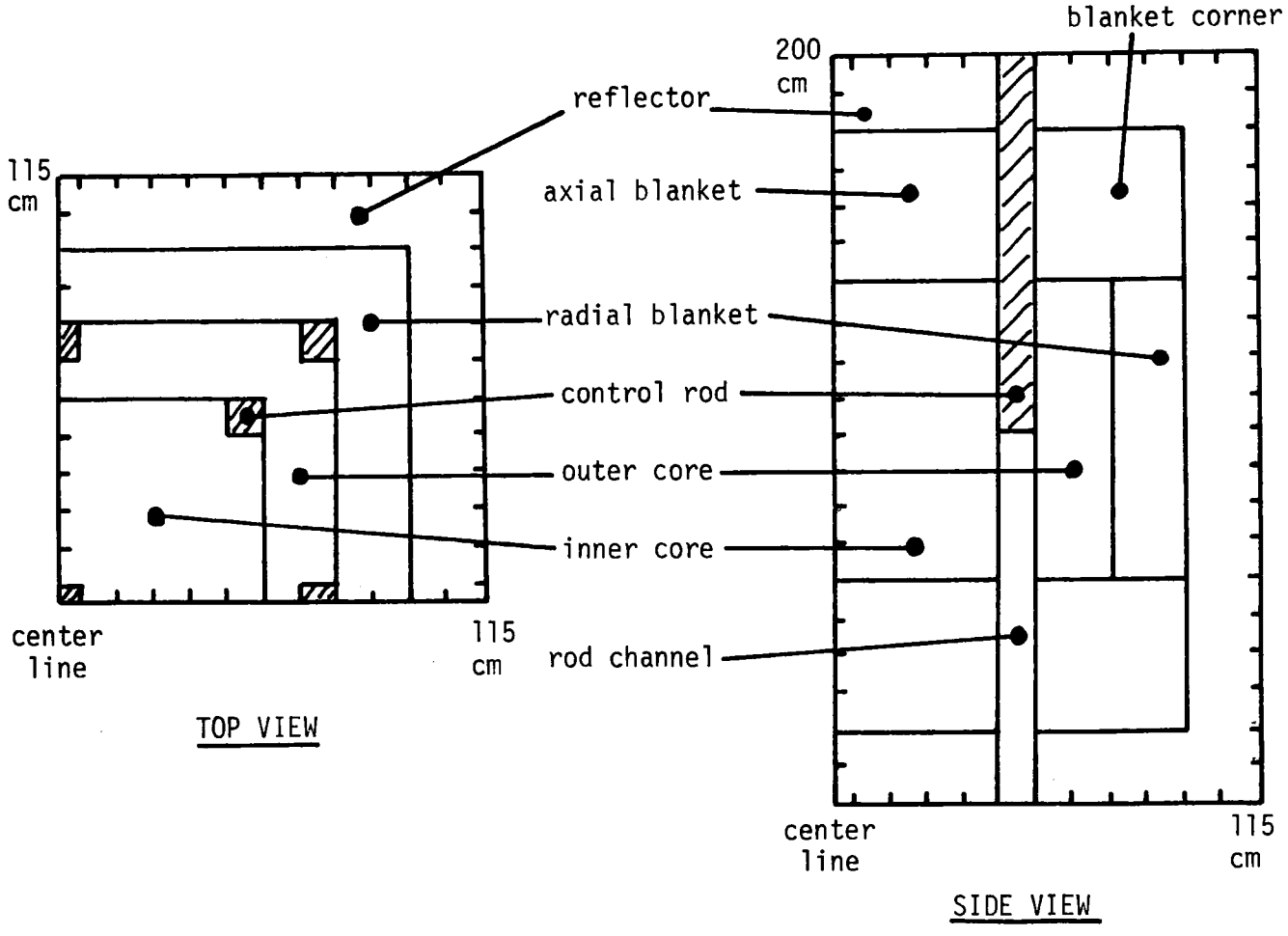


Fig. V-3. The Geometry of the 3D Test Model
ANL Neg. No. 116-75-171.

TABLE V-6. Compositions Used in Test Problems

Isotope Number		1	2	3	4	5	6	7
Isotope Name		^{239}Pu	^{238}U	^{23}Na	Fe	^{16}O	^{10}B	^{12}C
Composition Number	Description	Atom Densities (Atoms/cc * 1.E-24)						
1	inner core	.0011	.0064	.0104	.0181	.0149		
2	outer core	.0015	.0054	.0110	.0181	.0138		
3	axial blanket		.0080	.0088	.0244	.0160		
4	radial blanket		.0145	.0066	.0173	.0290		
5	reflector			.0044	.0691			
6	control rod			.0104	.0181	.0149	.0090	.0412
7	rod channel			.0220				

TABLE V-7. Description of the CDFILE BCD Data Blocks in File 4 of the Code Center Tape

Sequence Number	Interface File Name	File Description
1	RTFLUX	A 2D flux solution in the unrodded core plane of the model. A buckled (transverse distance = 120 cm.) eigenvalue calculation (k = .99596).
2	RTFLUX	A 2D flux solution in the rodded core plane. A buckled (transverse height = 150 cm.) eigenvalue calculation (k = 1.00914).
3	RTFLUX	A 2D flux solution in the unrodded, axial blanket plane. An inhomogeneous calculation.
4	RTFLUX	A 2D flux solution in the rodded, axial blanket plane. An inhomogeneous calculation.
5	ATFLUX	A 2D adjoint solution in the unrodded core plane.
6	ATFLUX	A 2D adjoint solution in the rodded core plane.
7	GEODST	A 3D geometry description of the model.
8	GEODST	A 2D geometry description of the unrodded reflector plane.
9	GEODST	A 2D geometry description of the unrodded axial blanket plane.
10	GEODST	A 2D geometry description of the unrodded core plane.
11	GEODST	A 2D geometry description of the rodded core plane.
12	GEODST	A 2D geometry description of the rodded axial blanket plane.
13	GEODST	A 2D geometry description of the rodded reflector plane.
14	GEODST	A 2D geometry description of a 12 x 12 mesh, uniform plane with zero-current boundary conditions.
15	NDXSRF	Cross section reference data.
16	ZNATDN	Atom density data.
17	ISOTXS	Microscopic cross sections.

number" indicates the order in which the card image blocks for each binary file are arranged in the card image file.

Sample Problem 1

The first sample problem is a fundamental mode calculation for the infinite medium eigenvalue and spectrum for composition 1, the material in the inner core of the model (see Table V-6). One of the GEODST files (sequence number 14 in Table V-7) represents a homogeneous, reflected plane containing composition 1. The synthesis calculation uses this GEODST file, a flat expansion function (1.0 everywhere in space and energy) and zero-current axial boundary conditions.

This first sample problem requires four input interface files: the uniform plane GEODST mentioned above, NDXSRF, ZNATDN and ISOTXS. The GEODST file is used only in this calculation; the other three files define the compositions and cross sections and are used in all four sample problems. The SYN3D BCD input for the job is shown in Fig. V-4.

Appendix H-1 is the complete output (16 pages) from sample problem 1. In this one case the macroscopic cross section edits (card type 2) have been turned on to provide a printed record of their values. The infinite medium fundamental eigenvalue for composition 1 is 1.3017, and the eigenvector (from the synthesis combining coefficient edits) is

1.000, 1.400, 0.04585

Sample Problem 2

One of the RTFLUX files in file 5 of the Code Center tape (sequence number 1 in Table V-7) was generated from a buckled, 2D diffusion theory calculation in the unrodded core plane of the 3D model. The buckling corresponded to a transverse slab thickness of 120 cm., and the 2D eigenvalue was .99596. Sample problem 2 is a synthesis calculation of a 3D model which is axially uniform and is described in the plane by the 2D GEODST file defining the unrodded core plane (sequence number 10 in Table V-7). The model is 60 cm. high and has zero current and zero flux boundary conditions on the first and second z boundary planes, respectively.

The unrodded core RTFLUX file is provided as the only expansion function, and the flat (UNIT) weighting option is used. Since the expansion function is "perfect" for the problem, and the flat weighting reduces the synthesis equations to the balance satisfied by the original 2D calculation, SYN3D should reproduce the 2D eigenvalue and yield combining coefficients which are cosine shaped and equal in magnitude in all three groups. Figure V-5 lists the input interface files and shows the BCD input.

Appendix H-2 shows the complete output (6 pages) from this sample problem. The eigenvalue is .99600 and the combining coefficients are essentially equal in all groups. The output shown in Appendix H-2 comes from a job run on an IBM 370/195; the same job run on a CDC 7600 gave an eigenvalue of .99599. Small deviations are to be expected because of the finite axial mesh and the fact that on IBM machines the cross sections are stored in SYN3D in REAL*4 words.

FIGURE V-4. SYN3D BCD INPUT AND INPUT INTERFACE FILES FOR THE 1ST SAMPLE PROBLEM. EACH INPUT FILE IS IDENTIFIED BY A SEQUENCE NUMBER FROM TABLE V-7 AND IS ASSIGNED A LOGICAL UNIT NUMBER CONSISTENT WITH TABLE V-3. THE BCD DATA CONSISTS OF THE SEEK INITIALIZATION CARD, A "CARDS-PER-CARD-TYPE" CARD AND A SET OF TYPE-NUMBERED CARDS.

INPUT INTERFACE FILES

```
SYN3D LOGICAL UNIT NUMBER          11 39 40 41
FILE SEQUENCE NUMBER (TABLE V-7)   14 17 15 16
```

BCD INPUT

```
          1                                111
  1  1  0  1  1  0  1
01     THREE GROUP, FUNDAMENTAL MODE CALCULATION, COMPOSITION 1.
02         5     1                                                    2
04               3        10.0
05               1                 0.0        10.0
07    UNIT                         0.0        10.0
```

FIGURE V-5. SYN3D BCD INPUT AND INPUT INTERFACE FILES FOR THE 2ND SAMPLE PROBLEM. EACH INPUT FILE IS IDENTIFIED BY A SEQUENCE NUMBER FROM TABLE V-7 AND IS ASSIGNED A LOGICAL UNIT NUMBER CONSISTENT WITH TABLE V-3. THE BCD DATA CONSISTS OF THE SEEK INITIALIZATION CARD, A "CARDS-PER-CARD-TYPE" CARD AND A SET OF TYPE-NUMBERED CARDS.

INPUT INTERFACE FILES

```
SYN3D LOGICAL UNIT NUMBER          11 22 39 40 41
FILE SEQUENCE NUMBER (TABLE V-7)   10  1 17 15 16
```

BCD INPUT

```
          1          1                 111
  2  1  1  1  1  0  1  1
01    THREE GROUP, 2D BUCKLED PLANE (THE UNRODDED CORE PLANE FROM THE
01    3D MODEL), HALF CORE SYMMETRY.
02         5     1    20                            2     1
03                 1.00                       10.0
04              30        60.0
05               1                 0.0        60.0
07    RTFLUX     1                 0.0        60.0
08    UNIT                         0.0        60.0
```

While of little practical interest, this sort of calculation is useful as a debug tool and as a consistency check between SYN3D and whatever diffusion theory code is used to generate expansion functions. Significant discrepancies might indicate that the two codes are based on different finite-difference formulations.

Sample Problem 3

This is a calculation of the full, three-dimensional model shown in Fig. V-3. The approach used illustrates the way SYN3D has been used to calculate a variety of fast reactor models. The three-dimensional model is described in terms of the six, unique axial zones (reflector, blanket and core planes, each of which may be either rodded or unrodded). The six input GEODST files are sequence numbers 8-13 of Table V-7. Four expansion functions (sequence numbers 1-4) are provided. Two are buckled, eigenvalue calculations in the unrodded and rodded core planes. Two are from inhomogeneous calculations in the axial blankets in which the fixed source is the product of the expansion function associated with the adjacent core zone and the blanket diffusion coefficient distribution. Typically, the solution in the reflector is of little interest, and reflector expansion functions are not included.

Figure V-6 lists the input interface files and shows the BCD input. The core expansion functions are used everywhere, but each blanket function is used only over 40% of the height of the model. It is unlikely that a rodded (top) blanket function could contribute significantly to the unrodded (bottom) axial blanket. Economies of this sort can significantly reduce running times with little sacrifice of accuracy.

Appendix H-3 shows selected pages of the output for this job. The eigenvalue is .97506 (v. .97532 for a 3D finite-difference calculation). Samples of the flux, power density and zone average flux edits are included, as is a sample printer-plot of the contributions from each expansion function to the axial flux distribution (i.e. the 3D flux integrated over the x and y dimensions). Selective use of these plots can help identify poor choices of expansion functions and anomalous solutions.

Sample Problem 4

This last calculation is intended to illustrate some of the other options available in SYN3D. Figure V-7 lists the input interface files and shows the BCD input. The model geometry is the same as that of sample problem 3, but now there is a single, three-dimensional input GEODST file (sequence number 7 in Table V-7). At the top and bottom boundaries the boundary conditions are now logarithmic. The same four expansion functions used in problem 3 are used in problem 4, but each blanket function is used over half the height of the core, and the group 3 flux of each blanket function is not used at all. Two of the four weighting functions are now adjoint fluxes (sequence numbers 5 and 6 in Table V-7), and both direct and adjoint synthesis problems are solved. Sample problem 4 is intended as an illustration of some of the more exotic options in the code and should not be taken as a recommendation. Sample problem 3 is a more typical example of an application of SYN3D.

FIGURE V-6. SYN3D BCD INPUT AND INPUT INTERFACE FILES FOR THE 3RD SAMPLE PROBLEM. EACH INPUT FILE IS IDENTIFIED BY A SEQUENCE NUMBER FROM TABLE V-7 AND IS ASSIGNED A LOGICAL UNIT NUMBER CONSISTENT WITH TABLE V-3. THE BCD DATA CONSISTS OF THE SEEK INITIALIZATION CARD, A "CARDS-PER-CARD-TYPE" CARD AND A SET OF TYPE-NUMBERED CARDS.

INPUT INTERFACE FILES

SYN3D LOGICAL UNIT NUMBER	11	12	13	14	15	16	22	23	24	25	39	40	41
FILE SEQUENCE NUMBER (TABLE V-7)	8	9	10	11	12	13	1	2	3	4	17	15	16

BCD INPUT

```
          111111     1111             111
  3  1  1  1  6  0  4  0  0  0  0  0  0  0  0  1  1  0  1  0  1
01    3 GROUP, 3-DIMENSIONAL MODEL, FLUX WEIGHTED SYNTHESIS
01         BLANKET FUNCTIONS (3 AND 4) NOT USED EVERYWHERE
01         3D GEOMETRY BUILT UP FROM 2D GEODST FILES
02        10     1    20                              1     1
03                  1.00                     10.0
04              20       200.0
05               1                 0.          20.
05               2                20.          60.
05               3                60.         100.
05               4               100.         140.
05               5               140.         180.
05               6               180.         200.
07    RTFLUX     1                0.0        200.0
07    RTFLUX     2                0.0        200.0
07    RTFLUX     3                 0.          80.
07    RTFLUX     4               120.         200.
16                                              1
17         1     2     3
19         1    10     2    10     3    10
21        10
```

FIGURE V-7. SYN3D BCD INPUT AND INPUT INTERFACE FILES FOR THE 4TH SAMPLE PROBLEM. EACH INPUT FILE IS IDENTIFIED BY A SEQUENCE NUMBER FROM TABLE V-7 AND IS ASSIGNED A LOGICAL UNIT NUMBER CONSISTENT WITH TABLE V-3. THE BCD DATA CONSISTS OF THE SEEK INITIALIZATION CARD, A "CARDS-PER-CARD-TYPE" CARD AND A SET OF TYPE-NUMBERED CARDS.

INPUT INTERFACE FILES

SYN3D LOGICAL UNIT NUMBER	11	22	23	24	25	32	33	39	40	41
FILE SEQUENCE NUMBER (TABLE V-7)	7	1	2	3	4	5	6	17	15	16

BCD INPUT

```
            1           1111       11      111
  1  1  1  0  0  0  4  4  0  0  0  0  0  0  0  1  1  1  1  1  1
01     3 GROUP, 3-DIMENSIONAL MODEL
02         15      2    20                                  1      1                2
03                    1.00                        10.0
07     RTFLUX       1                 0.0        200.0
07     RTFLUX       2                 0.0        200.0
07     RTFLUX       3                 0.0        100.0
07     RTFLUX       4               100.0        200.0
08     ATFLUX       1                 0.0        200.0
08     ATFLUX       2                 0.0        200.0
08     RTFLUX       3                 0.0        100.0
08     RTFLUX       4               100.0        200.0
16                  5      3      1      1            1
17          1       2      3
18          1       2      3
19          1       5      1      8      1     11      2      8      3      8
20          1       5      1      8      1     11      2      8      3      8
21          1       3      6      9     12     15     18     20
```

Appendix H-4 shows selected pages of output for this job. The eigenvalue is .97520 (vs. .97532 for a 3D finite-difference calculation). The input decks shown in Figs. V-1 and V-2 are set up to run this sample problem.

F. Suggested Modifications to the Code

TIMER

TIMER is a CCCC subroutine with a variety of options for returning elapsed and clock time, job identification, data, etc. Every computer installation has its own set of FORTRAN callable system routines for providing some or all of this information, and so no universal TIMER can offer all options. The version of TIMER included in both IBM and CDC versions of the Code Center package returns elapsed CP time; in addition the IBM version returns the date and wall clock time. SYN3D uses TIMER to determine the time spent in the several parts of the calculation and to provide the date and clock time for file identification and page headers.

SEEK Initialization

Those installations which have their own SEEK and an established SEEK initialization procedure will want to make some changes in the main driver of SYN3D. In the Code Center SYN3D the correspondence between file name and logical unit number is set by the DATA statements defining the elements of the arrays DSNAME and NREF. The file named DSNAME(N) is assigned to logical unit number NREF(N).

On the first call to SEEK (with an operation code of 3) the entire DSNAME array (up to the $), as well as the NREF array, is transferred to a table in the subroutine. Files with the same names are assigned version numbers in ascending order. Blank file names are ignored. Existence flags are initialized to 0 (the file has not been written).

The main driver then reads the SEEK initialization card and looks for columns which contain a number greater than zero. It interprets column numbers as logical unit numbers and for a non-zero entry in a column requests the corresponding file name from SEEK (with an operation code of 5). When it has the file name and version number it calls SEEK with an operation code of 1 to set the existence flag.

Changes to any part or all of this initialization procedure can be made by recoding the main driver and SEEK. No other routines are affected.

Eliminating BCD Input Data

Some installations may prefer to run SYN3D in a mode that completely eliminates direct BCD card input. LASL, for example, uses a general input processor which converts BCD cards to binary interface files; ANL has the ARC System input processors SCAN and STUFF which convert BCD cards to BCD files.

The first overlay in SYN3D, CARDS, reads BCD data either from the BCD card input file or the BCD disk file SYNFIL, depending on the value of the

sentinel IWHERE set in the main driver. CARDS then rewrites the input data to the binary file SYNCON (see the Appendix E for the file description). SYNCON is a binary version of the BCD card input; the data on each card is rewritten to an unformatted record. The user can write SYNCON outside of SYN3D and drop the call to CARDS from the main driver. The rest of the code is unaffected.

CARDS provides one function which is lost if the overly is eliminated. For historical reasons, SYN3D was set up to build 3D (or 2D) geometries from 2D (or 1D) GEODST files. After the code was written an option was added to permit an input 3D (or 2D) file. CARDS was coded to break up an input 3D (or 2D) GEODST into the required number of 2D (or 1D) files and to create the additional, required BCD input data (cards types 4 and 5) before writing SYNCON. If CARDS is eliminated the user must specify 3D (or 2D) models in terms of 2D (or 1D) GEODST files.

Matrix Inversion and Multiplication Subroutines

The matrix inversion routine INVERT and matrix arithmetic routine ARITH which are supplied with the Code Center SYN3D are coded to minimize running time for large problems (many groups and/or expansion functions) when the code is compiled under the IBM FORTRAN H Extended compiler and run on the 370/195. There may be more efficient routines available for other computers.

Restrictions on Problem Size in SOLVE

It is unlikely that the problem size limitations (see Section III-G) will affect users who have large IBM computers; more than enough fast core should be available. CDC users (with a 50K core limitation), however, may reach the problem size limit when the number of energy groups (after group collapsing) times the number of expansion functions used concurrently at any one axial mesh interval is about 50.

The difficulty is with the solution overlay SOLVE. As it is currently written SOLVE must have enough storage to keep six matrices in-core at the same time. These matrices are A_k^-, A_k^o, A_k^+ H_k, REM and FIS (see Eqs. (38), (39), (41), (42), (43) and Section III-D). With a modest investment in programming some or most of these matrices could be kept in LCM.

APPENDIX A

Code Abstract

1. Name or Designation - SYN3D

2. Computer for which Program is Designed and Others upon which it is Operable - IBM 370/195, CDC 7600.

3. Description of Problem or Function - SYN3D solves the direct and adjoint, diffusion theory, static eigenvalue equations in two and three dimensions. The geometries available are x-y, r-z, x-y-z and triangular-z.

4. Method and Solution - SYN3D uses single-channel spatial flux synthesis to calculate approximate solutions to the three-dimensional (or two-dimensional) diffusion theory difference equations. Synthesis expansion functions must be supplied by the user from two-dimensional (or one-dimensional) finite-difference calculations performed by some other code. SYN3D sets up the synthesis equations and solves them by power iteration with Wielandt acceleration. Each iteration is an exact inversion of the block-tridiagonal synthesis equations by forward-elimination, backward-substitution.

5. Restrictions on the Complexity of the Problem - For the most part, SYN3D uses variably dimensioned arrays and disk scratch files to manage data for any size problem in the available fast core. The only serious limitation is on the product of the number of groups and the maximum number of expansion functions used at any particular axial elevation; for CDC users (with a 64K machine) this product is limited to about 50.

6. Typical Running Time - Exclusive of the time required to generate expansion functions SYN3D will solve an 11-group, 12,000 mesh point model with two expansion functions in .9 minutes (CPU). A 28-group, 30,000 mesh point model with three expansion functions requires 8.9 minutes (CPU). These times are for jobs run on an IBM 370/195. For large problems the PP time is less than the CPU time.

7. Unusual Features of the Program - The difference equations SYN3D solves are the mesh-interval-centered type. Expansion functions should be generated using diffusion theory codes solving the same equations (e.g. 2DB, CITATION, VENTURE). The code is designed with restart capabilities which reduce, on the average, the running times for individual problems when a series of similar problems is to be run. SYN3D requires input cross sections, expansion functions and geometry descriptions in the Version III formats defined by the Committee on Computer Code Coordination (CCCC). Special options include group collapsing and the use of different expansion functions in different axial zones of the model.

8. Related and Auxiliary Programs - SYN3D requires binary input files containing cross sections, expansion functions and geometry descriptions. Although a small program is provided with the code to read these data from cards, the user may wish to use other programs which generate CCCC files. A finite-difference, diffusion theory program is required to generate expansion functions.

9. Status -

10. References - C. H. Adams, "SYN3D - A Single-Channel, Spatial Flux Synthesis Code for Diffusion Theory Calculations", ANL 76-21, Argonne National Laboratory (1976).

11. Machine Requirements - The code requires at least a 35 K full-word core to execute small problems and runs more efficiently with larger storage. SYN3D does not use BULK (IBM) or LCM (CDC) storage. Depending on the complexity of the problem, SYN3D may require up to 45 logical units.

12. Programming Language Used - FORTRAN IV. Both IBM and CDC version of SYN3D contain a few routines written in assembler language.

13. Operating System or Monitor under which Program is Executed - The IBM version of SYN3D has been compiled and executed under OS-370 with the FORTRAN H Extended compiler. The CDC SYN3D has been compiled and executed at Berkeley Laboratory under the COKE System with the FORTRAN FTN4.5 compiler.

14. Any Other Programming or Operating Information or Restrictions -

15. Name and Establishment of Author -

C. H. Adams
Applied Physics Division
Argonne National Laboratory
Argonne, Illinois 60439

16. Material Available - Separate tapes are available for the IBM and CDC versions of SYN3D. The SYN3D package includes:

Source decks for SYN3D and auxiliary input program,
Input for sample problems,
Reference report.

17. Category - C

Keywords - two-dimensional, three-dimensional, diffusion equations, synthesis, x-y, r-z, x-y-z, triangular-z.

APPENDIX B. STP018 - THE ARC SYSTEM STANDARD PATH FOR SYN3D.

```
      DOUBLE PRECISION DSNAME
      REAL*8 STFNAM, BLKNAM
      REAL*8 GNIP, GEOM, CHANGE, BC, XSCMIN, XNHOMG, HOMOG, SYN3D,
     1 SYNBLK, TRGNIP, ANIP, X, COMPXS
      COMMON / STFARC / STFNAM, BLKNAM(50), IBLTAB(3,50), NBLOCK, NRET
      COMMON / IOPUT / NIN, NOUT, NOUT2
      DIMENSION DSNAME(87)
      DATA DSNAME / 6HGEOM01, 6HGEOM02, 6HGEOM03, 6HGEOM04, 6HGEOM05,
     1 6HGEOM06, 6HGEOM07, 6HGEOM08, 6HGEOM09, 6HGEOM10,
     2 6HGEOD01, 6HGEOD02, 6HGEOD03, 6HGEOD04, 6HGEOD05, 6HGEOD06,
     3 6HGEOD07, 6HGEOD08, 6HGEOD09, 6HGEOD10,
     4 4HBC01, 4HBC02, 4HBC03, 4HBC04, 4HBC05, 4HBC06, 4HBC07,
     5 4HBC08, 4HBC09, 4HBC10 ,
     6 6HFLUX01, 6HFLUX02, 6HFLUX03, 6HFLUX04, 6HFLUX05, 6HFLUX06,
     7 6HFLUX07, 6HFLUX08, 6HFLUX09, 6HFLUX10, 6HRTFL01, 6HRTFL02,
     8 6HRTFL03, 6HRTFL04, 6HRTFL05, 6HRTFL06, 6HRTFL07, 6HRTFL08,
     9 6HRTFL09, 6HRTFL10, 6HSYNFIL, 6HCOMPXS, 6HREQFLX, 6HREQXSE,
     1 6HINTTC1, 6HINTTC2,8HXS.C.MIN,6HVOLIN1, 6HVOLIN2, 6HDIFIN1,
     2 6HDIFIN2, 6HINTGLS, 5HHFILE,  6HDCCOEF, 6HACCOEF, 4HGEOM,
     3 5HA.NIP, 2HBC, 6HXS.ISO, 7HB.HOMOG, 7HXS.ISC2, 6HSCR001,
     4 6HSCR002, 7HSP.CICN, 7HSP.CRIT, 8HXS.C.AU1, 6HSCR003,
     5 8HXS.M.AUX, 8HXS.M.MIN, 6HSYNCON, 6HATFLUX, 6HPWDINT,
     6 6HRZFLUX, 6HISOTXS, 6HNDYSRF, 6HZNATDN, 1H$ /
C
      DIMENSION ISCR(50)
      DATA ISCR / 50*0 /
      DATA GNIP/6HNUI002/, GEOM/4HGEOM/, CHANGE/6HCHANGE/, BC/2HBC/
      DATA XSCMIN/8HXS.C.MIN/, XNHOMG/6HNUI001/, HOMOG/6HNUC001/,
     1 SYN3D/6HNUC012/, TRGNIP/6HNUI004/, ANIP/5HA.NIP/
      DATA COMPXS/6HCOMPXS/, SYNBLK/5HSYN3D/
C
  500 FORMAT(A8,2I5)
  501 FORMAT(16I5)
C
C  LOOP OVER A.NIP DATA SETS.
C
      I0=0
      I1=1
      I2=2
      NIN=5
      NOUT=6
      NOUT2=0
      N=1
      IRW=1
      CALL LOAD('SNIFF')
      CALL SNIFF(DSNAME,N,IRW)
      CALL SCAN
      L=0
      K=20
    2 CONTINUE
```

APPENDIX B. STP018. CONTINUED.

```
      STFNAM=GEOM
      CALL STUFF
      IF( NRET.LE.0 ) GO TO 10
      L=L+1
      K=K+1
C
C  CREATE A MACROSCOPIC CROSS SECTION FILE ON THE FIRST LOOP IF
C  NONE EXISTS. ICALL=4 FOR NO OUTPUT, ICALL=1 FOR OUTPUT.
C
      ICALL=4
      IF( L.GT.1 ) GO TO 4
      CALL SNIFF( COMPXS, NXS, I0)
      IF( NXS.GT.0 ) GO TO 4
      CALL SNIFF( XSCMTN, NXS, I0)
      IF( NXS.GT.0 ) GO TO 4
      IXS=1
      CALL LINK(XNHOMG)
      CALL LINK( HOMOG, ICALL, I0, I0, I0, IXS)
C
C  CREATE GEOM AND BC FILES.
C
    4 CONTINUE
      CALL SNIFF( DSNAME(L), J, I0)
      IF( J.GT.0 ) GO TO 2
      CALL SNIFF( GEOM, I, I1)
      CALL SNIFF( DSNAME(L), J, I1)
      CALL SNIFF( CHANGE, I, J)
      CALL SNIFF( GEOM, I, I2)
      CALL SNIFF( BC, I, I1)
      CALL SNIFF( DSNAME(K), J, I1)
      CALL SNIFF( CHANGE, I, J)
      CALL SNIFF( BC, I, I2)
      CALL SNIFF( ANIP, NIP, I0)
      IF( NIP.LE.0 ) GO TO 2
      READ(NIP,500) Y,NREC
      READ(NIP,501) (ISCR(I),I=1,NREC)
      REWIND NIP
      IF( ISCR(29).EQ.0 ) GO TO 6
      CALL LINK(TRGNIP)
    6 CONTINUE
      CALL LINK(GNIP,I)
      CALL SNIFF( GEOM, I, I1)
      CALL SNIFF( DSNAME(L), J, I1)
      CALL SNIFF( CHANGE, I, J)
      CALL SNIFF( GEOM, I, I2)
      CALL SNIFF( BC, I, I1)
      CALL SNIFF( DSNAME(K), J, I1)
      CALL SNIFF( CHANGE, I, J)
      CALL SNIFF( BC, I, I2)
      GO TO 2
```

APPENDIX B. STP018. CONTINUED.

```
C
C  LINK TO SYN3D.
C
   10 CONTINUE
      STFNAM=SYNBLK
      CALL STUFF
      IF( NRET.LE.0 ) GO TO 100
      CALL LINK(SYN3D)
      GO TO 10
  100 RETURN
      END
```

APPENDIX C. ARCSP018 - THE ARC SYSTEM CATALOGUED PROCEDURE FOR SYN3D.

```
//ARCSP018 PROC ACCOEF='&ACCOEF',ACCDSP='(NEW,DELETE)',ACCVOL=,
//              BC01='&BC01',BC02='&BC02',BC03='&BC03',
//              BC04='&BC04',BC05='&BC05',BC06='&BC06',
//              BC07='&BC07',BC08='&BC08',BC09='&BC09',BC10='&BC10',
//              BCDSP01='(NEW,DELETE)',BCDSP10='(NEW,DELETE)',
//              BCDSP02='(NEW,DELETE)',BCDSP03='(NEW,DELETE)',
//              BCDSP04='(NEW,DELETE)',BCDSP05='(NEW,DELETE)',
//              BCDSP06='(NEW,DELETE)',BCDSP07='(NEW,DELETE)',
//              BCDSP08='(NEW,DELETE)',BCDSP09='(NEW,DELETE)',
//              BCVOL01=,BCVOL02=,BCVOL03=,BCVOL04=,BCVOL05=,
//              BCVOL06=,BCVOL07=,BCVOL08=,BCVOL09=,BCVOL10=,
//              COMPXS1='&XSCMIN1',COMPXS2='&XSCMIN2',
//              CXSDISP='(NEW,DELETE)',CXSVOLM=,
//              CXSBLK1=1028,CXSBLK2=6136,
//              DCCOEF='&DCCOEF',DCCDSP='(NEW,DELETE)',DCCVOL=,
//              DIFINT1=NULLFILE,DMPDEST=F,
//              DNTVOL1=,DNTDSP1='(OLD,KEEP)',
//              DIFINT2='&DIFINT2',DNTVOL2=,DNTDSP2='(NEW,DELETE)',
//              FLDSP01='(OLD,KEEP)',
//              FLDSP02='(OLD,KEEP)',FLDSP03='(OLD,KEEP)',
//              FLDSP04='(OLD,KEEP)',FLDSP05='(OLD,KEEP)',
//              FLDSP06='(OLD,KEEP)',FLDSP07='(OLD,KEEP)',
//              FLDSP08='(OLD,KEEP)',FLDSP09='(OLD,KEEP)',
//              FLDSP10='(OLD,KEEP)',
//              FLUX01=NULLFILE,FLUX02=NULLFILE,FLUX03=NULLFILE,
//              FLUX04=NULLFILE,FLUX05=NULLFILE,FLUX06=NULLFILE,
//              FLUX07=NULLFILE,FLUX08=NULLFILE,FLUX09=NULLFILE,
//              FLUX10=NULLFILE,
//              FLVOL01=,FLVOL02=,FLVOL03=,FLVOL04=,FLVOL05=,
//              FLVOL06=,FLVOL07=,FLVOL08=,FLVOL09=,FLVOL10=,
//              FULLBLK=12280,
//              GEDSP01='(NEW,DELETE)',GEDSP10='(NEW,DELETE)',
//              GEDSP02='(NEW,DELETE)',GEDSP03='(NEW,DELETE)',
//              GEDSP04='(NEW,DELETE)',GEDSP05='(NEW,DELETE)',
//              GEDSP06='(NEW,DELETE)',GEDSP07='(NEW,DELETE)',
//              GEDSP08='(NEW,DELETE)',GEDSP09='(NEW,DELETE)',
//              GEOM01='&GEOM01',GEOM02='&GEOM02',GEOM03='&GEOM03',
//              GEOM04='&GEOM04',GEOM05='&GEOM05',GEOM06='&GEOM06',
//              GEOM07='&GEOM07',GEOM08='&GEOM08',GEOM09='&GEOM09',
//              GEOM10='&GEOM10',GEVOL01=,GEVOL02=,GEVOL03=,GEVOL04=,
//              GEVOL05=,GEVOL06=,GEVOL07=,GEVOL08=,GEVOL09=,GEVOL10=,
//              HALFBLK=6136,
//              ISOTXS=NULLFILE,ISODSP='(OLD,KEEP)',ISOVOL=,
//              INTTOC1=NULLFILE,INTTOC2='&INTTOC2',
//              LIBBLK2=12280,
//              MICRXS1=NULLFILE,MICRXS2=NULLFILE,MICRVOL=,
//              NDXSRF=NULLFILE,NDXDSP='(OLD,KEEP)',NDXVOL=,
```

APPENDIX C. ARCSP018. CONTINUED.

```
//              PATH=STP018,
//              POSTLIB='SYS1.DUMMYLIB',PPELIB='SYS1.DUMMYLIB',
//              QRTRBLK=3064,
//              TIMLIM='(600,0)',
//              TOCDSP1='(OLD,KEEP)',TOCDSP2='(NEW,DELETE)',
//              TOCVCL1=,TOCVOL2=,
//              UNITS=BATCHDSK,
//              VOLINT1=NULLFILE,VNTVOL1=,VNTDSP1='(OLD,KEEP)',
//              VOLINT2='&VOLINT2',VNTVOL2=,VNTDSP2='(NEW,DELETE)',
//              ZNATDN=NULLFILE,ZNADSP='(OLD,KEEP)',ZNAVOL=
//*
//*  ****************************************************************
//*  *                                                              *
//*  *              CATALOGUED PROCEDURE FOR SYN3D FLUX             *
//*  *                     SYNTHESIS CALCULATION                    *
//*  *                                                              *
//*  ****************************************************************
//*
//*                          SYMBOLIC PARAMETERS
//*
//*  PARAMETER  DEFAULT VALUE            USAGE                  FTNN001
//*  =========  =============            =====                  =======
//*
//*   ACCOEF    &ACCOEF          DSN OF ACCOEF FILE               75
//*   ACCDSP    (NEW,DELETE)     DISPOSITION OF ACCOEF            75
//*   ACCVOL    ------           VOLUME FOR ACCOEF                75
//*   BC01-     &BC01-           DSN OF BC FILES                 31-40
//*     BC10      &BC10
//*   BCDSP01-  (NEW,DELETE)     DISPOSITION OF BC FILES         31-40
//*     BCDSP10
//*   BCVOL01-  ------           VOLUMES FOR BC FILES            31-40
//*     BCVOL10
//*   COMPXS1   &XSCMIN1         DSN OF XS.C.MIN FILE 1           67
//*   COMPXS2   &XSCMIN2         DSN OF XS.C.MIN FILE 2           67
//*   CXSDISP   (NEW,DELETE)     DISPOSITION OF XS.C.MIN          67
//*   CXSVOLM   ------           VOLUME FOR XS.C.MIN              67
//*   CXSBLK1   1028             BLKSIZE FOR XS.C.MIN FILE 1      67
//*   CXSBLK2   6136             BLKSIZE FOR XS.C.MIN FILE 2      67
//*   DCCDSP    (NEW,DELETE)     DISPOSITION OF DCCOEF            74
//*   DCCOEF    &DCCOEF          DSN OF DCCOEF FILE               74
//*   DCCVOL    ------           VOLUME FOR DCCOEF                74
//*   DIFINT1   NULLFILE         DSN OF INPUT DIFINT FILE         70
//*   DIFINT2   &DIFINT2         DSN OF OUTPUT DIFINT FILE        71
//*   DMPDEST   F                ROUTE DUMP TO FICHE            SYSUDUMP
//*   DNTDSP1   (OLD,KEEP)       DISPOSITOON OF INPUT DIFINT      70
//*   DNTDSP2   (NEW,DELETE)     DISPOSITION OF OUTPUT DIFINT     71
//*   DNTVOL1   ------           VOLUME FOR INPUT DIFINT          70
//*   DNTVOL2   ------           VOLUME FOR OUTPUT DIFINT         71
//*   FLDSP01-  (OLD,KEEP)       DISPOSITION OF INPUT FLUXES     41-50
//*     FLDSP10
//*   FLUX01-   NULLFILE         DSN OF INPUT FLUX FILES         41-50
//*     FLUX10
```

APPENDIX C. ARCSP018. CONTINUED.

```
//*    FLVOL01-  ------          VOLUMES FOR INPUT FLUXES          41-50
//*      FLVOL10
//*    FULLBLK   12280           FULL TRACK BLKSIZE
//*    GEDSP01-  (NEW,DELETE)    DISPOSITION OF GEOM FILES         11-20
//*      GEDSP10
//*    GEOM01-   &GEOM01         DSN OF GEOM FILES                 11-20
//*      GEOM10    &GEOM10
//*    GEVOL01-  ------          VOLUMES FOR GEOM FILES            11-20
//*      GEVOL10
//*    HALFBLK   6136            HALF TRACK BLKSIZE
//*    INTTOC1   NULLFILE        DSN OF INPUT INTTOC FILE           65
//*    INTTOC2   &INTTOC2        DSN OF OUTPUT INTTOC FILE          66
//*    ISODSP    (OLD,KEEP)      DISPOSITION OF INPUT ISOTXS        94
//*    ISOTXS    NULLFILE        DSN OF INPUT ISOTXS                94
//*    ISOVOL    ------          VOLUME FOR ISOTXS                  94
//*    LIBBLK2   12280           BLKSIZE, OUTPUT DIFINT & VOLINT 69,71
//*    MICRXS1   NULLFILE        DSN OF XS.ISO FILE 1               79
//*    MICRXS2   NULLFILE        DSN OF XS.ISO FILE 2               79
//*    MICRVOL   ------          VOLUME FOR XS.ISO                  79
//*    NDXDSP    (OLD,KEEP)      DISPOSITION OF INPUT NDXSRF        95
//*    NDXSRF    NULLFILE        DSN OF INPUT NDXSRF                95
//*    NDXVOL    ------          VOLUME FOR NDXSRF                  95
//*    PATH      STP018          PROGRAM NAME                      EXEC
//*    POSTLIB   SYS1.DUMMYLIB   ADDITIONAL LIBRARY DSN          STEPLIB
//*    PRELIB    SYS1.DUMMYLIB   ADDITIONAL LIBRARY DSN          STEPLIB
//*    QRTRBLK   3064            QUARTER TRACK BLKSIZE
//*    TIMLIM    (600,0)         STEP TIME LIMIT                   EXEC
//*    TOCDSP1   (OLD,KEEP)      DISPOSITION OF INPUT INTTOC        65
//*    TOCDSP2   (NEW,DELETE)    DISPOSITION OF OUTPUT INTTOC       66
//*    TOCVOL1   ------          VOLUME FOR INPUT INTTOC            65
//*    TOCVOL2   ------          VOLUME FOR OUTPUT INTTOC           66
//*    UNITS     BATCHDSK        DEFAULT UNIT PARAMETER
//*    VNTDSP1   (OLD,KEEP)      DISPOSITION OF INPUT VOLINT        68
//*    VNTDSP2   (NEW,DELETE)    DISPOSITION OF OUTPUT VOLINT       69
//*    VNTVOL1   ------          VOLUME FOR INPUT VOLINT            68
//*    VNTVOL2   ------          VOLUME FOR OUTPUT VOLINT           69
//*    VOLINT1   NULLFILE        DSN OF INPUT VOLINT FILE           68
//*    VOLINT2   &VOLINT2        DSN OF OUTPUT VOLINT FILE          69
//*    ZNATDN    NULLFILE        DSN OF INPUT ZNATDN                96
//*    ZNAVOL    ------          VOLUME FOR ZNATDN                  96
//*    ZNADSP    (OLD,KEEP)      DISPOSITION OF INPUT ZNATDN        96
//*
//*  ***************************************************************
//*
//GO EXEC PGM=&PATH,TIME=&TIMLIM
//STEPLIB DD DSN=&PRELIB,DISP=SHR
//         DD DSN=C116.B21006.MODLIB,DISP=SHR
//         DD DSN=C116.ARC.MODLIB,DISP=SHR
//         DD DSN=&POSTLIB,DISP=SHR
//FT05F001 DD DDNAME=SYSIN
//FT06F001 DD SYSOUT=A
//SYSUDUMP DD SYSOUT=&DMPDEST
```

APPENDIX C. ARCSP018. CONTINUED.

```
//FT09F001 DD UNIT=2314,SPACE=(CYL,(1,1)),
//      DCB=(RECFM=VBS,LRECL=84,BLKSIZE=3364)
//FT11F001 DD DSN=&GEOM01,VOL=SER=&GEVOL01,DISP=&GEDSP01,
//      UNIT=&UNITS,SPACE=(CYL,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//*     FILES 11 THRU 20 ARE GEOM FILES
//FT12F001 DD DSN=&GEOM02,VOL=SER=&GEVOL02,DISP=&GEDSP02,
//      UNIT=&UNITS,SPACE=(CYL,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//FT13F001 DD DSN=&GEOM03,VOL=SER=&GEVOL03,DISP=&GEDSP03,
//      UNIT=&UNITS,SPACE=(CYL,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//FT14F001 DD DSN=&GEOM04,VOL=SER=&GEVOL04,DISP=&GEDSP04,
//      UNIT=&UNITS,SPACE=(CYL,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//FT15F001 DD DSN=&GEOM05,VOL=SER=&GEVOL05,DISP=&GEDSP05,
//      UNIT=&UNITS,SPACE=(CYL,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//FT16F001 DD DSN=&GEOM06,VOL=SER=&GEVOL06,DISP=&GEDSP06,
//      UNIT=&UNITS,SPACE=(CYL,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//FT17F001 DD DSN=&GEOM07,VOL=SER=&GEVOL07,DISP=&GEDSP07,
//      UNIT=&UNITS,SPACE=(CYL,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//FT18F001 DD DSN=&GEOM08,VOL=SER=&GEVOL08,DISP=&GEDSP08,
//      UNIT=&UNITS,SPACE=(CYL,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//FT19F001 DD DSN=&GEOM09,VOL=SER=&GEVOL09,DISP=&GEDSP09,
//      UNIT=&UNITS,SPACE=(CYL,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//FT20F001 DD DSN=&GEOM10,VOL=SER=&GEVOL10,DISP=&GEDSP10,
//      UNIT=&UNITS,SPACE=(CYL,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//*     FILES 11 THRU 20 ARE GEOM FILES
//FT21F001 DD DSN=&GEODS01,DISP=(NEW,DELETE),SPACE=(CYL,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK),UNIT=SASCR
//*     FILES 21 THRU 30 ARE CCCC GEODST FILES
//FT22F001 DD DSN=&GEODS02,DISP=(NEW,DELETE),SPACE=(CYL,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK),UNIT=SASCR
//FT23F001 DD DSN=&GEODS03,DISP=(NEW,DELETE),SPACE=(CYL,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK),UNIT=SASCR
//FT24F001 DD DSN=&GEODS04,DISP=(NEW,DELETE),SPACE=(CYL,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK),UNIT=SASCR
//FT25F001 DD DSN=&GEODS05,DISP=(NEW,DELETE),SPACE=(CYL,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK),UNIT=SASCR
//FT26F001 DD DSN=&GEODS06,DISP=(NEW,DELETE),SPACE=(CYL,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK),UNIT=SASCR
//FT27F001 DD DSN=&GEODS07,DISP=(NEW,DELETE),SPACE=(CYL,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK),UNIT=SASCR
//FT28F001 DD DSN=&GEODS08,DISP=(NEW,DELETE),SPACE=(CYL,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK),UNIT=SASCR
```

APPENDIX C. ARCSP018. CONTINUED.

```
//FT29F001 DD DSN=&GEODS09,DISP=(NEW,DELETE),SPACE=(CYL,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK),UNIT=SASCR
//FT30F001 DD DSN=&GEODS10,DISP=(NEW,DELETE),SPACE=(CYL,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK),UNIT=SASCR
//*     FILES 21 THRU 30 ARE CCCC GEODST FILES
//FT31F001 DD DSN=&BC01,VOL=SER=&BCVOL01,DISP=&BCDSP01,
//      UNIT=&UNITS,SPACE=(TRK,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=304)
//*     FILES 31 THRU 40 ARE THE BC FILES ASSOCIATED WITH THE GEOM
//*     FILES (11 THRU 20)
//FT32F001 DD DSN=&BC02,VOL=SER=&BCVOL02,DISP=&BCDSP02,
//      UNIT=&UNITS,SPACE=(TRK,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=304)
//FT33F001 DD DSN=&BC03,VOL=SER=&BCVOL03,DISP=&BCDSP03,
//      UNIT=&UNITS,SPACE=(TRK,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=304)
//FT34F001 DD DSN=&BC04,VOL=SER=&BCVOL04,DISP=&BCDSP04,
//      UNIT=&UNITS,SPACE=(TRK,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=304)
//FT35F001 DD DSN=&BC05,VOL=SER=&BCVOL05,DISP=&BCDSP05,
//      UNIT=&UNITS,SPACE=(TRK,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=304)
//FT36F001 DD DSN=&BC06,VOL=SER=&BCVOL06,DISP=&BCDSP06,
//      UNIT=&UNITS,SPACE=(TRK,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=304)
//FT37F001 DD DSN=&BC07,VOL=SER=&BCVOL07,DISP=&BCDSP07,
//      UNIT=&UNITS,SPACE=(TRK,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=304)
//FT38F001 DD DSN=&BC08,VOL=SER=&BCVOL08,DISP=&BCDSP08,
//      UNIT=&UNITS,SPACE=(TRK,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=304)
//FT39F001 DD DSN=&BC09,VOL=SER=&BCVOL09,DISP=&BCDSP09,
//      UNIT=&UNITS,SPACE=(TRK,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=304)
//FT40F001 DD DSN=&BC10,VOL=SER=&BCVOL10,DISP=&BCDSP10,
//      UNIT=&UNITS,SPACE=(TRK,(1,1)),
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=304)
//*     FILES 31 THRU 40 ARE THE BC FILES ASSOCIATED WITH THE GEOM
//*     FILES (11 THRU 20)
//FT41F001 DD DSN=&FLUX01,UNIT=&UNITS,VOL=SER=&FLVOL01,DISP=&FLDSP01
//*     FILES 41 THRU 50 ARE INPUT FR.D2, FA.D2, FR.D1 AND FA.D1 FILES
//FT42F001 DD DSN=&FLUX02,UNIT=&UNITS,VOL=SER=&FLVOL02,DISP=&FLDSP02
//FT43F001 DD DSN=&FLUX03,UNIT=&UNITS,VOL=SER=&FLVOL03,DISP=&FLDSP03
//FT44F001 DD DSN=&FLUX04,UNIT=&UNITS,VOL=SER=&FLVOL04,DISP=&FLDSP04
//FT45F001 DD DSN=&FLUX05,UNIT=&UNITS,VOL=SER=&FLVOL05,DISP=&FLDSP05
//FT46F001 DD DSN=&FLUX06,UNIT=&UNITS,VOL=SER=&FLVOL06,DISP=&FLDSP06
//FT47F001 DD DSN=&FLUX07,UNIT=&UNITS,VOL=SER=&FLVOL07,DISP=&FLDSP07
//FT48F001 DD DSN=&FLUX08,UNIT=&UNITS,VOL=SER=&FLVOL08,DISP=&FLDSP08
//FT49F001 DD DSN=&FLUX09,UNIT=&UNITS,VOL=SER=&FLVOL09,DISP=&FLDSP09
//FT50F001 DD DSN=&FLUX10,UNIT=&UNITS,VOL=SER=&FLVOL10,DISP=&FLDSP10
//*     FILES 41 THRU 50 ARE INPUT FR.D2, FA.D2, FR.D1 AND FA.D1 FILES
```

APPENDIX C. ARCSP018. CONTINUED.

```
//FT51F001 DD DSN=&RTFL01,UNIT=SASCR,DISP=(NEW,DELETE),
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//*     FILES 51 THRU 60 ARE CCCC RTFLUX AND ATFLUX FILES
//FT52F001 DD DSN=&RTFL02,UNIT=SASCR,DISP=(NEW,DELETE),
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//FT53F001 DD DSN=&RTFL03,UNIT=SASCR,DISP=(NEW,DELETE),
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//FT54F001 DD DSN=&RTFL04,UNIT=SASCR,DISP=(NEW,DELETE),
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//FT55F001 DD DSN=&RTFL05,UNIT=SASCR,DISP=(NEW,DELETE),
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//FT56F001 DD DSN=&RTFL06,UNIT=SASCR,DISP=(NEW,DELETE),
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//FT57F001 DD DSN=&RTFL07,UNIT=SASCR,DISP=(NEW,DELETE),
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//FT58F001 DD DSN=&RTFL08,UNIT=SASCR,DISP=(NEW,DELETE),
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//FT59F001 DD DSN=&RTFL09,UNIT=SASCR,DISP=(NEW,DELETE),
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//FT60F001 DD DSN=&RTFL10,UNIT=SASCR,DISP=(NEW,DELETE),
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//*     FILES 51 THRU 60 ARE CCCC RTFLUX AND ATFLUX FILES
//FT61F001 DD DSN=&SYNFIL,DISP=(NEW,DELETE),UNIT=SASCR,
//      DCB=(RECFM=VBS,LRECL=84,BLKSIZE=3156),SPACE=(TRK,(1,1))
//*     THE BCD INPUT FILE
//FT62F001 DD DSN=&XSCMIN,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=6447)
//*     A ONE-FILE XS.C.MIN
//FT63F001 DD DSN=&REQFLX,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(CYL,(2,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&FULLBLK)
//*     REWRITTEN FLUXES AND GEOMETRIES
//FT64F001 DD DSN=&REQXST,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(CYL,(2,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&FULLBLK)
//*     REWRITTEN CROSS SECTIONS
//FT65F001 DD DSN=&INTTOC1,VOL=SER=&TOCVOL1,DISP=&TOCDSP1,UNIT=&UNITS
//*     THE INPUT INTTOC FILE
//FT66F001 DD DSN=&INTTOC2,VOL=SER=&TOCVOL2,DISP=&TOCDSP2,
//      SPACE=(TRK,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&QRTRBLK),
//      UNIT=&UNITS
//*     THE OUTPUT INTTOC FILE
//FT67F001 DD DSN=&COMPXS1,UNIT=&UNITS,VOL=SER=&CXSVOLM,DISP=&CXSDISP,
//      SPACE=(TRK,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&CXSBLK1)
//*     THE FIRST FILE OF THE INPUT, TWO-FILE XS.C.MIN
//FT67F002 DD DSN=&COMPXS2,UNIT=&UNITS,VOL=SER=&CXSVOLM,DISP=&CXSDISP,
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&CXSBLK2)
//*     THE SECOND FILE OF THE INPUT, TWO-FILE XS.C.MIN
//FT68F001 DD DSN=&VOLINT1,VOL=SER=&VNTVOL1,DISP=&VNTDSP1,UNIT=&UNITS
//*     THE INPUT VOLINT FILE
```

APPENDIX C. ARCSP018. CONTINUED.

```
//FT69F001 DD DSN=&VOLINT2,VOL=SER=&VNTVOL2,DISP=&VNTDSP2,
//      SPACE=(CYL,(2,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&LIBBLK2),
//      UNIT=&UNITS
//*     THE OUTPUT VOLINT FILE
//FT70F001 DD DSN=&DIFINT1,VOL=SER=&DNTVOL1,DISP=&DNTDSP1,UNIT=&UNITS
//*     THE INPUT DIFINT FILE
//FT71F001 DD DSN=&DIFINT2,VOL=SER=&DNTVOL2,DISP=&DNTDSP2,
//      SPACE=(TRK,(2,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&LIBBLK2),
//      UNIT=&UNITS
//*     THE OUTPUT DIFINT FILE
//FT72F001 DD DSN=&INTGLS,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(CYL,(2,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&FULLBLK)
//*     THE INTGLS FILE CONTAINS REWRITTEN INTEGRALS
//FT73F001 DD DSN=&HFILE,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(CYL,(2,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&FULLBLK)
//*     A SCRATCH FILE
//FT74F001 DD DSN=&DCCOEF,VOL=SER=&DCCVOL,DISP=&DCCDSP,UNIT=&UNITS,
//      SPACE=(TRK,(2,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//*     THE DIRECT COMBINING COEFFICIENTS
//FT75F001 DD DSN=&ACCOEF,VOL=SER=&ACCVOL,DISP=&ACCDSP,UNIT=&UNITS,
//      SPACE=(TRK,(2,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//*     THE ADJOINT COMBINING COEFFICIENTS
//FT76F001 DD DSN=&GEOM,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&QRTRBLK)
//*     A SCRATCH GEOM FILE
//FT77F001 DD DSN=&ANIP,UNIT=SASCR,SPACE=(CYL,(1,1)),
//      DCB=(RECFM=VBS,LRECL=94,BLKSIZE=1684),DISP=(NEW,DELETE)
//*     THE BCD A.NIP FILE
//FT78F001 DD DSN=&BC,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=304)
//*     A SCRATCH BC FILE
//FT79F001 DD DSN=&MICRXS1,DISP=SHR,UNIT=&UNITS,VOL=SER=&MICRVOL
//*     FIRST FILE OF INPUT XS.ISO
//FT79F002 DD DSN=&MICRXS2,DISP=SHR,UNIT=&UNITS,VOL=SER=&MICRVOL
//*     SECOND FILE OF INPUT XS.ISO
//FT80F001 DD DSN=&BHOMG,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//*     FILES 80 THRU 89 ARE NEEDED IN THE CROSS SECTION GENERATION
//FT81F001 DD DSN=&XIS21,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//FT81F002 DD DSN=&XIS22,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//FT81F003 DD DSN=&XIS23,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//FT81F004 DD DSN=&XIS24,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//FT82F001 DD DSN=&SCR001,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//FT83F001 DD DSN=&SCR002,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//FT94F001 DD DSN=&SPCICN0,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(76,1),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=76)
```

APPENDIX C. ARCSP018. CONTINUED.

```
//FT85F001 DD DSN=&SPCRIT,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(TRK,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=388)
//FT86F001 DD DSN=&XSCAUX1,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(TRK,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=516)
//FT86F002 DD DSN=&XSCAUX2,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//FT87F001 DD DSN=&SCR003A,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//FT87F002 DD DSN=&SCR003B,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//FT88F001 DD DSN=&XSMAUX,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&QRTRBLK)
//FT89F001 DD DSN=&XSMMIN,DISP=(NEW,DELETE),UNIT=SASCR,
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//*     FILES 80 THRU 89 ARE NEEDED IN THE CROSS SECTION GENERATION
//FT90F001 DD DSN=&SYNCON,DISP=(NEW,DELETE),UNIT=SASCR,
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=304),SPACE=(TRK,(1,1))
//*     THE BINARY CONTROL FILE FOR SYN3D
//FT91F001 DD DSN=&ATFL01,UNIT=SASCR,DISP=(NEW,DELETE),
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//*     A CCCC ATFLUX FILE FOR ADJOINT FLUXES
//FT92F001 DD DSN=&PWDINT,UNIT=SASCR,DISP=(NEW,DELETE),
//      SPACE=(CYL,(1,1)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//*     POWER DENSITY, CCCC FORMAT
//FT93F001 DD DSN=&RZFLUX,UNIT=SASCR,DISP=(NEW,DELETE),
//      SPACE=(TRK,(5,2)),DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)
//*     AVERAGE FLUXES BY ZONE, CCCC FORMAT
//FT94F001 DD DSN=&ISOTXS,UNIT=&UNITS,VOL=SER=&ISOVOL,DISP=&ISODSP
//*     INPUT MICROSCOPIC CROSS SECTIONS IN CCCC FORMAT
//FT95F001 DD DSN=&NDXSRF,UNIT=&UNITS,VOL=SER=&NDXVOL,DISP=&NDXDSP
//*     CROSS SECTION REFERENCE FILE, CCCC FORMAT
//FT96F001 DD DSN=&ZNATDN,UNIT=&UNITS,VOL=SER=&ZNAVOL,DISP=&ZNADSP
//*     ATOM DENSITIES, CCCC FORMAT
//FT97F001 DD DSN=&XSCMII1,UNIT=SASCR,SPACE=(CYL,(1,1)),
//             DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&QRTRBLK)                  *
//             FILE 1 OF COMPOSITION CROSS SECTION SET XS.M.MI1
//FT97F002 DD DSN=&XSCMII2,UNIT=SASCR,SPACE=(CYL,(1,1)),
//             DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)                  *
//             FILE 2 OF COMPOSITION CROSS SECTION SET XS.M.MI1
//*
//*     ************************************************************
//*     *                                                          *
//*     *    ANYONE EXPERIENCING DIFFICULTY WITH THIS PROCEDURE    *
//*     *    SEE C. H. ADAMS, BLDG 208, ROOM W-117                 *
//*     *                                                          *
//*     ************************************************************
//*
```

APPENDIX D. INPUT DATA SET SYNFIL.

```
C*********************************************************************
C                                                                    -
C                        PREPARED 09/19/74 AT ANL                    -
C                                                                    -
CE          SYNFIL                                                   -
CE          BCD INPUT FOR SYNTHESIS CALCULATIONS                     -
C                                                                    -
CN                       THIS IS A USER SUPPLIED BCD DATA SET.       -
CN                       THE LIST FOR EACH RECORD IS GIVEN IN TERMS  -
CN                       OF THE BCD FORMAT OF THAT DATA CARD.        -
CN                       COLUMNS 1-2 CONTAIN THE CARD TYPE NUMBER.   -
CN                       BLANK FIELDS PRODUCE THE DEFAULT VALUES.    -
CN                                                                   -
CN                       CARD TYPES 01 THROUGH 06 CONTAIN THE MODEL  -
CN                       GEOMETRY SPECIFICATIONS. CARD TYPES 07      -
CN                       THROUGH 21 DESCRIBE THE SYNTHESIS SCHEME.   -
C                                                                    -
C*********************************************************************


C--------------------------------------------------------------------
CR          PROBLEM TITLE (TYPE 01)                                  -
C                                                                    -
CL    FORMAT-----(I2,4X,11A6)                                        -
C                                                                    -
CD    COLUMNS            CONTENTS...IMPLICATIONS, IF ANY             -
CD    =======    ==================================================-
CD    1-2        01                                                  -
CD                                                                   -
CD    7-72       ANY ALPHANUMERIC CHARACTERS.                        -
C                                                                    -
CN               AS MANY TYPE 01 CARDS MAY BE USED AS ARE NECESSARY. -
C                                                                    -
C--------------------------------------------------------------------


C--------------------------------------------------------------------
CR          GENERAL MODEL GEOMETRY SPECIFICATIONS (TYPE 02)          -
C                                                                    -
CL    FORMAT-----(I2,4X,11I6)                                        -
C                                                                    -
CD    COLUMNS            CONTENTS...IMPLICATIONS, IF ANY             -
CD    =======    ==================================================-
CD    1-2        02                                                  -
CD                                                                   -
CD    7-12       MAXSTZ, SIZE OF MAIN CORE STORAGE ARRAY IN REAL*8   -
CD               WORDS (SINGLE WORDS ON CDC SYSTEMS), SPECIFIED IN   -
CD               THOUSANDS OF WORDS (DEFAULT=10, I.E., 10000 WORDS). -
CD                                                                   -
```

APPENDIX D. INPUT DATA SET SYNFIL. (CONTD.)

```
CD      13-18     NCALC, CALCULATION OPTIONS.                              -
CD                0...DO NOT SOLVE SYNTHESIS EQUATIONS, ONLY UPDATE        -
CD                    INTEGRALS TO INCLUDE WHAT IS NEEDED FOR FLUX AND     -
CD                    POWER EDITS AND GO TO EDITS.  IF THERE ARE ANY       -
CD                    CARDS OF TYPES 16 THRU 21 A COMBINING COEFFICIENT    -
CD                    FILE (DCCOEF OR ACCOEF) MUST BE AVAILABLE            -
CD                    (DEFAULT).                                           -
CD                1...UPDATE INTEGRALS AND SOLVE A DIRECT EIGENVALUE       -
CD                    PROBLEM.                                             -
CD                2...UPDATE INTEGRALS AND SOLVE BOTH A DIRECT AND         -
CD                    ADJOINT EIGENVALUE PROBLEM.                          -
CD                3...UPDATE INTEGRALS AND SOLVE AN ADJOINT EIGENVALUE     -
CD                    PROBLEM.                                             -
CD                                                                         -
CD      19-24     MAXITR, MAXIMUM NUMBER OF EIGENVALUE ITERATIONS          -
CD                ALLOWED (DEFAULT=10).                                    -
CD                                                                         -
CD      25-30     IBCXL, BOUNDARY CONDITION FOR THE LOWER "X" BOUNDARY     -
CD                (X=0.) OF THE THREE-DIMENSIONAL MODEL.                   -
CD                                                                         -
CD      31-36     IBCXU, BOUNDARY CONDITION FOR THE UPPER "X" BOUNDARY     -
CD                OF THE THREE-DIMENSIONAL MODEL.                          -
CD                                                                         -
CD      37-42     IBCYL, BOUNDARY CONDITION FOR THE LOWER "Y" BOUNDARY     -
CD                OF THE THREE-DIMENSIONAL MODEL.                          -
CD                                                                         -
CD      43-48     IBCYU, BOUNDARY CONDITION FOR THE UPPER "Y" BOUNDARY     -
CD                OF THE THREE-DIMENSIONAL MODEL.                          -
CD                                                                         -
CD      49-54     IBCZL, BOUNDARY CONDITION FOR THE LOWER "Z" BOUNDARY     -
CD                OF THE THREE-DIMENSIONAL MODEL.                          -
CD                                                                         -
CD      55-60     IBCZU, BOUNDARY CONDITION FOR THE UPPER "Z" BOUNDARY     -
CD                OF THE THREE-DIMENSIONAL MODEL.                          -
CD                                                                         -
CD                THE POSSIBLE BOUNDARY CONDITIONS ARE:                    -
CD                1...ZERO FLUX.                                           -
CD                2...REFLECTIVE.                                          -
CD                3...EXTRAPOLATED (C*D*DEL PHI + PHI = 0).                -
CD                    THE CONSTANTS C FOR THE EXTRAPOLATED BOUNDARY        -
CD                    CONDITION ARE SPECIFIED ON CARD TYPE 06.             -
CD                4...PERIODIC WITH OPPOSITE BOUNDARY.                     -
CD                5...PERIODIC WITH NEXT BOUNDARY GOING IN THE ORDER       -
CD                    LOWER X, UPPER Y, UPPERX, LOWER Y.                   -
CD                6...PERIODIC WITH NEXT BOUNDARY GOING IN THE ORDER       -
CD                    LOWER X, UPPER Y, UPPERX, LOWER Y.                   -
CD                    CLOCKWISE.                                           -
CD                7...PERIODIC, INVERTED ALONG THE SAME BOUNDARY.          -
CD                                                                         -
CD                PERIODIC CONDITIONS (CONDITIONS 4 THROUGH 7) CAN ONLY    -
CD                APPLY TO "X" AND "Y" BOUNDARIES.                         -
```

APPENDIX D. INPUT DATA SET SYNFIL. (CONTD.)

```
CD                                                                      -
CD     61-66      LGROUP, THE NUMBER OF ENERGY GROUPS AFTER GROUP       -
CD                COLLAPSING. THIS NUMBER MUST BE PROVIDED WHEN A GENERAL-
CD                GROUP COLLAPSING SCHEME IS EMPLOYED (CARD TYPES 11 AND -
CD                12 PRESENT IN INPUT), OTHERWISE, MAY BE IGNORED.      -
CD                                                                      -
CD     67-72      IEDT, EDIT OPTIONS FOR HMG4C OVERLAY. IGNORED IN THE  -
CD                ARC SYSTEM SYN3D.                                     -
CD                                                                      -
CD                0...NO EDIT DESIRED.                                  -
CD                1...NORMAL EDIT SHOWING CORE USED AND ELAPSED TIME.   -
CD                2...EDIT 1 PLUS COMPLETE EDIT OF MACROSCOPIC CROSS    -
CD                    SECTION FILE WRITTEN BY HMG4C (COMPXS).           -
CD                3...EDIT 2 PLUS RUNNING EDIT OF ISOTXS (I.E. ONLY THAT -
CD                    DATA FROM ISOTXS WHICH IS ACTUALLY USED IS EDITED).-
CD                4...EDIT 3 PLUS BPOINTER TRACE PRINTS.                -
C                                                                       -
CN                WHEN THERE IS NO INPUT INTTOC FILE THE "X" AND "Y"    -
CN                BOUNDARY CONDITIONS ARE PICKED UP FROM THE FIRST      -
CN                GEODST FILE ON THE TYPE 05 CARD. WHEN THERE IS AN     -
CN                INPUT INTTOC FILE THE OLD BOUNDARY CONDITIONS ARE     -
CN                ASSUMED. THE DEFAULT "Z" BOUNDARY CONDITIONS ARE      -
CN                ZERO CURRENT.                                         -
C                                                                       -
CN                IF THE "X" AND "Y" BOUNDARY CONDITIONS ARE EXTRAPOLATED-
CN                THE CODE DOES NOT PICK UP THE CONSTANTS FROM THE      -
CN                GOEDST FILE'- CARD TYPE 06 IS REQUIRED.               -
C                                                                       -
CN                FOR TWO-DIMENSIONAL (XY OR RZ) PROBLEMS THE SECOND    -
CN                DIMENSION IS TREATED AS THE "Z" DIMENSION.  THE       -
CN                SECOND DIMENSION BOUNDARY CONDITIONS GO IN COLS.      -
CN                49-54 AND 55-60.                                      -
C                                                                       -
C-----------------------------------------------------------------------
```

```
C-----------------------------------------------------------------------
CR          GENERAL PROBLEM CONSTANTS (TYPE 03)                         -
C                                                                       -
CL     FORMAT-----(I2,10X,5E12.5)                                       -
C                                                                       -
CD     COLUMNS            CONTENTS...IMPLICATIONS, IF ANY               -
CD     =======    ==========================================================-
CD     1-2        03                                                    -
CD                                                                      -
CD     13-24      GUESS, K (EIGENVALUE) ESTIMATE FOR WIELANDT ITERATION -
CD                (DEFAULT=NO WIELANDT ITERATION).  THE BEST CHOICE     -
CD                IS A NUMBER SLIGHTLY HIGHER THAN THE EXPECTED K.      -
CD                                                                      -
CD     25-36      CONVRG, EIGENVALUE CONVERGENCE CRITERION              -
CD                (DEFAULT=1.E-5).                                      -
CD                                                                      -
CD     37-48      TOTAL POWER IN WATTS (DEFAULT = 1 WATT).              -
C                                                                       -
C-----------------------------------------------------------------------
```

APPENDIX D. INPUT DATA SET SYNFIL. (CONTD.)

```
C-----------------------------------------------------------------------
CR          AXIAL MESH DESCRIPTION (TYPE 04)                          -
C                                                                     -
CL    FORMAT-----(I2,10X,3(I6,E12.5))                                 -
C                                                                     -
CD    COLUMNS           CONTENTS...IMPLICATIONS, IF ANY               -
CD    =======   ==================================================-
CD    1-2       04                                                    -
CD                                                                    -
CD    13-18     N, NUMBER OF INTERVALS INTO WHICH A PORTION OF THE "Z" -
CD              AXIS IS TO BE DIVIDED (DEFAULT=2).                    -
CD                                                                    -
CD    19-30     Z, UPPER COORDINATE OF THAT PORTION                   -
CD              (DEFAULT=.5CM EACH).                                  -
CD                                                                    -
CD    31-36     N, NUMBER OF INTERVALS INTO WHICH A PORTION OF THE "Z" -
CD              AXIS IS TO BE DIVIDED.                                -
CD                                                                    -
CD    37-48     Z, UPPER COORDINATE OF THAT PORTION.                  -
CD                                                                    -
CD    49-54     N, NUMBER OF INTERVALS INTO WHICH A PORTION OF THE "Z" -
CD              AXIS IS TO BE DIVIDED.                                -
CD                                                                    -
CD    55-66     Z, UPPER COORDINATE OF THAT PORTION.                  -
C                                                                     -
CN              THE AXIAL MESH DESCRIPTION STARTS AT Z=0.             -
CN                                                                    -
CN              AS MANY TYPE 04 CARDS ARE USED AS ARE NECESSARY TO    -
CN              SPECIFY THE AXIAL MESH DESCRIPTION.                   -
CN                                                                    -
CN              WHEN THERE ARE NO TYPE 04 OR 05 CARDS THE CODE WILL   -
CN              EXPECT TO FIND A GEOMETRY FILE (GEODST,1) FROM WHICH  -
CN              TO EXTRACT THE DATA.                                  -
C                                                                     -
C-----------------------------------------------------------------------


C-----------------------------------------------------------------------
CR          AXIAL GEOMETRY DESCRIPTION (TYPE 05)                      -
C                                                                     -
CL    FORMAT-----(I2,10X,I6,6X,4E12.5)                                -
C                                                                     -
CD    COLUMNS           CONTENTS...IMPLICATIONS, IF ANY               -
CD    =======   ==================================================-
CD    1-2       05                                                    -
CD                                                                    -
CD    13-18     IVER, THE VERSION NUMBER FOR A GEODST FILE DESCRIBING -
CD              A TWO-DIMENSIONAL GEOMETRY.                           -
CD                                                                    -
CD    25-36     ZBOT, THE LOWER AXIAL LIMIT OF AN AXIAL ZONE          -
CD              CHARACTERIZED BY THE TWO-DIMENSIONAL GEOMETRY IN      -
CD              GEODST, IVER.                                         -
CD                                                                    -
CD    37-48     ZTOP, THE UPPER AXIAL LIMIT OF THE SAME ZONE.         -
```

APPENDIX D. INPUT DATA SET SYNFIL. (CONTD.)

```
CD                                                                      -
CD     49-60      ZBOT, THE LOWER AXIAL LIMIT OF AN AXIAL ZONE          -
CD                CHARACTERIZED BY THE TWO-DIMENSIONAL GEOMETRY IN      -
CD                GEODST, IVER.                                         -
CD                                                                      -
CD     61-72      ZTOP, THE UPPER AXIAL LIMIT OF THE SAME ZONE.         -
C                                                                       -
CN                AS MANY TYPE 05 CARDS ARE USED AS ARE NECESSARY TO    -
CN                SPECIFY THE AXIAL GEOMETRY DESCRIPTION.               -
CN                                                                      -
CN                WHEN THERE ARE NO TYPE 04 OR 05 CARDS THE CODE WILL   -
CN                EXPECT TO FIND A GEOMETRY FILE (GEODST,1) FROM WHICH  -
CN                TO EXTRACT THE DATA.                                  -
CN                                                                      -
CN                THE USER MAY OVERLAY GEOMETRIES IN BUILDING A MODEL.  -
C                                                                       -
C-----------------------------------------------------------------------

C-----------------------------------------------------------------------
CR          CONSTANTS FOR EXTRAPOLATED BOUNDARY CONDITIONS (TYPE 06)    -
C                                                                       -
CL     FORMAT-----(I2,8X,A2,2(2I6,E12.5))                               -
C                                                                       -
CD     COLUMNS            CONTENTS...IMPLICATIONS, IF ANY               -
CD     =======    ==================================================-
CD     1-2        06                                                    -
CD                                                                      -
CD     11-12      B, THE BOUNDARY DESIGNATOR IDENTIFYING THE BOUNDARY   -
CD                OF ONE OF THE THREE DIMENSIONS.                       -
CD                XL..."X" LOWER.                                       -
CD                XU..."X" UPPER.                                       -
CD                YL..."Y" LOWER.                                       -
CD                YU..."Y" UPPER.                                       -
CD                ZL..."Z" LOWER.                                       -
CD                ZU..."Z" UPPER.                                       -
CD                                                                      -
CD     13-18      IGHI, THE HIGHEST ENERGY GROUP WHICH USES THE         -
CD                CONSTANT C.                                           -
CD                                                                      -
CD     19-24      IGLO, THE LOWEST ENERGY GROUP WHICH USES THE          -
CD                CONSTANT C.                                           -
CD                                                                      -
CD     25-36      C, THE CONSTANT FOR IBC=3 ON THE TYPE 02 CARD         -
CD                                                                      -
CD     37-42      IGHI, THE HIGHEST ENERGY GROUP WHICH USES THE         -
CD                CONSTANT C.                                           -
CD                                                                      -
CD     43-48      IGLO, THE LOWEST ENERGY GROUP WHICH USES THE          -
CD                CONSTANT C.                                           -
```

APPENDIX D. INPUT DATA SET SYNFIL. (CONTD.)

```
CD                                                                      -
CD    49-60      C, THE CONSTANT FOR IBC=3 ON THE TYPE 02 CARD          -
C                                                                       -
CN               AS MANY TYPE 06 CARDS ARE USED AS ARE NECESSARY TO     -
CN               SPECIFY THE REQUIRED VALUES FOR THE CONSTANT C.        -
C                                                                       -
CN               WHEN AN EXTRAPOLATED BOUNDARY CONDITION IS SPECIFIED   -
CN               ON THE TYPE 2 CARD, AND THE CORRESPONDING CONSTANTS    -
CN               ARE NOT SPECIFIED ON A TYPE 6 CARD, A DEFAULT VALUE    -
CN               OF C=2.13 IS USED (FOR THE PARTICULAR BOUNDARY AND     -
CN               GROUP RANGE NOT SPECIFIED).                            -
C                                                                       -
C-----------------------------------------------------------------------


C-----------------------------------------------------------------------
CR          EXPANSION FUNCTION SPECIFICATION (TYPE 07)                  -
C                                                                       -
CL    FORMAT-----(I2,4X,A6,I6,6X,4E12.5)                                -
C                                                                       -
CD    COLUMNS            CONTENTS...IMPLICATIONS, IF ANY                -
CD    =======    ==========================================================-
CD    1-2        07                                                     -
CD                                                                      -
CD    7-12       TITFUN, FLUX FILE NAME. TITFUN MAY BE "UNIT" WHICH     -
CD               IMPLIES A UNIT FLUX IN ALL GROUPS EVEN THOUGH SUCH A   -
CD               FILE DOES NOT ACTUALLY EXIST. "UNIT" MUST BE ENTERED   -
CD               IN COLS. 7-10.                                         -
CD                                                                      -
CD    13-18      IVER, FLUX FILE VERSION NUMBER.  IN THE CASE OF A UNIT -
CD               FLUX IVER IS UNNECESSARY.                              -
CD                                                                      -
CD    25-36      ZBOT, THE LOWER LIMIT OF AN AXIAL ZONE WHERE THE       -
CD               FUNCTION IS USED.                                      -
CD                                                                      -
CD    37-48      ZTOP, THE UPPER LIMIT OF THAT ZONE.                    -
CD                                                                      -
CD    49-60      ZBOT, THE LOWER LIMIT OF AN AXIAL ZONE WHERE THE       -
CD               FUNCTION IS USED.                                      -
CD                                                                      -
CD    61-72      ZTOP, THE UPPER LIMIT OF THAT ZONE.                    -
CD                                                                      -
CD               (DEFAULT= A UNIT FLUX WILL BE USED EVERYWHERE AS THE   -
CD               ONLY EXPANSION FUNCTION).                              -
C                                                                       -
CN               AS MANY TYPE 07 CARDS ARE USED AS ARE NECESSARY TO     -
CN               SPECIFY THE EXPANSION FUNCTION DATA.                   -
C                                                                       -
C-----------------------------------------------------------------------
```

APPENDIX D. INPUT DATA SET SYNFIL. (CONTD.)

```
C-----------------------------------------------------------------------
CR          WEIGHTING FUNCTION SPECIFICATION (TYPE 08)                 -
C                                                                      -
CL    FORMAT-----(I2,4X,A6,I6,6X,4E12.5)                               -
C                                                                      -
CD    COLUMNS            CONTENTS...IMPLICATIONS, IF ANY               -
CD    =======    ==================================================-
CD    1-2        08                                                    -
CD                                                                     -
CD    7-12       TITFUN, FLUX FILE NAME. TITFUN MAY BE "UNIT" WHICH    -
CD               IMPLIES A UNIT FLUX IN ALL GROUPS EVEN THOUGH SUCH A  -
CD               FILE DOES NOT ACTUALLY EXIST. "UNIT" MUST BE ENTERED  -
CD               IN COLS. 7-10.                                        -
CD                                                                     -
CD    13-18      IVER, FLUX FILE VERSION NUMBER.  IN THE CASE OF A     -
CD               FLUX IVER IS UNNECESSARY.                             -
CD                                                                     -
CD    25-36      ZBOT, THE LOWER LIMIT OF AN AXIAL ZONE WHERE THE      -
CD               FUNCTION IS USED.                                     -
CD                                                                     -
CD    37-48      ZTOP, THE UPPER LIMIT OF THAT ZONE.                   -
CD                                                                     -
CD    49-60      ZBOT, THE LOWER LIMIT OF AN AXIAL ZONE WHERE THE      -
CD               FUNCTION IS USED.                                     -
CD                                                                     -
CD    61-72      ZTOP, THE UPPER LIMIT OF THAT ZONE.                   -
CD                                                                     -
CD               (DEFAULT = IF NO TYPE 08 CARDS ARE PROVIDED THE       -
CD               EXPANSION FUNCTIONS WILL BE USED AS WEIGHTING         -
CD               FUNCTIONS).                                           -
C                                                                      -
CN               AS MANY TYPE 08 CARDS ARE USED AS ARE NECESSARY TO    -
CN               SPECIFY THE WEIGHTING FUNCTION DATA.                  -
C                                                                      -
C-----------------------------------------------------------------------
```

APPENDIX D. INPUT DATA SET SYNFIL. (CONTD.)

```
C-----------------------------------------------------------------------
CR          SPECIAL GROUP COLLAPSING SCHEME FOR EXPANSION FUNCTION     -
CR          (TYPE 09)                                                  -
C                                                                      -
CL    FORMAT-----(I2,4X,11I6)                                          -
C                                                                      -
CD    COLUMNS            CONTENTS...IMPLICATIONS, IF ANY               -
CD    =======    ==========================================================-
CD    1-2        09                                                     -
CD                                                                      -
CD    7-12       LGP, LOWEST ENERGY GROUP IN COLLAPSED GROUP I.         -
CD                                                                      -
CD    13-18      LGP, LOWEST ENERGY GROUP NUMBER IN COLLAPSED GROUP     -
CD               I+1.                                                   -
CD                                                                      -
CD    19-24      LGP, LOWEST ENERGY GROUP NUMBER IN COLLAPSED GROUP     -
CD               I+2.                                                   -
CD                                                                      -
CD    25-30      LGP, LOWEST ENERGY GROUP NUMBER IN COLLAPSED GROUP     -
CD               I+3.                                                   -
CD                                                                      -
CD    31-36      LGP, LOWEST ENERGY GROUP NUMBER IN COLLAPSED GROUP     -
CD               I+4.                                                   -
CD                                                                      -
CD    37-42      LGP, LOWEST ENERGY GROUP NUMBER IN COLLAPSED GROUP     -
CD               I+5.                                                   -
CD                                                                      -
CD    43-48      LGP, LOWEST ENERGY GROUP NUMBER IN COLLAPSED GROUP     -
CD               I+6.                                                   -
CD                                                                      -
CD    49-54      LGP, LOWEST ENERGY GROUP NUMBER IN COLLAPSED GROUP     -
CD               I+7.                                                   -
CD                                                                      -
CD    55-60      LGP, LOWEST ENERGY GROUP NUMBER IN COLLAPSED GROUP     -
CD               I+8.                                                   -
CD                                                                      -
CD    61-66      LGP, LOWEST ENERGY GROUP NUMBER IN COLLAPSED GROUP     -
CD               I+9.                                                   -
CD                                                                      -
CD    67-72      LGP, LOWEST ENERGY GROUP NUMBER IN COLLAPSED GROUP     -
CD               I+10.                                                  -
CD                                                                      -
CD               (DEFAULT = NO GROUP COLLAPSING).                       -
C                                                                      -
CN               AS MANY TYPE 09 CARDS MAY BE USED AS ARE NECESSARY TO  -
CN               SWEEP THE NUMBER OF COLLAPSED GROUPS. THE TYPE 09 CARDS-
CN               MUST BE IN ORDER, STARTING WITH THE HIGHEST ENERGY     -
CN               GROUP. THE LAST GROUP NUMBER ON THE LAST CARD MUST BE  -
CN               EQUAL TO THE NUMBER OF GROUPS BEFORE GROUP COLLAPSING. -
C                                                                      -
C-----------------------------------------------------------------------
```

APPENDIX D. INPUT DATA SET SYNFIL. (CONTD.)

```
C-----------------------------------------------------------------------
CR          SPECIAL GROUP COLLAPSING SCHEME FOR WEIGHTING FUNCTION      -
CR          (TYPE 10)                                                   -
C                                                                       -
CL    FORMAT-----(I2,4X,11I6)                                           -
C                                                                       -
CD    COLUMNS            CONTENTS...IMPLICATIONS, IF ANY                -
CD    =======    ==================================================-
CD    1-2        10                                                     -
CD                                                                      -
CD    7-12       LGP, LOWEST ENERGY GROUP NUMBER IN COLLAPSED GROUP I.  -
CD                                                                      -
CD    13-18      LGP, LOWEST ENERGY GROUP NUMBER IN COLLAPSED GROUP     -
CD               I+1.                                                   -
CD                                                                      -
CD    19-24      LGP, LOWEST ENERGY GROUP NUMBER IN COLLAPSED GROUP     -
CD               I+2.                                                   -
CD                                                                      -
CD    25-30      LGP, LOWEST ENERGY GROUP NUMBER IN COLLAPSED GROUP     -
CD               I+3.                                                   -
CD                                                                      -
CD    31-36      LGP, LOWEST ENERGY GROUP NUMBER IN COLLAPSED GROUP     -
CD               I+4.                                                   -
CD                                                                      -
CD    37-42      LGP, LOWEST ENERGY GROUP NUMBER IN COLLAPSED GROUP     -
CD               I+5.                                                   -
CD                                                                      -
CD    43-48      LGP, LOWEST ENERGY GROUP NUMBER IN COLLAPSED GROUP     -
CD               I+6.                                                   -
CD                                                                      -
CD    49-54      LGP, LOWEST ENERGY GROUP NUMBER IN COLLAPSED GROUP     -
CD               I+7.                                                   -
CD                                                                      -
CD    55-60      LGP, LOWEST ENERGY GROUP NUMBER IN COLLAPSED GROUP     -
CD               I+8.                                                   -
CD                                                                      -
CD    61-66      LGP, LOWEST ENERGY GROUP NUMBER IN COLLAPSED GROUP     -
CD               I+9.                                                   -
CD                                                                      -
CD    67-72      LGP, LOWEST ENERGY GROUP NUMBER IN COLLAPSED GROUP     -
CD               I+10.                                                  -
CD                                                                      -
CD               (DEFAULT = NO GROUP COLLAPSING IF NO TYPE 09 CARD.     -
CD               IF TYPE 09 CARD IS PRESENT, BUT NO TYPE 10 CARD, THE   -
CD               EXPANSION FUNCTION COLLAPSING SCHEME IS REPEATED FOR   -
CD               THE WEIGHTING FUNCTION).                               -
C                                                                       -
CN               AS MANY TYPE 10 CARDS MAY BE USED AS ARE NECESSARY TO  -
CN               SWEEP THE NUMBER OF COLLAPSED GROUPS. THE TYPE 10 CARDS-
CN               MUST BE IN ORDER, STARTING WITH THE HIGHEST ENERGY     -
CN               GROUP. THE LAST GROUP NUMBER ON THE LAST CARD MUST BE  -
CN               EQUAL TO THE NUMBER OF GROUPS BEFORE GROUP COLLAPSING. -
C                                                                       -
C-----------------------------------------------------------------------
```

APPENDIX D. INPUT DATA SET SYNFIL. (CONTD.)

```
C-----------------------------------------------------------------------
CR          GENERAL GROUP COLLAPSING SCHEME FOR EXPANSION FUNCTION     -
CR          (TYPE 11)                                                  -
C                                                                      -
CL    FORMAT-----(I2,10X,5E12.4)                                       -
C                                                                      -
CD    COLUMNS            CONTENTS...IMPLICATIONS, IF ANY               -
CD    =======    ==========================================================-
CD    1-2        11                                                    -
CD                                                                     -
CD    13-24      U(I,J), GROUP COLLAPSING MATRIX FOR EXPANSION FUNCTION.-
CD                                                                     -
CD    25-36      U(I,J), GROUP COLLAPSING MATRIX FOR EXPANSION FUNCTION.-
CD                                                                     -
CD    37-48      U(I,J), GROUP COLLAPSING MATRIX FOR EXPANSION FUNCTION.-
CD                                                                     -
CD    49-60      U(I,J), GROUP COLLAPSING MATRIX FOR EXPANSION FUNCTION.-
CD                                                                     -
CD    61-72      U(I,J), GROUP COLLAPSING MATRIX FOR EXPANSION FUNCTION.-
CD                                                                     -
CD               (DEFAULT = NO GROUP COLLAPSING).                      -
C                                                                      -
CN               EXPANSION FUNCTION DATA IS SPECIFIED IN THE ORDER     -
CN               ((U(I,J),I=1,LGROUP,J=1,NGROUP), U BEING EQUAL TO THE -
CN               GROUP COLLAPSING MATRIX, LGROUP BEING EQUAL TO THE    -
CN               NUMBER OF ENERGY GROUPS AFTER GROUP COLLAPSING AND    -
CN               NGROUP BEING EQUAL TO THE NUMBER OF ENERGY GROUPS     -
CN               BEFORE GROUP COLLAPSING.                              -
CN                                                                     -
CN               AS MANY TYPE 11 CARDS ARE USED AS ARE NECESSARY TO    -
CN               SPECIFY THE EXPANSION FUNCTION DATA.                  -
C                                                                      -
C-----------------------------------------------------------------------
```

APPENDIX D. INPUT DATA SET SYNFIL. (CONTD.)

```
C-----------------------------------------------------------------------
CR          GENERAL GROUP COLLAPSING SCHEME FOR WEIGHTING FUNCTION      -
CR              (TYPE 12)                                               -
C                                                                       -
CL    FORMAT-----(I2,10X,5E12.4)                                        -
C                                                                       -
CD    COLUMNS            CONTENTS...IMPLICATIONS, IF ANY                -
CD    =======    ==========================================================-
CD    1-2        12                                                      -
CD                                                                      -
CD    13-24      U(I,J), GROUP COLLAPSING MATRIX FOR WEIGHTING FUNCTION.-
CD                                                                      -
CD    25-36      U(I,J), GROUP COLLAPSING MATRIX FOR WEIGHTING FUNCTION.-
CD                                                                      -
CD    37-48      U(I,J), GROUP COLLAPSING MATRIX FOR WEIGHTING FUNCTION.-
CD                                                                      -
CD    49-60      U(I,J), GROUP COLLAPSING MATRIX FOR WEIGHTING FUNCTION.-
CD                                                                      -
CD    61-72      U(I,J), GROUP COLLAPSING MATRIX FOR WEIGHTING FUNCTION.-
CD                                                                      -
CD               (DEFAULT = NO GROUP COLLAPSING IF NO TYPE 11 CARD.     -
CD               IF TYPE 11 CARD IS PRESENT, BUT NO TYPE 12 CARD, THE   -
CD               EXPANSION FUNCTION COLLAPSING SCHEME IS REPEATED FOR   -
CD               THE WEIGHTING FUNCTION).                               -
C                                                                       -
CN               WEIGHTING FUNCTION DATA IS SPECIFIED IN THE ORDER      -
CN               ((U(I,J),I=1,LGROUP,J=1,NGROUP), U BEING EQUAL TO THE  -
CN               GROUP COLLAPSING MATRIX, LGROUP BEING EQUAL TO THE     -
CN               NUMBER OF ENERGY GROUPS AFTER GROUP COLLAPSING AND     -
CN               NGROUP BEING EQUAL TO THE NUMBER OF ENERGY GROUPS      -
CN               BEFORE GROUP COLLAPSING.                               -
CN                                                                      -
CN               AS MANY TYPE 12 CARDS ARE USED AS ARE NECESSARY TO     -
CN               SPECIFY THE WEIGHTING FUNCTION DATA.                   -
C                                                                       -
C-----------------------------------------------------------------------
```

```
C-----------------------------------------------------------------------
                    APPENDIX D.  INPUT DATA SET SYNFIL.  (CONTD.)

CR          GROUP FLUX ELIMINATION FOR INPUT FUNCTIONS (TYPE 13)        -
C                                                                       -
CL     (I2,4X,A6,9I6)                                                   -
C                                                                       -
CD     COLUMNS          CONTENTS...IMPLICATIONS, IF ANY                 -
CD     =======    ==================================================-
CD     1-2        13                                                   -
CD                                                                     -
CD     7-12       TITFUN, FLUX FILE NAME. TITFUN MAY BE "UNIT" WHICH   -
CD                MUST BE ENTERED IN COLS. 7-10.                       -
CD                                                                     -
CD     13-18      IVER, FLUX FILE VERSION NUMBER.                      -
CD                                                                     -
CD     19-24      IGHI, HIGHEST ENERGY GROUP OF A SEQUENCE OF GROUP    -
CD                FLUXES (AFTER COLLAPSING, IF ANY) TO BE EXCLUDED FROM -
CD                THE SYNTHESIS CALCULATION.                           -
CD                                                                     -
CD     25-30      IGLO, LOWEST ENERGY GROUP OF THE SEQUENCE.           -
CD                                                                     -
CD     31-36      IGHI, HIGHEST ENERGY GROUP OF A SEQUENCE OF GROUP    -
CD                FLUXES (AFTER COLLAPSING, IF ANY) TO BE EXCLUDED FROM -
CD                THE SYNTHESIS CALCULATION.                           -
CD                                                                     -
CD     37-42      IGLO, LOWEST ENERGY GROUP OF THE SEQUENCE.           -
CD                                                                     -
CD     43-48      IGHI, HIGHEST ENERGY GROUP OF A SEQUENCE OF GROUP    -
CD                FLUXES (AFTER COLLAPSING, IF ANY) TO BE EXCLUDED FROM -
CD                THE SYNTHESIS CALCULATION.                           -
CD                                                                     -
CD     49-54      IGLO, LOWEST ENERGY GROUP OF THE SEQUENCE.           -
CD                                                                     -
CD     55-60      IGHI, HIGHEST ENERGY GROUP OF A SEQUENCE OF GROUP    -
CD                FLUXES (AFTER COLLAPSING, IF ANY) TO BE EXCLUDED FROM -
CD                THE SYNTHESIS CALCULATION.                           -
CD                                                                     -
CD     61-66      IGLO, LOWEST ENERGY GROUP OF THE SEQUENCE.           -
CD                                                                     -
CD                (DEFAULT = ALL GROUP FLUXES ARE USED).               -
C                                                                      -
CN                AS MANY TYPE 13 CARDS ARE USED AS ARE NECESSARY TO   -
CN                SPECIFY THE ENERGY GROUPS TO BE EXCLUDED FROM THE    -
CN                SYNTHESIS CALCULATION.                               -
C                                                                      -
C-----------------------------------------------------------------------
```

APPENDIX D. INPUT DATA SET SYNFIL. (CONTD.)

```
C-----------------------------------------------------------------------
CR          EXPANSION FUNCTION SCALING FACTORS (TYPE 14)                -
C                                                                       -
CL    FORMAT-----(I2,4X,A6,I6,2(2I6,E12.4))                             -
C                                                                       -
CD    COLUMNS           CONTENTS...IMPLICATIONS, IF ANY                 -
CD    =======   ==========================================================-
CD    1-2       14                                                      -
CD                                                                      -
CD    7-12      TITFUN, FLUX FILE NAME. TITFUN MAY BE "UNIT" WHICH      -
CD              MUST BE ENTERED IN COLS. 7-10.                          -
CD                                                                      -
CD    13-18     IVER, FLUX FILE VERSION NUMBER.                         -
CD                                                                      -
CD    19-24     IGLO, THE FIRST ENERGY GROUP OF A SEQUENCE OF GROUP     -
CD              FLUXES TO BE SCALED BY ESCALE WHEN USED AS EXPANSION    -
CD              FUNCTIONS.                                              -
CD                                                                      -
CD    25-30     IGHI, THE LAST ENERGY GROUP OF THAT SEQUENCE.           -
CD                                                                      -
CD    31-42     ESCALE, THE EXPANSION FUNCTION SCALING FACTOR           -
CD              (DEFAULT = 1.0).                                        -
CD                                                                      -
CD    43-48     IGLO, THE FIRST ENERGY GROUP OF A SEQUENCE OF GROUP     -
CD              FLUXES TO BE SCALED BY ESCALE WHEN USED AS EXPANSION    -
CD              FUNCTIONS.                                              -
CD                                                                      -
CD    49-54     IGHI, THE LAST ENERGY GROUP OF THAT SEQUENCE.           -
CD                                                                      -
CD    55-66     ESCALE, THE EXPANSION FUNCTION SCALING FACTOR           -
CD              (DEFAULT = 1.0).                                        -
C                                                                       -
CN              IF THE FLUX FILE VERSION NUMBER IS BLANK, THE LAST      -
CN              NAMED FLUX FILE IS AUTOMATICALLY ASSUMED.               -
CN                                                                      -
CN              AS MANY TYPE 14 CARDS ARE USED AS ARE NECESSARY TO      -
CN              SPECIFY THE REQUIRED SCALING FACTOR DATA.               -
C                                                                       -
C-----------------------------------------------------------------------
```

APPENDIX D. INPUT DATA SET SYNFIL. (CONTD.)

```
C-----------------------------------------------------------------------
C                                                                      -
CR          WEIGHTING FUNCTION SCALING FACTORS (TYPE 15)               -
C                                                                      -
CL    FORMAT-----(I2,4X,A6,I6,2(2I6,E12.4))                            -
C                                                                      -
CD    COLUMNS            CONTENTS...IMPLICATIONS, IF ANY               -
CD    =======    ==========================================================-
CD    1-2        15                                                    -
CD                                                                     -
CD    7-12       TITFUN, FLUX FILE NAME. TITFUN MAY BE "UNIT" WHICH    -
CD               MUST BE ENTERED IN COLS. 7-10.                        -
CD                                                                     -
CD    13-18      IVER, FLUX FILE VERSION NUMBER.                       -
CD                                                                     -
CD    19-24      IGLO, THE FIRST ENERGY GROUP OF A SEQUENCE OF GROUP   -
CD               FLUXES TO BE SCALED BY ESCALE WHEN USED AS WEIGHTING  -
CD               FUNCTIONS.                                            -
CD                                                                     -
CD    25-30      IGHI, THE LAST ENERGY GROUP OF THAT SEQUENCE.         -
CD                                                                     -
CD    31-42      ESCALE, THE WEIGHTING FUNCTION SCALING FACTOR.        -
CD               (DEFAULT = 1.0).                                      -
CD                                                                     -
CD    43-48      IGLO, THE FIRST ENERGY GROUP OF A SEQUENCE OF GROUP   -
CD               FLUXES TO BE SCALED BY ESCALE WHEN USED AS WEIGHTING  -
CD               FUNCTIONS.                                            -
CD                                                                     -
CD    49-54      IGHI, THE LAST ENERGY GROUP OF THAT SEQUENCE.         -
CD                                                                     -
CD    55-66      ESCALE, THE WEIGHTING FUNCTION SCALING FACTOR         -
CD               (DEFAULT = 1.0).                                      -
C                                                                      -
CN               IF THE FLUX FILE VERSION NUMBER IS BLANK, THE LAST    -
CN               NAMED FLUX FILE IS AUTOMATICALLY ASSUMED.             -
CN                                                                     -
CN               AS MANY TYPE 15 CARDS ARE USED AS ARE NECESSARY TO    -
CN               SPECIFY THE REQUIRED SCALING FACTOR DATA.             -
C                                                                      -
C-----------------------------------------------------------------------
```

APPENDIX D. INPUT DATA SET SYNFIL. (CONTD.)

```
C-----------------------------------------------------------------------
C                                                                      -
CR          SYNTHESIS OUTPUT OPTIONS (TYPE 16)                         -
C                                                                      -
CL    FORMAT-----(I2,4X,11I6)
C                                                                      -
CD    COLUMNS            CONTENTS...IMPLICATIONS, IF ANY               -
CD    =======    ==========================================================-
CD    1-2        16                                                    -
CD                                                                     -
CD    7-12       NDENOM, PERTURBATION DENOMINATOR OPTION.              -
CD               0...DO NOT CALCULATE PERTURBATION DENOMINATOR         -
CD                   (DEFAULT).                                        -
CD               1...CALCULATE PERTURBATION DENOMINATOR.               -
CD                                                                     -
CD    13-18      N3DFLX, OUTPUT RTFLUX OPTION.                         -
CD               0...DO NOT CONSTRUCT AN OUTPUT RTFLUX FILE (DEFAULT). -
CD               .GT.0...THE VERSION NUMBER FOR THE OUTPUT RTFLUX FILE. -
CD               BE CAREFUL NOT TO ACCIDENTALLY DESTROY AN INPUT       -
CD               RTFLUX FILE.                                          -
CD                                                                     -
CD    19-24      N3DADJ, OUTPUT ATFLUX OPTION.                         -
CD               0...DO NOT CONSTRUCT AN OUTPUT ATFLUX FILE (DEFAULT). -
CD               .GT.0...THE VERSION NUMBER FOR THE OUTPUT ATFLUX FILE. -
CD               BE CAREFUL NOT TO ACCIDENTALLY DESTROY AN INPUT       -
CD               ATFLUX FILE.                                          -
CD                                                                     -
CD    25-30      NPWDNT, OUTPUT PWDINT OPTION.                         -
CD               0...DO NOT CONSTRUCT AN OUTPUT PWDINT FILE (DEFAULT). -
CD               .GT.0...THE VERSION NUMBER FOR THE OUTPUT PWDINT FILE. -
CD                                                                     -
CD    31-36      NRZFLX, OUTPUT RZFLUX OPTION.                         -
CD               0...DO NOT CONSTRUCT AN OUTPUT RZFLUX (DEFAULT).      -
CD               .GT.0...THE VERSION NUMBER FOR THE OUTPUT RZFLUX FILE. -
CD                                                                     -
CD    37-42      NGEODT, OUTPUT GEODST OPTION.                         -
CD               0...DO NOT CONSTRUCT AN OUTPUT GEODST FILE (DEFAULT). -
CD               .GT.0...THE VERSION NUMBER FOR THE OUTPUT GEODST FILE. -
CD               BE CAREFUL NOT TO ACCIDENTALLY DESTROY AN INPUT       -
CD               GEODST FILE.                                          -
CD                                                                     -
CD    43-48      NPRRZF, FLUX INTEGRAL EDIT OPTION.                    -
CD               0...DO NOT EDIT THE AVERAGE FLUXES BY ZONE (DEFAULT). -
CD               .GT.0...EDIT THE AVERAGE FLUXES.                      -
C                                                                      -
C-----------------------------------------------------------------------
```

APPENDIX D. INPUT DATA SET SYNFIL. (CONTD.)

```
C-----------------------------------------------------------------------
CR          DIRECT COMBINING COEFFICIENT PLOTS (TYPE 17)                -
C                                                                       -
CL    FORMAT-----(I2,4X,11I6)                                           -
C                                                                       -
CD    COLUMNS            CONTENTS...IMPLICATIONS, IF ANY                -
CD    =======    ==========================================================-
CD    1-2        17                                                     -
CD                                                                      -
CD    7-12       IPLDCC(1), AN ENERGY GROUP (AFTER GROUP COLLAPSING, IF -
CD               ANY) FOR WHICH THE MODAL COMPONENTS OF THE TOTAL AXIAL -
CD               DIRECT FLUX ARE TO BE PRINTER-PLOTTED.                 -
CD                                                                      -
CD    13-18      IPLDCC(2), AN ENERGY GROUP (AFTER GROUP COLLAPSING, IF -
CD               ANY) FOR WHICH THE MODAL COMPONENTS OF THE TOTAL AXIAL -
CD               DIRECT FLUX ARE TO BE PRINTER-PLOTTED.                 -
CD                                                                      -
CD    19-24      IPLDCC(3), AN ENERGY GROUP (AFTER GROUP COLLAPSING, IF -
CD               ANY) FOR WHICH THE MODAL COMPONENTS OF THE TOTAL AXIAL -
CD               DIRECT FLUX ARE TO BE PRINTER-PLOTTED.                 -
CD                                                                      -
CD    25-30      IPLDCC(4), AN ENERGY GROUP (AFTER GROUP COLLAPSING, IF -
CD               ANY) FOR WHICH THE MODAL COMPONENTS OF THE TOTAL AXIAL -
CD               DIRECT FLUX ARE TO BE PRINTER-PLOTTED.                 -
CD                                                                      -
CD    31-36      IPLDCC(5), AN ENERGY GROUP (AFTER GROUP COLLAPSING, IF -
CD               ANY) FOR WHICH THE MODAL COMPONENTS OF THE TOTAL AXIAL -
CD               DIRECT FLUX ARE TO BE PRINTER-PLOTTED.                 -
CD                                                                      -
CD    37-42      IPLDCC(6), AN ENERGY GROUP (AFTER GROUP COLLAPSING, IF -
CD               ANY) FOR WHICH THE MODAL COMPONENTS OF THE TOTAL AXIAL -
CD               DIRECT FLUX ARE TO BE PRINTER-PLOTTED.                 -
CD                                                                      -
CD    43-48      IPLDCC(7), AN ENERGY GROUP (AFTER GROUP COLLAPSING, IF -
CD               ANY) FOR WHICH THE MODAL COMPONENTS OF THE TOTAL AXIAL -
CD               DIRECT FLUX ARE TO BE PRINTER-PLOTTED.                 -
CD                                                                      -
CD    49-54      IPLDCC(8), AN ENERGY GROUP (AFTER GROUP COLLAPSING, IF -
CD               ANY) FOR WHICH THE MODAL COMPONENTS OF THE TOTAL AXIAL -
CD               DIRECT FLUX ARE TO BE PRINTER-PLOTTED.                 -
CD                                                                      -
CD    55-60      IPLDCC(9), AN ENERGY GROUP (AFTER GROUP COLLAPSING, IF -
CD               ANY) FOR WHICH THE MODAL COMPONENTS OF THE TOTAL AXIAL -
CD               DIRECT FLUX ARE TO BE PRINTER-PLOTTED.                 -
CD                                                                      -
CD    61-66      IPLDCC(10), AN ENERGY GROUP (AFTER GROUP COLLAPSING, IF-
CD               ANY) FOR WHICH THE MODAL COMPONENTS OF THE TOTAL AXIAL -
CD               DIRECT FLUX ARE TO BE PRINTER-PLOTTED.                 -
CD                                                                      -
CD    67-72      IPLDCC(11), AN ENERGY GROUP (AFTER GROUP COLLAPSING, IF-
CD               ANY) FOR WHICH THE MODAL COMPONENTS OF THE TOTAL AXIAL -
CD               DIRECT FLUX ARE TO BE PRINTER-PLOTTED.                 -
```

APPENDIX D. INPUT DATA SET SYNFIL. (CONTD.)

```
CD                                                                      -
CD              IF NO TYPE 17 CARDS ARE PRESENT, THERE WILL BE NO       -
CD              PLOTS (DEFAULT).                                        -
C                                                                       -
CN              DIRECT COMBINING COEFFICIENT PLOTS DATA IS SPECIFIED    -
CN              SUCH THAT (IPLDCC(I),I=1,NPLDCC), NPLDCC BEING THE      -
CN              NUMBER OF GROUPS FOR WHICH PLOTS ARE TO BE OUTPUT       -
CN              (NPLDCC.LE.LGROUP).                                     -
CN                                                                      -
CN              AS MANY TYPE 17 CARDS ARE USED AS ARE NECESSARY TO      -
CN              SPECIFY THE DATA FOR THE REQUIRED PLOTS.                -
C                                                                       -
C-----------------------------------------------------------------------

C-----------------------------------------------------------------------
CR          ADJOINT COMBINING COEFFICIENTS PLOTS (TYPE 18)              -
C                                                                       -
CL    FORMAT-----(I2,4X,11I6)                                           -
C                                                                       -
CD    COLUMNS          CONTENTS...IMPLICATIONS, IF ANY                  -
CD    =======          ==============================================-
CD    1-2              18                                               -
CD                                                                      -
CD    7-12             IPLACC(1), AN ENERGY GROUP (AFTER GROUP COLLAPSING, IF -
CD                     ANY) FOR WHICH THE MODAL COMPONENTS OF THE TOTAL AXIAL -
CD                     ADJOINT FLUX ARE TO BE PRINTER-PLOTTED.          -
CD                                                                      -
CD    13-18            IPLACC(2), AN ENERGY GROUP (AFTER GROUP COLLAPSING, IF -
CD                     ANY) FOR WHICH THE MODAL COMPONENTS OF THE TOTAL AXIAL -
CD                     ADJOINT FLUX ARE TO BE PRINTER-PLOTTED.          -
CD                                                                      -
CD    19-24            IPLACC(3), AN ENERGY GROUP (AFTER GROUP COLLAPSING, IF -
CD                     ANY) FOR WHICH THE MODAL COMPONENTS OF THE TOTAL AXIAL -
CD                     ADJOINT FLUX ARE TO BE PRINTER-PLOTTED.          -
CD                                                                      -
CD    25-30            IPLACC(4), AN ENERGY GROUP (AFTER GROUP COLLAPSING, IF -
CD                     ANY) FOR WHICH THE MODAL COMPONENTS OF THE TOTAL AXIAL -
CD                     ADJOINT FLUX ARE TO BE PRINTER-PLOTTED.          -
CD                                                                      -
CD    31-36            IPLACC(5), AN ENERGY GROUP (AFTER GROUP COLLAPSING, IF -
CD                     ANY) FOR WHICH THE MODAL COMPONENTS OF THE TOTAL AXIAL -
CD                     ADJOINT FLUX ARE TO BE PRINTER-PLOTTED.          -
CD                                                                      -
CD    37-42            IPLACC(6), AN ENERGY GROUP (AFTER GROUP COLLAPSING, IF -
CD                     ANY) FOR WHICH THE MODAL COMPONENTS OF THE TOTAL AXIAL -
CD                     ADJOINT FLUX ARE TO BE PRINTER-PLOTTED.          -
CD                                                                      -
CD    43-48            IPLACC(7), AN ENERGY GROUP (AFTER GROUP COLLAPSING, IF -
CD                     ANY) FOR WHICH THE MODAL COMPONENTS OF THE TOTAL AXIAL -
CD                     ADJOINT FLUX ARE TO BE PRINTER-PLOTTED.          -
```

APPENDIX D. INPUT DATA SET SYNFIL. (CONTD.)

```
CD                                                                      -
CD     49-54      IPLACC(8), AN ENERGY GROUP (AFTER GROUP COLLAPSING, IF -
CD                ANY) FOR WHICH THE MODAL COMPONENTS OF THE TOTAL AXIAL -
CD                ADJOINT FLUX ARE TO BE PRINTER-PLOTTED.                -
CD                                                                      -
CD     55-60      IPLACC(9), AN ENERGY GROUP (AFTER GROUP COLLAPSING, IF -
CD                ANY) FOR WHICH THE MODAL COMPONENTS OF THE TOTAL AXIAL -
CD                ADJOINT FLUX ARE TO BE PRINTER-PLOTTED.                -
CD                                                                      -
CD     61-66      IPLACC(10), AN ENERGY GROUP (AFTER GROUP COLLAPSING, IF-
CD                ANY) FOR WHICH THE MODAL COMPONENTS OF THE TOTAL AXIAL -
CD                ADJOINT FLUX ARE TO BE PRINTER-PLOTTED.                -
CD                                                                      -
CD     67-72      IPLACC(11), AN ENERGY GROUP (AFTER GROUP COLLAPSING, IF-
CD                ANY) FOR WHICH THE MODAL COMPONENTS OF THE TOTAL AXIAL -
CD                ADJOINT FLUX ARE TO BE PRINTER-PLOTTED.                -
CD                                                                      -
CD                IF NO TYPE 18 CARDS ARE PRESENT, THERE WILL BE NO      -
CD                PLOTS (DEFAULT).                                       -
C                                                                       -
CN                ADJOINT COMBINING COEFFICIENT PLOTS DATA IS SPECIFIED  -
CN                SUCH THAT (IPLACC(I),I=1,NPLACC), NPLACC BEING THE     -
CN                NUMBER OF GROUPS FOR WHICH PLOTS ARE TO BE OUTPUT      -
CN                (NPLACC.LE.LGROUP).                                    -
CN                                                                      -
CN                AS MANY TYPE 18 CARDS ARE USED AS ARE NECESSARY TO     -
CN                SPECIFY THE DATA FOR THE REQUIRED PLOTS.               -
C                                                                       -
C-----------------------------------------------------------------------
```

APPENDIX D. INPUT DATA SET SYNFIL. (CONTD.)

```
C-----------------------------------------------------------------------
CR          TWO-DIMENSIONAL DIRECT FLUX EDITS (TYPE 19)                 -
C                                                                       -
CL    FORMAT-----(I2,4X,10I6)                                           -
C                                                                       -
CD    COLUMNS            CONTENTS...IMPLICATIONS, IF ANY                -
CD    =======    ==========================================================-
CD    1-2        19                                                      -
CD                                                                      -
CD    7-12       IPRRTF(1,1), A GROUP NUMBER USED IN IDENTIFYING A PLANE-
CD               OF DIRECT FLUXES TO BE EDITED.                         -
CD                                                                      -
CD    13-18      IPRRTF(2,1), AN AXIAL MESH INTERVAL USED IN IDENTIFYING-
CD               THE PLANE OF DIRECT FLUXES TO BE EDITED.               -
CD                                                                      -
CD    19-24      IPRRTF(1,2), A GROUP NUMBER USED IN IDENTIFYING A PLANE-
CD               OF DIRECT FLUXES TO BE EDITED.                         -
CD                                                                      -
CD    25-30      IPRRTF(2,2), AN AXIAL MESH INTERVAL USED IN IDENTIFYING-
CD               THE PLANE OF DIRECT FLUXES TO BE EDITED.               -
CD                                                                      -
CD    31-36      IPRRTF(1,3), A GROUP NUMBER USED IN IDENTIFYING A PLANE-
CD               OF DIRECT FLUXES TO BE EDITED.                         -
CD                                                                      -
CD    37-42      IPRRTF(2,3), AN AXIAL MESH INTERVAL USED IN IDENTIFYING-
CD               THE PLANE OF DIRECT FLUXES TO BE EDITED.               -
CD                                                                      -
CD    43-48      IPRRTF(1,4), A GROUP NUMBER USED IN IDENTIFYING A PLANE-
CD               OF DIRECT FLUXES TO BE EDITED.                         -
CD                                                                      -
CD    49-54      IPRRTF(2,4), AN AXIAL MESH INTERVAL USED IN IDENTIFYING-
CD               THE PLANE OF DIRECT FLUXES TO BE EDITED.               -
CD                                                                      -
CD    55-60      IPRRTF(1,5), A GROUP NUMBER USED IN IDENTIFYING A PLANE-
CD               OF DIRECT FLUXES TO BE EDITED.                         -
CD                                                                      -
CD    61-66      IPRRTF(2,5), AN AXIAL MESH INTERVAL USED IN IDENTIFYING-
CD               THE PLANE OF DIRECT FLUXES TO BE EDITED.               -
CD                                                                      -
CD               (DEFAULT = NO EDITS).                                  -
C                                                                       -
CN               THE TWO-DIMENSIONAL DIRECT FLUX EDIT DATA IS SPECIFIED -
CN               SUCH THAT ((IPRRTF(I,N),I=1,2),N=1,NPRRTF), NPRRTF     -
CN               BEING THE NUMBER OF PLANAR EDITS TO BE DONE.           -
CN               WHEN THE PROBLEM IS TWO-DIMENSIONAL ALL AXIAL MESH     -
CN               INTERVALS ARE EDITED WHEN IPRRTF(2,N).GT.0.            -
CN                                                                      -
CN               AS MANY TYPE 19 CARDS ARE USED AS ARE NECESSARY TO     -
CN               SPECIFY THE DATA REQUIRED FOR THE DIRECT FLUX EDITS.   -
C                                                                       -
C-----------------------------------------------------------------------
```

APPENDIX D. INPUT DATA SET SYNFIL. (CONTD.)

```
C-----------------------------------------------------------------------
CD          TWO-DIMENSIONAL ADJOINT FLUX EDITS (TYPE 20)                -
C                                                                       -
CL    FORMAT-----(I2,4X,10I6)                                           -
C                                                                       -
CD    COLUMNS            CONTENTS...IMPLICATIONS, IF ANY                -
CD    =======    ==========================================================-
CD    1-2        20                                                      -
CD                                                                      -
CD    7-12       IPRATF(1,1), A GROUP NUMBER USED IN IDENTIFYING A PLANE -
CD               OF ADJOINT FLUXES TO BE EDITED.                        -
CD                                                                      -
CD    13-18      IPRATF(2,1), AN AXIAL MESH INTERVAL USED IN IDENTIFYING-
CD               THE PLANE OF ADJOINT FLUXES TO BE EDITED.              -
CD               A PLANE OF ADJOINT FLUXES TO BE EDITED.                -
CD                                                                      -
CD    19-24      IPRATF(1,2), A GROUP NUMBER USED IN IDENTIFYING A PLANE -
CD               OF ADJOINT FLUXES TO BE EDITED.                        -
CD                                                                      -
CD    25-30      IPRATF(2,2), AN AXIAL MESH INTERVAL USED IN IDENTIFYING-
CD               THE PLANE OF ADJOINT FLUXES TO BE EDITED.              -
CD                                                                      -
CD    31-36      IPRATF(1,3), A GROUP NUMBER USED IN IDENTIFYING A PLANE -
CD               OF ADJOINT FLUXES TO BE EDITED.                        -
CD                                                                      -
CD    37-42      IPRATF(2,3), AN AXIAL MESH INTERVAL USED IN IDENTIFYING-
CD               THE PLANE OF ADJOINT FLUXES TO BE EDITED.              -
CD                                                                      -
CD    43-48      IPRATF(1,4), A GROUP NUMBER USED IN IDENTIFYING A PLANE -
CD               OF ADJOINT FLUXES TO BE EDITED.                        -
CD                                                                      -
CD    49-54      IPRATF(2,4), AN AXIAL MESH INTERVAL USED IN IDENTIFYING-
CD               THE PLANE OF ADJOINT FLUXES TO BE EDITED.              -
CD                                                                      -
CD    55-60      IPRATF(1,5), A GROUP NUMBER USED IN IDENTIFYING A PLANE -
CD               OF ADJOINT FLUXES TO BE EDITED.                        -
CD                                                                      -
CD    61-66      IPRATF(2,5), AN AXIAL MESH INTERVAL USED IN IDENTIFYING-
CD               THE PLANE OF ADJOINT FLUXES TO BE EDITED.              -
CD                                                                      -
CD               (DEFAULT = NO EDITS).                                  -
CN                                                                      -
CN               THE TWO-DIMENSIONAL ADJOINT FLUX EDIT DATA IS SPECIFIED-
CN               SUCH THAT ((IPRATF(I,N),I=1,2),N=1,NPRATF), NPRATF     -
CN               BEING THE NUMBER OF PLANAR EDITS TO BE DONE.           -
CN               WHEN THE PROBLEM IS TWO-DIMENSIONAL ALL AXIAL MESH     -
CN               INTERVALS ARE EDITED WHEN IPRATF(2,N).GT.0.            -
CN                                                                      -
CN               AS MANY TYPE 20 CARDS ARE USED AS ARE NECESSARY TO     -
CN               SPECIFY THE DAT REQUIRED FOR THE ADJOINT FLUX EDITS.   -
C                                                                       -
C-----------------------------------------------------------------------
```

APPENDIX D. INPUT DATA SET SYNFIL. (CONTD.)

```
C-----------------------------------------------------------------------
CR          TWO-DIMENSIONAL PLANAR POWER EDITS (TYPE 21)                -
C                                                                       -
CL    FORMAT-----(I2,4X,10I6)                                           -
C                                                                       -
CD    COLUMNS          CONTENTS...IMPLICATIONS, IF ANY                  -
CD    =======    ==========================================================-
CD    1-2        21                                                     -
CD                                                                      -
CD    7-12       IPRPWD(1), AN AXIAL MESH INTERVAL IDENTIFYING A PLANE  -
CD               OF POWER EDITS                                         -
CD                                                                      -
CD    13-18      IPRPWD(2), AN AXIAL MESH INTERVAL IDENTIFYING A PLANE  -
CD               OF POWER EDITS                                         -
CD                                                                      -
CD    19-24      IPRPWD(3), AN AXIAL MESH INTERVAL IDENTIFYING A PLANE  -
CD               OF POWER EDITS                                         -
CD                                                                      -
CD    25-30      IPRPWD(4), AN AXIAL MESH INTERVAL IDENTIFYING A PLANE  -
CD               OF POWER EDITS                                         -
CD                                                                      -
CD    31-36      IPRPWD(5), AN AXIAL MESH INTERVAL IDENTIFYING A PLANE  -
CD               OF POWER EDITS                                         -
CD                                                                      -
CD    37-42      IPRPWD(6), AN AXIAL MESH INTERVAL IDENTIFYING A PLANE  -
CD               OF POWER EDITS                                         -
CD                                                                      -
CD    43-48      IPRPWD(7), AN AXIAL MESH INTERVAL IDENTIFYING A PLANE  -
CD               OF POWER EDITS                                         -
CD                                                                      -
CD    49-54      IPRPWD(8), AN AXIAL MESH INTERVAL IDENTIFYING A PLANE  -
CD               OF POWER EDITS                                         -
CD                                                                      -
CD    55-60      IPRPWD(9), AN AXIAL MESH INTERVAL IDENTIFYING A PLANE  -
CD               OF POWER EDITS                                         -
CD                                                                      -
CD    61-66      IPRPWD(10), AN AXIAL MESH INTERVAL IDENTIFYING A PLANE -
CD               OF POWER EDITS                                         -
CD                                                                      -
CD               (DEFAULT = NO EDITS).                                  -
CN                                                                      -
CN               THE TWO-DIMENSIONAL PLANAR POWER EDIT DATA IS          -
CN               SPECIFIED SUCH THAT (IPRPWD(I),I=1,NPRPWD), NPRPWD     -
CN               BEING THE NUMBER OF PLANAR EDITS DESIRED.              -
CN               WHEN THE PROBLEM IS TWO-DIMENSIONAL ALL AXIAL MESH     -
CN               INTERVALS ARE EDITED IF IPRPWD(1).GT.0.                -
CN                                                                      -
CN               AS MANY TYPE 21 CARDS ARE USED AS ARE NECESSARY TO     -
CN               SPECIFY THE DATA REQUIRED FOR THE PLANAR POWER EDITS.  -
C                                                                       -
C-----------------------------------------------------------------------

COFF
```

APPENDIX E. CODE-DEPENDENT BINARY FILES. COMPXS.

```
C*********************************************************************
C                                                                    -
C                        PREPARED 8/26/75 AT ANL                     -
C                                                                    -
CF          COMPXS                                                   -
CE          MACROSCOPIC COMPOSITION CROSS SECTIONS                   -
C                                                                    -
C*********************************************************************


C--------------------------------------------------------------------
CS          FILE STRUCTURE                                           -
CS                                                                   -
CS          RECORD TYPE                              PRESENT IF      -
CS          ==================================       ===============-
CS          SPECIFICATIONS                           ALWAYS          -
CS          SET CHI                                  ISCHI.GT.0      -
CS    ********* (REPEAT FOR ALL COMPOSITIONS)                        -
CS    *     COMPOSITION SPECIFICATIONS               ALWAYS          -
CS    *  ****** (REPEAT FOR ALL ENERGY GROUPS                        -
CS    *  *       IN THE ORDER OF DECREASING                          -
CS    *  *       ENERGY)                                             -
CS    *  *  COMPOSITION MACROSCOPIC GROUP            ALWAYS          -
CS    *  *  CROSS SECTIONS                                           -
CS    *********                                                      -
CS                                                                   -
C                                                                    -
C--------------------------------------------------------------------


CD    NGROUP              NUMBER OF ENERGY GROUPS.
CD    ICHI                PROMPT FISSION SPECTRUM FLAG FOR THIS
CD                        COMPOSITION. ICHI=-1 IF COMPOSITION USES THE
CD                        SET-WIDE PROMPT CHI GIVEN IN SET CHI RECORD
CD                        (BELOW). ICHI=0 IF COMPOSITION IS NOT
CD                        FISSIONABLE. ICHI=1 FOR COMPOSITION PROMPT CHI
CD                        VECTOR. ICHI=NGROUP FOR COMPOSITION PROMPT CHI
CD                        MATRIX.
CD    NUP                 NUMBER OF GROUPS OF UPSCATTERING FOR THIS
CD                        COMPOSITION.
CD    NDN                 NUMBER OF GROUPS OF DOWNSCATTERING FOR THIS
CD                        COMPOSITION.
CD    ISCHI               PROMPT FISSION SPECTRUM FLAG. ISCHI=0 IF
CD                        THERE IS NO SET-WIDE PROMPT CHI. ISCHI=1 IF
CD                        THERE IS A SET-WIDE PROMPT CHI VECTOR.
CD                        ISCHI=NGROUP IF THERE IS A SET-WIDE PROMPT
CD                        CHI MATRIX.
CD    MULT                2 FOR IBM MACHINES, 1 OTHERWISE.
```

APPENDIX E. CODE-DEPENDENT BINARY FILES (CONTD.). COMPXS.

```
C-----------------------------------------------------------------------
CR          SPECIFICATIONS (TYPE 1)                                    -
C                                                                      -
CL    NCMP,NGROUP,ISCHI,NFCMP,MAXUP,MAXDN,NDUM1,NDUM2,NDUM3,NDUM4      -
C                                                                      -
CW    10                                                               -
C                                                                      -
CD    NCMP                NUMBER OF COMPOSITIONS.                    -
CD    NFCMP               NUMBER OF FISSIONABLE COMPOSITIONS.        -
CD    MAXUP               MAXIMUM NUMBER OF GROUPS OF UPSCATTERING FOR -
CD                        THE SET.                                   -
CD    MAXDN               MAXIMUM NUMBER OF GROUPS OF DOWNSCATTERING -
CD                        FOR THE SET.                               -
CD    NDUM1               RESERVED.                                  -
CD    NDUM2               RESERVED.                                  -
CD    NDUM3               RESERVED.                                  -
CD    NDUM4               RESERVED.                                  -
C                                                                      -
C-----------------------------------------------------------------------


C-----------------------------------------------------------------------
CR          SET CHI (TYPE 2)                                           -
C                                                                      -
CC          PRESENT IF ISCHI.GT.0                                      -
C                                                                      -
CL    ((CHI(I,J),I=1,ISCHI),J=1,NGROUP)                                -
C                                                                      -
CW    MULT*ISCHI*NGROUP                                                -
C                                                                      -
CD    CHI                 PROMPT FISSION FRACTION INTO GROUP J FROM  -
CD                        GROUP I. IF ISCHI=1, THE LIST REDUCES TO   -
CD                        (CHI(J),J=1,NGROUP), WHERE CHI(J) IS THE   -
CD                        FISSION FRACTION INTO GROUP J.             -
C                                                                      -
C-----------------------------------------------------------------------


C-----------------------------------------------------------------------
CR          COMPOSITION SPECIFICATIONS (TYPE 3)                        -
C                                                                      -
CC          ALWAYS PRESENT                                             -
C                                                                      -
CL    ICHI,(NUP(I),I=1,NGROUP), (NDN(I),I=1,NGROUP)                    -
C                                                                      -
CW    1+2*NGROUP                                                       -
C                                                                      -
C-----------------------------------------------------------------------
```

APPENDIX E. CODE-DEPENDENT BINARY FILES (CONTD.). COMPXS.

```
C-----------------------------------------------------------------------
CR          COMPOSITION MACROSCOPIC GROUP CROSS SECTIONS (TYPE 4)       -
C                                                                       -
CC          ALWAYS PRESENT                                              -
C                                                                       -
CL    XA,XTOT,XREM,XTR,XF,XNF,(CHI(I),I=1,ICHI),                        -
CL   1(XSCATU(I),I=1,NUMUP),XSCATJ,(XSCATD(I),I=1,NUMDN),               -
CL   2PC,A1,B1,A2,B2,A3,B3                                              -
C                                                                       -
CC    NUMUP = NUP FOR THE CURRENT GROUP.                                -
CC    NUMDN = NDN FOR THE CURRENT GROUP.                                -
C                                                                       -
CW    MULT*(14+ICHI+NUMUP+NUMDN)    IF ICHI.GT.0                        -
CW    MULT*(14+NUMUP+NUMDN)         IF ICHI.EQ.-1                       -
CW    MULT*(12+NUMUP+NUMDN)         IF ICHI.EQ.0                        -
C                                                                       -
CD    XA                  ABSORPTION CROSS SECTION.                     -
CD    XTOT                TOTAL CROSS SECTION.                          -
CD    XREM                REMOVAL CROSS SECTION, TOTAL CROSS SECTION    -
CD                        FOR REMOVING A NEUTRON FROM GROUP J DUE TO ALL -
CD                        PROCESSES.                                    -
CD    XTR                 TRANSPORT CROSS SECTION.                      -
CD    XF                  FISSION CROSS SECTION, PRESENT ONLY IF        -
CD                        ICHI.NE.0.                                    -
CD    XNF                 TOTAL NUMBER OF NEUTRONS EMITTED PER FISSION  -
CD                        TIMES XF, PRESENT ONLY IF ICHI.NE.0.          -
CD    CHI                 PROMPT FISSION FRACTION INTO GROUP J FROM     -
CD                        GROUP I, PRESENT ONLY IF ICHI.GT.0. IF ICHI=1, -
CD                        THE LIST REDUCES TO THE SINGLE NUMBER CHI,    -
CD                        WHICH IS THE PROMPT FISSION FRACTION INTO     -
CD                        GROUP J.                                      -
CD    XSCATU              TOTAL SCATTERING CROSS SECTION INTO GROUP J   -
CD                        FROM GROUPS J+NUP(J),J+NUP(J)-1,...,J+2,J+1,  -
CD                        PRESENT ONLY IF NUP(J).GT.0.                  -
CD    XSCATJ              TOTAL SELF-SCATTERING CROSS SECTION FROM      -
CD                        GROUP J TO GROUP J.                           -
CD    XSCATD              TOTAL SCATTERING CROSS SECTION INTO GROUP J   -
CD                        FROM GROUPS J-1,J-2,...,J-NDN(J), PRESENT     -
CD                        ONLY IF NDN(J).GT.0.                          -
CD    PC                  PC TIMES THE GROUP J REGION INTEGRATED        -
CD                        FLUX FOR THE REGIONS CONTAINING THE CURRENT   -
CD                        COMPOSITION YIELDS THE POWER IN WATTS IN THOSE -
CD                        REGIONS AND ENERGY GROUP J DUE TO FISSIONS    -
CD                        AND NON-FISSION ABSORPTIONS.                  -
CD    A1                  FIRST DIMENSION DIRECTIONAL DIFFUSION         -
CD                        COEFFICIENT MULTIPLIER.                       -
CD    B1                  FIRST DIMENSION DIRECTIONAL DIFFUSION         -
CD                        COEFFICIENT ADDITIVE TERM.                    -
```

APPENDIX E. CODE-DEPENDENT BINARY FILES (CONTD.). COMPXS.

```
CD     A2                SECOND DIMENSION DIRECTIONAL DIFFUSION          -
CD                       COEFFICIENT MULTIPLIER.                         -
CD     B2                SECOND DIMENSION DIRECTIONAL DIFFUSION          -
CD                       COEFFICIENT ADDITIVE TERM.                      -
CD     A3                THIRD DIMENSION DIRECTIONAL DIFFUSION           -
CD                       COEFFICIENT MULTIPLIER.                         -
CD     B3                THIRD DIMENSION DIRECTIONAL DIFFUSION           -
CD                       COEFFICIENT ADDITIVE TERM.                      -
C                                                                        -
C-----------------------------------------------------------------------

CEOF
```

APPENDIX E. CODE-DEPENDENT BINARY FILES (CONTD.). DCCOEF.

```
C*********************************************************************
C                                                                    -
C                        PREPARED 1/27/76 AT ANL                     -
C                                                                    -
CF          DCCOEF (OR ACCOEF)                                       -
CE          DIRECT (OR ADJCINT) SYNTHESIS COMBINING COEFFICIENT FILE -
C                                                                    -
C*********************************************************************


CD    NGROUP            NUMBER OF ENERGY GROUPS BEFORE COLLAPSING.
CD    LGROUP            NUMBER OF ENERGY GROUPS AFTER COLLAPSING.
CD    MAXFUN            NUMBER OF FUNCTION FILE NAMES IN TOC.
CD    NCHNST            THE NUMBER OF CHANNEL STRUCTURE SCHEMES.
CD    MAXKNM            THE MAXIMUM NUMBER OF WEIGHTING FUNCTIONS USED
CD                      IN A SINGLE ZONE, OR THE MAXIMUM NUMBER OF
CD                      EXPANSION FUNCTIONS, WHICHEVER IS LARGER.
CD                      MAXKNM.LE.MAXUSE.
CD    NCOLGP            NCOLGP = 0 FOR GROUP DEPENDENT SYNTHESIS.
CD                             = 1 FOR GENERAL GROUP COLLAPSING.
CD                             = 2 FOR SPECIAL GROUP COLLAPSING.
CD    NTITLE            THE NUMBER OF A6 WORDS USED TO STORE THE
CD                      TITLE.
CD    NUMKZN            THE NUMBER OF AXIAL ZONES IN THE MODEL. THERE
CD                      IS A NEW ZONE WHEN EITHER THE PLANAR GEOMETRY
CD                      OF THE FUNCTION SETS CHANGE.


C-------------------------------------------------------------------
CS          FILE STRUCTURE                                          -
CS                                                                  -
CS          RECORD TYPE                              PRESENT IF     -
CS          ==================================       ==============-
CS          FILE IDENTIFICATION                      ALWAYS         -
CS          SPECIFICATIONS                           ALWAYS         -
CS          FIXED POINT ARRAYS                       ALWAYS         -
CS          FLOATING POINT ARRAYS                    ALWAYS         -
CS          COMBINING COEFFICIENTS                   ALWAYS         -
C                                                                   -
C-------------------------------------------------------------------


C-------------------------------------------------------------------
CR          FILE IDENTIFICATION                                     -
C                                                                   -
CL    HNAME,(HUSE(I),I=1,2),IVERS                                   -
C                                                                   -
CW    1+3*MULT                                                      -
C                                                                   -
```

APPENDIX E. CODE-DEPENDENT BINARY FILES (CONTD.). DCCOEF.

```
CD     HNAME                HOLLERITH FILE NAME - DCCOEF (OR ACCOEF) - (A6)-
CD     HUSE                 HOLLERITH USER IDENTIFICATION (A6).            -
CD     IVERS                FILE VERSION NUMBER.                           -
CD     MULT                 WORD LENGTH PARAMETER.                         -
CD                          MULT=1, A6 WORD IS SINGLE WORD.                -
CD                              =2, A6 WORD IS DOUBLE PRECISION WORD.      -
C                                                                          -
C-------------------------------------------------------------------------


C-------------------------------------------------------------------------
CR           SPECIFICATIONS                                                -
C                                                                          -
CL     NGROUP,LGROUP,MAXFUN,MAXCHN,NCHNST,KMAX,MAXKNM,NCOLGP,NTITLE,       -
CL    1NUMKZN                                                              -
C                                                                          -
CW     10                                                                  -
C                                                                          -
CD     MAXCHN               THE MAXIMUM NUMBER OF CHANNELS IN ANY CHANNEL -
CD                          STRUCTURE SCHEME. MAXCHN.EQ.THE LARGEST       -
CD                          VALUE OF NUMCHN(I),I=1,NCHNST.                -
CD     KMAX                 NUMBER OF AXIAL MESH INTERVALS.               -
C                                                                          -
C-------------------------------------------------------------------------


C-------------------------------------------------------------------------
CR           FIXED POINT ARRAYS                                            -
C                                                                          -
CL      ((TGPUSE(N,J),N=1,LGROUP),J=1,MAXFUN),                             -
CL     1((IWT(J,K),J=1,MAXKNM),K=1,NUMKZN),                                -
CL     2((IFL(J,K),J=1,MAXKNM),K=1,NUMKZN),                                -
CL     3((NCHAN(N,J),N=1,LGROUP),J=1,MAXFUN),(NUMCHN(I),I=1,NCHNST),       -
CL     4(KCHANG(I),I=1,NUMKZN),(KDIM(I),I=1,NUMKZN),                       -
CL     5(IVRFUN(J),J=1,MAXFUN)                                             -
C                                                                          -
CW     2*LGROUP*MAXFUN+2*MAXKNM*NUMKZN+NCHNST+2*NUMKZN+MAXFUN              -
C                                                                          -
CD     TGPUSE               A PROJECTION MATRIX (ELEMENTS ARE 0 OR 1)     -
CD                          SHOWING WHICH GROUP FLUXES OF EACH FUNCTION   -
CD                          ARE TO BE USED (1) OR OMITTED (0).            -
CD     IWT                  THE WEIGHTING FUNCTIONS USED IN ZONE K. IF    -
CD                          THERE ARE FEWER THAN MAXKNM, THE OTHER ENTRIES -
CD                          FOR A PARTICULAR ZONE ARE ZERO.               -
CD     IFL                  THE EXPANSION FUNCTIONS USED IN ZONE K. IF    -
CD                          THERE ARE FEWER THAN MAXKNM, THE OTHER ENTRIES -
CD                          FOR A PARTICULAR ZONE ARE ZERO.               -
CD     NCHAN                CHANNEL SCHEME ASSIGNMENT FOR EACH GROUP-     -
CD                          COLLAPSED GROUP FLUX.                         -
CD     NUMCHN               NUMBER OF CHANNELS IN CHANNEL STRUCTURE       -
CD                          SCHEME I.                                     -
```

APPENDIX E. CODE-DEPENDENT BINARY FILES (CONTD.). DCCOEF.

```
CD    KCHANG              THE TOPMOST MESH INTERVAL IN EACH ZONE.        -
CD                        KCHANG(NUMKZN)=KMAX.                           -
CD    KDIM                THE NUMBER OF UNKNOWN COMBINING COEFFICIENTS   -
CD                        (AND THEREFORE EQUATIONS) ASSOCIATED WITH ONE  -
CD                        MESH INTERVAL IN ZONE I.                       -
CD    IVRFUN              VERSION NUMBER OF FILE FOR FUNCTION J.         -
CD                        SEE FUNNAM.                                    -
C                                                                        -
C-----------------------------------------------------------------------


C-----------------------------------------------------------------------
CR          FLOATING POINT ARRAYS                                        -
C                                                                        -
CL    ((FUNNAM(I,J),I=1,3),J=1,MAXFUN),(TITLE(I),I=1,NTITLE),            -
CL   1((U(I,J,K),I=1,LGROUP),J=1,NGROUP),K=1,2),EIGEN                    -
C                                                                        -
CW    3*MULT*MAXFUN+MULT*NTITLE+1 IF NCOLGP.EQ.0                         -
CW    3*MULT*MAXFUN+MULT*NTITLE+2*LGROUP*NGROUP+1 IF NCOLGP.GT.0         -
C                                                                        -
CD    FUNNAM              NAME OF FILE FOR FUNCTION J.                   -
CD    TITLE               USER INPUT TITLE.                              -
CD    U                   GENERAL GROUP COLLAPSING MATRIX FOR THE        -
CD                        EXPANSION FUNCTIONS (K=1) AND WEIGHTING        -
CD                        FUNCTIONS (K=2).                               -
CD    EIGEN               SYNTHESIS EIGENVALUE.                          -
C                                                                        -
CN                        U IS OMITTED WHEN NCOLGP=0.                    -
C                                                                        -
C-----------------------------------------------------------------------
```

APPENDIX E. CODE-DEPENDENT BINARY FILES (CONTD.). DCCOEF.

```
C-----------------------------------------------------------------------
CR          COMBINING COEFFICIENTS                                     -
C                                                                      -
CL    (A(I),I=1,LENA)                                                  -
C                                                                      -
CW    LENA                                                             -
C                                                                      -
CD    A                    SYNTHESIS COMBINING COEFFICIENTS, PACKED TO -
CD                         ELIMINATE ZEROS.                            -
CD    LENA                 THE TOTAL NUMBER OF NONZERO COMBINING       -
CD                         COEFFICIENTS.                               -
C                                                                      -
CN                         THE DIRECT COMBINING COEFFICIENTS, CC(N,I,K), -
CN                         ASSOCIATED WITH EACH COLLAPSED GROUP (N),   -
CN                         EXPANSION FUNCTION (I) AND AXIAL MESH INTERVAL -
CN                         (K) CAN BE UNPACKED FROM VECTOR A IN THE    -
CN                         FOLLOWING MANNER.                           -
CN                                                                     -
CN                              DIMENSION CC(LGROUP,MAXFUN,KMAX)       -
CN                                                                     -
CN                              NPT=0                                  -
CN                              K2=0                                   -
CN                              DO 20 L=1,NUMKZN                       -
CN                              K1=K2+1                                -
CN                              K2=KCHANG(L)                           -
CN                              DO 20 K=K1,K2                          -
CN                              DO 20 M=1,MAXKNM                       -
CN                              I=IFL(M,L)                             -
CN                              IF (I.EQ.0) GO TO 20                   -
CN                              DO 10 N=1,LGROUP                       -
CN                              CC(N,I,K)=0.                           -
CN                              IF (IGPUSE(N,I).EQ.0) GO TO 20         -
CN                              NPT=NPT+1                              -
CN                              CC(N,I,K)=A(NPT)                       -
CN                           10 CONTINUE                               -
CN                           20 CONTINUE                               -
CN                                                                     -
CN                         FOR THE ADJOINT COMBINING COEFFICIENT (IN THE -
CN                         ACCOEF FILE) USE IWT(M,L) INSTEAD OF IFL(M,L). -
C                                                                      -
C-----------------------------------------------------------------------

CEOF
```

APPENDIX E. CODE-DEPENDENT BINARY FILES (CONTD.). DIFINT.

```
C*********************************************************************
C                                                                    -
C                        PREPARED 1/27/76 AT ANL                     -
C                                                                    -
CF          DIFINT                                                   -
CE          AXIAL LEAKAGE INTEGRALS FOR SYN3D                        -
C                                                                    -
C*********************************************************************


CD    NRCDIF              NUMBER OF RECORDS IN DIFINT FILE (SEE
CD                        SPECIFICATIONS RECORDS OF INTTOC FILE).


C--------------------------------------------------------------------
CS          FILE STRUCTURE                                           -
CS                                                                   -
CS          RECORD TYPE                              PRESENT IF      -
CS          ==================================       ================-
CS    ******** (REPEAT FOR NRCDIF RECORDS)                           -
CS    *     INTEGRALS                                ALWAYS          -
CS    ********                                                       -
C                                                                    -
C--------------------------------------------------------------------


C--------------------------------------------------------------------
CR          INTEGRALS                                                -
C                                                                    -
CL    (X(I),I=1,LEN)                                                 -
C                                                                    -
CW    MULT*LEN                                                       -
C                                                                    -
CD    X                   A DIF INTEGRAL. SEE THE INTEGRAL TABLE OF -
CD                        CONTENTS IDIFTB IN THE INTTOC FILE.        -
CD    LEN                 RECORD LENGTH. LEN=LENDIF(I) FOR RECORD I -
CD    LENDIF              SEE FIXED POINT ARRAYS IN INTTOC FILE.     -
CD                                                                   -
CD                        THE DIF INTEGRALS ARE STORES IN THE FOLLOWING -
CD                        FORMS.                                     -
CD                        IF NSTDIF = 0  (ONLY IF THE DIF MATRIX IS  -
CD                                        BLOCK DIAGONAL).           -
CD                            (((DIF(I,J,K),I=1,NUMCHN(NCHAN(K,IW))),-
CD                              J=1,NUMCHN(NCHAN(K,IE))),K=1,LGROUP) -
CD                        IF NSTDIF = 1                              -
CD                            ((((DIF(I,J,K,L),I=1,NUMCHN(NCHAN(J,IW))),-
CD                                J=1,LGROUP,K=1,NUMCHN(NCHAN(L,IE))),-
CD                                L=1,LGROUP)                        -
```

APPENDIX E. CODE-DEPENDENT BINARY FILES (CONTD.). DIFINT.

```
CD                                                                      -
CD     IW                WEIGHTING FUNCTION IDENTIFIER                  -
CD                       (1.LE.IW.LE.MAXFUN).                           -
CD     IE                EXPANSION FUNCTION IDENTIFIER                  -
CD                       (1.LE.IE.LE.MAXFUN).                           -
CD     IP                PLANAR GEOMETRY IDENTIFIER (1.LE.IP.LE.MAXPLN).-
C                                                                       -
CN                       SEE THE INTTOC FILE DESCRIPTION FOR            -
CN                       DEFINITIONS OF THE OTHER VARIABLES.            -
C                                                                       -
C-----------------------------------------------------------------------

CEOF
```

APPENDIX E. CODE-DEPENDENT BINARY FILES (CONTD.). INTTOC.

```
C*********************************************************************
C                                                                    -
C                        PREPARED 1/27/76 AT ANL                     -
C                                                                    -
CF          INTTOC                                                   -
CE          TABLE OF CONTENTS (TOC) FOR SYNTHESIS INTEGRAL           -
CE          DATA SETS VOLINT AND DIFINT                              -
C                                                                    -
C*********************************************************************


CD     KMAX                NUMBER OF AXIAL MESH INTERVALS.
CD     LDIFTB              NUMBER OF ENTRIES IN THE IDIFTB TABLE.
CD     LENDLZ              LENGTH OF DLZRAT ARRAY.
CD     LGROUP              NUMBER OF ENERGY GROUPS AFTER COLLAPSING.
CD     LVOLTB              NUMBER OF ENTRIES IN THE IVOLTB TABLE.
CD     MAXFUN              NUMBER OF FUNCTION FILE NAMES IN TOC.
CD     MAXKNM              THE MAXIMUM NUMBER OF WEIGHTING FUNCTIONS USED
CD                         IN A SINGLE ZONE, OR THE MAXIMUM NUMBER OF
CD                         EXPANSION FUNCTIONS, WHICHEVER IS LARGER.
CD                         MAXKNM.LE.MAXUSE.
CD     MAXPLN              NUMBER OF PLANAR GEOMETRY FILE NAMES IN TOC.
CD     NCHNST              THE NUMBER OF CHANNEL STRUCTURE SCHEMES.
CD     NCOLGP              NCOLGP = 0 FOR GROUP DEPENDENT SYNTHESIS.
CD                                  = 1 FOR GENERAL GROUP COLLAPSING.
CD                                  = 2 FOR SPECIAL GROUP COLLAPSING.
CD     NGROUP              NUMBER OF ENERGY GROUPS BEFORE COLLAPSING.
CD     NRCDIF              NUMBER OF RECORDS IN THE DIFINT FILE.
CD     NRCVOL              NUMBER OF RECORDS IN THE VOLINT FILE.
CD     NSCALE              NSCALE = 1 IF USER SUPPLIED SCALING FACTORS
CD                                     ESCALE AND WSCALE ARE TO BE
CD                                     APPLIED.
CD                                  = 0 IF NOT TO BE APPLIED.
CD     NTITLE              THE NUMBER OF A6 WORDS USED TO STORE THE
CD                         TITLE.
CD     NUMKZN              THE NUMBER OF AXIAL ZONES IN THE MODEL. THERE
CD                         IS A NEW ZONE WHEN EITHER THE PLANAR GEOMETRY
CD                         OF THE FUNCTION SETS CHANGE.


C-------------------------------------------------------------------
CS          FILE STRUCTURE                                           -
CS                                                                   -
CS          RECORD TYPE                          PRESENT IF          -
CS          ================================     ===================-
CS          FILE IDENTIFICATION                  ALWAYS              -
CS          SPECIFICATIONS                       ALWAYS              -
CS          FIXED POINT ARRAYS                   ALWAYS              -
CS          FLOATING POINT ARRAYS                ALWAYS              -
CS          VOLINT TOC                           ALWAYS              -
CS          DIFINT TOC                           LDIFTB.GT.0         -
CS          SCALING FACTORS                      NSCALE.EQ.1         -
CS          BOUNDARY CONDITION CONSTANTS         ALWAYS              -
C                                                                    -
C-------------------------------------------------------------------
```

APPENDIX E. CODE-DEPENDENT BINARY FILES (CONTD.). INTTOC.

```
C-----------------------------------------------------------------------
CR          FILE IDENTIFICATION                                        -
C                                                                      -
CL    HNAME,(HUSE(I),I=1,2),IVERS                                      -
C                                                                      -
CW    1+3*MULT                                                         -
C                                                                      -
CD    HNAME              HOLLERITH FILE NAME - INTTOC - (A6).         -
CD    HUSE               HOLLERITH USER IDENTIFICATION (A6).          -
CD    IVERS              FILE VERSION NUMBER.                         -
CD    MULT               WORD LENGTH PARAMETER.                       -
CD                       MULT=1, A6 WORD IS SINGLE WORD.              -
CD                           =2, A6 WORD IS DOUBLE PRECISION WORD.    -
C                                                                      -
C-----------------------------------------------------------------------


C-----------------------------------------------------------------------
CR          SPECIFICATIONS                                             -
C                                                                      -
CL    TOTPOW,EPS,POWFIS,XEPS,IBCXL,IBCXU,IBCYL,IBCYU,IBCZL,IBCZU,      -
CL   1IBNDCH,IGEOM,IMAX,JMAX,KMAX,LDIFTB,LENA,LENDLZ,LENFLU,LENINT,    -
CL   2LENPOW,LGROUP,LVOLTB,MAXCHN,MAXCMP,MAXDIM,MAXDN,MAXFUN,MAXKNM,   -
CL   3MAXMD,MAXPLN,MAXREG,MAXSIZ,MAXUP,MAXUSE,NCAIC,NCHNST,NCOLGP,    -
CL   4NFLUNI,NGROUP,NRCDIF,NRCVOL,NSCALE,NSTDIF,NTITLE,NTRIAG,        -
CL   5NTRIPT,NUMKZN                                                    -
C                                                                      -
CW    48                                                               -
C                                                                      -
CD    TOTPOW             TOTAL POWER (WATTS).                         -
CD    EPS                A SMALL NUMBER USED IN TESTS FOR EQUALITY OF -
CD                       MESH INTERVALS.                              -
CD    POWFIS                                NOT USED.                 -
CD    XEPS               A SMALL NUMBER USED IN TESTS FOR ZERO CROSS  -
CD                       SECTIONS.                                    -
CD    IBCXL              THE LOWER X BOUNDARY CONDITION.              -
CD                                                                    -
CD                       1 - ZERO FLUX.                               -
CD                       2 - REFLECTIVE.                              -
CD                       3 - EXTRAPOLATED, C*D*DEL PHI + PHI = 0.     -
CD                       4 - PERIODIC WITH OPPOSITE BOUNDARY.         -
CD                       5 - PERIODIC WITH NEXT BOUNDARY GOING        -
CD                           CLOCKWISE.                               -
CD                       6 - PERIODIC WITH NEXT BOUNDARY GOING        -
CD                           COUNTERCLOCKWISE.                        -
CD                       7 - PERIODIC, INVERTED ALONG SAME BOUNDARY.  -
CD                                                                    -
CD    IBCXU              THE UPPER X BOUNDARY CONDITION.              -
CD    IBCYL              THE LOWER Y BOUNDARY CONDITION.              -
CD    IBCYU              THE UPPER Y BOUNDARY CONDITION.              -
CD    IBCZL              THE LOWER Z BOUNDARY CONDITION.              -
CD    IBCZU              THE UPPER Z BOUNDARY CONDITION.              -
```

APPENDIX E. CODE-DEPENDENT BINARY FILES (CONTD.). INTTOC.

```
CD     IBNDCH            LOWEST ENERGY GROUP (AFTER GROUP COLLAPSING)   -
CD                       FOR WHICH THERE IS A NONZERO CHI.              -
CD     IGEOM             PLANAR GEOMETRY TYPE SENTINEL.                 -
CD     IMAX              THE NUMBER OF MESH INTERVALS IN THE            -
CD                       FIRST (X) DIRECTION.                           -
CD     JMAX              THE NUMBER OF MESH INTERVALS IN THE            -
CD                       SECOND (Y) DIRECTION.                          -
CD     LENA              THE STORAGE REQUIRED FOR THE COMBINING         -
CD                       COEFFICIENTS.                                  -
CD     LENFLU            LENGTH OF THE ARRAY FLUX IN OVERLAY SOLVE.     -
CD     LENINT            THE MAXIMUM RECORD LENGTH FOR VOLINT AND       -
CD                       DIFINT INTEGRAL FILES.                         -
CD     LENPOW            LENGTH OF THE ARRAY POW IN OVERLAY SOLVE.      -
CD     MAXCHN            THE MAXIMUM NUMBER OF CHANNELS IN ANY CHANNEL  -
CD                       STRUCTURE SCHEME. MAXCHN.EQ.THE LARGEST        -
CD                       VALUE OF NUMCHN(I),I=1,NCHNST.                 -
CD     MAXCMP            THE NUMBER OF MATERIALS REPRESENTED IN THE     -
CD                       INPUT CROSS SECTION FILE.                      -
CD     MAXDIM            THE LARGEST DIMENSION OF ANY MATRIX USED IN    -
CD                       THE SOLUTION.                                  -
CD     MAXDN             MAXIMUM NUMBER OF DOWNSCATTERING GROUPS.       -
CD     MAXMD             THE LARGEST DIMENSION OF AN INPUT MATRIX (THE  -
CD                       LARGEST NUMBER OF GROUP-CHANNEL COMBINATIONS   -
CD                       FOR A SINGLE FUNCTION). MAXMD**2 IS THE        -
CD                       MINIMUM SPACE REQUIRED FOR A RECORD OF         -
CD                       REWRITTEN INTEGRALS.                           -
CD     MAXREG            THE MAXIMUM NUMBER OF REGIONS ASSOCIATED WITH  -
CD                       ANY OF THE PLANAR GEOMETRIES.                  -
CD     MAXSTZ            THE LENGTH OF THE BPOINTER CONTAINER ARRAY.    -
CD     MAXUP             MAXIMUM NUMBER OF UPSCATTERING GROUPS.         -
CD     MAXUSE            MAXIMUM NUMBER OF INPUT FUNCTIONS USED ANY-    -
CD                       WHERE IN THE MODEL AS EXPANSION FUNCTIONS OR   -
CD                       WEIGHTING FUNCTIONS, WHICHEVER IS LARGER.      -
CD                       MAXUSE.LE.MAXFUN.                              -
CD     NCALC             CALCULATION TYPE SENTINEL. SEE TYPE 2 CARD     -
CD                       OF SYNFIL.                                     -
CD     NFLUNI            A BOGUS FILE NUMBER FOR THE UNIT FLUX.         -
CD     NSTDIF            FORMAT SENTINEL FOR DIFINT FILE.               -
CD     NTRIAG            TRIANGULAR MESH SENTINEL.                      -
CD     NTRIPT            SECONDARY TRIANGULAR MESH SENTINEL.            -
C                                                                       -
C-----------------------------------------------------------------------
```

APPENDIX E. CODE-DEPENDENT BINARY FILES (CONTD.). INTTOC.

```
C-----------------------------------------------------------------------
CR            FIXED POINT ARRAYS                                       -
C                                                                      -
CL     (IBNDS1(I),I=1,LGROUP),(IBNDS2(I),I=1,LGROUP),                  -
CL    1(IBNDFI(I),I=1,MAXPLN),(LENVOL(I),I=1,NRCVOL),                  -
CL    2(LENDIF(I),I=1,NRCDIF),((IGPUSE(N,J),N=1,LGROUP),J=1,MAXFUN),   -
CL    3((IWT(J,K),J=1,MAXKNM),K=1,NUMKZN),                             -
CL    4((IFL(J,K),J=1,MAXKNM),K=1,NUMKZN),                             -
CL    5((NCHAN(N,J),N=1,LGROUP),J=1,MAXFUN),(NUMCHN(I),I=1,NCHNST),    -
CL    6(KCHANG(I),I=1,NUMKZN),(KGEOM(I),I=1,NUMKZN),                   -
CL    7(IVRFUN(J),J=1,MAXFUN),(IVRPLN(J),J=1,MAXPLN)                   -
C                                                                      -
CW     2*LGROUP+2*MAXPLN+NRCVOL+NRCDIF+2*LGROUP*MAXFUN+2*MAXKNM*NUMKZN -
CW     +NCHNST+2*NUMKZN+MAXFUN                                         -
C                                                                      -
CD     IBNDS1              THE POSITION IN COLUMN I OF THE GROUP       -
CD                         COLLAPSED SCATTERING MATRIX OF THE TOPMOST, -
CD                         NONZERO ELEMENT. EQUIVALENT TO LOCSCT WHEN  -
CD                         THERE IS NO GROUP COLLAPSING.               -
CD     IBNDS2              THE POSITION IN COLUMN I OF THE GROUP       -
CD                         COLLAPSED SCATTERING MATRIX OF THE BOTTOM,  -
CD                         NONZERO ELEMENT.                            -
CD     IBNDFI              LOWEST ENERGY GROUP (AFTER GROUP COLLAPSING) -
CD                         FOR WHICH THERE IS A NONZERO FISSION CROSS  -
CD                         SECTION FOR PLANE I. A ZERO MEANS NO FISSION. -
CD     LENVOL              LENGTH OF RECORD I OF THE VOLINT FILE.      -
CD     LENDIF              LENGTH OF RECORD I OF DIFINT FILE.          -
CD     IGPUSE              A PROJECTION MATRIX (ELEMENTS ARE 0 OR 1)   -
CD                         SHOWING WHICH GROUP FLUXES OF EACH FUNCTION -
CD                         ARE TO BE USED (1) OR OMITTED (0).          -
CD     IWT                 THE WEIGHTING FUNCTIONS USED IN ZONE K. IF  -
CD                         THERE ARE FEWER THAN MAXKNM, THE OTHER ENTRIES -
CD                         FOR A PARTICULAR ZONE ARE ZERO.             -
CD     IFL                 THE EXPANSION FUNCTIONS USED IN ZONE K. IF  -
CD                         THERE ARE FEWER THAN MAXKNM, THE OTHER ENTRIES -
CD                         FOR A PARTICULAR ZONE ARE ZERO.             -
CD     NCHAN               CHANNEL SCHEME ASSIGNMENT FOR EACH GROUP-   -
CD                         COLLAPSED GROUP FLUX.                       -
CD     NUMCHN              NUMBER OF CHANNELS IN CHANNEL STRUCTURE     -
CD                         SCHEME I.                                   -
CD     KCHANG              THE TOPMOST MESH INTERVAL IN EACH ZONE.     -
CD                         KCHANG(NUMKZN)=KMAX.                        -
CD     KGEOM               THE GEOMETRY FOR MESH INTERVALS KCHANG(I-1) -
CD                         TO KCHANG(I). KCHANG(0) IS DEFINED TO BE 1. -
CD     IVRFUN              VERSION NUMBER OF FILE FOR FUNCTION J.      -
CD                         SEE FUNNAM.                                 -
CD     IVRPLN              VERSION NUMBER OF FILE FOR PLANAR GEOMETRY J. -
CD                         SEE PLNNAM.                                 -
C                                                                      -
C-----------------------------------------------------------------------
```

APPENDIX E. CODE-DEPENDENT BINARY FILES (CONTD.). INTTOC.

```
C-----------------------------------------------------------------------
CR          FLOATING POINT ARRAYS                                      -
C                                                                      -
CL     ((FUNNAM(I,J),I=1,3),J=1,MAXFUN),                               -
CL    1((PLNNAM(I,J),I=1,3),J=1,MAXPLN),(TITLE(I),I=1,NTITLE),         -
CL    2(((U(I,J,K),I=1,LGROUP),J=1,NGROUP),K=1,2),                     -
CL    3(DLZRAT(I),I=1,LENDLZ),(ZMESH(K),K=1,KMAX)                      -
C                                                                      -
CW     3*MULT*MAXFUN+3*MULT*MAXPLN+MULT*NTITLE+LENDLZ+KMAX             -
CW     IF NCOLGP.EQ.0.                                                 -
CW     3*MULT*MAXFUN+3*MULT*MAXPLN+MULT*NTITLE+LENDLZ+KMAX+2*LGROUP    -
CW     *NGROUP IF NCOLGP.GT.0.                                         -
C                                                                      -
CD     FUNNAM            NAME OF FILE FOR FUNCTION J.                  -
CD     PLNNAM            NAME OF FILE FOR PLANAR GEOMETRY J.           -
CD     TITLE             USER INPUT TITLE.                             -
CD     U                 GENERAL GROUP COLLAPSING MATRIX FOR THE       -
CD                       EXPANSION FUNCTIONS (K=1) AND WEIGHTING       -
CD                       FUNCTIONS (K=2).                              -
CD     DLZRAT            RATIO OF 2 ADJACENT AXIAL MESH INTERVALS.     -
CD                                                                     -
CD                                  (LOWER/UPPER)                      -
CD                                                                     -
CD     ZMESH             POSITION OF UPPER BOUNDARY OF AXIAL MESH      -
CD                       INTERVAL K.                                   -
C                                                                      -
CN                       FUNNAM, PLNNAM AND TITLE ARE DOUBLE PRECISION -
CN                       ARRAYS ON MULT=2 MACHINES.                    -
CN                                                                     -
CN                       IF NCOLGP=0, U IS NOT INCLUDED.               -
C                                                                      -
C-----------------------------------------------------------------------
```

APPENDIX E. CODE-DEPENDENT BINARY FILES (CONTD.). INTTOC.

```
C-----------------------------------------------------------------------
CR          VOLINT TOC                                                 -
C                                                                      -
CL    ((IVOLTB(I,K),I=1,7),K=1,LVOLTB)                                 -
C                                                                      -
CW    7*LVOLTB                                                         -
C                                                                      -
CD    IVOLTB              TABLE OF CONTENTS FOR REM AND FIS INTEGRALS  -
CD                        IN THE VOLINT FILE.                          -
CD                                                                     -
CD                        IVOLTB(1,K) = 1 FOR REM INTEGRAL.            -
CD                                    = 2 FOR A FIS INTEGRAL.          -
CD                                    = 3 FOR A POW INTEGRAL.          -
CD                                    = 4 FOR A FLUX INTEGRAL.         -
CD                        IVOLTB(2,K) THE RECORD OF THE VOLINT FILE    -
CD                                    CONTAINING THE INTEGRAL.         -
CD                                    = 0 IF THE INTEGRAL COULD NOT BE -
CD                                        DONE.                        -
CD                                    = -1 IF THE INTEGRAL COULD HAVE  -
CD                                         BEEN DONE BUT FOR SOME REASON -
CD                                         WAS NOT.                    -
CD                        IVOLTB(3,K) POINTER TO THE FIRST WORD OF THE -
CD                                    INTEGRAL BLOCK WITHIN THAT RECORD. -
CD                        IVOLTB(4,K) PLANAR GEOMETRY IDENTIFIER.      -
CD                        IVOLTB(5,K) WEIGHTING FUNCTION IDENTIFIER.   -
CD                        IVOLTB(6,K) EXPANSION FUNCTION IDENTIFIER.   -
CD                        IVOLTB(7,K) NUMBER OF RECORDS REQUIRED FOR ALL -
CD                                    THE INTEGRALS OF THIS COMBINATION. -
C                                                                      -
C-----------------------------------------------------------------------
```

APPENDIX E. CODE-DEPENDENT BINARY FILES (CONTD.). INTTOC.

```
C-----------------------------------------------------------------------
CR          DIFINT TOC                                                 -
C                                                                      -
CL     ((IDIFTH(I,K),I=1,8),K=1,LDIFTB)                                -
C                                                                      -
CW     9*LDIFTB                                                        -
C                                                                      -
CD     IDIFTB              TABLE OF CONTENTS FOR DIF INTEGRALS IN      -
CD                         DIFINT FILE.                                -
CD                                                                     -
CD                         IDIFTB(1,K) RECORD OF THE DIFINT FILE       -
CD                                     CONTAINING THE INTEGRALS.       -
CD                         IDIFTB(2,K) POINTER TO THE FIRST WORD OF THE -
CD                                     INTEGRAL BLOCK WITHIN THAT RECORD. -
CD                         IDIFTB(3,K) LOWER PLANAR GEOMETRY IDENTIFIER. -
CD                                     = 0 FOR THE BOTTOM BOUNDARY     -
CD                                         INTEGRAL.                   -
CD                         IDIFTB(4,K) UPPER PLANAR GEOMETRY IDENTIFIER. -
CD                                     = 0 FOR THE TOP BOUNDARY INTEGRAL. -
CD                         IDIFTB(5,K) POINTER TO A MESH INTERVAL RATIO -
CD                                     IN THE DLZRAT ARRAY.            -
CD                         IDIFTB(6,K) WEIGHTING FUNCTION IDENTIFIER.  -
CD                         IDIFTB(7,K) EXPANSION FUNCTION IDENTIFIER.  -
CD                         IDIFTB(8,K) NUMBER OF RECORDS REQUIRED FOR ALL -
CD                                    THE INTEGRALS OF THIS COMBINATION. -
C                                                                      -
C-----------------------------------------------------------------------


C-----------------------------------------------------------------------
CR          SCALING FACTORS                                            -
C                                                                      -
CL     ((ESCALE(I,J),I=1,NGROUP),J=1,MAXFUN),                          -
CL    1((WSCALE(I,J),J=1,NGROUP),J=1,MAXFUN)                           -
C                                                                      -
CW     2*NGROUP*MAXFUN                                                 -
C                                                                      -
CD     ESCALE              A USER SUPPLIED SCALING FACTOR FOR EACH GROUP -
CD                         OF FUNCTION J WHEN FUNCTION J IS USED AS AN -
CD                         EXPANSION FUNCTION. IT CAN ONLY HAVE AN EFFECT -
CD                         WHEN GROUP COLLAPSING IS EMPLOYED.          -
CD     WSCALE              A USER SUPPLIED SCALING FACTOR FOR EACH GROUP -
CD                         OF FUNCTION J WHEN FUNCTION J IS USED AS A  -
CD                         WEIGHTING FUNCTION. IT CAN ONLY HAVE AN EFFECT -
CD                         WHEN GROUP COLLAPSING IS EMPLOYED.          -
C                                                                      -
CN                         PRESENT ONLY IF NSCALE.EQ.1.                -
C                                                                      -
C-----------------------------------------------------------------------
```

APPENDIX E. CODE-DEPENDENT BINARY FILES (CONTD.). INTTOC.

```
C-----------------------------------------------------------------------
CR          BOUNDARY CONDITION CONSTANTS                                -
C                                                                       -
CL     ((C(I,J),I=1,6),J=1,NGROUP)                                      -
C                                                                       -
CW     6*NGROUP                                                         -
C                                                                       -
CD     C                  CONSTANT IN THE HOMOGENEOUS BOUNDARY CONDITION -
CD                        EXPRESSION DEL PHI+C*PHI = 0.                 -
C                                                                       -
C-----------------------------------------------------------------------

CEOF
```

APPENDIX E. CODE-DEPENDENT BINARY FILES (CONTD.). REQFLX.

```
C*********************************************************************
C                                                                    -
C                        PREPARED 1/27/76 AT ANL                     -
C                                                                    -
CF          REQFLX                                                   -
CF          THIS IS A SCRATCH FILE CONTAINING THE GROUP FLUXES,      -
CE          MESH SPACING AND COMPOSITION MAPS FOR RANGES OF THE      -
CE          X AND Y MESH. ALL THE GROUP FLUXES AND PLANAR            -
CE          COMPOSITION MAPS REQUIRED FOR THE SYNTHESIS INTEGRAL     -
CE          CALCULATION ARE INCLUDED                                 -
C                                                                    -
C*********************************************************************


CD    LREQF              NUMBER OF RECORDS IN THE REQFLX FILE.
CD    LENFLX             RECORD SIZE FOR REQFLX.


C-------------------------------------------------------------------
CS          FILE STRUCTURE                                           -
CS                                                                   -
CS          RECORD TYPE                              PRESENT IF      -
CS          ==================================       ================-
CS    ******** (REPEAT FOR LREQF RECORDS)                            -
CS    *     DATA                                     ALWAYS          -
CS    ********                                                       -
C                                                                    -
C-------------------------------------------------------------------


C-------------------------------------------------------------------
CP          DATA                                                     -
C                                                                    -
CL    ((((FLUX(I,J,N,JDOFUN(L)),I=I1,I2),J=J1,J2),N=1,NGROUP),       -
CL   1L=1,NUMFUN),(X(I),I=I1-1,I2),(Y(J),J=J1-1,J2),                 -
CL   2(((ICOMP(I,J,JDOPLN(L)),I=I1,I2),J=J1,J2),L=1,NUMPLN)          -
C                                                                    -
CW    IBAND*JBAND*(NGROUP*NUMFUN+NUMPLN)+IBAND+JBAND+2               -
C                                                                    -
CD    FLUX               THE FLUX FOR MESH INTERVAL (I,J), GROUP N,  -
CD                       OF FUNCTION NUMBER JDOFUN(L). UNIT FLUXES   -
CD                       ARE NOT INCLUDED IN THE FILE.               -
CD    X                  THE X POSITION OF THE MESH LINE SEPARATING  -
CD                       INTERVALS I AND I+1.                        -
CD    Y                  THE Y POSITION OF THE MESH LINE SEPARATING  -
CD                       INTERVALS J AND J+1.                        -
CD    ICOMP              THE COMPOSITION NUMBER IN MESH INTERVAL (I,J) -
CD                       OF PLANAR GEOMETRY NUMBER JDOPLN(L).        -
CD    I1,I2              THE FIRST AND LAST COLUMNS ASSOCIATED WITH A -
CD                       RECORD OF FLUXES. I2-I1=IBAND-1 EXCEPT,     -
CD                       PERHAPS, WHEN I2 IS THE LAST COLUMN. FOR THE -
CD                       FIRST RECORD I1=0.                          -
CD    J1,J2              THE FIRST AND LAST ROWS ASSOCIATED WITH A   -
CD                       RECORD OF FLUXES. J2-J1=JBAND-1 EXCEPT,     -
CD                       PERHAPS, WHEN J2 IS THE LAST ROW. FOR THE   -
CD                       FIRST RECORD J1=0.                          -
```

APPENDIX E. CODE-DEPENDENT BINARY FILES (CONTD.). REQFLX.

```
CD     IBAND          THE NUMBER OF COLUMNS OF FLUXES IN ONE RECORD  -
CD                    OF THE REQFLX FILE.                            -
CD     JBAND          THE NUMBER OF ROWS OF FLUXES IN ONE RECORD     -
CD                    OF THE REQFLX FILE.                            -
CD     JDOFUN         THE LIST OF FUNCTIONS REQUIRED TO CALCULATE    -
CD                    THE INTEGRALS, IN THE ORDER IN WHICH THEY      -
CD                    APPEAR IN THE REQFLX FILE. WHEN IT IS PRESENT, -
CD                    THE UNIT FUNCTION IS LAST IN THE LIST.         -
CD     JDOPLN         THE LIST OF PLANAR GEOMETRIES REQUIRED TO      -
CD                    CALCULATE THE INTEGRALS.                       -
CD     NUMPLN         THE NUMBER OF PLANAR GEOMETRIES REQUIRED TO    -
CD                    CALCULATE THE INTEGRALS (NUMPLN.LE.MAXPLN).    -
CD     NUMFUN         THE NUMBER OF FUNCTIONS REQUIRED TO CALCULATE  -
CD                    THE INTEGRALS. IF THE UNIT FUNCTION IS         -
CD                    REQUIRED, IT IS INCLUDED IN NUMFUN, EVEN       -
CD                    THOUGH NO SUCH FLUX FILE IS EVER WRITTEN       -
CD                    (NUMFUN.LE.MAXFUN).                            -
C                                                                    -
CN                    THE BLOCKS OF DATA OVERLAP ONE MESH INTERVAL   -
CN                    IN THE X DIRECTION BUT DO NOT OVERLAP IN THE   -
CN                    Y DIRECTION. THE RANGES OF X AND Y MESH        -
CN                    ASSOCIATED WITH EACH RECORD OF REQFLX ARE      -
CN                    DEFINED IN THE FOLLOWING SEQUENCE.             -
CN                                                                   -
CN                     RECORD      I1        I2        J1        J2  -
CN                       1          0     IBAND-1      0     JBAND-1 -
CN                       2          0     IBAND-1   JBAND  2*JBAND-1 -
CN                       .          .        .        .        .    -
CN                       .          .        .        .        .    -
CN                       .      IBAND-1 2*(IBAND-1)   0     JBAND-1 -
CN                       .          .        .        .        .    -
CN                       .          .        .        .        .    -
C                                                                    -
C--------------------------------------------------------------------

CEOF
```

APPENDIX E. CODE-DEPENDENT BINARY FILES (CONTD.). REQXST.

```
C*********************************************************************
C                                                                    -
C                        PREPARED 1/27/76 AT ANL                     -
C                                                                    -
CF          REQXST                                                   -
CE          THIS IS A SCRATCH FILE CONTAINING THE MACROSCOPIC CROSS  -
CE          SECTIONS REQUIRED FOR DOING THE SYNTHESIS INTEGRALS      -
C                                                                    -
C*********************************************************************


CD    LREQX1              NUMBER OF RECORDS OF THE REQXST FILE EXCLUDING
CD                        DIFFUSION COEFFICIENTS.
CD    LREQX2              NUMBER OF RECORDS OF THE REQXST FILE CONTAINING
CD                        ONLY DIFFUSION COEFFICIENTS.


C---------------------------------------------------------------------
CS          FILE STRUCTURE                                           -
CS                                                                   -
CS          RECORD TYPE                                PRESENT IF    -
CS          ==================================         ==============-
CS    ******** (REPEAT FOR LREQX1 RECORDS)                           -
CS    *     FISSION AND REMOVAL DATA                 LPEQX1.GT.0    -
CS    ********                                                      -
CS    ******** (REPEAT FOR LREQX2 RECORDS)                           -
CS    *     DIFFUSION COEFFICIENTS                   LREQX2.GT.0    -
CS    ********                                                      -
C                                                                    -
C---------------------------------------------------------------------


C---------------------------------------------------------------------
CR          FISSION AND REMOVAL DATA                                 -
C                                                                    -
CL    ((SIGMA(I,J),I=1,LXST1),J=1,LXST2)                             -
C                                                                    -
CW    LXST1*LXST2                                                    -
C                                                                    -
CD    LXST1               THE NUMBER OF CROSS SECTION DATA PER       -
CD                        COMPOSITION, FOR RECORDS OF REQXST         -
CD                        CONTAINING FISSION AND REMOVAL DATA.       -
CD                        LXST1=LENSCT+3*NGROUP                      -
CD    LENSCT              THE NUMBER OF DATA IN THE REMOVAL CROSS    -
CD                        SECTION MATRIX. THE MATRIX IS STORED IN    -
CD                        PACKED FORM, EXCLUDING ENTRIES OUTSIDE     -
CD                        THE SCATTERING BAND.                       -
CD                        LENSCT=NGROUP+(MAXUP*(2*NGROUP-MAXUP-1)    -
CD                               +MAXDN*(2*NGROUP-MAXDN-1))/2        -
CD    LXST2               THE NUMBER OF COMPOSITIONS PER RECORD, FOR -
CD                        RECORDS OF REQXST CONTAINING FISSION AND   -
CD                        REMOVAL DATA.                              -
CD    MAXDN               MAXIMUM NUMBER OF DOWNSCATTERING GROUPS.   -
CD    MAXUP               MAXIMUM NUMBER OF UPSCATTERING GROUPS.     -
```

APPENDIX E. CODE-DEPENDENT BINARY FILES (CONTD.). REQXST.

```
CD    SIGMA              FISSION AND REMOVAL DATA FOR REQUIRED          -
CD                       COMPOSITIONS. REQUIRED COMPOSITIONS 1 THROUGH  -
CD                       LXST2 ARE IN THE FIRST RECORD OF REQXST,       -
CD                       REQUIRED COMPOSITIONS LXST2+1 THROUGH 2*LXST2  -
CD                       IN THE SECOND, ETC. THE ACTUAL (COMPXS)        -
CD                       COMPOSITION NUMBER FOR REQUIRED COMPOSITION    -
CD                       NUMBER K IS JDOCMP(K). FOR EACH COMPOSITION,   -
CD                       THE REMOVAL MATRIX IS STORED FIRST (SEE THE    -
CD                       DEFINITION OF LENSCT), FOLLOWED BY VECTORS     -
CD                       CONTAINING NU SIGMA F, CHI AND THE POWER CROSS -
CD                       SECTION. SCATTERING CROSS SECTIONS INTO A      -
CD                       GROUP APPEAR AS NEGATIVE NUMBERS IN THE        -
CD                       REMOVAL MATRIX.                                -
CD    JDOCMP             THE LIST OF COMPOSITIONS REQUIRED TO           -
CD                       CALCULATE THE INTEGRALS.                       -
C                                                                       -
C-----------------------------------------------------------------------


C-----------------------------------------------------------------------
CR          DIFFUSION COEFFICIENTS                                      -
C                                                                       -
CL    (((D(I,J,K),I=1,3),J=1,NUMCMP),K=1,LXST3)                         -
C                                                                       -
CW    3*NUMCMP*LXST3                                                    -
C                                                                       -
CD    LXST3              THE NUMBER OF GROUPS PER RECORD FOR RECORDS    -
CD                       CONTAINING ONLY DIFFUSION COEFFICIENTS.        -
CD    NUMCMP             THE NUMBER OF MATERIALS FOR WHICH CROSS        -
CD                       SECTIONS ARE REQUIRED WHEN THE INTEGRALS ARE   -
CD                       CALCULATED (NUMCMP.LE.MAXCMP).                 -
CD    D                  THE DIFFUSION COEFFICIENT FOR EACH OF THREE    -
CD                       DIRECTIONS FOR ALL REQUIRED COMPOSITIONS. ALL  -
CD                       THE DATA FOR GROUPS 1 THROUGH LXST3 ARE STORED -
CD                       IN THE FIRST DIFFUSION COEFFICIENT RECORD,     -
CD                       GROUPS LXST3+1 THROUGH 2*LXST3 IN THE SECOND,  -
CD                       ETC.                                           -
C                                                                       -
C-----------------------------------------------------------------------

CEOF
```

APPENDIX E. CODE-DEPENDENT BINARY FILES (CONTD.). SYNCON.

```
C*********************************************************************
C                                                                    -
C                        PREPARED 1/27/76 AT ANL                     -
C                                                                    -
CF          SYNCON                                                   -
CE          A BINARY FILE CONTAINING THE DATA IN THE BCD FILE        -
CE          SYNFIL. THIS IS A SCRATCH FILE WRITTEN IN OVERLAY        -
CE          CARDS OF SYN3D                                           -
C                                                                    -
C*********************************************************************


C--------------------------------------------------------------------
CS          FILE STRUCTURE                                           -
CS                                                                   -
CS          RECORD TYPE                              PRESENT IF      -
CS          ==================================       ================-
CS          MAXIMUM CARD TYPE                        ALWAYS          -
CS          CARDS PER CARD TYPE                      ALWAYS          -
CS     ******** (REPEAT FOR EACH INPUT                               -
CS     *          SYNFIL CARD)                                      -
CS     *    SYNFIL CARD DATA                        ALWAYS          -
CS     ********                                                      -
C                                                                    -
C--------------------------------------------------------------------


C--------------------------------------------------------------------
C                                                                    -
CR          MAXIMUM CARD TYPE                                        -
C                                                                    -
CL     MAXREC                                                        -
C                                                                    -
CW     1                                                             -
C                                                                    -
CD     MAXREC              MAXIMUM CARD TYPE NUMBER OF SYNFIL INPUT. -
C                                                                    -
C--------------------------------------------------------------------


C--------------------------------------------------------------------
CR          CARDS PER CARD TYPE                                      -
C                                                                    -
CL     (NREC(I),I=1,MAXREC)                                          -
C                                                                    -
CW     MAXREC                                                        -
C                                                                    -
CD     NREC                NUMBER OF RECORDS (CARDS) OF CARD TYPE I -
CD                         INCLUDED IN SYNFIL INPUT.                 -
C                                                                    -
C--------------------------------------------------------------------
```

APPENDIX E. CODE-DEPENDENT BINARY FILES (CONTD.). SYNCON.

```
C-----------------------------------------------------------------------
CR          SYNFIL CARD DATA                                          -
C                                                                     -
CN                      EACH RECORD OF THIS TYPE CONTAINS THE DATA ON -
CN                      ONE CARD OF THE SYNFIL INPUT, EXCLUDING THE   -
CN                      CARD TYPE NUMBER. THE CARDS MUST BE IN ORDER  -
CN                      OF ASCENDING CARD TYPE NUMBER.                -
C                                                                     -
C-----------------------------------------------------------------------

CEOF
```

APPENDIX F. CODE-DEPENDENT BINARY FILES (CONTD.). VOLINT.

```
C*********************************************************************
C                                                                    -
C                        PREPARED 1/27/76 AT ANL                     -
C                                                                    -
CF          VOLINT                                                   -
CE          REMOVAL, FISSION, POWER AND FLUX INTEGRALS FOR SYN3D     -
C                                                                    -
C*********************************************************************


CD    NRCVOL              NUMBER OF RECORDS IN VOLINT FILE. (SEE
CD                        SPECIFICATIONS RECORD OF INTTOC FILE).


C--------------------------------------------------------------------
CS          FILE STRUCTURE                                           -
CS                                                                   -
CS          RECORD TYPE                              PRESENT IF      -
CS          ==================================       ================-
CS    ******** (REPEAT FOR NRCVOL RECORDS)                           -
CS    *     INTEGRALS                                ALWAYS          -
CS    ********                                                       -
C                                                                    -
C--------------------------------------------------------------------


C--------------------------------------------------------------------
CR          INTEGRALS                                                -
C                                                                    -
CL    (X(I),I=1,LEN)                                                 -
C                                                                    -
CT    MULT*LEN                                                       -
C                                                                    -
CD    X                   A FIS, REM, POW OR FLUX INTEGRAL. SEE THE -
CD                        INTEGRAL TABLE OF CONTENTS IVOLTB IN THE  -
CD                        INTTOC FILE.                               -
CD    LEN                 RECORD LENGTH. LEN=LENVOL(I) FOR RECORD I. -
CD    LENVOL              SEE FIXED POINT ARRAYS IN INTTOC FILE.     -
CD                                                                   -
CD                        THE FIS INTEGRALS ARE STORED               -
CD                             ((((FIS(I,J,K,L),I=1,NUMCHN(NCHAN(J,IW))), -
CD                                 J=1,IBNDCH),K=1,NUMCHN(NCHAN(L,IE))), -
CD                                 I=1,IBNDFI(IP))                   -
CD                        THE REM INTEGRALS ARE STORED               -
CD                             ((((REM(I,J,K,L),I=1,NUMCHN(NCHAN(J,IW))), -
CD                                 J=IBNDS1(L),IBNDS2(L)),           -
CD                                 K=1,NUMCHN(NCHAN(L,IE))),L=1,LGROUP) -
CD                        THE POW INTEGRALS ARE STORED               -
CD                             ((POW(I,J),I=1,NUMCHN(NCHAN(J,IE))),  -
CD                               J=1,IBNDFI(IP))                     -
CD                        THE FLUX INTEGRALS ARE STORED              -
CD                             ((FLUX(I,J),I=1,NUMCHN(NCHAN(J,IE))), -
CD                               J=1,LGROUP)                         -
```

APPENDIX E. CODE-DEPENDENT BINARY FILES (CONTD.). VOLINT.

```
CD                                                                      -
CD     IW                 WEIGHTING FUNCTION IDENTIFIER                -
CD                        (1.LE.IW.LE.MAXFUN).                         -
CD     IE                 EXPANSION FUNCTION IDENTIFIER                -
CD                        (1.LE.IE.LE.MAXFUN).                         -
CD     IP                 PLANAR GEOMETRY IDENTIFIER (1.LE.IP.LE.MAX2LN).-
C                                                                       -
CN                        SEE THE INTTOC FILE DESCRIPTION FOR          -
CN                        DEFINITIONS OF THE OTHER VARIABLES.          -
C                                                                       -
C-----------------------------------------------------------------------

CEOF
```

APPENDIX F. SYN3D ERROR MESSAGES. ERRORS ARE IDENTIFIED BY SUBROUTINE NAME AND ERROR NUMBER.

SUBR.	NUMBER	DESCRIPTION
BRKUP	10	THE CODE CANNOT HANDLE THE GEOMETRY TYPE SPECIFIED IN THE INPUT GEODST FILE.
BRKUP	152	AN OUTPUT GEODST FILE CANNOT BE WRITTEN.
CARDS	12	THERE IS NO INPUT SYNFIL FILE.
CARDS	14	THERE ARE NO INPUT CARDS.
CARDS	222	THERE ARE NEITHER TYPE 4 AND 5 CARDS NOR AN INPUT GEODST FILE.
CARDS	410	AN OUTPUT SYNCON FILE CANNOT BE WRITTEN.
DECIDE	50	CODE BUG. THE OUTPUT INTEGRALS FOR A SINGLE COMBINATION ARE TOO BIG FOR THE SPECIFIED RECORD LENGTH. INCREASE LENINT.
DECIDE	52	CODE BUG.
DECIDE	130	SAME AS 50.
DECIDE	134	CODE BUG.
DECIDE	232	CODE BUG.
DIVVY	48	THERE IS NOT ENOUGH SPACE IN THE BPOINTER CONTAINER TO HOLD THE MATRICES GENERATED IN THE SOLUTION ROUTINE.
DIVVY	110	CODE BUG.
EDITS	16	NO COMBINING COEFFICIENT DATASETS EXIST.
EDITS	20	THERE IS NO INTEGRAL DATASET AVAILABLE.
EDITS	26	THERE IS NO INTTOC DATASET AVAILABLE.
EDITS	60	TO CALCULATE THE PERTURBATION DENOMINATOR BOTH DCCOEF AND ACCOEF FILES MUST BE AVAILABLE. SUCH IS NOT THE CASE.
EDITS	82	THE BPOINTER CONTAINER IS NOT LARGE ENOUGH TO HOLD ALL THE DATA REQUIRED TO CONSTRUCT AN OUTPUT FLUX INTEGRAL FILE.
EDITS	102	THE BPOINTER CONTAINER IS NOT LARGE ENOUGH TO HOLD ALL THE DATA REQUIRED TO CONSTRUCT AN OUTPUT POWER FILE.
FILLUP	40	CODE BUG. MISSING DIFINT INTEGRAL.
FILLUP	130	CODE BUG. MISSING DIFINT INTEGRAL.
FILLUP	160	CODE BUG. MISSING DIFINT INTEGRAL.
FILLUP	220	CODE BUG. MISSING VOLINT INTEGRAL.
FILLUP	260	CODE BUG. MISSING VOLINT INTEGRAL.
FILLUP	340	CODE BUG. MISSING DIFINT INTEGRAL.
FLUX3D	10	AN OUTPUT FILE CANNOT BE WRITTEN.
FLUX3D	12	THE CROSS SECTION FILE XSCMIN IS NOT AVAILABLE.
FLUX3D	62	A REQUIRED EXPANSION FUNCTION FILE IS NOT AVAILABLE.
HMG4C	1	A FATAL ERROR HAS BEEN ENCOUNTERED DURING THE CROSS SECTION PROCESSING.
INPRO1	10	THERE IS A SYNFIL CARD TYPE NUMBER GREATER THAN THE LARGEST DEFINED.

APPENDIX F. SYN3D ERROR MESSAGES. CONTINUED.

INPRO1	28	THERE ARE MORE THAN ONE TYPE 2 CARDS. ALL BUT THE FIRST ARE IGNORED.
INPRO1	34	THE BOUNDARY CONDITIONS HAVE BEEN CHANGED SINCE THE INPUT INTEGRALS WERE CALCULATED. SOME OF THE INTEGRALS MAY NO LONGER BE CORRECT.
INPRO1	44	THERE ARE MORE THAN ONE TYPE 3 SYNFIL CARDS. ALL BUT THE FIRST ARE IGNORED.
INPRO1	62	THERE IS NO TYPE 5 SYNFIL CARD. IT IS REQUIRED.
INPRO1	68	A REQUIRED GEOMETRY FILE IS MISSING.
INPRO1	72	A REQUIRED GEOMETRY FILE IS MISSING.
INPRO1	74	THE LABEL ON A GEOMETRY FILE DOES NOT MATCH THE LABEL ON THE FILE WHEN THE INPUT INTEGRALS WERE CALCULATED. IF THE GEODST FILE HAS BEEN RECONSTRUCTED ARE YOU SURE NO CHANGES HAVE BEEN MADE IN THE CONTENT.
INPRO1	76	THE LOWER X BOUNDARY CONDITION READ FROM AN INPUT GEODST FILE IS NOT ALLOWED OR, IN THE CASE OF PERIODIC CONDITIONS, IS INCONSISTENT.
INPRO1	78	THE UPPER X BOUNDARY CONDITION READ FROM AN INPUT GEODST FILE IS NOT ALLOWED OR, IN THE CASE OF PERIODIC CONDITIONS, IS INCONSISTENT.
INPRO1	80	THE LOWER Y BOUNDARY CONDITION READ FROM AN INPUT GEODST FILE IS NOT ALLOWED OR, IN THE CASE OF PERIODIC CONDITIONS, IS INCONSISTENT.
INPRO1	82	THE UPPER Y BOUNDARY CONDITION READ FROM AN INPUT GEODST FILE IS NOT ALLOWED OR, IN THE CASE OF PERIODIC CONDITIONS, IS INCONSISTENT.
INPRO1	104	THE BOUNDARY SYMBOL ON A TYPE 6 SYNFIL CARD IS UNRECOGNIZABLE.
INPRO1	108	THE GROUP NUMBERS ON A TYPE 6 SYNFIL CARD ARE EITHER OUT OF SEQUENCE OR EXCEED THE TOTAL NUMBER OF GROUPS.
INPRO1	140	THERE IS NO FUNCTION NAME ON THE FIRST SYNFIL TYPE 7 CARD.
INPRO1	148	A REQUIRED EXPANSION FUNCTION FLUX FILE IS MISSING.
INPRO1	154	A REQUIRED EXPANSION FUNCTION FLUX FILE IS MISSING.
INPRO1	160	THE LABEL ON A FLUX FILE DOES NOT MATCH THE LABEL ON THE FILE WHEN THE INPUT INTEGRALS WERE CALCULATED. IF THE RTFLUX FILE HAS BEEN RECONSTRUCTED ARE YOU SURE NO CHANGES HAVE BEEN MADE IN THE CONTENT.
INPRO1	182	THERE IS NO FUNCTION NAME ON THE FIRST SYNFIL TYPE 8 CARD.
INPRO1	188	A REQUIRED WEIGHTING FUNCTION FLUX FILE IS MISSING.
INPRO1	194	A REQUIRED WEIGHTING FUNCTION FLUX FILE IS MISSING.
INPRO1	200	THE LABEL ON A FLUX FILE DOES NOT MATCH THE LABEL ON THE FILE WHEN THE INPUT INTEGRALS WERE CALCULATED. IF THE RTFLUX FILE HAS BEEN RECONSTRUCTED ARE YOU SURE NO CHANGES HAVE BEEN MADE IN THE CONTENT.

APPENDIX F. SYN3D ERROR MESSAGES. CONTINUED.

INPRO1	243	PLANAR GEOMETRY FILES HAVE NOT BEEN DEFINED FOR ALL AXIAL MESH INTERVALS.
INPRO1	256	WHEN THERE ARE INPUT INTEGRALS THE OLD GROUP COLLAPSING SCHEME IS AUTOMATICALLY USED. SYNFIL MUST CONTAIN NO CARDS OF TYPE 9-12.
INPRO1	262	WHEN THERE ARE NO TYPE 9 CARDS THERE CANNOT BE ANY TYPE 10 CARDS.
INPRO1	278	THE GROUP NUMBERS ON A TYPE 9 CARD ARE EITHER OUT OF SEQUENCE OR EXCEED THE TOTAL NUMBER OF GROUPS.
INPRO1	294	SAME AS 278, BUT FOR A TYPE 10 CARD.
INPRO1	298	THE NUMBER OF COLLAPSED GROUPS IS DIFFERENT FOR EXPANSION AND WEIGHTING FUNCTIONS.
INPRO1	302	MORE THAN ONE TYPE OF GROUP COLLAPSING IS SPECIFIED. IT CAN BE SPECIAL OR GENERAL, BUT NOT BOTH.
INPRO1	308	A TYPE 2 CARD MUST BE PROVIDED WITH THE PARAMETER IGROUP SPECIFIED.
INPRO1	312	THERE IS A WRONG AMOUNT OF DATA ON A TYPE 11 CARD.
INPRO1	328	GENERAL GROUP COLLAPSING IS SPECIFIED FOR THE WEIGHTING FUNCTIONS BUT NOT FOR THE EXPANSION FUNCTIONS.
INPRO1	334	THERE IS A WRONG AMOUNT OF DATA ON A TYPE 12 CARD.
INPRO1	346	THE FUNCTION NAME ON A SYNFIL TYPE 13 CARD DOES NOT MATCH ANY FUNCTION SPECIFIED ON CARD TYPES 7 AND 8.
INPRO1	354	THE GROUP NUMBERS ON A TYPE 13 CARD ARE ENTERED INCORRECTLY.
INPRO1	382	THERE ARE INPUT INTEGRALS,AND SCALING IS SPECIFIED ON TYPE 14 AND/OR 15 CARDS. MAKE SURE THE SCALING IS THE SAME AS WHEN THE INPUT INTEGRALS WERE CALCULATED.
INPRO1	384	THE FUNCTION NAME ON A TYPE 14 OR 15 CARD DOES NOT MATCH ANY FUNCTIONS SPECIFIED ON CARD TYPES 7 AND 8.
INPRO1	388	SCALING IS SPECIFIED FOR FUNCTIONS ASSOCIATED WITH THE INPUT INTEGRALS. THE ORIGINAL SCALING FACTORS WILL BE USED IF MORE INTEGRALS ARE DONE.
INPRO1	392	A GROUP NUMBER IS OUT OF RANGE ON A TYPE 14 OR 15 CARD.
INPRO1	610	THE SCATTERING BANDWIDTH HAS CHANGED SINCE THE INPUT INTEGRALS WERE CALCULATED. THEY CANNOT BE USED.
INPRO4	62	A REQUIRED FLUX FILE IS NOT AVAILABLE.
INPRO4	64	A REQUIRED GEOMETRY FILE IS NOT AVAILABLE.
INPRO4	90	THERE IS NOT ENOUGH CONTAINER STORAGE TO HOLD AN AN INPUT FLUX FILE.

APPENDIX F. SYN3D ERROR MESSAGES. CONTINUED.

INTEG	12	THERE IS NEITHER AN INPUT INTTOC DATASET NOR A SYNFIL DATASET.
INTEG	14	THERE IS NO MACROSCOPIC CROSS SECTION DATASET.
INTEG	34	THE INITIAL STORAGE ALLOCATIONS ASSIGNED BY THE CODE TO SEVERAL ARRAYS ARE FAR TOO SMALL. THIS IS UNUSUAL. CHECK YOUR INPUT.
INTEG	116	NOT ENOUGH STORAGE IS AVAILABLE TO DO THE INTEGRATION.
INVERT	10100	A MATRIX IS SINGULAR. POSSIBLE LINEAR DEPENDENCE PROBLEM.
INT1	110	THE CODE CANNOT YET HANDLE THIS PARTICULAR GEOMETRY TYPE.
INT1	142	CODE BUG.
INT1	148	CODE BUG.
INT1	180	CODE BUG.
INT2	21	CODE BUG.
INT2	24	CODE BUG.
INT2	30	CODE BUG.
INT21	1	THE CODE CANNOT YET HANDLE THIS PARTICULAR GEOMETRY TYPE.
INT21	14	CODE BUG. THERE ARE MISSING COMPOSITIONS IN THE MATERIAL MAP.
INT21	40	SAME AS 14.
INT21	90	SAME AS 14.
INT21	106	SAME AS 14.
INT21	132	SAME AS 14.
INT21	148	SAME AS 14.
INT21	166	SAME AS 14.
INT21	180	SAME AS 14.
INT21	198	SAME AS 14.
INT3	110	THE CODE CANNOT YET HANDLE THIS PARTICULAR GEOMETRY TYPE.
INT3	142	CODE BUG.
INT3	148	CODE BUG.
INT3	180	CODE BUG.
INT3	184	CODE BUG.
INT4	14	CODE BUG.
INT4	104	CODE BUG.
ORTH	110	NO FUNCTIONS HAVE BEEN SPECIFIED FOR ONE OF THE ENERGY GROUPS AT SOME MESH POINT.
OUTPRO	10	A COMBINING COEFFICIENT FILE (ACCOEF OR DCCOEF) CANNOT BE WRITTEN.
PDENOM	64	A REQUIRED INTEGRAL IS NOT AVAILABLE.
READCD	34	THE CARDS-PER-CARD-TYPE DATA IS WRONG.
REDED	16	A DIRECT COMBINING COEFFICIENT PLOT IS REQUESTED FOR A GROUP NUMBER LARGER THAN THE TOTAL NUMBER OF GROUPS (AFTER COLLAPSING).
REDED	26	AN ADJOINT COMBINING COEFFICIENT PLOT IS REQUESTED FOR A GROUP NUMBER LARGER THAN THE TOTAL NUMBER OF GROUPS (AFTER COLLAPSING).
REWRIT	8	THE REQFLX FILE CANNOT BE WRITTEN.
REWRIT	224	CODE BUG.
REWRIT	222	CODE BUG. LENXST, THE RECORD LENGTH FOR REQXST, IS TOO SMALL.
REWRIT	310	THE REQXST FILE CANNOT BE WRITTEN.

APPENDIX F. SYN3D ERROR MESSAGES. CONTINUED.

RITGEO	10	A REQUIRED, INPUT GEODST FILE CANNOT BE FOUND.
RITGEO	40	THE CODE CANNOT HANDLE THE GEOMETRY TYPE SPECIFIED IN AN INPUT GEODST FILE.
RITGEO	96	SAME AS 10.
RITGEO	100	TWO INPUT GEODST FILES ARE INCOMPATIBLE.
RITGEO	102	THE OUTPUT GEODST FILE CANNOT BE WRITTEN.
SETUP	10	THE VOLINT,2 FILE CANNOT BE WRITTEN.
SETUP	14	THE DIFINT,2 FILE CANNOT BE WRITTEN.
SETUP	20	THE VOLINT,1 FILE CANNOT BE FOUND.
SETUP	30	THE DIFINT,1 FILE CANNOT BE FOUND.
SHUFFL	26	CODE BUG.
SHUFFL	56	CODE BUG.
SHUFFL	114	CODE BUG.
SHUFFL	126	CODE BUG.
SOLVE	10	THE INTTOC,2 FILE CANNOT BE READ.
SOLVE	66	CODE BUG. IDIV.NE.1 AFTER DIVVY.
SOLVE	72	THE INTGLS FILE CANNOT BE WRITTEN.
SOLVE	74	THE VOLINT,2 FILE CANNOT BE READ.
SOLVE	76	THE DIFINT,2 FILE CANNOT BE READ.
SOLVE	86	THE HFILE FILE CANNOT BE WRITTEN.
TRANSI	1	A GEODST FILE CANNOT BE WRITTEN.
TRFLUX	1	AN RTFLUX FILE CANNOT BE WRITTEN.
TRGEO1	14	THE TRANSLATOR CANNOT YET HANDLE THIS TYPE OF GEOMETRY.
TRGEO1	60	THE TRANSLATOR CANNOT HANDLE THE PLANAR BOUNDARY CONDITIONS.
TRGEO1	70	SAME AS 60.
TRXSCM	12	THE XS.C.MIN FILE CANNOT BE FOUND.
WINTGL	18	CODE BUG.
WINTGL	110	CODE BUG. MULTICHANNEL SYNTHESIS NOT AVAILABLE.
WINTGL	126	NO FUNCTIONS HAVE BEEN SPECIFIED FOR ONE OF THE ENERGY GROUPS AT SOME MESH POINT.
WRITXS	20	THERE IS SOMETHING WRONG WITH THE XSCMIN DATASET. THE CODE EXPECTED TO FIND THE GROUP NUMBER IN THE RECORD BEING READ.

APPENDIX G. FORTRAN VARIABLE GLOSSARY.

((A(I,K),I=1,KDIM(IZ)),K=1,KMAX) = IN OVERLAY SOLVE, EITHER THE DIRECT OR ADJOINT COMBINING COEFFICIENTS. IZ IS THE SYNTHESIS ZONE ASSOCIATED WITH MESH INTERVAL K.

((ACCOEF(I,K),I=1,KDIM(IZ)),K=1,KMAX) = ADJOINT COMBINING COEFFICIENTS. IZ IS THE SYNTHESIS ZONE ASSOCIATED WITH MESH INTERVAL K.

((AMINUS(I,J),I=1,KDIM(IZ)),J=1,KDIM(IZM)) = THE SUBBLOCK (FOR THE CURRENT AXIAL MESH INTERVAL) BELOW THE DIAGONAL OF THE BLOCK-TRIDIAGONAL SYSTEM OF SYNTHESIS EQUATIONS. IZ IS THE SYNTHESIS ZONE ASSOCIATED WITH THE CURRENT MESH INTERVAL. IZM IS THE SYNTHESIS ZONE ASSOCIATED WITH THE PREVIOUS AXIAL MESH INTERVAL.

((APLUS(I,J),I=1,KDIM(IZ)),J=1,KDIM(IZP)) = THE SUBBLOCK (FOR THE CURRENT AXIAL MESH INTERVAL) ABOVE THE DIAGONAL OF THE BLOCK-TRIDIAGONAL SYSTEM OF SYNTHESIS EQUATIONS. IZ IS THE SYNTHESIS ZONE ASSOCIATED WITH THE CURRENT MESH INTERVAL. IZP IS THE SYNTHESIS ZONE ASSOCIATED WITH THE NEXT AXIAL MESH INTERVAL.

(ARRAY(I),I=1,36) = THE LIST OF NAMES OF DIMENSIONED VARIABLES DEFINED THROUGH BPOINTER.

((AZERO(I,J),I=1,KDIM(IZ)),J=1,KDIM(IZ)) = THE SUBBLOCK (FOR THE CURRENT AXIAL MESH INTERVAL) ON THE DIAGONAL OF THE BLOCK-TRIDIAGONAL SYSTEM OF SYNTHESIS EQUATIONS. IZ IS THE SYNTHESIS ZONE ASSOCIATED WITH THE CURRENT MESH INTERVAL.

(BLK(I),I=1,MAXSIZ) = THE BPOINTER CONTAINER.

((CARD(I,J),I=1,11),J=1,NREC) = THE CONTENTS OF EACH INPUT CARD, EXCLUDING THE CARD TYPE NUMBER. NREC = THE NUMBER OF DATA CARDS.

(((CBC(I,J,K),I=1,NGROUP),J=1,6),K=1,2) = THE BOUNDARY CONDITION CONSTANTS C1 AND C2 FOR EACH GROUP AND EACH OF THE 6 BOUNDARY PLANES.

CONVRG = EIGENVALUE CONVERGENCE CRITERION.

((DCCOEF(I,K),I=1,KDIM(IZ)),K=1,KMAX) = DIRECT COMBINING COEFFICIENTS. IZ IS THE SYNTHESIS ZONE ASSOCIATED WITH MESH INTERVAL K.

(DLZRAT(I),I=1,LENDLZ) = RATIO OF 2 ADJACENT AXIAL MESH INTERVALS. (LOWER/UPPER)

EIGEN = EIGENVALUE

EPS = A SMALL NUMBER USED IN TESTS FOR EQUALITY OF MESH INTERVALS.

((ESCALR(I,J),I=1,NGROUP),J=1,MAXFUN) = A USER SUPPLIED SCALING FACTOR FOR EACH GROUP OF FUNCTION J WHEN FUNCTION J IS USED AS A EXPANSION FUNCTION. IT CAN ONLY HAVE AN EFFECT WHEN GROUP COLLAPSING IS EMPLOYED.

((FIS(I,J),I=1,KDIM(IZ)),J=1,KDIM(IZ)) = THE SUBBLOCK (FOR THE CURRENT AXIAL MESH INTERVAL) CONTAINING THE INTEGRALS OVER THE FISSION CROSS SECTIONS. IZ IS THE SYNTHESIS ZONE ASSOCIATED WITH THE CURRENT AXIAL MESH INTERVAL.

(FLUX(I),I=1,MAXFUN*LGROUP) = AN ARRAY CONTAINING FUNCTION INTEGRALS. THE INTEGRALS ARE STORED IN THE SAME WAY AS THE COMBINING COEFFICIENTS, WITH BLANKS OMITTED. POINTERS TO THE FIRST NONZERO GROUP ARE GIVEN IN THE ARRAY IFLTOC.

APPENDIX G. FORTRAN VARIABLE GLOSSARY. (CONTD.)

(FLUX1(I),I=1,LENFLX) = THE ARRAY INTO WHICH A RECORD OF REQFLX IS READ. FLUX2 AND FLUX3 SERVE THE SAME PURPOSE.

(((FUNNAM(I,J),I=1,3),IVRFUN(J)),J=1,MAXFUN) = FULL NAME OF FILE FOR FUNCTION J.

GUESS = EIGENVALUE ESTIMATE.

((H(I,J),I=1,KDIM(IZ)),J=1,KDIM(IZP)) = THE MATRIX FORMED DURING THE FORWARD ELIMINATION OF THE SYNTHESIS EQUATIONS FOR THE CURRENT MESH INTERVAL. IZ IS THE SYNTHESIS ZONE ASSOCIATED WITH THE CURRENT AXIAL MESH INTERVAL, IZP IS THE ZONE FOR THE NEXT INTERVAL.

IBAND = THE NUMBER OF COLUMNS OF FLUXES IN ONE RECORD OF THE REQFLX FILE.

IBCXL = THE LOWER X BOUNDARY CONDITION.

1 = ZERO FLUX
2 = REFLECTIVE
3 = EXTRAPOLATED C*D*DEL PHI + PHI = 0
4 = PERIODIC WITH OPPOSITE BOUNDARY
5 = PERIODIC WITH NEXT BOUNDARY GOING CLOCKWISE
6 = PERIODIC WITH NEXT BOUNDARY GOING COUNTERCLOCKWISE
7 = PERIODIC, INVERTED ALONG SAME BOUNDARY.

IBCXU = THE UPPER X BOUNDARY CONDITION.

IBCYL = THE LOWER Y BOUNDARY CONDITION.

IBCYU = THE UPPER Y BOUNDARY CONDITION.

IBCZL = THE LOWER Z BOUNDARY CONDITION.

IBCZU = THE UPPER Z BOUNDARY CONDITION.

IBNDCH = LOWEST ENERGY GROUP (AFTER GROUP COLLAPSING) FOR WHICH THERE IS A NONZERO CHI.

(IBNDFI(I),I=1,MAXPLN) = LOWEST ENERGY GROUP (AFTER GROUP COLLAPSING) FOR WHICH THERE IS A NONZERO FISSION CROSS SECTION FOR PLANE I. A ZERO MEANS NO FISSION.

(IBNDS1(I),I=1,LGROUP) = THE POSITION IN COLUMN I OF THE GROUP COLLAPSED SCATTERING MATRIX OF THE TOPMOST, NONZERO ELEMENT. EQUIVALENT TO LOCSCT WHEN THERE IS NO GROUP COLLAPSING.

(IBNDS2(I),I=1,LGROUP) = THE POSITION IN COLUMN I OF THE GROUP COLLAPSED SCATTERING MATRIX OF THE BOTTOM, NONZERO ELEMENT.

((IDIFTB(I,K),I=1,8),K=1,LDIFTB) = TABLE OF CONTENTS FOR DIF INTEGRALS IN DIFINT FILE.

IDIFTB(1,K) = RECORD OF THE DIFINT FILE CONTAINING THE INTEGRALS.
IDIFTB(2,K) = POINTER TO THE FIRST WORD OF THE INTEGRAL BLOCK WITHIN THAT RECORD.
IDIFTB(3,K) = LOWER PLANAR GEOMETRY IDENTIFIER. =0 FOR THE BOTTOM BOUNDARY INTEGRAL.
IDIFTB(4,K) = UPPER PLANAR GEOMETRY IDENTIFIER. =0 FOR THE TOP BOUNDARY INTEGRAL.
IDIFTB(5,K) = POINTER TO A MESH INTERVAL RATIO IN THE DLZRAT ARRAY.
IDIFTB(6,K) = WEIGHTING FUNCTION IDENTIFIER.
IDIFTB(7,K) = EXPANSION FUNCTION IDENTIFIER.
IDIFTB(8,K) = NUMBER OF RECORDS REQUIRED FOR ALL THE INTEGRALS OF THIS COMBINATION.

APPENDIX G. FORTRAN VARIABLE GLOSSARY. (CONTD.)

(IDIM(I),I=1,MAXFUN) = THE NUMBER OF COMBINING COEFFICIENTS (OR EQUATIONS) ASSOCIATED WITH AN EXPANSION FUNCTION (OR WEIGHTING FUNCTION).

((IFL(J,I),J=1,MAXKNM),I=1,NUMKZN) = THE EXPANSION FUNCTIONS USED IN ZONE I. IF THERE ARE FEWER THAN MAXKNM, THE OTHER ENTRIES FOR A PARTICULAR ZONE ARE ZERO.

(IFLTOC(I),I=1,MAXFUN) = POINTERS TO THE FIRST GROUP FLUX INTEGRAL FOR FUNCTION I IN THE ARRAY FLUX. A ZERO MEANS THAT THERE ARE NO INTEGRALS FOR A FUNCTION.

IGEOM = PLANAR GEOMETRY TYPE SENTINEL.

((IGPUSE(N,J),N=1,LGROUP),J=1,MAXFUN) = A PROJECTION MATRIX (ELEMENTS ARE 0 OR 1) SHOWING WHICH GROUP FLUXES OF EACH FUNCTION ARE TO BE USED (1) OR OMITTED(0).

IMAX = THE NUMBER OF MESH INTERVALS IN THE X DIRECTION.

(INTGLS(I),I=1,NCONRC*MAXINT) = STORAGE USED FOR RECORDS OF THE INTGLS FILE. DURING THE SOLUTION NCONRC=1.

(IPLACC(I),I=1,NPLACC) = THE GROUP FOR WHICH THE ADJOINT COMBINING COEFFICIENTS ARE TO BE PLOTTED.

(IPLDCC(I),I=1,NPLDCC) = THE GROUP FOR WHICH THE DIRECT COMBINING COEFFICIENTS ARE TO BE PLOTTED.

((IPRATE(I,J),I=1,2),J=1,NPRATE) = GROUP NUMBERS (I=1) AND AXIAL MESH INTERVALS (I=2) FOR WHICH THE PLANAR ADJOINT IS TO BE EDITED. FOR TWO DIMENSIONAL MODELS J=1 WILL EDIT ALL FLUXES.

IPRINT = BPOINTER DEBUG EDIT SENTINAL.

(IPRPWD(I),I=1,NPRPWD) = AXIAL MESH INTERVALS FOR WHICH THE PLANAR POWER IS TO BE EDITED. FOR TWO DIMENSIONAL MODELS I=1 WILL EDIT ALL POWERS.

((IPRRTE(I,J),I=1,2),J=1,NPRRTE) = GROUP NUMBERS (I=1) AND AXIAL MESH INTERVALS (I=2) FOR WHICH THE PLANAR FLUX IS TO BE EDITED. FOR TWO DIMENSIONAL MODELS J=1 WILL EDIT ALL FLUXES.

((IPT(I,J),I=1,LGROUP),J=1,2) = THE NUMBER OF ROWS OF THE REM MATRIX STORED IN THE OUTPUT INTEGRAL FILE FOR THE COLUMNS ASSOCIATED WITH COLLAPSED GROUP I. IT IS THE SUM OF THE NUMBERS OF CHANNELS ASSOCIATED WITH EACH COLLAPSED GROUP BETWEEN IBNDS1(I) AND IBNDS2(I). J=1 OR 2 DEPENDING ON WHETHER THE WEIGHTING/EXPANSION FLUX COMBINATION BEING CONSIDERED IS IN THE PROPER ORDER FOR THE OUTPUT INTEGRAL DESIRED OR IS TRANSPOSED.

((IPWTOC(I,J),I=1,MAXFUN),J=1,MAXPLN) = POINTERS TO THE FIRST GROUP POWER INTEGRAL FOR FUNCTION I AND PLANE J IN THE ARRAY POW. A ZERO MEANS THAT THERE ARE NO INTEGRALS.

IRCDIF = DIFINT FILE RECORD COUNTER.

IRCINT = INTGLS FILE RECORD COUNTER.

IRCITC = INTTOC FILE RECORD COUNTER.

IRCVOL = VOLINT FILE RECORD COUNTER.

ISCHI = SET-WIDE PROMPT CHI SENTINEL FROM XSCMIN FILE.

APPENDIX G. FORTRAN VARIABLE GLOSSARY. (CONTD.)

((IVOLTB(I,K),I=1,7),K=1,LVOLTB) = TABLE OF CONTENTS FOR REM AND FIS INTEGRALS IN THE VOLINT FILE.

IVOLTB(1,K) = 1 FOR A REM INTEGRAL, 2 FOR A FIS INTEGRAL, 3 FOR A POW INTEGRAL, 4 FOR A FLUX INTEGRAL.

IVOLTB(2,K) = THE RECORD OF THE VOLINT FILE CONTAINING THE INTEGRAL. =0 IF THE INTEGRAL COULD NOT BE DONE AND -1 IF THE INTEGRAL COULD HAVE BEEN DONE BUT FOR SOME REASON WAS NOT.

IVOLTB(3,K) = POINTER TO THE FIRST WORD OF THE INTEGRAL BLOCK WITHIN THAT RECORD.

IVOLTB(4,K) = PLANAR GEOMETRY IDENTIFIER.

IVOLTB(5,K) = WEIGHTING FUNCTION IDENTIFIER.

IVOLTB(6,K) = EXPANSION FUNCTION IDENTIFIER.

IVOLTB(7,K) = NUMBER OF RECORDS REQUIRED FOR ALL THE INTEGRALS OF THIS COMBINATION.

(IVRFUN(J),J=1,MAXFUN) = VERSION NUMBER OF FILE FOR FUNCTION J. SEE FUNNAM.

(IVRPLN(J),J=1,MAXPLN) = VERSION NUMBER OF FILE FOR PLANAR GEOMETRY J. SEE PLNNAM.

IWHERE = 1 IF THE INPUT DATA IS TO BE READ DIRECTLY FROM CARDS.
= 2 IF THE CARD INPUT IS TO BE PROCESSED THRU THE ARC SYSTEM ROUTINES.

((IWT(J,I),J=1,MAXKNM),I=1,NUMKZN) = THE WEIGHTING FUNCTIONS USED IN ZONE I. IF THERE ARE FEWER THAN MAXKNM, THE OTHER ENTRIES FOR A PARTICULAR ZONE ARE ZERO.

(I48ARR(I),I=1,50) = THE WORD LENGTH PARAMETER FOR EACH DIMENSIONED VARIABLE DEFINED THROUGH BPOINTER. THIS ARRAY IS OF DIFFERENT LENGTH IN EACH OVERLAY.

JBAND = THE NUMBER OF ROWS OF FLUXES IN ONE RECORD OF THE REQFLX FILE.

(JDIFTB(I,K),I=1,7),K=1,MDIFTB) = TABLE OF CONTENTS FOR DIF INTEGRALS IN THE INTGLS FILE. THE DEFINITIONS ARE THE SAME AS FOR IDIFTB, EXCEPT THAT THE LAST ENTRY IS OMITTED.

(JDOCMP(I),I=1,NUMCMP) = THE LIST OF COMPOSITIONS REQUIRED TO CALCULATE THE INTEGRALS.

(JDOFUN(I),I=1,NUMFUN) = THE LIST OF FUNCTIONS REQUIRED TO CALCULATE THE INTEGRALS, IN THE ORDER IN WHICH THEY APPEAR IN THE REQFLX FILE. WHEN IT IS PRESENT, THE UNIT FUNCTION IS LAST IN THE LIST.

(JDOPLN(I),I=1,NUMPLN) = THE LIST OF PLANAR GEOMETRIES REQUIRED TO CALCULATE THE INTEGRALS.

JMAX = THE NUMBER OF MESH INTERVALS IN THE Y DIRECTION.

(((JPT(I,J,K),I=1,IBNDCH),K=1,MAXPLN),J=1,2) = A POINTER IN A COLUMN OF THE GROUP COLLAPSED FIS INTEGRAL FOR PLANE K TO THE FIRST ELEMENT ASSOCIATED WITH WEIGHTING FUNCTION GROUP I. THE DIFFERENCE BETWEEN JPT(I,J,K) AND JPT(I+1,J,K) IS THE NUMBER OF CHANNELS ASSOCIATED WITH GROUP I OF THE WEIGHTING FUNCTION. J=1 OR 2 DEPENDING ON WHETHER THE WEIGHTING/EXPANSION FLUX COMBINATION BEING CONSIDERED IS IN THE PROPER ORDER FOR THE OUTPUT INTEGRAL DESIRED OR IS TRANSPOSED.

APPENDIX G. FORTRAN VARIABLE GLOSSARY. (CONTD.)

(JVOLTB(I,K),I=1,6),K=1,MVOLTB) = TABLE OF CONTENTS FOR REM & FIS INTEGRALS IN THE INTGLS FILE. THE DEFINITIONS ARE THE SAME AS FOR IVOLTB, EXCEPT THAT THE LAST ENTRY IS OMITTED.

(KCHANG(I),I=1,NUMKZN) = THE TOPMOST MESH INTERVAL IN EACH ZONE. KCHANG(NUMKZN)=KMAX.

(KDIM(I),I=1,NUMKZN) = THE NUMBER OF UNKNOWN COMBINING COEFFICIENTS (AND THEREFORE EQUATIONS) ASSOCIATED WITH ONE MESH INTERVAL IN ZONE I.

(KGEOM(I),I=1,NUMKZN) = THE GEOMETRY FOR MESH INTERVALS KCHANG(I-1) TO KCHANG(I). KCHANG(0) IS DEFINED TO BE 1.

KMAX = NUMBER OF AXIAL MESH INTERVALS.

(KNUMFL(I),I=1,NUMKZN) = THE NUMBER OF FLUX FILES REFERENCED AS EXPANSION FUNCTIONS FOR ZONE I.

(KNUMWT(I),I=1,NUMKZN) = THE NUMBER OF FLUX FILES REFERENCED AS WEIGHTING FUNCTIONS FOR ZONE I.

(((KPT(I,J,K),I=1,LGROUP),J=1,LGROUP),K=1,2) = A POINTER IN THE 1D ARRAY CONTAINING THE 2D, GROUP-COLLAPSED REM INTEGRAL TO THE FIRST STORED ELEMENT OF THE INTEGRALS ASSOCIATED WITH WEIGHTING FUNCTION GROUP I AND EXPANSION FUNCTION GROUP J. THE DIFFERENCE BETWEEN KPT(I,J,K) AND KPT(I+1,J,K) IS THE NUMBER OF CHANNELS FOR WEIGHTING FUNCTION GROUP I. K=1 OR 2 DEPENDING ON WHETHER THE WEIGHTING/EXPANSION FLUX COMBINATION BEING CONSIDERED IS IN THE PROPER ORDER FOR THE OUTPUT INTEGRAL DESIRED OR IS TRANSPOSED.

LDIFTB = NUMBER OF ENTRIES IN THE IDIFTB TABLE.

LENA = THE STORAGE REQUIRED FOR THE COMBINING COEFFICIENTS.

(LENARR(I),I=1,50) = THE LENGTH OF EACH DIMENSIONED VARIABLE DEFINED THROUGH BPOINTER. THIS ARRAY IS OF DIFFERENT LENGTH IN EACH OVERLAY.

(LENCRD(I),I=1,NREC) = THE LENGTH (IN R*4 WORDS) OF EACH DATA RECORD OF SYNCON. NREC = THE NUMBER OF DATA RECORDS.

(LENDIF(I),I=1,NRCDIF) = LENGTH OF RECORD I OF DIFINT FILE.

LENDLZ = LENGTH OF DIZRAT ARRAY.

LENFLX = RECORD SIZE FOR REQFLX.

LENFLU = LENGTH OF THE ARRAY FLUX IN OVERLAY SOLVE.

LENH = MAXIMUM RECORD SIZE FOR THE HFILE FILE.

LENINT = THE MAXIMUM RECORD LENGTH FOR VOLINT AND DIFINT INTEGRAL FILES.

LENLST = THE MAXIMUM LENGTH OF THE LIST OF INTEGRALS, LISTV.

LENPOW = LENGTH OF THA ARRAY POW IN OVERLAY SOLVE.

(LENRCH(I),I=1,NRCH) = THE LENGTH OF EACH WORD OF THE HFILE FILE.

(LENRCI(I),I=1,NRCINT) = THE LENGTH OF EACH RECORD OF THE INTGLS FILE.

(LENVOL(I),I=1,NRCVOL) = LENGTH OF RECORD I OF THE VOLINT FILE.

LENXST = RECORD SIZE FOR CROSS SECTION FILE REQXST.

LEN1 = IBAND*JBAND = THE MAXIMUM NUMBER OF MESH BLOCKS REPRESENTED IN EACH RECORD OF REQFLX.

LEN2=LEN1*NGROUP

LEN3 = LXST1.

LGROUP = NUMBER OF ENERGY GROUPS AFTER COLLAPSING.

(LISTV(I),I=1,LENIST) = A LIST OF ENTRIES IN IVOLTB AND/OR IDIFTB DESIGNATING INTEGRALS TO BE DONE AND THE ORDER IN WHICH THEY ARE TO BE DONE. THE IVOLTB ENTRIES ARE LISTED FIRST, THEN THE IDIFTB ENTRIES. ALSO SEE NTRYV AND NTRYD.

APPENDIX G. FORTRAN VARIABLE GLOSSARY. (CONTD.)

(LOCSCT(I),I=1,NGROUP) = THE POSITION IN COLUMN I OF THE SCATTERING MATRIX OF THE TOPMOST, NONZERO ELEMENT. EQUIVALENT TO IBNDS1 WHEN THERE IS NO GROUP COLLAPSING.

(((LPT(I,J,K),I=1,LGROUP),K=1,MAXPLN),J=1,2) = A POINTER IN THE 1D ARRAY CONTAINING THE 2D, GROUP-COLLAPSED FIS INTEGRAL FOR PLANE K TO THE TOP OF THE FIRST COLUMN ASSOCIATED WITH EXPANSION FUNCTION GROUP I. THE DIFFERENCE BETWEEN LPT(I,J,K) AND LPT(I+1,J,K) IS MPT(J,K) TIMES THE NUMBER OF CHANNELS ASSOCIATED WITH GROUP I OF THE EXPANSION FUNCTION. J=1 OR 2 DEPENDING ON WHETHER THE WEIGHTING/EXPANSION FLUX COMBINATION BEING CONSIDERED IS IN THE PROPER ORDER FOR THE OUTPUT INTEGRAL DESIRED OR IS TRANSPOSED.

LREQF = NUMBER OF RECORDS IN THE REQFLX FILE.

LREQX1 = NUMBER OF RECORD OF THE REQXST FILE EXCLUDING DIFFUSION COEFFICIENTS.

LREQX2 = NUMBER OF RECORDS OF THE REQXST FILE CONTAINING ONLY DIFFUSION COEFFICIENTS.

LVOLTB = NUMBER OF ENTRIES IN THE IVOLTB TABLE.

LXST1 = THE NUMBER OF CROSS SECTION DATA PER COMPOSITION, FOR FOR RECORDS OF REQXST EXCLUDING DIFFUSION COEFFICIENTS.

LXST2 = THE NUMBER OF COMPOSITIONS PER RECORD OF REQXST, FOR RECORDS EXCLUDING DIFFUSION COEFFICIENTS.

LXST3 = THE NUMBER OF GROUPS PER RECORD FOR RECORDS CONTAINING ONLY DIFFUSION COEFFICIENTS.

MAXCHN = THE MAXIMUM NUMBER OF CHANNELS IN ANY CHANNEL STRUCTURE SCHEME. = THE LARGEST VOLUE OF NUMCHN(I),I=1,NCHNST.

MAXCMP = THE NUMBER OF MATERIALS REPRESENTED IN THE INPUT CROSS SECTION FILE.

MAXDIM = THE LARGEST DIMENSION OF ANY MATRIX USED IN THE SOLUTION.

MAXDN = MAXIMUM NUMBER OF DOWNSCATTERING GROUPS.

MAXFUN = NUMBER OF FUNCTION FILE NAMES IN TOC.

MAXINT = THE MAXIMUM RECORD LENGTH FOR THE INTGLS INTEGRAL FILE.

MAXITR = MAXIMUM NUMBER OF ITERATIONS ALLOWED.

MAXKNM = THE MAXIMUM NUMBER OF WEIGHTING FUNCTIONS USED IN A SINGLE ZONE, OR THE MAXIMUM NUMBER OF EXPANSION FUNCTIONS, WHICHEVER IS LARGER. MAXKNM.LE.MAXUSE.

MAXMD = THE LARGEST DIMENSION OF AN INPUT MATRIX (THE LARGEST NUMBER OF GROUP-CHANNEL COMBINATIONS FOR A SINGLE FUNCTION). MAXMD**2 IS THE MINIMUM SPACE REQUIRED FOR A RECORD OF REWRITTEN INTEGRALS.

MAXPLN= NUMBER OF PLANAR GEOMETRY FILE NAMES IN TOC.

MAXREG = THE MAXIMUM NUMBER OF REGIONS ASSOCIATED WITH ANY OF THE PLANAR GEOMETRIES.

MAXSIZ = THE LENGTH OF THE BPOINTER CONTAINER ARRAY.

MAXTIT = MAXIMUM ALLOWED NUMBER OF INPUT TITLE CARDS.

MAXUP = MAXIMUM NUMBER OF UPSCATTERING GROUPS.

MAXUSE = MAXIMUM NUMBER OF INPUT FUNCTIONS USED ANYWHERE IN THE MODEL AS EXPANSION FUNCTIONS OR WEIGHTING FUNCTIONS, WHICHEVER IS LARGER. MAXUSE.LE.MAXFUN.

MDIFTB = NUMBER OF ENTRIES IN THE JDIFTB TABLE.

(MDIM(I),I=1,MAXFUN) = THE NUMBER OF COMBINING COEFFICIENTS (OR EQUATIONS) ASSOCIATED WITH FUNCTION I.

APPENDIX G. FORTRAN VARIABLE GLOSSARY. (CONTD.)

((MPT(I,J),I=1,MAXPLN),J=1,2) = THE NUMBER OF ROWS IN THE GROUP COLLAPSED FIS INTEGRAL FOR PLANE I. IT IS THE SUM OF THE NUMBER OF CHANNELS ASSOCIATED WITH EACH COLLAPSED GROUP DOWN TO THE LAST NONZERO CHI. J=1 OR 2 DEPENDING ON WHETHER THE WEIGHTING/EXPANSION FLUX COMBINATION BEING CONSIDERED IS IN THE PROPER ORDER FOR THE OUTPUT INTEGRAL DESIRED OR IS TRANSPOSED.
MULT = THE WORD LENGTH PARAMETER FOR INPUT/OUTPUT.
MVOLTB = NUMBER OF ENTRIES IN THE JVOLTB TABLE.
NBUFFR = 0 FOR NO BUFFERING, 1 FOR BUFFERING IN READ/RITE.
NCALC = CALCULATION TYPE SENTINEL. SEE TYPE 2 CARD OF SYNFIL.
((NCHAN(N,J),N=1,IGROUP),J=1,MAXFUN) = CHANNEL SCHEME ASSIGNMENT FOR EACH GROUP-COLLAPSED GROUP FLUX.
NCHNST = THE NUMBER OF CHANNEL STRUCTURE SCHEMES.
NCOLGP = 0 FOR GROUP DEPENDENT SYNTHESIS, 1 FOR GENERAL GROUP COLLAPSING, 2 FOR SPECIAL GROUP COLLAPSING.
NCONRC = THE NUMBER OF CONCURRENT INTGLS RECORDS THAT CAN BE HELD IN CORE DURING THE INTEGRAL REWRITE.
NDENOM = 0, DO NOT CALCULATE PERTURBATION DENOMINATOR.
1, CALCULATE PERTURBATION DENOMINATOR.
NFLDIF = THE FILE NUMBER FOR THE DIFINT FILE.
NFLFLX = REQFLX FILE NUMBER.
(NFLFUN(I),I=1,MAXFUN) = THE FILE NUMBER FOR EACH FLUX FILE.
NFLH = HFILE FILE NUMBER.
NFLINT = INTGLS FILE NUMBER.
NFLITC = THE FILE NUMBER FOR THE INTTOC FILE.
(NFLPLN(I),I=1,MAXPLN) = THE FILE NUMBER FOR EACH PLANAR GEOMENTRY FILE.
NFLSYN = SYNCON FILE NUMBER.
NFLUNI = A BOGUS FILE NUMBER FOR THE UNIT FLUX.
NFLVOL = THE FILE NUMBER FOR THE VOLINT FILE.
NFLXSC = XSCMIN FILE NUMBER.
NFLXST = REQXST FILE NUMBER.
NFNOLD = THE NUMBER OF FUNCTIONS REPRESENTED IN INPUT INTEGRAL FILES.
NGEODT = 0, DO NOT CONSTRUCT AN OUTPUT GEODST FILE.
.GT. 0, THE VERSION NUMBER FOR THE OUTPUT GEODST FILE.
NGROUP = NUMBER OF ENERGY GROUPS BEFORE COLLAPSING.
NOUT = PRINTED OUTPUT FILE NUMBER.
NPLACC = THE NUMBER OF ADJOINT COMBINING COEFFICIENT PLOTS.
NPLDCC = THE NUMBER OF DIRECT COMBINING COEFFICIENT PLOTS.
NPLOLD = THE NUMBER OF PLANAR GEOMETRIES REPRESENTED IN INPUT INTEGRAL FILES.
NPRATE = THE NUMBER OF PLANAR ADJOINT GROUP FLUXES TO BE EDITED.
NPRPWD = THE NUMBER OF PLANAR POWER DISTRIBUTIONS TO BE EDITED.
NPRRIF = THE NUMBER OF PLANAR DIRECT GROUP FLUXES TO BE EDITED.
NPRRZF = 0, DO NOT EDIT THE AVERAGE FLUXES BY ZONE.
.GT. 0, EDIT THE AVERAGE FLUXES BY ZONE (NRZFLX MUST BE .GT. 0).
(NPTARE(I),I=1,36) = THE POINTER TO EACH DIMENSIONED VARIABLE DEFINED THROUGH BPOINTER.

APPENDIX G. FORTRAN VARIABLE GLOSSARY. (CONTD.)

(NPTOUT(I),I=1,2*LENLST) = A SCRATCH ARRAY CONTAINING POINTERS WITHIN THE OUTPUT RECORDS FOR EACH ENTRY OF LISTV.
NPTXMS = A POINTER TO THE LOCATION JUST BEFORE THE START OF THE MESH INTERVAL DATA IN A RECORD OF REQFLX.
(NPTXST(I),I=1,LENLST) = A SCRATCH ARRAY USED TO STORE POINTERS TO COMPOSITIONS FOR EACH ENTRY IN LISTV.
NPWDNT = 0, DO NOT CONSTRUCT AN OUTPUT PWDINT FILE.
.GT. 0, THE VERSION NUMBER FOR THE OUTPUT PWDINT FILE.
NRCDIF = NUMBER OF RECORDS IN THE DIFINT FILE.
NRCH = THE NUMBER OF RECORDS IN THE HFILE FILE.
NRCINT = THE NUMBER OF RECORDS IN THE INTGLS FILE.
NRCVOL = NUMBER OF RECORDS IN THE VOLINT FILE.
NRECD = THE NUMBER OF RECORDS OF THE DIFINT FILE BEING CONSTRUCTED ON A PARTICULAR PASS THRU THE INTEGRATION LOOP.
NRECV = THE NUMBER OF RECORDS OF THE VOLINT FILE BEING CONSTRUCTED ON A PARTICULAR PASS THRU THE INTEGRATION LOOP.
NRZFLX = 0, DO NOT CONSTRUCT AN OUTPUT RZFLUX FILE.
.GT. 0, THE VERSION NUMBER FOR THE OUTPUT RZFLUX FILE.
NSCALE = 1 IF USER SUPPLIED SCALING FACTORS ESCALE AND WSCALE ARE TO BE APPLIED, 0 IF NOT.
NSTDIF = FORMAT SENTINEL FOR DIFINT FILE.
NTITLE = THE NUMBER OF A6 WORDS USED TO STORE THE TITLE.
NTRIAG = TRIANGULAR MESH SENTINAL.
NTRIPT = SECONDARY TRIANGULAR MESH SENTINAL.
NTRYD = THE NUMBER OF ENTRIES IN LISTV WHICH PERTAIN TO THE IDIFTB TABLE OF CONTENTS.
NTRYV = THE FIRST NTRYV ENTRIES IN LISTV PERTAIN TO THE IVOLTB TABLE OF CONTENTS.
NTYPES = MAXIMUM ALLOWED NUMBER OF INPUT CARD TYPES.
NUMREC = THE NUMBER OF OUTPUT INTEGRAL RECORDS THAT CAN BE CONTAINED IN CORE.
(NUMCHN(I),I=1,NCHNST) = NUMBER OF CHANNELS IN CHANNEL STRUCTURE SCHEME I.
NUMCMP = THE NUMBER OF MATERIALS FOR WHICH CROSS SECTIONS ARE REQUIRED WHEN THE INTEGRALS ARE CALCULATED (NUMCMP.LE.MAXCMP)
NUMFUN = THE NUMBER OF FUNCTIONS REQUIRED TO CALCULATE THE INTEGRALS. IF THE UNIT FUNCTION IS REQUIRED, IT IS INCLUDED IN NUMFUN, EVEN THOUGH NO SUCH FLUX FILE IS EVER WRITTEN (NUMFUN.LE.MAXFUN).
NUMKZN = THE NUMBER OF AXIAL ZONES IN THE MODEL. THERE IS AN NEW ZONE WHEN EITHER THE PLANAR GEOMETRY OF THE FUNCTION SETS CHANGE.
NUMPLN = THE NUMBER OF PLANAR GEOMETRIES REQUIRED TO CALCULATE THE INTEGRALS. (NUMPLN.LE.MAXPLN)
N3DADJ = 0, DO NOT CONSTRUCT AN OUTPUT ATFLUX FILE.
.GT. 0, THE VERSION NUMBER FOR THE OUTPUT ATFLUX FILE.
N3DFLX = 0, DO NOT CONSTRUCT AN OUTPUT RTFLUX FILE.
.GT. 0, THE VERSION NUMBER FOR THE OUTPUT RTFLUX FILE.
((ORTHFC(I,J),I=1,MAXDIM),J=1,NUMKZN) = THE FACTORS FOR EACH SYNTHESIS ZONE USED IN THE NORMALIZATION/DIFFERENCING TRANSFORMATION APPLIED TO THE SYNTHESIS EQUATIONS. FOR EACH ZONE THE FACTORS ARE STORED IN THE SAME MANNER AS THE CORRESPONDING COMBINING COEFFICIENT.

APPENDIX G. FORTRAN VARIABLE GLOSSARY. (CONTD.)

(((PLNNAM(I,J),I=1,3),IVRPLN(J)),J=1,MAXPLN) = FULL NAME OF FILE FOR PLANAR GEOMETRY J.

(POW(I),I=1,MAXFUN*LGROUP*MAXPLN) = AN ARRAY CONTAINING POWER INTEGRALS FOR EACH FUNCTION AND PLANE. THE INTEGRALS ARE STORED IN THE SAME WAY AS THE COMBINING COEFFICIENTS, WITH BLANKS OMITTED. POINTERS TO THE FIRST NONZERO GROUP ARE GIVEN IN THE ARRAY IPWTOC.

POWFIS = WATTS PER FISSION.

(PP(I),I=1,LEN1) = A SCRATCH ARRAY USED IN CALCULATING THE INTEGRALS. FOR A MULTICHANNEL CALCULATION 3*LEN1 IS RESERVED.

((REM(I,J),I=1,KDIM(IZ)),J=1,KDIM(IZ)) = THE SUBBLOCK (FOR THE CURRENT AXIAL MESH INTERVAL) CONTAINING THE INTEGRALS OVER THE REMOVAL CROSS SECTIONS. IZ IS THE SYNTHESIS ZONE ASSOCIATED WITH THE CURRENT AXIAL MESH INTERVAL.

((RESULT(I,J),I=1,LENINT),J=1,NUMREC) = ARRAYS FOR OUTPUT INTEGRALS.

(TIME(I),I=1,10) = THE ARRAY IN THE ARGUMENT OF SUBROUTINE TIMER.

(TITLE(I),I=1,NTITLE) = USER INPUT TITLE.

(((U(I,J,K),I=1,LGROUP),J=1,NGROUP),K=1,2) = GENERAL GROUP COLLAPSING MATRIX FOR THE EXPANSION FUNCTIONS (K=1) AND WEIGHTING FUNCTIONS (K=2).

(VOL(I),I=1,LEN1) = A SCRATCH ARRAY FOR MESH BLOCK VOLUMES.

((WSCALE(I,J),I=1,NGROUP),J=1,MAXFUN) = A USER SUPPLIED SCALING FACTOR FOR EACH GROUP OF FUNCTION J WHEN FUNCTION J IS USED AS A WEIGHTING FUNCTION. IT CAN ONLY HAVE AN EFFECT WHEN GROUP COLLAPSING IS EMPLOYED.

XEPS = A SMALL NUMBER USED IN TESTS FOR ZERO CROSS SECTIONS.

(XSECT1(I),I=1,LENXSI) = THE ARRAY INTO WHICH A RECORD OF REQXST IS READ. XSECT2 SERVES THE SAME PURPOSE.

(ZMESH(K),K=1,KMAX) = POSITION OF UPPER BOUNDARY OF AXIAL MESH INTERVAL K.

APPENDIX H. Sample Problem Output. Problem 1 - Complete Output, with Cross Section Edits

```
SYN3D, OVERLAY CARDS        THREE GROUP, FUNDAMENTAL MODE CALCULATION                    1/20/, 04.43., PAGE   1

LISTING OF SYN3D INPUT


 CARDS-PER-CARD-TYPE DATA
 1  1  0  1  1  0  1  0  0  0  0  0  0  0  0  0  0  0  0  0  0


   CARD
   TYPE
     1     THREE GROUP, FUNDAMENTAL MODE CALCULATION
     2         5     1     0     0     0     0     0     0     0     0     2
     4               3 0.10000E+02     0 0.0             0 0.0
     5               1       0.0         0.10000E+02 0.0         0.0
     7    UNIT       0 0.0         0.10000E+02 0.0         0.0
```

```
* * * HMG4C - CCCC TO ARC SYSTEM CROSS SECTION HOMOGENIZATION * * *

FILE NDXSRF IS LUN  40 AND CONTAINS THE USER ID -3D,3GP MODEL-

FILE ZNATDN IS LUN  41 AND CONTAINS THE USER ID -3D,3GP MODEL-

FILE ISOTXS IS LUN  39 AND CONTAINS THE USER ID -3D,3GP MODEL-

FILE COMPXS   WILL NOW BE WRITTEN ON LUN  50
```

* * * EDIT OF MACROSCOPIC CROSS SECTION FILE COMPXS * * *

```
NCMP, NUMBER OF COMPOSITIONS                        =    7
NGROUP, NUMBER OF ENERGY GROUPS                     =    3
ISCHI, PROMPT FISSION SPECTRUM FLAG                 =    1
NFCMP, NUMBER OF FISSIONABLE COMPOSITIONS           =    4
MAXUP, MAXIMUM NUMBER OF GROUPS OF UPSCATTERING     =    0
MAXDN, MAXIMUM NUMBER OF GROUPS OF DOWNSCATTERING   =    2
NDUM1, RESERVED VARIABLE                            =    0
NDUM2, RESERVED VARIABLE                            =    0
NDUM3, RESERVED VARIABLE                            =    0
NDUM4, RESERVED VARIABLE                            =    0
```

PROMPT FISSION SPECTRUM (SET CHI VECTOR)

```
1,   9.673173D-01    2,   3.266419D-02    3,   1.947201D-05
```

EDIT OF (FISSIONABLE) COMPOSITION NO. 1

ICHI = -1

GROUP	ABSORPTION	TOTAL	REMOVAL	TRANSPORT	FISSION	NU*FISSION	CHI	NUP	NDN
1	3.523270D-03	1.468634D-01	1.221477D-02	1.630343D-01	2.502560D-03	7.417706D-03	9.673173D-01	0	0
2	5.731064D-03	2.573538D-01	6.526065D-03	2.848233D-01	1.984178D-03	5.708737D-03	3.266419D-02	0	1
3	2.428450D-02	3.329800D-01	2.428450D-02	3.556871D-01	7.802667D-03	2.239440D-02	1.947201D-05	0	2

GROUP	POWER CONVERSION FACTOR	DIRECTIONAL DIFFUSION COEFF. MULTIPLIER DIMENSION 1	DIMENSION 2	DIMENSION 3	DIRECTIONAL DIFFUSION COEFF. ADDITIVE TERM DIMENSION 1	DIMENSION 2	DIMENSION 3
1	8.008189D-14	1.00000D+00	1.00000D+00	1.00000D+00	0.0	0.0	0.0
2	6.349367D-14	1.00000D+00	1.00000D+00	1.00000D+00	0.0	0.0	0.0
3	2.496852D-13	1.00000D+00	1.00000D+00	1.00000D+00	0.0	0.0	0.0

TOTAL SCATTERING CROSS SECTION

INTO GROUP/FROM GROUP, CROSS SECTION

1	1,	1.445734D-01				
2	1,	8.724962D-03	2,	2.564739D-01		
3	1,	3.404449D-08	2,	7.950015D-04	3,	3.094165D-01

EDIT OF (FISSIONABLE) COMPOSITION NO. 2

ICHI = -1

GROUP	ABSORPTION	TOTAL	REMOVAL	TRANSPORT	FISSION	NU*FISSION	CHI	NUP	NDN
1	3.987741D-03	1.423374D-01	1.227609D-02	1.580075D-01	3.051815D-03	9.094516D-03	9.673173D-01	0	0
2	6.289723D-03	2.495602D-01	7.069132D-03	2.765452D-01	2.705698D-03	7.784643D-03	3.266419D-02	0	1
3	2.861195D-02	3.321146D-01	2.861195D-02	3.542007D-01	1.064000D-02	3.053783D-02	1.947201D-05	0	2

GROUP	POWER CONVERSION FACTOR	DIRECTIONAL DIFFUSION COEFF. MULTIPLIER DIMENSION 1	DIMENSION 2	DIMENSION 3	DIRECTIONAL DIFFUSION COEFF. ADDITIVE TERM DIMENSION 1	DIMENSION 2	DIMENSION 3
1	9.765805D-14	1.00000D+00	1.00000D+00	1.00000D+00	0.0	0.0	0.0
2	8.658229D-14	1.00000D+00	1.00000D+00	1.00000D+00	0.0	0.0	0.0
3	3.404799D-13	1.00000D+00	1.00000D+00	1.00000D+00	0.0	0.0	0.0

TOTAL SCATTERING CROSS SECTION

INTO GROUP/FROM GROUP, CROSS SECTION

1	1,	1.395472D-01				
2	1,	8.316985D-03	2,	2.484781D-01		
3	1,	3.013967D-08	2,	7.794088D-04	3,	3.043286D-01

EDIT OF (FISSIONABLE) COMPOSITION NO. 3

ICHI = -1

GROUP	ABSORPTION	TOTAL	REMOVAL	TRANSPORT	FISSION	NU*FISSION	CHI	NUP	NDN
1	2.002615D-03	1.631573D-01	1.143702D-02	1.802969D-01	8.674156D-04	2.453750D-03	9.673173D-01	0	0
2	3.802708D-03	2.912817D-01	4.677445D-03	3.199527D-01	7.999996D-53	0.0	3.266419D-02	0	1
3	1.181054D-02	3.762518D-01	1.181054D-02	4.020662D-01	7.999996D-53	0.0	1.947201D-05	0	2

GROUP	POWER CONVERSION FACTOR	DIRECTIONAL DIFFUSION COEFF. MULTIPLIER DIMENSION 1	DIMENSION 2	DIMENSION 3	DIRECTIONAL DIFFUSION COEFF. ADDITIVE TERM DIMENSION 1	DIMENSION 2	DIMENSION 3
1	2.775729D-14	1.00000D+00	1.00000D+00	1.00000D+00	0.0	0.0	0.0
2	2.559998D-63	1.00000D+00	1.00000D+00	1.00000D+00	0.0	0.0	0.0
3	2.559998D-63	1.00000D+00	1.00000D+00	1.00000D+00	0.0	0.0	0.0

TOTAL SCATTERING CROSS SECTION

INTO GROUP/FROM GROUP, CROSS SECTION

1	1,	1.618901D-01				
2	1,	9.475268D-03	2,	2.912643D-01		
3	1,	3.976433D-08	2,	8.747375D-04	3,	3.649189D-01

EDIT OF (FISSIONABLE) COMPOSITION NO. 4

ICHI = -1

GROUP	ABSORPTION	TOTAL	REMOVAL	TRANSPORT	FISSION	NU*FISSION	CHI	NUP	NDN
1	3.503615D-03	2.085107D-01	1.707075D-02	2.324194D-01	1.572191D-03	4.447421D-03	9.673173D-01	0	0
2	6.454643D-03	3.597723D-01	7.506461D-03	3.964838D-01	1.449999D-52	0.0	3.266419D-02	0	1
3	1.828476D-02	4.069050D-01	1.828476D-02	4.382179D-01	1.449999D-52	0.0	1.947201D-05	0	2

GROUP	POWER CONVERSION FACTOR	DIRECTIONAL DIFFUSION COEFF. MULTIPLIER DIMENSION 1	DIMENSION 2	DIMENSION 3	DIRECTIONAL DIFFUSION COEFF. ADDITIVE TERM DIMENSION 1	DIMENSION 2	DIMENSION 3
1	5.031009D-14	1.00000D+00	1.00000D+00	1.00000D+00	0.0	0.0	0.0
2	4.639996D-63	1.00000D+00	1.00000D+00	1.00000D+00	0.0	0.0	0.0
3	4.639996D-63	1.00000D+00	1.00000D+00	1.00000D+00	0.0	0.0	0.0

TOTAL SCATTERING CROSS SECTION

INTO GROUP/FROM GROUP, CROSS SECTION

1	1,	2.076730D-01				
2	1,	1.364120D-02	2,	3.562942D-01		
3	1,	7.015717D-08	2,	1.051819D-03	3,	3.891484D-01

EDIT OF (NONFISSIONABLE) COMPOSITION NO. 5

ICHI = 0

GROUP	ABSORPTION	TOTAL	REMOVAL	TRANSPORT	NUP	NDN
1	3.028794D-04	1.747152D-01	5.736323D-03	1.856762D-01	0	0
2	1.077997D-03	3.577270D-01	2.075549D-03	3.793013D-01	0	1
3	7.891622D-03	6.468946D-01	7.891622D-03	6.794924D-01	0	2

GROUP	POWER CONVERSION FACTOR	DIRECTIONAL DIFFUSION COEFF. MULTIPLIER DIMENSION 1	DIMENSION 2	DIMENSION 3	DIRECTIONAL DIFFUSION COEFF. ADDITIVE TERM DIMENSION 1	DIMENSION 2	DIMENSION 3
1	0.0	1.00000D+00	1.00000D+00	1.00000D+00	0.0	0.0	0.0
2	0.0	1.00000D+00	1.00000D+00	1.00000D+00	0.0	0.0	0.0
3	0.0	1.00000D+00	1.00000D+00	1.00000D+00	0.0	0.0	0.0

TOTAL SCATTERING CROSS SECTION

INTO GROUP/FROM GROUP, CROSS SECTION

1	1,	1.703031D-01				
2	1,	5.433439D-03	2,	3.577306D-01		
3	1,	4.915400D-09	2,	9.975514D-04	3,	6.397847D-01

EDIT OF (NONFISSIONABLE) COMPOSITION NO. 6

ICHI = 0

GROUP	ABSORPTION	TOTAL	REMOVAL	TRANSPORT	NUP	NDN
1	5.218654D-03	1.893785D-01	3.074153D-02	2.385605D-01	0	0
2	2.706030D-02	3.225606D-01	2.875027D-02	4.146590D-01	0	1
3	1.772749D-01	5.525084D-01	1.772749D-01	6.375915D-01	0	2

GROUP	POWER CONVERSION FACTOR	DIRECTIONAL DIFFUSION COEFF. MULTIPLIER DIMENSION 1	DIMENSION 2	DIMENSION 3	DIRECTIONAL DIFFUSION COEFF. ADDITIVE TERM DIMENSION 1	DIMENSION 2	DIMENSION 3
1	0.0	1.00000D+00	1.00000D+00	1.00000D+00	0.0	0.0	0.0
2	0.0	1.00000D+00	1.00000D+00	1.00000D+00	0.0	0.0	0.0
3	0.0	1.00000D+00	1.00000D+00	1.00000D+00	0.0	0.0	0.0

TOTAL SCATTERING CROSS SECTION

INTO GROUP/FROM GROUP, CROSS SECTION

1	1,	1.747316D-01				
2	1,	2.552287D-02	2,	3.009916D-01		
3	1,	1.287798D-09	2,	1.689964D-03	3,	3.797170D-01

EDIT OF (NONFISSIONABLE) COMPOSITION NO. 7

ICHI = 0

GROUP	ABSORPTION	TOTAL	REMOVAL	TRANSPORT	NUP	NDN
1	2.335810D-05	5.512930D-02	4.101986D-03	6.344391D-02	0	0
2	5.105912D-05	8.294149D-02	4.686827D-04	1.026733D-01	0	1
3	1.349709D-04	6.623252D-02	1.349709D-04	7.422477D-02	0	1

GROUP	POWER CONVERSION FACTOR	DIRECTIONAL DIFFUSION COEFF. MULTIPLIER DIMENSION 1	DIMENSION 2	DIMENSION 3	DIRECTIONAL DIFFUSION COEFF. ADDITIVE TERM DIMENSION 1	DIMENSION 2	DIMENSION 3
1	0.0	1.00000D+00	1.00000D+00	1.00000D+00	0.0	0.0	0.0
2	0.0	1.00000D+00	1.00000D+00	1.00000D+00	0.0	0.0	0.0
3	0.0	1.00000D+00	1.00000D+00	1.00000D+00	0.0	0.0	0.0

TOTAL SCATTERING CROSS SECTION

INTO GROUP/FROM GROUP, CROSS SECTION

1	1,	5.587875D-02		
2	1,	4.078628D-03	2,	9.286808D-02
3	2,	4.176236D-04	3,	6.619230D-02

```
SIZE OF CONTAINER ALLOCATED FOR HMG4C -  5000

SIZE OF CONTAINER ACTUALLY USED BY HMG4C -   445


ELAPSED CPU TIME =      0.22 SEC.

ELAPSED PP  TIME =      0.00 SEC.

                                        * * * END OF HMG4C * * *
```

```
GENERAL PROBLEM DATA
   NUMBER OF GROUPS =  3    (NGROUP)
   BPOINTER CONTAINER SIZE =    5000
   NUMBER OF AXIAL MESH INTERVALS =  3
   THERE IS NO GROUP COLLAPSING
   THERE IS NO IO BUFFERING
   THERE IS NO INPUT FUNCTION SCALING
   THERE WERE NO INPUT INTEGRALS

BOUNDARY CONDITIONS
   LOWER X BOUNDARY CONDITION = ZERO CURRENT
   UPPER X BOUNDARY CONDITION = ZERO CURRENT
   LOWER Y BOUNDARY CONDITION = ZERO CURRENT
   UPPER Y BOUNDARY CONDITION = ZERO CURRENT
   LOWER Z BOUNDARY CONDITION = ZERO CURRENT
   UPPER Z BOUNDARY CONDITION = ZERO CURRENT
```

```
  FUNCTION   FILE
   NUMBER   NUMBER            FILE NAME              GROUPS USED
      1      999      UNIT  ,       ,       ,  0       ALL  3

  AXIAL POSITION      PLANAR        GEOMETRY                                    EXPANSION          WEIGHTING
     (CM)         GEOMETRY NUMBER  FILE NUMBER     GEOMETRY FILE NAME        FUNCTION NUMBERS   FUNCTION NUMBERS
   0.0 TO  10.0          1             11       GEODST,   FLAT,  FLUX ,  1      1                   1

  AXIAL MESH INTERVALS
      3.333D+00 3.333D+00 3.333D+00

DATA MANAGEMENT PARAMETERS FOR INTEGRAL CALCULATION
   SPACE AVAILABLE DURING FLUX AND CROSS SECTION REWRITE =  7998
   REQFLX FILE, WORDS/RECORD =   226                          NUMBER OF CONCURRENT RECORDS DURING REWRITE = 34
       ROWS OF FLUXES/RECORD =  14                            COLUMNS OF FLUXES/RECORD =  14
   REQXST FILE, WORDS/RECORD =    15                          NUMBER OF CONCURRENT RECORDS DURING REWRITE =513
       COMPOSITIONS/RECORD FOR FISSION-REMOVAL RECORDS =   1  GROUPS/RECORD FOR DIFFUSION COEFFICIENT RECORDS =   3
   SPACE AVAILABLE DURING INTEGRATION =  2120
   VOLINT AND DIFINT FILES, WORDS/RECORD =  2000              NUMBER OF CONCURRENT RECORDS DURING INTEGRATION =  1
```

FINAL INTEGRAL TOCS

VOLINT FILE

ENTRY	1=REM,2=FIS 3=POW,4=FLUX	RECORD NO.	POINTER IN RECORD	PLANAR GEOMETRY NO.	WEIGHTING FUN. NO.	EXPANSION FUN. NO.	NO. OF RECORDS
1	3	1	16	1	0	1	1
2	4	1	19	0	0	1	1
3	1	1	1	1	1	1	1
4	2	1	7	1	1	1	1

DIFINT FILE

MESH RATIO = (LOWER DELTA Z)/(UPPER DELTA Z)
LOWER PLANE = 0 FOR LOWER BOUNDARY INTEGRAL
UPPER PLANE = 0 FOR UPPER BOUNDARY INTEGRAL

ENTRY	RECORD NO.	POINTER IN RECORD	LOWER PLANAR GEOMETRY NO.	UPPER PLANAR GEOMETRY NO.	MESH RATIO	WEIGHTING FUN. NO.	EXPANSION FUN. NO.	NO. OF RECORDS
1	1	1	0	1	1.00	1	1	1
2	1	4	1	1	1.00	1	1	1
3	1	7	1	0	1.00	1	1	1

```
TIME SPENT IN OVERLAY INTEG , CP =    0.4, PP =    0.0
      SUBROUTINE INPRO1, CP =    0.0, PP =    0.0
      SUBROUTINE REDTOC, CP =    0.0, PP =    0.0
      SUBROUTINE REWRIT, CP =    0.1, PP =    0.0
      SUBROUTINE INT1  , CP =    0.0, PP =    0.0
      SUBROUTINE INT2  , CP =    0.0, PP =    0.0
      SUBROUTINE INT3  , CP =    0.0, PP =    0.0
      SUBROUTINE INT4  , CP =    0.0, PP =    0.0
      SUBROUTINE RITTOC, CP =    0.0, PP =    0.0
      SUBROUTINE INTRIT, CP =    0.0, PP =    0.0
```

```
INTTOC FILE LABEL =  1/20/ 0443.6, VERSION NUMBER =   2

DATA MANAGEMENT PARAMETERS FOR SOLUTION
   INTGLS FILE, WORDS/RECORD =    45          NUMBER OF CONCURRENT RECORDS DURING GAUSS ELIMINATION =  1
       NUMBER OF RECORDS =  1
   H FILE, WORDS/RECORD =    18               NUMBER OF RECORDS =  1

DIRECT EIGENVALUE CALCULATION
   EIGENVALUE ESTIMATE = 0.0        , MAXIMUM NUMBER OF ITERATIONS = 10, CONVERGENCE CRITERION = 0.10000E-04
   ITERATION  EIGENVALUE
       1     0.12906E+01
       2     0.13017E+01
       3     0.13017E+01
       4     0.13017E+01

THE CALCULATION HAS CONVERGED ON AN EIGENVALUE

NORMALIZATION, FLUX * SIGMA-F * POWER/FISSION =  0.10000E+01 WATTS.
```

COMBINING COEFFICIENTS FOR DIRECT CALCULATION

FUNCTION NO. =		1	1	1
GROUP =		1	2	3
AXIAL POSITION	AXIAL GEOM.			
1.67	1	4.191E+07	5.868E+07	1.921E+06
5.00	1	4.191E+07	5.868E+07	1.921E+06
8.33	1	4.191E+07	5.868E+07	1.921E+06

```
TIME SPENT IN OVERLAY SOLVE , CP =     0.2, PP =     0.0
      SUBROUTINE REDTOC, CP =     0.0, PP =     0.0
      SUBROUTINE WINTGL, CP =     0.0, PP =     0.0
      SUBROUTINE CALPOW, CP =     0.0, PP =     0.0
      SUBROUTINE SPROB , CP =     0.1, PP =     0.0
      SUBROUTINE OUTPRO, CP =     0.0, PP =     0.0
```

APPENDIX H. Sample Problem Output. Problem 2 - Complete Output

```
SYN3D, OVERLAY CARDS      2D BUCKLED PLANE (THE UNRODDED CORE PLANE FROM THE 3D MODEL)          1/20/, 05.07., PAGE   1
                                HALF CORE AXIAL SYMMETRY

LISTING OF SYN3D INPUT


 CARDS-PER-CARD-TYPE DATA
 2  1  1  1  1  0  1  1  0  0  0  0  0  0  0  0  0  0  0  0  0


   CARD
   TYPE
     1     2D BUCKLED PLANE (THE UNRODDED CORE PLANE FROM THE 3D MODEL)
     1          HALF CORE AXIAL SYMMETRY
     2          6     1    20     0     0     0     0     2     1     0     0
     3            0.10000E+01 0.0          0.10000E+02
     4               30 0.60000E+02     0 0.0             0 0.0
     5                1       0.0         0.60000E+02 0.0          0.0
     7     RTFLUX     1 0.0          0.60000E+02 0.0          0.0
     8     UNIT       0 0.0          0.60000E+02 0.0          0.0
```

HALF CORE AXIAL SYMMETRY

```
GENERAL PROBLEM DATA
   NUMBER OF GROUPS =  3   (NGROUP)
   BPOINTER CONTAINER SIZE =   6000
   NUMBER OF AXIAL MESH INTERVALS = 30
   THERE IS NO GROUP COLLAPSING
   THERE IS NO IO BUFFERING
   THERE IS NO INPUT FUNCTION SCALING
   THERE WERE NO INPUT INTEGRALS

BOUNDARY CONDITIONS
   LOWER X BOUNDARY CONDITION = ZERO CURRENT
   UPPER X BOUNDARY CONDITION = ZERO FLUX
   LOWER Y BOUNDARY CONDITION = ZERO CURRENT
   UPPER Y BOUNDARY CONDITION = ZERO FLUX
   LOWER Z BOUNDARY CONDITION = ZERO CURRENT
   UPPER Z BOUNDARY CONDITION = ZERO FLUX
```

HALF CORE AXIAL SYMMETRY

FUNCTION NUMBER	FILE NUMBER	FILE NAME	GROUPS USED
1	22	RTFLUX, UNROD, CORE, 1	ALL 3
2	999	UNIT , , , 0	ALL 3

AXIAL POSITION (CM)	PLANAR GEOMETRY NUMBER	GEOMETRY FILE NUMBER	GEOMETRY FILE NAME	EXPANSION FUNCTION NUMBERS	WEIGHTING FUNCTION NUMBERS
0.0 TO 60.0	1	11	GEODST, CORE, UNROD, 1	1	2

AXIAL MESH INTERVALS

```
2.000D+00 2.000D+00 2.000D+00 2.000D+00 2.000D+00 2.000D+00 2.000D+00 2.000D+00 2.000D+00 2.000D+00 2.000D+00 2.000D+00
2.000D+00 2.000D+00 2.000D+00 2.000D+00 2.000D+00 2.000D+00 2.000D+00 2.000D+00 2.000D+00 2.000D+00 2.000D+00 2.000D+00
2.000D+00 2.000D+00 2.000D+00 2.000D+00 2.000D+00 2.000D+00
```

DATA MANAGEMENT PARAMETERS FOR INTEGRAL CALCULATION

```
SPACE AVAILABLE DURING FLUX AND CROSS SECTION REWRITE =  9858
REQFLX FILE, WORDS/RECORD =   814                          NUMBER OF CONCURRENT RECORDS DURING REWRITE = 11
    ROWS OF FLUXES/RECORD =  14                            COLUMNS OF FLUXES/RECORD =  14
REQXST FILE, WORDS/RECORD =    75                          NUMBER OF CONCURRENT RECORDS DURING REWRITE =127
    COMPOSITIONS/RECORD FOR FISSION-REMOVAL RECORDS =   5  GROUPS/RECORD FOR DIFFUSION COEFFICIENT RECORDS =   3
SPACE AVAILABLE DURING INTEGRATION =  2416
VOLINT AND DIFINT FILES, WORDS/RECORD =  2000              NUMBER OF CONCURRENT RECORDS DURING INTEGRATION =  1
```

HALF CORE AXIAL SYMMETRY

FINAL INTEGRAL TOCS

VOLINT FILE

ENTRY	1=REM,2=FIS 3=POW,4=FLUX	RECORD NO.	POINTER IN RECORD	PLANAR GEOMETRY NO.	WEIGHTING FUN. NO.	EXPANSION FUN. NO.	NO. OF RECORDS
1	3	1	16	1	0	1	1
2	4	1	19	0	0	1	1
3	3	1	22	1	0	2	1
4	4	1	25	0	0	2	1
5	1	1	1	1	2	1	1
6	2	1	7	1	2	1	1

DIFINT FILE

MESH RATIO = (LOWER DELTA Z)/(UPPER DELTA Z)
LOWER PLANE = 0 FOR LOWER BOUNDARY INTEGRAL
UPPER PLANE = 0 FOR UPPER BOUNDARY INTEGRAL

ENTRY	RECORD NO.	POINTER IN RECORD	LOWER PLANAR GEOMETRY NO.	UPPER PLANAR GEOMETRY NO.	MESH RATIO	WEIGHTING FUN. NO.	EXPANSION FUN. NO.	NO. OF RECORDS
1	1	1	0	1	1.00	2	1	1
2	1	4	1	1	1.00	2	1	1
3	1	7	1	0	1.00	2	1	1

```
TIME SPENT IN OVERLAY INTEG , CP =    0.5, PP =    0.0
      SUBROUTINE INPRO1, CP =    0.1, PP =    0.0
      SUBROUTINE REDTOC, CP =    0.0, PP =    0.0
      SUBROUTINE REWRIT, CP =    0.1, PP =    0.0
      SUBROUTINE INT1  , CP =    0.0, PP =    0.0
      SUBROUTINE INT2  , CP =    0.0, PP =    0.0
      SUBROUTINE INT3  , CP =    0.0, PP =    0.0
      SUBROUTINE INT4  , CP =    0.0, PP =    0.0
      SUBROUTINE RITTOC, CP =    0.0, PP =    0.0
      SUBROUTINE INTRIT, CP =    0.0, PP =    0.0
```

HALF CORE AXIAL SYMMETRY

```
INTTOC FILE LABEL =  1/20/ 0507.8, VERSION NUMBER =   2

DATA MANAGEMENT PARAMETERS FOR SOLUTION
   INTGLS FILE, WORDS/RECORD =    45          NUMBER OF CONCURRENT RECORDS DURING GAUSS ELIMINATION =  1
       NUMBER OF RECORDS =  1
   H FILE, WORDS/RECORD =   261               NUMBER OF RECORDS =  1

DIRECT EIGENVALUE CALCULATION
   EIGENVALUE ESTIMATE = 0.10000E+01, MAXIMUM NUMBER OF ITERATIONS = 20, CONVERGENCE CRITERION = 0.10000E-04
   ITERATION  EIGENVALUE
       1     0.99508E+00
       2     0.99600E+00
       3     0.99600E+00
       4     0.99600E+00

THE CALCULATION HAS CONVERGED ON AN EIGENVALUE

NORMALIZATION, FLUX * SIGMA-F * POWER/FISSION =  0.10000E+02 WATTS.
```

HALF CORE AXIAL SYMMETRY

COMBINING COEFFICIENTS FOR DIRECT CALCULATION

FUNCTION NO. =		1	1	1	2	2	2
GROUP =		1	2	3	1	2	3
AXIAL POSITION	AXIAL GEOM.						
1.00	1	2.015E+01	2.015E+01	2.015E+01	0.0	0.0	0.0
3.00	1	2.010E+01	2.010E+01	2.010E+01	0.0	0.0	0.0
5.00	1	1.999E+01	1.999E+01	1.999E+01	0.0	0.0	0.0
7.00	1	1.982E+01	1.982E+01	1.982E+01	0.0	0.0	0.0
9.00	1	1.960E+01	1.960E+01	1.960E+01	0.0	0.0	0.0
11.00	1	1.933E+01	1.933E+01	1.933E+01	0.0	0.0	0.0
13.00	1	1.900E+01	1.900E+01	1.900E+01	0.0	0.0	0.0
15.00	1	1.862E+01	1.862E+01	1.863E+01	0.0	0.0	0.0
17.00	1	1.819E+01	1.820E+01	1.820E+01	0.0	0.0	0.0
19.00	1	1.772E+01	1.772E+01	1.772E+01	0.0	0.0	0.0
21.00	1	1.719E+01	1.719E+01	1.719E+01	0.0	0.0	0.0
23.00	1	1.661E+01	1.661E+01	1.661E+01	0.0	0.0	0.0
25.00	1	1.599E+01	1.599E+01	1.599E+01	0.0	0.0	0.0
27.00	1	1.533E+01	1.533E+01	1.533E+01	0.0	0.0	0.0
29.00	1	1.462E+01	1.462E+01	1.462E+01	0.0	0.0	0.0
31.00	1	1.388E+01	1.388E+01	1.388E+01	0.0	0.0	0.0
33.00	1	1.309E+01	1.309E+01	1.309E+01	0.0	0.0	0.0
35.00	1	1.227E+01	1.227E+01	1.227E+01	0.0	0.0	0.0
37.00	1	1.142E+01	1.142E+01	1.142E+01	0.0	0.0	0.0
39.00	1	1.053E+01	1.053E+01	1.053E+01	0.0	0.0	0.0
41.00	1	9.619E+00	9.619E+00	9.619E+00	0.0	0.0	0.0
43.00	1	8.679E+00	8.679E+00	8.679E+00	0.0	0.0	0.0
45.00	1	7.714E+00	7.715E+00	7.715E+00	0.0	0.0	0.0
47.00	1	6.729E+00	6.729E+00	6.729E+00	0.0	0.0	0.0
49.00	1	5.725E+00	5.726E+00	5.726E+00	0.0	0.0	0.0
51.00	1	4.706E+00	4.706E+00	4.706E+00	0.0	0.0	0.0
53.00	1	3.674E+00	3.674E+00	3.674E+00	0.0	0.0	0.0
55.00	1	2.631E+00	2.631E+00	2.631E+00	0.0	0.0	0.0
57.00	1	1.582E+00	1.582E+00	1.582E+00	0.0	0.0	0.0
59.00	1	5.277E-01	5.277E-01	5.277E-01	0.0	0.0	0.0

TIME SPENT IN OVERLAY SOLVE , CP = 0.4, PP = 0.0
SUBROUTINE REDTOC, CP = 0.0, PP = 0.0
SUBROUTINE WINTGL, CP = 0.0, PP = 0.0
SUBROUTINE CALPOW, CP = 0.0, PP = 0.0
SUBROUTINE SPROB , CP = 0.2, PP = 0.0
SUBROUTINE OUTPRO, CP = 0.0, PP = 0.0

APPENDIX H. Sample Problem Output. Problem 3 - Partial Output

```
SYN3D, OVERLAY CARDS      3 GROUP, 3-DIMENSIONAL MODEL, FLUX WEIGHTED SYNTHESIS                1/20/, 05.12., PAGE   1
                                BLANKET FUNCTIONS (3 AND 4) NOT USED EVERYWHERE
                                3D GEOMETRY BUILT UP FROM 2D GEODST FILES

LISTING OF SYN3D INPUT


 CARDS-PER-CARD-TYPE DATA
 3  1  1  1  6  0  4  0  0  0  0  0  0  0  0  1  1  0  1  0  1


   CARD
   TYPE
     1     3 GROUP, 3-DIMENSIONAL MODEL, FLUX WEIGHTED SYNTHESIS
     1          BLANKET FUNCTIONS (3 AND 4) NOT USED EVERYWHERE
     1          3D GEOMETRY BUILT UP FROM 2D GEODST FILES
     2         10     1    20     0     0     0     0     1     1     0     0
     3            0.10000E+01 0.0          0.10000E+02
     4               20 0.20000E+03     0 0.0             0 0.0
     5                1       0.0         0.20000E+02 0.0          0.0
     5                2       0.20000E+02 0.60000E+02 0.0          0.0
     5                3       0.60000E+02 0.10000E+03 0.0          0.0
     5                4       0.10000E+03 0.14000E+03 0.0          0.0
     5                5       0.14000E+03 0.18000E+03 0.0          0.0
     5                6       0.18000E+03 0.20000E+03 0.0          0.0
     7     RTFLUX     1 0.0          0.20000E+03 0.0          0.0
     7     RTFLUX     2 0.0          0.20000E+03 0.0          0.0
     7     RTFLUX     3 0.0          0.80000E+02 0.0          0.0
     7     RTFLUX     4 0.12000E+03 0.20000E+03 0.0          0.0
    16          0     0     0     0     0     0     1     0     0     0     0
    17          1     2     3     0     0     0     0     0     0     0     0
    19          1    10     2    10     3    10     0     0     0     0     0
    21         10     0     0     0     0     0     0     0     0     0     0
```

```
                    BLANKET FUNCTIONS (3 AND 4) NOT USED EVERYWHERE
                    3D GEOMETRY BUILT UP FROM 2D GEODST FILES

GENERAL PROBLEM DATA
   NUMBER OF GROUPS =  3   (NGROUP)
   BPOINTER CONTAINER SIZE =  10000
   NUMBER OF AXIAL MESH INTERVALS = 20
   THERE IS NO GROUP COLLAPSING
   THERE IS NO IO BUFFERING
   THERE IS NO INPUT FUNCTION SCALING
   THERE WERE NO INPUT INTEGRALS

BOUNDARY CONDITIONS
   LOWER X BOUNDARY CONDITION = ZERO CURRENT
   UPPER X BOUNDARY CONDITION = ZERO FLUX
   LOWER Y BOUNDARY CONDITION = ZERO CURRENT
   UPPER Y BOUNDARY CONDITION = ZERO FLUX
   LOWER Z BOUNDARY CONDITION = ZERO FLUX
   UPPER Z BOUNDARY CONDITION = ZERO FLUX
```

BLANKET FUNCTIONS (3 AND 4) NOT USED EVERYWHERE
3D GEOMETRY BUILT UP FROM 2D GEODST FILES

FUNCTION NUMBER	FILE NUMBER	FILE NAME	GROUPS USED
1	22	RTFLUX, UNROD, CORE, 1	ALL 3
2	23	RTFLUX, ROD, CORE, 2	ALL 3
3	24	RTFLUX, UNROD, BLANKT, 3	ALL 3
4	25	RTFLUX, ROD, BLANKT, 4	ALL 3

AXIAL POSITION (CM)	PLANAR GEOMETRY NUMBER	GEOMETRY FILE NUMBER	GEOMETRY FILE NAME	EXPANSION FUNCTION NUMBERS	WEIGHTING FUNCTION NUMBERS
0.0 TO 20.0	1	11	GEODST, REFL, UNROD, 1	1 2 3	1 2 3
20.0 TO 60.0	2	12	GEODST, BLAN, UNROD, 2	1 2 3	1 2 3
60.0 TO 80.0	3	13	GEODST, CORE, UNROD, 3	1 2 3	1 2 3
80.0 TO 100.0	3	13	GEODST, CORE, UNROD, 3	1 2	1 2
100.0 TO 120.0	4	14	GEODST, CORE, ROD, 4	1 2	1 2
120.0 TO 140.0	4	14	GEODST, CORE, ROD, 4	1 2 4	1 2 4
140.0 TO 180.0	5	15	GEODST, BLAN, ROD, 5	1 2 4	1 2 4
180.0 TO 200.0	6	16	GEODST, REFL, ROD, 6	1 2 4	1 2 4

AXIAL MESH INTERVALS
1.000D+01 1.000D+01 1.000D+01 1.000D+01 1.000D+01 1.000D+01 1.000D+01 1.000D+01 1.000D+01 1.000D+01 1.000D+01 1.000D+01
1.000D+01 1.000D+01 1.000D+01 1.000D+01 1.000D+01 1.000D+01 1.000D+01 1.000D+01

DATA MANAGEMENT PARAMETERS FOR INTEGRAL CALCULATION
SPACE AVAILABLE DURING FLUX AND CROSS SECTION REWRITE = 16132
REQFLX FILE, WORDS/RECORD = 2799 NUMBER OF CONCURRENT RECORDS DURING REWRITE = 5
ROWS OF FLUXES/RECORD = 11 COLUMNS OF FLUXES/RECORD = 14
REQXST FILE, WORDS/RECORD = 105 NUMBER OF CONCURRENT RECORDS DURING REWRITE =150
COMPOSITIONS/RECORD FOR FISSION-REMOVAL RECORDS = 7 GROUPS/RECORD FOR DIFFUSION COEFFICIENT RECORDS = 3
SPACE AVAILABLE DURING INTEGRATION = 2784
VOLINT AND DIFINT FILES, WORDS/RECORD = 2000 NUMBER OF CONCURRENT RECORDS DURING INTEGRATION = 1

```
SYN3D, OVERLAY SOLVE        3 GROUP, 3-DIMENSIONAL MODEL, FLUX WEIGHTED SYNTHESIS
                                 BLANKET FUNCTIONS (3 AND 4) NOT USED EVERYWHERE
                                 3D GEOMETRY BUILT UP FROM 2D GEODST FILES

INTTOC FILE LABEL =  1/20/ 0513.0, VERSION NUMBER =   2

DATA MANAGEMENT PARAMETERS FOR SOLUTION
   INTGLS FILE, WORDS/RECORD =  2655          NUMBER OF CONCURRENT RECORDS DURING GAUSS ELIMINATION =  1
       NUMBER OF RECORDS =  1
   H FILE, WORDS/RECORD =  1350               NUMBER OF RECORDS =  1

DIRECT EIGENVALUE CALCULATION
   EIGENVALUE ESTIMATE = 0.10000E+01, MAXIMUM NUMBER OF ITERATIONS = 20, CONVERGENCE CRITERION = 0.10000E-04
   ITERATION  EIGENVALUE
       1     0.96700E+00
       2     0.97495E+00
       3     0.97505E+00
       4     0.97506E+00
       5     0.97506E+00

THE CALCULATION HAS CONVERGED ON AN EIGENVALUE

NORMALIZATION, FLUX * SIGMA-F * POWER/FISSION =  0.10000E+02 WATTS.
```

BLANKET FUNCTIONS (3 AND 4) NOT USED EVERYWHERE
3D GEOMETRY BUILT UP FROM 2D GEODST FILES

COMBINING COEFFICIENTS FOR DIRECT CALCULATION

	FUNCTION NO. =	1	1	1	2	2	2	3	3	3	4
	GROUP =	1	2	3	1	2	3	1	2	3	1
AXIAL POSITION	AXIAL GEOM.										
5.00	1	-4.011E-02	-6.790E-02	-3.858E-01	1.939E-02	4.160E-02	3.288E-01	4.569E-04	5.733E-04	8.672E-04	0.0
15.00	1	-1.140E-01	-2.015E-01	-1.101E+00	4.963E-02	1.413E-01	9.705E-01	1.485E-03	1.760E-03	2.523E-03	0.0
25.00	2	-1.336E-01	-1.373E-01	-4.234E-01	2.138E-02	8.618E-02	3.904E-01	2.831E-03	2.923E-03	3.250E-03	0.0
35.00	2	-1.084E-01	2.187E-01	-7.839E-01	2.074E-02	1.178E-01	8.638E-01	4.929E-03	3.992E-03	4.663E-03	0.0
45.00	2	2.150E-01	1.187E+00	-1.835E+00	4.994E-02	3.294E-01	2.303E+00	7.625E-03	4.549E-03	6.462E-03	0.0
55.00	2	1.755E+00	3.531E+00	-1.828E+00	9.521E-02	5.260E-01	3.591E+00	8.641E-03	3.516E-03	7.214E-03	0.0
65.00	3	6.756E+00	7.527E+00	8.237E+00	1.678E-01	-2.078E-01	-8.951E-01	5.292E-04	8.050E-04	1.083E-03	0.0
75.00	3	9.014E+00	9.430E+00	1.008E+01	4.874E-01	1.275E-01	-5.675E-01	-2.723E-04	7.937E-05	1.892E-04	0.0
85.00	3	9.909E+00	1.001E+01	1.061E+01	1.159E+00	1.013E+00	3.418E-01	0.0	0.0	0.0	0.0
95.00	3	9.286E+00	9.171E+00	9.971E+00	2.677E+00	2.687E+00	1.639E+00	0.0	0.0	0.0	0.0
105.00	4	2.670E+00	3.224E+00	9.039E-01	1.047E+01	9.597E+00	1.244E+01	0.0	0.0	0.0	0.0
115.00	4	6.270E-01	9.224E-01	1.263E-01	1.174E+01	1.124E+01	1.226E+01	0.0	0.0	0.0	0.0
125.00	4	1.029E-01	1.566E-01	-1.331E-02	1.040E+01	1.017E+01	1.066E+01	0.0	0.0	0.0	-4.728E-04
135.00	4	-7.924E-02	-2.836E-01	-6.129E-02	7.609E+00	8.149E+00	7.885E+00	0.0	0.0	0.0	5.586E-04
145.00	5	-2.617E-02	-6.264E-01	2.831E-01	2.018E+00	4.849E+00	-5.096E-01	0.0	0.0	0.0	9.911E-03
155.00	5	-4.339E-03	-3.208E-01	1.429E-01	2.671E-01	1.757E+00	-9.739E-01	0.0	0.0	0.0	8.670E-03
165.00	5	-3.609E-03	-1.178E-01	2.961E-02	-1.026E-01	3.453E-01	-4.490E-01	0.0	0.0	0.0	5.491E-03
175.00	5	-4.999E-03	-4.665E-02	-2.023E-02	-1.220E-01	-9.064E-02	-1.979E-01	0.0	0.0	0.0	3.084E-03
185.00	6	-9.930E-03	-6.423E-02	-8.034E-02	-6.927E-02	-7.638E-02	-3.406E-01	0.0	0.0	0.0	1.594E-03
195.00	6	-3.628E-03	-2.155E-02	-2.923E-02	-2.239E-02	-3.399E-02	-1.242E-01	0.0	0.0	0.0	4.861E-04

BLANKET FUNCTIONS (3 AND 4) NOT USED EVERYWHERE
3D GEOMETRY BUILT UP FROM 2D GEODST FILES

COMBINING COEFFICIENTS FOR DIRECT CALCULATION

FUNCTION NO. =	4	4
GROUP =	2	3

AXIAL POSITION	AXIAL GEOM.		
5.00	1	0.0	0.0
15.00	1	0.0	0.0
25.00	2	0.0	0.0
35.00	2	0.0	0.0
45.00	2	0.0	0.0
55.00	2	0.0	0.0
65.00	3	0.0	0.0
75.00	3	0.0	0.0
85.00	3	0.0	0.0
95.00	3	0.0	0.0
105.00	4	0.0	0.0
115.00	4	0.0	0.0
125.00	4	4.128E-04	1.459E-04
135.00	4	1.122E-03	1.496E-03
145.00	5	4.308E-03	1.017E-02
155.00	5	5.536E-03	8.542E-03
165.00	5	4.736E-03	5.697E-03
175.00	5	3.376E-03	3.735E-03
185.00	6	2.035E-03	2.896E-03
195.00	6	6.639E-04	9.832E-04

TIME SPENT IN OVERLAY SOLVE , CP = 1.2, PP = 0.0
SUBROUTINE REDTOC, CP = 0.0, PP = 0.0
SUBROUTINE WINTGL, CP = 0.1, PP = 0.0
SUBROUTINE CALPOW, CP = 0.0, PP = 0.0
SUBROUTINE SPROP , CP = 0.8, PP = 0.0
SUBROUTINE OUTPRO, CP = 0.1, PP = 0.0

PLANAR FLUX DISTRIBUTION, Z = 95.00, GROUP = 1

ROW	COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4	COLUMN 5	COLUMN 6	COLUMN 7	COLUMN 8	COLUMN 9
1	1.9046D+08	2.0897D+08	2.1233D+08	2.0565D+08	1.9234D+08	1.7381D+08	1.5026D+08	9.8743D+07	4.8302D+07
2	2.0897D+08	2.1277D+08	2.1206D+08	2.0448D+08	1.9112D+08	1.7346D+08	1.5419D+08	1.1214D+08	4.8459D+07
3	2.1233D+08	2.1206D+08	2.0806D+08	1.9906D+08	1.8543D+08	1.6881D+08	1.5272D+08	1.1512D+08	4.8747D+07
4	2.0565D+08	2.0448D+08	1.9906D+08	1.8904D+08	1.7473D+08	1.5814D+08	1.4432D+08	1.1007D+08	4.6609D+07
5	1.9234D+08	1.9112D+08	1.8543D+08	1.7473D+08	1.5881D+08	1.3953D+08	1.2964D+08	9.9527D+07	4.2206D+07
6	1.7381D+08	1.7346D+08	1.6881D+08	1.5814D+08	1.3953D+08	1.1186D+08	1.1084D+08	8.4747D+07	3.5923D+07
7	1.5026D+08	1.5419D+08	1.5272D+08	1.4432D+08	1.2964D+08	1.1084D+08	9.2576D+07	6.5384D+07	2.7982D+07
8	9.8743D+07	1.1214D+08	1.1512D+08	1.1007D+08	9.9527D+07	8.4747D+07	6.5384D+07	4.0483D+07	1.9421D+07
9	4.8302D+07	4.8459D+07	4.8747D+07	4.6609D+07	4.2206D+07	3.5923D+07	2.7982D+07	1.9421D+07	9.5611D+06
10	1.8800D+07	1.8798D+07	1.8650D+07	1.7777D+07	1.6103D+07	1.3723D+07	1.0773D+07	7.5529D+06	4.2673D+06
11	8.4087D+06	8.3831D+06	8.2339D+06	7.8146D+06	7.0760D+06	6.0433D+06	4.7848D+06	3.4236D+06	2.1167D+06
12	2.4764D+06	2.4656D+06	2.4115D+06	2.2834D+06	2.0668D+06	1.7676D+06	1.4061D+06	1.0181D+06	6.5214D+05

ROW	COLUMN 10	COLUMN 11	COLUMN 12
1	1.8800D+07	8.4087D+06	2.4764D+06
2	1.8798D+07	8.3831D+06	2.4656D+06
3	1.8650D+07	8.2339D+06	2.4115D+06
4	1.7777D+07	7.8146D+06	2.2834D+06
5	1.6103D+07	7.0760D+06	2.0668D+06
6	1.3723D+07	6.0433D+06	1.7676D+06
7	1.0773D+07	4.7848D+06	1.4061D+06
8	7.5529D+06	3.4236D+06	1.0181D+06
9	4.2673D+06	2.1167D+06	6.5214D+05
10	2.1540D+06	1.1782D+06	3.7670D+05
11	1.1782D+06	6.2775D+05	1.9806D+05
12	3.7670D+05	1.9806D+05	6.2043D+04

PLANAR POWER DENSITY (WATTS/CC), Z = 95.00

ROW	COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4	COLUMN 5	COLUMN 6	COLUMN 7	COLUMN 8	COLUMN 9
1	0.0	3.4749E-05	3.4801E-05	3.3536E-05	3.1213E-05	2.7897E-05	3.0186E-05	0.0	2.4301E-06
2	3.4749E-05	3.5052E-05	3.4698E-05	3.3331E-05	3.1004E-05	2.7796E-05	3.0652E-05	2.3299E-05	2.4380E-06
3	3.4801E-05	3.4698E-05	3.3960E-05	3.2415E-05	3.0060E-05	2.7004E-05	3.0153E-05	2.3343E-05	2.4525E-06
4	3.3536E-05	3.3331E-05	3.2415E-05	3.0739E-05	2.8311E-05	2.5307E-05	2.8451E-05	2.2199E-05	2.3449E-06
5	3.1213E-05	3.1004E-05	3.0060E-05	2.8311E-05	2.5718E-05	2.2482E-05	2.5641E-05	2.0097E-05	2.1234E-06
6	2.7897E-05	2.7796E-05	2.7004E-05	2.5307E-05	2.2482E-05	0.0	2.2204E-05	1.7248E-05	1.8073E-06
7	3.0186E-05	3.0652E-05	3.0153E-05	2.8451E-05	2.5641E-05	2.2204E-05	1.8412E-05	1.3644E-05	1.4078E-06
8	0.0	2.3299E-05	2.3343E-05	2.2199E-05	2.0097E-05	1.7248E-05	1.3644E-05	0.0	9.7707E-07
9	2.4301E-06	2.4380E-06	2.4525E-06	2.3449E-06	2.1234E-06	1.8073E-06	1.4078E-06	9.7707E-07	4.8102E-07
10	9.4583E-07	9.4573E-07	9.3829E-07	8.9435E-07	8.1014E-07	6.9040E-07	5.4199E-07	3.7999E-07	2.1469E-07
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

ROW	COLUMN 10	COLUMN 11	COLUMN 12
1	9.4583E-07	0.0	0.0
2	9.4573E-07	0.0	0.0
3	9.3829E-07	0.0	0.0
4	8.9435E-07	0.0	0.0
5	8.1014E-07	0.0	0.0
6	6.9040E-07	0.0	0.0
7	5.4199E-07	0.0	0.0
8	3.7999E-07	0.0	0.0
9	2.1469E-07	0.0	0.0
10	1.0837E-07	0.0	0.0
11	0.0	0.0	0.0
12	0.0	0.0	0.0

ZONE AVERAGE FLUX

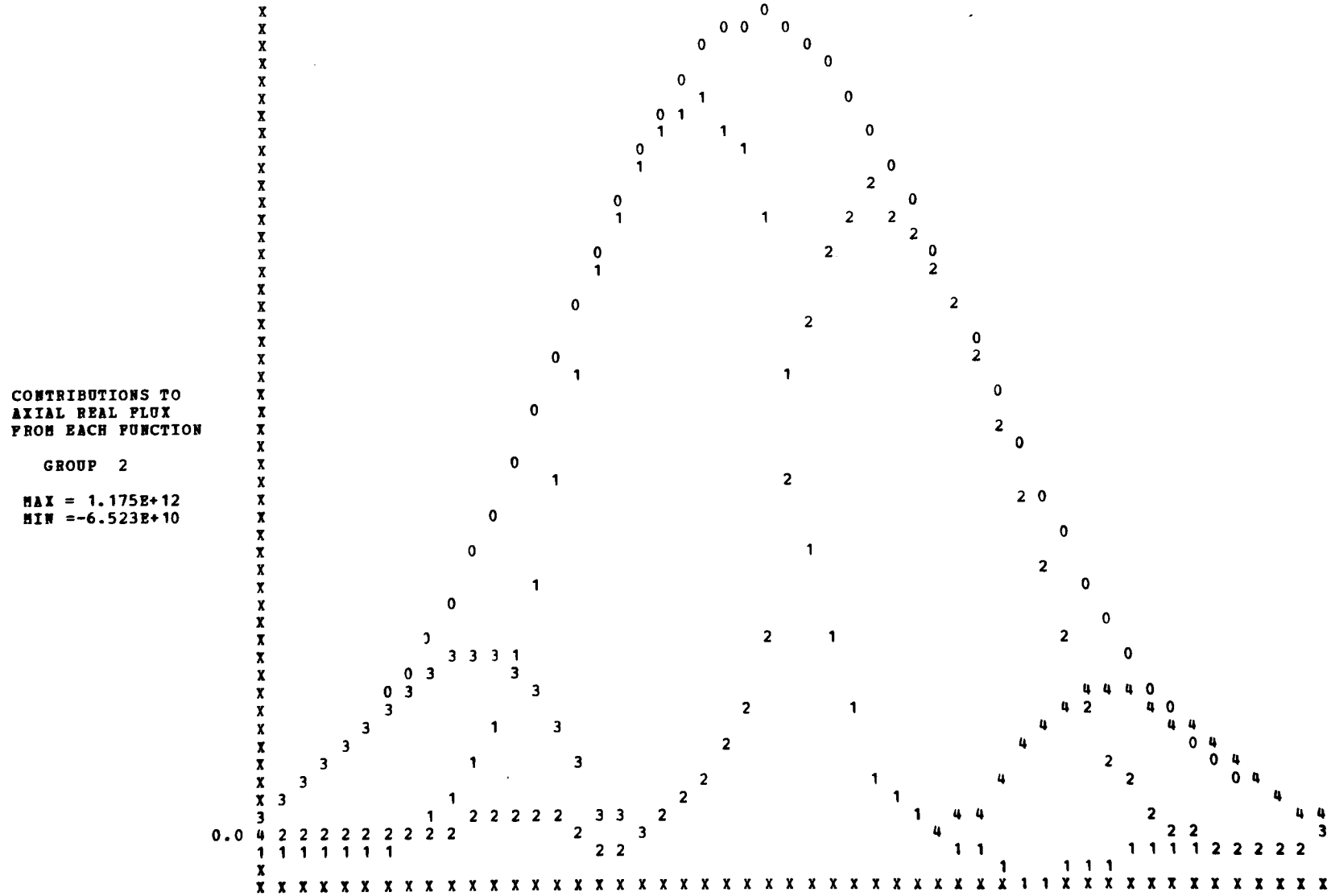
ZONE	GROUP 1	GROUP 2	GROUP 3
1	1.5182E+08	1.8024E+08	5.7973E+06
2	9.3248E+07	1.0261E+08	3.0418E+06
3	1.4133E+07	3.4796E+07	2.3965E+06
4	1.9114E+07	4.0616E+07	2.2294E+06
5	1.3812E+06	5.3950E+06	5.8987E+05
6	2.4808E+07	3.7031E+07	5.7260E+05
7	3.9452E+07	5.9773E+07	2.9702E+06

BLANKET FUNCTIONS (3 AND 4) NOT USED EVERYWHERE
3D GEOMETRY BUILT UP FROM 2D GEODST FILES

CONTRIBUTIONS TO
AXIAL REAL FLUX
FROM EACH FUNCTION

GROUP 2

MAX = 1.175E+12
MIN =-6.523E+10



MIN =5.000E+00 0 = SUM
MAX =1.950E+02 1,2...ETC = INDIVIDUAL MODES

APPENDIX H. Sample Problem Output. Problem 4 - Partial Output

```
SYN3D, OVERLAY CARDS       3 GROUP, 3-DIMENSIONAL MODEL, MIXED FLUX AND ADJOINT WEIGHTING          1/20/, 05.21., PAGE   1
                                BLANKET FUNCTIONS (3 AND 4) NOT USED EVERYWHERE
                                GROUP 3 OF BLANKET FUNCTIONS NOT USED AT ALL
                                INPUT 3D GEODST FILE

LISTING OF SYN3D INPUT


 CARDS-PER-CARD-TYPE DATA
 4  1  1  0  0  2  4  4  0  0  0  0  2  0  0  1  1  1  1  1  1


   CARD
   TYPE
     1     3 GROUP, 3-DIMENSIONAL MODEL, MIXED FLUX AND ADJOINT WEIGHTING
     1          BLANKET FUNCTIONS (3 AND 4) NOT USED EVERYWHERE
     1          GROUP 3 OF BLANKET FUNCTIONS NOT USED AT ALL
     1          INPUT 3D GEODST FILE
     2         15     2    20     0     0     0     0     3     3     0     1
     3            0.10000E+01 0.0          0.10000E+02
     6         ZL     1     3 0.21300E+01     0     0 0.0
     6         ZU     1     3 0.21300E+01     0     0 0.0
     7     RTFLUX     1 0.0          0.20000E+03 0.0          0.0
     7     RTFLUX     2 0.0          0.20000E+03 0.0          0.0
     7     RTFLUX     3 0.0          0.10000E+03 0.0          0.0
     7     RTFLUX     4 0.10000E+03 0.20000E+03 0.0          0.0
     8     ATFLUX     1 0.0          0.20000E+03 0.0          0.0
     8     ATFLUX     2 0.0          0.20000E+03 0.0          0.0
     8     RTFLUX     3 0.0          0.10000E+03 0.0          0.0
     8     RTFLUX     4 0.10000E+03 0.20000E+03 0.0          0.0
    13     RTFLUX     3     3     3     0     0     0     0     0     0
    13     RTFLUX     4     3     3     0     0     0     0     0     0
    16          0     5     3     1     1     0     1     0     0     0     0
    17          1     2     3     0     0     0     0     0     0     0     0
    18          1     2     3     0     0     0     0     0     0     0     0
    19          1     5     1     8     1    11     2     8     3     8     0
    20          1     5     1     8     1    11     2     8     3     8     0
    21          3     6     9    12    15    18     0     0     0     0     0

THE DATA FOR THE TYPE 4 AND 5 CARDS IS BEING EXTRACTED FROM THE FILE GEODST, 3D,3GP,  MODEL,  1
     4               20 0.20000E+03     0 0.0              0 0.0
     5                2       0.0          0.20000E+02
     5                3       0.20000E+02 0.60000E+02
     5                4       0.60000E+02 0.10000E+03
     5                5       0.10000E+03 0.14000E+03
     5                6       0.14000E+03 0.18000E+03
     5                7       0.18000E+03 0.20000E+03
```

```
                    BLANKET FUNCTIONS (3 AND 4) NOT USED EVERYWHERE
                    GROUP 3 OF BLANKET FUNCTIONS NOT USED AT ALL
                    INPUT 3D GEODST FILE

GENERAL PROBLEM DATA
   NUMBER OF GROUPS =  3   (NGROUP)
   BPOINTER CONTAINER SIZE =  15000
   NUMBER OF AXIAL MESH INTERVALS = 20
   THERE IS NO GROUP COLLAPSING
   THERE IS NO IO BUFFERING
   THERE IS NO INPUT FUNCTION SCALING
   THERE WERE NO INPUT INTEGRALS

BOUNDARY CONDITIONS
   LOWER X BOUNDARY CONDITION = ZERO CURRENT
   UPPER X BOUNDARY CONDITION = ZERO FLUX
   LOWER Y BOUNDARY CONDITION = ZERO CURRENT
   UPPER Y BOUNDARY CONDITION = ZERO FLUX
   LOWER Z BOUNDARY CONDITION = LOGARITHMIC
    C(1), BY GROUP
       2.130E+00 2.130E+00 2.130E+00
    C(2), BY GROUP
       1.000E+00 1.000E+00 1.000E+00
   UPPER Z BOUNDARY CONDITION = LOGARITHMIC
    C(1), BY GROUP
       2.130E+00 2.130E+00 2.130E+00
    C(2), BY GROUP
       1.000E+00 1.000E+00 1.000E+00
```

BLANKET FUNCTIONS (3 AND 4) NOT USED EVERYWHERE
GROUP 3 OF BLANKET FUNCTIONS NOT USED AT ALL
INPUT 3D GEODST FILE

FUNCTION NUMBER	FILE NUMBER	FILE NAME	GROUPS USED
1	22	RTFLUX, UNROD, CORE, 1	ALL 3
2	23	RTFLUX, ROD, CORE, 2	ALL 3
3	24	RTFLUX, UNROD, BLANKT, 3	1 2
4	25	RTFLUX, ROD, BLANKT, 4	1 2
5	32	ATFLUX, UNROD, CORE, 1	ALL 3
6	33	ATFLUX, ROD, CORE, 2	ALL 3

AXIAL POSITION (CM)	PIANAR GEOMETRY NUMBER	GEOMETRY FILE NUMBER	GEOMETRY FILE NAME	EXPANSION FUNCTION NUMBERS	WEIGHTING FUNCTION NUMBERS
0.0 TO 20.0	1	12	GEODST, 1/20/, 0521.2, 2	1 2 3	3 5 6
20.0 TO 60.0	2	13	GEODST, 1/20/, 0521.2, 3	1 2 3	3 5 6
60.0 TO 100.0	3	14	GEODST, 1/20/, 0521.2, 4	1 2 3	3 5 6
100.0 TO 140.0	4	15	GEODST, 1/20/, 0521.2, 5	1 2 4	5 6 4
140.0 TO 180.0	5	16	GEODST, 1/20/, 0521.2, 6	1 2 4	5 6 4
180.0 TO 200.0	6	17	GEODST, 1/20/, 0521.2, 7	1 2 4	5 6 4

AXIAL MESH INTERVALS
1.000D+01 1.000D+01 1.000D+01 1.000D+01 1.000D+01 1.000D+01 1.000D+01 1.000D+01 1.000D+01 1.000D+01 1.000D+01 1.000D+01
1.000D+01 1.000D+01 1.000D+01 1.000D+01 1.000D+01 1.000D+01 1.000D+01 1.000D+01

DATA MANAGEMENT PARAMETERS FOR INTEGRAL CALCULATION
SPACE AVAILABLE DURING FLUX AND CROSS SECTION REWRITE = 26070
REQFLX FILE, WORDS/RECORD = 4734 NUMBER OF CONCURRENT RECORDS DURING REWRITE = 5
ROWS OF FLUXES/RECORD = 14 COLUMNS OF FLUXES/RECORD = 14

INITIAL ESTIMATES OF STORAGE REQUIREMENTS FOR FLUX, GEOMETRY AND/OR CROSS SECTION REWRITE WAS WRONG. SYN3D WILL START THE REWRITE AGAIN WITH BETTER ESTIMATES.

DATA MANAGEMENT PARAMETERS FOR INTEGRAL CALCULATION
SPACE AVAILABLE DURING FLUX AND CROSS SECTION REWRITE = 25846
REQFLX FILE, WORDS/RECORD = 4734 NUMBER OF CONCURRENT RECORDS DURING REWRITE = 5
ROWS OF FLUXES/RECORD = 14 COLUMNS OF FLUXES/RECORD = 14
REQXST FILE, WORDS/RECORD = 105 NUMBER OF CONCURRENT RECORDS DURING REWRITE =240
COMPOSITIONS/RECORD FOR FISSION-REMOVAL RECORDS = 7 GROUPS/RECORD FOR DIFFUSION COEFFICIENT RECORDS = 3
SPACE AVAILABLE DURING INTEGRATION = 5561
VOLINT AND DIFINT FILES, WORDS/RECORD = 2000 NUMBER OF CONCURRENT RECORDS DURING INTEGRATION = 2

```
SYN3D, OVERLAY SOLVE      3 GROUP, 3-DIMENSIONAL MODEL, MIXED FLUX AND ADJOINT WEIGHTING          1/20/, 05.21., PAGE   8
                                BLANKET FUNCTIONS (3 AND 4) NOT USED EVERYWHERE
                                GROUP 3 OF BLANKET FUNCTIONS NOT USED AT ALL
                                INPUT 3D GEODST FILE

INTTOC FILE LABEL =  1/20/ 0521.7, VERSION NUMBER =   2

DATA MANAGEMENT PARAMETERS FOR SOLUTION
   INTGLS FILE, WORDS/RECORD =  2214          NUMBER OF CONCURRENT RECORDS DURING GAUSS ELIMINATION =  1
       NUMBER OF RECORDS =  1
   H FILE, WORDS/RECORD =  1216               NUMBER OF RECORDS =  1

DIRECT EIGENVALUE CALCULATION
   EIGENVALUE ESTIMATE = 0.10000E+01, MAXIMUM NUMBER OF ITERATIONS = 20, CONVERGENCE CRITERION = 0.10000E-04
   ITERATION  EIGENVALUE
       1      0.97289E+00
       2      0.97518E+00
       3      0.97520E+00
       4      0.97520E+00
       5      0.97520E+00

THE CALCULATION HAS CONVERGED ON AN EIGENVALUE

NORMALIZATION, FLUX * SIGMA-F * POWER/FISSION =  0.10000E+02 WATTS.
```

BLANKET FUNCTIONS (3 AND 4) NOT USED EVERYWHERE
GROUP 3 OF BLANKET FUNCTIONS NOT USED AT ALL
INPUT 3D GEODST FILE

COMBINING COEFFICIENTS FOR DIRECT CALCULATION

FUNCTION NO. =		1	1	1	2	2	2	3	3	4	4
GROUP =		1	2	3	1	2	3	1	2	1	2
AXIAL POSITION	AXIAL GEOM.										
5.00	1	-2.205E-03	3.212E-01	1.944E+00	-4.265E-02	-3.450E-01	-7.119E-01	6.798E-04	6.021E-04	0.0	0.0
15.00	1	-3.573E-02	-1.853E-01	3.242E+00	-1.966E-02	6.313E-02	1.700E-01	1.462E-03	1.958E-03	0.0	0.0
25.00	2	-8.764E-02	-1.261E-01	4.739E+00	-1.785E-02	4.543E-02	-3.025E-01	2.806E-03	3.030E-03	0.0	0.0
35.00	2	-1.489E-01	3.669E-01	6.383E+00	4.707E-02	2.298E-02	3.901E-02	5.052E-03	3.904E-03	0.0	0.0
45.00	2	-6.116E-02	1.676E+00	7.997E+00	2.480E-01	7.690E-02	1.201E+00	8.230E-03	4.059E-03	0.0	0.0
55.00	2	1.097E+00	4.715E+00	9.134E+00	5.667E-01	-6.315E-02	2.323E+00	1.006E-02	2.247E-03	0.0	0.0
65.00	3	6.707E+00	8.495E+00	9.964E+00	2.046E-01	-7.160E-01	-1.133E+00	6.387E-04	-1.974E-04	0.0	0.0
75.00	3	8.851E+00	9.824E+00	1.045E+01	6.109E-01	-1.116E-01	-6.752E-01	4.980E-05	-2.784E-04	0.0	0.0
85.00	3	9.304E+00	1.023E+01	1.072E+01	1.599E+00	8.199E-01	2.259E-01	1.246E-03	-1.005E-04	0.0	0.0
95.00	3	7.632E+00	9.666E+00	1.014E+01	3.828E+00	2.266E+00	1.443E+00	3.626E-03	-2.828E-04	0.0	0.0
105.00	4	2.750E+00	3.285E+00	8.460E-01	1.004E+01	9.015E+00	1.248E+01	0.0	0.0	1.829E-03	1.101E-03
115.00	4	7.082E-01	9.588E-01	1.094E-01	1.156E+01	1.086E+01	1.226E+01	0.0	0.0	3.830E-04	7.380E-04
125.00	4	1.316E-01	1.289E-01	-3.661E-02	1.028E+01	1.026E+01	1.085E+01	0.0	0.0	-2.793E-05	2.825E-04
135.00	4	-8.474E-02	-4.222E-01	-2.615E-01	7.538E+00	8.768E+00	9.809E+00	0.0	0.0	9.650E-04	1.371E-04
145.00	5	-5.773E-02	-9.160E-01	-1.117E+00	2.108E+00	6.125E+00	1.251E+01	0.0	0.0	9.613E-03	2.302E-03
155.00	5	-1.486E-02	-4.825E-01	-1.038E+00	3.104E-01	2.416E+00	9.991E+00	0.0	0.0	8.501E-03	4.542E-03
165.00	5	-4.595E-03	-1.757E-01	-7.635E-01	-1.002E-01	5.644E-01	6.900E+00	0.0	0.0	5.498E-03	4.436E-03
175.00	5	-3.712E-03	-5.592E-02	-5.467E-01	-1.347E-01	-7.333E-02	4.673E+00	0.0	0.0	3.181E-03	3.410E-03
185.00	6	-9.074E-03	-6.586E-02	-5.061E-01	-8.581E-02	-1.071E-01	3.541E+00	0.0	0.0	1.756E-03	2.196E-03
195.00	6	-5.959E-03	-2.290E-02	-2.005E-01	-3.724E-02	-6.697E-02	1.387E+00	0.0	0.0	7.301E-04	8.869E-04

BLANKET FUNCTIONS (3 AND 4) NOT USED EVERYWHERE
GROUP 3 OF BLANKET FUNCTIONS NOT USED AT ALL
INPUT 3D GEODST FILE

COMBINING COEFFICIENTS FOR DIRECT CALCULATION

FUNCTION NO. =		5	5	5	6	6	6
GROUP =		1	2	3	1	2	3
AXIAL POSITION	AXIAL GEOM.						
5.00	1	0.0	0.0	0.0	0.0	0.0	0.0
15.00	1	0.0	0.0	0.0	0.0	0.0	0.0
25.00	2	0.0	0.0	0.0	0.0	0.0	0.0
35.00	2	0.0	0.0	0.0	0.0	0.0	0.0
45.00	2	0.0	0.0	0.0	0.0	0.0	0.0
55.00	2	0.0	0.0	0.0	0.0	0.0	0.0
65.00	3	0.0	0.0	0.0	0.0	0.0	0.0
75.00	3	0.0	0.0	0.0	0.0	0.0	0.0
85.00	3	0.0	0.0	0.0	0.0	0.0	0.0
95.00	3	0.0	0.0	0.0	0.0	0.0	0.0
105.00	4	0.0	0.0	0.0	0.0	0.0	0.0
115.00	4	0.0	0.0	0.0	0.0	0.0	0.0
125.00	4	0.0	0.0	0.0	0.0	0.0	0.0
135.00	4	0.0	0.0	0.0	0.0	0.0	0.0
145.00	5	0.0	0.0	0.0	0.0	0.0	0.0
155.00	5	0.0	0.0	0.0	0.0	0.0	0.0
165.00	5	0.0	0.0	0.0	0.0	0.0	0.0
175.00	5	0.0	0.0	0.0	0.0	0.0	0.0
185.00	6	0.0	0.0	0.0	0.0	0.0	0.0
195.00	6	0.0	0.0	0.0	0.0	0.0	0.0

```
                    BLANKET FUNCTIONS (3 AND 4) NOT USED EVERYWHERE
                    GROUP 3 OF BLANKET FUNCTIONS NOT USED AT ALL
                    INPUT 3D GEODST FILE

DATA MANAGEMENT PARAMETERS FOR SOLUTION
   INTGLS FILE, WORDS/RECORD =  2214          NUMBER OF CONCURRENT RECORDS DURING GAUSS ELIMINATION =  1
       NUMBER OF RECORDS =  1
   H FILE, WORDS/RECORD =  1216               NUMBER OF RECORDS =  1

ADJOINT EIGENVALUE CALCULATION
   EIGENVALUE ESTIMATE = 0.97620E+00, MAXIMUM NUMBER OF ITERATIONS = 20, CONVERGENCE CRITERION = 0.10000E-04
   ITERATION  EIGENVALUE
       1      0.97541E+00
       2      0.97520E+00
       3      0.97520E+00
       4      0.97520E+00

THE CALCULATION HAS CONVERGED ON AN EIGENVALUE

NORMALIZATION, ADJOINT * SIGMA-F * POWER/FISSION =  0.10000E+02 WATTS.
```

BLANKET FUNCTIONS (3 AND 4) NOT USED EVERYWHERE
GROUP 3 OF BLANKET FUNCTIONS NOT USED AT ALL
INPUT 3D GEODST FILE

COMBINING COEFFICIENTS FOR ADJOINT CALCULATION

FUNCTION NO. =		1	1	1	2	2	2	3	3	4	4
GROUP =		1	2	3	1	2	3	1	2	1	2
AXIAL POSITION	AXIAL GEOM.										
5.00	1	0.0	0.0	0.0	0.0	0.0	0.0	1.225E-03	6.946E-05	0.0	0.0
15.00	1	0.0	0.0	0.0	0.0	0.0	0.0	2.863E-03	1.840E-04	0.0	0.0
25.00	2	0.0	0.0	0.0	0.0	0.0	0.0	4.769E-03	3.018E-04	0.0	0.0
35.00	2	0.0	0.0	0.0	0.0	0.0	0.0	7.088E-03	4.487E-04	0.0	0.0
45.00	2	0.0	0.0	0.0	0.0	0.0	0.0	9.197E-03	5.953E-04	0.0	0.0
55.00	2	0.0	0.0	0.0	0.0	0.0	0.0	8.457E-03	5.931E-04	0.0	0.0
65.00	3	0.0	0.0	0.0	0.0	0.0	0.0	1.328E-03	1.304E-04	0.0	0.0
75.00	3	0.0	0.0	0.0	0.0	0.0	0.0	-4.939E-05	-3.299E-05	0.0	0.0
85.00	3	0.0	0.0	0.0	0.0	0.0	0.0	-6.862E-04	-1.352E-04	0.0	0.0
95.00	3	0.0	0.0	0.0	0.0	0.0	0.0	-8.471E-04	-2.135E-04	0.0	0.0
105.00	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-3.823E-04	2.848E-04
115.00	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.441E-04	2.032E-04
125.00	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.136E-04	1.042E-04
135.00	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.682E-03	1.519E-04
145.00	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.561E-03	6.972E-04
155.00	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.027E-02	6.559E-04
165.00	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.811E-03	4.609E-04
175.00	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.166E-03	2.910E-04
185.00	6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.075E-03	1.701E-04
195.00	6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.339E-03	6.481E-05

BLANKET FUNCTIONS (3 AND 4) NOT USED EVERYWHERE
GROUP 3 OF BLANKET FUNCTIONS NOT USED AT ALL
INPUT 3D GEODST FILE

COMBINING COEFFICIENTS FOR ADJOINT CALCULATION

FUNCTION NO. =		5	5	5	6	6	6
GROUP =		1	2	3	1	2	3
AXIAL POSITION	AXIAL GEOM.						
5.00	1	-5.279E-01	1.110E-01	1.065E-01	2.916E-01	-1.308E-01	-1.151E-01
15.00	1	-1.622E+00	1.383E-01	2.334E-01	1.151E+00	-1.521E-01	-2.300E-01
25.00	2	-2.637E+00	3.317E-01	4.614E-01	1.913E+00	-3.194E-01	-4.241E-01
35.00	2	-3.699E+00	7.820E-01	9.814E-01	2.854E+00	-5.708E-01	-8.387E-01
45.00	2	-4.166E+00	1.737E+00	2.065E+00	3.761E+00	-8.524E-01	-1.500E+00
55.00	2	-1.691E+00	3.658E+00	4.090E+00	3.500E+00	-8.860E-01	-1.962E+00
65.00	3	6.684E+00	7.046E+00	7.096E+00	5.528E-01	1.261E-01	3.152E-01
75.00	3	9.611E+00	9.453E+00	9.478E+00	3.477E-01	4.486E-01	5.645E-01
85.00	3	1.099E+01	1.071E+01	1.075E+01	7.613E-01	9.983E-01	8.984E-01
95.00	3	1.042E+01	1.022E+01	1.054E+01	2.283E+00	2.520E+00	1.900E+00
105.00	4	3.627E+00	2.319E+00	6.326E-01	9.939E+00	1.106E+01	1.384E+01
115.00	4	1.106E+00	4.493E-01	4.551E-02	1.156E+01	1.219E+01	1.327E+01
125.00	4	3.041E-01	6.759E-02	8.073E-03	1.038E+01	1.067E+01	1.115E+01
135.00	4	8.162E-02	-6.551E-02	-1.732E-04	7.554E+00	7.863E+00	8.032E+00
145.00	5	7.049E-01	-2.500E-01	-2.652E-02	4.863E-01	3.417E+00	2.637E+00
155.00	5	8.832E-01	-1.865E-01	-8.340E-03	-2.152E+00	1.322E+00	8.229E-01
165.00	5	7.091E-01	-1.187E-01	-2.621E-03	-2.253E+00	4.934E-01	2.582E-01
175.00	5	4.781E-01	-7.472E-02	-9.341E-04	-1.673E+00	1.890E-01	8.573E-02
185.00	6	2.749E-01	-5.590E-02	-1.028E-03	-1.032E+00	9.778E-02	2.959E-02
195.00	6	1.123E-01	-2.204E-02	-2.430E-04	-4.513E-01	3.240E-02	6.766E-03

TIME SPENT IN OVERLAY SOLVE , CP = 2.1, PP = 0.0
SUBROUTINE REDTOC, CP = 0.0, PP = 0.0
SUBROUTINE WINTGL, CP = 0.2, PP = 0.0
SUBROUTINE CALPOW, CP = 0.0, PP = 0.0
SUBROUTINE SPROB , CP = 1.2, PP = 0.0
SUBROUTINE OUTPRO, CP = 0.1, PP = 0.0

APPENDIX I

CCCC Version III Standard Interface Files

The CCCC Standard Interface Files used in SYN3D are defined by the specifications in Ref. 24 with the following two additions:

(1) In the File Specification record of GEODST. The 23rd entry (one of the "Reserved" in Ref. 24) is used to specify the orientation of the (1,1) mesh triangle for triangular mesh geometries (IGOM=9 or 17) bounded, in the x-y plane, by rectangles (NTRIAG=2). In SYN3D that entry is designated "NTRIPT" and has the following definition.

NTRIPT = 1 - Triangle (1,1) points away from the first dimensions axis. i.e., no internal mesh line intersects the origin.

2 - Triangle (1,1) points towards the first dimension axis. i.e., an internal mesh line intersects the origin.

(2) In the Mesh Interval Boundary record of GEODST. For triangular mesh geometries (IGOM=9 or 17) the length (L) of a side of a triangle is calculated from

$$L = 2\,\frac{XMESH(2) - XMESH(1)}{IFINTS(1)}$$

The other entries in XMESH and YMESH are never used.

The rest of this appendix consists of listings of the following CCCC Standard Interface Files from Reference 24:

GEODST
ISOTXS
NDXSRF
ZNATDN
RTFLUX
ATFLUX
PWDINT
RZFLUX

APPENDIX I. CCCC Version III Standard Interface Files. GEODST

```
C*********************************************************************
C                        REVISED 07/22/75                            -
C                                                                    -
CF          GEODST - III                                             -
C                                                                    -
CE          GEOMETRY DESCRIPTION                                     -
C                                                                    -
C*********************************************************************


C--------------------------------------------------------------------
CR          FILE IDENTIFICATION                                      -
C                                                                    -
CL    HNAME,(HUSE(I),I=1,2),IVERS                                    -
C                                                                    -
CW    1+3*MULT=NUMBER OF WORDS                                       -
C                                                                    -
CD    HNAME                HOLLERITH FILE NAME - GEODST - (A6)      -
CD    HUSE(I)              HOLLERITH USER IDENTIFICATION (A6)       -
CD    IVERS                FILE VERSION NUMBER                      -
CD    MULT                 DOUBLE PRECISION PARAMETER               -
CD                             1- A6 WORD IS SINGLE WORD              -
CD                             2- A6 WORD IS DOUBLE PRECISION WORD    -
C                                                                    -
C--------------------------------------------------------------------


C--------------------------------------------------------------------
CR          FILE SPECIFICATIONS        (1D RECORD)                   -
C                                                                    -
CL    IGOM,NZONE,NREG,NZCL,NCINTI,NCINTJ,NCINTK,NINTI,NINTJ,NINTK,IMB1,-
CL    IMB2,JMB1,JMB2,KMB1,KMB2,NBS,NBCS,NIBCS,NZWBB,NTRIAG,NRASS,    -
CL    (NGOP(I),I=1,5)                                                -
C                                                                    -
CW    27=NUMBER OF WORDS                                             -
C                                                                    -
CD    IGOM                 GEOMETRY  0- POINT (FUNDAMENTAL MODE)    -
CD                                   1- SLAB                         -
CD                                   2- CYLINDER                     -
CD                                   3- SPHERE                       -
CD                                   6- X-Y                          -
CD                                   7- R-Z                          -
CD                                   8- THETA-R                      -
CD                                   9- TRIAGONAL (6 MESH POINTS IN EACH -
CD                                                 HEXAGONAL ELEMENT) -
CD                                  10- HEXAGONAL (1 MESH POINT IN EACH -
CD                                                 HEXAGONAL ELEMENT) -
CD                                  11- R-THETA                      -
CD                                  12- R-THETA-Z                    -
CD                                  13- R-THETA-ALPHA                -
CD                                  14- X-Y-Z                        -
CD                                  15- THETA-R-Z                    -
CD                                  16- THETA-R-ALPHA                -
CD                                  17- TRIAGONAL-Z (MESH POINTS AS IN 9, -
CD                                                   ABOVE)          -
CD                                  18- HEXAGON-Z   (MESH POINTS AS IN 10 -
CD                                                   ABOVE)          -
```

APPENDIX I. CCCC Version III Standard Interface Files. GEODST (Contd.)

```
CD     NZONE                NUMBER OF ZONES (EACH HOMOGENEOUS IN NEUTRONICS-
CD                          PROBLEM - A ZONE CONTAINS ONE OR MORE REGIONS) -
CD     NREG                 NUMBER OF REGIONS                              -
CD     NZCL                 NUMBER OF ZONE CLASSIFICATIONS (EDIT PURPOSES) -
CD     NCINTI               NUMBER OF FIRST DIMENSION COARSE MESH INTERVALS-
CD     NCINTJ               NUMBER OF SECOND DIMENSION COARSE MESH         -
CD                                  INTERVALS.  NCINTJ.EQ.1 FOR ONE        -
CD                                  DIMENSIONAL CASE.                      -
CD     NCINTK               NUMBER OF THIRD DIMENSION COARSE MESH INTERVALS-
CD                                  NCINTK.EQ.1 FOR ONE AND TWO            -
CD                                  DIMENSIONAL CASES.                     -
CD     NINTI                NUMBER OF FIRST DIMENSION FINE MESH INTERVALS  -
CD     NINTJ                NUMBER OF SECOND DIMENSION FINE MESH INTERVALS -
CD                                  NINTJ.EQ.1 FOR ONE DIMENSIONAL CASE.   -
CD     NINTK                NUMBER OF THIRD DIMENSION FINE MESH INTERVALS  -
CD                                  NINTK.EQ.1 FOR ONE AND TWO DIMENSIONAL-
CD                                  CASES.                                 -
CD     IMB1                 FIRST BOUNDARY ON FIRST DIMENSION              -
CD                                  0- ZERO FLUX (DIFFUSION)               -
CD                                  1- REFLECTED                           -
CD                                  2- EXTRAPOLATED (DIFFUSION - DEL PHI   -
CD                                     /PHI =-C/D WHERE C IS GIVEN AS BNDC-
CD                                     BELOW AND D IS THE GROUP DIFFUSION -
CD                                     CONSTANT, TRANSPORT - NO RETURN)   -
CD                                  3- REPEATING (PERIODIC) WITH OPPOSITE -
CD                                     FACE                                -
CD                                  4- REPEATING (PERIODIC) WITH NEXT      -
CD                                     ADJACENT FACE GOING CLOCKWISE       -
CD                                     AROUND THE FIRST AND SECOND         -
CD                                     DIMENSION PERIMETER.  PERTINENT     -
CD                                     ONLY FOR 2 OR 3 DIMENSIONAL         -
CD                                     PROBLEMS.                           -
CD                                  5- INVERTED REPEATING ALONG THIS FACE -
CD                                     (180 DEGREE ROTATION)               -
CD                                  6- ISOTROPIC RETURN (TRANSPORT)        -
C            NOTE THAT FOR REPEATING BOUNDARIES, THE FIRST BOUNDARY IN  -
C            ORDER WHICH IS INVOLVED CARRIES THE DESIGNATOR DEFINING    -
C            THE REPEATING CONDITION.                                   -
CD     IMB2                 LAST BOUNDARY ON FIRST DIMENSION               -
CD     JMB1                 FIRST BOUNDARY ON SECOND DIMENSION             -
CD     JMB2                 LAST BOUNDARY ON SECOND DIMENSION              -
CD     KMB1                 FIRST BOUNDARY ON THIRD DIMENSION              -
CD     KMB2                 LAST BOUNDARY ON THIRD DIMENSION               -
CD     NBS                  NUMBER OF BUCKLING SPECIFICATIONS              -
CD                               1- SINGLE VALUE APPLIES EVERYWHERE         -
CD                               .EQ.NZONE, ZONE-DEPENDENT                  -
CD                               .GT.NZONE, DATA IS GIVEN OVER ALL ZONES FOR-
CD                                 THE FIRST ENERGY GROUP, THEN FOR THE NEXT-
CD                                 GROUP, TO END OF LIST - IF THERE ARE MORE-
CD                                 GROUPS, LAST GROUP DATA GIVEN IS USED    -
CD     NBCS                 NUMBER OF CONSTANTS FOR EXTERNAL BOUNDARIES    -
CD                               1- SINGLE VALUE USED EVERYWHERE            -
CD                               6- INDIVIDUAL VALUES FOR EACH POSSIBLE     -
CD                                 SURFACE (BOUNDARY SPECS GIVE ACTUAL USE) -
CD                               .GT.6- SIX VALUES ARE GIVEN FOR THE FIRST  -
CD                                 ENERGY GROUP, THEN SIX FOR THE NEXT, TO  -
CD                                 THE END OF THE LIST - THE LAST GROUP DATA-
CD                                 GIVEN APPLIES TO ALL ADDITIONAL GROUPS   -
```

APPENDIX I. CCCC Version III Standard Interface Files. GEODST (Contd.)

```
CD     NIBCS                 NUMBER OF CONSTANTS FOR INTERNAL BOUNDARIES
CD                               1- SINGLE VALUES USED EVERYWHERE
CD                               .GT.1- VALUES ARE GIVEN BY ENERGY GROUP
CD                                 WITH NON-BLACK CONDITION INDICATED BY
CD                                 ZERO ENTRY - LAST VALUE APPLIES TO
CD                                 ADDITIONAL GROUPS
CD     NZWBB                 NUMBER OF ZONES WHICH ARE BLACK ABSORBERS
CD     NTRIAG                TRIAGONAL GEOMETRY OPTION
CD                               0- RHOMBUS WITH COORDINATES AT 120 DEGREES
CD                                  ORIGIN IS AT THE CENTER OF A HEXAGONAL
CD                                  ASSEMBLY,  BOUNDARIES PASS THROUGH
CD                                  CORNERS OF HEXAGONAL ASSEMBLIES,
CD                               1- SAME AS OPTION 0 EXCEPT COORDINATES AT
CD                                  60 DEGREES
CD                               2- RECTANGLE (COORDINATES AT 90 DEGREES),
CD                                  FIRST BOUNDARY PERPENDICULAR TO
CD                                  HEXAGONAL FLAT,
CD                               3- EQUILATERAL (60 DEGREE) TRIANGLE,  TWO
CD                                  BOUNDARIES ORIGINATING AT CENTER OF
CD                                  HEXAGONAL ASSEMBLY PASS THROUGH CORNERS
CD                                  OF HEXAGONAL ASSEMBLIES,
CD                               4- TRIANGLE (30-60 DEGREE), FIRST BOUNDARY
CD                                  PERPENDICULAR TO FLATS,
CD     NRASS                 REGION ASSIGNMENTS
CD                               0- TO COARSE MESH
CD                               1- TO FINE MESH
CD     NGOP(I)               RESERVED
C
C-----------------------------------------------------------------------

C-----------------------------------------------------------------------
CR          ONE DIMENSIONAL COARSE MESH INTERVAL BOUNDARIES AND FINE
CR          MESH INTERVALS            (2D RECORD)
C
CC          PRESENT IF IGOM.GT.0 AND IGOM.LE.3
C
CL     (XMESH(I),I=1,NCBNDI),(IFINTS(I),I=1,NCINTI)
C
CW     NCBNDI*MULT+NCINTI=NUMBER OF WORDS
C
CD     XMESH(I)              COARSE MESH BOUNDARIES, FIRST DIMENSION
CD     IFINTS(I)             NUMBER OF FINE MESH INTERVALS PER COARSE MESH
CD                               INTERVAL, FIRST DIMENSION
CD     NCBNDI                NCINTI+1, NUMBER OF FIRST DIMENSION COARSE MESH
CD                               BOUNDARIES
C
CC         UNITS ARE CM FOR LINEAR DIMENSIONS AND RADIANS FOR ANGULAR
CC         DIMENSIONS
C
C-----------------------------------------------------------------------
```

APPENDIX I. CCCC Version III Standard Interface Files. GEODST (Contd.)

```
C-----------------------------------------------------------------------
CR          TWO DIMENSIONAL COARSE MESH INTERVAL BOUNDARIES AND FINE   -
CR          MESH INTERVALS            (3D RECORD)                      -
C                                                                      -
CC          PRESENT IF IGOM,GE,6 AND IGOM,LE,11                        -
C                                                                      -
CL    (XMESH(I),I=1,NCBNDI),(YMESH(J),J=1,NCBNDJ),                     -
CL   1(IFINTS(I),I=1,NCINTI),(JFINTS(J),J=1,NCINTJ)                    -
C                                                                      -
CW    (NCBNDI+NCBNDJ)*MULT+NCINTI+NCINTJ=NUMBER OF WORDS               -
C                                                                      -
CD    YMESH(J)            COARSE MESH BOUNDARIES, SECOND DIMENSION     -
CD    JFINTS(J)           NUMBER OF FINE MESH INTERVALS PER COARSE MESH -
CD                            INTERVAL, SECOND DIMENSION               -
CD    NCBNDJ              NCINTJ+1, NUMBER OF SECOND DIMENSION COARSE  -
CD                            MESH BOUNDARIES                          -
C                                                                      -
C-----------------------------------------------------------------------


C-----------------------------------------------------------------------
CR          THREE DIMENSIONAL COARSE MESH INTERVAL BOUNDARIES AND FINE -
CR          MESH INTERVALS          (4D RECORD)                        -
C                                                                      -
CC          PRESENT IF IGOM,GE,12                                      -
C                                                                      -
CL    (XMESH(I),I=1,NCBNDI),(YMESH(J),J=1,NCBNDJ),                     -
CL   1(ZMESH(K),K=1,NCBNDK),(IFINTS(I),I=1,NCINTI),                    -
CL   2(JFINTS(J),J=1,NCINTJ),(KFINTS(K),K=1,NCINTK)                    -
C                                                                      -
CW    (NCBNDI+NCBNDJ+NCBNDK)*MULT+NCINTI+NCINTJ+NCINTK=NUMBER OF WORDS -
C                                                                      -
CD    ZMESH(K)            COARSE MESH BOUNDARIES, THIRD DIMENSION      -
CD    KFINTS(K)           NUMBER OF FINE MESH INTERVALS PER COARSE MESH -
CD                            INTERVAL, THIRD DIMENSION                -
CD    NCBNDK              NCINTK+1, NUMBER OF THIRD DIMENSION COARSE MESH-
CD                            BOUNDARIES                               -
C                                                                      -
C-----------------------------------------------------------------------


C-----------------------------------------------------------------------
CR          GEOMETRY DATA         (5D RECORD)                          -
C                                                                      -
CC          PRESENT IF IGOM,GT,0 OR NBS,GT,0                           -
C                                                                      -
CL    (VOLR(N),N=1,NREG),(BSQ(N),N=1,NBS),(BNDC(N),N=1,NBCS),          -
CL    (BNCI(N),N=1,NIBCS),(NZHBB(N),N=1,NZWBB),(NZC(N),N=1,NZONE),     -
CL    (NZNR(N),N=1,NREG)                                               -
C                                                                      -
CW    2*NREG+NBS+NBCS+NIBCS+NZWBB+NZONE=NUMBER OF WORDS                -
C                                                                      -
CD    VOLR(N)             REGION VOLUMES (CC)                          -
CD    BSQ(N)              BUCKLING (B**2) VALUES (CM**-2)              -
CD    BNDC(N)             BOUNDARY CONSTANTS (DEL PHI/PHI =-C/D)       -
CD    BNCI(N)             INTERNAL BLACK BOUNDARY CONSTANTS            -
CD    NZHBB(N)            ZONE NUMBERS WITH BLACK ABSORBER CONDITIONS  -
CD    NZC(N)              ZONE CLASSIFICATIONS                         -
```

APPENDIX I. CCCC Version III Standard Interface Files. GEODST (Contd.)

```
CD    NZNR(N)            ZONE NUMBER ASSIGNED TO EACH REGION              *
C                                                                         *
C-------------------------------------------------------------------------*
C-------------------------------------------------------------------------*
CR          REGION ASSIGNMENTS TO COARSE MESH INTERVALS                   *
CR                              (6D RECORD)                               *
C                                                                         *
CC          PRESENT IF IGOM.GT.0 AND NRASS.EQ.0                           *
C                                                                         *
CL    ((MR(I,J),I=1,NCINTI),J=1,NCINTJ)----NOTE STRUCTURE BELOW----       *
C                                                                         *
CW    NCINTI*NCINTJ=NUMBER OF WORDS                                       *
C                                                                         *
CS    DO 1 K=1,NCINTK                                                     *
CS  1 READ(N) *LIST AS ABOVE*                                             *
C                                                                         *
CD    MR(I,J)            REGION NUMBERS ASSIGNED TO COARSE MESH           *
CD                           INTERVALS                                    *
C                                                                         *
C-------------------------------------------------------------------------*
C-------------------------------------------------------------------------*
CR          REGION ASSIGNMENTS TO FINE MESH INTERVALS                     *
CR                                (7D RECORD)                             *
C                                                                         *
CC          PRESENT IF IGOM.GT.0 AND NRASS.EQ.1                           *
C                                                                         *
CL    ((MR(I,J),I=1,NINTI),J=1,NINTJ)----NOTE STRUCTURE BELOW----         *
C                                                                         *
CW    NINTI*NINTJ=NUMBER OF WORDS                                         *
CS    DO 1 K=1,NINTK                                                      *
CS  1 READ(N) *LIST AS ABOVE*                                             *
C                                                                         *
CD    MR(I,J)            REGION NUMBERS ASSIGNED TO FINE MESH INTERVALS   *
C                                                                         *
C-------------------------------------------------------------------------*

CEOF
```

APPENDIX I. CCCC Version III Standard Interface Files. ISOTXS

```
C*********************************************************************
C                         REVISED 07/23/75                            -
C                                                                     -
CF          ISOTXS-III                                                -
CE          MICROSCOPIC GROUP NEUTRON CROSS SECTIONS                  -
C                                                                     -
CN                        THIS FILE PROVIDES A BASIC BROAD GROUP      -
CN                        LIBRARY, ORDERED BY ISOTOPE                 -
CN                        FORMATS GIVEN ARE FOR FILE EXCHANGE PURPOSES -
CN                        ONLY.                                       -
C                                                                     -
C*********************************************************************


C---------------------------------------------------------------------
CS          FILE STRUCTURE                                            -
CS                                                                    -
CS             RECORD TYPE                          PRESENT IF        -
CS             ============================         ==============    -
CS             FILE IDENTIFICATION                  ALWAYS            -
CS             FILE CONTROL                         ALWAYS            -
CS             FILE DATA                            ALWAYS            -
CS             SET CHI DATA                         ICHIST.GT.1       -
CS                                                                    -
CS   *************(REPEAT FOR ALL ISOTOPES)                          -
CS   *         ISOTOPE CONTROL AND GROUP                              -
CS   *                        INDEPENDENT DATA     ALWAYS            -
CS   *         PRINCIPAL CROSS SECTIONS             ALWAYS            -
CS   *         ISOTOPE CHI DATA                     ICHI.GT.1         -
CS   *                                                                -
CS   *  **********(REPEAT TO NSCMAX SCATTERING BLOCKS)                -
CS   *  *  *******(REPEAT FROM 1 TO NSBLOK)                           -
CS   *  *  *   SCATTERING SUB-BLOCK                 LORD(N).GT.0      -
CS   *************                                                    -
C                                                                     -
C---------------------------------------------------------------------


C---------------------------------------------------------------------
CR          FILE IDENTIFICATION                                       -
C                                                                     -
CL    HNAME,(HUSE(I),I=1,2),IVERS                                     -
C                                                                     -
CW    1+3*MULT=NUMBER OF WORDS                                        -
C                                                                     -
CB    FORMAT(11H 0V ISOTXS ,A6,1H*,                                   -
CB   12A6,1H*,I6)                                                     -
C                                                                     -
CD    HNAME          HOLLERITH FILE NAME - ISOTXS - (A6)              -
CD    HUSE(I)        HOLLERITH USER IDENTIFICATION (A6)               -
CD    IVERS          FILE VERSION NUMBER                              -
CD    MULT           DOUBLE PRECISION PARAMETER                       -
CD                       1- A6 WORD IS SINGLE WORD                    -
CD                       2- A6 WORD IS DOUBLE PRECISION WORD          -
C                                                                     -
C---------------------------------------------------------------------
```

APPENDIX I. CCCC Version III Standard Interface Files. ISOTXS (Contd.)

```
C-----------------------------------------------------------------------
CR          FILE CONTROL      (1D RECORD)                              -
C                                                                      -
CL    NGROUP,NISO,MAXUP,MAXDN,MAXORD,ICHIST,NSCMAX,NSBLOK              -
C                                                                      -
CW    8=NUMBER OF WORDS                                                -
C                                                                      -
CB    FORMAT(4H 1D ,8I6)                                               -
C                                                                      -
CD    NGROUP          NUMBER OF ENERGY GROUPS IN SET                   -
CD    NISO            NUMBER OF ISOTOPES IN SET                        -
CD    MAXUP           MAXIMUM NUMBER OF UPSCATTER GROUPS               -
CD    MAXDN           MAXIMUM NUMBER OF DOWNSCATTER GROUPS             -
CD    MAXORD          MAXIMUM SCATTERING ORDER (MAXIMUM VALUE OF       -
CD                       LEGENDRE EXPANSION INDEX USED IN FILE).       -
CD    ICHIST          SET FISSION SPECTRUM FLAG                        -
CD                       ICHIST.EQ.0,       NO FISSION SPECTRUM         -
CD                       ICHIST.EQ.1,       SET VECTOR                  -
CD                       ICHIST.GT.1,       SET MATRIX                  -
CD    NSCMAX          MAXIMUM NUMBER OF BLOCKS OF SCATTERING DATA      -
CD    NSBLOK          BLOCKING CONTROL FOR SCATTER MATRICES.  THE      -
CD                       SCATTERING DATA ARE BLOCKED INTO NSBLOK       -
CD                       RECORDS PER SCATTERING BLOCK.                 -
C                                                                      -
C-----------------------------------------------------------------------


C-----------------------------------------------------------------------
CR          FILE DATA         (2D RECORD)                              -
C                                                                      -
CL    (HSETID(I),I=1,12),(HISONM(I),I=1,NISO),                         -
CL   1(CHI(J),J=1,NGROUP),(VEL(J),J=1,NGROUP),                         -
CL   2(EMAX(J),J=1,NGROUP),EMIN,(LOCA(I),I=1,NISO)                     -
C                                                                      -
CW    (NISO+12)*MULT+1+NISO                                            -
CW    +NGROUP*(2+ICHIST*(2/(ICHIST+1)))=NUMBER OF WORDS                -
C                                                                      -
CB    FORMAT(4H 2D ,1H*,11A6,1H*/       HSETID,HISONM                  -
CB   11H*,A6,1H*,9(1X,A6)/(10(1X,A6)))                                 -
CB    FORMAT(1P6E12.5)                  CHI (PRESENT IF ICHIST.EQ.1)   -
CB    FORMAT(1P6E12.5)                  VEL,EMAX,EMIN                  -
CB    FORMAT(12I6)                      LOCA                           -
C                                                                      -
CD    HSETID(I)       HOLLERITH IDENTIFICATION OF SET (A6)             -
CD    HISONM(I)       HOLLERITH ISOTOPE LABEL FOR ISOTOPE I (A6)       -
CD    CHI(J)          SET FISSION SPECTRUM (PRESENT IF ICHIST.EQ.1)    -
CD    VEL(J)          MEAN NEUTRON VELOCITY IN GROUP J (CM/SEC)        -
CD    EMAX(J)         MAXIMUM ENERGY BOUND OF GROUP J (EV)             -
CD    EMIN            MINIMUM ENERGY BOUND OF SET (EV)                 -
CD    LOCA(I)         NUMBER OF RECORDS TO BE SKIPPED TO READ DATA FOR -
CD                       ISOTOPE I.  LOCA(1)=0                         -
C                                                                      -
C-----------------------------------------------------------------------
```

APPENDIX I. CCCC Version III Standard Interface Files. ISOTXS (Contd.)

```
C-----------------------------------------------------------------------
CR          SET CHI DATA      (3D RECORD)                              -
C                                                                      -
CC        PRESENT IF ICHIST.GT.1                                       -
C                                                                      -
CL    ((CHI(K,J),K=1,ICHIST),J=1,NGROUP),(ISSPEC(I),I=1,NGROUP)        -
C                                                                      -
CW    NGROUP*(ICHIST+1)=NUMBER OF WORDS                                -
C                                                                      -
CB    FORMAT(4H 3D ,1P5E12.5/(6E12.5)) CHI                             -
CB    FORMAT(12I6)                        ISSPEC                       -
C                                                                      -
CD    CHI(K,J)       FRACTION OF NEUTRONS EMITTED IN GROUP J AS A      -
CD                      RESULT OF FISSION IN ANY GROUP USING SPECTRUM K -
CD    ISSPEC(I)      ISSPEC(I)=K IMPLIES THAT SPECTRUM K IS USED       -
CD                      TO CALCULATE EMISSION SPECTRUM FROM FISSION    -
CD                      IN GROUP I                                     -
C                                                                      -
C-----------------------------------------------------------------------


C-----------------------------------------------------------------------
CR          ISOTOPE CONTROL AND GROUP INDEPENDENT DATA  (4D RECORD)    -
C                                                                      -
CL    HABSID,HIDENT,HMAT,AMASS,EFISS,ECAPT,TEMP,SIGPOT,ADENS,KBR,ICHI, -
CL   1IFIS,IALF,INP,IN2N,IND,INT,LTOT,LTRN,ISTRPD,                     -
CL   2(IDSCT(N),N=1,NSCMAX),(LORD(N),N=1,NSCMAX),                      -
CL   3((JBAND(J,N),J=1,NGROUP),N=1,NSCMAX),                            -
CL   4((IJJ(J,N),J=1,NGROUP),N=1,NSCMAX)                               -
C                                                                      -
CW    3*MULT+17+NSCMAX*(2*NGROUP+2)=NUMBER OF WORDS                    -
C                                                                      -
CB    FORMAT(4H 4D ,3(1X,A6)/1P6E12.5/                                 -
CB   1(12I6))                                                          -
C                                                                      -
CD    HABSID         HOLLERITH ABSOLUTE ISOTOPE LABEL - SAME FOR ALL   -
CD                              VERSIONS OF THE SAME ISOTOPE IN SET (A6) -
CD    HIDENT         IDENTIFIER OF LIBRARY FROM WHICH BASIC DATA       -
CD                              CAME(E.G. ENDF/B) (A6)                 -
CD    HMAT           ISOTOPE IDENTIFICATION (E.G. ENDF/B MAT NO.) (A6) -
CD    AMASS          GRAM ATOMIC WEIGHT                                -
CD    EFISS          TOTAL THERMAL ENERGY YIELD/FISSION (W.SEC/FISS)   -
CD    ECAPT          TOTAL THERMAL ENERGY YIELD/CAPTURE (W.SEC/CAPT)   -
CD    TEMP           ISOTOPE TEMPERATURE (DEGREES KELVIN)              -
CD    SIGPOT         AVERAGE EFFECTIVE POTENTIAL SCATTERING IN         -
CD                              RESONANCE RANGE (BARNS/ATOM)           -
CD    ADENS          DENSITY OF ISOTOPE IN MIXTURE IN WHICH ISOTOPE    -
CD                              CROSS SECTIONS WERE GENERATED (A/BARN.CM)-
CD    KBR            ISOTOPE CLASSIFICATION                            -
CD                      0=UNDEFINED                                    -
CD                      1=FISSILE                                      -
CD                      2=FERTILE                                      -
CD                      3=OTHER ACTINIDE                               -
CD                      4=FISSION PRODUCT                              -
CD                      5=STRUCTURE                                    -
CD                      6=COOLANT                                      -
CD                      7=CONTROL                                      -
CD    ICHI           ISOTOPE FISSION SPECTRUM FLAG                     -
```

APPENDIX I. CCCC Version III Standard Interface Files. ISOTXS (Contd.)

```
CD                          ICHI.EQ.0,      USE SET CHI                          -
CD                          ICHI.EQ.1,      ISOTOPE CHI VECTOR                   -
CD                          ICHI.GT.1,      ISOTOPE CHI MATRIX                   -
CD     IFIS            (N,F) CROSS SECTION FLAG                                 -
CD                        IFIS=0, NO FISSION DATA IN PRINCIPAL CROSS             -
CD                                          SECTION RECORD                       -
CD                            =1, FISSION DATA PRESENT IN PRINCIPAL              -
CD                                          CROSS SECTION RECORD                 -
CD     IALF            (N,ALPHA) CROSS SECTION FLAG                             -
CD                        SAME OPTIONS AS IFIS                                   -
CD     INP             (N,P) CROSS SECTION FLAG                                 -
CD                        SAME OPTIONS AS IFIS                                   -
CD     IN2N            (N,2N) CROSS SECTION FLAG                                -
CD                        SAME OPTIONS AS IFIS                                   -
CD     IND             (N,D) CROSS SECTION FLAG                                 -
CD                        SAME OPTIONS AS IFIS                                   -
CD     INT             (N,T) CROSS SECTION FLAG                                 -
CD                        SAME OPTIONS AS IFIS                                   -
CD     LTOT            NUMBER OF MOMENTS OF TOTAL CROSS SECTION PROVIDED        -
CD                        IN PRINCIPAL CROSS SECTIONS RECORD                     -
CD     LTRN            NUMBER OF MOMENTS OF TRANSPORT CROSS SECTION             -
CD                        PROVIDED IN PRINCIPAL CROSS SECTIONS RECORD            -
CD     ISTRPD          NUMBER OF COORDINATE DIRECTIONS FOR WHICH                -
CD                        COORDINATE DEPENDENT TRANSPORT CROSS SECTIONS          -
CD                        ARE GIVEN. IF ISTRPD=0, NO COORDINATE DEPENDENT        -
CD                        TRANSPORT CROSS SECTIONS ARE GIVEN.                    -
CD     IDSCT(N)        SCATTERING MATRIX TYPE IDENTIFICATION FOR                -
CD                        SCATTERING BLOCK N.  SIGNIFICANT ONLY IF               -
CD                        LORD(N).GT.0                                           -
CD                        IDSCT(N)=000 + NN, TOTAL SCATTERING (SUM OF            -
CD                        ELASTIC, INELASTIC, AND N, 2N SCATTERING)              -
CD                                =100 + NN, ELASTIC SCATTERING                  -
CD                                =200 + NN, INELASTIC SCATTERING                -
CD                                =300 + NN, (N,2N) SCATTERING PER EMITTED-
CD                                                              NEUTRON,       -
CD                        WHERE NN IS THE LEGENDRE EXPANSION INDEX OF THE        -
CD                        FIRST MATRIX IN BLOCK N                                -
CD     LORD(N)         NUMBER OF SCATTERING ORDERS IN BLOCK N.  IF              -
CD                        LORD(N)=0, THIS BLOCK IS NOT PRESENT FOR THIS          -
CD                        ISOTOPE.  IF NN IS THE VALUE TAKEN FROM                -
CD                        IDSCT(N), THEN THE MATRICES IN THIS BLOCK              -
CD                        HAVE LEGENDRE EXPANSION INDICES OF NN,NN+1,            -
CD                        NN+2,...,NN+LORD(N)-1                                  -
CD     JBAND(J,N)      SCATTERING BANDWIDTH FOR GROUP J, SCATTERING             -
CD                        BLOCK N                                                -
CD     IJJ(J,N)        POSITION OF IN-GROUP SCATTERING CROSS SECTION IN         -
CD                        SCATTERING DATA FOR GROUP J, SCATTERING BLOCK          -
CD                        N,COUNTED FROM THE FIRST WORD OF GROUP J DATA.         -
C                                                                                -
C-----------------------------------------------------------------------------
```

APPENDIX I. CCCC Version III Standard Interface Files. ISOTXS (Contd.)

```
C-----------------------------------------------------------------------
CR          PRINCIPAL CROSS SECTIONS   (5D RECORD)                      -
C                                                                        -
CL     ((STRPL(J,L),J=1,NGROUP),L=1,LTRN),                               -
CL    1((STOTPL(J,L),J=1,NGROUP),L=1,LTOT),(SNGAM(J),J=1,NGROUP),        -
CL    2(SFIS(J),J=1,NGROUP),(SNUTOT(J),J=1,NGROUP),                      -
CL    3(CHISO(J),J=1,NGROUP),(SNALF(J),J=1,NGROUP),                      -
CL    4(SNP(J),J=1,NGROUP),(SN2N(J),J=1,NGROUP),                         -
CL    5(SND(J),J=1,NGROUP),(SNT(J),J=1,NGROUP)                           -
CL    6((STRPD(J,I),J=1,NGROUP),I=1,ISTRPD)                              -
C                                                                        -
CW     (1+LTRN+LTOT+IALF+INP+IN2N+IND+INT+ISTRPD+2*IFIS+                 -
CW     ICHI*(2/(ICHI+1)))*NGROUP=NUMBER OF WORDS                         -
C                                                                        -
CB     FORMAT(4H 5D ,1P5E12.5/(6E12.5)) LENGTH OF LIST AS ABOVE          -
C                                                                        -
CD     STRPL(J,L)     PL WEIGHTED TRANSPORT CROSS SECTION                -
CD     STOTPL(J,L)    PL WEIGHTED TOTAL CROSS SECTION                    -
CD                       THE FIRST ELEMENT OF ARRAY STRPL IS THE         -
CD                       CURRENT (P1) WEIGHTED TRANSPORT CROSS SECTION   -
CD                       THE FIRST ELEMENT OF ARRAY STOTPL IS THE        -
CD                       FLUX (P0) WEIGHTED TOTAL CROSS SECTION          -
CD     SNGAM(J)       (N,GAMMA)                                          -
CD     SFIS(J)        (N,F)          (PRESENT IF IFIS.GT.0)              -
CD     SNUTOT(J)      TOTAL NEUTRON YIELD/FISSION  (PRESENT IF IFIS.GT.0)-
CD     CHISO(J)       ISOTOPE CHI  (PRESENT IF ICHI.EQ.1)                -
CD     SNALF(J)       (N,ALPHA)    (PRESENT IF IALF.GT.0)                -
CD     SNP(J)         (N,P)        (PRESENT IF INP.GT.0)                 -
CD     SN2N(J)        (N,2N)(LOSS) (PRESENT IF IN2N.GT.0)                -
CD     SND(J)         (N,D)        (PRESENT IF IND.GT.0)                 -
CD     SNT(J)         (N,T)        (PRESENT IF INT.GT.0)                 -
CD     STRPD(J,I)     COORDINATE DIRECTION I TRANSPORT CROSS SECTION    -
CD                                  (PRESENT IF ISTRPD.GT.0)             -
C                                                                        -
C-----------------------------------------------------------------------


C-----------------------------------------------------------------------
CR          ISOTOPE CHI DATA      (6D RECORD)                            -
C                                                                        -
CC          PRESENT IF ICHI.GT.1                                         -
C                                                                        -
CL     ((CHIISO(K,J),K=1,ICHI),J=1,NGROUP),(ISOPEC(I),I=1,NGROUP)        -
C                                                                        -
CW     NGROUP*(ICHI+1)=NUMBER OF WORDS                                   -
C                                                                        -
CB     FORMAT(4H 6D ,1P5E12.5/(6E12.5)) CHIISO                           -
CB     FORMAT(12I6)                     ISOPEC                           -
C                                                                        -
CD     CHIISO(K,J)    FRACTION OF NEUTRONS EMITTED IN GROUP J AS A       -
CD                       RESULT OF FISSION IN ANY GROUP USING SPECTRUM K -
CD     ISOPEC(I)      ISOPEC(I)=K IMPLIES THAT SPECTRUM K IS USED        -
CD                       TO CALCULATE EMISSION SPECTRUM FROM FISSION     -
CD                       IN GROUP I                                      -
C                                                                        -
C                                                                        -
C-----------------------------------------------------------------------
```

APPENDIX I. CCCC Version III Standard Interface Files. ISOTXS (Contd.)

```
C*------------------------------------------------------------------------*
CR          SCATTERING SUB-BLOCK      (7D RECORD)                         *
C                                                                          *
CC        PRESENT IF LORD(N).GT.0                                          *
C                                                                          *
CL    ((SCAT(K,L),K=1,KMAX),L=1,LORDN)                                     *
C                                                                          *
CC    KMAX=SUM OVER J OF JBAND(J) WITHIN THE J-GROUP RANGE OF THIS         *
CC       SUB-BLOCK.  IF M IS THE INDEX OF THE SUB-BLOCK, THE J-GROUP       *
CC       RANGE CONTAINED WITHIN THIS SUB-BLOCK IS                          *
CC       JL=(M-1)*((NGROUP-1)/NSBLOK+1)+1 TO JU=M*((NGROUP-1)/NSBLOK+1)*
CC    LORDN=LORD(N)                                                        *
C                                                                          *
CW    KMAX*LORDN=NUMBER OF WORDS                                           *
C                                                                          *
CB    FORMAT(4H 7D ,1P5E12.5/(6E12.5))                                     *
C                                                                          *
CD    SCAT(K,L)      SCATTERING MATRIX OF SCATTERING ORDER L, FOR          *
CD                      REACTION TYPE IDENTIFIED BY IDSCT(N) FOR THIS     *
CD                      BLOCK.  JBAND(J) VALUES FOR SCATTERING INTO       *
CD                      GROUP J ARE STORED AT LOCATIONS K=SUM FROM 1      *
CD                      TO (J-1) OF JBAND(I) PLUS 1 TO K-1+JBAND(J).      *
CD                      THE SUM IS ZERO WHEN J=1.  J-TO-J SCATTER IS      *
CD                      THE IJJ(J)-TH ENTRY IN THE RANGE JBAND(J).        *
CD                      VALUES ARE STORED IN THE ORDER (J+JUP),           *
CD                      (J+JUP-1),...,(J+1),J,(J-1),...,(J-JDN),          *
CD                      WHERE JUP=IJJ(J)-1 AND JDN=JBAND(J)-IJJ(J)        *
C                                                                          *
C*------------------------------------------------------------------------*

CEOF
```

APPENDIX I. CCCC Version III Standard Interface Files. NDXSRF

```
C*********************************************************************
C                         REVISED 07/22/75                            -
C                                                                     -
CF          NDXSRF - III                                              -
C                                                                     -
CE          NUCLIDE DENSITY, DATA, CROSS SECTION REFERENCING          -
C                                                                     -
C*********************************************************************


C---------------------------------------------------------------------
CR          FILE IDENTIFICATION                                       -
C                                                                     -
CL    HNAME,(HUSE(I),I=1,2),IVERS                                     -
C                                                                     -
CW    1+3*MULT=NUMBER OF WORDS                                        -
C                                                                     -
CD    HNAME          HOLLERITH FILE NAME - NDXSRF - (A6)              -
CD    HUSE(I)        HOLLERITH USER IDENTIFICATION (A6)               -
CD    IVERS          FILE VERSION NUMBER                              -
CD    MULT           DOUBLE PRECISION PARAMETER                       -
CD                       1= A6 WORD IS SINGLE WORD                    -
CD                       2=A6 WORD IS DOUBLE PRECISION WORD           -
C                                                                     -
C---------------------------------------------------------------------


C---------------------------------------------------------------------
CR          SPECIFICATIONS          (1D RECORD)                       -
C                                                                     -
CL    NON,NSN,NNS,NAN,NZONE,NSZ                                       -
C                                                                     -
CW    6   =NUMBER OF WORDS                                            -
C                                                                     -
CD    NON                NUMBER OF NUCLIDES IN CROSS SECTION DATA   -
CD    NSN                NUMBER OF NUCLIDE SETS IDENTIFIED          -
CD    NNS                MAXIMUM NUMBER OF NUCLIDES IN ANY SET      -
CD    NAN                NUMBER OF DIFFERENT NUCLIDES IN DATA       -
CD    NZONE              NUMBER OF ZONES                            -
CD    NSZ                NUMBER OF SUBZONES (SUBASSEMBLIES)         -
C                                                                     -
C---------------------------------------------------------------------


C---------------------------------------------------------------------
C           NUCLIDE REFERENCING DATA        (2D RECORD)               -
C                                                                     -
CL      (HNNAME(N),N=1,NON),(HANAME(N),N=1,NON),(WPF(N),N=1,NON),     -
CL    (ATWT(J),J=1,NAN),(NCLN(N),N=1,NON),((NDXS(K,L),K=1,4),L=1,NSN), -
CL    ((NOS(I,L),I=1,NNS),L=1,NSN),((NOR(N,L),N=1,NON),L=1,NSN)       -
C                                                                     -
CW   NAN+2*NON*(1+MULT)+NSN*(4+NNS+NON)=NUMBER OF WORDS               -
C                                                                     -
CD    HNNAME(N)          UNIQUE REFERENCE NUCLIDE NAME, IN LIBRARY ORDER-
CD                           (A6) ALPHANUMERIC                        -
CD    HANAME(N)          ABSOLUTE NUCLIDE REFERENCE, IN LIBRARY ORDER -
CD                           (A6) ALPHANUMERIC                        -
```

APPENDIX I. CCCC Version III Standard Interface Files. NDXSRF (Contd.)

```
CD     WPF(N)              RESERVED                                          -
CD     ATWT(J)             ATOMIC WEIGHT                                     -
CD     NCLN(N)             NUCLIDE CLASSIFICATION                            -
CD                             1- FISSILE                                    -
CD                             2- FERTILE                                    -
CD                             3- OTHER ACTINIDE                             -
CD                             4- FISSION PRODUCT                            -
CD                             5- STRUCTURAL                                 -
CD                             6- COOLANT                                    -
CD                             7- CONTROL ROD                                -
CD                             GREATER THAN 7, UNDEFINED                     -
CD     NDXS(K,L)           REFERENCE DATA FOR SET L                          -
CD                             K = 1, NUMBER OF NUCLIDES IN SET              -
CD                             K = 2, RESERVED                               -
CD                             K = 3, RESERVED                               -
CD                             K = 4, RESERVED                               -
CD     NOS(I,L)            ORDER NUMBER OF NUCLIDE IN CROSS SECTION DATA     -
CD                             (IN HNNAME LIST) OF NUCLIDE ORDERED I IN      -
CD                             SET L                                         -
CD     NOR(N,L)            ORDER NUMBER OF NUCLIDE IN SET L GIVEN ORDER      -
CD                             NUMBER N IN CROSS SECTION DATA                -
C                                                                            -
C-----------------------------------------------------------------------------


C-----------------------------------------------------------------------------
CR           NUCLIDE CONCENTRATION ASSIGNM+-T DATA      (3D RECORD)           -
C                                                                            -
CL     (VOLZ(N),N=1,NZONE),(VFPA(N),N=1,NZONE),(VLSA(M),M=1,NSZ),            -
CL     (NSPA(N),N=1,NZONE),(NSSA(M),M=1,NSZ),(NZSZ(M),M=1,NSZ)                -
C                                                                            -
CW     3*(NZONE+NSZ)=NUMBER OF WORDS                                         -
C                                                                            -
CD     VOLZ(N)             VOLUMES OF ZONES, CC                              -
CD     VFPA(N)             VOLUME FRACTIONS FOR PRIMARY ZONE ASSIGNMENTS     -
CD     VLSA(M)             VOLUMES OF SUBZONES                               -
CD     NSPA(N)             NUCLIDE SET REFERENCE, PRIMARY ZONE ASSIGNMENT    -
CD                             (MAY BE ZERO ONLY IF THERE ARE SUBZONES)      -
CD     NSSA(M)             NUCLIDE SET REFERENCE ASSIGNMENT TO SUBZONES      -
CD     NZSZ(M)             ZONE CONTAINING SUBZONE                           -
C                                                                            -
C      NOTE THAT TO CALCULATE MACROSCOPIC CROSS SECTIONS FOR A ZONE,         -
C      IT IS NECESSARY TO CONSIDER THE CONCENTRATION OF EACH NUCLIDE         -
C      IN THE PRIMARY SET ASSIGNMENT (UNLESS A ZERO IN NSPA INDICATES        -
C      THERE ARE NONE) TIMES THE VOLUME FRACTION, AND THE CONCENTRATION      -
C      OF EACH NUCLIDE IN EACH SUBZONE ASSIGNED TO THE ZONE TIMES THE        -
C      RATIO OF THE SUBZONE VOLUME TO THE ZONE VOLUME.                       -
C                                                                            -
C-----------------------------------------------------------------------------


CEOF
```

APPENDIX I. CCCC Version III Standard Interface Files. ZNATDN

```
C*********************************************************************
C                         REVISED 07/22/75                            *
C                                                                     *
CF          ZNATDN - III                                              *
C                                                                     *
CE          ZONE ATOMIC DENSITIES (OF NUCLIDES)                       *
C                                                                     *
C*********************************************************************


C---------------------------------------------------------------------
CR          FILE IDENTIFICATION                                       *
C                                                                     *
CL    HNAME,(HUSE(I),I=1,2),IVERS                                     *
C                                                                     *
CW    1+3*MULT=NUMBER OF WORDS                                        *
C                                                                     *
CD    HNAME                 HOLLERITH FILE NAME - ZNATDN -(A6)        *
CD    HUSE(I)               HOLLERITH USER IDENTIFICATION (A6)        *
CD    IVERS                 FILE VERSION NUMBER                       *
CD    MULT                  DOUBLE PRECISION PARAMETER                *
CD                              1- A6 WORD IS SINGLE WORD             *
CD                              2- A6 WORD IS DOUBLE PRECISION WORD   *
C                                                                     *
C---------------------------------------------------------------------


C---------------------------------------------------------------------
CR          SPECIFICATIONS            (1D RECORD)                     *
C                                                                     *
CL    TIME,NCY,NTZSZ,NNS,NBLKAD                                       *
C                                                                     *
CW    5=NUMBER OF WORDS                                               *
C                                                                     *
CD    TIME                  REFERENCE REAL TIME, DAYS                 *
CD    NCY                   REFERENCE CYCLE NUMBER                    *
CD    NTZSZ                 NUMBER OF ZONES PLUS NUMBER OF SUBZONES   *
CD    NNS                   MAXIMUM NUMBER OF NUCLIDES IN ANY SET     *
CD    NBLKAD                NUMBER OF BLOCKS OF ATOM DENSITY DATA     *
C                                                                     *
C---------------------------------------------------------------------


C---------------------------------------------------------------------
CR          ZONE ATOMIC DENSITIES (OF NUCLIDES)       (2D RECORD)     *
C                                                                     *
CL    ((ADEN(N,J),N=1,NNS),J=JL,JU)----SEE STRUCTURE BELOW----        *
C                                                                     *
CW    NNS*((NTZSZ-1)/NBLKAD+1)=NUMBER OF WORDS                        *
C                                                                     *
CC    DO 1 M=1,NBLKAD                                                 *
CC  1 READ(N) *LIST AS ABOVE*                                         *
C                                                                     *
CC        WITH M AS THE BLOCK INDEX, JL=(M-1)*((NTZSZ-1)/NBLKAD+1)+1  *
CC        AND JU=M*((NTZSZ-1)/NBLKAD+1)                               *
```

APPENDIX I. CCCC Version III Standard Interface Files. ZNATDN (Contd.)

```
C                                                                       *
CD     ADEN(N,J)          ATOMIC DENSITY OF NUCLIDE ORDERED N IN THE    *
CD                        ASSOCIATED SET GIVEN IN ORDER FOR EACH ZONE   *
CD                        FOLLOWED IN ORDER FOR EACH SUBZONE            *
C                                                                       *
C-----------------------------------------------------------------------*

CEOF
```

APPENDIX I. CCCC Version III Standard Interface Files. RTFLUX

```
C*********************************************************************
C                         REVISED 07/23/75                            -
C                                                                     -
CF          RTFLUX-III                                                -
CE          REGULAR TOTAL FLUXES                                      -
C                                                                     -
C*********************************************************************

CD                        ORDER OF GROUPS IS ACCORDING TO DECREASING
CD                        ENERGY, NOTE THAT DOUBLE PRECISION FLUXES ARE
CD                        GIVEN WHEN MULT.EQ.2.

C---------------------------------------------------------------------
CR          FILE IDENTIFICATION                                       -
C                                                                     -
CL    HNAME,(HUSE(I),I=1,2),IVERS                                     -
C                                                                     -
CW    1+3*MULT=NUMBER OF WORDS                                        -
C                                                                     -
CD    HNAME               HOLLERITH FILE NAME - RTFLUX - (A6)         -
CD    HUSE(I)             HOLLERITH USER IDENTIFICATION (A6)          -
CD    IVERS               FILE VERSION NUMBER                         -
CD    MULT                DOUBLE PRECISION PARAMETER                  -
CD                            1- A6 WORD IS SINGLE WORD               -
CD                            2- A6 WORD IS DOUBLE PRECISION WORD     -
C                                                                     -
C---------------------------------------------------------------------


C---------------------------------------------------------------------
CR          SPECIFICATIONS     (1D RECORD)                            -
C                                                                     -
CL    NDIM,NGROUP,NINTI,NINTJ,NINTK,ITER,EFFK,POWER                   -
C                                                                     -
CW    8=NUMBER OF WORDS                                               -
C                                                                     -
CD    NDIM                NUMBER OF DIMENSIONS                        -
CD    NGROUP              NUMBER OF ENERGY GROUPS                     -
CD    NINTI               NUMBER OF FIRST DIMENSION FINE MESH INTERVALS -
CD    NINTJ               NUMBER OF SECOND DIMENSION FINE MESH INTERVALS -
CD    NINTK               NUMBER OF THIRD DIMENSION FINE MESH INTERVALS, -
CD                        NINTK.EQ.1 IF NDIM.LE.2                     -
CD    ITER                OUTER ITERATION NUMBER AT WHICH FLUX WAS    -
CD                        WRITTEN                                     -
CD    EFFK                EFFECTIVE MULTIPLICATION FACTOR             -
CD    POWER               POWER IN WATTS TO WHICH FLUX IS NORMALIZED  -
C                                                                     -
C---------------------------------------------------------------------


C---------------------------------------------------------------------
CR          ONE DIMENSIONAL REGULAR TOTAL FLUX    (2D RECORD)         -
C                                                                     -
CC          PRESENT IF NDIM.EQ.1                                      -
C                                                                     -
CL    ((FREG(I,J),I=1,NINTI),J=1,NGROUP)                              -
C                                                                     -
```

APPENDIX I. CCCC Version III Standard Interface Files. RTFLUX (Contd.)

```
CW     NINTI*NGROUP*MULT=NUMBER OF WORDS                                 -
C                                                                        -
CD     FREG(I,J)          ONE DIMENSIONAL REGULAR TOTAL FLUX BY INTERVAL -
CD                        AND GROUP.                                     -
C                                                                        -
C-----------------------------------------------------------------------

C-----------------------------------------------------------------------
CR            MULTI-DIMENSIONAL REGULAR TOTAL FLUX   (3D RECORD)         -
C                                                                        -
CC            PRESENT IF NDIM.GE.2                                       -
C                                                                        -
CL     ((FREG(I,J),I=1,NINTI),J=1,NINTJ)-----NOTE STRUCTURE BELOW-----   -
C                                                                        -
CW     NINTI*NINTJ*MULT=NUMBER OF WORDS                                  -
C                                                                        -
C      DO 1 L=1,NGROUP                                                   -
C      DO 1 K=1,NINTK                                                    -
C    1 READ(N)    *LIST AS ABOVE*                                        -
C                                                                        -
CD     FREG(I,J)          MULTI-DIMENSIONAL REGULAR TOTAL FLUX           -
CD                        BY INTERVAL AND GROUP.                         -
C                                                                        -
C-----------------------------------------------------------------------

CEOF
```

APPENDIX I. CCCC Version III Standard Interface Files. ATFLUX

```
C*********************************************************************
C                         REVISED 07/23/75                            -
C                                                                     -
CF          ATFLUX-III                                                -
CE          ADJOINT TOTAL FLUXES                                      -
C                                                                     -
C*********************************************************************

CD                        ORDER OF GROUPS IS ACCORDING TO INCREASING
CD                        ENERGY, NOTE THAT DOUBLE PRECISION FLUXES ARE
CD                        GIVEN WHEN MULT.EQ.2.

C---------------------------------------------------------------------
CR          FILE IDENTIFICATION                                       -
C                                                                     -
CL    HNAME,(HUSE(I),I=1,2),IVERS                                     -
C                                                                     -
CW    1+3*MULT=NUMBER OF WORDS                                        -
C                                                                     -
CD    HNAME               HOLLERITH FILE NAME - ATFLUX - (A6)         -
CD    HUSE(I)             HOLLERITH USER IDENTIFICATION (A6)          -
CD    IVERS               FILE VERSION NUMBER                         -
CD    MULT                DOUBLE PRECISION PARAMETER                  -
CD                            1- A6 WORD IS SINGLE WORD               -
CD                            2- A6 WORD IS DOUBLE PRECISION WORD     -
C                                                                     -
C---------------------------------------------------------------------


C---------------------------------------------------------------------
CR          SPECIFICATIONS      (1D RECORD)                           -
C                                                                     -
CL    NDIM,NGROUP,NINTI,NINTJ,NINTK,ITER,EFFK,ADUM                    -
C                                                                     -
CW    8=NUMBER OF WORDS                                               -
C                                                                     -
CD    NDIM                NUMBER OF DIMENSIONS                        -
CD    NGROUP              NUMBER OF ENERGY GROUPS                     -
CD    NINTI               NUMBER OF FIRST DIMENSION FINE MESH INTERVALS -
CD    NINTJ               NUMBER OF SECOND DIMENSION FINE MESH INTERVALS -
CD    NINTK               NUMBER OF THIRD DIMENSION FINE MESH INTERVALS. -
CD                        NINTK.EQ.1 IF NDIM.LE.2                     -
CD    ITER                OUTER ITERATION NUMBER AT WHICH FLUX WAS    -
CD                        WRITTEN                                     -
CD    EFFK                EFFECTIVE MULTIPLICATION FACTOR             -
CD    ADUM                RESERVED                                    -
C                                                                     -
C---------------------------------------------------------------------


C---------------------------------------------------------------------
CR          ONE DIMENSIONAL ADJOINT TOTAL FLUX    (2D RECORD)         -
C                                                                     -
CC          PRESENT IF NDIM.EQ.1                                      -
C                                                                     -
CL    ((FADJ(I,J),I=1,NINTI),J=1,NGROUP)                              -
C                                                                     -
```

APPENDIX I. CCCC Version III Standard Interface Files. ATFLUX (Contd.)

```
CW     NINTI*NGROUP*MULT=NUMBER OF WORDS                                 *
C                                                                        *
CD     FADJ(I,J)          ONE DIMENSIONAL ADJOINT TOTAL FLUX BY INTERVAL *
CD                        AND GROUP.                                     *
C                                                                        *
C*************************************************************************


C*************************************************************************
CR            MULTI-DIMENSIONAL ADJOINT TOTAL FLUX   (3D RECORD)         *
C                                                                        *
CC            PRESENT IF NDIM.GE.2                                       *
C                                                                        *
CL     ((FADJ(I,J),I=1,NINTI),J=1,NINTJ)*----NOTE STRUCTURE BELOW-----   *
C                                                                        *
CW     NINTI*NINTJ*MULT=NUMBER OF WORDS                                  *
C                                                                        *
C      DO 1 L=1,NGROUP                                                   *
C      DO 1 K=1,NINTK                                                    *
C    1 READ(N)    *LIST AS ABOVE*                                        *
C                                                                        *
CD     FADJ(I,J)          MULTI-DIMENSIONAL ADJOINT TOTAL FLUX           *
CD                        BY INTERVAL AND GROUP.                         *
C                                                                        *
C*************************************************************************

CEOF
```

APPENDIX I. CCCC Version III Standard Interface Files. PWDINT

```
C*********************************************************************
C                         REVISED 07/23/75                            -
C                                                                     -
CF          PWDINT-III                                                -
C                                                                     -
CE          POWER DENSITY BY INTERVAL                                 -
C                                                                     -
C*********************************************************************

C---------------------------------------------------------------------
CR          FILE IDENTIFICATION                                       -
C                                                                     -
CL    HNAME,(HUSE(I),I=1,2),IVERS                                     -
C                                                                     -
CW    1+3*MULT=NUMBER OF WORDS                                        -
C                                                                     -
CD    HNAME                 HOLLERITH FILE NAME - PWDINT - (A6)       -
CD    HUSE(I)               HOLLERITH USER IDENTIFICATION (A6)        -
CD    IVERS                 FILE VERSION NUMBER                       -
CD    MULT                  DOUBLE PRECISION PARAMETER                -
CD                              1- A6 WORD IS SINGLE WORD             -
CD                              2- A6 WORD IS DOUBLE PRECISION WORD   -
C                                                                     -
C---------------------------------------------------------------------

C---------------------------------------------------------------------
CR          SPECIFICATIONS      (1D RECORD)                           -
C                                                                     -
CL    TIME, POWER, VOL, IM, JM, KM, NCY                               -
C                                                                     -
CW    7=NUMBER OF WORDS                                               -
C                                                                     -
CD    TIME                  REFERENCE REAL TIME, DAYS                 -
CD    POWER                 POWER LEVEL FOR ACTUAL NEUTRONICS PROBLEM, -
CD                              WATTS THERMAL                         -
CD    VOL                   VOLUME OVER WHICH POWER WAS DETERMINED,CC -
CD    IM                    NUMBER OF FIRST DIMENSION FINE INTERVALS  -
CD    JM                    NUMBER OF SECOND DIMENSION FINE INTERVALS -
CD    KM                    NUMBER OF THIRD DIMENSION FINE INTERVALS  -
CD    NCY                   REFERENCE COUNT (CYCLE NUMBER)            -
C                                                                     -
C---------------------------------------------------------------------

C---------------------------------------------------------------------
CR                          POWER DENSITY VALUES   (2D RECORD)        -
C                                                                     -
CL    ((PWR(I,J),I=1,IM),J=1,JM)-----NOTE STRUCTURE BELOW-----        -
C                                                                     -
CW    IM*JM=NUMBER OF WORDS                                           -
C                                                                     -
CS    DO 1 K=1,KM                                                     -
CS  1 READ(N) *LIST AS ABOVE*                                         -
C                                                                     -
CD    PWR(I,J)              POWER DENSITY BY INTERVAL, WATTS/CC       -
C                                                                     -
C---------------------------------------------------------------------
CEOF
```

APPENDIX I. CCCC Version III Standard Interface Files. RZFLUX

```
C*********************************************************************
C                        REVISED 07/23/75                            *
C                                                                    *
CF          RZFLUX-III                                               *
C                                                                    *
CE          REGULAR ZONE FLUX BY GROUP, AVERAGED OVER EACH ZONE      *
C                                                                    *
C*********************************************************************

C---------------------------------------------------------------------
CR          FILE IDENTIFICATION                                      *
C                                                                    *
CL    HNAME,(HUSE(I),I=1,2),IVERS                                    *
C                                                                    *
CW    1+3*MULT=NUMBER OF WORDS                                       *
C                                                                    *
CD    HNAME                HOLLERITH FILE NAME - RZFLUX - (A6)      *
CD    HUSE(I)              HOLLERITH USER IDENTIFICATION (A6)       *
CD    IVERS                FILE VERSION NUMBER                      *
CD    MULT                 DOUBLE PRECISION PARAMETER               *
CD                             1- A6 WORD IS SINGLE WORD              *
CD                             2- A6 WORD IS DOUBLE PRECISION WORD    *
C                                                                    *
C---------------------------------------------------------------------

C---------------------------------------------------------------------
CR          SPECIFICATIONS     (1D RECORD)                           *
C                                                                    *
CL    TIME,POWER,VOL,EFFK,EIVS,DKDS,TNL,TNA,TNSL,TNBL,TNBAL,TNCRA,   *
CL   1(X(I),I=1,4),ITRVS,NZONE,NGROUP,NCY                            *
C                                                                    *
CW    20=NUMBER OF WORDS                                             *
C                                                                    *
CD    TIME                 REFERENCE REAL TIME, DAYS                *
CD    POWER                POWER LEVEL FOR ACTUAL NEUTRONICS PROBLEM,WATTS*
CD                             THERMAL                              *
CD    VOL                  VOLUME OVER WHICH POWER WAS DETERMINED, CC *
CD    EFFK                 MULTIPLICATION FACTOR                    *
CD    EIVS                 EIGENVALUE OF SEARCH OF SEARCH PROBLEM   *
CD    DKDS                 DERIVATIVE OF SEARCH PROBLEM             *
CD    TNL                  TOTAL NEUTRON LOSSES                     *
CD    TNA                  TOTAL NEUTRON ABSORPTIONS                *
CD    TNSL                 TOTAL NEUTRON SURFACE LEAKAGE            *
CD    TNBL                 TOTAL NEUTRON BUCKLING LOSS              *
CD    TNBAL                TOTAL NEUTRON BLACK ABSORBER LOSS        *
CD    TNCRA                TOTAL NEUTRON CONTROL ROD ABSORPTIONS    *
CD    X(I),I=1,4           RESERVED                                 *
CD    ITPS                 ITERATIVE PROCESS STATE                  *
CD                              =0, NO ITERATIONS DONE              *
CD                              =1, CONVERGENCE SATISFIED           *
CD                              =2, NOT CONVERGED, BUT CONVERGING   *
CD                              =3, NOT CONVERGED, NOT CONVERGING   *
CD    NZONE                NUMBER OF GEOMETRIC ZONES                *
CD    NGROUP               NUMBER OF NEUTRON ENERGY GROUPS          *
CD    NCY                  REFERENCE COUNT (CYCLE NUMBER)           *
C                                                                    *
C---------------------------------------------------------------------
```

APPENDIX I. CCCC Version III Standard Interface Files. RZFLUX (Contd.)

```
C-----------------------------------------------------------------------
CR          FLUX VALUES       (2D RECORD)                              -
C                                                                      -
CL    ((ZGF(K,M),K=1,NGROUP),M=1,NZONE)                                -
C                                                                      -
CW    NGROUP*NZONE=NUMBER OF WORDS                                     -
C                                                                      -
CD    ZGF(K,M)            REGULAR ZONE FLUX BY GROUP, AVERAGED OVER ZONE -
CD                        NEUTRONS/SEC-CM**2                           -
C                                                                      -
C-----------------------------------------------------------------------

CEOF
```

APPENDIX J. ARCSP016 - THE ARC SYSTEM CATALOGUED PROCEDURE FOR GENERATING A FIXED SOURCE FOR AN INHOMOGENEOUS CALCULATION OF A LOW-REACTIVITY-PLANE SYNTHESIS EXPANSION FUNCTION.

```
//ARCSP016 PROC COMPXS1='&XSCMIN1',COMPXS2='&XSCMIN2',
//      CXSDISP='(NEW,PASS)',CXSVOLM=SCR001,CXSBLK1=1028,CXSBLK2=6136,
//      DMPDEST=F,
//      FLUX2D=NULLFILE,FLUX1D=NULLFILE,FLUXVOL=,
//      HALFBLK=6136,
//      MICRXS1=NULLFILE,MICRXS2=NULLFILE,
//      MICRVOL=,
//      PATH=STP016,
//      PRELIB='SYS1.DUMMYLIB',
//      QRTRBLK=3064,
//      SORS1D='&ESD1D',SORS2D='&ESD2D',
//      TIMLIM='(600,0)',
//      UNITS=BATCHDSK
//*
//*  ******************************************************************
//*  *                                                                *
//*  *      CATALOGUED PROCEDURE FOR STANDARD PATH 16 - SETS UP       *
//*  *  DISTRIBUTED SOURCE FILE CONTAINING, FOR EACH MESH POINT AND   *
//*  * GROUP, THE PRODUCT OF THE FLUX AND LOCAL DIFFUSION COEFFICIENT. *
//*  *                                                                *
//*  ******************************************************************
//*
//*                          SYMBOLIC PARAMETERS
//*
//*  PARAMETER  DEFAULT VALUE            USAGE                    FTNN001
//*  =========  ======= =====            =====                    =======
//*
//*   COMPXS1   &XSCMIN1        DSN OF XS.C.MIN FILE 1              11
//*   COMPXS2   &XSCMIN2        DSN OF XS.C.MIN FILE 2              11
//*   CXSDISP   (NEW,PASS)      DISPOSITION OF XS.C.MIN FILES       11
//*   CXSVOLM   SCR001          VOLUME FOR XS.C.MIN                 11
//*   CXSBLK1   1028            BLKSIZE FOR XS.C.MIN FILE 1         11
//*   CXSBLK2   6136            BLKSIZE FOR XS.C.MIN FILE 2         11
//*   FLUX1D    NULLFILE        DSN OF INPUT FR.D1                  13
//*   FLUX2D    NULLFILE        DSN OF INPUT FR.D2                  14
//*   FLUXVOL   ------          VOLUME FOR INPUT FLUX FILE        13, 14
//*   HALFBLK   6136            HALF TRACK BLKSIZE
//*   MICRVOL   ------          VOLUME OF XS.ISO FILES              23
//*   MICRXS1   NULLFILE        DSN OF XS.ISO FILE 1                23
//*   MICRXS2   NULLFILE        DSN OF XS.ISO FILE 2                23
//*   PATH      STP016          PROGRAM NAME                       EXEC
//*   PRELIB    SYS1.DUMMYLIB   ADDITIONAL LIBRARY               STEPLIB
//*   QRTRBLK   3064            QUARTER TRACK BLKSIZE
//*   SORS1D    &ESD1D          1D SOURCE FILE DSN                  15
//*   SORS2D    &ESD2D          2D SOURCE FILE DSN                  16
//*   TIMLIM    (600,0)         STEP TIME LIMIT                    EXEC
//*   UNITS     BATCHDSK        DEFAULT UNIT PARAMETER
//*
//*  ******************************************************************
//*
```

APPENDIX J. ARCSP016. CONTINUED.

```
//GO EXEC PGM=&PATH,TIME=&TIMLIM
//STEPLIB DD DSN=&PRELIB,DISP=SHR
//         DD DSN=C116.B21006.MODLIB,DISP=SHR
//         DD DSN=C116.ARC.MODLIB,DISP=SHR
//FT05F001 DD DDNAME=SYSIN
//FT06F001 DD SYSOUT=A
//SYSUDUMP DD SYSOUT=&DMPDEST
//FT09F001 DD UNIT=SASCR,SPACE=(CYL,(1,1)),                                X
//              DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)                   X
//              ARC SYSTEM BCD INPUT STREAM
//FT11F001 DD DSN=&COMPXS1,UNIT=&UNITS,VOL=SER=&CXSVOLM,                   X
//      DISP=&CXSDISP,SPACE=(TRK,(1,1)),                                   X
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&CXSBLK1)                           X
//              FILE 1 OF DATA SET XS.C.MIN
//FT11F002 DD DSN=&COMPXS2,UNIT=&UNITS,VOL=SER=&CXSVOLM,                   X
//      DISP=&CXSDISP,SPACE=(CYL,(1,1)),                                   X
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&CXSBLK2)                           X
//              FILE 2 OF COMPOSITION CROSS SECTION SET XS.C.MIN
//FT12F001 DD DSN=&GEOM,UNIT=SASCR,DISP=(NEW,PASS),SPACE=(TRK,(1,1)),      X
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&QRTRBLK)                           X
//              GEOMETRY SPECIFICATIONS DATA SET
//FT13F001 DD DSN=&FLUX1D,UNIT=&UNITS,VOL=SER=&FLUXVOL,                    X
//      DISP=(OLD,KEEP)                                                    X
//              1D REAL FLUX DATA SET
//FT14F001 DD DSN=&FLUX2D,UNIT=&UNITS,VOL=SER=&FLUXVOL,                    X
//      DISP=(OLD,KEEP)                                                    X
//              2D REAL FLUX DATA SET
//FT15F001 DD DSN=&SORS1D,UNIT=SASCR,                                      X
//      DISP=(NEW,PASS),SPACE=(CYL,(1,1)),                                 X
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)                           X
//              1D DISTRIBUTED SOURCE DATA SET
//FT16F001 DD DSN=&SORS2D,UNIT=SASCR,                                      X
//      DISP=(NEW,PASS),SPACE=(CYL,(1,1)),                                 X
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)                           X
//              2D DISTRIBUTED SOURCE DATA SET
//FT17F001 DD DSN=&ANIP,UNIT=SASCR,DISP=(NEW,PASS),SPACE=(TRK,(5,1)),      X
//      DCB=(RECFM=VBS,LRECL=84,BLKSIZE=&QRTRBLK)                          X
//              GENERAL NEUTRONICS INPUT DATA SET
//FT18F001 DD DSN=&BC,UNIT=SASCR,DISP=(NEW,PASS),SPACE=(TRK,(1,1)),        X
//      DCB=(RECFM=VBS,LRECL=X,BLKSIZE=304)                                X
//              BOUNDARY CONDITION SPECIFICATIONS
//FT19F001 DD DSN=&BHOMOG,UNIT=SASCR,SPACE=(TRK,(5,1)),                    X
//              DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)                   X
//              MATERIAL AND COMPOSITION SPECIFICATIONS
//FT20F001 DD DSN=&SCR001,UNIT=SASCR,SPACE=(CYL,(1,1)),                    X
//              DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)                   X
//              SCRATCH DATA SET FOR MODULE NUC001
//FT21F001 DD DSN=&SCR002,UNIT=SASCR,SPACE=(CYL,(1,1)),                    X
//              DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)                   X
//              SCRATCH DATA SET FOR MODULE NUC001
//FT22F001 DD DSN=&XSMMIN,UNIT=SASCR,SPACE=(CYL,(1,1)),                    X
//              DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)                   X
//              DATA SET XS.M.MIN CONTAINS MATERIALS CROSS SECTIONS
```

APPENDIX J. ARCSP016. CONTINUED.

```
//FT23F001 DD DSN=&MICRXS1,                                            X
//            UNIT=&UNITS,DISP=SHR,VOL=SER=&MICRVOL                    X
//            THIS IS FILE 1 OF THE DATA SET XS.ISO DEFINING           X
//            ISOTOPE CROSS SECTIONS
//FT23F002 DD DSN=&MICRXS2,                                            X
//            UNIT=&UNITS,DISP=SHR,VOL=SER=&MICRVOL                    X
//            THIS IS FILE 2 OF THE DATA SET XS.ISO DEFINING           X
//            ISOTOPE CROSS SECTIONS
//FT24F001 DD DSN=&XSISO2A,UNIT=SASCR,SPACE=(TRK,(1,1)),               X
//            DCB=(RECFM=VBS,LRECL=X,BLKSIZE=644)                      X
//            FILE 1 OF DATA SET XS.ISO2 CONTAINS A SHORTENED FORM OF X
//            THE DATA SET XS.ISO
//FT24F002 DD DSN=&XSISO2B,UNIT=SASCR,SPACE=(CYL,(1,1)),               X
//            DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)                 X
//            FILE 2 OF DATA SET XS.ISO2
//FT25F001 DD DSN=&&XSCAN1,UNIT=SASCR,SPACE=(TRK,(1,1)),               X
//            DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)                 X
//            FILE 1 OF DATA SET XS.C.ANI
//FT25F002 DD DSN=&&XSCAN2,UNIT=SASCR,SPACE=(TRK,(5,2),RLSE),          X
//            DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)                 X
//            FILE 2 OF DATA SET XS.C.ANI
//FT26F001 DD DSN=&XSCAUX1,UNIT=SASCR,SPACE=(TRK,(1,1)),               X
//            DCB=(RECFM=VBS,LRECL=X,BLKSIZE=516)                      X
//            FILE 1 OF DATA SET XS.C.AUX
//FT26F002 DD DSN=&XSCAUX2,UNIT=SASCR,SPACE=(CYL,(1,1)),               X
//            DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)                 X
//            FILE 2 OF DATA SET XS.C.AUX CONTAINS                     X
//            COMPOSITION CROSS SECTION INFORMATION
//FT27F001 DD DSN=&&XSMANI,UNIT=SASCR,SPACE=(TRK,(5,2),RLSE),          X
//            DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)                 X
//            DATA SET XS.M.ANI CONTAINS MATERIAL CROSS SECTIONS
//FT28F001 DD DSN=&XSMAUX,UNIT=SASCR,SPACE=(CYL,(1,1)),                X
//            DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)                 X
//            DATA SET XS.M.AUX CONTAINS MATERIAL CROSS SECTION        X
//            INFORMATION ON CAPTURE AND SCATTERING
//FT29F001 DD DSN=&SCRANI,UNIT=SASCR,SPACE=(CYL,(1,1)),                X
//            DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)                 X
//            SCRATCH DATA SET FOR MODULE NUC001
//FT30F001 DD DSN=&SCRAUX,UNIT=SASCR,SPACE=(CYL,(1,1)),                X
//            DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)                 X
//            SCRATCH DATA SET FOR MODULE NUC001
//FT31F001 DD DSN=&XSCMII1,UNIT=SASCR,SPACE=(CYL,(1,1)),               X
//            DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&QRTRBLK)                 X
//            FILE 1 OF COMPOSITION CROSS SECTION SET XS.C.MI1
//FT31F002 DD DSN=&XSCMII2,UNIT=SASCR,SPACE=(CYL,(1,1)),               X
//            DCB=(RECFM=VBS,LRECL=X,BLKSIZE=&HALFBLK)                 X
//            FILE 2 OF COMPOSITION CROSS SECTION SET XS.C.MI1
//*     ************************************************************
//*     *                                                          *
//*     *    ANYONE EXPERIENCING DIFFICULTY WITH THIS PROCEDURE    *
//*     *    SEE C. H. ADAMS, BLDG 208, ROOM F-143                 *
//*     *                                                          *
//*     ************************************************************
//*
// PEND
```

APPENDIX K. STP016 - THE ARC SYSTEM STANDARD PATH FOR GENERATING A FIXED SOURCE FOR AN INHOMOGENEOUS CALCULATION OF A LOW-REACTIVITY-PLANE SYNTHESIS EXPANSION FUNCTION.

```
C
C     PATH DRIVER FOR PREPARATION OF DATA SETS ES.D1D OR ES.D2D
C
C     MODULES LINKED TO BY PATH DRIVER
C
C     NUT002              GENERAL NEUTRONICS INPUT PROCESSOR
C     AJC010              PREPARES DATA SETS ES.D1D OR ES.D2D USING
C                         DIFFUSION COEFFICIENTS FROM DATA SET XS.C.MIN
C                         AND REAL FLUXES FROM DATA SETS FR.D1 OR FR.D2
C     SUBPROGRAMS CALLED BY PATH DRIVER
C
C     SYSTEM              INITIALIZES THE SYSTEM ROUTINES
C     RCDDS               SPOOLS IN THE INPUT STREAM ONTO LOGICAL UNIT
C                         NUMBER 9
C     ERROR               ROUTINE TO PRINT ERROR MESSAGES
C
C     FILES REFERENCED BY PATH DRIVER
C
C     FILE NAME    LOGICAL UNIT NUMBER    RECORD POINTER
C     =========    ===================    ==============
C       GEOM              IGEOM               IRECGM
C
C     DECLARE VARIABLES TO BE DOUBLE PRECISION USING THE IBM
C     IMPLICIT REAL*8 CONVENTION
C
      IMPLICIT REAL*8 (A-H,O-Z)
      REAL*8 NUT002
      DIMENSION DSNAME(22)
C
C     INITIALIZE VARIABLES IN DATA STATEMENT
      DATA DSNAME / 8HXS.C.MIN, 4HGEOM, 5HFR.D1, 5HFR.D2, 6HES.D1D,
     1 6HES.D2D, 5HA.NIP, 2HBC, 7HB.HOMOG, 6HSCR001, 6HSCR002,
     2 8HXS.M.MIN, 6HXS.TSO, 7HXS.TSO2, 8HXS.C.ANT, 8HXS.C.AUX,
     3 8HXS.M.ANT, 8HXS.M.AUX, 6HSCRANT, 6HSCRAUX, 8HXS.C.M11, 1HS /
      DATA NUT002/6HNUT002/, AJC010/6HAJC010/, STP016/6HSTP016/,
     1 FATAL/5HFATAL/, SUBNAM/6HSTP016/, GEOM/4HGEOM/, HOMOG/6HNUC001/,
     2 XNHOMG/6HNUT001/
C
C     INITIALIZE THE SYSTEM
C
      CALL SYSTEM(DSNAME)
C
C     DETERMINE IF THE DATA SET GEOM HAS BEEN PROVIDED
C
      IO=0
```

APPENDIX K. STP016. CONTINUED.

```
      CALL SNIFF(GEOM,IGEOM,I0)
      IF(IGEOM.GT.0) GO TO 100
C
C     SPOOL IN THE INPUT STREAM
C
      CALL BCDDS(STP016,N1)
      IF(N1.GT.0) GO TO 110
10100 CONTINUE
C*********************************************************************
C
C     FATAL ERROR -10100. NO DATA SET GEOM WAS PROVIDED AND NO INPUT
C     DATA WAS SUPPLIED
C
C*********************************************************************
      NERR=-10100
      CALL ERROR(SUBNAM,NERR)
      CALL ERROR(FATAL,NERR)
  110 CONTINUE
C
C     LINK TO MODULE NUI002 TO PREPARE DATA SET GEOM
C
      CALL LINK(NUI002,NOR)
  100 CONTINUE
C
C  WRITE XS.C.MIN IF ONE DOES NOT EXIST.
C
      CALL SNIFF( DSNAME(1), IXSCM, I0)
      IF( IXSCM.GT.0 ) GO TO 120
      IXS=1
      ICALL=4
      CALL LINK(XNHOMG)
      CALL LINK( HOMOG, ICALL, I0, I0, I0, IXS)
  120 CONTINUE
C
C     LINK TO MODULE AJC010
C
      CALL LINK(AJC010)
      RETURN
      END
```

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REFERENCES

1. W. R. Cadwell, "PDQ-7 Reference Manual", WAPD-TM-678 (1967).

2. E. L. Wachspress, "Iterative Solution of Elliptic Systems", (Prentice-Hall, 1966), p. 31.

3. W. W. Little, Jr., and R. W. Hardie, "2DB User's Manual", BNWL-831 (1968).

4. T. A. Daly, G. K. Leaf and A. S. Kennedy, "The ARC System Two-Dimensional Diffusion Theory Capability, DARC2D", ANL-7716 (1972).

5. T. B. Fowler, D. R. Vondy, G. W. Cunningham, "Nuclear Reactor Core Analysis Code: CITATION", ORNL-TM-2496 (Rev. 2) (1971).

6. D. R. Vondy, T. B. Fowler and G. W. Cunningham, "VENTURE: A Code Block for Solving Multigroup Neutronics Problems Applying the Finite-Difference Diffusion-Theory Approximation to Neutron Transport", ORNL-5062 (1975).

7. S. Kaplan, "Some New Methods of Flux Synthesis", Nucl. Sci. Eng., 13, 22 (1962).

8. S. Kaplan, O. J. Marlowe and W. R. Cadwell, "Equations and Programs for Solutions of the Neutron Group Diffusion Equations by Synthesis Approximations", WAPD-TM-377 (1963).

9. J. B. Yasinsky and S. Kaplan, "Synthesis of Three-Dimensional Flux Shapes Using Discontinuous Sets of Trial Functions", Nucl. Sci. Eng., 28, 426 (1967).

10. J. B. Yasinsky, "Combined Space-Time Synthesis with Axially Discontinuous Trial Functions", WAPD-TM-736 (1967).

11. W. M. Stacey, Jr., "A Variational Multichannel Space-Time Synthesis Method for Nonseparable Reactor Transients", Nucl. Sci. Eng., 34, 45 (1968).

12. V. Luco, G. K. Leaf and J. C. Stork, "SYN2D, A Flux-Synthesis Program Based on a Discontinuous Trial-Function Formulation", ANL-7847 (1971).

13. G. Buckel, "Approximation der Stationären, Dreidimensionalen Mehrgruppen-Neutronen-Diffusionsgleichung Durch ein Syntheseverfahren mit dem Karlsruher Synthese-Programm KASY", KFK-1349 (1971).

14. H. Schaffler, P. Schnur and R. Rühle, "Ein Rechenprogramm zur Lösung der Dreidimensionalen Multigruppendiffusionsgleichungen nach dem Erweiterten Fluss-Syntheseverfahren", BMBW-FB K 72-06 (1972).

15. E. L. Wachspress and M. Becker, "Variational Multichannel Synthesis with Discontinuous Trial Functions", KAPL-3095 (1965); also see "Variational Synthesis with Discontinuous Trial Functions", in Proc. Conference on the Applications of Computing Methods to Reactor Problems, Argonne National Laboratory, ANL-7050 (1965).

16. W. L. Woodruff, "Some Improvements in Variational Flux Synthesis Methods", ANL-7696 (1970).

17. W. B. Terney, "Interface Conditions for Discontinuous Flux Synthesis Methods", Nucl. Sci. Eng., 41, 303 (1970).

18. E. L. Wachspress, "On the Use of Different Radial Trial Functions in Different Axial Zones of a Neutron Flux Synthesis Computation", Nucl. Sci. Eng., 34, 342 (1968).

19. J. E. Meyer, "Synthesis of Three-Dimensional Power Shapes - A Flux-Weighting Synthesis Technique", Proc. 2nd Intern. Conf. Peaceful Uses of Atomic Energy, Geneva, 1958, P/636, 11, 519 (1958).

20. J. B. Yasinsky, "On the Use of Space-Synthesis with Energy Group Collapsing", WAPD-TM-959 (1970).

21. C. H. Adams and W. M. Stacey, Jr., "An Anomaly Arising in the Collapsed-Group Flux Synthesis Approximation", Nucl. Sci. Eng., 36, 444 (1969).

22. E. L. Wachspress, "Iterative Solution of Elliptic Systems", (Prentice-Hall, 1966), p. 83.

23. E. L. Wachspress, ibid, p. 26.

24. B. M. Carmichael, "Standard Interface Files and Procedures for Reactor Physics Codes, Version III", Los Alamos Scientific Laboratory Report LA-5486-MS (February 1974).

25. L. C. Just, et.al., "The System Aspects and Interface Data Sets of the Argonne Reactor Computation (ARC) System", Argonne National Laboratory Report ANL-7711 (April 1971).

26. E. A. Kovalsky and D. E. Neal, "The ARC System Neutronics Input Processor", Argonne National Laboratory Report ANL-7713 (Jan. 1971).

27. C. H. Adams and W. M. Stacey, Jr., "Flux Synthesis Calculations for Fast Reactors", Nucl. Sci. Eng., 54, 201 (1974).

28. C. H. Adams and M. J. Lineberry, "Experience with Single-Channel Flux Synthesis Calculations for Three-Dimensional, Fast Reactor Models", Proc. Meeting on Computational Methods in Nuclear Engineering, Charleston, South Carolina, April 15-17 (1975).

29. C. H. Adams and M. J. Lineberry, Private communication (1975).

30. S. Pilate et al., "A Three-Dimensional Synthesis Method Tested and Applied in Fast Breeders," KFK-1345, Kernforschungszentrum, Karlsruhe (1971).

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