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**GENERAL REACTOR ANALYSIS COMPUTER PROGRAM
FOR THE IBM 704, PROGRAM GEORGE**

T. A. Hoffman

W. B. Henderson

GENERAL ELECTRIC

AIRCRAFT NUCLEAR PROPULSION DEPARTMENT

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Abstract

Program George is an IBM 704 code that combines standard ANPD reactor analysis methods for computing multiplication constant and spatial distribution of flux and power, as well as other nuclear parameters, in aircraft reactors. Formerly these methods were embodied in three IBM 704 codes and two IBM 650 codes. The elapsed time and the chance for human error between initial input and final output are greatly reduced in Program George. A matched set of reflector savings for a reflected, cylindrical core, which was formerly obtained by hand, is now computed by the program. In the C_2 portion of Program George, the code computes the neutron slowing-down density and flux at 19 lethargy levels plus a thermal group in bare, homogeneous compositions with normal mode, energy-dependent bucklings. The diffusion coefficient contains a transport correction as well as a Behrens correction for heterogeneous structure. Flux-depression factors at thermal and two epithermal levels are computed in annular, cylindrical geometry by one-energy, P_3 transport theory approximation in the I_2 portion of the program, or they may be given as input. Flux weighting of various cross sections, transmission factors, and other parameters are computed in a multigroup representation. Two-energy-group constants from the regional compositions are supplied in the F_2 portion of the program, in which a two-energy group, one-space-dimensional, multiregion diffusion calculation yields multiplication constant, normalized fission density, fast flux, and slow flux in each one-dimensional reactor portrayed.

If a reactivity match is requested, the reflector savings of the specified compositions are adjusted until the multiplication constant in the radial F_2 , longitudinal F_2 , and the reference bare equivalent core of a cylindrical reflected reactor converge to the same value.

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1. Introduction and Summary

Following the evolution and extensive use of a set of three digital computer programs in an effectively standardized manner for reactor nuclear analysis, it was recognized that analysis time could be substantially reduced by combining the three programs and mechanizing the transfer of information between blocks of the combined program.

The standard reactor analysis programs that have been extensively and successfully correlated against the small, heterogeneous, hydrogen-moderated, intermediate-spectrum reactors of interest to GE-ANPD include: a one-energy P_3 transport theory approximation (Program I), a multi-energy bare homogeneous diffusion slowing-down analysis with normal-mode geometrical buckling (Program C), and a two-energy group one-space-dimensional diffusion analysis (Program F). Programs C and F were originally coded for the IBM 701 computer in 1955, Program I was coded for the IBM 701 in 1956. Improved or enlarged versions of these programs have been coded for the present IBM 704 computer.^{1,2,3} In Program F a central absorber rod, annulus, or plate can be represented by a two-energy-group albedo. The rod and annulus albedo calculations⁴ were originally coded for the IBM 650 computer. The plate albedos⁵ were formerly computed by hand.

The three reactor analysis programs I, C, and F must be run in the sequence named. This means that the nuclear analyst must, for each of three successive calculations, fill out a set of input data sheets and have the data key-punched onto IBM cards. Filling out the input data sheets usually requires considerable transcription and repetition of data from one analysis step to the next.

Program George has been prepared to effectively mechanize the standard analysis sequence. The typical elapsed time for a standard analysis sequence is reduced from 3 days under the best of circumstances to 1 day under normal circumstances. Actual machine running time is the same as or slightly longer than previously. The opportunity for human error in transposition and repetition of data between analysis steps has been eliminated. Coding of Program George began at ANPD early in 1957, and the first production version was put into operation in September, 1958. The first round of modifications, the only ones contemplated for the IBM 704 version of the program, have been completed and are incorporated in this document.

Program George incorporates an iterative procedure for computing the radial and longitudinal reflector savings for cylindrical geometry which gives the same value for the multiplication constant from the 19-energy-level bare homogeneous reactor analysis, the two-group radial (concentric annuli) multiregion analysis, and the two-group longitudinal (circular slab) multiregion analysis. The reflector-savings matching calculation was previously performed manually and graphically using a set of precomputed 19-energy-level bare homogeneous, two-group radial, and two-group longitudinal analyses.

Mechanization of the reflector-savings matching calculation has resulted in much more general use of computed multiplication constants based on matched savings and a complementary reduction in the quotation of multiplication constant values based on estimated end-reflector savings. The calculation of matched multiplication constant typically consumes 10 to 20 minutes of IBM 704 computer time, whereas the unmatched calculation of multiplication constant and one-dimensional power distribution typically takes 5 minutes.

2. Physical Analysis and Calculation Methods

2.1 THE PHYSICAL PROBLEM

Program George is an attempt to provide the reactor nuclear engineer with a tool that will enable him to compute the basic nuclear characteristics of a heterogeneous reactor with a minimum of time, effort, and expense, and yet with adequate precision for most engineering work.

Reduced to its barest essentials, the problem is to solve the energy-dependent Boltzmann equation for the conservation of neutrons in three dimensions with arbitrary discontinuities in material composition, and settle for the distribution of the scalar neutron flux in space and energy. Unfortunately, but characteristically, the uncertainty in the solution asymptotically approaches a limiting value as the calculation time (and therefore expense) increases without limit. Even if the "exact" scalar flux were computed, a procedure that would require infinite detail in the six components of neutron position in phase space, the flux would still have to be assigned an uncertainty of $\pm X$ percent, where X is undoubtedly greater than 2. This uncertainty arises because the basic nuclear cross sections required in the calculations are not presently known to an accuracy better than ± 2 percent at thermal neutron energies, and the uncertainty increases with energy.

2.2 THE ENGINEERING APPROACH

The engineering approach to this problem, partly by design and partly by the evolutionary process in methods development, has been to break up the calculation into smaller pieces, either coupled loosely enough to be solved as independent problems or coupled in a simple fashion. In each of these smaller problems the sophistication of the approximation can be chosen to provide a consistent level of precision in each piece. For example, a higher-order approximation than diffusion theory is needed to compute adequately the spatial distribution of scalar flux in the fine cell inhomogeneities found in some regions of the reactor; but in a homogeneous medium many mean free paths thick, diffusion theory gives an adequate spatial distribution of the flux, except possibly within a few mean free paths of the boundaries.

2.3 HOMOGENIZATION

In Program George the computation of scalar flux is reduced from a six-variable problem to several problems having no more than three variables. The first simplification is to reduce any region of the reactor containing fine cell inhomogeneities to an equivalent homogeneous region. By definition (but in practice only by accident) the equivalent homogenized region allows the computation of a flux that produces the same reaction rates as the actual flux in the inhomogeneous medium. Ordinarily the computation of flux-depression factors (called g -factors) and corrections to the diffusion coefficients (called Behrens factors⁶ after the Englishman who derived them), which are intended to correct for inhomogeneous distribution of material in the cells, is carried out for an infinite array. At epithermal levels a monoenergetic calculation is ordinarily considered adequate. This

amounts to assuming no coupling between the fine flux detail in the cell and the gross flux distribution in the homogeneous medium (although the number of atoms of each type in the cell is usually preserved in an equal volume of the homogeneous medium and this could be regarded as the coupling).

2.4 THE NORMAL-MODE SPATIAL ASSUMPTION

The next simplification is to assume that the scalar flux (and source, if any), which is a function of position and energy, is separable as a product of a function of energy and a function of position. The spatial solution is assumed to satisfy the homogeneous Helmholtz equation

$$\nabla^2 \varphi(r) + K^2 \varphi(r) = 0 \quad (2.1)$$

where K^2 is the coupling between the space-dependent and energy-dependent equation, and is called the geometrical buckling in the spatial equation and the material buckling in the energy-dependent equation. The solutions of the Helmholtz equation are taken to be the oscillatory solutions of the lowest frequency which go to zero at the extrapolated boundary of the medium. These solutions are referred to as the normal-mode solutions. Recognition that the space and energy variables are really not separable is provided by allowing the position of the extrapolated boundary, and hence K^2 , to be a function of energy. The solution of the energy-dependent Boltzmann equation for a homogeneous, critical reactor can be shown⁷ to yield the multi-energy diffusion equation used in Program George when (1) the spatial solution satisfies equation (2.1), (2) the differential scattering cross section in laboratory coordinates is represented by the zeroth and first moments of a Legendre spherical harmonic expansion; and (3) only the zeroth scattering moment leads to energy transfer. Under these assumptions simple diffusion theory will be valid if the diffusion coefficient is defined as

$$D = \frac{1}{3(\gamma \Sigma_T - \bar{\mu}_0 \Sigma_s)} \quad (2.2)$$

Σ_T is the total macroscopic cross section;

Σ_s is the zeroth moment of the macroscopic scattering cross section;

$\bar{\mu}_0$ is the average value of the cosine of the scattering angle in laboratory coordinates;

$$\gamma = \frac{K^2 \tan^{-1} \left(\frac{K}{\Sigma_T} \right)}{3 \Sigma_T^2 \left[\frac{K}{\Sigma_T} - \tan^{-1} \left(\frac{K}{\Sigma_T} \right) \right]} \quad (2.3)$$

2.5 THE SLOWING-DOWN PROBLEM

A further approximation is made to simplify the evaluation of the integral that describes the contributions to the neutron population at a given energy due to "scattering in" from a collision at higher energy. Two slowing-down models are commonly used at ANPD, both of which reduce the integral equation for the energy-dependent flux to a first order differential equation in lethargy, where lethargy, u , is related to energy, E , by

$$u = \ln \frac{10^7}{E(\text{ev})} \quad (2.4)$$

Since the neutron slowing-down density, q , is a smoother function of lethargy than the flux, (the former being the integral of the sources minus the integral of the losses from lethargy zero to the lethargy in question), it is the differential equation of the slowing-down

density that is solved in Program George. The slowing-down models provide an algebraic equation relating the flux, slowing-down density, and cross sections at each lethargy, from which the flux per unit lethargy is then computed.

2.6 DERIVATION AND COMPARISON OF SLOWING-DOWN MODELS

The differential conservation equation

$$\frac{dq}{du} = S(u) - \Sigma_L(u) \varphi(u), \quad \text{where} \quad (2.5)$$

$S(u)$ is the source per unit lethargy and $\Sigma_L(u)$ is the total loss cross section including both absorption and leakage,

$$\Sigma_L(u) = \Sigma_a(u) + D(u) K^2(u), \quad (2.6)$$

is equally valid independent of any slowing-down model. The integral conservation equation is

$$\Sigma_r(u) \varphi(u) = S(u) + \sum_i \int_{-\infty}^u \Sigma_s^i(u') \varphi(u') p^i(u'/u) du', \quad (2.7)$$

where $p^i(u'/u)$ is the scatter-transfer probability from lethargy u' to u per unit lethargy at u for the i -th element and $\Sigma_r(u) = \Sigma_L(u) + \Sigma_s(u)$. Equation (2.7) can be written in terms of the slowing-down density,

$$q(u) = \sum_i \int_{-\infty}^u \Sigma_s^i(u') \varphi(u') \left[\int_u^{\infty} p^i(u'/u'') du'' \right] du' \quad (2.8)$$

under certain assumptions that constitute the slowing-down model. Equation (2.7) can then be used to eliminate the flux in (2.5) to give the differential equation for q of the form

$$\frac{dq}{du} = A(u) S(u) - B(u) q(u), \quad (2.9)$$

where $A(u)$ and $B(u)$ are combinations of cross sections at u involving ξ , the average logarithmic energy decrement per collision.

In media where the principal moderation is due to hydrogen, the modified age model⁸ is used. Scattering is assumed to be elastic and isotropic in the center of mass. Equation (2.7) can then be written

$$\Sigma_r(u) \varphi(u) = S(u) + \sum_i \frac{1}{1 - \alpha^i} \int_{u - \epsilon^i}^u \Sigma_s^i(u') \varphi(u') e^{-(u - u')} du', \quad (2.10)$$

where $\alpha^i = \left(\frac{A^i - 1}{A^i + 1} \right)^2$, A^i = atom/neutron mass ratio of the i -th element, and $\epsilon^i = L_n \frac{1}{\alpha^i}$.

Equation (2.8) becomes

$$q(u) = \sum_i \frac{1}{1 - \alpha^i} \int_{u - \epsilon^i}^u \Sigma_s^i(u') \varphi(u') [e^{-(u - u')} - \alpha^i] du'. \quad (2.11)$$

Substituting (2.11) in (2.10) yields

$$\Sigma_r(u) \varphi(u) = S(u) + q(u) + \sum_i \frac{\alpha^i}{1 - \alpha^i} \int_{u - \epsilon^i}^u \Sigma_s^i(u') \varphi(u') du'. \quad (2.12)$$

In order to evaluate the integral in (2.12) the assumption is made that $\Sigma_s^i(u) \varphi(u)$ is constant from $u - \epsilon^i$ to u . Using the relation $\Sigma_r(u) = \Sigma_s(u) + \Sigma_L(u)$ the modified age model becomes

$$[\xi \Sigma_s(u) + \Sigma_L(u)] \varphi(u) = S(u) + q(u), \quad (2.13)$$

where

$$\xi \Sigma_s(u) = \sum_i \left(1 + \frac{\alpha^i}{1 - \alpha^i} \ln \alpha^i \right) \Sigma_s^i(u). \quad (2.14)$$

Eliminating $\varphi(u)$ between (2.13) and (2.5) gives the differential q equation

$$\frac{dq}{du} = \frac{\xi \Sigma_s(u) S(u) - \Sigma_L(u) q(u)}{\xi \Sigma_s(u) + \Sigma_L(u)}. \quad (2.15)$$

Since α^i is zero for $A^i = 1$, the modified age model is correct for hydrogen moderation under the assumption of elastic, isotropic scattering in the center of mass. If elements other than hydrogen are present, however, the error in the integral term of (2.12) depends directly on the error in the assumption of constant scatter-collision density.

In media in which the principal moderation is due to elements heavier than hydrogen, the Coveyou-Macauley model⁹ is used. This model for a single scattering element is equivalent to using the Wigner kernel

$$P(u'/u) = \frac{1}{\xi} e^{-(u-u')/\xi} \quad (2.16)$$

in the scatter-transfer integrals of equations (2.7) and (2.8).

The Wigner kernel is continuous from lethargy u to lethargy plus infinity and produces the correct first moment, ξ , of the actual kernel which, except for hydrogen, is discontinuous. Using the Wigner kernel, the scattered-transfer integral in (2.7) is simply $q(u)/\xi$ since

$$\int_{-\infty}^u \Sigma_s(u') \varphi(u') \frac{e^{-(u-u')/\xi}}{\xi} du' = \frac{1}{\xi} \int_{-\infty}^u \Sigma_s(u') \varphi(u') \left[\int_u^{\infty} e^{-(u''-u')/\xi} \frac{du''}{\xi} \right] du'. \quad (2.17)$$

The Coveyou-Macauley model is

$$\Sigma_r(u) \varphi(u) = S(u) + q(u)/\xi, \quad \text{and} \quad (2.18)$$

the corresponding differential q equation is

$$\frac{dq}{du} = \frac{\Sigma_s(u) S(u) - \Sigma_L(u) q(u)/\xi}{\Sigma_s(u) + \Sigma_L(u)}. \quad (2.19)$$

The use of the Wigner kernel leaves the question of mixtures unresolved; it is somewhat more informative to examine the Coveyou-Macauley model for the case of more than one scattering element and ascertain the conditions under which the model is valid. The Coveyou-Macauley model would be exact if

$$\xi(u) = \frac{\sum_i \int_{-\infty}^u \Sigma_s^i(u') \varphi(u') \left[\int_u^{\infty} P^i(u'/u'') du'' \right] du'}{\sum_i \int_{-\infty}^u \Sigma_s^i(u') \varphi(u') P^i(u'/u) du'}. \quad (2.20)$$

Under the same assumptions that are required for the validity of the modified age model with mixtures, namely elastic isotropic scattering in the center of mass and constant $\Sigma_s^i(u) \varphi(u)$ from $u - \epsilon^i$ to u , equation (2.20) becomes

$$\xi(u) = \frac{\sum_i \left(1 + \frac{\alpha^i}{1 - \alpha^i} \ln \alpha^i \right) \Sigma_s^i(u)}{\sum_i \Sigma_s^i} \quad (2.21)$$

which is identical to (2.14) in the modified age model since

$$\Sigma_s = \sum_i \Sigma_s^i$$

Comparing the modified age and Coveyou-Macauley models brings out the following points.

1. When scattering is elastic and isotropic in the center of mass and $A = 1$ (hydrogen satisfies these requirements except in the thermal range), both models are exact.
2. When nonhydrogenous scatters are present, the Coveyou-Macauley model is less sensitive to errors in the assumption of constant scatter-collision density since $\Sigma_s(u') \varphi(u')$ appears in both numerator and denominator of $\xi(u)$ in equation (2.20).
3. The fact that modified age theory generally produces more nearly correct values of multiplication constant in hydrogenous reactors, where scattering due to other elements is small but not insignificant, is a result of a fortuitous cancellation of errors at high and low energy¹⁰. The modified age model overpredicts the flux when $S(u)$ is not zero and ξ is not unity, but makes up for this by overestimating the losses. The Coveyou-Macauley model has somewhat the same errors qualitatively, but quantitatively the errors are considerably smaller. In nonhydrogenous reactors the Coveyou-Macauley model is far superior¹⁰.

2.7 TWO-GROUP CONSTANTS AND ONE-DIMENSIONAL SPATIAL SOLUTIONS

The calculations of slowing-down density and flux, using the appropriate model are performed at 19 more or less evenly spaced lethargy levels from lethargy zero (10 Mev) to thermal, plus a thermal group. The cross sections required in the calculation are obtained from a permanent library of microscopic and macroscopic cross sections for elements, compounds, and mixtures, which are stored on magnetic tape. The spectrum of neutrons producing the flux in the slowing-down calculation is chosen from one of several contained in the nuclear-data-tape library. These spectra are normalized to

$\int_{-\infty}^{\infty} S(u) du = 1$. The slowing-down calculation is treated as a critical, steady-state problem with the eigenvalue $k = \int_{-\infty}^{\infty} v \Sigma_f(u) \varphi(u) du$. An off-critical calculation¹¹ can

be requested that will give the eigenvalue corresponding to a reactor period $\omega \text{ sec}^{-1}$.

Finally, the 19-level-plus-thermal-group portrayal of the energy-dependent flux, slowing-down density, and cross sections are combined into a two-energy-group conservation equation by obtaining appropriately flux-averaged two-group constants, which define the leakage, absorption, production, and transfer probabilities in the two groups. Referring to the Helmholtz equation, it is assumed that the heterogeneous reactor, made up of homogeneous compositions for which there are now two-energy-group constants,

can be represented in either rectangular, cylindrical, or spherical symmetry. The spatial function for the flux is assumed to be separable into a product of functions involving only one of the spatial variables. By reinstating an energy dependence of the flux in the form of the two-group constants, the original Boltzmann conservation equation is reduced to a conservation equation in two-energy groups and one space dimension. The couplings between the spatial equations in each direction are the components of buckling. The two-group diffusion equations are second-order differential equations in one space variable, which are subject to two-group albedo-type boundary conditions at the left-hand and right-hand boundaries of the one-dimensional reactor. These equations can be solved explicitly for the flux, by finite difference methods, if the source is known. If fissioning supplies all or part of the source of neutrons, iteration on the source is necessary since the source is dependent on the flux, which is initially unknown.

For consistency the material buckling used in the slowing-down calculation that yielded the two-group constants for a particular region should be the same as the sum of the three components of buckling that apply to the region when the spatial solutions are obtained. This procedure is not applicable unless the spatial solutions are computed in the same energy detail as the slowing-down calculations. Instead, in the two-group analysis a matched reflector savings scheme is used. This procedure is carried out automatically in Program George in cylindrical geometry only. The method involves the use of radial savings, S_r , and longitudinal savings, S_z , which are defined as the amount the radius and end respectively of a bare core dimension must be increased to produce the same multiplication constant as exists in the heterogeneous reactor-shield assembly. The values of S_r and S_z , together with an extrapolation distance are used in determining the normal-mode bucklings K_r^2 and K_z^2 respectively. The Laplacian operator for the two-group diffusion equations and the 19-level slowing-down calculation are:

$$\begin{aligned} \text{radial, two-group, diffusion, } & -\nabla_r^2 + K_z^2 \\ \text{longitudinal, two-group, diffusion, } & -\nabla_z^2 + K_r^2 \\ \text{19-level slowing down, } & K_r^2 + K_z^2. \end{aligned}$$

The values of S_r and S_z are adjusted by iteration between the 19-level calculation and the two-group calculations until the multiplication constant in each of the three calculations is the same to within a pre-assigned tolerance. If the core has only one composition, the composition for the 19-level calculation is unambiguous; but if more than one core composition radially or longitudinally makes up the composite core, then some average core composition must be defined in which to perform the savings match. This composition is not necessarily used in either the radial or longitudinal two-group calculation.

The proper treatment of a multiregion core requires both flux and adjoint weighting of the core cross sections¹². Also, the use of a fission spectrum source, especially in non-fertile regions, to generate a flux from which to compute group constants is a recipe. A more accurate treatment of the few-group, one-dimensional approximation could be obtained by more sophisticated analyses than have been used in program George, or a multi-dimensional analysis could be performed.

2.8 ORDER OF OPERATIONS AND DEVELOPMENT OF PROGRAM METHODS

The assumptions that have been made in order to break up the scalar flux problem into essentially three smaller pieces have been presented in a general way. The basic operations performed by Program George in solving these problems and the manner in which these methods were developed will now be examined.

The order of operations in Program George is as follows:

1. Perform the calculations required to homogenize the fine structure of a cell and produce the homogenized cross sections at 19 lethargy levels plus a temperature-dependent thermal group.
2. Perform a slowing-down calculation for each homogenized composition (the slowing-down calculation is cut off at the average velocity of a Maxwellian distribution of neutrons at a temperature, T , and the neutrons surviving to this lethargy are dumped discontinuously into the Maxwellian distribution for T), and produce the two-group constants.
3. If requested, perform radial and longitudinal, two-group, multiregion diffusion calculations, and iterate with a reference core composition to find matched savings S_r and S_z .
4. Perform any other two-group diffusion calculations requested, which may be for direct flux or adjoint, and in rectangular, cylindrical, or spherical geometry.

To place the development of Program George in proper perspective, it should be emphasized that all of the methods necessary to implement the operations just described had been in use before the development of Program George. The evolution of these methods at ANPD began with theory development of the individual pieces of the problem and application of those calculations that were feasible on a desk calculator. With the installation of the IBM 650, 701, and 704 machines in the Evendale area, the hand calculations were mechanized in individual machine programs, and some calculations that would have been impractical to perform by hand (except once, at least in part, for machine program check-out) were coded for the machines. Although the development of these individual programs made possible parameter studies of reactor nuclear characteristics that would have been virtually impossible using desk calculators, many time-consuming calculations were still required to prepare input for each machine program and to process results from the programs. In addition to the time lost by the manual handling of data, there was always the possibility of human error that might go undetected. By combination of the individual programs into a single program, the calculation of input data is reduced to a minimum and all intermediate handling is performed by the program.

Perhaps the greatest economy achieved by Program George comes from eliminating the "dead time" that results from having to make several passes at the machine in series. The slowing-down calculations cannot be performed in heterogeneous media until flux-depression factors have been computed. The two-group, multiregion diffusion calculations in one space dimension cannot be performed until the two-group constants have been obtained from the slowing-down calculation. All these operations, which Program George can perform in a single pass on the IBM 704 computer, might have taken anywhere from a few days to several weeks of elapsed time (although no more machine time) to accomplish with individual programs, depending on the quality of the machine service, the number of human errors in transcribing data, and the occurrence of an occasional machine error. One-day service on the IBM 704 computer is virtually guaranteed with Program George.

3. Terms and Program Definitions

Element	The set of nuclear data identified by a code number and read from the Nuclear Data Tape. These data may be microscopic or macroscopic cross sections of a chemical element, compound, mixture, or isotope; spectral data; or other nuclear data, tabulated in the format of element cross sections.
Material	A grouping of elements to form a set of macroscopic cross sections for Program I ₂ input.
Composition	A grouping of elements to form a set of macroscopic cross sections for use in Program C ₂ .
Region	A portion of the reactor uniquely defined by its location in Program F ₂ . It contains a single composition and uniform radial intervals.
Program I ₂	A P ₃ approximation to transport theory in cylindrical geometry from which disadvantage factors are obtained for the fine cell structure.
Program C ₂	A bare reactor calculation, using a homogenized core composition to compute the flux and slowing-down density at 19 lethargy values, from which group constants are obtained for use in multiregion calculations.
Program F ₂	A one-dimensional, two-group diffusion calculation, in as many as 50 regions and at as many as 100 intervals, which yields reactivity, fast and slow flux, and local-to-average power ratio.
Reactivity Match	An iterative loop between a Program C ₂ composition calculation and a set of Program F ₂ radial and longitudinal calculations to find consistent reflector savings S_r and S_z .
Nuclear Data Tape	A magnetic tape for the IBM 704 computer, upon which are found all cross-sectional and spectral data for the Program C ₂ portion of Program George.
Program George	A general program combining Programs I ₂ , C ₂ , and F ₂ plus a reactivity match, and employing the Nuclear Data Tape.

4. Glossary and Nomenclature

4.1 UPPER-CASE ENGLISH SYMBOLS

A	absorption spectrum; atomic weight; albedo; left-hand flux ratio
B	right-hand flux ratio
C	control word or digit
D	diameter; diffusion coefficient
D_{co}	composition outer diameter
D_{ci}	composition inner diameter
D_{ch}	channel diameter
D_o	rod diameter; plate thickness
D_1	fuel inner diameter
D_2	fuel outer diameter
D_3	cell diameter
E	energy
F	spectrum of fissions
H	height
I	element code number
K^2	buckling
L^2	diffusion area
L	leakage spectrum; length of composition
N_o	Avogadro's number $\times 10^{-24} = 0.60247$
N	atomic density $\times 10^{-24}$; lethargy index for group division
N_j	number of intervals in j -th region
P	fraction of fissions; power level; total number of iterations
R	radius
S	reflector savings; source spectrum
T	temperature
U	lethargy interval
V	volume
V_c	composition volume

V_m	material volume
W	weight of element in composition; weight of element in material; weight fraction of microscopic element in macroscopic element
Z	atomic number

4.2 LOWER-CASE ENGLISH SYMBOLS

a	recursion coefficient
b	average cosine of scattering angle; recursion coefficient
c	recursion coefficient
d	extrapolation distance; recursion coefficient
f	density fraction; Behrens factor
g	cell correction
h_j	interval width in j -th region
k	calculated multiplication constant; multiplication constant for infinite medium
l	hydraulic diameter; length of material
m	number of cells
p	absorption escape probability
q	slowing-down density
r	distance
t	reflector thickness; transmission fraction
u	lethargy value
v	slowing-down parameter; solution of recursion equation
w	slowing-down parameter; solution of recursion equation
x	attenuation factor in fuel
y	attenuation factor in moderator

4.3 GREEK SYMBOLS

α	expansion parameter for transport correction; parameter for transmission calculations
β	delayed-neutron fraction; geometric coefficient
γ	geometric coefficient
δ	twice the extrapolation distance; geometric coefficient
ϵ	smallness parameter for transport correction; annulus wall thickness; convergence parameter
σ	microscopic cross section $\times 10^{24}$ (barns); optical thickness
Σ	macroscopic cross section (cm^{-1})
μ	integer defining geometry

ν	number of neutrons per fission
ξ	average loss in lethargy per scattering collision
ρ	density
ϕ	flux
ω	inverse period

4.4 SUBSCRIPTS

a	absorption
c	composition
f	fission
fuel	fuel
F	Fahrenheit
h	homogenized
H	hydrogen
i	composition index in reactor; inner dimension
I	largest value of i
j	delayed-neutron group index; region index
K	Kelvin
l	leakage
m	material
mod	moderator
n	lethargy index
N	lethargy index for two-group division
o	outer dimension
r	radial component
s	scattering; slowing-down or transfer; spherical component
T	total
t	last epithermal lethargy index
$t + 1$	thermal lethargy index
tr	transport
z	longitudinal component
zone	zone of Program I ₂
1, 2, ...	lethargy groups
68, 500, ...	Fahrenheit temperatures
$I, II, \dots$	lethargy for multigroup division

4.5 SUPERSCRIPTS

P	iteration index
$+, -$	values next larger and next smaller than; values just to the right or just to the left of a discontinuity
$-$	average value
i	element index

4.6 PROGRAM MNEMONICS

<u>Symbol</u>	<u>Mnemonic</u>	<u>Definition</u>
	NAME	BCI name identification
	CASE	BCI case identification
	DATE	BCI date identification
	CLSFT	BCI classification identification
	NCE	number of core/end C_2 calculations
	NSC	number of side C_2 calculations
	NCC	number of control C_2 calculations
	NF2C	number of F_2 cases
C_1-C_{33}	CTN1-CTN33	control word options
	REFCP	BCI reference core identification used in C_2-F_2 reactivity match
	LONGF	BCI longitudinal F_2 case identification used in C_2-F_2 reactivity match
	RADF	BCI radial F_2 case identification used in C_2-F_2 reactivity match
ω	OMEGA	inverse period of reactor
	CCN	BCI C_2 composition case number
	CSP	spectrum code number
N	NG	lethargy index for group division
T_{MOD}	TPM	moderator temperature
H	HT	core height
S_z	SRL	savings on one end
D	DC	core diameter
S_r	SRR	savings on the radius
R	RAD	radius
S_s	SRS	spherical savings
D_1	D1	fuel inner diameter
D_2	D2	fuel outer diameter

<u>Symbol</u>	<u>Mnemonic</u>	<u>Definition</u>
D_3	D3	cell diameter
m	MC	number of cells
D_0	DPO	rod diameter; plate thickness
D_{CH}	DCH	channel diameter
ϵ	ET	annulus thickness
	REFC	BCI reference core identification for flux and buckling in C_2 side and control calculations
	REFB	BCI reference case identification for buckling in C_2 - F_2 reactivity match
	REFA	BCI reference case identification for albedos in C_2 - F_2
D_{CO}	DCO	composition outer diameter
D_{ci}	DCI	composition inner diameter
L	LG	composition length
$A(\omega)$	ACALC	calculated A of omega
U_{t+1}	MUTM	calculated thermal lethargy
	NUMIS	number of different elements
	MATCH	cross-section interpolation trigger
l_{fuel}	LFUEL	hydraulic diameter fuel
l_{mod}	LMOD	hydraulic diameter moderator
V_c	VOC	composition volume
k	RCVTY	criticality
P_{17}	P17	power at level 17
P_t	PT	power at last epithermal level
P_{t+1}	PTP1	power at thermal
	BALCD	balance check discrepancy
D_1	DG1	fast diffusion coefficient, one-group buckling
D_2	DG2	slow diffusion coefficient, one-group buckling
D_1'	DG1P	fast diffusion coefficient, two-group buckling
D_2'	DG2P	slow diffusion coefficient, two-group buckling
Σ_{a_1}	SA1	fast absorption term
Σ_{a_2}	SA2	slow absorption term
$\nu \Sigma_{f_1}$	NSF1	fast fission production term
$\nu \Sigma_{f_2}$	NSF2	slow fission production term
Φ_1	PHI1	fast flux

<u>Symbol</u>	<u>Mnemonic</u>	<u>Definition</u>
ϕ_2	PHI2	slow flux
k_1	K1	fast multiplication
k_2	K2	slow multiplication
Σ_{l_1}	SL1	fast leakage term
Σ_{l_2}	SL2	slow leakage term
L_1^2	L1SQ	fast diffusion area, one-group buckling
L_2^2	L2SQ	slow diffusion area, one-group buckling
$L_1^{2'}$	L1SQP	fast diffusion area, two-group buckling
$L_2^{2'}$	L2SQP	slow diffusion area, two-group buckling
d_1	DEX1	fast extrapolation distance
d_2	DEX2	slow extrapolation distance
Σ_{s_1}	SS1	scatter transfer term
K^2	KSQ	average buckling
d	DEX	average extrapolation distance
p	P	absorption escape probability
k	KG	multiplication constant, one-group buckling
k'	KGP	multiplication constant, two-group buckling
t_1	FCT1	fast transmission fraction
t_2	FCT2	slow transmission fraction
K_1^2	K1SQ	fast buckling
K_2^2	K2SQ	slow buckling
d_{MG}	DEXMG	average extrapolation distance, multigroup calculation
K_{MG}^2	KSQMG	average buckling multigroup calculation
k_{MG}	KGMG	multiplication constant, one-group buckling multigroup calculation
k'_{MG}	KGMGP	multiplication constant, multigroup buckling multigroup calculation
	NCAS	total number of C_2 cases
	NCASF	total number of C_2 and F_2 cases
	CPCTR	C_2 case counter
	F2CTR	F_2 case counter
	RMCTR	C_2 - F_2 reactivity match iteration counter
	TRCTR	total rerun C_2 case counter used in C_2 - F_2 reactivity match

<u>Symbol</u>	<u>Mnemonic</u>	<u>Definition</u>
	RRCTR	rerun C_2 case counter used in C_2 - F_2 reactivity match
	COCTR	core/end composition counter
	SICTR	side composition counter
	CNCTR	control composition counter
	SWF2	C_2 - F_2 reactivity match completion trigger; 0 = NO, 1 = YES
	SWRL	C_2 - F_2 reactivity match radial or longitudinal F_2 case trigger; 0 = radial, 1 = longitudinal
S'_r	SRRP	adjusted radial savings
S'_z	SRLP	adjusted longitudinal savings
	TICTR	library tape 4 record counter
	TSCL	longitudinal savings value trigger; 0 if $S_z \leq 2.0$ 1 if $S_z > 2.0$
	TSCR	radial savings value trigger; 0 if $S_r \leq 2.0$ 1 if $S_r > 2.0$
	NRCTR	radial F_2 case counter
	NLCTR	longitudinal F_2 case counter
	TESTL	lethargy level 17 trigger; 1 = YES, -1 = NO

5. Programming Method

5.1 GENERAL PROGRAM LOGIC

Program George is basically a merging of two previously developed programs (I_2 Intermediate and F_2) together with a Program C_2 , which was developed for Program George and which emerges as a special case of Program George when I_2 and F_2 are not called into the calculation. Since Programs I_2 and F_2 , as originally designed and coded, are self-contained programs, both had to be modified when combined with Program C_2 to form Program George. This was necessary because the C_2 portion of Program George is the master controlling program and directs the execution of the I_2 and F_2 calculations. In the case of I_2 , the modifications consisted of bypassing the data-load subroutine, transferring the radial flux, the radii and the average flux per zone to Program C_2 , and changing the post-mortem stop and final stop to transfers to Program C_2 . In the case of F_2 , a program consisting of a control routine and eight calculation routines, the modifications consisted of bypassing the data-load subroutine, bypassing the portion of the F_2 control routine that writes the eight calculation routines on a binary tape, changing the print-out to floating point, and changing the post-mortem stop and final stop to transfers to Program C_2 . Since neither Program I_2 nor F_2 has been modified with regard to the physical and mathematical statement of the problem and its solution, and since published reports describe the two programs in detail, the remainder of this section will present the programming method of Program George in general and the C_2 portion of Program George in particular.

The C_2 portion of Program George, which is the master controlling portion, is composed of five large subroutines.

1. Master Control
2. Core or End Composition Calculation
3. Side Composition Calculation
4. Control Composition Calculation
5. F_2 Input Calculation

All calculations in C_2 have been programmed as closed subroutines for ease in making program modifications. This is true not only of the five major subroutines but also of the numerous minor subroutines comprising the five major ones. The five major subroutines are described in the following paragraphs.

5.2 MASTER CONTROL

After the first record, containing the input-output package and the master control routine, is read into core storage from the production tape, transfer is made to the master control routine or specifically to the mnemonic "BEGIN." The master control routine then executes, depending upon the type George case to be calculated, the following list of transfer instructions.

BEGIN	SXJ	GPC, 4	(General Program Clear)
	SXJ	GOP, 4	(General Output Print)
	SXJ	CPCB, 4	(Composition Program Control Begin)
	SXJ	CORE, 4	(Core or End Calculation Routine)

SXJ	CPCE, 4	(Composition Program Control End)
SXJ	SIDE, 4	(Side Calculation Routine)
SXJ	CPCE, 4	(Composition Program Control End)
SXJ	CNTL, 4	(Control Calculation Routine)
SXJ	CPCE, 4	(Composition Program Control End)
SXJ	RMCB, 4	(Reactivity Match Control Begin)
SXJ	C2F2, 4	(F ₂ Input Calculation Routine)
SXJ	PF2, 4	(Program F ₂ Control)
SXJ	RMCE, 4	(Reactivity Match Control End)
SXJ	LIC, 4	(Loop, Iterate, Converge)
SXJ	RRCB, 4	(Rerun Control Begin)
SXJ	LCORE, 4	(Long Core or End Calculation Routine)
SXJ	RRCE, 4	(Rerun Control End)
SXJ	SCORE, 4	(Short Core or End Calculation Routine)
SXJ	RRCE, 4	(Rerun Control End)
SXJ	SSIDE, 4	(Short Side Calculation Routine)
SXJ	RRCE, 4	(Rerun Control End)
SXJ	SCNTL, 4	(Short Control Calculation Routine)
SXJ	RRCE, 4	(Rerun Control End)
SXJ	F2CB, 4	(F ₂ Control Begin)
SXJ	C2F2, 4	(F ₂ Input Calculation Routine)
SXJ	PF2, 4	(Program F ₂ Control)
SXJ	F2CE, 4	(F ₂ Control End)
SXJ	END, 4	(End of George Case)

AGAIN HTJ

The flow of the George case is directed through this list of transfer instructions and program control is always returned to one of these instructions after the calculation requested is performed. A general flow chart illustrating the flow of the program directed by the master control routine is given as Appendix B. A brief description of each of the routines signified by these instructions follows.

GPC - General Program Clear. This routine sets to zero all input storage, all C₂ output storage, and all special counters, switches, and other mnemonic signals. Tapes 5, 6, 7, 8, and 9 are rewound, and the first record of input data (the general input) is read into core storage. If F₂ calculations are to be performed, the eight F₂ calculation routines are read from the production tape into core storage and written as eight binary records on tape 5, which is then rewound. If there are no F₂ calculations to perform, the production tape is forward-spaced past the eight F₂ calculation routines in a position to read the core or end calculation. The exit of this routine always is to the routine immediately following, GOP.

GOP - General Output Print. This routine prints out the general input data: the engineer's name, case identification, date, security classification, the number each of core or end, side and control composition calculations, the number of F₂ cases, the inverse period of the reactor and, if there is a reactivity match, the reference C₂ composition case, radial F₂ case and longitudinal F₂ case. The exit of this routine always is to the routine immediately following, CPCB.

CPCB - Composition Program Control Begin. This routine controls the processing of all composition calculations by determining the type of composition to be

calculated from a record of composition input data read into core storage and then transferring control to the calculation requested. If the type of composition is core or end, the CORE subroutine is read from the production tape into core storage and transfer is made to the beginning of this subroutine. If the type of composition is side, the binary tape containing the reference constants, logical unit number 9, is rewound and then searched for the reference constants from a previously calculated core or end composition needed as supplementary input for the side composition. After the record of reference constants is located and read into core storage, tape 9 is forward-positioned for the writing of the reference constants from the side composition, which may be needed in a subsequent control of F_2 calculation. If there are no control or F_2 calculations, tape 9 is rewound, since the reference constants from the side composition are not needed. The SIDE subroutine is then read from the production tape into core storage, and transfer is made to the beginning of this subroutine. If the type of composition is control, the binary tape containing the reference constants, logical unit number 9, is rewound and then searched for the reference constants from a previously calculated core, end, or side composition needed as supplementary input for the control composition. After the record of reference constants is located and read into core storage, tape 9 is forward-positioned for the writing of the reference constants from the control composition, which may be needed in a subsequent F_2 calculation. If there are no F_2 calculations tape 9 is rewound, since the reference constants from the control composition are not needed. The CNTL subroutine is then read from the production tape into core storage, and transfer is made to the beginning of this subroutine. When all I_2 - C_2 composition calculations have been completed, tapes 5, 6, 8, and 9 are rewound, and exit is made to routine RMCB. The composition subroutine is not reread into core storage from the production tape if the present composition to be calculated is the same as the previously calculated type.

- CORE - Core or End Calculation Routine. This subroutine is described in section 5.3.
- CPCE - Composition Program Control End. Control is transferred to this routine, after the composition subroutine (CORE, SIDE, or CNTL) has been calculated. This routine tests the composition for rerunning in the event of a reactivity match, writes the reference constants from the composition on tape 9 if subsequent calculations warrant it, rewinds tape 9 if the composition is side or control, determines whether the composition input core storage is to be set to zero or whether a change case is in effect, and sets all Program C_2 calculated output core storage to zero. This routine always exits to CPCB.
- SIDE - Side Calculation Routine. This subroutine is described in section 5.4.
- CNTL - Control Calculation Routine. This subroutine is described in section 5.5.

Description of the various routines of the master control portion of Program C_2 is interrupted here for an account of the mechanics for obtaining an I_2 - C_2 - F_2 reactivity match.

The purpose of a reactivity match is to determine the radial and longitudinal reflector savings in a reflected reactor. The method is to adjust the radial and longitudinal savings of a reference core composition until the multiplication constant, k_c , is the same in the C_2 portion of the program as in the radial F_2 calculation using the longitudinal savings in the perpendicular buckling, and is also the same in the longitudinal F_2 calculation using the radial savings in the perpendicular buckling. The procedure applies only to a cylindri-

cal reactor. If the core composition is not uniform throughout the reactor, an average core composition must be used for the reference core in determining savings. However, provision has been made for adjusting the reflector savings in any C_2 composition designated by the user. Thus the reactivity match can be obtained even though the F_2 configurations contain a multiregion core.

The procedure used to find the matched savings is to find the variation of the radial F_2 multiplication constant k_r with longitudinal savings S_z , and the variation of the longitudinal F_2 multiplication constant k_z with radial savings S_r , using the core two-group constants computed with input values of savings in the reference composition. If the savings used in the reference composition do not produce $k_c = k_r = k_z$ within 10^{-4} , then the quadratic variations of S_r and S_z with k , determined by three radial and three longitudinal F_2 calculations, are used in a separate trial-and-error procedure to determine a value of k that produces S_r and S_z which, when substituted in the two-group expression for k_c , produce the trial k . These values of S_r and S_z are then used to rerun the C_2 reference composition, and any other compositions specified, to determine revised two-group constants. The loop between the C_2 compositions and the three radial and three longitudinal F_2 calculations is continued until the convergence criterion is satisfied or until the maximum of six iterations has occurred.

After all the I_2 - C_2 type calculations have been completed, the radial F_2 calculation is performed and the multiplication constant k_r is saved in core storage. Next the longitudinal F_2 calculation is performed, and the multiplication constant k_z is also saved in core storage. Using the multiplication constant from the C_2 reference core composition, k_c , along with those of the radial and longitudinal F_2 calculations, the following convergence test is made,

$$\begin{aligned} &|k_c - k_r| \leq 10^{-4}, \\ \text{and} \quad &|k_c - k_z| \leq 10^{-4}. \end{aligned}$$

If both criteria are satisfied, the reactivity match is completed and the final reflector savings and multiplication constants are printed out.

However, if the criteria are not satisfied, two more radial F_2 calculations are performed with the longitudinal savings S_z altered in one of the following ways depending upon the iteration.

First Iteration: If $S_{z,1} \leq 2.0$, perform two radial F_2 calculations with longitudinal savings of $S_{z,2} = S_{z,1} - 2.0$ and $S_{z,3} = S_{z,1} + 2.0$.

If $S_{z,1} > 2.0$, perform two radial F_2 calculations with longitudinal savings of $S_{z,2} = 0.5 S_{z,1}$ and $S_{z,3} = 0$.

Second-Sixth Iteration: Perform two radial F_2 calculations with longitudinal savings of $S_{z,2} = S_{z,1} - 2.0$ and $S_{z,3} = S_{z,1} + 2.0$.

The multiplication constants of these radial F_2 calculations are saved in core storage along with the multiplication constant of the first radial F_2 calculation.

With the completion of the two radial F_2 calculations, two more longitudinal F_2 calculations are performed with the radial savings S_r being altered in the manner just described. The multiplication constants of these longitudinal F_2 calculations are also saved in core storage along with the multiplication constant of the first longitudinal F_2 calculation.

Using the three estimates of radial savings and the corresponding three values of the multiplication constant obtained from the longitudinal F_2 calculations, the following system

of equations is solved for the coefficients A_0 , A_1 , and A_2 :

$$S_{r,1} = A_0 + A_1 k_{z,1} + A_2 k_{z,1}^2$$

$$S_{r,2} = A_0 + A_1 k_{z,2} + A_2 k_{z,2}^2$$

$$S_{r,3} = A_0 + A_1 k_{z,3} + A_2 k_{z,3}^2$$

Using the three estimates of longitudinal savings and the corresponding three values of the multiplication constant obtained from the radial F_2 calculations, the following system of equations is solved for the coefficients A_0 , A_1 , and A_2 :

$$S_{z,1} = A_0 + A_1 k_{r,1} + A_2 k_{r,1}^2$$

$$S_{z,2} = A_0 + A_1 k_{r,2} + A_2 k_{r,2}^2$$

$$S_{z,3} = A_0 + A_1 k_{r,3} + A_2 k_{r,3}^2$$

Having found the two sets of coefficients $(A_0, A_1, A_2)_z$ and $(A_0, A_1, A_2)_r$, $k_{r,1}$ is used as an initial reactivity estimate, k_{in} , in solving the following two equations for S_r and S_z , the adjusted savings.

$$a) \quad S_r(k) = [A_0 + A_1 k_{in} + A_2 k_{in}^2]_z$$

$$b) \quad S_z(k) = [A_0 + A_1 k_{in} + A_2 k_{in}^2]_r$$

The adjusted savings are then inserted in the following two-group equation to determine approximately what the multiplication constant would be if the Program C_2 reference core composition were recalculated with the adjusted savings.

$$c) \quad k_c = \frac{k_1(1-p)}{1 + L_1^2 K_1^2} + \frac{k_2 p}{(1 + L_1^2 K_1^2)(1 + L_2^2 K_2^2)}$$

where,

$$k_1 = v \Sigma_{f1} / \Sigma_{a1}, \quad k_2 = v \Sigma_{f2} / \Sigma_{a2}$$

$$p = \Sigma_{s1} / (\Sigma_{s1} + \Sigma_{a1})$$

$$L_1^2 = D_1 / (\Sigma_{a1} + \Sigma_{s1}), \quad L_2^2 = D_2 / \Sigma_{a2}$$

and

$$K_1^2 = K_2^2 = \frac{9.87}{(H + 2 S_z(k) + 2d)^2} + \frac{23.13}{(D + 2 S_r(k) + 2d)^2}$$

if one-group buckling is used; or if two group buckling is used

$$K_1^2 = \frac{9.87}{(H + 2 S_z(k) + 2d_1)^2} + \frac{23.13}{(D + 2 S_r(k) + 2d_1)^2}$$

and

$$K_2^2 = \frac{9.87}{(H + 2 S_z(k) + 2d_2)^2} + \frac{23.13}{(D + 2 S_r(k) + 2d_2)^2}$$

With the initial reactivity, k_{in} , and the reactivity yielded by the two-group equation, k_c , the following test is made:

$$|k_{in} - k_c| \leq 10^{-6}$$

If this test is satisfied, the C_2 reference core composition, and any other compositions specified by the user, are rerun using the new estimates of the radial and longitudinal savings. Consequently new two-group constants are calculated by the C_2 program and are supplied to the radial and longitudinal F_2 calculations to ascertain whether these newly adjusted savings have produced multiplication constants in the C_2 reference core, the radial F_2 , and the longitudinal F_2 that agree in value to 10^{-4} . If not, the whole procedure repeats. A maximum of six iterations is allowed for this procedure, although convergence usually occurs during the third or fourth iteration.

However, if the test $|k_{in} - k_c| \leq 10^{-6}$ is not satisfied, a second guess of k_{in} is determined as

$$k_{in}' = k_{in} - 2(k_{in} - k_c) = k_{in} - 2\Delta k.$$

Equations a, b, and c are repeated, and a new value of Δk is determined as $k_{in}' - k_c'$. A linear extrapolation to $\Delta k = 0$ is then used to find a new k_{in} for a second attempt to satisfy $|k_{in} - k_c| \leq 10^{-6}$. This procedure is repeated until the test is satisfied. If the initial values of the savings S_r and S_z are not greater than the ultimate solution, it may happen that $|k_{in} - k_c| \leq 10^{-6}$ cannot be satisfied. Therefore it is best to make an initial estimate of S_r and S_z that is on the high side so that the solution will be bracketed by the three radial and three longitudinal F_2 calculations.

With the mechanics of the I_2 - C_2 - F_2 reactivity match described, the routines of the master control portion of Program C_2 pertaining to the reactivity match can be understood more easily.

RMCB - Reactivity Match Control Begin. This routine determines whether a reactivity match is to be calculated. If not, tape 9 is rewound and control is transferred to routine F_2CB . If a reactivity match is requested, this routine determines the type (radial or longitudinal) F_2 calculation, the number (first, second, or third) of the type calculation, and the number of times the reactivity match has iterated. These three pieces of information are necessary for the reading of the set of input data describing the calculation from the correct peripheral unit. If the calculation is the first radial F_2 of the first iteration, the input data is read in decimal form either from the decimal input tape 2 or the on-line card reader and written in binary form on tape 7 immediately following the last Program C_2 composition input data that is to be rerun in the reactivity match. If the calculation is the first longitudinal F_2 of the first iteration, the input data is read in decimal form either from the decimal input tape 2 or from the on-line card reader and written in binary form on tape 7 immediately following the input data describing the radial F_2 calculation. If the calculation is the second radial or longitudinal of the first iteration, or the first or second radial or longitudinal of the second through sixth iteration, the input data is read in binary form from tape 7. If the calculation is the third radial or longitudinal of the first through sixth iteration, the input data is already in core storage and is not reread from any of the peripheral units. After the input data is read into core storage, this routine reads from the production tape the C_2F_2 subroutine into core storage, rewinds tape 9 and transfers control to the beginning of C_2F_2 .

- C2F2 - F₂ Input Calculation Routine. This routine is described in section 5.6.
- PF2 - Program F₂ Control. This routine rewinds tapes 5, 8, and 9, and reads the control routine of Program F₂ from the production tape into core storage. Index register 4 is not reloaded when exiting from the PF2 routine. Program F₂ has been modified to load index register 4 from a reserved location in core storage (41)₁₀ when the F₂ calculation is completed. The PF2 routine always exits to location 2126 decimal and the F₂ program always exits, unless a malfunction has occurred, to the routine immediately following, RMCE.
- RMCE - Reactivity Match Control End. This routine tests the multiplication constants from the reference Program C₂ core, the radial F₂ calculation and the longitudinal F₂ calculation for convergence. If the multiplication constants have converged, tapes 5, 7, 8, and 9 are rewound, the values of the multiplication constants and savings are printed out, and control is transferred to routine F2CB. If the multiplication constants have not converged and six iterations have been made, tapes 5, 7, and 9 are rewound, a comment is printed out that convergence was not attained, and control is transferred to routine F2CB. If the multiplication constants have not converged, six iterations have not been made, and the remaining two radial and two longitudinal F₂ calculations needed for the parabolic fit have not been performed, then tapes 5, 6, 8, and 9 are rewound, tape 7 is backspaced two records, and control is transferred to RMCB. If the multiplication constants have not converged, six iterations have not been made, but the remaining two radial and two longitudinal F₂ calculations needed for the parabolic fit have been performed, then tapes 5, 6, 7, 8, and 9 are rewound and exit is made to the routine immediately following, LIC. In the last two alternatives, the values of the multiplication constants and the savings are printed out.
- LIC - Loop, Iterate, and Converge. This routine computes algebraically a pair of consistent reflector savings, which are then used in rerunning the Program C₂ compositions and the radial and longitudinal F₂ calculations. If consistent reflector savings are computed, tapes 5, 6, 7, 8, and 9 are rewound and control is transferred to routine RRCB. If consistent reflector savings cannot be computed, tapes 5, 6, 7, 8, and 9 are rewound and control is transferred to F2CB. In either case the values of the savings are printed out.
- RRCB - Rerun Control Begin. This routine controls the processing of all I₂-C₂ compositions that are to be rerun in the reactivity match. This is done by determining the type of composition to be calculated from a record of input read into core storage from the binary rerun tape, logical number 7. The newly adjusted set of consistent reflector savings is then inserted in this set of input replacing the previous set. Control is then transferred to the calculation requested. If the type of composition is core or end, the CORE subroutine is read from the production tape into core storage; transfer is made to the routine LCORE if I₂ calculations are to be performed, and to the routine SCORE if no I₂ calculations are to be performed. Tape 9, the reference constants tape, is then forward-spaced for the writing of the reference constants associated with the rerun compositions and tapes 5, 6, and 8 are rewound. If the type of composition is side, tape 9 is backspaced to a point just before the first record of reference constants from the first rerun I₂-C₂ composition. The tape is then searched for the reference constants from a previously calculated rerun core or end composition needed as supplementary input for the side composition. After the record of reference constants is located and

read into core storage, tape 9 is forward-positioned for the writing of the reference constants from the side composition, which may be needed in a subsequent control or F_2 calculation, and tapes 5, 6, and 8 are rewound. The SIDE subroutine is then read from the production tape into core storage, and transfer is made to the routine SSIDE. If the type of composition is control, tape 9 is backspaced to a point just before the first record of reference constants from the first rerun I_2 - C_2 composition. The tape is then searched for the reference constants from a previously calculated rerun core, end, or side composition needed as supplementary input for the control composition. After the record of reference constants is located and read into core storage, tape 9 is forward-positioned for the writing of the reference constants from the control composition, which may be needed in a subsequent F_2 calculation, and tapes 5, 6, and 8 are rewound. The CNTL subroutine is then read from the production tape into core storage and transfer is made to the routine SCNTL. If all the I_2 - C_2 compositions that are to be rerun in the reactivity match have been processed, tapes 5, 6, 8, and 9 are rewound and control is transferred to routine RMCB.

- LCORE - Long Core or End Calculation Routine. This subroutine is described in section 5.3.
- RRCE - Rerun Control End. Control is transferred to this routine, after the composition subroutine (CORE, SIDE or CNTL) has been calculated. This routine writes the reference constants from the composition on tape 9 if subsequent calculations warrant it, determines whether the composition input core storage is to be set to zero or whether a change case is in effect, and, finally, sets all Program C_2 calculated output core storage to zero. This routine always exits to RRCB.
- SCORE - Short Core or End Calculation Routine. This subroutine is described in section 5.3.
- SSIDE - Short Side Calculation Routine. This subroutine is described in section 5.4.
- SCNTL - Short Control Calculation Routine. This subroutine is described in section 5.5.
- F2CB - F_2 Control Begin. This routine controls the processing of all Program F_2 calculations exclusive of those needed for a reactivity match. The F_2 change case control word is tested and then a record of input data describing the F_2 calculation is read into core storage from the decimal input tape or from the on-line card reader. Next, the C2F2 subroutine is read from the production tape into core storage if necessary. Control is then transferred to the C2F2 routine. If all F_2 calculations are completed, exit is made to routine END.
- F2CE - F_2 Control End. This routine keeps a running count of the number of F_2 calculations. If more F_2 calculations are to be made, tapes 5, 7, 8, and 9 are rewound and control is transferred to routine F2CB. If all F_2 calculations have been made control is transferred to routine END.
- END - End of a George Case. This is the final routine of a George case. Tapes 5, 6, 7, 8, and 9 are rewound, and a comment is printed out identifying the user's name and stating that the George case is finished. Throughout the explanations in this section the phrase "production tape" has been used often, but no logical unit number was assigned to the tape. This was done because two versions of Program George are available. The first version was designed specifically for the Aircraft Nuclear Propulsion Department for use

with an Integrated Operator System. This program uses the production tape on logical unit number 4 and does not permit the use of multi-case George calculations. In other words, the master control routine and input-output package must be read into core storage with each new George case. After completing the END routine this version transfers control to the Integrated Operator System. The second version was designed for use on any 32 K, 8 tape unit IBM 704 computer. This program uses the production tape on logical unit number 1 and permits the use of multi-case George calculations. After completing the END routine, this version tests sense switch 4. If sense switch 4 is down, tape 1 is backspaced to a position just before the core or end calculation subroutine, CORE, and transfers control to the mnemonic BEGIN in order to begin another George case. If sense switch 4 is up, tape 1 is re-wound and control is transferred to the mnemonic AGAIN, the location of which contains all zeros. Hence the computer is halted and the computer operator can take whatever action is desired.

5.3 CORE OR END COMPOSITION CALCULATION

After the core or end calculation routine, CORE, has been read into core storage from the production tape, control is transferred to one of three mnemonics (CORE, LCORE, SCORE) identifying a list of transfer instructions. This list of transfer instructions, like the list contained in the master control routine, directs the flow of the calculation to be performed. The mnemonic CORE indicates that a complete core or end composition calculation must be performed. The mnemonic LCORE indicates that the core or end composition is being rerun in a reactivity match and that the user wants to recalculate the g-factors with Program I₂. The mnemonic SCORE indicates that the core or end composition is being rerun in a reactivity match and that Program I₂ is not to be called into the calculation. The list of transfer instructions follows; a brief summary of the calculations performed in each subroutine is given, together with the equation numbers in Appendix A that are used by the subroutine.

CORE	SXD	41, 4	(Save Index Register 4)
	SXJ	1013A, 4	
	SXJ	1013B, 4	
	SXJ	1013C, 4	
	UNJ	LCORE + 1	
LCORE	SXD	41, 4	
	SXJ	1P013, 4	
	SXJ	1P014, 4	
	SXJ	1P015, 4	
	SXJ	1P016, 4	
	SXJ	1016A, 4	
	SXJ	1016B, 4	
	SXJ	1P017, 4	
	SXJ	1017A, 4	
	SXJ	1017B, 4	
	SXJ	1P018, 4	
	SXJ	1018A, 4	
	SXJ	1018B, 4	
	SXJ	1P021, 4	
	SXJ	1P023, 4	
	SXJ	1025A, 4	
	SXJ	1P031, 4	

	SXJ	1031A, 4	
	SXJ	1031C, 4	
	SXJ	1031B, 4	
	SXJ	1031D, 4	
	SXJ	1031E, 4	
	SXJ	1P032, 4	
	SXJ	1032A, 4	
	UNJ	SCORE + 1	
SCORE	SXD	41, 4	(Save Index Register 4)
	SXJ	1P033, 4	
	SXJ	1033A, 4	
	SXJ	1033C, 4	
	SXJ	1033D, 4	
	SXJ	1P04, 4	
	SXJ	1P04A, 4	
	SXJ	1P04B, 4	
	SXJ	1P04C, 4	
	SXJ	1P05, 4	
	SXJ	1P05A, 4	
	SXJ	1P06, 4	
	SXJ	1P06A, 4	
	SXJ	1P09, 4	
	SXJ	1P10, 4	
	SXJ	1P20, 4	
	SXJ	1P10A, 4	
	SXJ	1P20A, 4	
	SXJ	1P23, 4	
	SXJ	1P24, 4	
	SXJ	1P24A, 4	
	SXJ	1P25, 4	
	SXJ	1P25A, 4	
	SXJ	1P28, 4	
	SXJ	1P28A, 4	
	SXJ	1P22A, 4	
	SXJ	1P22, 4	
	SXJ	1P22B, 4	
	SXJ	1P35, 4	
	LXD	41, 4	(Reload Index Register 4)
	UNJ	1, 4	(Transfer to Master Control Routine)

1013A - This routine converts the core dimensions, Behrens dimensions, composition dimensions, and dimensions used in the absorber calculation to the centimeter-gram-second system of units if these dimensions are given in the English system of units.

1013B - This routine converts the weights of the elements given as input in the moderator and fuel tables to the centimeter-gram-second system of units, if necessary.

1013C - This routine converts the input data associated with the Program I₂ calculation to the centimeter-gram-second system of units, if necessary. This input data consists of the dimensions for the volume calculation of each material

given, the weights of the elements in each material given, and the radii describing the fine cell structure.

- 1P013 - This routine calculates the cell diameter if it is not given as input and if the number of cells is not zero. Equation (1).
- 1P014 - This routine reads into core storage, from the Nuclear Data Tape, the neutron source spectrum requested by the user. If an off-critical analysis is requested, this routine reads from the Nuclear Data Tape the six delayed spectra data records and performs the off-critical calculation. Equations (2) and (3).
- 1P015 - This routine calculates the thermal lethargy from the moderator temperature. Equation (4).
- 1P016 - This routine calculates the volume of the composition from the composition dimensions. Equation (6).
- 1016A - If Program I₂ calculations are requested, this routine calculates the volume of each I₂ material given as input by the user. Equation (5).
- 1016B - If Program I₂ calculations are requested, this routine sets the moderator and fuel input regions to zero.
- 1P017 - This routine sets to zero the arrays of core storage in which the moderator and fuel cross sections are to be computed. Also the core storage needed for the logical sorting of the code numbers of the elements given as input by the user is set to zero.
- 1017A - If Program I₂ calculations are requested, this routine forms a list of unrepeated element code numbers from all the I₂ materials given as input. Also if an off-critical analysis is requested, the element code number 0.980 indicating the element ACCUMULATION and its unhomogenized density are inserted in each I₂ material given as input. Equation (7).
- 1017B - This routine forms a list of unrepeated element code numbers from the moderator and fuel tables given as input. If an off-critical analysis is requested, the element code number 0.980 indicating the element ACCUMULATION and its homogenized density are inserted in the moderator and fuel regions. Equations (8) and (9).
- 1P018 - This routine sorts the unrepeated list of element code numbers in absolute ascending order. After the list is sorted, the index record of the Nuclear Data Tape is scanned to determine the positions of the element records relative to one another. At the same time the name corresponding to each element code number given as input is stored for the print-out later in the program.
- 1018A - This routine sets the g -factors in the moderator and fuel regions to 1.
- 1018B - This routine reads into core storage from the Nuclear Data Tape a record of cross-section data corresponding to one of the sorted element code numbers given as input.
- 1P021 - If Program I₂ calculations are requested, this routine calculates, for each I₂ material of which the element under consideration is a member, the weight, unhomogenized atomic density, or unhomogenized fractional density, depend-

ing upon the input given by the user. The radius of the cell is then calculated, followed by the calculation of the homogenized density or homogenized volume fraction of the element in the moderator and fuel regions. Equations (10) through (18).

- 1P023 - This routine calculates the weight, homogenized density, or homogenized volume fraction of the element under consideration in the moderator or fuel region. If the element is fissionable and if the inverse period of the reactor is non-zero, the fission cross section is corrected for off-critical analysis. This routine then calculates the macroscopic composition cross sections for the moderator and fuel regions from lethargy level zero to 15, inclusive. A fourth-order Lagrangian interpolation is performed in the Maxwellian-averaged cross sections to find the cross sections at thermal lethargy, if necessary. Also a third-order Lagrangian interpolation is performed in the epithermal levels 16, 17, and 18 to find the last epithermal cross section t , if requested by the user. Equations (19) through (27).
- 1025A - This routine identifies the arrays of storage containing the cross sections for lethargy levels 16, 17, 18, t , and $t+1$ by inserting the proper element code number as the first word of each array.
- 1P031 - If Program I_2 calculations are requested, this routine sets the storage arrays for the average flux per zone and the g -factor per zone to zero.
- 1031A - If Program I_2 calculations are requested, this routine calculates the cross sections for each I_2 material given as input by the user. These cross sections may include absorption, scattering, transport, first-moment scattering, second-moment scattering, and if necessary the diffusion coefficient. Equations (28) through (34).
- 1031C - This routine reads the I_2 program from the production tape into core storage.
- 1031B - If Program I_2 calculations are requested, this routine transfers the I_2 input data into the proper core storage. This input data consists of the source terms, zone data, and material cross-section data. The title page for each I_2 calculation is also printed out in this routine.
- 1031D - If Program I_2 calculations are requested, this routine transfers the I_2 calculated radii and radial flux to the proper Program C_2 core storage.
- 1031E - If Program I_2 calculations are requested, this routine transfers the I_2 calculated average flux per zone to the proper Program C_2 core storage.
- 1P032 - If Program I_2 calculations are requested, this routine calculates the average flux over the cell or over the moderator, the g -factor for each zone, and finally the g -factors for the moderator and fuel regions. Equations (35) through (40).
- 1032A - If Program I_2 calculations are requested, this routine modifies certain program instructions associated with the I_2 calculation.
- 1P033 - If Program I_2 calculations are requested, this routine writes the radial flux, the radii, and the average flux per zone in binary form as one record on tape number 6. This is done to free the core storage arrays containing these quantities for other purposes. If a reactivity match is requested, and if this core or end composition is to be rerun in the reactivity match, all data needed to rerun the composition are written in binary form as one record on tape number 7. Tape 6 is rewound before exiting from this routine, but tape 7 is left in position to write the next record of rerun data.

- 1033A - This routine prints out all input data.
- 1033C - If Program I_2 calculations are requested, this routine prints out the I_2 material tables given as input by the user.
- 1033D - This routine prints out the moderator and fuel tables.
- 1P04 - This routine sets the Behrens factors equal to 1.
- 1P04A - This routine calculates the hydraulic diameter in the moderator and fuel, the Behrens cross sections for lethargy levels zero through 15, the Behrens cross sections with or without g -factors applied for lethargy levels 16 through $t+1$, the attenuation factors in the moderator and fuel for lethargy levels zero through $t+1$ and finally the isotropic or anisotropic Behrens factors for lethargy levels zero through $t+1$. Equations (41) through (60).
- 1P04B - If a Behrens calculation is performed and if the long print-out is requested by the user, this routine prints out the Behrens cross sections, attenuation factors, and hydraulic diameters.
- 1P04C - If the long print-out is requested by the user, this routine prints out the Behrens factors and the neutron source spectrum.
- 1P05 - This routine calculates the total homogenized composition cross sections for lethargy levels 0 through $t+1$. For lethargy levels 16 through $t+1$, either all the cross sections may have g -factors applied or just the absorption and fission cross sections. Equations (61) through (64).
- 1P05A - If the long print-out is requested by the user, this routine prints out the total homogenized composition cross sections.
- 1P06 - This routine calculates the extrapolation distance, the component and total buckling for slab, spherical, or cylindrical geometry, the expansion and smallness parameters for transport correction, and the component and total leakage cross sections for slab, spherical, or cylindrical geometry. All these quantities are calculated for lethargy levels zero through $t+1$. Equations (65) through (81).
- 1P06A - If the long print-out is requested by the user, this routine prints out the extrapolation distance, the component and total buckling, the expansion and smallness parameters, and the component and total leakage.
- 1P09 - This routine establishes the lethargies and lethargy intervals for the slowing-down calculation and flux weighting. Equations (84) and (85).
- 1P10 - This routine calculates the slowing-down parameters V and W , the slowing-down density, and the flux for the five slowing-down models available in the program. All the quantities are calculated for lethargy levels zero through t . The slowing-down density at lethargy level zero is set to zero. Equations (86) through (101).
- 1P20 - This routine calculates the flux at the thermal lethargy level, the flux-weighted absorption, leakage and fission spectra; performs the balance check discrepancy test; calculates the reactivity; and calculates the power at the thermal, last epithermal, and 17th lethargy levels. Equations (102) through (111).
- 1P10A - This routine transfers the calculated extrapolation distance, longitudinal buckling, and flux to an array in core storage from which the record of reference constants is to be written on tape number 9.

- 1P20A - If the intermediate or long print-out is requested by the user, this routine prints out the lethargy; the slowing-down parameters V and W ; the slowing-down density; the flux; and the flux-weighted leakage, absorption, and fission spectra.
- 1P23 - This routine calculates the two-group division at the half-power point if requested. Equations (112) and (113).
- 1P24 - This routine calculates the ordinary two-group constants associated with a bare-reactor calculation. These group constants consist of the flux; absorption; fission; leakage; multiplication; scattering-out; absorption escape probability; extrapolation distance; one-group and two-group buckling for slab, spherical, or cylindrical geometry; and the diffusion coefficient, diffusion area, and reactivity based on both the one-group and two-group buckling. Equations (114) through (150).
- 1P24A - This routine prints out the calculated reactivity, power, balance check discrepancy, lethargy, and lethargy index for two-group division and all the calculated two-group constants.
- 1P25 - This routine calculates the ordinary group constants and parameters associated with a bare-reactor calculation in a multigroup representation if requested by the user. First a linear interpolation is performed in the values for the source spectrum; slowing-down density; flux; extrapolation distance; and the flux-weighted absorption, fission, and leakage spectra. Then a trapezoidal integration in the linearly interpolated values of the flux, absorption, fission, leakage, extrapolation distance, and source spectrum is performed to find the group constants associated with the given energy group divisions. From these quantities the multiplication constant, scattering-out term, absorption escape probability, one-group and multigroup buckling, and the diffusion coefficient, diffusion area, and reactivity based on both one-group and multigroup buckling are computed in a multigroup representation. Equations (151) through (176). For a control composition calculation, the equations are (201) through (207).
- 1P25A - This routine prints out the results of the multigroup calculation.
- 1P28 - This routine calculates the photon-production parameters if requested by the user. The elements' records, corresponding to the code numbers given by the user, are read from the Nuclear Data Tape and the homogenized absorption and fission cross sections are computed for lethargy levels zero through $t+1$. A linear interpolation is then performed in the values of the absorption and fission cross sections and the flux. These quantities are then trapezoidally integrated to find the group constants associated with the given energy group divisions. Equations (177) through (183).
- 1P28A - This routine prints out the results of the photon-production parameter calculation.
- 1P22A - If the fine radial power calculation is requested by the user, this routine reads into core storage in binary form the radial flux, radii, and average flux per zone from tape 6, which is then rewound.
- 1P22 - This routine calculates, utilizing Program I₂ results, the normalized radial flux and the radial power at the lethargy levels at which I₂ calculations were performed. Equations (184) through (186).

- 1P22B - This routine prints out the zone number, the weighting-factor for the zone, the lattice number, and the radius and power associated with the lattice number from the fine radial power calculation.
- 1P35 - This routine converts the weights in the moderator and fuel regions, core dimensions, Behrens dimensions, composition dimensions, and dimensions used in the absorber calculation from the centimeter-gram-second system of units to the English system if originally given in the English system. If Program I₂ calculations were requested, the radii for the zone data, the dimensions and weights associated with the material data, and the I₂-calculated radii are converted to the English system.

5.4 SIDE COMPOSITION CALCULATION

After the side calculation routine (SIDE) has been read into core storage from the production tape, control is transferred to one of two mnemonics (SIDE, SSIDE) identifying a list of transfer instructions. This list of transfer instructions, like the list contained in the master control routine and the core or end calculation routine, directs the flow of the calculation to be performed. The mnemonic SIDE indicates that a complete side composition calculation must be performed. The mnemonic SSIDE indicates that the side composition is being rerun in a reactivity match. The list of transfer instructions follows, and a brief summary of each calculation not previously explained in section 5.3 is given.

SIDE	SXD	41,4	(Save Index Register 4)
	SXJ	1P012,4	
	SXJ	1013A,4	
	SXJ	1013B,4	
	SXJ	1P014,4	
	SXJ	1P015,4	
	SXJ	1P016,4	
	SXJ	1P017,4	
	SXJ	1017B,4	
	SXJ	1P018,4	
	SXJ	1018A,4	
	SXJ	1018B,4	
	SXJ	1P023,4	
	SXJ	1025A,4	
	UNJ	SSIDE+2	
SSIDE	SXD	41,4	(Save Index Register 4)
	SXJ	1P012,4	
	SXJ	1033B,4	
	SXJ	1033D,4	
	SXJ	1033F,4	
	SXJ	1P04,4	
	SXJ	1P04C,4	
	SXJ	1P05,4	
	SXJ	1P05A,4	
	SXJ	1P07,4	
	SXJ	1P07A,4	
	SXJ	1P09,4	
	SXJ	1P10,4	
	SXJ	1P20,4	
	SXJ	1P10A,4	

SXJ	1P20A, 4	
SXJ	1P24, 4	
SXJ	1P24A, 4	
SXJ	1P25, 4	
SXJ	1P25A, 4	
SXJ	1P28, 4	
SXJ	1P28A, 4	
SXJ	1P35, 4	
LXD	41, 4	(Reload Index Register 4)
UNJ	1, 4	(Transfer to Master Control Routine)

1P012 - This routine inserts the reference constants from the specified core or end composition calculation in the proper core storage locations. The reference constants needed by the side composition are the core height, longitudinal reflector savings, lethargy index for two-group division, control word for the multigroup calculation (C_{22}), and extrapolation distance and longitudinal buckling for lethargy levels zero through $t+1$.

1013A-1025A - These routines are the same as those described in section 5.3 for the core or end composition calculation.

1033B - This routine prints out all side composition input data.

1033D - This routine is the same as that described in section 5.3 for the core or end composition calculation.

1033F - If a reactivity match is requested and if this side composition is to be rerun in the reactivity match, all data needed to rerun the composition are written in binary form as one record on tape number 7.

1P04-1P05A - These routines are the same as those described in section 5.3 for the core or end composition calculation.

1P07 - This routine calculates the total leakage cross section. If the geometry is cylindrical, the longitudinal buckling from the reference core or end composition is used in the calculation. If the geometry is slab or spherical, the buckling is set equal to 10^{-20} . Equations (82) and (83).

1P07A - This routine prints out the extrapolation distance, longitudinal buckling, and leakage cross section.

1P09-1P35 - These routines are the same as those described in section 5.3 for the core or end composition calculation.

5.5 CONTROL COMPOSITION CALCULATION

After the control calculation routine (CNTL) has been read into core storage from the production tape, control is transferred to one of two mnemonics (CNTL, SCNTL) identifying a list of transfer instructions. This list of transfer instructions, like the list contained in the master control routine, core or end calculation routine, and side calculation routine, directs the flow of the calculation to be performed. The mnemonic CNTL indicates that a complete control composition calculation must be performed. The mnemonic SCNTL indicates that the control composition is being rerun in a reactivity match. The list of transfer instructions follows, and a brief summary of each calculation not previously explained in section 5.3 is given.

CNTL	SXD	41, 4	(Save Index Register 4)
	SXJ	1012A, 4	
	SXJ	1013A, 4	
	SXJ	1013B, 4	
	SXJ	1P016, 4	
	SXJ	1P017, 4	
	SXJ	1017B, 4	
	SXJ	1P018, 4	
	SXJ	1018A, 4	
	SXJ	1018B, 4	
	SXJ	1P023, 4	
	SXJ	1025A, 4	
	UNJ	SCNTL + 2	
SCNTL	SXD	41, 4	(Save Index Register 4)
	SXJ	1012A, 4	
	SXJ	1033E, 4	
	SXJ	1033D, 4	
	SXJ	1033F, 4	
	SXJ	1P04, 4	
	SXJ	1P04C, 4	
	SXJ	1P05, 4	
	SXJ	1P05A, 4	
	SXJ	1P07, 4	
	SXJ	1P07A, 4	
	SXJ	1P09, 4	
	SXJ	1P201, 4	
	SXJ	1201A, 4	
	SXJ	1P26, 4	
	SXJ	1P24A, 4	
	SXJ	1P25, 4	
	SXJ	1P25A, 4	
	SXJ	1P28, 4	
	SXJ	1P28A, 4	
	SXJ	1P29, 4	
	SXJ	1P30, 4	
	SXJ	1P31, 4	
	SXJ	1P32, 4	
	SXJ	1P32A, 4	
	SXJ	1P34, 4	
	SXJ	1P34A, 4	
	SXJ	1P35, 4	
	LXD	41, 4	(Reload Index Register 4)
	UNJ	1, 4	(Transfer to Master Control Routine)

1012A - This routine inserts the reference constants from the specified core, end, or side composition calculation in the proper core storage locations. The reference constants needed by the control composition are the thermal lethargy; lethargy index for two-group division; control word for the multigroup calculation (C_{22}); fast, slow, and average extrapolation distance from the two-group calculation; fast and slow flux terms from the two-group calculation; fast, slow, and average buckling from the two-group calculation; one-group buckling from the multigroup calculation; calculated $A(\omega)$ term from the

off-critical analysis; and two logical program signals needed in determining the temperature and lethargy distribution that was used in the reference core end, or side composition. Also needed are the extrapolation distance, longitudinal buckling and flux for lethargy levels zero through $t + 1$; and the group lethargies, flux, extrapolation distance, and total buckling from the multi-group calculation.

1013A-1025-A - These routines are the same as those described in section 5.3 for the core or end composition calculation.

1033E - This routine prints out all control composition input data.

1033D - This routine is the same as that described in section 5.3 for the core or end composition calculation.

1033F - If a reactivity match is requested and if this control composition is to be rerun in the reactivity match, all data needed to rerun the composition are written in binary form as one record on tape number 7.

1P04-1P05A - These routines are the same as those described in section 5.3 for the core or end composition calculation.

1P07 - This routine calculates the total leakage cross section. If the geometry is cylindrical, the longitudinal buckling from the reference core, end, or side composition is used in the calculation. If the geometry is slab or spherical, the buckling is set equal to 10^{-20} . Equations (82) and (83).

1P07A - This routine prints out the extrapolation distance, longitudinal buckling, and leakage cross section.

1P09 - This routine is the same as that described in section 5.3 for the core or end composition calculation.

1P201 - This routine calculates the flux-weighted absorption and leakage spectra using the flux from a reference core, end, or side composition in the calculation. Equations (187) and (188).

1201A - This routine prints out the lethargy, the flux, and the flux-weighted absorption and leakage spectra.

1P26 - This routine calculates the ordinary two-group constants associated with a bare reactor calculation. These calculated group constants consist of the absorption and leakage terms and the diffusion coefficient and diffusion area based on both one-group and two-group buckling. The extrapolation distance, flux, and buckling are taken from the reference core, end, or side composition. The scattering-out and fission terms along with the reactivity are set equal to zero. Equations (189) through (200).

1P24A-1P28A - These routines are the same as those described in section 5.3 for the core or end composition calculation.

1P29 - This routine calculates the transmission factors for a rod in a channel for lethargy levels zero through $t+1$, if requested by the user. Equations (208) through (211).

1P30 - This routine calculates the transmission factors for an annulus in a channel for lethargy levels zero through $t+1$, if requested by the user. Equations (212) through (216).

1P31 - This routine calculates the transmission factors for a plate for lethargy levels zero through $t+1$, if requested by the user. Equations (217) through (219).

- 1P32 - This routine calculates the two-group flux-weighted transmission fractions if one of the three absorber calculations is requested by the user. Equations (220) and (221).
- 1P32A - This routine prints out the geometry used in the absorber calculation along with the calculated transmission factors and flux-weighted transmission fractions.
- 1P34 - This routine calculates the flux-weighted transmission fractions in a multi-group representation, if requested by the user. First a linear interpolation is performed in the values for the flux and transmission factors. Then a trapezoidal integration in the interpolated values of the flux and transmission factors is performed to find the group constants associated with the given energy group divisions. Equations (222) and (223).
- 1P34A - This routine prints out the results of the multigroup transmission calculation.
- 1P35 - This routine is the same as that described in section 5.3 for the core or end composition calculation.

5.6 F_2 INPUT CALCULATION

After the F_2 input calculation routine C2F2, has been read into core storage from the production tape, control is transferred to the mnemonic C2F2. The purpose of this routine is to essentially complete the set of input data describing an F_2 calculation. This F_2 calculation may be the radial or longitudinal part of a reactivity match or may be an independent F_2 calculation.

If the calculation is the radial or longitudinal part of the reactivity match, the first operation performed by this routine is to scan the tape containing Program C_2 reference constants, tape number 9, for the reference core or end composition whose multiplication constant is to be used in the reactivity match and for any other composition two-group constants that the user may want inserted in the F_2 composition input. At the same time, if the user requests that the albedos from a C_2 control composition be used in the F_2 calculation, the fast and slow C_2 two-group transmission fractions are inserted in the F_2 core storage locations reserved for the fast and slow albedos left-hand boundary. If the radial F_2 calculation is to be performed, the core height and longitudinal reflector savings of the reference C_2 core or end composition used in the match or of the C_2 reference composition for buckling are inserted in the F_2 core storage locations reserved for those two quantities. If the longitudinal F_2 calculation is to be performed, the core diameter and radial reflector savings of the reference C_2 core or end composition used in the match or of the C_2 reference composition for buckling are inserted in the F_2 core storage locations reserved for those two quantities. Then, depending upon the option requested by the user, this routine either calculates the perpendicular buckling for Program F_2 or lets Program F_2 calculate it from the dimensions that this routine has inserted in the proper F_2 core storage locations. If this routine is to calculate the perpendicular buckling for Program F_2 , it can either calculate the buckling in each region from the dimensions and extrapolation distance contained on the C_2 reference constants tape specified for the particular region, or it can calculate the buckling as constant in all regions using the dimensions and extrapolation distance of the C_2 reference core or end composition whose multiplication constant is to be used in the reactivity match or of the C_2 reference composition for buckling. Equations (233) through (247).

If the F_2 calculation is not part of a reactivity match, the first operation performed by this routine is to scan the tape containing the Program C_2 reference constants, tape number 9, for any composition two-group constants that the user may want inserted in the F_2

composition input. If the user wishes the albedos from a C_2 control composition to be used in the F_2 calculation, the procedure previously described is used. For the perpendicular buckling calculation, however, the procedure is radically different. None of the dimensions, core height, core diameter, longitudinal reflector savings, or radial reflector savings are inserted by the C2F2 routine in the F_2 core storage locations. If the user wishes Program F_2 to calculate the perpendicular buckling, all the dimensions needed must be inserted by the user in the F_2 data input sheets. However, if the user wants the C2F2 routine to calculate the perpendicular buckling, only the core height and/or core diameter must be given by the user on the F_2 data input sheets. The reflector savings and extrapolation distance from the C_2 reference composition for buckling are used if the perpendicular buckling is to be calculated as constant over all regions; the reflector savings and extrapolation distance from the C_2 reference constants associated with the particular region are used if the perpendicular buckling is to be calculated for each region. In either case the buckling is inserted in the proper F_2 core storage locations; tapes 5, 8, and 9 are rewound, and control is transferred to the master control routine, section 5.2. The reference constants that may be needed by the F_2 calculation are the core height, core diameter, longitudinal and radial reflector savings, fast and slow transmission factors, fast and slow diffusion coefficients calculated with one-group buckling, fast and slow diffusion coefficients calculated with two-group buckling, fast and slow absorption terms, fast and slow multiplication terms, and the scattering out term. Equations (224) through (232).

6. Description of Input

6.1 REACTOR CONFIGURATION

Although the Program C₂-type calculations are performed for either slab, cylindrical, or spherical geometry, the program is slanted toward cylindrical geometry. Cell corrections can be provided as input for any type of cell for which they are available, although the I₂ portion of Program George will compute corrections only for annular, cylindrical cells. The full capability of Program I₂ Intermediate is available in Program George. This capability embraces one to ten materials, three to 50 zones and zero to ten radii per zone. Formulae for Behrens corrections to the diffusion coefficient apply only to annular, cylindrical cells.

The Program C₂ computations are divided into three types by composition identification.

1. Core or End Compositions. These computations may involve the subroutines necessary to achieve homogenization of the heterogeneous structures by means of cell corrections, either supplied or computed, and Behrens corrections. These computations are independent of other compositions and must be completed prior to the other two types of compositions. Although the configuration considered here is a cylindrical core or cylindrical end reflector with cell structure, this composition type also would be useful for slab or spherical geometries.
2. Side Compositions. These computations involve only the subroutine for a homogeneous structure. The longitudinal buckling in cylindrical geometry is taken from that of the reference core or end composition specified, and the radial buckling is assumed to be zero. If the geometry is slab or spherical and this type of composition is specified, the total buckling is set equal to 10^{-20} . These computations must be completed prior to control compositions. Considered here was an annular cylindrical reflector on the radius of a cylindrical core.
3. Control Compositions. These computations involve flux weighting of control-composition cross sections using the flux from a reference core, end, or side composition. Longitudinal buckling is taken the same as the specified reference composition if the geometry is cylindrical. If the geometry is slab or spherical and this type of composition is specified, the total buckling is set equal to 10^{-20} . Three types of absorber transmission calculations are available in this composition. Considered here was a control element or other structure embedded in the reference composition so that the cross sections of the substance "see" the flux in the surrounding medium.

The capability of Program F₂ has not been altered with its inclusion in Program George. The one-dimensional, two-group diffusion calculation may be computed in as many as 50 regions and at as many as 100 lattice points for a slab, spherical, or cylindrical reactor.

6.2 BASIC INPUT

The basic input data required by Program George are:

1. The permanent file of nuclear data contained on magnetic tape.

2. The inverse reactor period if an off-critical analysis is desired. (Normally the inverse period is zero in parameter studies.)
3. The data necessary to describe each composition in the reactor or in the parameter study, since more than one reactor may be analyzed in a single George calculation.
 - a. Geometrical, material, and source data defining an annular cylindrical cell for a monoenergetic P_3 spherical-harmonics calculation of the fine radial flux or flux-depression factors, if known.
 - b. Geometrical and material data describing the gross homogenized composition. If the P_3 calculation is requested, most of these data are computed by the program.
 - c. Identification of the neutron-source spectrum to be used.
 - d. Identification of the slowing-down model to be used.
 - e. Neutron (moderator) temperature.
 - f. Identification of lethargy for two-group division as thermal lethargy, specified level, or next level below half-power point (in energy).
 - g. Energies (electron volts) for making group divisions in multigroup constants and in photon production calculations.
 - h. Weighting factors (proportional to fission cross section) in each zone of the annular cell if fine radial power calculation is requested.
 - i. Geometry defining annulus of low scattering in the cell (fuel region) for Behrens correction to diffusion coefficient and selection of appropriate formulation.
4. If albedo calculations are required, geometrical and material data for computing albedo of slab, rod, or annulus are needed as well as the reference composition whose flux is to be used to generate two-group and multigroup weighted albedos.
5. In a matched savings calculation the needed data are:
 - a. Geometrical data describing the radial and longitudinal dispositions of compositions.
 - b. An indication of where albedo boundary conditions are to be found, that is, supplied as input or computed in albedo calculations.
 - c. The reference core composition to be used for the match.
 - d. A list of compositions whose savings are to be adjusted to the same values as the reference core composition for each iteration.
6. If additional one-dimensional, two-group, multiregion diffusion calculations are desired the needed data are:
 - a. The geometrical data describing the disposition of compositions and the buckling perpendicular to the direction of computation.
 - b. An indication of where albedo boundary conditions are to be found.

6.3 GENERAL INFORMATION

The input data cards are loaded by the DL9C data-load program, which is contained in a standard input-output production package, GEPRO.* The input routine will accept fixed-point decimal numbers, floating-point decimal numbers, and binary coded information (BCI), which comprise the three types of input used in the program. On the Program George input sheets fixed-point data are indicated by the letter D or 12-4 punch in the first column, floating-point data by the letter C or 12-3 punch, and binary coded information by the letter B or 12-2 punch. The input sheets to be used with the program are standardized and have the control information and loading addresses already typed in. A rectangle on the input sheets indicates one data card, and with one exception (George data page 21 - card 5), all information must be punched starting in column one and pro-

*M. Milby, "GEPRO, General Electric Production Package," May 7, 1956.

ceeding to the right. Card 5 on data page 21 contains an encircled one (1). This indicates a control carryover from card 4 and means that the first column should be left blank and punching should begin in column two.

The limit of any number, fixed or floating, is eight significant digits, and the decimal point and signed exponent combination can be used. For example, the quantity π may be punched:

3.1415926,
31415926/-7, and
.31415926/1

The plus sign indicating positive amounts or positive exponents is optional. All numbers, fixed and floating, must be followed by a comma to indicate field separation or end of a field. Here again the Program George input sheets have been standardized; all commas are already typed on the forms except on George data page 20 and 29, which are change case sheets and must be left general.

Data cards that would contain all zeros can be omitted entirely from the input deck except those signaling an end-of-record condition.

There are two possible end-of-record conditions in the program. The first is the letter C over 8 or a 12-8-3 punch in column one and is indicated by a period on the input sheets. The second is the letter D over 8 or a 12-8-4 punch in column one and is indicated by a right-hand parenthesis on the input sheets.

The end-of-record card signals the program that a set of data has been read into core storage and that the calculation requested can begin. It should be noted that one George case may comprise many records of input. The card which signals the completion of a George case is the end-of-file card. The end-of-file card does not appear on the input sheets since it contains only an 8 punch in column one with the remainder of the card left blank. This end-of-file card is always the last card of the decimal input deck.

6.4 GENERAL INPUT (George Data Page 1)

The first card, with a loading address of 8500, contains 24 letters of binary coded information reserved for the user's name. Blanks (spaces) must be indicated by an encircled integer. The user's name should always appear here to aid the computer operators in identifying the output.

The second card, with a loading address of 8504, contains 24 letters of binary coded information reserved for the George case identification and is intended as an aid in bookkeeping.

The third card, with a loading address of 8508, contains 24 letters of binary coded information reserved for the date.

The fourth card, with a loading address of 8512, contains 42 letters of binary coded information reserved for the security classification of the input data and the results.

The fifth card, with a loading address of 8519, contains the information describing the type of George calculation to be performed. The number of each type of composition and the number of F_2 cases is, for all practical purposes, unlimited. If the user intends to take advantage of the change case feature in the I_2 - C_2 portion or the F_2 portion of Program George, the number of change cases must be included in the total number of composition calculations or F_2 calculations. For example, one core composition followed by four core-composition change cases gives a total of five core compositions. One F_2

calculation followed by one F_2 change case gives a total of two F_2 calculations. If a reactivity-match calculation is requested, the radial and longitudinal F_2 calculations count as two F_2 cases in figuring the total, even though these two cases may be recalculated several times in the attempt to find consistent reflector savings. Control one, C_1 , is the input that governs the calculation of F_2 cases. It is not sufficient for the user merely to indicate the number of F_2 cases to be calculated; he must also indicate that there is an F_2 calculation under C_1 . The reactivity-match calculation is indicated under C_{23} . The minimum number of calculations for the reactivity match is one core-composition calculation and two F_2 calculations, radial and longitudinal.

The sixth card, with a loading address of 8525, contains 12 letters of binary coded information reserved for the reference core composition to be used in the reactivity match. This card must contain the core or end case identification that is identical to the core composition to be matched with the radial and longitudinal F_2 cases. This card may be omitted from the input deck if the reactivity match is not requested.

The seventh card, with a loading address of 8527, contains 12 letters of binary coded information reserved for the radial F_2 calculation to be used in the reactivity match. This card must contain the radial F_2 case identification that is identical to the radial F_2 to be matched with the reference core composition and the longitudinal F_2 case. This card may be omitted if the reactivity match is not requested.

The eighth card, with a loading address of 8529, contains 12 letters of binary coded information reserved for the longitudinal F_2 calculation to be used in the reactivity match. This card must contain the longitudinal F_2 case identification that is identical to the longitudinal F_2 to be matched with the reference core composition and the radial F_2 case. This card may be omitted if the reactivity match is not requested.

The ninth card, with a loading address of 8531, is reserved for the inverse reactor period if an off-critical analysis is wanted. If an off-critical analysis is not wanted, a value of zero must be given for this card. The reason is that this card also performs the function of signaling the end of the general input record.

The only data that may be altered by means of the I_2 - C_2 change case is the inverse reactor period, and this may be done only if more than one reactor is being analyzed in a single George case.

6.5 CORE- OR END-COMPOSITION INPUT (George Data Pages 2-14)

Page 2

The first card, with a loading address of 8533, contains 12 letters of binary coded information reserved for the core- or end-composition case number. This case number is used not only to identify the printed output but also, and more importantly, to identify the reference constants that may be used in subsequent side, control, or F_2 calculations. This card is also used for the identification of the core composition that is used in the reactivity-match calculation if that calculation is requested.

The second card, with a loading address of 9855, is used for the identification of the neutron source spectrum to be used in the composition calculation. The spectrum must be called from the nuclear data tape by the identifying code number 0.940, 0.941, etc. If a proper spectrum code number is not punched in this card, an error will result and the complete George case will be bypassed.

The third card, with a loading address of 9856, contains the following program control words:

- C₂ - If the centimeter-gram-second system (CGS) of units is used all input remains as given by the user. However, if the inch-pound-second system of units is used, all linear dimensions are converted to the CGS system by multiplying by 2.54, and all weights are converted to the CGS system by multiplying by 453.6.
- C₁₉ - Short output yields input data, power, and two-group constants. Intermediate output adds lethargy distribution of absorption, leakage, flux, fission, slowing-down density, and the slowing-down parameters ν and w . Long output adds Behrens factors, neutron source spectrum, homogenized core cross sections, extrapolation distance, total buckling, component buckling, expansion parameters, smallness parameters, total leakage, and component leakage. Special request calculations such as fine radial power, photon production parameters, and multigroup constants are printed out only if the calculation is performed. Program I₂ and F₂ results are printed out when calculated.

- C₃ - If the last epithermal cross section is computed, $\sigma_t \neq \sigma_{t+1}$, a third-order Lagrangian interpolation is performed in the cross sections at levels 16, 17, and 18 to find σ_t . The other option sets the last epithermal cross section equal to the thermal cross section $\sigma_t = \sigma_{t+1}$. A fourth-order Lagrangian interpolation in the Maxwellian averaged cross sections is performed to find the thermal cross section σ_{t+1} if the thermal lethargy u_{t+1} is not within 0.002 of a lethargy corresponding to the program established temperatures of 68°, 500°, 1000°, 1500°, 2000°, 2500°, or 3000°F.

- C₄ - The five slowing-down models available for use in the program are:

Modified Age - currently used for hydrogen moderation,

$$\phi (\xi \Sigma_s + \Sigma_a + \Sigma_l) = q + S(w);$$

Coveyou-Macauley - currently used for non-hydrogen moderation,

$$\phi (\Sigma_s + \Sigma_a + \Sigma_l) = \frac{\Sigma_s}{\xi \Sigma_s} q + S(w);$$

Semi-Consistent Wigner - not used in analysis work,

$$\phi \xi \Sigma_s (\Sigma_s + \Sigma_a + \Sigma_l) = \Sigma_s (q + S(w));$$

Inconsistent Wigner - not used in analysis work,

$$\phi \xi \Sigma_s (\Sigma_s + \Sigma_a) = \Sigma_s q; \text{ and}$$

Fermi Age - not used in analysis work,

$$\phi \xi \Sigma_s = q.$$

- C₅ - Three options exist for the two-group division in a core or end composition. The two-group division can be made at the last epithermal lethargy level, $N = t$. The two-group division can be calculated as the division at the first lethargy above the half-power point. Thus

$$P_N = \sum_{n=1}^N \frac{(F_n + F_{n-1})}{k} \frac{U_n}{2} \text{ such that } N \text{ is}$$

the first level for which $P_n \geq \frac{1}{2}$. However, if

$$P_t = \sum_{n=1}^t \frac{(F_n + F_{n-1})}{k} \cdot \frac{U_n}{2} < \frac{1}{2}, \text{ then the}$$

two-group division is set equal to the last epithermal lethargy level. The third option is that the user may supply the group division as $1 \leq N \leq 19$. If the group division is given, the integer N must be inserted in the last position of this data card.

The fourth card, with a loading address of 9862, contains the following program control words.

- C₆ - The Behrens factors may be computed or may be set equal to one. If they are to be computed, either the anisotropic Behrens factors

$$f_r = 1 + \left[\left(\frac{D_2^2 - D_1^2}{D_3^2} \right)^2 e^{-x} \left(\frac{y}{e^y - 1} + \frac{1}{2} y - 1 \right) \right]$$

$$f_z = 1 + \left[\left(\frac{D_2^2 - D_1^2}{D_3^2} \right) e^{-x} \left(\frac{y}{e^y - 1} + y - 1 \right) \right],$$

or the isotropic Behrens factors

$$f_r = f_z = \left[\frac{D_3^2 - D_2^2 + D_1^2}{D_3^2} \right] e^{-x} \left[1 + \frac{2(D_2^2 - D_1^2)}{(D_3^2 - D_2^2 + D_1^2)} + \left(\frac{D_2^2 - D_1^2}{D_3^2 - D_2^2 + D_1^2} \right)^2 \left(\frac{y}{e^y - 1} + \frac{2}{3} y \right) \right]$$

may be computed. In either computation the limit on the argument of the exponential is $|x|$ or $|y| < 88$.

- C₇ - This control word determines whether the g -factors are supplied by the user, set equal to one, or calculated by Program I₂. If the g -factors are supplied by the user, they must be inserted in the last three columns of the moderator and fuel input pages (4 and 5) in the row corresponding to the element to which they pertain. The lethargy levels at which the g -factors are to be applied are indicated by the columns labeled g_{t+1} (thermal), g_{16} (level 16) and g_{17} (level 17). If the g -factors are to be set equal to one, the program automatically inserts ones at all three levels of every element given on the moderator and fuel input pages. If the g -factors are to be computed, the user may request the Program I₂ calculation at any or all of the three levels available.

- C₈ - The g -factors can be applied to all the homogenized cross sections as

$$\Sigma_{x,h} = \text{SUM } N_{h,\text{fuel}}^i (g_{\text{fuel}}^i \sigma_x^i) + \text{SUM } N_{h,\text{mod}}^i (g_{\text{mod}}^i \sigma_x^i),$$

where $\Sigma_x = \Sigma_a, \Sigma_s, \Sigma_{tr}, \nu \Sigma_f, \xi \Sigma_s$,

and $\sigma_x^i = \sigma_a^i, \sigma_s^i, \sigma_{tr}^i, \nu \sigma_f^i, \xi \sigma_s^i$,

or the g -factors can be applied to nu sigma fission and sigma absorption only as

$$\Sigma_{x,h} = \text{SUM } N_{h,\text{fuel}}^i (g_{\text{fuel}}^i \sigma_x^i) + \text{SUM } N_{h,\text{mod}}^i (g_{\text{mod}}^i \sigma_x^i)$$

where $\Sigma_x = \Sigma_a$, $\nu \Sigma_f$ and $\sigma_x^i = \sigma_a^i$, $\nu \sigma_f^i$,

and $\Sigma_{x,h} = \text{SUM } N_{h,\text{fuel}}^i \sigma_x^i + \text{SUM } N_{h,\text{mod}}^i \sigma_x^i$

where $\Sigma_x = \Sigma_s$, Σ_{tr} , $\xi \Sigma_s$ and $\sigma_x^i = \sigma_s^i$, σ_{tr}^i , $\xi \sigma_s^i$

- C₉ - If the Program I₂ calculation is requested, the absorption cross section can be calculated with a leakage term added, $\Sigma_a + \frac{9.87 D}{(H + 2 S_z)^2}$, or without the leakage term, $\Sigma_a = N^i \sigma_a^i$. Whatever option is exercised will pertain to every I₂ calculations for that particular core composition.

- C₃₀ - The average flux in the denominator of the g -factor may be computed over the whole cell,

$$\bar{\Phi}_{\text{cell}} = \frac{\text{SUM}_{\text{all zones}} \bar{\Phi}_{\text{zone}} (r_0^2 - r_i^2)_{\text{zone}}}{\text{SUM}_{\text{all zones}} (r_0^2 - r_i^2)_{\text{zone}}}$$

or over the moderator only, i.e., zones with a source term of one.

$$\bar{\Phi}_{\text{mod}} = \frac{\text{SUM}_{\text{zones}} \text{source} = 1 \bar{\Phi}_{\text{zone}} (r_0^2 - r_i^2)_{\text{zone}}}{\text{SUM}_{\text{zones}} \text{source} = 1 (r_0^2 - r_i^2)_{\text{zone}}}$$

The fifth card, with a loading address of 9867, contains the following control words:

- C₁₀ - In computing the Behrens cross-section sigma absorption, the g -factor can be applied:

$$\Sigma_{a,\text{fuel}} = \left[\frac{D_3^2}{D_2^2 - D_1^2} \right] \text{SUM } N_{h,\text{fuel}}^i (g_{\text{fuel}}^i \sigma_a^i)$$

$$\Sigma_{a,\text{mod}} = \left[\frac{D_3^2}{D_3^2 - D_2^2 + D_1^2} \right] \text{SUM } N_{h,\text{mod}}^i (g_{\text{mod}}^i \sigma_a^i)$$

or can be omitted:

$$\Sigma_{a,\text{fuel}} = \left[\frac{D_3^2}{D_2^2 - D_1^2} \right] \text{SUM } N_{h,\text{fuel}}^i \sigma_a^i$$

$$\Sigma_{a,\text{mod}} = \left[\frac{D_3^2}{D_3^2 - D_2^2 + D_1^2} \right] \text{SUM } N_{h,\text{mod}}^i \sigma_a^i$$

In the computation of the Behrens cross-section sigma scatter, the g -factor will be applied only if the user requests that the g -factors be applied to the homogenized-composition cross sections ($C_8 = 0$) and to the Behrens cross sections ($C_{10} = 1$).

$$\Sigma_{s, \text{mod}} = \left[\frac{D_3^2}{D_3^2 - D_2^2 + D_1^2} \right] \text{SUM } N_{h, \text{mod}}^i (g_{\text{mod}}^i \sigma_s^i).$$

Otherwise the Behrens cross-section sigma scatter is computed as

$$\Sigma_{s, \text{mod}} = \left[\frac{D_3^2}{D_3^2 - D_2^2 + D_1^2} \right] \text{SUM } N_{h, \text{mod}}^i \sigma_s^i$$

- C₁₁ - Either the total cross section in the moderator can be used in the computation of the attenuation factor,

$$y = l_{\text{mod}} (\Sigma_{s, \text{mod}} + \Sigma_{a, \text{mod}}),$$

or the scatter cross section can be used,

$$y = l_{\text{mod}} \Sigma_{s, \text{mod}}.$$

- C₁₈ - The Terrall method is not available in the program. It is an improved method of handling the thermal group by cutting off the slowing-down calculation above the Maxwellian distribution and assuming a flux $\phi(E)$ proportional to $1/E$ from the cut-off point to the point at which it intersects the Maxwellian. Thermal cross sections weighted over this improved thermal flux are available, but coding of the method was not completed.

- C₂₀ - The fine radial power calculation can be executed only if a Program I₂ calculation has been run at one or more of the three available lethargy levels. The weighting factors, which are given proportional to the fission cross section in each zone of the annular cell, are non-zero for power-producing zones and zero for zones producing no power. Two analysis requirements for requesting the calculation are that at least one zone must be producing power (weighting factor non-zero), and each zone described in the I₂ - C₂ input data must have at least one radius.

- C₂₁ - The lethargy adjoint calculations are not available in the program.

The sixth card, with a loading address of 9872, contains the moderator temperature in Fahrenheit degrees. The range of the temperature in Program George is

$$68^\circ\text{F} \leq T_{\text{mod}} \leq 3000^\circ\text{F}.$$

Any temperature less than 68°F is set by the program at 68°F , and any temperature greater than 3000°F is set at 3000°F . In the program the moderator temperature is used in calculating the thermal lethargy,

$$u_{t+1} = 16.118 - \text{Ln} \left\{ 1.0971 \times 10^{-4} \left[\frac{5}{9} (T_{\text{mod}} - 32) + 273.18 \right] \right\}$$

The remainder of the sixth card pertains to the unavailable Terrall method and consequently must be left blank.

The seventh card, with a loading address of 9875, contains the controls that govern the type of Program I₂ calculation to be computed at each level. C₁₂ signifies thermal level $t+1$; C₁₃ signifies level 16; and C₁₄ signifies level 17. Three calculation options exist for each level. The first option is that the g-factors can be set to one; secondly, an I₂ calculation utilizing the scattering cross section,

$$\Sigma_{s0} = \text{SUM } N^i \sigma_s^i,$$

the absorption cross section,

$$\Sigma_a = \text{SUM } N^i \sigma_a^i,$$

and the diffusion coefficient,

$$D = \frac{1}{3(\Sigma_{tr} + \Sigma_a)} \text{ where } \Sigma_{tr} = \text{SUM } N^i \sigma_{tr}^i$$

can be computed; and thirdly, an I₂ calculation utilizing the scattering cross section,

$$\Sigma_{s0} = \text{SUM } N^i \sigma_s^i,$$

the absorption cross section,

$$\Sigma_a = \text{SUM } N^i \sigma_a^i,$$

the scattering cross section first moment,

$$\Sigma_{s1} = \Sigma_{s0} - \Sigma_{tr} \text{ where } \Sigma_{tr} = \text{SUM } N^i \sigma_{tr}^i,$$

and the scattering cross section second moment,

$$\Sigma_{s2} = \text{SUM } N^i \sigma_{s2}^i,$$

can be used.

Page 3

The first card, with a loading address of 9878, contains the following control words.

- C₁₇ - A multigroup calculation of photon-production parameters is available in the program. This calculation yields the group energies and lethargies, trapezoidally integrated flux, sigma absorption, and sigma fission. If the calculation is requested, no more than 30 elements from the nuclear data tape may be used in the composition, and only three of these 30 may be fissionable.
- C₂₂ - A multigroup calculation of the usual group constants and parameters is available in the program. This calculation yields group energies and lethargies, slowing-down density, multiplication, scattering-out, absorption escape probability, one-group buckling, multigroup buckling, diffusion coefficient based on both one-group and multigroup buckling, trapezoidally integrated flux, sigma absorption, nu-sigma fission, sigma leakage, neutron source spectrum, and extrapolation distance plus the reactivity calculation based on both one-group and multigroup parameters. It is permissible to make group divisions within the fission spectrum.

The second, third, and fourth cards with loading addresses of 9474, 9480, and 9486, respectively, contain the group energies for photon production division in electron volts. The energies must be given in decreasing order with only one division per standard

lethargy interval allowed. A maximum case of 18 energies resulting in a 19 group photon-production calculation is permissible. If this calculation is requested at least one non-zero energy must be given.

The following energies in electron volts when used in the expression

$$u = 16.118 - \ln E$$

will yield lethargies that are as close as possible to the standard lethargy divisions utilized as parameters in Program George:

<u>u (Standard Lethargy Division)</u>	<u>E (Energy)</u>
0.0	9.9990411/6
0.5	6.0647288/6
1.0	3.6784437/6
1.5	2.2310883/6
2.0	1.3532238/6
2.5	8.2077106/5
3.0	4.9782312/5
3.5	3.0194478/5
4.0	1.8313892/5
6.0	2.4785165/4
8.0	3.3543075/3
10.0	4.5395602/2
12.0	6.1436239/1
14.0	8.3144920
15.5	1.8552136
16.5	6.8249490/-1
17.5	2.5107580/-1
18.5	9.2365630/-2
19.795	2.5298745/-2

If the last energy in the table, which may be the first or the eighteenth entry, corresponds to a lethargy at or beyond thermal, the thermal group is treated as a separate group and the last epithermal group ends at thermal lethargy.

The eighth card, with a loading address of 9880, contains the type of geometry of the composition. Slab, spherical, and cylindrical geometries are available in the program, although g -factors can be computed only for cylindrical geometry. The geometry of the composition must be known for calculation of the buckling of the system and the leakage cross section.

The ninth card, with a loading address of 9881, contains the dimensions for buckling and is used only to compute the buckling and perhaps the cell diameter. The longitudinal savings on one end is denoted by S_z ; the radial savings is denoted by S_r ; and the spherical savings on the radius is denoted by S_s . If slab geometry is used, H denotes the length, D denotes the width, and R denotes the height. If cylindrical geometry is used, H denotes the height, D denotes the diameter, and R is not used. If spherical geometry is used, R denotes the radius, and H and D are not used.

The tenth card, with a loading address of 9887, contains the dimensions for the Behrens correction and is used only to compute the Behrens correction. The dimensions are self-contained, although the cell diameter, D_g , can be omitted if the number of cells, M , is

given. In this event the program computes D_s by

$$D_s = D/\sqrt{M}$$

D_1 denotes the fuel inner diameter, and D_2 denotes the fuel outer diameter. If the Behrens correction calculation is not requested, the entire set of dimensions can be omitted.

The eleventh card, with a loading address of 9905, contains the dimensions for the composition volume calculation. This set of dimensions need not be given if the atomic densities or fractional densities are given as input for the elements and the weights are of no interest to the user. The composition volume is computed as

$$\frac{\pi}{4} (D_{co}^2 - D_{ci}^2) L.$$

D_{co} denotes the outer diameter of the composition; D_{ci} denotes the inner diameter of the composition; and L denotes the length of the composition.

Page 4

The 15 data cards on this page, the first with a loading address of 8562, comprise the data table for the moderator region. The nomenclature is perhaps unfortunate, since the "moderator" and "fuel" regions really mean scattering medium and non-scattering medium respectively in the Behrens correction. The fuel region does not necessarily contain a fissionable element, and the moderator region may contain fuel. If the Program I_2 calculation is not requested, the user must supply the elements wanted in the moderator region by inserting the element code numbers (I), the weights (W), or homogenized core densities (f_h or N_h) in the moderator table. If g -factors are given, they must be inserted in the moderator table corresponding to the element to which they are to be applied and at all three levels. A maximum of 15 elements may be designated by the user for the moderator table. In the program, however, enough core storage is left after the fifteenth element for the element ACCUMULATION (0.980) in case an off-critical analysis is desired. If the density of an element is given and if the dimensions of the composition are non-zero, the weight will be calculated. If the weight is given, the dimensions of the composition must be non-zero in order that the homogenized densities, which are subsequently used in calculating the homogenized cross sections, may be calculated as non-zero quantities. If, by error or intent, both the weight and density are given for an element, the density will be calculated anew from the weight and composition volume. It should be noted that elements may not be repeated in the moderator table and that all elements used must be specified by code number.

Page 5

The 15 data cards on this page, the first with a loading address of 8658, comprise the data table for the fuel region. Essentially all the information pertaining to the fuel table is identical to that concerning the moderator table. Both the moderator and fuel tables may be used for input, even though a Behrens correction is not requested, thus affording a maximum of 30 elements as input. Although an element may not be repeated in the moderator table or in the fuel table, it may be contained in both tables. If the Program I_2 calculation is requested, Program George uses the I_2 geometrical, material, and source data defining the annular cylindrical cell to essentially "fill in" the moderator and fuel data tables. A ramification of the program on which the user can easily err occurs when the user requests an off-critical analysis and inserts the g -factors. In this case the user must give the element ACCUMULATION (0.980) and its density. If, however, the g -factors

are set to one or calculated by Program I₂, ACCUMULATION is properly added by Program George.

Page 6

The 11 data cards on this page constitute the first set of Program I₂ material input. Whenever an I₂ calculation is requested, the material tables are used as input and not the moderator and fuel tables. The first card, with a loading address of 8754, contains the material number, fuel or non-fuel control word, outer radius of the material, inner radius of the material, and the length of the material. The material number "one" is already inserted in its proper location on this page. The material number identifies this I₂ material when the Program I₂ calculation is requested. The control word C₂₈ is needed to designate the material for the fuel region or the moderator region. The outer and inner radius, and the length of the material are used to calculate the volume of the material,

$$V = \pi l (r_{mo}^2 - r_{mt}^2).$$

The address of the last word on the first card is 8758 and the address of the first word on the second card is 8760. Address 8759 is reserved for storing the calculated volume of the material. This should be remembered when the addresses are inserted for the I₂ material input pages after the first. There is always an increment of six between lines of data. The second through eleventh cards on this page contain the elements the user wishes to place in the material. The element code number (*I*), the weight (*W*), or the un-homogenized density (*f* or *N*) for one to a maximum of ten elements may be provided in the material. No element may be repeated in the same material, however the same element may be used in all the materials given. If a type "B" Program I₂ input is used, the scattering cross-section second moment, σ_{s2} or Σ_{s2} , if used is inserted by the user in the line corresponding to the element to which it applies and at the desired level.

Page 7

The 11 data cards on this page constitute the Program I₂ material input that is to be used for materials two to ten. A maximum of ten materials, numbered consecutively one to ten, may be used in an I₂ calculation. Note that this material table is constructed like the first I₂ material table, the only difference being that the loading addresses on data page 7 have been left blank. To determine the loading addresses for materials following the first, add 72 (*m*-1) to the address for material one where "*m*" is the material number. For example, to determine the initial loading address of material six,

$$\text{Material number 6} = 8754 + 72 (6 - 1) = 9114.$$

Although there is storage for 100 elements in the ten materials, there may be no more than 30 different elements in the ten materials. The reason for this restriction is that the moderator and fuel tables are constructed from the material tables when an I₂ calculation is requested, and these two tables combined can contain only 30 elements maximum. It is possible to use the Program I₂ material sheets and yet not calculate the *g*-factors. The user can accomplish this by requesting the I₂ calculation through control C₇, using the material data sheets, and then telling the program through controls C₁₂, C₁₃, and C₁₄ to set the *g*-factors to one. Program George then proceeds to calculate the homogenized densities for the moderator and fuel regions from the I₂ geometrical, material, and source data defining the annular cylindrical cell. If an off-critical analysis is requested, the program inserts the element ACCUMULATION (0.980) and its density in every material given by the user. All other information pertaining to this material table is identical to that of material number one.

Page 8

The first card, with a loading address of 9850, contains the Program I_2 case number and must be a number between 0.00000 and 999.99999. Binary coded information is not permitted. Note that even though I_2 calculations can be requested at three levels, only one case number is provided. This idiosyncrasy evolved from the difference in program logic for Program I_2 and Program George. To Program I_2 each calculation is a case, whereas to Program George from one to three I_2 calculations are considered as nothing more than another subroutine to be executed. The user, however, will have no trouble identifying the I_2 output because each I_2 calculation is preceded by a title page giving the user's name, the security classification, the core composition name, and the level at which the I_2 was calculated.

The next nine cards, the first with a loading address of 9650, contain the source terms that are to be used if an I_2 calculation is run at thermal, level $t+1$. A source term must be given for each zone of the annular cylindrical cell, listed from the outermost to innermost zone. Program I_2 has the restriction of a minimum of three and a maximum of 50 zones, and hence source terms, per calculation. At least one of the source terms must be zero, and one must be non-zero. If the average flux is to be computed over the moderator portions of the cell only, a source term of one must be assigned to these moderator portions. This tells the program that a zone contains moderator.

Page 9

The nine cards on this data page, the first with a loading address of 9700, contain the source terms that are to be used if an I_2 calculation is run at level 16. Essentially all information pertaining to this data table is identical to that given concerning the level $t+1$ source terms.

Page 10

The nine cards on this data page, the first with a loading address of 9750, contain the source terms that are to be used if an I_2 calculation is run at level 17. Essentially all information pertaining to this data table is identical to that given concerning the level $t+1$ source terms.

Page 11

The first card, with a loading address of 9852, contains the number of materials, the number of zones, and the number of radii per zone. As many material tables must be supplied (1 to 10) as are indicated under the first position of this card. If a material is supplied but not used in any zone of the annular cylindrical cell, the elements contained in that material will not be used by either Program I_2 or Program George. Of course there must be at least one material that is used in the zones of the cell for each I_2 calculation. The number of zones (3 to 50) are used in describing the fine cell structure, and the number of radii per zone (1 to 10) are used if lattice point flux and current are desired or if fine radial power is to be computed.

The next nine cards, the first with a loading address of 9550, contain the zone data describing the annular cylindrical cell. The zone data must be ordered from outermost to innermost zone. Within a given zone, "r" is the outer radius of the zone and "material number" is the integer "m" (1 to 10) associated with a particular material. This pattern continues for as many zones as the user has specified. Ordinarily the outer diameter of the cell used to homogenize the densities for the moderator and fuel regions is taken to be D_3 of the Behrens dimensions, if D_3 is non-zero. This is done to allow a cell surrounded by a void annulus to be calculated in Program I_2 by omitting the void but providing

the correct homogenized densities in the material input. If D_3 is given as zero then the outer radius of the outermost zone is used as the outer diameter of the cell.

Page 12

The eight data cards on this page, the first with a loading address of 9604, are simply a continuation of the zone data input. If the number of zones specified by the user is 28 or more, page 12 must be used to continue the zone data input.

Page 13

The ten cards on this page, the first with a loading address of 9800, constitute the set of fine radial power zone codes or weighting factors. The fine radial power calculation may be requested only if at least one I_2 calculation has been executed. This data page is analogous to the I_2 source-term data page inasmuch as a weighting factor must be provided for every zone specified and the factors must be listed from the outermost to the innermost zone. The weighting factors, which may be expressed in proportion to the fission cross section in each zone, are given as zero if no power is produced and non-zero if power is produced in the zone. At least one of the zones must be producing power. The expression in which the weighting factors f are used is the equation for computing the normalized radial flux,

$$\phi'(r) = \frac{\varphi(r) f(z) \text{SUM} (r_0^2 - r_i^2)_z}{\text{SUM} \bar{\varphi}(z) f(z) (r_0^2 - r_i^2)_z}$$

Page 14

The first card, with a loading address of 8536, is the control word that specifies whether the core or end composition is to be rerun if the I_2 -C₂-F₂ reactivity match is requested. If the composition is to be rerun, the input for the composition is saved on a binary tape and is called into core storage and recalculated whenever the iterative procedure has produced new estimates of the longitudinal and radial reflector savings. These new reflector savings, along with the original input for the composition, are then used in recalculating the composition.

The second card, with a loading address of 8535, is the I_2 -C₂ change case card. If a change case is wanted, the I_2 -C₂ portion of input core storage is not set to zero. If no change case is wanted, all I_2 -C₂ composition input is cleared from core storage.

The third card, with a loading address of 8537, is the control word that specifies whether the I_2 calculations in a core or end composition are to be rerun if the I_2 -C₂-F₂ reactivity match is requested. It should be noted that the core or end composition itself must be rerun before the I_2 calculations in that core or end can be rerun. The only reason for rerunning the I_2 calculations is if a leakage term $\frac{9.87 D}{(H + 2 S_z)^2}$ is added to the absorption cross section in the I_2 materials. If the leakage term is not added, the longitudinal savings do not enter into the Program George calculation until the buckling is calculated. A tremendous amount of computer time can be saved by not rerunning the I_2 calculations: the actual time ratio involved can be as great as 60 to 1; the actual time involved for rerunning a core or end calculation, starting with the homogenized cross sections already calculated, is approximately seven to ten seconds.

The fourth card, with a loading address of 8532, specifies the type of composition, core or end, that Program George is to calculate. Since this card already has the proper value inserted, the user need not be concerned with it. The end-of-record condition for the data

input package is also signified by this card. This essentially tells the program that a complete set of data has been read into core storage and the calculation can begin.

6.6 SIDE COMPOSITION INPUT (George Data Pages 15-17)

Page 15

The first card, with a loading address of 8533, contains 12 letters of binary coded information reserved for the side-composition case number. This case number is used not only to identify the printed output but also, and more importantly, to identify the reference constants that may be used in subsequent control or F_2 calculations.

The second card, with a loading address of 9855, is explained under the description for the core- or end-composition data pages.

The third card, with a loading address of 9856, contains the control words C_2 , C_3 , and C_4 , for which an explanation is given under the description for the core- or end-composition data pages. Also contained on the card are the controls C_{19} and C_5 which have the following explanation when used in a side composition:

- C_{19} - Short output yields input data, power, and two-group constants. Intermediate output adds lethargy distribution of absorption, leakage, flux, fission, slowing-down density, and the slowing-down parameters ν and w . Long output adds source spectrum, homogenized-core cross sections, Behrens factors, extrapolation distance, longitudinal buckling, and leakage cross sections. The Behrens factors and g -factors are set to unity in a side composition and are printed out as such.
- C_5 - In a side composition the calculated two-group division at half-power point may not be requested. The options of giving the two-group division or setting the two-group division equal to the last epithermal are available in a side composition. If the two-group division is given by the user, the integer N where $1 \leq N \leq 19$ is inserted in the last position of this card.

The fourth card, with a loading address of 9880, contains the type of geometry of the composition. If the geometry is cylindrical, the longitudinal buckling is taken from the reference constants of the reference core or end composition. The radial buckling is assumed to be zero. If the geometry is slab or spherical, the total buckling is set equal to 10^{-20} .

The fifth card, with a loading address of 9872, contains the temperature of the side reflector in Fahrenheit degrees. The temperature of the side must be below or above 1056°F in accordance with the reference-core moderator temperature, below or above 1056°F . This condition insures that the number of lethargy levels in the reference core composition and the side composition is the same. In establishing the last epithermal lethargy interval for the slowing-down calculation and flux weighting, the thermal lethargy of 18.5 is recognized as being equal to lethargy level 17. Since a temperature of 1056°F yields approximately a thermal lethargy of 18.5 and since on the average there would be no slowing down of neutrons beyond the thermal lethargy, level 17 must not enter into the calculation. This is why it is important that the moderator and side temperatures be on the same side of 1056°F .

The sixth card, with a loading address of 9863, tells the program to set the g -factors equal to one. Since this card has the proper value inserted, the user need not be concerned with it.

The seventh card, with a loading address of 9894, contains 12 letters of binary coded information reserved for the case number of the reference-core or end composition for

buckling and extrapolation distance. Before a side composition is calculated, supplementary input in the form of reference constants is read into core storage from the binary reference tape. The case number given on this card by the user must be identical to a previously calculated core or end composition. Through a matching procedure, the program is able to select from tape the correct reference constants needed as supplementary side-composition input.

The eighth card, with a loading address of 9871, is explained under the description for the core- or end-composition data pages.

The ninth card, with a loading address of 8535, is explained under the description for the core- or end-composition data pages.

The tenth card, with a loading address of 8536, is the control word that specifies whether the side composition is to be rerun if the I_2 - C_2 - F_2 reactivity match is requested. If the side composition is to be rerun, it must use as reference a core or end composition that is also being rerun in the reactivity match.

Page 16

The first card, with a loading address of 9878, is explained under the description for the core- or end-composition data pages.

It is noted on this data page that C_{22} , the multigroup-calculation control word, is taken from the core or end reference constants. If a multigroup calculation is requested in the core or end composition used as reference by the side composition, an "automatic" multigroup calculation is executed in the side composition. The user must, however, supply the energies for the group divisions. At least one non-zero energy must be given.

The remainder of the cards on this data page are explained under the description for the core- or end-composition data pages.

Page 17

The first 15 cards on this data page, beginning with loading address 8562, constitute the moderator table for the side composition. Since the g -factors are always set equal to one in a side composition, the three columns used for the g -factor input have been deleted. All other information pertaining to the use of the moderator table is explained under the description for the core- or end-composition data pages.

The sixteenth card, with a loading address of 8532, specifies the type of composition, side, that Program George is to calculate. Since this card already has the proper value inserted, the user need not be concerned with it. The end-of-record condition for the data-input package is also signified by this card. This essentially tells the program that a complete set of data has been read into core storage and the calculation can begin.

6.7 CONTROL COMPOSITION INPUT (George Data Pages 18-19)

Page 18

The first card, with a loading address of 9863, tells the program to set the g -factors equal to one. Since this card has the proper value inserted, the user need not be concerned with it.

The second and third cards, with loading addresses of 8535 and 9878 respectively, are explained under the description for the core- or end-composition data pages.

The fourth card, with a loading address of 8533, contains 12 letters of binary coded information reserved for the control-composition case number. This case number is used

not only to identify the printed output but also, and more importantly, to identify the reference constants that may be used in subsequent F_2 calculations.

The fifth card, with a loading address of 8536, is the control word that specifies whether the control composition is to be rerun if the I_2 - C_2 - F_2 reactivity match is requested. If the control composition is to be rerun, it must use as reference a core, end, or side composition that is also being rerun in the reactivity match.

The sixth card, with a loading address of 9880, is explained under the description for the side-composition data pages.

The seventh card, with a loading address of 9894, contains 12 letters of binary coded information reserved for the case number of the reference core, end, or side composition for flux, buckling, and extrapolation distance. Before a control composition is calculated, supplementary input in the form of reference constants is read into core storage from the binary reference tape. The case number given on this card by the user must be identical to a previously calculated core, end, or side composition. Through a matching procedure, the program is able to select from tape the correct reference constants needed as supplementary control-composition input.

The eighth card, with a loading address of 9896, contains the control word for absorber transmission calculations. If a transmission calculation is requested, three types (rod, annulus, or plate) are available.

The ninth, tenth, and eleventh cards, with loading addresses of 9474, 9480, and 9486 respectively, are explained under the description for the core- or end-composition data pages.

The twelfth card, with a loading address of 9856, contains the control words C_2 and C_3 , for which an explanation is given under the description for the core- or end-composition data pages. Also contained on the card is the control C_{19} , which has the following explanation when used in a control composition:

C_{19} - Short output yields input data and two-group constants. Intermediate output adds lethargy distribution of absorption, leakage, and flux. Long output adds source spectrum, longitudinal buckling, leakage cross section, homogenized-core cross sections, Behrens factors, and extrapolation distance. The Behrens factors and g -factors are set equal to unity in a control composition and are printed out as such. The source spectrum, also, is set to zero and printed out as such.

The thirteenth card, with a loading address of 9905, is explained under the description for the core- or end-composition data pages.

The fourteenth card contains the dimensions for the absorber-transmission calculation. If a rod transmission is requested, D_o denotes the diameter of the rod, D_{ch} denotes the diameter of the void channel containing the rod in such a way that $D_{ch} \geq D_o$, and ϵ is not used. If an annulus transmission is requested, D_o denotes the outer diameter of the annulus, D_{ch} denotes the diameter of the void channel containing the annulus in such a way that $D_{ch} \geq D_o$. ϵ denotes the thickness of the annulus. If a plate transmission is requested, D_o denotes the plate thickness, D_{ch} and ϵ are not used.

Page 19

The first 15 cards on this data page, beginning with loading address 8562, constitute the moderator table for the control composition. Since the g -factors are always set equal to

one in a control composition, the three columns used for the g -factor input have been deleted. All other information pertaining to the use of the moderator table is explained under the description for the core- or end-composition data pages.

The sixteenth card, with a loading address of 8532, specifies the type of composition, control, that Program George is to calculate. Since this card already has the proper value inserted, the user need not be concerned with it. The end-of-record condition for the data-input package is also signified by this card. This essentially tells the program that a complete set of data has been read into core storage and the calculation can begin.

6.8 I₂-C₂ CHANGE CASE INPUT (George Data Page 20)

Page 20

The first card, with a loading address of 8533, contains 12 letters of binary coded information reserved for the composition case number of the I₂-C₂ change case. This case number is used not only to identify the printed output but also, and more importantly, to identify the reference constants that may be used in subsequent calculations. Core, end, side, or control composition input may be changed by the use of the change-case feature. It is recommended that the change-case option be used only when a few values of the previous composition are to be changed. When a change case is used, the previous composition data are not cleared in core storage. Hence the user need only fill in the blank addressed cards contained on this page with the storage address of the value to be changed in the first half of the card and the actual value to be inserted in that address in the second half of the card. In this way the number of input data cards can be substantially reduced. All data in Program George must end in a comma except binary coded information. The regular George data pages should be used as a guide when making change cases, since these have the correct control and address information. It is not recommended that the change-case option be employed in changing the type of composition to be calculated.

The last card on this data page, with a loading address of 8535, is explained under the description for the core- or end-composition data page.

6.9 F₂ INPUT (George Data Pages 21-28)

Page 21

The first card, with a loading address of 8076, contains 12 letters of binary coded information reserved for the F₂ case number identification. Blanks (spaces) must be indicated by an encircled integer.

The second card, with a loading address of 8078, contains 12 letters of binary coded information reserved for the date.

The third card, with a loading address of 8193, contains 36 letters of binary coded information reserved for the security classification of the input data and the results.

The fourth card, with a loading address of 8000, contains the following program control words:

- C₀ - The minimum number of regions is one and the maximum number is 50 for any one calculation.
- C₁ - Three program solutions are possible: two-group direct-flux calculation, two-group adjoint-flux calculation, and a one-group calculation that is self-adjoint.

- C₂ - Three types of geometry are available in the program: plane, cylindrical, and spherical. For cylindrical geometry the volume of the core is calculated as

$$V_c = 2\pi H \cdot \int_{\text{core}} r dr,$$

for spherical geometry the volume of the core is calculated as

$$V_c = 4\pi \cdot \int_{\text{core}} r^2 dr;$$

for rectangular slab geometry the volume of the core is calculated as

$$V_c = H \cdot D \cdot \int_{\text{core}} dr;$$

and for circular slab geometry the volume of the core is calculated as

$$V_c = \frac{\pi D^2}{4} \int_{\text{core}} dr;$$

where compositions specified as core must have $\nu \Sigma_{f2} \neq 0$.

When the reactivity match is requested, the first set of F_2 input data must be the radial F_2 ($C_2=1$), and the second set must be the longitudinal F_2 ($C_2=0$).

- C₃ - Four options for the perpendicular buckling exist in the F_2 program. If the buckling is to be calculated with the extrapolation distance, δ , δ is taken to be 4.26 times the diffusion coefficient. The other options are that the perpendicular buckling may be given as constant over all regions, calculated without the extrapolation distance, or given in each region. The perpendicular buckling control option (C_{25}) on George data page 22 is initially examined by Program George to determine the type of option wanted by the user. The option exercised under C_3 secondarily determines the buckling procedure and only in the F_2 program. For cylindrical geometry the perpendicular buckling is calculated as

$$K^2 = \frac{\pi^2}{(H + 2S_z + \delta)^2}$$

for spherical geometry the perpendicular buckling is set equal to zero; for rectangular slab geometry the perpendicular buckling is calculated as

$$K^2 = \frac{\pi^2}{(H + 2S_z + \delta)^2} + \frac{\pi^2}{(D + 2S_r + \delta)^2};$$

for circular slab geometry the perpendicular buckling is calculated as

$$K^2 = \frac{23.13}{(D + 2S_r + \delta)^2}.$$

- C₄ - Three options exist in the F_2 program for the boundary conditions. If natural boundary conditions are used, the fast and slow, left- and right-hand flux ratios are computed from the fast and slow, left- and right-hand albedos. For rectangular geometry, natural albedo conditions are zero at the left-hand and right-hand boundaries. For cylindrical and spherical geometry, natural albedo conditions are "one" at the left-hand boundary and "zero" at the right-hand boundary. If the albedos are given, the fast and slow, left- and right-hand flux ratios are computed from the values given by the user for the albedos. If the flux ratios are given by the user, the albedos need not be specified. The flux ratio is defined as the ratio of the flux at the first lattice point inside the boundary to the flux at the boundary.

It should be noted that the albedo control option (C₂₆) on George data page 22 is initially examined by Program George to determine the type of option desired by the user. The option exercised under C₄ secondarily determines the boundary procedure and only in the F₂ program.

The fifth card, with no loading address and a blank column one, contains the following control words:

- C₅ - Three options exist for the insertion of extra intervals. Extra intervals can be inserted on either side of each interface between regions along with extra intervals at the inner and outer boundaries. Extra intervals can be inserted only at the inner and outer boundaries. Extra intervals need not be inserted at all. Whatever option the user requests, there must be no more than 100 intervals.
- C₆ - Three options exist with regard to the external source. An external source need not be given at all. An external source may be given "constant" in each region. An external source may be given at each lattice point. Whenever an external source is given, the source term for successive iterations is not normalized by dividing by the eigenvalue k . Hence in a critical or supercritical reactor, the flux will increase with each iteration and convergence is impossible. In that event the program should be controlled by specification of the number of iterations to be made.
- C₇ - Only two options are available for requesting the type of convergence test to be made. If the number of iterations is not specified, then all of the other three tests are performed. The convergence criterion for the maximum difference and reactivity tests is 10^{-7} . The convergence criterion for the mean square test is 10^{-10} .
- C₈ - There are three options pertaining to the normalization of the flux. The user can normalize the flux to $\Phi_{1 \text{ core}} = 1$ by averaging the fast flux over all core compositions, $\nu \Sigma_{f2} \neq 0$, and dividing the fast and slow flux by this value. The user also can normalize the flux to $\Phi_n = 1$ by dividing the fast and slow flux by the fast flux at a particular radius specified by the user. Or the user can normalize the flux to $\bar{\Phi}_2, \alpha_0$ by averaging the slow flux over all compositions specified and dividing the fast and slow flux by this value. Regardless of how the flux is normalized, the fission density is always normalized to a core average of unity.
- C₉ - The only output available in this program is the printed output. The cathode ray tube routines have been bypassed, although they are still physically present in the program.

The last location on the fifth card contains the number of iterations, if the user should wish to exercise this option of the convergence control word. The number of iterations can be no greater than 50.

The sixth card, with a loading address of 8011, contains the dimensions needed for the perpendicular-buckling calculation, the radius of the left-hand boundary of the reactor, and the lattice radius for the flux normalization. In the independent F₂ calculation, the core height and diameter must always be given by the user if the buckling is to be calculated. In the radial and longitudinal F₂ calculations of the reactivity match, the user need not give the core height and diameter since they are selected by the program from the reference composition. The longitudinal and radial reflector savings must be given by the user in the independent F₂ calculation only if the perpendicular-buckling control option (C₂₅) on George data page 22 indicates that the Program F₂ data and controls are being used. In

the radial and longitudinal F_2 calculations of the reactivity match the user never gives the reflector savings. In slab geometry the left-hand boundary can be assigned any radius consistent with the other regional data. When the user wants the flux to be normalized the radius for flux normalization is given by dividing the fast and slow flux by the fast flux at a specified radius. If the radius given by the user does not agree within 10^{-5} of a lattice radius of the reactor, an error will occur.

The seventh card, with a loading address of 8017, is used only if the albedos are given by the user. This card contains the fast and slow albedos at the left- and right-hand boundaries.

The eighth card, with a loading address of 8021, is used only if the flux ratios are given by the user. This card contains the fast and slow flux ratios at the left- and right-hand boundaries.

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The first card, with a loading address of 8532, specifies the type of calculation, F_2 , that Program George is to perform. Since this card already has the proper value inserted, the user need not be concerned with it.

The second card, with a loading address of 5990, contains 12 letters of binary coded information reserved for the reference-composition case number identification for the perpendicular-buckling calculation. If the perpendicular-buckling control option C_{25} calls for the computation of the perpendicular buckling from reference-composition data, then this card must be filled with the composition-identification case number of a previously calculated Program C_2 core, end, side, or control composition.

The third card, with a loading address of 5992, contains 12 letters of binary coded information reserved for the reference-composition case number identification for albedos. If albedo option C_{26} calls for a reference control composition, then this card must be filled with the composition-identification case number of a previously calculated Program C_2 control composition.

The fourth card, with a loading address of 5997, contains the control word that determines whether the group constants are to be taken from Program C_2 calculations based on the Terrall method. Since the Terrall method is not available in Program George, this card is already filled with the proper value and the user need not be concerned with it.

The fifth card, with a loading address of 5994, contains the following program control words:

- C_{24} - Either the fast and slow diffusion coefficients calculated with one-group buckling or the fast and slow diffusion coefficients calculated with two-group buckling can be used in the F_2 calculation. If the perpendicular buckling is to be calculated by Program C_2 , either the average extrapolation distance or the fast and slow extrapolation distance can be used.
- C_{25} - Three options other than those involved in a reactivity match pertain to the calculation of the perpendicular buckling for F_2 calculations in Program George. The user can request that Program F_2 calculate the buckling by using the data and controls specified in the F_2 input. The buckling can be calculated as constant over all regions by the use of the reflector savings and extrapolation distance from the specified C_2 reference composition for buckling. The buckling can be calculated for each region from the reflector savings and extrapolation distance from the C_2 composition specified by the user for that particular region. In all

of these options the core height and diameter are taken from the F_2 input given by the user.

There are also three options pertaining to the calculation of the perpendicular buckling for the radial and longitudinal F_2 calculations of the reactivity match. If the user requests that Program F_2 calculate the buckling, then the core height and diameter and the reflector savings of the reference C_2 core composition used in the match are inserted in the proper F_2 input locations and Program F_2 proceeds to calculate the buckling. The user can request that the buckling be calculated as constant over all regions by using the core height, diameter, reflector savings, and extrapolation distance from the specified C_2 reference composition for buckling. If the user requests that the buckling be calculated for each region, then the core height, diameter, and extrapolation distance from the C_2 composition specified for that region, along with the reflector savings of the reference C_2 core composition used in the match, are used to calculate the buckling.

- C_{26} - The user can either give the albedos in the F_2 input or can request the insertion of the fast and slow transmission factors in the F_2 input from the specified control composition for albedos.

Page 23

Each of the 25 cards on this data page, beginning with a loading address of 8025, contains 12 letters of binary coded information that are reserved for compositions specified by the user from which the slow flux is averaged for the flux normalization. The maximum number of compositions that can be specified for any one calculation is 25.

Page 24

The 51 cards on this data page, beginning with a loading address of 6850, contain any external source terms the user is giving. If the source is given constant in each region, only the columns labeled $S_1^+(\text{ext})$ and $S_2^+(\text{ext})$ are used, and a maximum of 50 regions is allowed. If a source is given at each lattice point, all four columns are used but the source at lattice-point zero ($n=0$) and the source at the outer boundary are of no consequence since the flux ratios uniquely determine the relation between the flux at the boundary and the flux at the first lattice point inside the boundary. When the source is given at each lattice point, this data table can be extended to 101 lattice points simply by increasing the loading addresses by four. In this case the region number becomes meaningless.

Page 25

The two sets of 25 cards on this data page contain the regional data describing the reactor. The first card of the first set has a loading address of 6000; the first card of the second set has a loading address of 6100. In the first set, each card contains twelve letters of binary coded information reserved for the composition identification for the group constants defining the region. The second set of cards, which are in one-to-one correspondence with the first set, contains the outer radius, number of intervals, and fast and slow perpendicular buckling associated with the region. Compositions may be repeated in more than one region, but each composition specified by the user must be given in the composition data table, George data page 28. Each region must have an outer radius and number of intervals associated with it, with the regions listed from innermost to outermost. The number of intervals given plus the number of extra intervals must not exceed 100. If the buckling is given constant over all regions, only the perpendicular bucklings for the first line are necessary. Otherwise each region must have the buckling associated with itself.

Page 26

The two sets of 25 cards on this data page are used in the same manner as those described for the previous data page. The first card of the first set has a loading address of 6050; the first card of the second set having a loading address of 6200. This data page is to be used only if the number of regions given by the user is 26 or more.

Page 27

The ten cards on this data page, beginning with a loading address of 6750, contain the fast and slow spectral fractions associated with the compositions given by the user in the composition data table, George data page 28. In the C_2 part of Program George, provision was not made for the calculation of the fast and slow spectral fractions. Consequently, the user must give the values of S_1 and S_2 on this data page. If all the fast and slow spectral fractions are $S_1 = 1$ and $S_2 = 0$, as is usually the case, then this data page does not have to be used. Program F_2 examines all the fast spectral fractions to determine whether any of them are non-zero. If all are zero, the F_2 program knows that the "usual" case is being run ($S_1 = 1$, $S_2 = 0$) and sets all the fast spectral fractions to one and the slow to zero. If, however, any one of the fast spectral fractions is non-zero, the F_2 program leaves all the spectral fractions in the original form.

When this data page is used, the spectral data must be given in correspondence with the composition data table, George data page 28. For example, locations 6750 and 6800 belong with location 6300, and locations 6751 and 6801 belong with location 6302.

Page 28

Each of the first ten cards on this data page, beginning with a loading address of 6300, contains 60 letters of binary coded information reserved for the identification of the compositions given by the user for the F_2 calculation. Each card is designed to identify five composition identifications of 12 letters of binary coded information. These composition identifications will have associated with them the following group constants: fast and slow diffusion coefficients, fast and slow absorption terms, fast and slow multiplication terms, scattering-out term, and the fast and slow spectral fractions. These group constants can either be inserted by Program George from Program C_2 calculated core, end, side, or control compositions or be inserted by the user from previously run calculations. If the user wishes to insert his own group constants, the original independent Program F_2 composition data sheet can be used as a guide to obtain the correct loading addresses. The sample input sheet indicates the procedure to follow. The first two compositions are CORE 1 and CORE 2 for which the C_2 part of Program George will calculate the group constants and store them in the correct locations. The third composition is left blank. The fourth and fifth compositions, PRIOR RUN 1 and PRIOR RUN 2, have group constants inserted by the user that were obtained from previously run calculations. Program George will not insert or change any data after a blank-composition identification (in this example the third composition) is found in the composition table. When a reactivity match is run, the reference core composition used in the match must be given by the user in the composition data table for the longitudinal F_2 calculation.

The last card on this data page, with a loading address of 8192, is the F_2 change case card. If a change is wanted, the F_2 portion of input core storage is not set to zero. If no change case is wanted, all F_2 input data will be cleared from core storage. This card must be punched, because it signals the end-of-record condition for the data input package. This essentially tells the program that a complete set of data has been read into core storage, and the calculation can begin.

Note: This table may be extended to 50 materials by striking out the printed address and writing in above the correct initial address for a new sheet.

6300 → 6310 → 6320 → etc.

6400 → 6405 → 6410 → etc.

		22	34	46	58
Materials (12 letter BCI)	B 6300,10,	CORE ① 1	CORE ① 2	PRIOR ① RUN ① 1	PRIOR ① RUN ① 2
D ₁ fast diffusion coefficient	C 6400,	O	O	O	X.XXX X.XXX
D ₂ slow (or l-group) diffusion coefficient	C 6450,	O	O	O	X.XXX X.XXX
Σ _{a1} fast absorption cross section	C 6500,	O	O	O	X.XXX X.XXX
Σ _{a2} slow (or l-group) absorption cross section	C 6550,	O	O	O	X.XXX X.XXX
νΣ _{f1} fast multiplication cross section	C 6600,	O	O	O	X.XXX X.XXX
νΣ _{f2} slow (or l-group) multiplication cross section	C 6650,	O	O	O	X.XXX X.XXX
Σ _{s1} scattering out cross section	C 6700,	O	O	O	X.XXX X.XXX
*S ₁ fast source spectrum	C 6750,	O	O	O	X.XXX X.XXX
*S ₂ slow (or l-group) source spectrum	C 6800,	O	O	O	X.XXX X.XXX

*S₁ and S₂ may be omitted if, as is usually the case, S₁ is unity and S₂ is zero.

6.10 F₂ CHANGE CASE INPUT (George Data Page 29)Page 29

The first card on this data page, with a loading address of 8076, contains 12 letters of binary coded information reserved for the new case number of the F₂ calculation. When a change case is used, the previous F₂ input data is not cleared in core storage. Hence the user needs only to fill in the blank-addressed cards contained on this page, with the storage address of the value to be changed in the first half of the card and the actual value to be inserted in that address in the second half of the card. In this way the number of input data cards can be substantially reduced. All data in the F₂ program must end in a comma except binary coded information. The regular input pages should be used as a guide when making change cases since these pages have the correct control and address information.

The last card on this data page, with a loading address of 8192, is explained in the last paragraph of the preceding section.

6.11 SUMMARY OF PROGRAM I₂-C₂ CONTROL WORDS

Control	Definition	Meaning
C ₁	F ₂ calculation requested	0 No 1 Yes
C ₂	Type of input	0 CGS 1 English
C ₃	Thermal base cross section	0 Calculate σ_{t+1} and σ_t 1 Calculate σ_{t+1} and set $\sigma_t = \sigma_{t+1}$
C ₄	Slowing-down model	0 Modified age theory 1 Coveyou-Macauley theory 2 Semi-consistent Wigner theory 3 Inconsistent Wigner theory 4 Age theory
C ₅	Group division	0 $N = t$ 1 Calculate N (core only) 2 N given
C ₆	Behrens correction	0 Set all $f_n = 1$ 1 Calculate $f_{n,r}$ and $f_{n,z}$ using anisotropic formula 2 Calculate $f_{n,r} = f_{n,z}$ using original isotropic formula
C ₇	I ₂ calculation	0 No I ₂ calculation; set $g_n^i = 1.0$ 1 I ₂ calculation required 2 No I ₂ calculation; g_n^i are given
C ₈	Use of g factors in $g\sigma$	0 Apply g_n^i to all σ_n 1 Apply g_n^i to $\sigma_{a,n}$ and $v\sigma_{f,n}$ only
C ₉	Leakage term in I ₂ input	0 Σ_a is calculated for I ₂ with no leakage term 1 Σ_a has leakage term added
C ₁₀	Use of g factors in Behrens correction	0 Cross sections not cell corrected 1 Cross sections have a g factor applied
C ₁₁	Moderator cross section for Behrens correction	0 Use $\Sigma_{s,mod}$ 1 Use $\Sigma_{f,mod}$
C ₁₂	I ₂ calculation at level $t + 1$	1 Type A input 0 No calculation; set g_{t+1}^i and g_t^i to 1.0 -1 Type B input
C ₁₃	I ₂ calculation at level 16	1 Type A input 0 No calculation; set $g_{16}^i = 1.0$ -1 Type B input
C ₁₄	I ₂ calculation at level 17	1 Type A input 0 No calculation; set $g_{17}^i = 1.0$ -1 Type B input

<u>Control</u>	<u>Definition</u>	<u>Meaning</u>
C ₁₅	Type of transmission calculation	0 No calculation required 1 Rod transmission 2 Annulus transmission 3 Plate transmission
C ₁₆	Composition geometry	0 Slab 1 Cylinder 2 Sphere
C ₁₇	Photon production parameters	0 No calculation 1 Calculation required
C ₁₈	Terrall method requested	0 No 1 Yes (Not available)
C ₁₉	Type of printout	0 Short 1 Intermediate 2 Long
C ₂₀	Fine radial power requested	0 No 1 Yes
C ₂₁	Adjoint flux in the slowing-down calculation requested	0 No 1 Yes (Not available)
C ₂₂	Multigroup constants desired	0 No 1 Yes
C ₂₃	I-C-F reactivity match requested	0 No 1 Yes
C ₂₄	Type of two-group parameters	0 Use one-group buckling 1 Use two-group buckling
C ₂₅	Perpendicular buckling calculation	0 Compute by controls in F ₂ using F ₂ data 1 Compute from reference composition data 2 Compute using composition data for each composition in the regional data
C ₂₆	Albedos	0 Given in F ₂ input 1 Use t_1 and t_2 computed in reference control composition
C ₂₇	All F ₂ parameters obtained from compositions are taken from the Terrall method	0 No 1 Yes (Not available)
C ₂₈	I ₂ material is a fuel	-1 Yes +1 No
C ₂₉	Type of composition	-1 Core or End 0 Side +1 Control +2 F ₂ calculation

<u>Control</u>	<u>Definition</u>	<u>Meaning</u>
C ₃₀	<i>g</i> recipe	0 $\bar{\phi}_{\text{cell}} = 1$ 1 $\bar{\phi}_{\text{mod}} = 1$
C ₃₁	Change case - clear input	-1 No +1 Yes
C ₃₂	Rerun this composition in I-C-F reactivity match	0 No 1 Yes
C ₃₃	Rerun I_2 calculations of this core or end composition in I-C-F reactivity match	0 No 1 Yes

6. 12 SUMMARY OF PROGRAM F₂ CONTROL WORDS

<u>Control</u>	<u>Definition</u>	<u>Meaning</u>
C ₀	Number of regions	An integer from 1 to 50
C ₁	Type of solution	0 Two-group direct 1 Two-group adjoint 2 One-group
C ₂	Geometry	0 Plane 1 Cylinder 2 Sphere
C ₃	Buckling	0 Buckling calculated 1 Buckling given, constant 2 Buckling calculated without extrapolation distance 3 Buckling given in each region
C ₄	Boundary Conditions	0 Use natural conditions 1 Albedos given 2 Flux ratios given
C ₅	Boundary Crossing	0 Extra intervals at each interface between regions 1 Extra intervals at outer boundaries only 2 No extra intervals
C ₆	External source	0 None 1 Constant in each region 2 Given at every point
C ₇	Convergence	≠3 Reactivity, maximum difference, mean square 3 <i>P</i> iterations
C ₈	Flux Normalization	0 Average fast flux in core 1 Fast flux at radius 2 Average slow flux in material
C ₉	Output	0 Print and photograph 1 Print only

7. Description of Output

7.1 GENERAL COMMENTS ON OUTPUT

All of the output data of the three programs comprising Program George are planned for 72-column paper and are printed in the order of the various calculations performed. The first page simply constitutes a print-out of the general input data and is followed by the Program C₂ core or end compositions, with or without Program I₂ calculations requested, and the Program C₂ side and control compositions if requested by the user. If a reactivity match is to be performed, the first radial and longitudinal Program F₂ calculations are printed out; and if convergence is not attained, two more radial and two more longitudinal F₂ calculations are printed out. At this point all the Program C₂ compositions that are to be rerun are calculated and printed out in the same order as before. This procedure continues until convergence is attained, at which time any other Program F₂ calculations following the reactivity match are performed and printed out.

It can be readily seen that the more extensive the Program George calculation, the more print-out is returned by the program. It is not unusual to use a complete 2400-foot output tape for one I₂-C₂-F₂ reactivity match calculation.

7.2 BASIC OUTPUT GENERATED BY PROGRAM GEORGE

For each composition calculation:

1. The fine radial flux, current, and power distributions in an annular cylindrical cell of as many as 50 zones, ten materials, and ten radii per zone are given, along with the average flux within a zone and the flux depression factors. The monoenergetic P₃ (Program I₂) calculations are restricted to the thermal group and lethargy levels 17 and 16. Preceding the print-out of the P₃ calculation results is an identification page giving the security classification, user's name, level at which the P₃ calculation was requested, and the core or end case number for which the flux depression factors were calculated.
2. The two-group constants associated with a bare-reactor calculation are printed out for later use in Program George or in other independent programs such as the one-dimensional Programs F₂ or F_n and the two-dimensional Program CURE.
3. If the calculation is requested, the multigroup constants and parameters, up to 19 groups, are printed out for use in such programs as Program CURE.¹³
4. Various composition cross sections and other parameters, such as the quantities involved in the Behrens corrections, buckling, leakage, and slowing-down calculation, are printed out at 20 levels plus a thermal group.
5. If the calculation is requested, a multigroup representation of photon-production parameters yielding microscopic or macroscopic absorption and fission cross sections for each element in the composition and averaged over the composition flux in up to 19 groups is printed out.
6. If the calculation is requested, a print-out of albedos at 20 levels plus a thermal group, and two-group and multigroup averages using a specified composition flux for plate, rod, or annulus geometry may be obtained.

7. The composition multiplication constant and power distribution in lethargy is also printed out for each composition.

For each one-dimensional, two-group calculation:

1. The fast and slow flux distribution in one dimension, either direct or adjoint as requested, is printed out. The spatial description is limited to 50 compositions, 50 regions, and 100 lattice intervals.
2. The power distribution in one dimension normalized to a volume average of unity for slab, cylindrical, or spherical geometry is printed out.
3. The print-out also includes the reactor multiplication constant.
4. Preceding the normal output of a one-dimensional, two-group calculation (Program F₂) is an identification page giving the F₂ case number and the options requested by the user for the I₂-C₂ control words C₂₄, C₂₅, C₂₆, and C₂₇. If a reactivity match is requested by the user, this identification page also contains the type (radial or longitudinal) F₂ calculation, the number (first, second, or third) of the type, and the iteration number. Also included are the case numbers of the reference core or end composition and radial F₂ and longitudinal F₂ calculations used in the reactivity match.

8. Programmer's Information

8.1 MAGNETIC CORE STORAGE

Program George must operate on an IBM 704 computer that has a magnetic-core-storage capacity of 32,768 locations. Because of the magnitude of the program, the same sections of core storage are used for more than one portion of the program. The following scheme illustrates the sections of core storage that the various routines occupy.

<u>Magnetic Core Storage</u>		<u>Program George</u>
<u>(Initial Address)₁₀</u>	<u>(Final Address)₁₀</u>	<u>Routine</u>
0	22	Self-loader*
32	1599	Input-output package [†]
1600	8175	Program I ₂ Intermediate
1630	2267	Program F ₂ - control 0
2276	2905	Program F ₂ - control 1
2276	2959	Program F ₂ - control A
2712	2859	Program F ₂ - control 2
2712	2861	Program F ₂ - control 3
2712	2789	Program F ₂ - control 4
2276	2701	Program F ₂ - control 5
2276	2908	Program F ₂ - control 6
2276	8198	Program F ₂ - control 7
8500	17621	Program C ₂ - master control
17622	28803	Program C ₂ - core or end calculation
17622	25062	Program C ₂ - side calculation
17622	25490	Program C ₂ - control calculation
17622	18861	Program C ₂ - F ₂ input calculation

With the most extensive allowable combination of routines in core storage at the same time, namely the input-output package, Program I₂ Intermediate, Program C₂ master control, and Program C₂ core or end calculation, there are still almost 4000 words of core storage available to the programmer for any modifications or additions to the program. Only two routines always remain in core storage throughout any Program George calculation — the input-output package and the Program C₂ master control routine. The rest of the routines are read into core storage from the production tape whenever needed.

In addition to several of the various routines occupying the same locations in core storage, it should be noted that different calculations within a particular routine also may occupy the same core storage. This is especially true in the C₂ portion of the program. This is made possible by printing out all answers as soon as there is no further need for them in subsequent calculations and also by making extensive use of binary tape storage.

*The self-loader is needed only for the general version of the program.

[†]The input-output package used in Program George is the General Electric Production Package (GEPRO), consisting of a post-mortem diagnostic program, general output program, and a data input program combined to achieve maximum utilization of storage and constants.

8.2 DATA TRANSFERRAL WITHIN PROGRAMS

Throughout a Program George calculation it is often necessary for the Program C₂ portion to transfer input data or calculated quantities to Program I₂ and F₂ or to transfer results from Programs I₂ and F₂ to Program C₂. In programming these various routines the actual decimal numbers associated with the core-storage locations containing these quantities were used rather than alpha-numeric mnemonics. The following outline gives the quantities transferred within the programs along with the actual I₂ and F₂ core-storage locations to or from which these quantities are transferred and any Program C₂ mnemonics associated with these quantities.

1. Program C₂ Transfers to Program I₂

Quantity	Extent	I ₂ Core-Storage Locations	C ₂ Mnemonics
Zone data	100 words	3750-3849	TI2Z
Material data	40 words	3700-3739	TI2AB
Source terms	50 words	3650-3699	TI2S, TI2S1, TI2S2
Control words	5 words	3850-3854	TI2G

2. Program I₂ Transfers to Program C₂

Quantity	Extent	I ₂ Core-Storage Locations	C ₂ Mnemonics
Radial flux	10 words per zone	6555-6564	TPHR1, TPHR2, TPHR3
Average flux	50 words	6500-6549	TPHZ1, TPHZ2, TPHZ3

3. Program C₂ Transfers to Program F₂

Quantity	Extent	F ₂ Core-Storage Locations	C ₂ Mnemonics
Buckling control option	1 word	8003	CTN25
Core height	1 word	8011	HT
Core diameter	1 word	8012	DC
Longitudinal savings	1 word	8013	SRL
Radial savings	1 word	8014	SRR
Fast albedo, left boundary	1 word	8017	FCT1
Slow albedo, left boundary	1 word	8019	FCT2
Fast diffusion coefficient, One-group buckling	50 words	6400-6449	DG1
Slow diffusion coefficient, One-group buckling	50 words	6450-6499	DG2
Fast diffusion coefficient Two-group buckling	50 words	6400-6449	DG1P
Slow diffusion coefficient, Two-group buckling	50 words	6450-6499	DG2P
Fast absorption term	50 words	6500-6549	SA1
Slow absorption term	50 words	6500-6599	SA2
Fast multiplication term	50 words	6600-6649	NSF1
Slow multiplication term	50 words	6650-6699	NSF2
Scattering-out term	50 words	6700-6749	SS1
Perpendicular buckling, (fast group)	50 words	6102-6298 (increments of 4)	
Perpendicular buckling, (slow group)	50 words	6103-6299 (increments of 4)	

4. Program F_2 Transfers to Program C_2

<u>Quantity</u>	<u>Extent</u>	<u>F_2 Core-Storage Locations</u>	<u>C_2 Mnemonics</u>
Multiplication constant	1 word	7960	TKR, TKZ
Geometry control option	1 word	8002	CTN16
Core height	1 word	8011	HT
Core diameter	1 word	8012	DC

8.3 TAPE LOGIC

Two tape systems are available with Program George. One is designed specifically for the Integrated Operator System in use at the ANP Department, and the other is designed for any IBM 704 computer with a magnetic core storage of 32,768 words and eight on-line tape units. The two systems will be described separately and similarities noted.

Version for Integrated Operator System

Tape Unit Number 1 - Logical unit number 1 contains the Integrated Operator System program tape. This unit is never selected by this version of Program George.

Tape Unit Number 2 - Logical unit number 2 contains the decimal input tape on which are written the decimal input data of the user. This unit is never written on, backspaced, or rewound by Program George.

Tape Unit Number 3 - Logical unit number 3 contains the decimal output tape on which are written the results of the George calculation for the purpose of peripheral printing. This unit is never read, backspaced, or rewound by Program George. A file protect ring must be inserted in this tape reel.

Tape Unit Number 4 - Logical unit number 4 contains the Production Operator Program (POP)* tape. This tape, which is compatible to the Integrated Operator System, contains the POP executive program and a library of extensively used production programs. The George program is written in binary form in its entirety on this tape and is kept as a permanent library tape in the computer area. Program George manipulates this tape both forward and backward but never rewinds it or writes on it. When the POP library tape is initially written, the POP program writes the George program as 15 binary records in the following manner.

<u>Record Number</u>	<u>Routine</u>
1	Input-output package and Program C_2 master control
2	Program F_2 , control 1
3	Program F_2 , control A
4	Program F_2 , control 2
5	Program F_2 , control 3
6	Program F_2 , control 4
7	Program F_2 , control 5
8	Program F_2 , control 6
9	Program F_2 , control 7
10	Program C_2 , core or end calculation
11	Program I_2 Intermediate
12	Program C_2 , side calculation
13	Program C_2 , control calculation

*J. C. Bartlett, Private Communication.

<u>Record Number</u>	<u>Routine</u>
14	Program C ₂ , F ₂ input calculation
15	Program F ₂ , control 0
	End of file

Tape Unit Number 5 - Logical unit number 5 contains a blank tape with a file protect ring inserted in the tape reel. If Program F₂ calculations are to be performed, Program George will transcribe the eight F₂ controls (1, A, 2, 3, 4, 5, 6, 7) as eight binary records onto this tape. The eight F₂ controls are read into core storage from the POP tape a control at a time and written on tape 5 in the same sequence in which they were on the POP tape. After the initial writing of tape 5, the tape is never written on again for a George calculation. This tape may be read, forward-spaced, and rewound several times for a George calculation. If there are no Program F₂ calculations to perform, tape 5 is selected only for rewinding. The F₂ controls are not written on it, and consequently it is never read or forward-spaced. The record number, routine, and approximate length of the routine are as follows.

<u>Record Number</u>	<u>Routine</u>	<u>Approximate Length</u>
1	Program F ₂ , control 1	629 words
2	Program F ₂ , control A	683 words
3	Program F ₂ , control 2	147 words
4	Program F ₂ , control 3	149 words
5	Program F ₂ , control 4	77 words
6	Program F ₂ , control 5	425 words
7	Program F ₂ , control 6	632 words
8	Program F ₂ , control 7	1226 words

This gives a total of 3968 words, approximately 119.2 inches or 9.9 feet of tape. The end-of-record gaps (0.75 inch) separating each record are not included in these figures.

Tape Unit Number 6 - Logical unit number 6 contains a blank tape with a file protect ring inserted in the tape reel. If Program I₂ calculations are requested, tape 6 is used for the temporary storage of calculated quantities from both the I₂ and C₂ portions of Program George. In the Program I₂ portion the tape is used for the storage of certain matrices and vectors calculated for each zone of the cylindrical cell. These quantities are needed only for the Program I₂ calculation and consequently can be disposed of once the calculation is completed. After the Program I₂ calculations are completed, Program C₂ writes the I₂-calculated average flux and radial flux from each zone and the radii describing the cell as one binary record on this tape. This record contains 2297 words, approximately 69 inches or 5.7 feet of tape. These quantities remain undisturbed on tape 6 until the fine radial power is calculated, at which time they are read back into their proper core-storage locations. This tape storage of intermediate results permits the active program use of the 2297 core-storage locations otherwise needed for these quantities. If Program I₂ calculations are not requested by the user, tape 6 is not selected except for rewinding.

Tape Unit Number 7 - Logical unit number 7 contains a blank tape with a file protect ring inserted in the tape reel. If the user requests the calculation of the I₂-C₂-F₂ reactivity match, tape 7 is used for the storage of the input data and other data of those compositions that are to be rerun with numerically adjusted reflector savings in each iteration of the reactivity match. The data for the rerun composition are written in binary form as one record in the same order as the compositions are calculated. Each record contains

4837 words, approximately 145.3 inches or 12.1 feet of tape. Besides the basic input data of the composition, the record also includes the neutron source spectrum, elemental cross sections from the Nuclear Data Tape, average flux, radial flux, and radii from the Program I₂ calculations and certain mnemonic signals needed for the logical flow of the program. After all the data of the various compositions that are to be rerun have been written on tape 7, the input data of the radial and longitudinal Program F₂ calculations are written on the tape. These two binary records each consist of 2208 words, approximately 66.3 inches or 5.5 feet of tape. Nothing more is written on tape 7 after the set of input data describing the longitudinal Program F₂ calculation is written. If there is no reactivity match, tape 7 is not selected except for rewinding.

Tape Unit Number 8 - Logical unit number 8 contains the Nuclear Data Tape, which is a permanent library tape on file in the computer area. This tape may be read, forward-spaced, and rewound several times during a calculation but is never written on by Program George.

Tape Unit Number 9 - Logical unit number 9 contains a blank tape with a file protect ring inserted in the tape reel. This tape is used for the storage of the reference constants, which are yielded by each Program C₂ composition calculation and may be needed as supplementary input for subsequent composition or Program F₂ calculations. The reference constants are written as one binary record in the same order as the compositions are calculated. Each record contains 177 words, approximately 5.3 inches of tape. If only C₂-type calculations are requested, the record of reference constants is written on tape 9 only if subsequent calculations warrant it. If Program F₂ calculations are requested, the reference constants are always written. If the I₂-C₂-F₂ reactivity match is requested, the reference constants yielded by the original composition calculations, together with those of the rerun compositions, are saved on tape 9. The reference constants of the rerun compositions are always written on the same portion of tape, with one group of records replacing the group of the previous iteration. The only type of calculation in which nothing is written on tape 9 is that containing only Program C₂ core or end calculations. Tape 9 is simply selected for rewinding in this type of calculation.

General Version

Tape Unit Number 1 - For this version, logical unit number 1 contains the Program George production tape. When the load-tape button on the computer is actuated, a self-loading bootstrap reads the first binary record of tape 1 into core storage and transfers control to the Program C₂ master control routine, which is then in control of the computer. Program George then manipulates the tape according to the type calculation that is requested. The entire George program is written as 15 binary records on this tape, which is then kept on file in the computer area. The records are written on the tape in the following manner.

<u>Record Number</u>	<u>Routine</u>	<u>Approximate Length</u>
1	Self-loader, input-output package, and Program C ₂ master control	17621 words
2	Program F ₂ , control 1	629 words
3	Program F ₂ , control A	683 words
4	Program F ₂ , control 2	147 words
5	Program F ₂ , control 3	149 words
6	Program F ₂ , control 4	77 words
7	Program F ₂ , control 5	425 words
8	Program F ₂ , control 6	632 words
9	Program F ₂ , control 7	1226 words

<u>Record Number</u>	<u>Routine</u>	<u>Approximate Length</u>
10	Program C ₂ , core or end calculation	11182 words
11	Program I ₂ Intermediate	4263 words
12	Program C ₂ , side calculation	7441 words
13	Program C ₂ , control calculation	7869 words
14	Program C ₂ , F ₂ input calculation	1238 words
15	Program F ₂ , control 0	637 words
	End of file	

This gives a total of 54,219 words, approximately 1628.2 inches or 135.7 feet of tape. The end-of-record gaps (0.75 inch) separating each record are not included in these figures.

Tape Unit Numbers 2 and 3 - These units are used in the manner described for the Integrated Operator System.

Tape Unit Number 4 - This unit is not selected in this version of Program George.

Tape Unit Number 5 - This unit is used in the manner described for the Integrated Operator System except that the eight F₂ controls are transcribed from the Program George production tape logical unit number 1.

Tape Unit Numbers 6, 7, 8, and 9 - These units are used in the manner described for the Integrated Operator System.

8.4 ASSEMBLY PROCEDURE

Program George is completely coded in the CAGE (Compiler and Assembler-General Electric) machine language. Because of the magnitude of the program and the desire to simplify the compiling procedure, the program is designed for compilation in parts. Any one part of the program can be assembled independently of the other parts, thus affording ease in making program modifications. The following paragraphs give all the information pertinent to the correct assembly procedure for each part of Program George.

1. Program C₂, Master Control - POP Verison - One file drawer contains 3670 source cards yielding 3904 assembled decimal locations. The initial decimal address is 8500; the final decimal address is 17566. The initial octal address of the first binary card is 20464; the final octal address of the last word on the last binary card is 42236. The transfer card at the end of the binary deck has an octal address of 34561. The total assembly time is approximately 9.6 minutes. Two cards must be pulled from the binary deck after assembly. The first is a transfer card to location 0; the second is a binary card with an octal address of 42326. These two cards may be disposed of since they are not necessary to the correct functioning of the program.
2. Program C₂, Core or End Calculation - Four file drawers contain 11,616 source cards yielding 12,223 assembled decimal locations. The initial decimal address is 8500; the final decimal address is 28803. The initial octal address of the first binary card is 20464; the final octal address of the last word on the last binary card is 70203. The transfer card at the end of the binary deck has an octal address of 42326. The total assembly time is approximately 37.8 minutes. The binary cards containing the octal locations 20464 up to, but not including, 42326 must be removed from the binary deck after assembly. These cards may be disposed of since they are not necessary to the correct functioning of the program.
3. Program C₂, Side Calculation - Three file drawers contain 7983 source cards yielding 8482 assembled decimal locations. The initial decimal address is 8500; the final deci-

mal address is 25062. The initial octal address of the first binary card is 20464; the final octal address of the last word on the last binary card is 60746. The transfer card at the end of the binary deck has an octal address of 42326. The total assembly time is approximately 28.2 minutes. The binary cards containing the octal locations 20464 up to, but not including, 42326 must be removed from the binary deck after assembly. These cards may be disposed of since they are not necessary to the correct functioning of the program.

4. Program C₂, Control Calculation - Three file drawers contain 7562 source cards yielding 8910 assembled decimal locations. The initial decimal address is 8500; the final decimal address is 25490. The initial octal address of the first binary card is 20464; the final octal address of the last word on the last binary card is 61622. The transfer card at the end of the binary deck has an octal address of 42326. The total assembly time is approximately 28.8 minutes. The binary cards containing the octal locations 20464 up to, but not including, 42326 must be removed from the binary deck after assembly. These cards may be disposed of since they are not necessary to the correct functioning of the program.
5. Program C₂, F₂ Input Calculation - One file drawer contains 2005 source cards yielding 2281 assembled decimal locations. The initial decimal address is 8500; the final decimal address is 18861. The initial octal address of the first binary card is 20464; the final octal address of the last word on the last binary card is 44655. The transfer card at the end of the binary deck has an octal address of 42326. The total assembly time is approximately 6.6 minutes. The binary cards containing the octal locations 20464 up to, but not including, 42326 must be removed from the binary deck after assembly. These cards may be disposed of since they are not necessary to the correct functioning of the program.
6. Program C₂, Master Control - General Version - One file drawer contains 3746 source cards yielding 3972 assembled decimal locations. The initial decimal address is 0; the final decimal address is 17611. The initial octal address of the first binary card is 0; the final octal address of the last word on the last binary card is 42313. The transfer card at the end of the binary deck has an octal address of 34561. The total assembly time is approximately 10.2 minutes. Two cards must be pulled from the binary deck after assembly. The first is a transfer card to location 0; the second is a binary card with an octal address of 42326. These two cards may be disposed of since they are not necessary to the correct functioning of the program.
7. Program I₂, Intermediate - Two file drawers contain 4375 source cards yielding 4263 assembled decimal locations. The initial decimal address is 1600; the final decimal address is 6244. The initial octal address of the first binary card is 3100; the final octal address of the last word on the last binary card is 14144. The transfer card at the end of the binary deck has an octal address of 7534. The total assembly time is approximately 16.4 minutes.
8. Program F₂ - Two file drawers contain 5272 source cards yielding 4182 assembled decimal locations. The initial decimal address is 1630; the final decimal address is 8198. The initial octal address of the first binary card is 3136; the final octal address of the last word on the last binary card is 20006. There are eight transfer cards within the binary deck, having the following octal addresses in order: 4051, 4060, 4064, 4070, 4074, 4100, 4104, and 4107. The total assembly time is approximately 21.3 minutes. One card must be pulled from the binary deck after assembly. This is a binary card with an octal address of 20000, which may be disposed of since it is not necessary to the correct functioning of the program.

The entire program is now assembled, and the first two steps in making the general production tape or the POP tape have been taken. The first step, of course, is the actual assembling of the program. The second step is the removal from the routines of the various binary cards that are not needed. These cards consist mainly of bookkeeping information needed for the correct assembly of the individual routines but not needed for the actual program calculation.

8.5 PRODUCTION TAPES

As was stated in section 8.3, two tape systems, the POP system and the general system, are available with Program George, each requiring its own special production tape. The methods used in preparing the binary decks for writing on the production tapes are quite different after the first two steps explained in section 8.4. The preparation of the production tapes will be described separately and the similarities noted.

In making the production tape for the POP system, the assembled binary decks are arranged in the following order.

- 1) Input-output package
- 1A) Program C₂, master control-POP version
- 1B) Transfer card (34561)₈
- 2) Program F₂, control 1
- 2A) Transfer card (4051)₈
- 3) Program F₂, control A
- 3A) Transfer card (4060)₈
- 4) Program F₂, control 2
- 4A) Transfer card (4064)₈
- 5) Program F₂, control 3
- 5A) Transfer card (4070)₈
- 6) Program F₂, control 4
- 6A) Transfer card (4074)₈
- 7) Program F₂, control 5
- 7A) Transfer card (4100)₈
- 8) Program F₂, control 6
- 8A) Transfer card (4104)₈
- 9) Program F₂, control 7
- 9A) Transfer card (4107)₈
- 10) Program C₂, core or end calculation
- 10A) Transfer card (42326)₈
- 11) Program I₂ Intermediate
- 11A) Transfer card (7534)₈
- 12) Program C₂, side calculation
- 12A) Transfer card (42326)₈
- 12) Program C₂, control calculation
- 13A) Transfer card (42326)₈
- 14) Program C₂, F₂ input calculation
- 14A) Transfer card (42326)₈
- 15) Program F₂, control 0
- 15A) Transfer card (42326)₈

A transfer card consists only of the octal address punched in the 9-left word of the binary card.

After the binary decks with transfer cards are arranged in this order, a program (FOPOP)* is used to prepare the individual binary decks for writing on the POP production tape. This must be done because of the incompatibility between the binary tape read/write routine in the POP executive program and the binary tape read/write routine in Program George. FOPOP essentially defines all nonconsecutive storage by punching blank binary cards, except for word count, address, and check sum and thus enables the POP executive program to write one record of consecutive storage representing the binary deck on the production tape. This repunching of the binary deck must be done for all the decks except 1 and 1A above. These repunched binary decks then replace those previously listed, with the transfer cards remaining the same. The whole group of decks is then given to the computer personnel for placing on the POP production tape.

In making the production tape for the general system, the assembled binary decks are arranged in the same order except for group 1, which is arranged as follows.

- 1) Self-loader
- 1A) Input-output package
- 1B) Program C₂, master control - general version
- 1C) Transfer card (34561)₈

In addition, all transfer cards, except that following the Program F₂ control 0 routine, are replaced by new transfer cards each containing an octal address of 4. The transfer card following the Program F₂, control 0 routine is replaced by a new transfer card containing an octal address of 3.

The binary decks are now ready to be written on the production tape. For this procedure a utility routine Basic Tape Writer 1 (BTW-1)[†] is used.

BTW-1 is a self-loading routine that reads absolute binary cards and writes their contents on tape as directed by various transfer cards. Its purpose is to produce a self-loading automatically sequenced production tape from binary cards.

BTW-1 recognizes five transfer cards:

Address 1 - Write a record on logical tape unit number 1 with the last word written being a standard ACL check sum. BTW-1 writes, as a unit record, all the information read from binary cards subsequent to the most recently encountered transfer card.

Address 2 - Write a record on logical tape unit number 1 with no check sum.

Address 3 - Write an end of file and rewind logical tape unit number 1, and halt at (150)₈.

Address 4 - Write a record on logical tape unit number 1 with the last word written being a standard ACL check sum; backspace and read the record to verify the check sum.

Address 5 - Write an end of file on logical tape unit number 1 and then continue card reading. This may be used for preparing multi-file production tapes.

BTW-1, after loading itself, proceeds to read absolute binary cards into core-storage location (200)₈ and following. The first absolute binary card must be that containing the first word written on the tape record. Subsequent cards may be in any order. When address transfer 1, 2, or 4 is encountered, the program writes on logical tape unit number 1 start-

*J. A. Delaney and D. S. Latimore, Private Communication.

[†]F. E. Ferrin, Private Communication

ing at location (200)₈ and terminating at the highest location loaded from the most recent absolute binary card. Consequently, the last absolute binary card must be that containing the last word to be written in the tape record.

The BTW-1 program cards are placed immediately before the Program George self-loader in group 1. No repunching of binary cards is necessary in making the general production tape.

8.6 OPERATING PROCEDURE

When Program George is being run from the POP production tape in conjunction with the Integrated Operator System, the operating procedure is essentially already determined, and the computer operator need do nothing except perhaps change the settings of the sense switches on the computer console. The sense switch options available in this version of Program George are:

- Sense Switch 2 - Up - The input data are read from tape, logical unit number 2.
- Down - The input data are read from the on-line card reader.
- Sense Switch 3 - Up - The output data are written on tape, logical unit number 3.
- Down - The output data are written on the on-line printer.
- Sense Switch 5 - Up - No effect on the program.
- Down - A monitoring of the convergence procedure for the reactivity match is given on the on-line printer.

Sense switches 1, 4, and 6 are always in the UP position.

When the POP version is used, there is no final stop in Program George since the last executed Program George instruction is a transfer of control to POP, UNJ 5.

When Program George is being run from the general production tape, the operating procedure is slightly more elaborate. After the computer operator has readied the tape system on the tape units and the input data are available in either the on-line card reader or tape 2, the CLEAR and LOAD TAPE buttons are pressed in that order. Program George then performs all the calculations processing the data input cards, a record at a time, until the end-of-file card is read. At that time the program tests sense switch 4 to determine whether a multicase calculation is requested. If sense switch 4 is up, the production tape on logical unit number 1 is rewound and the computer attains a final stop of (34615)₈. If sense switch 4 is down, the program is told that another George case is ready for calculation, and the production tape is backspaced to a point just before the second binary record. Without stopping, the program immediately begins to calculate the next George case. It is mandatory that the input data be stacked one case immediately following the other. When the last case of input data is being processed by the program, the computer operator should place sense switch 4 in the UP position so that the program is told that the last George case is being calculated and that the production tape on logical unit number 1 is rewound and the final stop of (34615)₈ attained.

Except for the sense switch 4 option, all other sense switch options are the same for the general version of the program as for the POP version of the program. At the completion of the Program George calculations the computer operator can remove the production tape, which should be kept on file in the computer area.

8.7 DIAGNOSTICS

There are no programmed stops in the C₂ and F₂ parts of Program George. The only possible stop that can occur in these two parts of the program, except for the final stop of (34615)₈ in the general version, is a read/write check on one of the tape units being

used. All other possible error stops are diagnosed by an automatic post-mortem, which prints out all the information needed by the user in diagnosing the error.

The first line of information printed out by the post-mortem contains the status of the four console sense lights, the contents of index registers one and two in octal, and the status of the accumulator overflow and divide-check indicator lights. Whenever the status of the various lights on the console is given, the number 1 indicates that the particular light was on, and the number 0 indicates that the particular light was off. The second line of information printed out by the post-mortem contains the contents of index register 4, the contents of the multiplier-quotient register, the contents of the accumulator, and the contents of the accumulator overflow positions all in octal, along with the status of the quotient overflow light. The third line of information printed out by the post-mortem contains the contents of the multiplier-quotient register and accumulator in floating-point decimal.

In the post-mortem for the C_2 portion of the program the fourth line contains the contents of the control-word option C_{29} for the type composition to calculate. The fifth line contains the description of the C_2 composition case identification in binary coded decimal.

In the post-mortem for the F_2 portion of the program the fourth line contains the description of the F_2 case number in binary coded decimal.

With this information and by taking the two's complement of the contents of index register 4 to determine the location from which the post-mortem was entered to ascertain the cause of the stop from the list of octal post-mortem entries given below, the user should encounter minimum difficulty in diagnosing the error.

If a diagnosable error has occurred in the F_2 part of Program George, a double post-mortem is printed out. The first is the post-mortem for the F_2 error, and the second is the post-mortem for the return from the F_2 program to the master control routine of the C_2 program.

1. The following list of octal post-mortem entries refers to the F_2 part of Program George. In the fourth line of the C_2 post-mortem the contents of the control word option C_{29} must be 2.

Tape 5 reading errors. Computer error or physically bad tape.	4120, 4125, 4141, 4146 4157, 4163, 4201, 4206
Tape 5 reading errors, end of file. Computer error or physically bad tape.	4121, 4126, 4142, 4147 4160, 4164, 4202, 4207
Denominator in geometry calculation equals zero.	5427, 5444, 5463 5470, 5474, 5502
Fast-group recursion coefficient at a lattice equals zero.	4456, 4507, 5276
Slow-group recursion coefficient at a lattice equals zero.	4621, 4652, 5415
Denominator in flux recursion coefficient calculation equals zero.	4475, 4640
Fast-group diffusion coefficient at a lattice equals zero.	4463, 5304
Slow-group diffusion coefficient at a lattice equals zero.	4626, 5423

Number of iterations greater than 50.	4715, 5142
$(H + 2S_H + \delta) = 0$	4555, 4717
$(D + 2S_D + \delta) = 0$	4567, 4643
Radius equals zero in regional data.	4473
Number of intervals exceeds 100.	4613
$1^+ + A^+ = 0$	5065
Diffusion coefficient equals zero at inner or outer boundary.	5071
Composition is not in table.	5103
$V(\alpha) = 0$	5130
Normalizing radius is not a lattice point.	5317
Normalizing material is not in table.	5356
Volume fraction equals zero.	5376
$2R + H_H + 1 = 0$	5401
φ core equals zero.	5415
Height at a lattice point equals zero.	5433
$2R + H = 0$	5442
Normalizing factor equals zero.	5442

2. The following list of octal post-mortem entries refers to the Program C₂, master control - POP version of Program George. In the fourth line of the C₂ post-mortem the contents of the control word option C₂₉ may be -1, 0, 1, or 2.

Data card errors. Examine data cards for incorrect punching.	34743, 35532, 35551, 36443, 36472, 41753, 41774, 42167
Tape 4 (POP) reading errors. POP tape possibly needs to be remade.	34776, 35022, 35046, 35072, 35116, 35142, 35166, 35212, 35721, 36622, 36677, 41322, 42066
Tape 4 (POP) reading errors, end of file. Check binary deck arrangement for POP tape.	35000, 35024, 35050, 35074, 35120, 35144, 35170, 35214
Tape 5 writing errors. Computer error or physically bad tape.	35006, 35032, 35056, 35102, 35126, 35152, 35176, 35222
Tape 7 reading errors. Computer error or physically bad tape.	36520, 41201
Tape 7 writing errors. Computer error or physically bad tape.	36451, 36500
Tape 9 reading errors. Computer error or physically bad tape. If reactivity match is requested, at least one composition must be rerun.	35623, 41244

The following entries pertain to the processing of end-of-record or end-of-file data cards at a time which indicates that the number of calculations requested by the user and the actual number given by the user are inconsistent.

Inverse period data card missing.	35223, 36055
Number of core or ends incorrect.	36030, 42113
Number of sides incorrect.	36037, 42122
Number of controls incorrect.	36046, 42131
Radial F_2 has no end-of-record card.	36643
Longitudinal F_2 has no end-of-record card.	36647
Number of F_2 calculations incorrect.	41754, 42140, 42170
Combination of above errors.	35536, 36061, 42144.

The following entries pertain to the convergence procedure used in adjusting the reflector savings in the reactivity match.

Reference core composition used in reactivity match not given in longitudinal F_2 composition input.	37057, 37611, 37635
Singular set of equations number 239.	37717
Singular set of equations number 240.	37757
$k'_{in} = k_{in}$ equation number 247.	40151
Extrapolated reactivity equals zero.	40260
$(H + 2S_z + 2d) = 0$, equation number 244.	40672
$(D + 2S_r + 2d) = 0$, equation number 244.	40677
$(H + 2S_z + 2d_1) = 0$, equation number 245.	40711
$(H + 2S_z + 2d_2) = 0$, equation number 246.	40716
$(D + 2S_r + 2d_1) = 0$, equation number 245.	40723
$(D + 2S_r + 2d_2) = 0$, equation number 246.	40730
$\Sigma_{s_1} + \Sigma_{a_1} = 0$, equation number 243.	40746, 40754
$1 + L_1^2 K_1^2 = 0$, equation number 243.	40764
$\Sigma_{a_1} = 0$, equation number 243.	40774
$\Sigma_{a_2} = 0$, equation number 243.	41002, 41010
$(1 + L_2^2 K_2^2) = 0$, equation number 243.	41020

The following entries pertain to logical consistency checks coded into this part of the program.

Number of core or end incorrect.	35563
Number of sides incorrect.	35567
Number of controls incorrect.	35573
Inverse period data card missing.	35574
No core or end compositions calculated.	35606
Reference constants cannot be found on tape 9.	35635, 41256
No core or end compositions rerun in reactivity match.	41227
C ₂₉ not proper value for F ₂ calculation.	36576, 42042

3. The following list of octal post-mortem entries refers to the Program C₂ core or end, side, and control calculations of Program George. In the fourth line of the C₂ post-mortem, C₂₉ is -1 for core or end, 0 for side, and 1 for control. In the three routines many of the error diagnostics are identical; only the locations are different.

	<u>-1</u>	<u>0</u>	<u>1</u>
Square root of the number of cells is not computable.	42667		
Square root of the number of cells equals zero.	42674		
Neutron source spectrum cannot be found on Nuclear Data Tape.	42704	42664	
Error in reading neutron source spectrum from Nuclear Data Tape.	42736	42716	
Delayed spectra cannot be found on Nuclear Data Tape.	43000	42760	
Error in reading delayed spectra from Nuclear Data Tape.	43012	42772	
$\omega + \omega_j = 0$, equation number 2.	43111	43071	
$\omega + \omega_j = 0$, equation number 3.	43173	43153	
$A(\omega) = 0$, equation number 2.	43232	43212	
Natural logarithm error, equation number 4.	43370	43350	
Cell diameter equals zero.	44000	43566	43037
Element cannot be found on Nuclear Data Tape.	44103	43671	43142
Error in reading element designation from Nuclear Data Tape.	44145, 44146, 44163	43733, 43734, 43751	43204, 43205, 43222

	-1	0	1
Element codes not ordered properly.	44255	44043	43314
Error in reading element from Nuclear Data Tape.	44301	44067	43340
$A^t V_m = 0$, equation number 12.	44505		
$\rho^t V_m = 0$, equation number 13.	44516		
Maximum number of elements exceeded in fuel region.	44570		
$R_{\text{cell}}^2 = 0$, equations 16 and 18.	44625		
Maximum number of elements exceeded in moderator region.	44674		
$R_{\text{cell}}^2 = 0$, equations 15 and 17.	44731		
$\rho^t V_c = 0$, equation number 21, fuel region.	45120	44234	43505
$A^t V_c = 0$, equation number 22, fuel region.	45132	44246	43517
$\rho^t V_c = 0$ equation number 21, moderator region.	45210	44324	43575
$A^t V_c = 0$ equation number 22, moderator region.	45222	44336	43607
Lagrangian interpolation error in thermal cross section.	45440	44554	44025
Lagrangian interpolation error in last epithermal cross section.	45521	44635	44106
$(\Sigma_{tr} + \Sigma_a) = 0$, equation number 31.	46374		
$(H + 2S_z) = 0$, equation number 34.	46424		
Tape 4 (POP) reading error.	46733		
$(r_o^2 - r_i^2) = 0$, or possibly $\bar{\Phi}_{\text{mod}}$ cannot be computed because no source terms of 1.0 are given. Equations 35 and 37.	47242		
$\bar{\Phi}_{\text{cell}} = 0$, equation number 36, or $\bar{\Phi}_{\text{mod}} = 0$, equation number 38.	47271		
$N^t R_{\text{cell}}^2 = 0$, equations 39 and 40.	47550		
Tape 6 writing error.	47725		
Tape 7 writing error.	47742	46212	45337
Error in reading element designation from Nuclear Data Tape.	51710, 51711 51726	45762, 45763, 46000	45107, 45110, 45125

-1	0	1
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The following entries pertain to the Behrens correction calculation.

$D_2 + D_1 = 0.$	52223
$D_1 = 0.$	52231
$D_2^2 - D_1^2 = 0.$	52241
$D_3^2 - D_2^2 + D_1^2 = 0.$	52247, 53202

Exponential of y cannot be calculated, equation number 58.	53227
--	-------

$e^y - 1 = 0$, equation number 58.	53235
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Exponential of x cannot be calculated, equation number 58.	53267
--	-------

$e^x \left(\frac{D_3^2}{D_3^2 - D_2^2 + D_1^2} \right) = 0,$ equation number 58.	53302
--	-------

Exponential of x cannot be calculated; equations 59 and 60.	53332, 53371
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$e^x \left(\frac{D_3^2}{D_2^2 - D_1^2} \right) = 0,$ equations 59 and 60.	53350, 53404
---	--------------

Exponential of y cannot be calculated, equations 59 and 60.	53354
---	-------

$e^y - 1 = 0,$ equations 59 and 60.	53362
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The following entries pertain to the buckling and leakage calculations

$(\Sigma_a + \Sigma_{tr}) = 0,$ equation number 65.	55242
$(D + 2S_r + 2d) = 0,$ equations 67 and 70.	55304, 55420

$(H + 2S_z + 2d) = 0,$ equations 66 and 71.	55326, 55376
--	--------------

$(R + 2S_s + 2d) = 0,$ equation number 68.	55442
---	-------

$(R + 2S_s + d) = 0,$ equation number 71.	55476
--	-------

$(\Sigma_a + \Sigma_s) = 0,$ equation number 75.	55526
---	-------

	-1	0	1
$(\Sigma_a + \Sigma_{tr} + \epsilon \Sigma_a + \epsilon \Sigma_s) = 0$, equations 77, 78, 79 and 81.	55710, 55735, 56004		
$(\Sigma_a + \Sigma_{tr}) = 0$, equations 82 and 83.		47653, 47634	47000, 46761

The following entries pertain to the slowing-down and flux calculations.

$(\xi \Sigma_s + \Sigma_a + \Sigma_l) = 0$.	56567, 57206	50175, 50614
$(\Sigma_s + \Sigma_a + \Sigma_l) = 0$.	56627, 56701, 57244, 57272	50235, 50307, 50652, 50700
$\xi \Sigma_s = 0$.	56634, 56674, 56747, 57003, 57237, 57341	50242, 50302, 50355, 50411, 50645, 50747
$(\Sigma_s + \Sigma_a) = 0$.	56754, 57321	50362, 50727
$U = 0$, equation number 88.	57131	50537
$\frac{2}{U} + W = 0$, equation number 88.	57155	50563

The following entries pertain to the calculation of the reactivity and power.

$(\Sigma_a + \Sigma_l) = 0$, equation number 102.	57520	51126
Reactivity equals zero, equations 108, 109, 110, and 111.	60071, 60111, 60131, 60147	51477, 51517, 51537, 51555
Reactivity equals zero, equations 112 and 113.	60513	

The following entries pertain to the calculation of the two-group constants.

Slow-group flux equals zero.	60574, 60601, 60606, 60776, 61014	52127, 52134, 52141, 52331, 52347	47677, 47707, 47717, 47724
Fast-group flux equals zero.	61163, 61170, 61175, 61202, 61232	52516, 52523, 52530, 52535, 52565	47615, 47622
Fast-absorption term equals zero.	61214	52547	47762, 50006
Slow-absorption term equals zero.	61221, 61553, 61560	52554, 53106, 53113	47767, 50013
$(\Sigma_{a_1} + \Sigma_{s_1}) = 0$.	61242, 61541, 61546	52575, 53074, 53101	
$(\phi_1 + \phi_2) = 0$.	61257	52612	
$(H + 2S_z + 2d, 2d_1, 2d_2) = 0$, equations 129 through 137.	61314, 61365, 61447	52647, 52720, 53002	
$(D + 2S_r + 2d, 2d_1, 2d_2) = 0$, equations 129 through 134.	61402, 61464	52735, 53017	

	-1	0	1
$(R + 2S_s + 2d, 2d_1, 2d_2) = 0$, equations 129 through 131 and 138 through 140.	61417, 61504	52752, 53037	
Average buckling equals zero.	61512, 61524	53045, 53057	47750, 47755
Fast-group buckling equals zero.	61517	53052	47774
Slow-group buckling equals zero.	61531	53064	50001
$(1 + L_1^2 K^2) = 0$, or $(1 + L_1'^2 K_1^2) = 0$.	61606	53141	
$(1 + L_1^2 K^2)(1 + L_2^2 K^2) = 0$, or	61627	53162	
$(1 + L_1'^2 K_1^2)(1 + L_2'^2 K_2^2) = 0$.			

The following entries pertain to the photon production parameters calculation.

Element cannot be found on the Nuclear Data Tape.	62772	54325	51123
Natural logarithm error, equation number 177.	63042	54375	51173
Error in reading element from the Nuclear Data Tape.	63473	55026	51624
Group flux equals zero, equations 182 and 183.	63777, 64016, 64024, 64033, 64167, 64203	55332, 55351, 55357, 55366, 55522, 55536	52130, 52147, 52155, 52164, 52320, 52334

The following entries pertain to the fine-radial-power calculation.

Tape 6 reading error.	64564
Denominator of equation number 184 equals zero, possibly because weighting factors are all zero.	65020

The following entries pertain to the multigroup calculation of group constants and parameters.

Natural logarithm of equation number 151 cannot be calculated.	66156	56721	57565
Group flux equals zero, equations 154 through 156, 159, and 161.	67052, 67057, 67064, 67071, 67076	57615, 57622, 57627, 57634, 57641	60461, 60466, 60473, 60500, 60505
Group absorption term equals zero, equation number 158.	67107	57652	60516
Group $(\Sigma_s + \Sigma_a) = 0$, equations 160, 172, and 175.	67122, 67506, 67532	57665, 60251 60275	60531, 61115, 61141
Group flux equals zero, equation number 162.	67146	57711	60555
$(R + S_s + d) = 0$, equation number 170.	67202	57745	60611

	-1	0	1
Group $(R + S_s + d) = 0$, equation number 169.	67220	57763	60627
$(H + 2S_z + 2d) = 0$, equations 164, 166 and 168.	67260	60023	60667
$(D + 2S_r + 2d) = 0$, equations 164 and 166.	67300	60043	60707
$(R + 2S_s + 2d) = 0$, equation number 164.	67320	60063	60727
Group $(H + 2S_z + 2d) = 0$, equations 163, 165 and 167.	67342	60105	60751
Group $(D + 2S_r + 2d) = 0$, equations 163 and 165.	67362	60125	60771
Group $(R + 2S_s + 2d) = 0$, equation number 163.	67402	60145	61011
Total buckling equals zero, equation number 171.	67473	60236	61102
Group buckling equals zero, equation number 174.	67517	60262	61126
Denominator in equations 173 or 176 equals zero.	70051	60614	61460
Group factor term $k(1 - p)$ equals zero in equations 173 or 176.	70070	60633	61477

The following entries pertain to the absorber calculations in a control composition.

Channel diameter equals zero.	52712
Bessel function $I_0(\sigma)$ cannot be calculated, equation number 210.	52752
Bessel function $I_1(\sigma)$ cannot be calculated, equation number 210.	52757
Bessel function $K_0(\sigma)$ cannot be calculated, equation number 210.	52764
Bessel function $K_1(\sigma)$ cannot be calculated, equation number 210.	52771
$\sigma = 0$, equations 210 and 211.	53007, 53057
$(\Sigma_a + \Sigma_s) = 0$, equation number 208.	53045
Denominator of equation number 211 equals zero.	53074
Channel diameter equals zero.	53117
$(\Sigma_a + \Sigma_s) = 0$, equation number 212.	53145

	-1	0	1
Exponential integral $E_3(\sigma)$ cannot be calculated, equation number 215.			53155
Exponential integral $E_3(2\sigma)$ cannot be calculated, equations 214 and 215.			53164
$\sigma = 0$, equations 214 and 215.			53174, 53205
Denominator of equation number 216 equals zero.			53224
$\Sigma_s = 0$, equation number 217.			53266
Exponential integral $E_3(\sigma)$ cannot be calculated, equation number 219.			53301
Denominator of equation number 219 equals zero.			53325
$(1+t) = 0$, equations 220 and 221.			53425, 53440
Denominator of equations 220 and 221 equals zero.			53467, 53517
Group $(1+t) = 0$, equation number 223.			54226, 54234, 54250, 54255, 54302, 54310, 54323, 54330, 54357, 54365, 54401, 54406
Denominator of equation number 223 equals zero.			54271, 54447, 54507

4. The following list of octal post-mortem entries refers to the Program C_2 , F_2 input calculation of Program George. In the fourth line of the C_2 post-mortem C_{29} must be 2.

Tape 9 reading error.	42440
Reference composition for albedos cannot be found on tape 9.	43124
Reference composition for buckling cannot be found on tape 9.	43127
C_2 composition specified on F_2 composition input page cannot be found on tape 9.	43147
$(H + 2S_z + 2d) = 0$, equations 224, 230, and 233.	44155, 44277, 44530, 44602
$(H + 2S_z + 2d_1) = 0$, equations 225, 231, and 234.	44164, 44246, 44537, 44621
$(H + 2S_z + 2d_2) = 0$, equations 226, 232, and 235.	44171, 44263, 44544, 44636

$(D + 2S_r + 2d) = 0$, equations 224, 227, 44203, 44234,
and 236. 44556, 44607

$(D + 2S_r + 2d_1) = 0$, equations 225, 228, 44212, 44253,
and 237. 44565, 44626

$(D + 2S_r + 2d_2) = 0$, equations 226, 232, 44217, 44270,
and 238. 44643, 44572

5. The automatic post-mortem has not been programmed into the I_2 part of Program George. However, there are several program-diagnosed errors that are indicated by a printed comment describing them. After the printed comment the automatic post-mortem is executed by the master control routine of the C_2 program. The location given in index register 4 is simply the transfer of control by Program I_2 to Program C_2 and indicates only that there was an error somewhere in Program I_2 . In the fourth line of the C_2 post-mortem C_{29} must be -1.

The following phrases indicate Program I_2 malfunctions.

ERROR - BESSEL FUNCTION OF $x = \pm N$. NNNNNNN, $\pm NN$ CANNOT BE COMPUTED. This indicates that the argument of a normalized Bessel function has exceeded the limits of the subroutine.

TAPE ERROR. This indicates that there was a reading or writing error on logical tape unit number 6.

ERROR-SINGULAR MATRIX. This indicates that in the attempt to invert a matrix, it was found to be singular.

ERROR-SINGULAR SET OF EQUATIONS. This indicates that in the attempt to solve a set of equations, they were found to be singular.

ERROR IN ASSOCIATION OF MATERIAL WITH RADIUS. This indicates that a material was not given with a radius or that a material number was given for which there was no material.

ERROR-MODERATOR ZONE NOT SPECIFIED. This indicates that a zero source term was given for every zone.

ERROR-NONMODERATOR ZONE NOT SPECIFIED. This indicates that a nonzero source term was given for every zone.

ERROR IN MATERIAL INPUT. This indicates an argument less than zero in using the square-root subroutine. This can occur with zero absorption or very small absorption.

If a stop does occur during operation of Program George, a manual post-mortem can be executed by entering the instruction

+0 07400 4 00040

and pressing Start. Enough information should be given to enable the user to diagnose the error.

6. For the general version of Program George all post-mortem entries are identical except those located in the Program C_2 master control routine. Whenever an error occurs in the general version of the master control routine, 27 octal must be subtracted from the two's complement of index register 4 and then the post-mortem entries in group 2 will indicate the nature of the error. In addition, whenever an

entry states an error in the use of tape 4, this is taken to be tape 1 in the general version. To the entries in group 2 there should be added the octal location 17, which is indicative of a bad production tape 1 for the general version.

7. Whenever a data card error occurs in Program George, the comment TYPE--ERROR IN DATA CARD--COLUMN... is printed out. There are ten diagnosed data-card errors in the input package:

TYPE	0	End of File
	1	Control not in table
	2	End of card
	3	Absolute location character
	4	Scaling factor or word-count character
	5	Error in data character
	6	Scaling too far right
	7	Scaling too far left
	8	Location symbol not in table
	9	Tape check

In addition to the type of error being printed out, the position of the data card from the previous end-of-record signal along with the column number in which the error occurs, is printed out. If the error is type 0, 2, or 9, the column number will be meaningless.

Appendix A-

Computational Equations - Program C₂

LOGICAL DIVISION

Each Program George sequence can be divided into four logical operations.

1. Calculations which are required before operation on the element cross sections can begin.
2. Operation on element cross sections to form appropriate tables of material and composition cross sections for use in I₂ and C₂.
3. Completion of the I₂-C₂ sequence using various subroutines depending on the value of control words.

These first three operations are repeated until all compositions requested have been processed.

4. Completion of various F₂ cases as indicated by F₂ input data and using some data saved from the I₂-C₂ sequences. In an I₂-C₂-F₂ reactivity match, the combination of all four logical operations may be performed several times.

CALCULATIONS THAT MAY BE REQUIRED BEFORE OPERATION ON THE ELEMENT CROSS SECTIONS CAN BEGIN

$$(1) \quad D_s = D/\sqrt{m}$$

$$(2) \quad A(\omega) = 1 - \sum_{j=1}^J \beta_j \omega / (\omega + \omega_j)$$

$$(3) \quad S_n(\omega) = \frac{\sum_{j=1}^J \beta_j \omega S_{j,n} / (\omega + \omega_j)}{1 - \sum_{j=1}^J \beta_j \omega / (\omega + \omega_j)}$$

$$(4) \quad U_{t+1} = 16.118 - \ln \left\{ 1.0971 \times 10^{-4} \left[\frac{5}{9} (T_{\text{mod}} - 32) + 273.18 \right] \right\}$$

$$(5) \quad V_m = \pi L (r_{m0}^2 - r_{mt}^2)$$

$$(6) \quad V_c = \frac{\pi}{4} L (D_{c0}^2 - D_{ct}^2)$$

$$(7) \quad N = \omega / 2.2 \times 10^5$$

$$(8) \quad N = (\omega / 2.2 \times 10^5) \left(1 - \frac{D_2^2 - D_1^2}{D_3^2} \right)$$

$$(9) \quad N = [\omega / 2.2 \times 10^5] \left[1 - \left(1 - \frac{D_2^2 - D_1^2}{D_3^2} \right) \right]$$

OPERATION ON ELEMENT CROSS SECTIONS

$$(10) \quad W_m^i = \frac{N_m^i A^i V_m}{0.60247}$$

$$(11) \quad W_m^i = f_m^i \rho^i V_m$$

$$(12) \quad N_m^i = \frac{0.60247 W_m^i}{A^i V_m}$$

$$(13) \quad f_m^i = \frac{W_m^i}{\rho^i V_m}$$

$$(14) \quad r_{\text{cell}} = D_s/2$$

$$(15) \quad f_{h,\text{mod}}^i = \text{Sum } f_m^i [(r_o^2 - r_i^2)/r_{\text{cell}}^2] \text{ zone.}$$

zones containing
I as a moderator

$$(16) \quad f_{h,\text{fuel}}^i = \text{Sum } f_m^i [(r_o^2 - r_i^2)/r_{\text{cell}}^2] \text{ zone.}$$

zones containing
I as a fuel

$$(17) \quad N_{h,\text{mod}}^i = \text{Sum } N_m^i [(r_o^2 - r_i^2)/r_{\text{cell}}^2] \text{ zone.}$$

zones containing
I as a moderator

$$(18) \quad N_{h,\text{fuel}}^i = \text{Sum } N_m^i [(r_o^2 - r_i^2)/r_{\text{cell}}^2] \text{ zone.}$$

zones containing
I as a fuel

$$(19) \quad W_{\text{mod or fuel}}^i = f_{h,\text{mod or fuel}}^i \rho^i V_c$$

$$(20) \quad W_{\text{mod or fuel}}^i = \frac{N_{h,\text{mod or fuel}}^i A^i V_c}{0.60247}$$

$$(21) \quad f_{h,\text{mod or fuel}}^i = \frac{W_{\text{mod or fuel}}^i}{\rho^i V_c}$$

$$(22) \quad N_{h,\text{mod or fuel}}^i = \frac{0.60247 W_{\text{mod or fuel}}^i}{A^i V_c}$$

$$(23) \quad v \sigma_{f,n} = A(\omega) v \sigma_{f,n}$$

To simplify notation and avoid confusion between macroscopic tape cross sections (Σ^i) and macroscopic material and composition cross sections, the following convention will be used:

N^i or $N^i \sigma^i$ or σ^i will be used to include the meaning of f^i or $f^i \Sigma^i$ or Σ^i respectively when $\rho^i \neq 0$.

$$(24) \quad \Sigma_{x,n,h,\text{fuel}} = (N_h^i \sigma_{x,n}^i)_{\text{fuel}}$$

$$(25) \quad \Sigma_{x,n,h,\text{mod}} = (N_h^i \sigma_{x,n}^i)_{\text{mod}}$$

In equations (24) and (25)

Σ_x refers to $\Sigma_s, \Sigma_{tr}, \xi \Sigma_s, \Sigma_a$, and $\nu \Sigma_f$

σ_x refers to $\sigma_s, \sigma_{tr}, \xi \sigma_s, \sigma_a$, and $\nu \sigma_f$

$$(26) \quad \text{Calculate } \sigma_{t+1} \text{ by fourth-order Lagrangian interpolation in the thermal levels 68, 500, 1000, 1500, 2000, 2500, and 3000 using } u_{68}, u_{500}, u_{1000}, u_{1500}, u_{2000}, u_{2500}, \text{ and } u_{3000} \text{ with } u_{t+1} \text{ as the point.}$$

$$(27) \quad \text{Calculate } \sigma_t \text{ by third-order Lagrangian interpolation in the epithermal levels 18, 17, and 16 using } u_{18}, u_{17}, \text{ and } u_{16} \text{ with } u_{t+1} \text{ as the point.}$$

In equations (26) and (27)

σ refers to $\sigma_s, \sigma_{tr}, \xi \sigma_s, \sigma_a$, and $\nu \sigma_f$

COMPLETION OF THE I_2 - C_2 SEQUENCE

$$(28) \quad \Sigma_{a,m} = \text{Sum } N^i \sigma_a^i$$

$$(29) \quad \Sigma_{s0,m} = \text{Sum } N^i \sigma_s^i$$

$$(30) \quad \Sigma_{tr,m} = \text{Sum } N^i \sigma_{tr}^i$$

$$(31) \quad D_m = \frac{1}{3 (\Sigma_{tr,m} + \Sigma_{a,m})}$$

$$(32) \quad \Sigma_{s2,m} = \text{Sum } N^i \sigma_{s2}^i$$

$$(33) \quad \Sigma_{s1,m} = \Sigma_{s0,m} - \Sigma_{tr,m}$$

$$(34) \quad \Sigma_{a,m} = \Sigma_{a,m} + \frac{9.87 D_m}{(H + 2 S_z)^2}$$

$$(35) \quad \bar{\Phi}_{\text{cell}} = \frac{\text{Sum}_{\text{all zones}} \bar{\Phi}_{\text{zone}} (r_0^2 - r_i^2)_{\text{zone}}}{\text{Sum}_{\text{all zones}} (r_0^2 - r_i^2)_{\text{zone}}}$$

$$(36) \quad g_{\text{zone}} = \frac{\bar{\Phi}_{\text{zone}}}{\bar{\Phi}_{\text{cell}}}$$

$$(37) \quad \bar{\Phi}_{\text{mod}} = \frac{\text{Sum}_{\text{zones with } S=1} \bar{\Phi}_{\text{zone}} (r_0^2 - r_i^2)_{\text{zone}}}{\text{Sum}_{\text{zones with } S=1} (r_0^2 - r_i^2)_{\text{zone}}}$$

$$(38) \quad g_{\text{zone}} = \frac{\bar{\Phi}_{\text{zone}}}{\bar{\Phi}_{\text{mod}}}$$

$$(39) \quad (g^i)_{\text{fuel}} = \frac{\text{Sum} \begin{array}{c} \text{zones containing} \\ I \text{ as a fuel} \end{array} [g N^i (r_0^2 - r_i^2)]_{\text{zone}}}{N_{h,\text{fuel}}^i r_{\text{cell}}^2}$$

$$(40) \quad (g^i)_{\text{mod}} = \frac{\text{Sum} \begin{array}{c} \text{zones containing} \\ I \text{ as a moderator} \end{array} [g N^i (r_0^2 - r_i^2)]_{\text{zone}}}{N_{h,\text{mod}}^i r_{\text{cell}}^2}$$

$$(41) \quad l_{\text{fuel}} = D_2 - D_1$$

$$(42) \quad l_{\text{mod}} = \frac{D_3^2 - D_2^2 + D_1^2}{D_2 + D_1}$$

$$(43) \quad l_{\text{fuel}} = \frac{D_2^2 - D_1^2}{D_1}$$

$$(44) \quad l_{\text{mod}} = D_1$$

$$(45) \quad \Sigma_{a,n,\text{fuel}} = \left[\frac{D_3^2}{D_2^2 - D_1^2} \right] \Sigma_{a,n,h,\text{fuel}}$$

$$(46) \quad \Sigma_{a,n,\text{mod}} = \left[\frac{D_3^2}{D_3^2 - D_2^2 + D_1^2} \right] \Sigma_{a,n,h,\text{mod}}$$

$$(47) \quad \Sigma_{s,n,\text{mod}} = \left[\frac{D_3^2}{D_3^2 - D_2^2 + D_1^2} \right] \Sigma_{s,n,h,\text{mod}}$$

$$(48) \quad \Sigma_{a,n,\text{fuel}} = \left[\frac{D_3^2}{D_2^2 - D_1^2} \right] \text{Sum } N_{h,\text{fuel}}^i \sigma_{a,n}^i$$

$$(49) \quad \Sigma_{a,n,\text{mod}} = \left[\frac{D_3^2}{D_3^2 - D_2^2 + D_1^2} \right] \text{Sum } N_{h,\text{mod}}^i \sigma_{a,n}^i$$

$$(50) \quad \Sigma_{s,n,\text{mod}} = \left[\frac{D_3^2}{D_3^2 - D_2^2 + D_1^2} \right] \text{Sum } N_{h,\text{mod}}^i \sigma_{s,n}^i$$

$$(51) \quad \Sigma_{a,n,\text{fuel}} = \left[\frac{D_3^2}{D_2^2 - D_1^2} \right] \text{Sum } N_{h,\text{fuel}}^i (g_{\text{fuel}}^i \sigma_a^i)_n$$

$$(52) \quad \Sigma_{a,n,\text{mod}} = \left[\frac{D_3^2}{D_3^2 - D_2^2 + D_1^2} \right] \text{Sum } N_{h,\text{mod}}^i (g_{\text{mod}}^i \sigma_a^i)_n$$

$$(53) \quad \Sigma_{s,n,\text{mod}} = \left[\frac{D_3^2}{D_3^2 - D_2^2 + D_1^2} \right] \text{Sum } N_{h,\text{mod}}^i (g_{\text{mod}}^i \sigma_s^i)_n$$

$$(54) \quad \Sigma_{s,n,\text{mod}} = \left[\frac{D_3^2}{D_3^2 - D_2^2 + D_1^2} \right] \text{Sum } N_{h,\text{mod}}^i \sigma_{s,n}^i$$

$$(55) \quad x_n = l_{\text{fuel}} \Sigma_{a,n,\text{fuel}}$$

$$(56) \quad y_n = l_{\text{mod}} \Sigma_{s,n,\text{mod}}$$

$$(57) \quad y_n = l_{\text{mod}} (\Sigma_{s,n,\text{mod}} + \Sigma_{a,n,\text{mod}})$$

$$(58) \quad f_{r,n} = f_{z,n} = \left[\frac{D_3^2 - D_2^2 + D_1^2}{D_3^2} \right]^2 e^{-x_n} \left[1 + \frac{2(D_2^2 - D_1^2)}{(D_3^2 - D_2^2 + D_1^2)} + \left(\frac{D_2^2 - D_1^2}{D_3^2 - D_2^2 + D_1^2} \right)^2 \left(\frac{y_n}{e^{y_n} - 1} + \frac{2}{3} y_n \right) \right]$$

$$(59) \quad f_{r,n} = 1 + \left[\left(\frac{D_2^2 - D_1^2}{D_3^2} \right)^2 e^{-x_n} \left(\frac{y_n}{e^{y_n} - 1} + \frac{1}{2} y_n - 1 \right) \right]$$

$$(60) \quad f_{z,n} = 1 + \left[\left(\frac{D_2^2 - D_1^2}{D_3^2} \right)^2 e^{-x_n} \left(\frac{y_n}{e^{y_n} - 1} + y_n - 1 \right) \right]$$

$$(61) \quad \Sigma_{x,n,h} = \Sigma_{x,n,h,\text{fuel}} + \Sigma_{x,n,h,\text{mod}}$$

In equation (61)

Σ_x refers to Σ_s , Σ_{tr} , $\xi \Sigma_s$, Σ_a , and $\nu \Sigma_f$

$$(62) \quad \Sigma_{x,n,h} = \text{Sum } N_{h,\text{fuel}}^i (g_{\text{fuel}}^i \sigma_x^i)_n + \text{Sum } N_{h,\text{mod}}^i (g_{\text{mod}}^i \sigma_x^i)_n$$

In equation (62)

σ_x^i refers to σ_a^i and $\nu \sigma_f^i$ and

Σ_x^i refers to Σ_a^i and $\nu \Sigma_f^i$.

$$(63) \quad \Sigma_{x,n,h} = \text{Sum } N_{h,\text{fuel}}^i (g_{\text{fuel}}^i \sigma_x^i)_n + \text{Sum } N_{h,\text{mod}}^i (g_{\text{mod}}^i \sigma_x^i)_n$$

In equation (63)

σ_x^i refers to σ_s^i , σ_{tr}^i , and $\xi \sigma_s^i$ and

Σ_x^i refers to Σ_s^i , Σ_{tr}^i , and $\xi \Sigma_s^i$.

$$(64) \quad \Sigma_{x,n,h} = \text{Sum } N_{h,\text{fuel}}^i \sigma_x^i + \text{Sum } N_{h,\text{mod}}^i \sigma_x^i$$

In equation (64)

σ_x^i refers to σ_s^i , σ_{tr}^i , and $\xi \sigma_s^i$ and

Σ_x^i refers to Σ_s^i , Σ_{tr}^i , and $\xi \Sigma_s^i$

$$(65) \quad d_n = \frac{.7105}{(\Sigma_a + \Sigma_{tr})_n}$$

$$(66) \quad (K_x^2)_n = \frac{9.87}{(H + 2S_z + 2d_n)^2}$$

$$(67) \quad (K_y^2)_n = \frac{9.87}{(D + 2S_r + 2d_n)^2}$$

$$(68) \quad (K_z^2)_n = \frac{9.87}{(R + 2S_s + 2d_n)^2}$$

$$(69) \quad (K^2)_n = (K_x^2)_n + (K_y^2)_n + (K_z^2)_n$$

$$(70) \quad (K_r^2)_n = \frac{23.13}{(D + 2S_r + 2d_n)^2}$$

$$(71) \quad (K_z^2)_n = \frac{9.87}{(H + 2S_z + 2d_n)^2}$$

$$(72) \quad (K^2)_n = (K_r^2)_n + (K_z^2)_n$$

$$(73) \quad (K_s^2)_n = \frac{9.87}{(R + S_s + d_n)^2}$$

$$(74) \quad (K^2)_n = (K_s^2)_n$$

$$(75) \quad \alpha_n^2 = \frac{(K^2)_n}{(\Sigma_a + \Sigma_s)_n}$$

$$(76) \quad \epsilon_n = A \alpha_n^2 + B \alpha_n^4 + C \alpha_n^6$$

In equation (76)

$$A = 0.26001$$

$$B = -0.043502$$

$$C = 0.0048942$$

$$(77) \quad \Sigma_{l,n} = \frac{(K^2)_n}{3(\Sigma_a + \Sigma_{tr} + \epsilon \Sigma_a + \epsilon \Sigma_s)_n}$$

$$(78) \quad \Sigma_{l,r,n} = \frac{(f_r K_r^2)_n}{3(\Sigma_a + \Sigma_{tr} + \epsilon \Sigma_a + \epsilon \Sigma_s)_n}$$

$$(79) \quad \Sigma_{l,z,n} = \frac{(f_z K_z^2)_n}{3(\Sigma_a + \Sigma_{tr} + \epsilon \Sigma_a + \epsilon \Sigma_s)_n}$$

$$(80) \quad \Sigma_{l,n} = \Sigma_{l,r,n} + \Sigma_{l,z,n}$$

$$(81) \quad \Sigma_{l,n} = \frac{(K^2)_n}{3(\Sigma_a + \Sigma_{tr} + \epsilon \Sigma_a + \epsilon \Sigma_s)_n}$$

$$(82) \quad \Sigma_{l,n} = \frac{(K_z^2)_n}{3(\Sigma_a + \Sigma_{tr})_n}$$

$$(83) \quad \Sigma_{l,n} = \frac{10^{-20}}{3(\Sigma_a + \Sigma_{tr})_n}$$

$$(84) \quad U_t = u_{t+1} - 17.5.$$

$$(85) \quad U_t = u_{t+1} - 18.5$$

$$(86) \quad v_n = \frac{\xi \Sigma_{s,n}}{(\xi \Sigma_s + \Sigma_a + \Sigma_l)_n}$$

$$(87) \quad w_n = 1 - v_n = \frac{(\Sigma_a + \Sigma_l)_n}{(\xi \Sigma_s + \Sigma_a + \Sigma_l)_n}$$

$$(88) \quad q_n = \frac{\left(\frac{2}{U_n} - w_{n-1} \right) q_{n-1} + v_n S_n(\omega) + v_{n-1} S_{n-1}(\omega)}{\frac{2}{U_n} + w_n}$$

$$(89) \quad \varphi_n = \frac{q_n + S_n(\omega)}{(\xi \Sigma_s + \Sigma_a + \Sigma_l)_n}$$

$$(90) \quad v_n = \frac{\Sigma_{s,n}}{(\Sigma_s + \Sigma_a + \Sigma_l)_n}$$

$$(91) \quad w_n = \left[\frac{\Sigma_{s,n}}{(\xi \Sigma_s)_n} \right] \frac{(\Sigma_a + \Sigma_l)_n}{(\Sigma_s + \Sigma_a + \Sigma_l)_n}$$

$$(92) \quad \varphi_n = \frac{\left[\frac{\Sigma_{s,n}}{(\xi \Sigma_s)_n} \right] q_n + S_n(\omega)}{(\Sigma_s + \Sigma_a + \Sigma_l)_n}$$

$$(93) \quad v_n = 1 - w_n$$

$$(94) \quad w_n = \left[\frac{\Sigma_{s,n}}{(\xi \Sigma_s)_n} \right] \frac{(\Sigma_a + \Sigma_l)_n}{(\Sigma_s + \Sigma_a + \Sigma_l)_n}$$

$$(95) \quad \varphi_n = \left[\frac{\Sigma_{s,n}}{(\xi \Sigma_s)_n} \right] \frac{[q_n + S_n(\omega)]}{(\Sigma_s + \Sigma_a + \Sigma_l)_n}$$

$$(96) \quad v_n = 1$$

$$(97) \quad w_n = \left[\frac{\Sigma_{s,n}}{(\xi \Sigma_s)_n} \right] \frac{(\Sigma_a + \Sigma_l)_n}{(\Sigma_s + \Sigma_a)_n}$$

$$(98) \quad \varphi_n = \left[\frac{\Sigma_{s,n}}{(\xi \Sigma_s)_n} \right] \frac{q_n}{(\Sigma_s + \Sigma_a)_n}$$

$$(99) \quad v_n = 1$$

$$(100) \quad w_n = \frac{(\Sigma_a + \Sigma_l)_n}{(\xi \Sigma_s)_n}$$

$$(101) \quad \varphi_n = \frac{q_n}{(\xi \Sigma_s)_n}$$

$$(102) \quad \varphi_{t+1} = \frac{q_t}{(\Sigma_a + \Sigma_l)_{t+1}}$$

$$(103) \quad A_n = \Sigma_{a,n} \varphi_n$$

$$(104) \quad L_n = \Sigma_{l,n} \varphi_n$$

$$(105) \quad F_n = v \Sigma_{f,n} \varphi_n$$

$$(106) \quad \text{Balance check discrepancy} = \left| \sum_{n=1}^t (A_n + A_{n-1} + L_n + L_{n-1}) \frac{U_n}{2} + A_{t+1} L_{t+1} - 1 \right| < 10^{-4}$$

$$(107) \quad k = \sum_{n=1}^t (F_n + F_{n-1}) \frac{U_n}{2} + F_{t+1}$$

$$(108) \quad P_{t+1} = \frac{F_{t+1}}{k}$$

$$(109) \quad P_t = \frac{(F_t + F_{10})}{k} \frac{U_t}{2}$$

$$(110) P_t = \frac{(F_t + F_{17})}{k} \frac{U_t}{2}$$

$$(111) P_{17} = \frac{(F_{17} + F_{18})}{k} \frac{U_{17}}{2}$$

$$(112) P_N = \sum_{n=1}^N \frac{(F_n + F_{n-1})}{k} \frac{U_n}{2}$$

such that N is the first level for which $P_N \geq 1/2$, if such an N exists. If

$$(113) P_t = \sum_{n=1}^t \frac{(F_n + F_{n-1})}{k} \frac{U_n}{2} < 1/2, \text{ set } N = t.$$

$$(114) \varphi_1 = \sum_{n=1}^N (\varphi_n + \varphi_{n-1}) \frac{U_n}{2}$$

$$(115) \varphi_2 = \sum_{n=N+1}^t (\varphi_n + \varphi_{n-1}) \frac{U_n}{2} + \varphi_{t+1}$$

$$(116) \Sigma_{a_1} = \frac{1}{\varphi_1} \sum_{n=1}^N (A_n + A_{n-1}) \frac{U_n}{2}$$

$$(117) \Sigma_{a_2} = \frac{1}{\varphi_2} \left[\sum_{n=N+1}^t (A_n + A_{n-1}) \frac{U_n}{2} + A_{t+1} \right]$$

$$(118) {}^v\Sigma_{f_1} = \frac{1}{\varphi_1} \sum_{n=1}^{\bar{N}} (F_n + F_{n-1}) \frac{U_n}{2}$$

$$(119) {}^v\Sigma_{f_2} = \frac{1}{\varphi_2} \left[\sum_{n=N+1}^t (F_n + F_{n-1}) \frac{U_n}{2} + F_{t+1} \right]$$

$$(120) \Sigma_{l_1} = \frac{1}{\varphi_1} \sum_{n=1}^N (L_n + L_{n-1}) \frac{U_n}{2}$$

$$(121) \Sigma_{l_2} = \frac{1}{\varphi_2} \left[\sum_{n=N+1}^t (L_n + L_{n-1}) \frac{U_n}{2} + L_{t+1} \right]$$

$$(122) k_1 = \frac{{}^v\Sigma_{f_1}}{\Sigma_{a_1}}$$

$$(123) k_2 = \frac{{}^v\Sigma_{f_2}}{\Sigma_{a_2}}$$

$$(124) \Sigma_{s_1} = \frac{q_N}{\varphi_1}$$

$$(125) p = \frac{\Sigma_{s_1}}{\Sigma_{s_1} + \Sigma_{a_1}}$$

$$(126) d_1 = \frac{1}{\varphi_1} \sum_{n=1}^N (d_n \varphi_n + d_{n-1} \varphi_{n-1}) \frac{U_n}{2}$$

$$(127) d_2 = \frac{1}{\varphi_2} \left[\sum_{n=N+1}^t (d_n \varphi_n + d_{n-1} \varphi_{n-1}) \frac{U_n}{2} + d_{t+1} \varphi_{t+1} \right]$$

$$(128) d = \frac{d_1 \varphi_1 + d_2 \varphi_2}{\varphi_1 + \varphi_2}$$

$$(129) K_1^2 = \frac{9.87}{(H + 2S_z + 2d_1)^2} + \frac{9.87}{(D + 2S_r + 2d_1)^2} + \frac{9.87}{(R + 2S_s + 2d_1)^2}$$

$$(130) K_2^2 = \frac{9.87}{(H + 2S_z + 2d_2)^2} + \frac{9.87}{(D + 2S_r + 2d_2)^2} + \frac{9.87}{(R + 2S_s + 2d_2)^2}$$

$$(131) K^2 = \frac{9.87}{(H + 2S_z + 2d)^2} + \frac{9.87}{(D + 2S_r + 2d)^2} + \frac{9.87}{(R + 2S_s + 2d)^2}$$

$$(132) K_1^2 = \frac{9.87}{(H + 2S_z + 2d_1)^2} + \frac{23.13}{(D + 2S_r + 2d_1)^2}$$

$$(133) K_2^2 = \frac{9.87}{(H + 2S_z + 2d_2)^2} + \frac{23.13}{(D + 2S_r + 2d_2)^2}$$

$$(134) K^2 = \frac{9.87}{(H + 2S_z + 2d)^2} + \frac{23.13}{(D + 2S_r + 2d)^2}$$

$$(135) K_1^2 = \frac{9.87}{(H + 2S_z + 2d_1)^2}$$

$$(136) K_2^2 = \frac{9.87}{(H + 2S_z + 2d_2)^2}$$

$$(137) K^2 = \frac{9.87}{(H + 2S_z + 2d)^2}$$

$$(138) K_1^2 = \frac{9.87}{(R + S_s + d_1)^2}$$

$$(139) K_2^2 = \frac{9.87}{(R + S_s + d_2)^2}$$

$$(140) K^2 = \frac{9.87}{(R + S_s + d)^2}$$

$$(141) D_1 = \frac{\Sigma l_1}{K^2}$$

$$(142) D_2 = \frac{\Sigma l_1}{K^2}$$

$$(143) L_1^2 = \frac{D_1}{\Sigma a_1 + \Sigma s_1}$$

$$(144) L_2^2 = \frac{D_2}{\Sigma a_2}$$

$$(145) k = \frac{(1-p)k_1}{1 + L_1^2 K^2} + \frac{p k_2}{(1 + L_1^2 K^2)(1 + L_2^2 K^2)}$$

$$(146) D_1' = \frac{\Sigma l_1}{K_1^2}$$

$$(147) D_2' = \frac{\Sigma l_2}{K_2^2}$$

$$(148) L_1^{2'} = \frac{D_1'}{\Sigma a_1 + \Sigma s_1}$$

$$(149) L_2^{2'} = \frac{D_2'}{\Sigma a_2}$$

$$(150) k' = \frac{(1-p)k_1'}{(1 + L_1^{2'} K_1^2)} + \frac{p k_2}{(1 + L_1^{2'} K_1^2)(1 + L_2^{2'} K_2^2)}$$

$$(151) u_I = 16.118 - \ln E_I$$

$$u_{II} = 16.118 - \ln E_{II}$$

$$u_{\bar{N}} = 16.118 - \ln E_{\bar{N}}$$

$$(152) \quad q_I, q_{II}, \dots, q_{\bar{N}}$$

$$\varphi_I, \varphi_{II}, \dots, \varphi_{\bar{N}}$$

$$A_I, A_{II}, \dots, A_{\bar{N}}$$

$$F_I, F_{II}, \dots, F_{\bar{N}}$$

$$L_I, L_{II}, \dots, L_{\bar{N}}$$

$$d_I, d_{II}, \dots, d_{\bar{N}}$$

$$S_I, S_{II}, \dots, S_{\bar{N}}$$

where the Roman numerals indicate interpolated values corresponding to the multigroup lethargies computed in equation (151)

$$(153) \quad \varphi_1 = \sum_{n=1}^I (\varphi_n + \varphi_{n-1}) \frac{U_n}{2},$$

$$\varphi_2 = \sum_{n=I+1}^{II} (\varphi_n + \varphi_{n-1}) \frac{U_n}{2},$$

$$\varphi_{N+1} = \sum_{n=\bar{N}+1}^t (\varphi_n + \varphi_{n-1}) \frac{U_n}{2} + \varphi_{t+1}$$

$$(154) \quad \Sigma_{a_1} = \frac{1}{\varphi_1} \sum_{n=1}^I (A_n + A_{n-1}) \frac{U_n}{2},$$

$$\Sigma_{a_2} = \frac{1}{\varphi_2} \sum_{n=I+1}^{II} (A_n + A_{n-1}) \frac{U_n}{2},$$

$$\Sigma_{a_{N+1}} = \frac{1}{\varphi_{N+1}} \left[\sum_{n=\bar{N}+1}^t (A_n + A_{n-1}) \frac{U_n}{2} + A_{t+1} \right]$$

$$(155) \quad {}^v\Sigma_{f_1} = \frac{1}{\varphi_1} \sum_{n=1}^I (F_n + F_{n-1}) \frac{U_n}{2},$$

$${}^v\Sigma_{f_2} = \frac{1}{\varphi_2} \sum_{n=I+1}^{II} (F_n + F_{n-1}) \frac{U_n}{2},$$

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$${}^v\Sigma_{f_{N+1}} = \frac{1}{\varphi_{N+1}} \left[\sum_{n=\bar{N}+1}^t (F_n + F_{n-1}) \frac{U_n}{2} + F_{t+1} \right]$$

$$(156) \quad \Sigma_{l_1} = \frac{1}{\varphi_1} \sum_{n=1}^I (L_n + L_{n-1}) \frac{U_n}{2},$$

$$\Sigma_{l_2} = \frac{1}{\varphi_2} \sum_{n=I+1}^{II} (L_n + L_{n-1}) \frac{U_n}{2},$$

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$$\Sigma_{l_{N+1}} = \frac{1}{\varphi_{N+1}} \left[\sum_{n=\bar{N}+1}^t (L_n + L_{n-1}) \frac{U_n}{2} + L_{t+1} \right]$$

$$(157) \quad S_1 = \sum_{n=1}^I (S_n + S_{n-1}) \frac{U_n}{2},$$

$$S_2 = \sum_{n=I+1}^{II} (S_n + S_{n-1}) \frac{U_n}{2},$$

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$$S_{N+1} = \sum_{n=\bar{N}+1}^t (S_n + S_{n-1}) \frac{U_n}{2} + S_{t+1}$$

$$(158) \quad k_1 = \frac{{}^v\Sigma_{f_1}}{\Sigma_{a_1}}, \quad k_2 = \frac{{}^v\Sigma_{f_2}}{\Sigma_{a_2}}, \quad \dots \quad k_{N+1} = \frac{{}^v\Sigma_{f_{N+1}}}{\Sigma_{a_{N+1}}}$$

$$(159) \quad \Sigma_{s_1} = \frac{q_I}{\Phi_1}, \quad \Sigma_{s_2} = \frac{q_{II}}{\Phi_2}, \quad \dots \quad \Sigma_{s_n} = \frac{q_N}{\Phi_N}$$

$$(160) \quad p_1 = \frac{\Sigma_{s_1}}{\Sigma_{s_1} + \Sigma_{a_1}}, \quad p_2 = \frac{\Sigma_{s_2}}{\Sigma_{s_2} + \Sigma_{a_2}}, \quad \dots \quad p_n = \frac{\Sigma_{s_n}}{\Sigma_{s_n} + \Sigma_{a_n}}$$

$$(161) \quad d_1 = \frac{1}{\Phi_1} \sum_{n=1}^I (d_n \varphi_n + d_{n-1} \varphi_{n-1}) \frac{U_n}{2},$$

$$d_2 = \frac{1}{\Phi_2} \sum_{n=I+1}^{II} (d_n \varphi_n + d_{n-1} \varphi_{n-1}) \frac{U_n}{2},$$

$$d_{N+1} = \frac{1}{\Phi_{N+1}} \left[\sum_{n=N+1}^t (d_n \varphi_n + d_{n-1} \varphi_{n-1}) + d_{t+1} \varphi_{t+1} \right],$$

$$(162) \quad d = \frac{d_1 \varphi_1 + d_2 \varphi_2 + \dots + d_{N+1} \varphi_{N+1}}{\varphi_1 + \varphi_2 + \dots + \varphi_{N+1}}.$$

$$(163) \quad K_1^2 = \frac{9.87}{(H + 2S_z + 2d_1)^2} + \frac{9.87}{(D + 2S_r + 2d_1)^2} + \frac{9.87}{(R + 2S_s + 2d_1)^2}$$

$$K_2^2 = \frac{9.87}{(H + 2S_z + 2d_2)^2} + \frac{9.87}{(D + 2S_r + 2d_2)^2} + \frac{9.87}{(R + 2S_s + 2d_2)^2}$$

$$K_{N+1}^2 = \frac{9.87}{(H + 2S_z + 2d_{N+1})^2} + \frac{9.87}{(D + 2S_r + 2d_{N+1})^2} + \frac{9.87}{(R + 2S_s + 2d_{N+1})^2}$$

$$(164) \quad K^2 = \frac{9.87}{(H + 2S_z + 2d)^2} + \frac{9.87}{(D + 2S_r + 2d)^2} + \frac{9.87}{(R + 2S_s + 2d)^2}$$

$$(165) K_1^2 = \frac{9.87}{(H+2S_z+2d_1)^2} + \frac{23.13}{(D+2S_r+2d_1)^2}$$

$$K_2^2 = \frac{9.87}{(H+2S_z+2d_2)^2} + \frac{23.13}{(D+2S_r+2d_2)^2}$$

$$K_{N+1}^2 = \frac{9.87}{(H+2S_z+2d_{N+1})^2} + \frac{23.13}{(D+2S_r+2d_{N+1})^2}$$

$$(166) K^2 = \frac{9.87}{(H+2S_z+2d)^2} + \frac{23.13}{(D+2S_r+2d)^2}$$

$$(167) K_1^2 = \frac{9.87}{(H+2S_z+2d_1)^2}$$

$$K_2^2 = \frac{9.87}{(H+2S_z+2d_2)^2}$$

$$K_{N+1}^2 = \frac{9.87}{(H+2S_z+2d_{N+1})^2}$$

$$(168) K^2 = \frac{9.87}{(H+2S_z+2d)^2}$$

$$(169) K_1^2 = \frac{9.87}{(R+S_s+d_1)^2}$$

$$K_2^2 = \frac{9.87}{(R+S_s+d_2)^2}$$

$$K_{N+1}^2 = \frac{9.87}{(R+S_s+d_{N+1})^2}$$

$$(170) K^2 = \frac{9.87}{(R+S_s+d)^2}$$

$$(171) D_1 = \frac{\Sigma l_1}{K^2}; \quad D_2 = \frac{\Sigma l_2}{K^2}; \quad \dots \quad D_{N+1} = \frac{\Sigma l_{N+1}}{K^2}$$

$$(172) L_1^2 = \frac{D_1}{\Sigma a_1 + \Sigma s_1}; \quad L_2^2 = \frac{D_2}{\Sigma a_2 + \Sigma s_2}; \quad \dots \quad L_{N+1}^2 = \frac{D_{N+1}}{\Sigma a_{N+1}}$$

$$(173) k = S_1 \left[\frac{k_1(1-p_1)}{1+L_1^2 K^2} + \frac{k_2 p_1(1-p_2)}{(1+L_1^2 K^2)(1+L_2^2 K^2)} \right. \\ \left. + \dots \frac{p_1 p_2 \dots p_N k_{N+1}}{(1+L_1^2 K^2)(1+L_2^2 K^2) \dots (1+L_{N+1}^2 K^2)} \right] \\ + S_2 \left[\frac{k_1(1-p_2)}{1+L_2^2 K^2} + \dots \frac{p_2 \dots p_N k_{N+1}}{(1+L_2^2 K^2) \dots (1+L_{N+1}^2 K^2)} \right] \\ + S_N \left[\frac{k_N(1-p_N)}{1+L_N^2 K^2} + \frac{p_N k_{N+1}}{(1+L_N^2 K^2)(1+L_{N+1}^2 K^2)} \right] \\ + S_{N+1} \left[\frac{k_{N+1}}{1+L_{N+1}^2 K^2} \right]$$

$$(174) D'_1 = \frac{\Sigma l_1}{K_1^2}; \quad D'_2 = \frac{\Sigma l_2}{K_2^2}; \quad \dots \quad D'_{N+1} = \frac{\Sigma l_{N+1}}{K_{N+1}^2}$$

$$(175) L_1'^2 = \frac{D'_1}{\Sigma a_1 + \Sigma s_1}; \quad L_2'^2 = \frac{D'_2}{\Sigma a_2 + \Sigma s_2}; \quad \dots \quad L_{N+1}'^2 = \frac{D'_{N+1}}{\Sigma a_{N+1}}$$

$$(176) k' = S_1 \left[\frac{k_1(1-p_1)}{1+L_1'^2 K_1^2} + \frac{k_2 p_1(1-p_2)}{(1+L_1'^2 K_1^2)(1+L_2'^2 K_2^2)} \right. \\ \left. + \dots \frac{p_1 p_2 \dots p_N k_{N+1}}{(1+L_1'^2 K_1^2)(1+L_2'^2 K_2^2) \dots (1+L_{N+1}'^2 K_{N+1}^2)} \right] \\ + S_2 \left[\frac{k_2(1-p_2)}{1+L_2'^2 K_2^2} + \dots \frac{p_2 \dots p_N k_{N+1}}{(1+L_2'^2 K_2^2) \dots (1+L_{N+1}'^2 K_{N+1}^2)} \right] \\ + S_N \left[\frac{k_N(1-p_N)}{1+L_N'^2 K_N^2} + \frac{p_N k_{N+1}}{(1+L_N'^2 K_N^2)(1+L_{N+1}'^2 K_{N+1}^2)} \right] \\ + S_{N+1} \left[\frac{k_{N+1}}{1+L_{N+1}'^2 K_{N+1}^2} \right]$$

$$(177) u_I = 16.118 - Ln E_I$$

$$u_{II} = 16.118 - Ln E_{II}$$

$$u_{\bar{P}} = 16.118 - Ln E_{\bar{P}}$$

$$(178) \Sigma_{a,n}^i = \left[(g_n^i N_h^i)_{\text{fuel}} + (g_n^i N_h^i)_{\text{mod}} \right] \sigma_{a,n}^i$$

$$(179) v \Sigma_{f,n}^i = \left[(g_n^i N_h^i)_{\text{fuel}} + (g_n^i N_h^i)_{\text{mod}} \right] A(\omega) v \sigma_{f,n}^i$$

$$(180) \Sigma_{a,I}^i, \Sigma_{a,II}^i, \dots, \Sigma_{a,\bar{P}}^i$$

$$v \Sigma_{f,I}^i, v \Sigma_{f,II}^i, \dots, v \Sigma_{f,\bar{P}}^i$$

$$\Phi_I, \Phi_{II}, \dots, \Phi_{\bar{P}}$$

where the Roman numerals indicate interpolated values corresponding to the group lethargies computed in equation (177)

$$(181) \Phi_1 = \sum_{n=1}^I (\Phi_n + \Phi_{n-1}) \frac{U_n}{2}$$

$$\Phi_2 = \sum_{n=I+1}^{II} (\Phi_n + \Phi_{n-1}) \frac{U_n}{2}$$

$$\Phi_{P+1} = \sum_{n=I+1}^t (\Phi_n + \Phi_{n-1}) \frac{U_n}{2} + \Phi_{t+1}$$

$$(182) \Sigma_{a,1}^i = \frac{1}{\Phi_1} \sum_{n=1}^I (\Sigma_{a,n}^i \Phi_n + \Sigma_{a,n-1}^i \Phi_{n-1}) \frac{U_n}{2}$$

$$\Sigma_{a,2}^i = \frac{1}{\Phi_2} \sum_{n=I+1}^{II} (\Sigma_{a,n}^i \Phi_n + \Sigma_{a,n-1}^i \Phi_{n-1}) \frac{U_n}{2}$$

$$\Sigma_{a,P+1}^i = \frac{1}{\Phi_{P+1}} \left[\sum_{n=\bar{P}+1}^t (\Sigma_{a,n}^i \Phi_n + \Sigma_{a,n-1}^i \Phi_{n-1}) \frac{U_n}{2} + \Sigma_{a,t+1}^i \Phi_{t+1} \right]$$

$$(183) \Sigma_{f,1}^i = \frac{1}{2.46 \varphi_1} \text{SUM}_{n=1}^I (\nu \Sigma_{f,n}^i \varphi_n + \nu \Sigma_{f,n-1}^i \varphi_{n-1}) \frac{U_n}{2}$$

$$\Sigma_{f,2}^i = \frac{1}{2.46 \varphi_2} \text{SUM}_{n=I+1}^{II} (\nu \Sigma_{f,n}^i \varphi_n + \nu \Sigma_{f,n-1}^i \varphi_{n-1}) \frac{U_n}{2}$$

$$\Sigma_{f,P+1}^i = \frac{1}{2.46 \varphi_{P+1}} \left[\text{SUM}_{n=\bar{P}+1}^t (\nu \Sigma_{f,n}^i \varphi_n + \nu \Sigma_{f,n-1}^i \varphi_{n-1}) \frac{U_n}{2} + \nu \Sigma_{f,t+1}^i \varphi_{t+1} \right]$$

$$(184) \varphi_r' = \frac{(\varphi_r)_{\text{zone}} (f)_{\text{zone}} \text{SUM} (r_0^2 - r_i^2)_{\text{zone}}}{\text{SUM} (\bar{\varphi})_{\text{zone}} (f)_{\text{zone}} (r_0^2 - r_i^2)_{\text{zone}}}$$

$$(185) P(r) = P_{t+1} \varphi'(r)_{t+1} + P_t \left[\frac{\varphi'(r)_{t+1} + \varphi'(r)_{17}}{2} \right] + P_{17} \left[\frac{\varphi'(r)_{17} + \varphi'(r)_{1e}}{2} \right] \\ + \left[1 - P_{t+1} - P_t - P_{17} \right]$$

$$(186) P(r) = P_{t+1} \varphi'(r)_{t+1} + P_t \left[\frac{\varphi'(r)_{t+1} + \varphi'(r)_{1e}}{2} \right] + \left[1 - P_{t+1} - P_t \right]$$

The following equations pertain only to control composition calculations.

$$(187) A_n = \Sigma_{a,n} \varphi_n$$

$$(188) L_n = \Sigma_{l,n} \varphi_n$$

$$(189) \Sigma_{a_1} = \frac{1}{\varphi_1} \text{SUM}_{n=1}^N (A_n + A_{n-1}) \frac{U_n}{2}$$

$$(190) \Sigma_{a_2} = \frac{1}{\varphi_2} \left[\text{SUM}_{n=N+1}^t (A_n + A_{n-1}) \frac{U_n}{2} + A_{t+1} \right]$$

$$(191) \Sigma_{l_1} = \frac{1}{\varphi_1} \text{SUM}_{n=1}^N (L_n + L_{n-1}) \frac{U_n}{2}$$

$$(192) \Sigma_{l_2} = \frac{1}{\varphi_2} \left[\text{SUM}_{n=N+1}^t (L_n + L_{n-1}) \frac{U_n}{2} + L_{t+1} \right]$$

$$(193) D_1 = \frac{\Sigma_{l_1}}{K^2}$$

$$(194) D_2 = \frac{\Sigma l_2}{K^2}$$

$$(195) L_1^2 = \frac{D_1}{\Sigma a_1}$$

$$(196) L_2^2 = \frac{D_2}{\Sigma a_2}$$

$$(197) D_1' = \frac{\Sigma l_1}{K_1^2}$$

$$(198) D_2' = \frac{\Sigma l_2}{K_2^2}$$

$$(199) L_1^{2'} = \frac{D_1'}{\Sigma a_1}$$

$$(200) L_2^{2'} = \frac{D_2'}{\Sigma a_2}$$

$$(201) \begin{array}{ll} A_I, A_{II}, \dots & A_{\bar{N}} \\ L_I, L_{II}, \dots & L_{\bar{N}} \end{array}$$

where the Roman numerals indicate interpolated values corresponding to the group lethargies computed in equation (151).

$$(202) \Sigma_{a_1} = \frac{1}{\Phi_1} \sum_{n=1}^I (A_n + A_{n-1}) \frac{U_n}{2}$$

$$\Sigma_{a_2} = \frac{1}{\Phi_2} \sum_{n=I+1}^{II} (A_n + A_{n-1}) \frac{U_n}{2}$$

$$\Sigma_{a_{N+1}} = \frac{1}{\Phi_{N+1}} \left[\sum_{n=\bar{N}+1}^t (A_n + A_{n-1}) \frac{U_n}{2} + A_{t+1} \right]$$

$$(203) \Sigma_{l_1} = \frac{1}{\varphi_1} \sum_{n=1}^I (L_n + L_{n-1}) \frac{U_n}{2}$$

$$\Sigma_{l_2} = \frac{1}{\varphi_2} \sum_{n=I+1}^{II} (L_n + L_{n-1}) \frac{U_n}{2}$$

$$\Sigma_{l_{N+1}} = \frac{1}{\varphi_{N+1}} \left[\sum_{n=\bar{N}+1}^t (L_n + L_{n-1}) \frac{U_n}{2} + L_{t+1} \right]$$

$$(204) D_1 = \frac{\Sigma_{l_1}}{K^2}; D_2 = \frac{\Sigma_{l_2}}{K^2}; \dots D_{N+1} = \frac{\Sigma_{l_{N+1}}}{K^2}$$

$$(205) L_1^2 = \frac{D_1}{\Sigma_{a_1}}; L_2^2 = \frac{D_2}{\Sigma_{a_2}}; \dots L_{N+1}^2 = \frac{D_{N+1}}{\Sigma_{a_{N+1}}}$$

$$(206) D'_1 = \frac{\Sigma_{l_1}}{K_1^2}; D'_2 = \frac{\Sigma_{l_2}}{K_2^2}; \dots D'_{N+1} = \frac{\Sigma_{l_{N+1}}}{K_{N+1}^2}$$

$$(207) L_1^{2'} = \frac{D'_1}{\Sigma_{a_1}}; L_2^{2'} = \frac{D'_2}{\Sigma_{a_2}}; \dots L_{N+1}^{2'} = \frac{D'_{N+1}}{\Sigma_{a_{N+1}}}$$

$$(208) \alpha_n = \frac{\Sigma_{s,n}}{\Sigma_{a,n} + \Sigma_{s,n}}$$

$$(209) \sigma_n = \frac{D_0}{2} (\Sigma_{a,n} + \Sigma_{s,n})$$

$$(210) g_n = \frac{4}{3} \sigma_n^2 \left[I_0(\sigma_n) K_1(\sigma_n) - I_1(\sigma_n) K_0(\sigma_n) + \frac{I_1(\sigma_n) K_1(\sigma_n)}{\sigma_n} \right. \\ \left. + 2 \sigma_n (I_0(\sigma_n) K_0(\sigma_n) + I_1(\sigma_n) K_1(\sigma_n)) - 2 \right]$$

$$(211) t_n = 1 - \frac{D_0}{D_{ch}} \frac{(1 - \alpha_n) g_n}{1 - \alpha_n \left(1 - \frac{g_n}{2 \sigma_n} \right)}$$

$$(212) \alpha_n = \frac{\Sigma_{s,n}}{\Sigma_{a,n} + \Sigma_{s,n}}$$

$$(213) \sigma_n = \varepsilon (\Sigma_{a,n} + \Sigma_{s,n})$$

$$(214) \bar{k}_n = \frac{1}{\sigma_n} [1 - 2E_s(2\sigma_n)]$$

$$(215) \bar{f}_n = \frac{1}{2\sigma_n} \left[E_s(2\sigma_n) - 2E_s(\sigma_n) + \frac{1}{2} \right]$$

$$(216) t_n = 1 - \frac{D_o}{D_{ch}} \frac{(1 - \alpha_n) \sigma_n \bar{k}_n}{1 - \alpha_n \bar{f}_n}$$

$$(217) \alpha_n = \frac{\Sigma_{a,n}}{\Sigma_{s,n}}$$

$$(218) \sigma_n = D_o (\Sigma_{a,n} + \Sigma_{s,n})$$

$$(219) t_n = 1 - \frac{2\alpha_n \sigma_n \left[\frac{1}{2} - E_s(\sigma_n) \right]}{\alpha_n \sigma_n + \left[\frac{1}{2} - E_s(\sigma_n) \right]}$$

$$(220) t_1 = \frac{\sum_{n=1}^N \left(\frac{t_n \varphi_n}{1+t_n} + \frac{t_{n-1} \varphi_{n-1}}{1+t_{n-1}} \right) \frac{U_n}{2}}{\sum_{n=1}^N \left(\frac{\varphi_n}{1+t_n} + \frac{\varphi_{n-1}}{1+t_{n-1}} \right) \frac{U_n}{2}}$$

$$(221) t_2 = \frac{\sum_{n=N+1}^t \left(\frac{t_n \varphi_n}{1+t_n} + \frac{t_{n-1} \varphi_{n-1}}{1+t_{n-1}} \right) \frac{U_n}{2}}{\sum_{n=N+1}^t \left(\frac{\varphi_n}{1+t_n} + \frac{\varphi_{n-1}}{1+t_{n-1}} \right) \frac{U_n}{2}} + t_{t+1}$$

$$(222) t_I, t_{II}, \dots, t_N$$

where the Roman numerals indicate interpolated values corresponding to the group lethargies computed in equation (151).

$$(223) \quad t_1 = \frac{\sum_{n=1}^I \left(\frac{t_n \varphi_n}{1+t_n} + \frac{t_{n-1} \varphi_{n-1}}{1+t_{n-1}} \right) \frac{U_n}{2}}{\sum_{n=1}^I \left(\frac{\varphi_n}{1+t_n} + \frac{\varphi_{n-1}}{1+t_{n-1}} \right) \frac{U_n}{2}}$$

$$t_2 = \frac{\sum_{n=I+1}^{II} \left(\frac{t_n \varphi_n}{1+t_n} + \frac{t_{n-1} \varphi_{n-1}}{1+t_{n-1}} \right) \frac{U_n}{2}}{\sum_{n=I+1}^{II} \left(\frac{\varphi_n}{1+t_n} + \frac{\varphi_{n-1}}{1+t_{n-1}} \right) \frac{U_n}{2}}$$

$$t_{N+1} = \frac{\sum_{n=\bar{N}+1}^t \left(\frac{t_n \varphi_n}{1+t_n} + \frac{t_{n-1} \varphi_{n-1}}{1+t_{n-1}} \right) \frac{U_n}{2}}{\sum_{n=\bar{N}+1}^t \left(\frac{\varphi_n}{1+t_n} + \frac{\varphi_{n-1}}{1+t_{n-1}} \right) \frac{U_n}{2}} + t_{t+1}$$

COMPLETION OF F_2 COMPUTATIONS

$$(224) \quad K_{1,\perp}^2 = K_{2,\perp}^2 = \frac{9.87}{(H+2S_z+2d)^2} + \frac{9.87}{(D+2S_r+2d)^2}$$

$$(225) \quad K_{1,\perp}^2 = \frac{9.87}{(H+2S_z+2d_1)^2} + \frac{9.87}{(D+2S_r+2d_1)^2}$$

$$(226) \quad K_{2,\perp}^2 = \frac{9.87}{(H+2S_z+2d_2)^2} + \frac{9.87}{(D+2S_r+2d_2)^2}$$

$$(227) \quad K_{1,\perp}^2 = K_{2,\perp}^2 = \frac{23.13}{(D+2S_r+2d)^2}$$

$$(228) \quad K_{1,\perp}^2 = \frac{23.13}{(D+2S_r+2d_1)^2}$$

$$(229) \quad K_{2,\perp}^2 = \frac{23.13}{(D+2S_r+2d_2)^2}$$

$$(230) \quad K_{1,\perp}^2 = K_{2,\perp}^2 = \frac{9.87}{(H+2S_z+2d)^2}$$

$$(231) K_{1,\perp}^2 = \frac{9.87}{(H + 2S_z + 2d_1)^2}$$

$$(232) K_{2,\perp}^2 = \frac{9.87}{(H + 2S_z + 2d_2)^2}$$

The following equations pertain only to the reactivity match.

$$(233) K_{1,\perp}^2 = K_{2,\perp}^2 = \frac{9.87}{(H + 2S_z + 2l)^2}$$

$$(234) K_{1,\perp}^2 = \frac{9.87}{(H + 2S_z + 2d_1)^2}$$

$$(235) K_{2,\perp}^2 = \frac{9.87}{(H + 2S_z + 2d_2)^2}$$

$$(236) K_{1,\perp}^2 = K_{2,\perp}^2 = \frac{23.13}{(D + 2S_r + 2d)^2}$$

$$(237) K_{1,\perp}^2 = \frac{23.13}{(D + 2S_r + 2d_1)^2}$$

$$(238) K_{2,\perp}^2 = \frac{23.13}{(D + 2S_r + 2d_2)^2}$$

$$(239) S_{r,1} = A_0 + A_1(k_{z,1}) + A_2(k_{z,1})^2$$

$$S_{r,2} = A_0 + A_1(k_{z,2}) + A_2(k_{z,2})^2$$

$$S_{r,3} = A_0 + A_1(k_{z,3}) + A_2(k_{z,3})^2$$

$$(240) S_{z,1} = A_0 + A_1(k_{r,1}) + A_2(k_{r,1})^2$$

$$S_{z,2} = A_0 + A_1(k_{r,2}) + A_2(k_{r,2})^2$$

$$S_{z,3} = A_0 + A_1(k_{r,3}) + A_2(k_{r,3})^2$$

$$(241) S_r(k) = [A_0 + A_1(k_{in}) + A_2(k_{in})^2]_z$$

$$(242) S_z(k) = [A_0 + A_1(k_{in}) + A_2(k_{in})^2]_r$$

$$(243) \quad k_c = \frac{k_1(1-p)}{1 + L_1^2 K_1^2} + \frac{k_2 p}{(1 + L_1^2 K_1^2)(1 + L_2^2 K_2^2)}$$

In equation (243)

$$k_1 = v \Sigma_{f_1} / \Sigma_{a_1}; \quad k_2 = v \Sigma_{f_2} / \Sigma_{a_2}$$

$$p = \Sigma_{s_1} / (\Sigma_{a_1} + \Sigma_{s_1})$$

$$L_1^2 = D_1 / (\Sigma_{a_1} + \Sigma_{s_1})$$

$$L_2^2 = D_2 / \Sigma_{a_2}$$

$$(244) \quad K_1^2 \doteq K_2^2 = \frac{9.87}{(H + 2S_z(k) + 2d)^2} + \frac{23.13}{(D + 2S_r(k) + 2d)^2}$$

$$(245) \quad K_1^2 = \frac{9.87}{(H + 2S_z(k) + 2d_1)^2} + \frac{23.13}{(D + 2S_r(k) + 2d_1)^2}$$

$$(246) \quad K_2^2 = \frac{9.87}{(H + 2S_z(k) + 2d_2)^2} + \frac{23.13}{(D + 2S_r(k) + 2d_2)^2}$$

$$(247) \quad k'_{in} = k_{in} - 2(k_{in} - k_c) = k_{in} - 2\Delta k$$

Appendix B-

General Flow Chart of Program GEORGE

Appendix C-

Sample Problem

When a longitudinal F_2 calculation is run an average core composition is defined as the volume average of core 1 and core 2

Fig. C1 - George II, sample test case reactor configuration

CAUTION

These input sheets may become
classified when filled in.

PROGRAM GEORGE GENERAL INPUT

Engineer's Name - 24 Letter BCI

B8500,4,	W. B. HENDERSON ① EXT. 736
----------	----------------------------

Case Identification - 24 Letter BCI

B8504,4,	GEORGE ① SAMPLE ① TEST ① CASE
----------	-------------------------------

Date - 24 Letter BCI

B8508,4,	AUGUST ① 5, 1959
----------	------------------

Classification - 42 Letter BCI - continue on second line

B8512,7,	UNCLASSIFIED
----------	--------------

	Number of Core or End Compositions	Number of Side Compositions	Number of Control Compositions	Number of F ₂ Cases	C1 F ₂ Calc	C23 C-F Reactivity Match
B8519,35,	4	1	1	2	1	1

C No 0 No
 1 Yes 1 Yes

Case Numbers for C-F Reactivity Match - All 12 Letter BCI

B8525,2,	AVG. CORE
----------	-----------

Reference Composition

B8527,2,	RAD
----------	-----

Radial F₂ Case Number

B8529,2,	LONG
----------	------

Longitudinal F₂ Case Number

.8531,	0
--------	---

Omega

This is the end of record card for the
first record - it must be punched.

5/28/58

PROGRAM GEORGE CORE OR END COMPOSITION

Core or End Case Number - 12 Letter BCI

B9533,2, CORE ①

Spectrum Code Number

C9855, .942

	C2 Input	C19 Output	C3 Thermal σ	C4 - Slowing Down Model	C5 Group Div.	N
D9856,35,	0	2	/	0	0	
	0 CGS 1 Eng.	0 Short 1 Inter. 2 Long	0 $\sigma_t \neq \sigma_{t+1}$ 1 $\sigma_t = \sigma_{t+1}$	0 $(\xi \Sigma_s + \Sigma_a + \Sigma_f) \phi = q + S$ 1 $\xi \Sigma_s \phi = q + \xi S$ 2 $\xi \Sigma_s \phi = q + S$ 3 $\xi (\Sigma_s + \Sigma_a) \phi = q$ 4 $\xi \Sigma_s \phi = q$	0 $N = t$ 1 Calc. N 2 N Given	If C5 = 2

	C6 - f_n	C7 - I_2 Calc.	C8 - $g\sigma$	C9 - Σ_a in I_2	C30- g_{recipe}
D9862,35,	/	/	0	0	0
	0 Set $f_n = 1$ 1 Calc. $f_{n,r}; f_{n,z}$ 2 Calc. $f_{n,r} = f_{n,z}$	0 No g_n^1 given 1 Yes 2 No. Set $g_n^1 = 1$	0 Apply g_n^1 to all σ 1 Apply g_n^1 to σ_a and $v\sigma_f$	0 Use Σ_a 1 Use $\Sigma_a + DK_1^2$	0 $\phi_{cell} = 1$ 1 $\phi_{mod} = 1$

	C10- g_n in f_n	C11- Σ_{mod} in f_n	C18-Terrall Meth.	C20-Fine Rad. Pwr.	C21-Adjoint
D9867,35,	/	/	0	/	0
	0 No 1 Yes	0 Use Σ_s 1 Use Σ_t	0 No 1 Yes	0 No 1 Yes	0 No 1 Yes

	$T_{moderator}$ °F	E*	T_{fuel} °F
C9872,	68		
	Moderator Temperature	Use Only if C18 = 1 (Terrall Method)	

	Type I_2 Input if C7 = 1	
	C12 - Level t+1	C13 - Level 16
D9875,35,	-/	-/
	-1 Type B 0 No Calculation set $g_{t+1} = 1$ 1 Type A	-1 Type B 0 No Calculation set $g_{16} = 1$ 1 Type A
		C14 - Level 17*
		-1 Type B 0 No Calculation set $g_{17} = 1$ 1 Type A

*If $T_{mod} \geq 1056^\circ$, use C14 = 0

CORE OR END COMPOSITION DATA

(Continued)

	C17 Photon Production	C22 Neutron Multi-Group
D9878,35,	/	/
	0 No 1 Yes	0 No 1 Yes

Energies in tables below must be in decreasing order.

Energies, $E_p(\text{ev})$, for Division of Photon Production Parameters

C9474,	1/6	1/3	.5	1/-4		
C9480,						
C9486,						

No more than one division between standard lethargy divisions is allowed.

Energies, $E_N(\text{ev})$, for Neutron Multi-Group Division

C9492,	100	1				
C9498,						
C9504,						

No more than one division between standard lethargy divisions is allowed.

C16
Geometry

D9880,35,	/
-----------	---

0 Slab
1 Cylinder
2 Sphere

Slab: H, D, R = Length, width, and height in any order, but S_r and S_z are used by F_2 in computing perpendicular buckling.

Cylinder: H, D, O = Height and diameter.

Sphere: O, O, R = Radius.

	H	S_z	D	S_r	R	S_b
C9881,	50	3.9685363	70	1.1898315/		

Geometry for Buckling

	D_1	D_2	D_3	M
C9887,	3.2	4	6	

Geometry for Behrens Correction

	D_{co}	D_{ci}	L
C9905,			

Geometry for Volume Calculation

CORE OR END COMPOSITION DATA

(Continued)

Table 3_m - I₂ Material

Material	C28 Fuel	r _{mo}	r _{mi}	l
C8754, 1	-/			
Number	-1 Yes 1 No	Geometry for Volume Calculation		

	I	W	f or N	σ_{s2} or Σ_{s2} Level t+1	σ_{s2} or Σ_{s2} Level 16	σ_{s2} or Σ_{s2} Level 17
C8760,	-1.13	0	.007			
C8766,	5.11	0	.093			
C8772,						
C8778,						
C8784,						
C8790,						
C8796,						
C8802,						
C8808,						
C8814,						

If C7 $\neq$ 1, this sheet is not used.

Caution: Elements may not be repeated in this material.

Elements must be designated by code numbers.

f or N entry is unhomogenized density.

CORE OR END COMPOSITION DATA

(Continued)

Table 3_m - I₂ Material

	Material	C28 Fuel	r _{mo}	r _{mi}	ℓ
8832	2	1			
	Number (2 - 10)	-1 Yes 1 No	Geometry for Volume Calculation		

	I	W	f or N	σ _{s2} or Σ _{s2} Level t+1	σ _{s2} or Σ _{s2} Level 16	σ _{s2} or Σ _{s2} Level 17
8832	2.51	0	1	.13	.24	.20
C						
C						
C						
C						
C						
C						
C						
C						
C						
C						

If C7 ≠ 1, this sheet is not used.

Insert addresses as follows:

To the addresses for material 1 add 72 (m-1) where m is the material number.

Caution: Elements may not be repeated in this material.

Elements must be designated by code numbers.

f or N entry is unhomogenized density.

DATA FORM - PROGRAM I₂ - Level t+1

Record all numbers as .XXXXXXXX where X's are the digits of the number (maximum of 8) and with the decimal point in desired place. If less than 8 digits are required, record number without unnecessary digits, e.g. X.XX.

	Case Number
D9850,17,	/

Case number must be between 0.00000 and 999.99999.

SOURCE TERMS - Level t+1

A source term, S_{oo}, must be given for each zone, from outer-most to inner-most zone.

	Outer S _{oo}	Next S _{oo}	...			
C9650,	/	0	/			
C9656,						
C9662,						
C9668,						
C9674,						
C9680,						
C9686,						
C9692,						
C9698,						

Used only if C7 = 1 and C12 ≠ 0.

DATA FORM - PROGRAM I₂ - Level 16

Record all numbers as .XXXXXXXX where X's are the digits of the number (maximum of 8) and with the decimal point in desired place. If less than 8 digits are required, record number without unnecessary digits, e.g. X.XX

SOURCE TERMS, Level 16

A source term, S_{00} , must be given for each zone, from outer-most to inner-most zone.

	Outer S_{00}	Next S_{00}	. . .			
C9700,	/	O	/			
C9706,						
C9712,						
C9718,						
C9724,						
C9730,						
C9736,						
C9742,						
C9748,						

Used only if C7 = 1 and C13 $\neq$ 0.

DATA FORM - PROGRAM I₂ - Level 17

Record all numbers as .XXXXXXXX where X's are the digits of the number (maximum of 8) and with the decimal point in desired place. If less than 8 digits are required, record number without unnecessary digits, e.g. X.XX

SOURCE TERMS, Level 17

A source term, S₀₀, must be given for each zone, from outer-most to inner-most zone.

	Outer S ₀₀	Next S ₀₀	. . .			
C9750,	/	O	/			
C9756,						
C9762,						
C9768,						
C9774,						
C9780,						
C9786,						
C9792,						
C9798,						

Used only if C7 = 1 and C14 ≠ 0.

I₂ ZONE DATA
Cases 1, 2, and 3

(One set of zone data is supplied per core. It is used at all three levels.)

Zone data must be ordered from outer-most to inner-most zone. Within a given zone, "r" is the outer radius of the zone and "material number" is the integer m associated with a particular material. (Another page is available if there is not enough space here to list zone data.)

	Number of Materials	Number of Zones	Number of Radii
D9852, 35,	2	3	10

	OUTER-MOST ZONE		NEXT ZONE			
	r	Material No.	r	Material No.	r	Material No.
C9550,	3.0	2	2.0	1	1.6	2

	r	Material No.	r	Material No.	r	Material No.
C9556,						

	r	Material No.	r	Material No.	r	Material No.
C9562,						

	r	Material No.	r	Material No.	r	Material No.
C9568,						

	r	Material No.	r	Material No.	r	Material No.
C9574,						

	r	Material No.	r	Material No.	r	Material No.
C9580,						

	r	Material No.	r	Material No.	r	Material No.
C9586,						

	r	Material No.	r	Material No.	r	Material No.
C9592,						

	r	Material No.	r	Material No.	r	Material No.
C9598,						

Used only of C7 = 1.

ZONE DATA
(Continued)

	r	Material No.	r	Material No.	r	Material No.
C9604,						

	r	Material No.	r	Material No.	r	Material No.
C9610,						

	r	Material No.	r	Material No.	r	Material No.
C9616,						

	r	Material No.	r	Material No.	r	Material No.
C9622,						

	r	Material No.	r	Material No.	r	Material No.
C9628,						

	r	Material No.	r	Material No.	r	Material No.
C9634,						

	r	Material No.	r	Material No.	r	Material No.
C9640,						

	r	Material No.	r	Material No.
C9646,				

Used only if C7 = 1.

PROGRAM GEORGE

TABLE OF FINE RADIAL POWER ZONE CODES

Use only if C20 = 1.

C9800,	0	,	/	,	0	,		,		,
C9805,		,		,		,		,		,
C9810,		,		,		,		,		,
C9815,		,		,		,		,		,
C9820,		,		,		,		,		,
C9825,		,		,		,		,		,
C9830,		,		,		,		,		,
C9835,		,		,		,		,		,
C9840,		,		,		,		,		,
C9845,		,		,		,		,		,

Note: Zone codes are ordered from outermost to innermost.

LAST PAGE CORE/END DATA

C32 - Rerun in C-F Match

D8536, 35, /
0 No
1 Yes

C31 - Clear Input

D8535, 35, -/
-1 No
1 Yes

C33 - Rerun I₂ in C-F Match

D8537, 35, 0
0 No
1 Yes

C29 - Composition

)8532, 35, -1,

This card must be punched and placed at the end of each core/end composition that is to be run.

PROGRAM GEORGE - DATA CHANGE SHEET - PARTS C₂ AND I₂

No data may be changed on General Input Page (Data Page 1). This composition must be added to total number of compositions.

New Case Number -.12 Letter BCI

B8533,2, **CORE ① 2**

Address	Value	Address	Value
C9889,	7.0 ,		
C9550,	3.5,		
D9850,	17, 2,		

C31 - Clear Input

B8535,35, -/ ,
 -1 No
 1 Yes

Always Punch - End of record card for change case

PROGRAM GEORGE - DATA CHANGE SHEET - PARTS C₂ AND I₂

No data may be changed on General Input Page (Data Page 1). This composition must be added to total number of compositions.

New Case Number - 12 Letter BCI

B8533,2, **AVG. CORE**

Address	Value	Address	Value
C9889,	6.5 ,		
C9550,	3.25 ,		
D9850,	17, 3 ,		

C31 - Clear Input

B8535,35, /

-1 No

1 Yes

Always Punch - End of record card for change case

PROGRAM GEORGE CORE OR END COMPOSITION

Core or End Case Number - 12 Letter BCI

B8533,2, **END**

Spectrum Code Number

C9855, **.942**

	C2 Input	C19 Output	C3 Thermal σ	C4 - Slowing Down Model	C5 Group Div.	N
D9856,35,	0	2	1	0	0	
	0 CGS 1 Eng.	0 Short 1 Inter. 2 Long	0 $\sigma_t \neq \sigma_{t+1}$ 1 $\sigma_t = \sigma_{t+1}$	0 $(\xi \Sigma_s + \Sigma_a + \Sigma_2)\phi = q + S$ 1 $\xi \Sigma_s \phi = q + \xi S$ 2 $\xi \Sigma_s \phi = q + S$ 3 $\xi (\Sigma_s + \Sigma_a)\phi = q$ 4 $\xi \Sigma_s \phi = q$	0 N = t 1 Calc. N 2 N Given	If C5 = 2

	C6 - f_n	C7 - I_2 Calc.	C8 - $g\sigma$	C9 - Σ_a in I_2	C30-Recipe
D9862,35,	1	2			
	0 Set $f_n = 1$ 1 Calc. $f_{n,r}; f_{n,z}$ 2 Calc. $f_{n,r} = f_{n,z}$	0 No g_n^1 given 1 Yes 2 No. Set $g_n^1 = 1$	0 Apply g_n^1 to all σ 1 Apply g_n^1 to σ_a and $v\sigma_f$	0 Use Σ_a 1 Use $\Sigma_a + DK_1^2$	0 $\phi_{cell} = 1$ 1 $\phi_{mod} = 1$

	C10- g_n in f_n	C11- Σ_{mod} in f_n	C18-Terrall Meth.	C20-Fine Rad. Pwr.	C21-Adjoint
D9867,35,	0	1			
	0 No 1 Yes	0 Use Σ_s 1 Use Σ_t	0 No 1 Yes	0 No 1 Yes	0 No 1 Yes

	$T_{moderator} ^\circ F$	E^*	$T_{fuel} ^\circ F$
C9872,	68		
	Moderator Temperature	Use Only if C18 = 1 (Terrall Method)	

	Type I_2 Input if C7 = 1		
	C12 - Level t+1	C13 - Level 16	C14 - Level 17*
D9875,35,			
	-1 Type B 0 No Calculation set $g_{t+1} = 1$ 1 Type A	-1 Type B 0 No Calculation set $g_{16} = 1$ 1 Type A	-1 Type B 0 No Calculation set $g_{17} = 1$ 1 Type A

*If $T_{mod} \geq 1056^\circ$, use C14 = 0

CORE OR END COMPOSITION DATA

(Continued)

C17 Photon Production		C22 Neutron Multi-Group	
D9878,35,			
0	No	0	No
1	Yes	1	Yes

Energies in tables below must be in decreasing order.

Energies, $E_p(\text{ev})$, for Division of Photon Production Parameters

C9474,						
C9480,						
C9486,						

No more than one division between standard lethargy divisions is allowed.

Energies, $E_n(\text{ev})$, for Neutron Multi-Group Division

C9492,						
C9498,						
C9504,						

No more than one division between standard lethargy divisions is allowed.

C16
Geometry

D9880,35,	1
-----------	---

0 Slab
1 Cylinder
2 Sphere

Slab: H, D, R = Length, width, and height in any order, but S_x and S_z are used by F_2 in computing perpendicular buckling.

Cylinder: H, D, O = Height and diameter.

Sphere: O, O, R = Radius.

	H	S_z	D	S_x	R	S_y
C9881,	50	3.9685363	70	1.1898315/1		

Geometry for Buckling

	D_1	D_2	D_3	M
C9887,	3.2	4	6.5	

Geometry for Behrens Correction

	D_{co}	D_{ci}	L
C9905,			

Geometry for Volume Calculation

CORE OR END COMPOSITION DATA

(Continued)

Table M1 - Moderator

	I	W	f_h or N_h	g_{t+1}	g_{16}	g_{17}
C8562,	2.5/	0	.882448			
C8568,						
C8574,						
C8580,						
C8586,						
C8592,						
C8598,						
C8604,						
C8610,						
C8616,						
C8622,						
C8628,						
C8634,						
C8640,						
C8646,						

If C7 = 1, this sheet is not used.

Caution: Elements may not be repeated in moderator region.

Elements must be designated by code numbers.

CORE OR END COMPOSITION DATA

(Continued)

Table F1 - Fuel

	I	W	f_h or N_h	g_{t+1}	g_{16}	g_{17}
C8658,	6.3	0	1/-5			
C8664,						
C8670,						
C8676,						
C8682,						
C8688,						
C8694,						
C8700,						
C8706,						
C8712,						
C8718,						
C8724,						
C8730,						
C8736,						
C8742,						

If C7 = 1, this sheet is not used.

Caution: Elements may not be repeated in fuel region.

Elements must be designated by code numbers.

LAST PAGE CORE/END DATA

C32 - Rerun in C-F Match

D8536,35, /

0 No
1 Yes

C31 - Clear Input

D8535,35, /

-1 No
1 YesC33 - Rerun I_2 in C-F Match

D8537,35, /

0 No
1 Yes

C29 - Composition

)8532,35,-1,

This card must be punched and placed at the end of each
core/end composition that is to be run.

PROGRAM GEORGE

SIDE COMPOSITION DATA

12 Letter BCI
 B8533,2, **SIDE**
 Case Number

Spectrum
 C9855, **.942**
 Code Number

	C2 Input	C19 Output	C3 Thermal Base	C4 Slowing Down Model	C5 Group Division	N
D9856,35,	0	2	1	0	0	
	0 CGS 1 English	0 Short 1 Intermed. 2 Long	0 $\sigma_t \neq \sigma_{t+1}$ 1 $\sigma_t = \sigma_{t+1}$	0 Modified Age 1 Coveyou-Macauley 2 Semi-Consistent Wigner 3 Inconsistent Wigner 4 Age Theory	0 $N = t$ 1 <u>Do not use</u> 2 N given	

C16
Geometry
 D9880,35, **1**
 0 Slab
 1 Cylinder
 2 Sphere

$T_{side}^{\circ F}$
 C9872, **68**
 Side Temperature

C7
 D9863,35, **2**

12 Letter BCI
 B9894,2, **CORE ① 2**
 Case number of reference
 Core or end composition
 for buckling

C21
Adjoint
 D9871,35, **0**
 0 No
 1 Yes

C31 - Clear Input
 D8535,35, **1**
 -1 No
 1 Yes

C32 - Rerun in C-F Match
 D8536,35, **1**
 0 No
 1 Yes

SIDE COMPOSITION DATA

(Continued)

C17 Photon Production	
D9878,35,	O
	0 No 1 Yes

C22 is taken from reference composition.

Energies in tables below must be in decreasing order.

Energies, $E_p(\text{ev})$, for Division of Photon Production Parameters

C9474,						
C9480,						
C9486,						

No more than one division between standard lethargy divisions is allowed.

Energies, $E_N(\text{ev})$, for Neutron Multi-Group Division

C9492,	100	1				
C9498,						
C9504,						

No more than one division between standard lethargy divisions is allowed.

	D _{co}	D _{ci}	L
C9905,			

Geometry for Volume Calculation

SIDE COMPOSITION DATA

(Continued)

Table M1 - Side

	I.	W	f_h or N_h
C8562,	2.51	0	1.0
C8568,			
C8574,			
C8580,			
C8586,			
C8592,			
C8598,			
C8604,			
C8610,			
C8616,			
C8622,			
C8628,			
C8634,			
C8640,			
C8646,			

Caution: Elements may not be repeated in moderator region.

Elements must be designated by code numbers.

C29 - Composition

)8532,35,0,

This card must be punched and placed at the
end of every side composition to be run.

PROGRAM GEORGE CONTROL COMPOSITION

C7 D9863,35,2,	C31 Clear Input D8535,35, / -1 No 1 Yes	C17 Photon Production D9878,35, / 0 No 1 Yes
Case Number - 12 Letter BCI B8533,2, ROD	C32 - Rerun in C-F Match D8536,35, / 0 No 1 Yes	C16 Geometry D9880,35, / 0 Slab 1 Cylinder 2 Sphere
12 Letter BCI B9894,2, CORE @ 1 Case number of reference core, end, or side compo- sition for flux and buckling.		C15 Transmission D9896,35, / 0 No Calculation 1 Rod 2 Annulus 3 Plate

Energies must be in decreasing order.

Energies, Ep(ev), for Group Division of Photon Production Parameters

C9474,	1/6	1/3	.5	1/-4		
C9480,						
C9486,						

No more than one division between standard lethargy divisions is allowed.

C2 - Input D9856,35, 0 0 CCS 1 Eng	C19 - Output 2 0 Short 1 Intermediate 2 Long	C3 - Thermal Base / 0 $\sigma_t \neq \sigma_{t+1}$ 1 $\sigma_t = \sigma_{t+1}$
---	--	---

D _{co}	D _{ci}	L
C9905,		

Geometry for Volume Calculation

D _o	D _{ch}	ϵ
C9891,	2.0	2.54

Geometry for Transmission Calculation

If C15 = 1, D_o = rod diameter, D_{ch} = channel diameter.If C15 = 2, D_o = annulus outer diameter, D_{ch} = channel diameter,
 ϵ = annulus thickness.If C15 = 3, D_o = plate thickness.

CONTROL COMPOSITION DATA

(Continued)

Table M1 - Control

	I	W	f_h or N_h
C8562,	8.05	0	.5
C8568,			
C8574,			
C8580,			
C8586,			
C8592,			
C8598,			
C8604,			
C8610,			
C8616,			
C8622,			
C8628,			
C8634,			
C8640,			
C8646,			

Caution: Elements may not be repeated in moderator region.

Elements must be designated by code numbers.

C29 - Composition

)8532,35,1,

This card must be punched and placed at the
end of every control composition to be run.

GENERAL DATA

*Note to Key punch: This card is always punched, whether input data entered or not.

Ordinarily card C8017 will be given and C8021 can be omitted

- NOTES:
1. Input is eight digit fixed or floating point except where BCI is indicated.
 2. In general a card need be completed only as far as the last word which has a non-zero value. If the entire card is zero, the entire card may be omitted.
 3. A card is indicated by an enclosed rectangle.
 4. Entries 0, 1, and 2 are equivalent since all three tests must now be satisfied.

704 PROGRAM GEORGE - F₂

Caution: This set of forms may
become classified when filled in.

GENERAL DATA

(continued)

C29	
D8532, 35,	2,

12 Letter BCI	
B5990, 2,	<i>AVG. CORE</i>
Reference Composition for Buckling C25 = 1, C3 = 1	

12 Letter BCI	
B5992, 2,	<i>ROD</i>
Control Composition for Albedos C26 = 1, C4 = 1	

C27
All F₂ Parameters Obtained
from Compositions are Taken
from Subroutines based on
Terrall Method

D5997, 35,	0,
	0 No 1 Yes

C24 Type Two-Group Constants	C25 Perpendicular Buckling	C26 Albedos
D5994, 35, /	/	/
. 0 Use one-group buckling	. 0 Use F ₂ data and controls	. 0 Given in F ₂ input
. 1 Use two-group buckling	. 1 Compute from reference	. 1 Use t ₁ and t ₂ from reference
.	. composition data (implies	. control composition
.	. C3, F ₂ = 1)	.
.	. 2 Compute using data in each	.
.	. composition of the regional	.
.	. data (implies C3, F ₂ = 3)	.

704 PROGRAM GEORGE - F₂

Caution: This set of forms may
become classified when filled in.

COMPOSITION FOR FLUX NORMALIZATION

Omit This Page Unless Normalization Code = 2

12 Letter BCI

B8025,2,	CORE ① 1
B8027,2,	CORE ① 2
B8029,2,	
B8031,2,	
B8033,2,	
B8035,2,	
B8037,2,	
B8039,2,	
B8041,2,	
B8043,2,	
B8045,2,	
B8047,2,	
B8049,2,	

12 Letter BCI

B8051,2,
B8053,2,
B8055,2,
B8057,2,
B8059,2,
B8061,2,
B8063,2,
B8065,2,
B8067,2,
B8069,2,
B8071,2,
B8073,2,

EXTERNAL SOURCE (S_{ext}) DISTRIBUTION

Caution: This set of forms may
become classified when filled in.

If S_{ext} code = 0, omit this page
If S_{ext} code = 1, use only S_{ext}⁺ columns

This Table May be Extended to 100 Lattice Points

j	n	S ₁ ⁺ (ext)	S ₁ ⁻ (ext)	S ₂ ⁺ (ext)	S ₂ ⁻ (ext)	j	n	S ₁ ⁺ (ext)	S ₁ ⁻ (ext)	S ₂ ⁺ (ext)	S ₂ ⁻ (ext)
1	0	C6850,	,	0	,	0	26	C6950,	,	,	,
2	1	C6854,	,	,	,	1	27	C6954,	,	,	,
3	2	C6858,	,	,	,	2	28	C6958,	,	,	,
4	3	C6862,	,	,	,	3	29	C6962,	,	,	,
5	4	C6866,	,	,	,	4	30	C6966,	,	,	,
6	5	C6870,	,	,	,	5	31	C6970,	,	,	,
7	6	C6874,	,	,	,	6	32	C6974,	,	,	,
8	7	C6878,	,	,	,	7	33	C6978,	,	,	,
9	8	C6882,	,	,	,	8	34	C6982,	,	,	,
10	9	C6886,	,	,	,	9	35	C6986,	,	,	,
11	10	C6890,	,	,	,	10	36	C6990,	,	,	,
12	11	C6894,	,	,	,	11	37	C6994,	,	,	,
13	12	C6898,	,	,	,	12	38	C6998,	,	,	,
14	13	C6902,	,	,	,	13	39	C7002,	,	,	,
15	14	C6906,	,	,	,	14	40	C7006,	,	,	,
16	15	C6910,	,	,	,	15	41	C7010,	,	,	,
17	16	C6914,	,	,	,	16	42	C7014,	,	,	,
18	17	C6918,	,	,	,	17	43	C7018,	,	,	,
19	18	C6922,	,	,	,	18	44	C7022,	,	,	,
20	19	C6926,	,	,	,	19	45	C7026,	,	,	,
21	20	C6930,	,	,	,	20	46	C7030,	,	,	,
22	21	C6934,	,	,	,	21	47	C7034,	,	,	,
23	22	C6938,	,	,	,	22	48	C7038,	,	,	,
24	23	C6942,	,	,	,	23	49	C7042,	,	,	,
25	24	C6946,	,	,	,	24	50	C7046,	,	,	,
						25	51	C7050,	,	,	,

Region number (j) or lattice number (n) are shown for
convenience and are not to be punched. j or n is numbered
left to right.

704 PROGRAM GEORGE - F₂

Caution: This set of forms may
become classified when filled in.

REGIONAL DATA

*Perpendicular Bucklings

j	Composition (12 Letter BCI)	Outer Radius	No. of Intervals	$K_{1,1}^2$	$K_{2,1}^2$
1	B6000,2, CORE ① 1	24.74	25		
2	B6002,2, CORE ① 2	35	10		
3	B6004,2, SIDE	45	10		
4	B6006,2,				
5	B6008,2,				
6	B6010,2,				
7	B6012,2,				
8	B6014,2,				
9	B6016,2,				
10	B6018,2,				
11	B6020,2,				
12	B6022,2,				
13	B6024,2,				
14	B6026,2,				
15	B6028,2,				
16	B6030,2,				
17	B6032,2,				
18	B6034,2,				
19	B6036,2,				
20	B6038,2,				
21	B6040,2,				
22	B6042,2,				
23	B6044,2,				
24	B6046,2,				
25	B6048,2,				

NOTE: The column at the left is for convenience in keeping track of the region number, j, and is not to be punched. The total number of intervals requested here plus the extra intervals, if any, must not exceed 100.

*If buckling code = 0, omit.
If buckling code = 1, fill in top line (j=1).
If buckling code = 2, omit.
If buckling code = 3, fill in a line for each region.

704 PROGRAM GEORGE - F₂

Caution: This set of forms may
become classified when filled in.

REGIONAL DATA

(continued)

j	Composition (12 Letter BCI)	Outer Radius	No. of Intervals	$K_{1,1}^2$	$K_{2,1}^2$
26	B6050,2,	C6200,			
27	B6052,2,	C6204,			
28	B6054,2,	C6208,			
29	B6056,2,	C6212,			
30	B6058,2,	C6216,			
31	B6060,2,	C6220,			
32	B6062,2,	C6224,			
33	B6064,2,	C6228,			
34	B6066,2,	C6232,			
35	B6068,2,	C6236,			
36	B6070,2,	C6240,			
37	B6072,2,	C6244,			
38	B6074,2,	C6248,			
39	B6076,2,	C6252,			
40	B6078,2,	C6256,			
41	B6080,2,	C6260,			
42	B6082,2,	C6264,			
43	B6084,2,	C6268,			
44	B6086,2,	C6272,			
45	B6088,2,	C6276,			
46	B6090,2,	C6280,			
47	B6092,2,	C6284,			
48	B6094,2,	C6288,			
49	B6096,2,	C6292,			
50	B6098,2,	C6296,			

704 PROGRAM GEORGE - F₂

Caution: This set of forms may
become classified when filled in.

SPECTRUM TABLE

This table may be omitted if, as is usually
the case, S₁ is unity and S₂ is zero for
all compositions.

Fast Spectral Fraction - S₁

C6750,										
C6760,										
C6770,										
C6780,										
C6790,										

Slow Spectral Fraction - S₂

C6800,										
C6810,										
C6820,										
C6830,										
C6840,										

NOTE: Spectral data, if given, refer in order to the compositions as they appear on page 28.

704 PROGRAM GEORGE - F₂

Caution: This set of forms may
become classified when filled in.

COMPOSITION TABLE

12 Letter BCI

	22	34	46	58
B6300,10,	CORE ① 1	CORE ① 2	SIDE	
B6310,10,				
B6320,10,				
B6330,10,				
B6340,10,				
B6350,10,				
B6360,10,				
B6370,10,				
B6380,10,				
B6390,10,				

Clear Input Before Next Case?

8192,35,	/
----------	---

0 No
1 Yes

GENERAL DATA

*Note to Key punch: This card is always punched, whether input data entered or not.

	Boundary Crossing	External Source	Convergence	Normalization	Output	P	
①	O	O	O	I	I		
.0	Extra interval at each interface.	.0	None	.0	Mean square	.0	Print. Number of
.1	Extra interval at outer	.1	Constant in each region.	.1	Max. difference.	.0	$\bar{\phi}_1$ in core
.	boundaries only	.2	Given at every point	.2	Reactivity	.1	ϕ_1 at r_n
.2	No extra intervals	.		.3	P iterations	.1	Print. convergence
.		.		.	see note 4.	.2	$\bar{\phi}_2$ (a_0)
						.	= 3. P < 50

All entries on the above card are to be given in centimeters . Omit unless normalization = 1
H, D, S_H, and S_D may be given as 0 if buckling = 1 or 3 .

Card C8017 should be omitted if boundary = 0

Ordinarily card C8017 will be given and C8021 can be omitted

- NOTES:
1. Input is eight digit fixed or floating point except where BCI is indicated.
 2. In general a card need be completed only as far as the last word which has a non-zero value. If the entire card is zero, the entire card may be omitted.
 3. A card is indicated by an enclosed rectangle.
 4. Entries 0, 1, and 2 are equivalent since all three tests must now be satisfied.

704 PROGRAM GEORGE - F₂

Caution: This set of forms may become classified when filled in.

GENERAL DATA

(continued)

C29	
D8532,35,	2,

12 Letter BCI		12 Letter BCI	
B5990,2,	AVG. CORE	B5992,2,	
Reference Composition for Buckling C25 = 1, C3 = 1		Control Composition for Albedos C26 = 1, C4 = 1	

C27
All F₂ Parameters Obtained
from Compositions are Taken
from Subroutines based on
Terrall Method

D5997,35,	0,
	0 No 1 Yes

C24 Type Two-Group Constants		C25 Perpendicular Buckling		C26 Albedos	
D5994,35,	/	/		0	
.	0 Use one-group buckling	.	0 Use F ₂ data and controls	.	0 Given in F ₂ input
.	1 Use two-group buckling	.	1 Compute from reference	.	1 Use t ₁ and t ₂ from reference
.		.	composition data (implies	.	control composition
.		.	C3, F ₂ = 1)	.	
.		.	2 Compute using data in each	.	
.		.	composition of the regional	.	
.		.	data (implies C3, F ₂ = 3)	.	

704 PROGRAM GEORGE - F₂

Caution: This set of forms may become classified when filled in.

REGIONAL DATA

*Perpendicular Bucklings

j	Composition (12 Letter BCI)	Outer Radius	No. of Intervals	$K_{1,1}^2$	$K_{2,1}^2$
1	B6000,2, <i>END</i>	C6100, 10 10	10		
2	B6002,2, <i>AVG. CORE</i>	C6104, 50 60	50		
3	B6004,2, <i>END</i>	C6108, 15 75	15		
4	B6006,2,	C6112,			
5	B6008,2,	C6116,			
6	B6010,2,	C6120,			
7	B6012,2,	C6124,			
8	B6014,2,	C6128,			
9	B6016,2,	C6132,			
10	B6018,2,	C6136,			
11	B6020,2,	C6140,			
12	B6022,2,	C6144,			
13	B6024,2,	C6148,			
14	B6026,2,	C6152,			
15	B6028,2,	C6156,			
16	B6030,2,	C6160,			
17	B6032,2,	C6164,			
18	B6034,2,	C6168,			
19	B6036,2,	C6172,			
20	B6038,2,	C6176,			
21	B6040,2,	C6180,			
22	B6042,2,	C6184,			
23	B6044,2,	C6188,			
24	B6046,2,	C6192,			
25	B6048,2,	C6196,			

NOTE: The column at the left is for convenience in keeping track of the region number, j, and is not to be punched. The total number of intervals requested here plus the extra intervals, if any, must not exceed 100.

*If buckling code = 0, omit.
 If buckling code = 1, fill in top line (j=1).
 If buckling code = 2, omit.
 If buckling code = 3, fill in a line for each region.

704 PROGRAM GEORGE - F₂

Caution: This set of forms may
become classified when filled in.

COMPOSITION TABLE

12 Letter BCI

	22	34	46	58
B6300,10, <i>END</i>	<i>AVG. CORE</i>			
B6310,10,				
B6320,10,				
B6330,10,				
B6340,10,				
B6350,10,				
B6360,10,				
B6370,10,				
B6380,10,				
B6390,10,				

Clear Input Before Next Case?

8192,35,	/
----------	---

0 No
1 Yes

704 PROGRAM GEORGE - F₂

Caution: This set of forms may
become classified when filled in.

New Case No. (12 Letter BCI)

B8076,2,

Address of data
to be changed

New Value

Address of data
to be changed

New Value

Clear Input Before Next Case?

8192,35,

0 No

1 Yes

B8500,4,W.B.HENDERSON EXT.736
B8504,4,GEORGE SAMPLE TEST CASE
B8508,4,AUGUST 5,1959
B8512,7,UNCLASSIFIED
D8519,35,4,1,1,2,1,1,
B8525,2,AVG.CORE
B8529,2,LONG
B8527,2,RAD
.8531,0,
B8533,2,CORE 1
C9855,.942,
D9856,35,0,2,1,0,0,
D9862,35,1,1,0,0,0,
D9867,35,1,1,0,1,0,
C9872,68,
D9875,35,-1,-1,-1,
D9878,35,1,1,
C9474,1/6,1/3,.5,1/-4,
C9492,100,1,
D9880,35,1,
C9881,50,3.9685363,70,1.1898315/1,
C9887,3.2,4,6,
C8754,1,-1,
C8760,-1.13,0,.007,
C8766,5.11,0,.093,
C8826,2,1,
C8832,2.51,0,1,.13,.24,.20,
D9850,17,1,
C9650,1,0,1,

C9700,1,0,1,
C9750,1,0,1,
D9852,35,2,3,10,
C9550,3,0,2,2,0,1,1.6,2,
C9800,0,1,0,
D8536,35,1,
D8535,35,-1,
D8537,35,0,
J8532,35,-1,
B8533,2,CORE 2
C9889,7,
C9550,3,5,
D9850,17,2,
J8535,35,-1,
B8533,2,AVG,CORE
C9889,6,5,
C9550,3,25,
D9850,17,3,
J8535,35,1,
B8533,2,END
C9855,.942,
D9856,35,0,2,1,0,0,
D9862,35,1,2,
D9867,35,0,1,
C9872,68,
D9880,35,1,
C9881,50,3.9685363,70,1.1898315/1,
C9887,3,2,4,6,5,
C8562,2,51,0,.882448,

C8658,6,3,0,1/-5,

D8536,35,1,

D8535,35,1,

I8532,35,-1,

B8533,2,SIDE

C9855,.942,

D9856,35,0,2,1,0,0,

D9880,35,1,

C9872,68,

D9863,35,2,

B9894,2,CORE 2

D9871,35,0,

D8535,35,1,

D8536,35,1,

D9878,35,0,

C9492,100,1,

C8562,2,51,0,1,0,

I8532,35,0,

D9863,35,2,

D9878,35,1,

B8533,2,ROD

D9880,35,1,

B9894,2,CORE 1

D9896,35,1,

C9474,1/6,1/3,.5,1/-4,

D9856,35,0,2,1,

C9891,2,0,2,54,

C8562,8,05,0,.5,

I8532,35,1,

B8076,2,RAD

B8078,2,8/5/59

B8193,6,UNCLASSIFIED

D8000,35,3,0,1,1,1,0,0,0,2,1,

C8011,0,0,0,0,1,

C8017,0,0,0,0,

D8532,35,2,

B5990,2,AVG,CORE

B5992,2,ROD

D5997,35,0,

D5994,35,1,1,1,

B8025,2,CORE 1

B8027,2,CORE 2

B6000,2,CORE 1

B6002,2,CORE 2

B6004,2,SIDE

C6100,24,74,25,

C6104,35,10,

C6108,45,10,

B6300,10,CORE 1 CORE 2 SIDE

18192,35,1,

B8076,2,LONG

B8078,2,8/5/59

B8193,6,UNCLASSIFIED

D8000,35,3,0,0,1,1,0,0,0,1,1,

C8011,0,0,0,0,0,35,

C8017,0,0,0,0,

D8532,35,2,

B5990,2,AVG,CORE

D5997,35,0,

D5994,35,1,1,0,

B6000,2,END

B6002,2,AVG.CORE

B6004,2,END

C6100,10,10,

C6104,60,50,

C6108,75,15,

B6300,10,END AVG.CORE

18192,35,1,

8

***** GENERAL INPUT *****

NAME W.B.HENDERSON EXT.736

GEORGE CASE GEORGE SAMPLE TEST CASE

DATE AUGUST 5,1959

CLASSIFICATION UNCLASSIFIED

NUMBER OF CORE OR END COMPOSITIONS 4

NUMBER OF SIDE COMPOSITIONS 1

NUMBER OF CONTROL COMPOSITIONS 1

NUMBER OF F2 CASES 2

C1-F2 CALCULATION YES

C23-REACTIVITY MATCH YES

***** CASE NUMBERS FOR C-F REACTIVITY MATCH *****

REFERENCE C2 COMPOSITION AVG.CORE

RADIAL F2 CASE NUMBER RAD

LONGITUDINAL F2 CASE NUMBER LONG

***** INVERSE PERIOD, OMEGA, (PER SECOND) *****

0.000000, 0

```
*****  
* UNCLASSIFIED *  
* W.B.HENDERSON EXT.736 *  
* THIS I2 AT LEVEL THERMAL *  
* CALCULATED FOR CORE/END CASE CORE 1 *  
*****
```

PROGRAM 12

P3 APPROXIMATION TO THE SOLUTION OF THE TRANSPORT EQUATION

BY WEIL METHOD

INTERMEDIATE PROGRAM

CASE NUMBER 1.00000

DATA INPUT

INPUT TYPE B

NUMBER OF MATERIALS 2

NUMBER OF ZONES 3

NUMBER OF RADII 10

MATERIAL NUMBER 1

SIGMA ABSR 1.8648197,-1

SIGMA SCAT0 1.1071330,-2

SIGMA SCAT1 2.1381594,-4

SIGMA SCAT2 0.0000000, 0

MATERIAL NUMBER 2

SIGMA ABSR 1.9539445,-2

SIGMA SCAT0 3.1578092, 0

SIGMA SCAT1 9.0823721,-1

SIGMA SCAT2 1.2999999,-1

ZONE DATA ORDERED FROM OUTER-MOST TO INNER-MOST ZONE

OUTER RADIUS OF ZONE	MATERIAL NUMBER	SOURCE TERM OF ZONE
3.0000000	2	1.0000000
2.0000000	1	0.0000000
1.6000000	2	1.0000000

OUTPUT

AVERAGE FLUX WITHIN A ZONE

ORDERED FROM OUTER-MOST TO INNER-MOST ZONE

124.05939
-----108.98369
-----122.24458

AVERAGE NON-MODERATOR FLUX
-----108.98369

AVERAGE MODERATOR FLUX
-----123.44485

CELL CORRECTION
-----0.8828533

ABSORPTION CHECK
-----T.A. 23.750442
-----T.S. 23.750440

FLUX AND RADIAL CURRENT		
RADIUS	FLUX	CURRENT
3.0000000	1.2918698, 2	-1.1235210, -6
2.9000000	1.2897939, 2	-3.8254464, -1
2.8000000	1.2853170, 2	-7.7962676, -1
2.7000000	1.2781229, 2	-1.1933250, 0
2.6000000	1.2678831, 2	-1.6260423, 0
2.5000000	1.2541713, 2	-2.0805720, 0
2.4000000	1.2363402, 2	-2.5601983, 0
2.3000000	1.2133133, 2	-3.0688466, 0
2.2000000	1.1831996, 2	-3.6113215, 0
2.1000001	1.1425711, 2	-4.1936885, 0
2.0000000	1.0850883, 2	-4.8239182, 0
1.9600000	1.0852149, 2	-4.1046795, 0
1.9200000	1.0856378, 2	-3.3721294, 0
1.8800000	1.0863638, 2	-2.6252012, 0
1.8400000	1.0874003, 2	-1.8627441, 0
1.8000000	1.0887553, 2	-1.0835148, 0
1.7600001	1.0904376, 2	-2.8616694, -1
1.7200001	1.0924563, 2	5.3076048, -1
1.6800001	1.0948217, 2	1.3688593, 0
1.6400001	1.0975447, 2	2.2298645, 0
1.6000000	1.1006373, 2	3.1156750, 0
1.4400000	1.1616494, 2	2.7746430, 0
1.2800000	1.2013621, 2	2.4460540, 0
1.1200000	1.2306423, 2	2.1257904, 0
0.9600000	1.2537662, 2	1.8117594, 0
0.8000000	1.2724390, 2	1.5026617, 0
0.6400000	1.2873565, 2	1.1975140, 0
0.4800000	1.2988128, 2	8.9546232, -1
0.3200000	1.3069391, 2	5.9570726, -1
0.1600000	1.3117965, 2	2.9747427, -1

```
*****  
* UNCLASSIFIED *  
* W.B.HENDERSON EXT.736 *  
* THIS I2 AT LEVEL SIXTEEN *  
* CALCULATED FOR CORE/END CASE CORE 1 *  
*****
```

PROGRAM I2

P3 APPROXIMATION TO THE SOLUTION OF THE TRANSPORT EQUATION

BY WEIL METHOD

INTERMEDIATE PROGRAM

CASE NUMBER 1.00000

DATA INPUT

INPUT TYPE B

NUMBER OF MATERIALS 2

NUMBER OF ZONES 3

NUMBER OF RADII 10

MATERIAL NUMBER 1

SIGMA ABSR 6.2742830,-2

SIGMA SCAT0 1.0836709,-2

SIGMA SCAT1 2.0744220,-4

SIGMA SCAT2 0.0000000, 0

MATERIAL NUMBER 2

SIGMA ABSR 6.6107795,-3

SIGMA SCAT0 1.8218130, 0

SIGMA SCAT1 9.2091649,-1

SIGMA SCAT2 2.3999999,-1

ZONE DATA ORDERED FROM OUTER-MOST TO INNER-MOST ZONE

OUTER RADIUS OF ZONE	MATERIAL NUMBER	SOURCE TERM OF ZONE
3.0000000	2	1.0000000
2.0000000	1	0.0000000
1.6000000	2	1.0000000

OUTPUT

AVERAGE FLUX WITHIN A ZONE
ORDERED FROM OUTER-MOST TO INNER-MOST ZONE
-----344.28037
-----335.50878
-----343.17978

AVERAGE NON-MODERATOR FLUX
-----335.50878

AVERAGE MODERATOR FLUX
-----343.90768

CELL CORRECTION
-----0.9755780

ABSORPTION CHECK
-----T.A. 23.750377
-----T.S. 23.750440

FLUX AND RADIAL CURRENT		
RADIUS	FLUX	CURRENT
3.0000000	3.4773081, 2	2.8230667, -5
2.9000000	3.4748556, 2	-4.0535741, -1
2.8000000	3.4712680, 2	-8.2566875, -1
2.7000000	3.4662763, 2	-1.2626339, 0
2.6000000	3.4595682, 2	-1.7182575, 0
2.5000000	3.4507555, 2	-2.1948762, 0
2.4000000	3.4393291, 2	-2.6952301, 0
2.3000000	3.4245973, 2	-3.2225554, 0
2.2000000	3.4056017, 2	-3.7807060, 0
2.1000001	3.3809939, 2	-4.3743107, 0
2.0000000	3.3488584, 2	-5.0089859, 0
1.9600000	3.3498673, 2	-4.2620410, 0
1.9200000	3.3509737, 2	-3.5012175, 0
1.8800000	3.3521805, 2	-2.7256165, 0
1.8400000	3.3534900, 2	-1.9342603, 0
1.8000000	3.3549056, 2	-1.1260859, 0
1.7600001	3.3564302, 2	-2.9993527, -1
1.7200001	3.3580674, 2	5.4545655, -1
1.6800001	3.3598205, 2	1.4114740, 0
1.6400001	3.3616939, 2	2.2996364, 0
1.6000000	3.3636916, 2	3.2115293, 0
1.4400000	3.3961202, 2	2.8847155, 0
1.2800000	3.4196475, 2	2.5601936, 0
1.1200000	3.4372264, 2	2.2373789, 0
0.9600000	3.4506401, 2	1.9158335, 0
0.8000000	3.4609672, 2	1.5952494, 0
0.6400000	3.4688609, 2	1.2753970, 0
0.4800000	3.4747155, 2	9.5609340, -1
0.3200000	3.4787669, 2	6.3718360, -1
0.1600000	3.4811512, 2	3.1852902, -1

```
*****  
* UNCLASSIFIED *  
* W.B. HENDERSON EXT. 736 *  
* THIS I2 AT LEVEL SEVENTEEN *  
* CALCULATED FOR CORE/END CASE CORE 1 *  
*****
```

PROGRAM I2

P3 APPROXIMATION TO THE SOLUTION OF THE TRANSPORT EQUATION

BY WEIL METHOD

INTERMEDIATE PROGRAM

CASE NUMBER 1.00000

DATA INPUT

INPUT TYPE B

NUMBER OF MATERIALS 2

NUMBER OF ZONES 3

NUMBER OF RADII 10

MATERIAL NUMBER 1

SIGMA ABSR 9.2052196,-2

SIGMA SCAT0 1.0605532,-2

SIGMA SCAT1 2.0185741,-4

SIGMA SCAT2 0.0000000, 0

MATERIAL NUMBER 2

SIGMA ABSR 1.1518749,-2

SIGMA SCAT0 2.4157374, 0

SIGMA SCAT1 1.0210160, 0

SIGMA SCAT2 1.9999999,-1

ZONE DATA ORDERED FROM OUTER-MOST TO INNER-MOST ZONE

OUTER RADIUS OF ZONE	MATERIAL NUMBER	SOURCE TERM OF ZONE
3.0000000	2	1.0000000
2.0000000	1	0.0000000
1.6000000	2	1.0000000

OUTPUT

AVERAGE FLUX WITHIN A ZONE

ORDERED FROM OUTER-MOST TO INNER-MOST ZONE

222.75179

212.25567

221.65310

AVERAGE NON-MODERATOR FLUX

212.25567

AVERAGE MODERATOR FLUX

222.37974

CELL CORRECTION

0.9544739

ABSORPTION CHECK

T.A. 23.750400

T.S. 23.750440

FLUX AND RADIAL CURRENT		
RADIUS	FLUX	CURRENT
3.0000000	2.2649582, 2	1.2686425, -5
2.9000000	2.2629796, 2	-3.7384798, -1
2.8000000	2.2595491, 2	-7.6160080, -1
2.7000000	2.2543789, 2	-1.1649536, 0
2.6000000	2.2471477, 2	-1.5858909, 0
2.5000000	2.2374426, 2	-2.0267309, 0
2.4000000	2.2246787, 2	-2.4902035, 0
2.3000000	2.2079795, 2	-2.9795563, 0
2.2000000	2.1859882, 2	-3.4987024, 0
2.1000001	2.1565627, 2	-4.0524266, 0
2.0000000	2.1162796, 2	-4.6466848, 0
1.9600000	2.1171945, 2	-3.9541654, 0
1.9200000	2.1182429, 2	-3.2486634, 0
1.8800000	2.1194281, 2	-2.5293157, 0
1.8400000	2.1207538, 2	-1.7951851, 0
1.8000000	2.1222240, 2	-1.0452535, 0
1.7600001	2.1238428, 2	-2.7841264, -1
1.7200001	2.1256146, 2	5.0654733, -1
1.6800001	2.1275443, 2	1.3109480, 0
1.6400001	2.1296369, 2	2.1362395, 0
1.6000000	2.1318976, 2	2.9840148, 0
1.4400000	2.1739230, 2	2.6734543, 0
1.2800000	2.2024398, 2	2.3680888, 0
1.1200000	2.2231906, 2	2.0662747, 0
0.9600000	2.2390443, 2	1.7670555, 0
0.8000000	2.2514408, 2	1.4698168, 0
0.6400000	2.2611066, 2	1.1741139, 0
0.4800000	2.2684105, 2	8.7958769, -1
0.3200000	2.2735398, 2	5.8592158, -1
0.1600000	2.2765885, 2	2.9282059, -1

 CORE OR END COMPOSITION

COMPOSITION INPUT

CASE NUMBER	CORE 1	
C2-INPUT UNITS	C.G.S.	
C3-THERMAL BASE	SET T=T+1	
C4-SLOWING DOWN MODEL	MODIFIED AGE	
C5-GROUP DIVISION	N=T	
C8-G FACTOR APPLICATION	ALL SIGMAS	
C17-PHOTON PRODUCTION CALCULATION		YES
C19-PRINT OUT		LONG
C21-ADJOINT CALCULATION		NO
C22-MULTI GROUP CALCULATION		YES
C31-CLEAR INPUT AFTER CALCULATION		NO
C32-RERUN THIS COMPOSITION IN REACTIVITY MATCH		YES

 BEHRENS INPUT

C6-BEHRENS CALCULATION	CALCULATE F/R, F/Z
C10-G FACTORS IN BEHRENS CORRECTION	YES
C11-MODERATOR X-SECTION IN BEHRENS CORRECTION	SIGMA TOTAL

D1	D2	D3	M
FUEL ZONE I.D.	FUEL ZONE O.D.	CELL DIAMETER	NUMBER OF CELLS
3.1999999, 0	4.0000000, 0	6.0000000, 0	0.0000000, 0

 I2 INPUT

C7-I2 CALCULATION	YES
C9-LEAKAGE TERM ADDED TO SIGMA A	NO
C12-I2 AT THERMAL	YES, TYPE B
C13-I2 AT LEVEL 16	YES, TYPE B
C14-I2 AT LEVEL 17	YES, TYPE B
C20-FINE RADIAL POWER CALCULATION	YES
C30-G RECIPE	G CELL=1

TERRALL INPUT

C18-TERRALL METHOD NO

ESTAR E*

TPF

SLOWING DOWN CUT-OFF (EV)

FUEL TEMPERATURE DEGREES F

0.000000, 0

0.000000, 0

BUCKLING GEOMETRY

C16-GEOMETRY CYLINDER

SAVINGS ON H

S/Z

3.9685362, 0

HEIGHT

H

5.000000, 1

SAVINGS ON D

S/R

1.1898314, 1

DIAMETER

D

7.000000, 1

VOLUME GEOMETRY

DCO

DCI

L

VOC

OUTER DIAMETER

INNER DIAMETER

LENGTH

COMPOSITION VOLUME

0.000000, 0

0.000000, 0

0.000000, 0

0.000000, 0

CSP

TPM

CODE NUMBER OF SPECTRUM

MODERATOR TEMPERATURE DEGREES F

0.9420

6.800000, 1

TABLE 3M,I2 MATERIAL NUMBER 1

C28-FUEL YES

GEOMETRY FOR VOLUME CALCULATION

OUTER RADIUS		INNER RADIUS		LENGTH		MATERIAL VOLUME	
0.0000000, 0		0.0000000, 0		0.0000000, 0		0.0000000, 0	
CODE	WEIGHT	F OR N	SIGMA/S2,I+1	SIGMA/S2,16	SIGMA/S2,17		
-1.130	0.000000, 0	6.9999999,-3	0.0000000, 0	0.0000000, 0	0.0000000, 0		
5.110	0.000000, 0	9.2999999,-2	0.0000000, 0	0.0000000, 0	0.0000000, 0		

TABLE 3M,I2 MATERIAL NUMBER 2

C28-FUEL NO

GEOMETRY FOR VOLUME CALCULATION

OUTER RADIUS		INNER RADIUS		LENGTH		MATERIAL VOLUME	
0.0000000, 0		0.0000000, 0		0.0000000, 0		0.0000000, 0	
CODE	WEIGHT	F OR N	SIGMA/S2,I+1	SIGMA/S2,16	SIGMA/S2,17		
2.510	0.000000, 0	1.0000000, 0	1.2999999,-1	2.3999999,-1	1.9999999,-1		

TABLE M1 MODERATOR

ELEMENT	CODE	WEIGHT	F/H OR N/H	G/T+1	G/16	G/17
*WATER	2.510	0.000000, 0	8.3929998, -1	1.019102	1.003923	1.007338

TABLE F1 FUEL

ELEMENT	CODE	WEIGHT	F/H OR N/H	G/T+1	G/16	G/17
*ORALLOY	-1.130	0.000000, 0	1.1200000, -3	0.899717	0.979405	0.961477
*ALUMINUM	5.110	0.000000, 0	1.4880000, -2	0.899717	0.979405	0.961477

HYDRAULIC DIAMETER		FUEL 8.0000001,-1		MODERATOR 4.1999999, 0	
BEHRENS CROSS SECTIONS					
N	SIGMA/S,MOD	SIGMA/A,MOD	SIGMA/A,FUEL	ATTENUATION FACTORS	
				X-FUEL	Y-MOD
0	7.3406384,-2	1.1080379,-6	5.5514335,-4	4.4411469,-4	3.0831145,-1
1	1.2545818,-1	1.4208439,-6	5.0696100,-4	4.0556880,-4	5.2693032,-1
2	2.1154385,-1	1.8239671,-6	4.7590223,-4	3.8072179,-4	8.8849183,-1
3	2.2355580,-1	2.3350303,-6	4.7526519,-4	3.8021216,-4	9.3894418,-1
4	3.4234068,-1	3.0179166,-6	4.7019193,-4	3.7615354,-4	1.4378435, 0
5	4.9949708,-1	3.9550029,-6	4.9665470,-4	3.9732376,-4	2.0979038, 0
6	5.4721123,-1	4.9564323,-6	5.2824621,-4	4.2259697,-4	2.2983079, 0
7	6.6566244,-1	6.3662620,-6	5.9071584,-4	4.7257268,-4	2.7958089, 0
8	7.9245529,-1	8.1726063,-6	6.2234862,-4	4.9787890,-4	3.3283464, 0
9	1.3196465, 0	2.2248874,-5	1.0292446,-3	8.2339571,-4	5.5426090, 0
10	1.4297561, 0	6.0358332,-5	1.8145380,-3	1.4516304,-3	6.0052292, 0
11	1.4597860, 0	1.6433326,-4	4.5483587,-3	3.6386870,-3	6.1317914, 0
12	1.4597860, 0	4.4718035,-4	2.0574323,-2	1.6459458,-2	6.1329793, 0
13	1.4614543, 0	1.2137752,-3	4.1648942,-2	3.3319154,-2	6.1432061, 0
14	1.4948209, 0	2.2843646,-3	1.2175612,-2	9.7404904,-3	6.2878420, 0
15	1.5014942, 0	4.3858919,-3	2.7117261,-2	2.1693809,-2	6.3246963, 0
16	1.8289597, 0	6.6367124,-3	6.1450645,-2	4.9160516,-2	7.7095048, 0
17	2.4334630, 0	1.1603268,-2	8.8506114,-2	7.0804892,-2	1.0269278, 1
18	3.3187796, 0	2.0866687,-2	1.9298820,-1	1.5439056,-1	1.4026514, 1
T	3.2181281, 0	1.9912677,-2	1.6778102,-1	1.3422481,-1	1.3599771, 1
T+1	3.2181281, 0	1.9912677,-2	1.6778102,-1	1.3422481,-1	1.3599771, 1

N	BEHRENS FACTOR F/R	BEHRENS FACTOR F/Z	SOURCE SPECTRUM
	F/R	F/Z	
0	1.0002023, 0	1.0041469, 0	0.0000000, 0
1	1.0005893, 0	1.0073313, 0	8.7378149,-2
2	1.0016617, 0	1.0130300, 0	3.7532886,-1
3	1.0018530, 0	1.0138669, 0	4.7365445,-1
4	1.0042639, 0	1.0226614, 0	4.2566089,-1
5	1.0087620, 0	1.0356045, 0	3.0059730,-1
6	1.0103825, 0	1.0397884, 0	1.5546837,-1
7	1.0148342, 0	1.0506036, 0	9.8710099,-2
8	1.0201612, 0	1.0627428, 0	3.2979099,-2
9	1.0458654, 0	1.1167524, 0	1.6243999,-4
10	1.0515720, 0	1.1283274, 0	2.2580000,-5
11	1.0530353, 0	1.1312372, 0	3.0299999,-6
12	1.0523743, 0	1.1295949, 0	4.7000000,-7
13	1.0516225, 0	1.1276787, 0	0.0000000, 0
14	1.0546492, 0	1.1343534, 0	0.0000000, 0
15	1.0544525, 0	1.1336712, 0	0.0000000, 0
16	1.0696601, 0	1.1636078, 0	0.0000000, 0
17	1.0986199, 0	1.2210814, 0	0.0000000, 0
18	1.1319166, 0	1.2857706, 0	0.0000000, 0
T	1.1298277, 0	1.2820395, 0	
T+1	1.1298277, 0	1.2820395, 0	

TABLE C4

N	SCATTER	XI-SCATTER	TRANSPORT	ABSORPTION	FISSION
	X-SECTION	X-SECTION	X-SECTION	X-SECTION	X-SECTION
0	6.3444914,-2	5.4406308,-2	3.7580390,-2	8.9753691,-5	1.9489231,-4
1	1.0729527,-1	7.9412470,-2	4.8548388,-2	8.2307271,-5	1.7314324,-4
2	1.7995491,-1	1.2265760,-1	1.0631944,-1	7.7676491,-5	1.6298346,-4
3	1.9091897,-1	1.6089551,-1	7.4109033,-2	7.8003859,-5	1.6255661,-4
4	2.8973653,-1	2.2220017,-1	1.5344187,-1	7.7765759,-5	1.5035152,-4
5	4.2256556,-1	2.8749671,-1	2.3330926,-1	8.2702957,-5	1.4812837,-4
6	4.6480850,-1	3.6147727,-1	2.5152360,-1	8.8682799,-5	1.5800360,-4
7	5.6119130,-1	4.6690931,-1	2.6769360,-1	9.9862198,-5	1.8269166,-4
8	6.7319387,-1	5.7397905,-1	2.8763065,-1	1.0644077,-4	1.9256689,-4
9	1.1103513, 0	1.0163961, 0	4.3904764,-1	1.8336819,-4	3.4069526,-4
10	1.2926729, 0	1.1088757, 0	4.6606849,-1	3.4102708,-4	5.4807499,-4
11	1.2278980, 0	1.1341008, 0	4.7559797,-1	8.6577735,-4	1.2146526,-3
12	1.2278902, 0	1.1341007, 0	4.7559018,-1	3.6675232,-3	4.6166678,-2
13	1.2292766, 0	1.1380240, 0	4.7809790,-1	7.6834021,-3	8.2458129,-3
14	1.2573757, 0	1.1604515, 0	4.8377292,-1	3.8669644,-3	2.7946887,-3
15	1.2636167, 0	1.1604541, 0	5.3425766,-1	8.0229111,-3	9.2333356,-3
16	1.5380243, 0	1.1875123, 0	7.6138737,-1	1.5406941,-2	1.9392050,-2
17	2.0457404, 0	1.2480140, 0	1.1817628, 0	2.3907724,-2	2.9547838,-2
18	2.7893227, 0	1.3197084, 0	2.1894649, 0	4.8406131,-2	6.3793645,-2
T	2.7648213, 0	1.2734407, 0	1.9272984, 0	4.3571613,-2	5.4953161,-2
T+1	2.7648213, 0	1.2734407, 0	1.9272984, 0	4.3571613,-2	5.4953161,-2

N	EXTRAPOLATION DISTANCE	TOTAL BUCKLING	X/R/S BUCKLING	Y/Z BUCKLING	Z BUCKLING
0	1.8861090, 1	2.4158176, -3	1.3372108, -3	1.0786068, -3	0.0000000, 0
1	1.4610113, 1	2.8277334, -3	1.5284328, -3	1.2993005, -3	0.0000000, 0
2	6.6778122, 0	3.9564275, -3	2.0145266, -3	1.9419009, -3	0.0000000, 0
3	9.5771446, 0	3.4737484, -3	1.8129928, -3	1.6607555, -3	0.0000000, 0
4	4.6280722, 0	4.3640731, -3	2.1779919, -3	2.1860811, -3	0.0000000, 0
5	3.0442350, 0	4.7260701, -3	2.3183244, -3	2.4077457, -3	0.0000000, 0
6	2.8230036, 0	4.7803732, -3	2.3390008, -3	2.4413724, -3	0.0000000, 0
7	2.6531640, 0	4.8227302, -3	2.3550622, -3	2.4676679, -3	0.0000000, 0
8	2.4692679, 0	4.8692621, -3	2.3726403, -3	2.4966217, -3	0.0000000, 0
9	1.6175997, 0	5.0942659, -3	2.4566721, -3	2.6375938, -3	0.0000000, 0
10	1.5233393, 0	5.1201723, -3	2.4662459, -3	2.6539264, -3	0.0000000, 0
11	1.4911942, 0	5.1290547, -3	2.4695238, -3	2.6595309, -3	0.0000000, 0
12	1.4825009, 0	5.1314609, -3	2.4704113, -3	2.6610496, -3	0.0000000, 0
13	1.4625923, 0	5.1369783, -3	2.4724457, -3	2.6645326, -3	0.0000000, 0
14	1.4570177, 0	5.1385249, -3	2.4730158, -3	2.6655091, -3	0.0000000, 0
15	1.3102073, 0	5.1795209, -3	2.4881010, -3	2.6914199, -3	0.0000000, 0
16	9.1465653, -1	5.2925805, -3	2.5294387, -3	2.7631417, -3	0.0000000, 0
17	5.8929061, -1	5.3885251, -3	2.5642180, -3	2.8243071, -3	0.0000000, 0
18	3.1748923, -1	5.4708024, -3	2.5938260, -3	2.8769763, -3	0.0000000, 0
T	3.6050067, -1	5.4576511, -3	2.5891068, -3	2.8685442, -3	0.0000000, 0
T+1	3.6050067, -1	5.4576511, -3	2.5891068, -3	2.8685442, -3	0.0000000, 0

N	EXPANSION PARAMETER	SMALLNESS PARAMETER	TOTAL LEAKAGE	RADIAL LEAKAGE	LONGITUDINAL LEAKAGE
0	5.9847034, -1	1.4107638, -1	1.7302062, -2	9.5602569, -3	7.7418058, -3
1	2.4525126, -1	6.1223409, -2	1.7137181, -2	9.2343175, -3	7.9028641, -3
2	1.2206775, -1	3.1099535, -2	1.1860769, -2	6.0057895, -3	5.8549803, -3
3	9.5223771, -2	2.4368901, -2	1.4798216, -2	7.6793485, -3	7.1188682, -3
4	5.1957997, -2	1.3392845, -2	9.3665168, -3	4.6320705, -3	4.7344462, -3
5	2.6457084, -2	6.8487466, -3	6.8167364, -3	3.2991543, -3	3.5175821, -3
6	2.2118108, -2	5.7297005, -3	6.4240525, -3	3.0972054, -3	3.3268470, -3
7	1.5307933, -2	3.9700392, -3	6.1507854, -3	2.9503761, -3	3.2004092, -3
8	1.0741019, -2	2.7877597, -3	5.8396587, -3	2.7858630, -3	3.0537956, -3
9	4.1306357, -3	1.0732657, -3	4.1739335, -3	1.9446070, -3	2.2293265, -3
10	3.5378810, -3	9.1934015, -4	3.9841341, -3	1.8490904, -3	2.1350437, -3
11	3.3970386, -3	8.8276218, -4	3.9151743, -3	1.8151707, -3	2.1000036, -3
12	3.3832294, -3	8.7917572, -4	3.8900921, -3	1.8041353, -3	2.0859568, -3
13	3.3573483, -3	8.7245397, -4	3.8373871, -3	1.7801675, -3	2.0572196, -3
14	3.2302871, -3	8.3945316, -4	3.8413540, -3	1.7789860, -3	2.0623680, -3
15	3.2060580, -3	8.3316016, -4	3.4814140, -3	1.6095425, -3	1.8718715, -3
16	2.1932260, -3	5.7005149, -4	2.5378280, -3	1.1597059, -3	1.3781221, -3
17	1.2579890, -3	3.2702088, -4	1.7313449, -3	7.7841069, -4	9.5293424, -4
18	6.7937446, -4	1.7662407, -4	9.8808799, -4	4.3722170, -4	5.5086629, -4
T	7.2251709, -4	1.8783895, -4	1.1164448, -3	4.9461721, -4	6.2182761, -4
T+1	7.2251709, -4	1.8783895, -4	1.1164448, -3	4.9461721, -4	6.2182761, -4

N	LETHARGY	SLOWING DOWN PARAMETER V	SLOWING DOWN PARAMETER W	SLOWING DOWN DENSITY
0	0.0000000, 0	7.5776781, -1	2.4223218, -1	0.0000000, 0
1	5.0000000, -1	8.2180337, -1	1.7819662, -1	1.7186280, -2
2	1.0000000, 0	9.1130166, -1	8.8698334, -2	1.1728134, -1
3	1.5000000, 0	9.1536624, -1	8.4633752, -2	3.0218813, -1
4	2.0000000, 0	9.5922940, -1	4.0770597, -2	5.0115463, -1
5	2.5000000, 0	9.7656409, -1	2.3435905, -2	6.6759982, -1
6	3.0000000, 0	9.8230186, -1	1.7698131, -2	7.7184069, -1
7	3.5000000, 0	9.8678956, -1	1.3210430, -2	8.2822111, -1
8	4.0000000, 0	9.8974678, -1	1.0253213, -2	8.5580389, -1
9	6.0000000, 0	9.9573129, -1	4.2687058, -3	8.7609207, -1
10	8.0000000, 0	9.9611467, -1	3.8853287, -3	8.6915954, -1
11	1.0000000, 1	9.9580206, -1	4.1979327, -3	8.6218865, -1
12	1.2000000, 1	9.9338015, -1	6.6198483, -3	8.5292647, -1
13	1.4000000, 1	9.8927795, -1	1.0022044, -2	8.3887346, -1
14	1.5500000, 1	9.9340131, -1	6.5986812, -3	8.2846792, -1
15	1.6500000, 1	9.9018367, -1	9.8163262, -3	8.2170148, -1
16	1.7500000, 1	9.8511371, -1	1.4886282, -2	8.1162738, -1
17	1.8500000, 1	9.7986966, -1	2.0130336, -2	7.9755876, -1
T	1.9554883, 1	9.6609735, -1	3.3902645, -2	7.7522824, -1
T+1	1.9554883, 1	0.0000000, 0	0.0000000, 0	0.0000000, 0

N	FLUX	LEAKAGE SPECTRUM	ABSORPTION SPECTRUM	FISSION SPECTRUM
0	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0
1	1.0820895, 0	1.8543964, -2	8.9063835, -5	1.8735649, -4
2	3.6599158, 0	4.3409419, -2	2.8428942, -4	5.9650575, -4
3	4.4139212, 0	6.5318163, -2	3.4430289, -4	7.1751209, -4
4	4.0010261, 0	3.7475678, -2	3.1114283, -4	6.0156039, -4
5	3.2887560, 0	2.2418583, -2	2.7198985, -4	4.8715810, -4
6	2.5199300, 0	1.6188162, -2	2.2347444, -4	3.9815801, -4
7	1.9590229, 0	1.2049529, -2	1.9563233, -4	3.5789715, -4
8	1.5325822, 0	8.9497573, -3	1.6312923, -4	2.9512459, -4
9	8.5843894, -1	3.5830671, -3	1.5741040, -4	2.9246608, -4
10	7.8079538, -1	3.1107935, -3	2.6627237, -4	4.2793442, -4
11	7.5705106, -1	2.9639869, -3	6.5543766, -4	9.1955410, -4
12	7.4709471, -1	2.9062672, -3	2.7399872, -3	3.4490881, -3
13	7.2974403, -1	2.8003104, -3	5.6069169, -3	6.0173328, -3
14	7.0920768, -1	2.7243178, -3	2.7424808, -3	1.9820146, -3
15	7.0113532, -1	2.4409423, -3	5.6251463, -3	6.4738176, -3
16	6.7329429, -1	1.7087051, -3	1.0373406, -2	1.3056556, -2
17	6.2619778, -1	1.0841643, -3	1.4970964, -2	1.8502790, -2
T	5.8812783, -1	6.5661227, -4	2.5625678, -2	3.2319483, -2
T+1	1.7347548, 1	1.9367580, -2	7.5586065, -1	9.5330262, -1

CALCULATED REACTIVITY	1.0341180, 0
POWER LEVEL 17	1.5259063, -2
POWER LEVEL T	2.5921388, -2
POWER LEVEL T+1	9.2185084, -1
BALANCE CHECK DISCREPANCY	-9.9888240, -5

LETHARGY INDEX	19
LETHARGY AT INDEX	1.9554883, 1

TWO-GROUP RESULTS

	FAST	SLOW
DIFFUSION COEFFICIENT, ONE-GROUP BUCKLING	1.3780604, 0	2.2558155, -1
DIFFUSION COEFFICIENT, TWO-GROUP BUCKLING	1.4777205, 0	2.0456507, -1
SIGMA ABSORPTION	2.8864023, -3	4.3571612, -2
NU SIGMA FISSION	3.4899848, -3	5.4953161, -2
FLUX	2.3156393, 1	1.7347548, 1
MULTIPLICATION	1.2091123, 0	1.2612147, 0
SIGMA LEAKAGE	6.8202759, -3	1.1164448, -3
DIFFUSION AREA, ONE-GROUP BUCKLING	3.7895931, 1	5.1772596, 0
DIFFUSION AREA, TWO-GROUP BUCKLING	4.0636531, 1	4.6949161, 0
BUCKLING	4.6154030, -3	5.4576511, -3
EXTRAPOLATION DISTANCE	3.5076990, 0	3.6050067, -1
SLOWING DOWN 8-SECTION	3.3477935, -2	
AVERAGE BUCKLING	4.9491848, -3	
AVERAGE EXTRAPOLATION DISTANCE	2.1597764, 0	
ABSORPTION ESCAPE PROBABILITY	9.2062547, -1	
REACTIVITY, ONE-GROUP BUCKLING	1.0341181, 0	
REACTIVITY, TWO-GROUP BUCKLING	1.0341181, 0	

MULTIGROUP CONSTANTS

N	ENERGY	LETHARGY	SLOWING DOWN DENSITY
1	1.0000000, 2	1.1512829, 1	8.5518261, -1
2	1.0000000, 0	1.6117999, 1	8.2428626, -1
GROUP	MULTIPLICATION	BUCKLING	EXTRAPOLATION DISTANCE
1	1.5240739, 0	4.4490632, -3	4.2381139, 0
2	1.0560930, 0	5.1371951, -3	1.4618104, 0
3	1.2599324, 0	5.4403165, -3	4.1744413, -1
GROUP	SIGMA LEAKAGE	FLUX	SIGMA ABSORPTION
1	7.9581993, -3	1.7553170, 1	2.7065942, -4
2	3.8419640, -3	3.3573543, 0	5.3808559, -3
3	1.2611435, -3	1.9593417, 1	4.0824064, -2
GROUP	SOURCE TERM	NU SIGMA FISSION	SLOWING DOWN X-SECTION
1	9.9999911, -1	4.1250498, -4	4.8719552, -2
2	8.5086441, -7	5.6826845, -3	2.4551661, -1
3	0.0000000, 0	5.1435566, -2	0.0000000, 0
GROUP	ABSORPTION ESCAPE PROBABILITY	DIFFUSION COEFFICIENT ONE-GROUP BUCKLING	DIFFUSION COEFFICIENT MULTIGROUP BUCKLING
1	9.9447523, -1	1.6079815, 0	1.7887359, 0
2	9.7855356, -1	7.7628204, -1	7.4787192, -1
3	0.0000000, 0	2.5481839, -1	2.3181437, -1
GROUP	DIFFUSION AREA ONE-GROUP BUCKLING	DIFFUSION AREA MULTIGROUP BUCKLING	
1	3.2822506, 1	3.6512109, 1	
2	3.0940210, 0	2.9807870, 0	
3	6.2418672, 0	5.6783756, 0	
REACTIVITY, ONE-GROUP BUCKLING		1.0340492, 0	
REACTIVITY, MULTIGROUP BUCKLING		1.0340492, 0	

PHOTON PRODUCTION PARAMETERS			ASSUMES NU = 2.46
P	ENERGY	LETHARGY	GROUP FLUX
1	1.0000000, 6	2.3024893, 0	6.7233151, 0
2	1.0000000, 3	9.2102446, 0	9.0886753, 0
3	5.0000000, -1	1.6811146, 1	5.5837655, 0
4	9.9999999, -5	1.9554883, 1	1.7606382, 0
5			1.7347548, 1

ELEMENT -1.130 *ORALLOY

GROUP	ABSORPTION CROSS SECTION	FISSION CROSS SECTION
1	7.6386501, -5	6.4849874, -5
2	1.5501812, -4	1.1987554, -4
3	3.3429650, -3	1.9689052, -3
4	1.3799540, -2	1.1548307, -2
5	2.6680301, -2	2.2338683, -2

ELEMENT 2.510 *WATER

GROUP	ABSORPTION CROSS SECTION	FISSION CROSS SECTION
1	1.9972937, -6	
2	1.8895593, -5	
3	1.0554230, -3	
4	8.8855330, -3	
5	1.6726649, -2	

ELEMENT 5.110 *ALUMINUM

GROUP	ABSORPTION CROSS SECTION	FISSION CROSS SECTION
1	2.2272244, -8	
2	2.1070875, -7	
3	1.1760383, -5	
4	9.2872456, -5	
5	1.6466311, -4	

FINE RADIAL POWER

ZONE 3	CODE 0.0000000, 0	LATTICE	RADIUS	POWER
		32	3.0000000, 0	0.0000000, 0
		31	2.9000000, 0	0.0000000, 0
		30	2.8000000, 0	0.0000000, 0
		29	2.7000000, 0	0.0000000, 0
		28	2.6000000, 0	0.0000000, 0
		27	2.5000000, 0	0.0000000, 0
		26	2.4000000, 0	0.0000000, 0
		25	2.3000000, 0	0.0000000, 0
		24	2.2000000, 0	0.0000000, 0
		23	2.1000000, 0	0.0000000, 0
		22	2.0000000, 0	0.0000000, 0
ZONE 2	CODE 1.0000000, 0	LATTICE	RADIUS	POWER
		21	2.0000000, 0	9.9585185, -1
		20	1.9600000, 0	9.9597162, -1
		19	1.9200000, 0	9.9634705, -1
		18	1.8800000, 0	9.9698400, -1
		17	1.8400000, 0	9.9788890, -1
		16	1.8000000, 0	9.9906866, -1
		15	1.7600000, 0	1.0005307, 0
		14	1.7200000, 0	1.0022832, 0
		13	1.6800000, 0	1.0043348, 0
		12	1.6400000, 0	1.0066951, 0
		11	1.5999999, 0	1.0093742, 0
ZONE 1	CODE 0.0000000, 0	LATTICE	RADIUS	POWER
		10	1.5999999, 0	0.0000000, 0
		9	1.4399999, 0	0.0000000, 0
		8	1.2800000, 0	0.0000000, 0
		7	1.1200000, 0	0.0000000, 0
		6	9.6000000, -1	0.0000000, 0
		5	8.0000001, -1	0.0000000, 0
		4	6.4000001, -1	0.0000000, 0
		3	4.8000001, -1	0.0000000, 0
		2	3.2000002, -1	0.0000000, 0
		1	1.6000002, -1	0.0000000, 0

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*****  
* UNCLASSIFIED *  
* W.B.HENDERSON EXT.736 *  
* THIS 12 AT LEVEL THERMAL *  
* CALCULATED FOR CORE/END CASE CORE 2 *  
*****
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PROGRAM 12

P3 APPROXIMATION TO THE SOLUTION OF THE TRANSPORT EQUATION

BY WEIL METHOD

INTERMEDIATE PROGRAM

CASE NUMBER 2.00000

DATA INPUT

INPUT TYPE B

NUMBER OF MATERIALS 2

NUMBER OF ZONES 3

NUMBER OF RADII 10

MATERIAL NUMBER 1

SIGMA ABSR 1.8648197,-1

SIGMA SCAT0 1.1071330,-2

SIGMA SCAT1 2.1381594,-4

SIGMA SCAT2 0.0000000, 0

MATERIAL NUMBER 2

SIGMA ABSR 1.9539445,-2

SIGMA SCAT0 3.1578092, 0

SIGMA SCAT1 9.0823721,-1

SIGMA SCAT2 1.2999999,-1

ZONE DATA ORDERED FROM OUTER-MOST TO INNER-MOST ZONE

OUTER RADIUS OF ZONE	MATERIAL NUMBER	SOURCE TERM OF ZONE
3.5000000	2	1.0000000
2.0000000	1	0.0000000
1.6000000	2	1.0000000

OUTPUT

AVERAGE FLUX WITHIN A ZONE
ORDERED FROM OUTER-MOST TO INNER-MOST ZONE
-----158.00722
-----131.21018
-----144.26217

AVERAGE NON-MODERATOR FLUX
-----131.21018

AVERAGE MODERATOR FLUX
-----154.75215

CELL CORRECTION
-----0.8478731

ABSORPTION CHECK
-----T.A. 33.960683
-----T.S. 33.960616

FLUX AND RADIAL CURRENT		
RADIUS	FLUX	CURRENT
3.5000000	1.6636098, 2	-1.9942499, -5
3.3500000	1.6605479, 2	-4.6544530, -1
3.2000000	1.6530488, 2	-9.5472840, -1
3.0500001	1.6405770, 2	-1.4726543, 0
2.9000001	1.6226620, 2	-2.0249311, 0
2.7500001	1.5987496, 2	-2.6184135, 0
2.6000001	1.5680259, 2	-3.2614470, 0
2.4500002	1.5290523, 2	-3.9644061, 0
2.3000002	1.4788658, 2	-4.7405712, 0
2.1500002	1.4106621, 2	-5.6077300, 0
2.0000000	1.3077462, 2	-6.5913961, 0
1.9600000	1.3076396, 2	-5.7405377, 0
1.9200000	1.3078819, 2	-4.8744981, 0
1.8800000	1.3084810, 2	-3.9920448, 0
1.8400000	1.3094454, 2	-3.0918479, 0
1.8000000	1.3107841, 2	-2.1724717, 0
1.7600001	1.3125073, 2	-1.2323616, 0
1.7200001	1.3146256, 2	-2.6983090, -1
1.6800001	1.3171507, 2	7.1695755, -1
1.6400001	1.3200953, 2	1.7300058, 0
1.6000000	1.3234731, 2	2.7715058, 0
1.4400000	1.3858806, 2	2.4661094, 0
1.2800000	1.4243814, 2	2.1732780, 0
1.1200000	1.4516632, 2	1.8884310, 0
0.9600000	1.4727090, 2	1.6093505, 0
0.8000000	1.4894977, 2	1.3347425, 0
0.6400000	1.5028299, 2	1.0636787, 0
0.4800000	1.5130393, 2	7.9537907, -1
0.3200000	1.5202711, 2	5.2912505, -1
0.1600000	1.5245910, 2	2.6422518, -1

```
*****  
* UNCLASSIFIED *  
* W.B.HENDERSON EXT.736 *  
* THIS I2 AT LEVEL SIXTEEN *  
* CALCULATED FOR CORE/END CASE CORE 2 *  
*****
```

PROGRAM I2

P3 APPROXIMATION TO THE SOLUTION OF THE TRANSPORT EQUATION

BY WEIL METHOD

INTERMEDIATE PROGRAM

CASE NUMBER 2.00000

DATA INPUT

INPUT TYPE B

NUMBER OF MATERIALS 2

NUMBER OF ZONES 3

NUMBER OF RADII 10

MATERIAL NUMBER 1

SIGMA ABSR 6.2742830,-2

SIGMA SCAT0 1.0836709,-2

SIGMA SCAT1 2.0744220,-4

SIGMA SCAT2 0.0000000, 0

MATERIAL NUMBER 2

SIGMA ABSR 6.6107795,-3

SIGMA SCAT0 1.8218130, 0

SIGMA SCAT1 9.2091649,-1

SIGMA SCAT2 2.3999999,-1

ZONE DATA ORDERED FROM OUTER-MOST TO INNER-MOST ZONE

OUTER RADIUS OF ZONE	MATERIAL NUMBER	SOURCE TERM OF ZONE
3.5000000	2	1.0000000
2.0000000	1	0.0000000
1.6000000	2	1.0000000

OUTPUT

AVERAGE FLUX WITHIN A ZONE

ORDERED FROM OUTER-MOST TO INNER-MOST ZONE

428.96373
-----413.80775
-----421.79852

AVERAGE NON-MODERATOR FLUX
-----413.80775

AVERAGE MODERATOR FLUX
-----427.26688

CELL CORRECTION
-----0.9684995

ABSORPTION CHECK
-----T.A. 33.960484
-----T.S. 33.960616

FLUX AND RADIAL CURRENT		
RADIUS	FLUX	CURRENT
3.5000000	4.3387463, 2	3.6888942, -5
3.3500000	4.3356726, 2	-5.2381224, -1
3.2000000	4.3309112, 2	-1.0731472, 0
3.0500001	4.3239650, 2	-1.6518868, 0
2.9000001	4.3143303, 2	-2.2647817, 0
2.7500001	4.3013903, 2	-2.9176348, 0
2.6000001	4.2842765, 2	-3.6176119, 0
2.4500002	4.2616568, 2	-4.3736760, 0
2.3000002	4.2313874, 2	-5.1972088, 0
2.1500002	4.1899164, 2	-6.1029189, 0
2.0000000	4.1312504, 2	-7.1101988, 0
1.9600000	4.1323248, 2	-6.2077663, 0
1.9200000	4.1335169, 2	-5.2890483, 0
1.8800000	4.1348301, 2	-4.3529880, 0
1.8400000	4.1362673, 2	-3.3984360, 0
1.8000000	4.1378321, 2	-2.4241431, 0
1.7600001	4.1395283, 2	-1.4287475, 0
1.7200001	4.1413600, 2	-4.1076286, -1
1.6800001	4.1433312, 2	6.3143868, -1
1.6400001	4.1454468, 2	1.6996426, 0
1.6000000	4.1477148, 2	2.7958144, 0
1.4400000	4.1822706, 2	2.5104000, 0
1.2800000	4.2066069, 2	2.2274925, 0
1.1200000	4.2242659, 2	1.9463427, 0
0.9600000	4.2373870, 2	1.6664616, 0
0.8000000	4.2472633, 2	1.3875163, 0
0.6400000	4.2546783, 2	1.1092676, 0
0.4800000	4.2601042, 2	8.3153231, -1
0.3200000	4.2638236, 2	5.5416087, -1
0.1600000	4.2659997, 2	2.7702320, -1

```
*****  
* UNCLASSIFIED *  
* W.B.HENDERSON EXT.736 *  
* THIS I2 AT LEVEL SEVENTEEN *  
* CALCULATED FOR CORE/END CASE CORE 2 *  
*****
```

PROGRAM 12

P3 APPROXIMATION TO THE SOLUTION OF THE TRANSPORT EQUATION

BY WEIL METHOD

INTERMEDIATE PROGRAM

CASE NUMBER 2.00000

DATA INPUT

INPUT TYPE 8

NUMBER OF MATERIALS 2

NUMBER OF ZONES 3

NUMBER OF RADII 10

MATERIAL NUMBER 1

SIGMA ABSR 9.2052196, -2

SIGMA SCAT0 1.0605532, -2

SIGMA SCAT1 2.0185741, -4

SIGMA SCAT2 0.0000000, 0

MATERIAL NUMBER 2

SIGMA ABSR 1.1518749, -2

SIGMA SCAT0 2.4157374, 0

SIGMA SCAT1 1.0210160, 0

SIGMA SCAT2 1.9999999, -1

ZONE DATA ORDERED FROM OUTER-MOST TO INNER-MOST ZONE

OUTER RADIUS OF ZONE	MATERIAL NUMBER	SOURCE TERM OF ZONE
3.5000000	2	1.0000000
2.0000000	1	0.0000000
1.6000000	2	1.0000000

OUTPUT

AVERAGE FLUX WITHIN A ZONE
ORDERED FROM OUTER-MOST TO INNER-MOST ZONE
-----274.65429
-----256.37589
-----265.77497

AVERAGE NON-MODERATOR FLUX
-----256.37589

AVERAGE MODERATOR FLUX
-----272.55151

CELL CORRECTION
-----0.9406511

ABSORPTION CHECK
-----T.A. 33.960713
-----T.S. 33.960616

FLUX AND RADIAL CURRENT		
RADIUS	FLUX	CURRENT
3.5000000	2.8035275, 2	-2.9351988, -5
3.3500000	2.8008790, 2	-4.6856619, -1
3.2000000	2.7957015, 2	-9.6022880, -1
3.0500001	2.7875108, 2	-1.4788552, 0
2.9000001	2.7758663, 2	-2.0290831, 0
2.7500001	2.7602365, 2	-2.6165550, 0
2.6000001	2.7328260, 2	-3.2482185, 0
2.4500002	2.7132735, 2	-3.9327714, 0
2.3000002	2.6780581, 2	-4.6813224, 0
2.1500002	2.6292836, 2	-5.5084842, 0
2.0000000	2.5571541, 2	-6.4340434, 0
1.9600000	2.5580668, 2	-5.6140114, 0
1.9200000	2.5591371, 2	-4.7700622, 0
1.8800000	2.5603692, 2	-3.9282006, 0
1.8400000	2.5617672, 2	-3.0603446, 0
1.8000000	2.5633356, 2	-2.1743209, 0
1.7600001	2.5650794, 2	-1.2688512, 0
1.7200001	2.5670035, 2	-3.4254106, -1
1.6800001	2.5691137, 2	6.0613371, -1
1.6400001	2.5714158, 2	1.5788449, 0
1.6000000	2.5732152, 2	2.5774318, 0
1.4400000	2.6173187, 2	2.3078563, 0
1.2800000	2.6455147, 2	2.0436031, 0
1.1200000	2.6652320, 2	1.7828323, 0
0.9600000	2.6798308, 2	1.5245091, 0
0.8000000	2.6909961, 2	1.2679990, 0
0.6400000	2.6995765, 2	1.0128664, 0
0.4800000	2.7060018, 2	7.5877537, -1
0.3200000	2.7104898, 2	5.0543949, -1
0.1600000	2.7131493, 2	2.5259751, -1

CORE OR END COMPOSITION

COMPOSITION INPUT

CASE NUMBER	CORE 2	
C2-INPUT UNITS	C.G.S.	
C3-THERMAL BASE	SET T=T+1	
C4-SLOWING DOWN MODEL	MODIFIED AGE	
C5-GROUP DIVISION	N=T	
C8-G FACTOR APPLICATION	ALL SIGMAS	
C17-PHOTON PRODUCTION CALCULATION		YES
C19-PRINT OUT		LONG
C21-ADJOINT CALCULATION		NO
C22-MULTI GROUP CALCULATION		YES
C31-CLEAR INPUT AFTER CALCULATION		NO
C32-RERUN THIS COMPOSITION IN REACTIVITY MATCH		YES

BEHRENS INPUT

C6-BEHRENS CALCULATION	CALCULATE F/R,F/Z
C10-G FACTORS IN BEHRENS CORRECTION	YES
C11-MODERATOR X-SECTION IN BEHRENS CORRECTION	SIGMA TOTAL

D1	D2	D3	M
FUEL ZONE I.D.	FUEL ZONE O.D.	CELL DIAMETER	NUMBER OF CELLS
3.1999999, 0	4.0000000, 0	7.0000000, 0	0.0000000, 0

I2 INPUT

C7-I2 CALCULATION	YES
C9-LEAKAGE TERM ADDED TO SIGMA A	NO
C12-I2 AT THERMAL	YES, TYPE B
C13-I2 AT LEVEL 16	YES, TYPE B
C14-I2 AT LEVEL 17	YES, TYPE B
C20-FINE RADIAL POWER CALCULATION	YES
C30-G RECIPE	G CELL=1

 TERRALL INPUT

C18-TERRALL METHOD	NO				
	ESTAR E*			TPF	
	SLOWING DOWN CUT-OFF (eV)		FUEL TEMPERATURE DEGREES F		
	0.0000000, 0		0.0000000, 0		

 BUCKLING GEOMETRY

C16-GEOMETRY	CYLINDER				
SAVINGS ON H	S/Z	3.9685362, 0	HEIGHT	H	5.0000000, 1
SAVINGS ON D	S/R	1.1898314, 1	DIAMETER	D	7.0000000, 1

 VOLUME GEOMETRY

DCG	DCI	L	VOC
OUTER DIAMETER	INNER DIAMETER	LENGTH	COMPOSITION VOLUME
0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0

CSP	TPM
CODE NUMBER OF SPECTRUM	MODERATOR TEMPERATURE DEGREES F
0.9420	6.8000000, 1

TABLE 3M.12 MATERIAL NUMBER 1

C28-FUEL YES

GEOMETRY FOR VOLUME CALCULATION

OUTER RADIUS	INNER RADIUS	LENGTH	MATERIAL VOLUME		
0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0		
CODE	WEIGHT	F OR N	SIGMA/S2,T+1	SIGMA/S2,16	SIGMA/S2,17
-1.130	0.000000, 0	6.9999999, -3	0.0000000, 0	0.0000000, 0	0.0000000, 0
5.110	0.000000, 0	9.2999999, -2	0.0000000, 0	0.0000000, 0	0.0000000, 0

TABLE 3M.12 MATERIAL NUMBER 2

C28-FUEL NO

GEOMETRY FOR VOLUME CALCULATION

OUTER RADIUS	INNER RADIUS	LENGTH	MATERIAL VOLUME		
0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0		
CODE	WEIGHT	F OR N	SIGMA/S2,T+1	SIGMA/S2,16	SIGMA/S2,17
2.510	0.000000, 0	1.0000000, 0	1.2999999, -1	2.3999999, -1	1.9999999, -1

TABLE M1 MODERATOR

ELEMENT	CODE	WEIGHT	F/H OR N/H	G/T+1	G/16	G/17
*WATER	2.510	0.000000	0 8.8244897	-1 1.018208	1.003717	1.007026

TABLE F1 FUEL

ELEMENT	CODE	WEIGHT	F/H OR N/H	G/T+1	G/16	G/17
*ORALLOY	-1.130	0.000000	0 8.2285715	-4 0.863311	0.972099	0.947260
*ALUMINUM	5.110	0.000000	0 1.0932244	-2 0.863311	0.972099	0.947260

HYDRAULIC DIAMETER			FUEL	8.0000001,-1	MODERATOR	6.0055555, 0
BEHRENS CROSS SECTIONS			ATTENUATION FACTORS			
N	SIGMA/S, MOD	SIGMA/A, MOD	SIGMA/A, FUEL	X-FUEL	Y-MOD	
0	7.3406384,-2	1.1080379,-6	5.5514334,-4	4.4411468,-4	4.4085276,-1	
1	1.2545818,-1	1.4208439,-6	5.0696100,-4	4.0556880,-4	7.5345461,-1	
2	2.1154385,-1	1.8239671,-6	4.7590222,-4	3.8072178,-4	1.2704493, 0	
3	2.2355580,-1	2.3350303,-6	4.7526520,-4	3.8021216,-4	1.3425908, 0	
4	3.4234068,-1	3.0179165,-6	4.7019192,-4	3.7615354,-4	2.0559640, 0	
5	4.9949708,-1	3.8550029,-6	4.9665462,-4	3.9732376,-4	2.9997805, 0	
6	5.4721122,-1	4.9564323,-6	5.2824619,-4	4.2259696,-4	3.2863371, 0	
7	6.6566244,-1	6.3662620,-6	5.9071583,-4	4.7257267,-4	3.9977109, 0	
8	7.9245529,-1	8.1726062,-6	6.2234861,-4	4.9787889,-4	4.7591832, 0	
9	1.3196465, 0	2.2248874,-5	1.0292446,-3	8.2339570,-4	7.9253444, 0	
10	1.4297561, 0	6.0358332,-5	1.8145380,-3	1.4516304,-3	8.5868424, 0	
11	1.4597860, 0	1.6433326,-4	4.5483586,-3	3.6386869,-3	8.7678130, 0	
12	1.4597860, 0	4.4718035,-4	2.0574323,-2	1.6459458,-2	8.7695116, 0	
13	1.4614543, 0	1.2137752,-3	4.1648942,-2	3.3319153,-2	8.7841347, 0	
14	1.4948209, 0	2.2843646,-3	1.2175612,-2	9.7404903,-3	8.9909487, 0	
15	1.5014942, 0	4.3858919,-3	2.7117261,-2	2.1693809,-2	9.0436466, 0	
16	1.8285841, 0	6.6353496,-3	6.0992246,-2	4.8793797,-2	1.1021512, 1	
17	2.4327092, 0	1.1599674,-2	8.7197335,-2	6.9757868,-2	1.4679432, 1	
18	3.3158708, 0	2.0848398,-2	1.8517922,-1	1.4814338,-1	2.0038852, 1	
T	3.2153075, 0	1.9895224,-2	1.6099200,-1	1.2879360,-1	1.9429189, 1	
T+1	3.2153075, 0	1.9895224,-2	1.6099200,-1	1.2879360,-1	1.9429189, 1	

BEHRENS FACTOR		BEHRENS FACTOR	SOURCE SPECTRUM
N	F/R	F/Z	
0	1.0002229, 0	1.0032675, 0	0.0000000, 0
1	1.0006473, 0	1.0058509, 0	8.7378149,-2
2	1.0018097, 0	1.0105841, 0	3.7532886,-1
3	1.0020150, 0	1.0112876, 0	4.7365445,-1
4	1.0045540, 0	1.0187536, 0	4.2566089,-1
5	1.0090763, 0	1.0297939, 0	3.0059730,-1
6	1.0106468, 0	1.0333429, 0	1.5546837,-1
7	1.0148284, 0	1.0424360, 0	9.8710099,-2
8	1.0196224, 0	1.0524878, 0	3.2979099,-2
9	1.0409447, 0	1.0956568, 0	1.6243999,-4
10	1.0454653, 0	1.1047068, 0	2.2580000,-5
11	1.0466085, 0	1.1069664, 0	3.0299999,-6
12	1.0460263, 0	1.1056268, 0	4.7000000,-7
13	1.0453543, 0	1.1040561, 0	0.0000000, 0
14	1.0478484, 0	1.1093658, 0	0.0000000, 0
15	1.0476354, 0	1.1087782, 0	0.0000000, 0
16	1.0593647, 0	1.1318873, 0	0.0000000, 0
17	1.0817010, 0	1.1762891, 0	0.0000000, 0
18	1.1074716, 0	1.2268588, 0	0.0000000, 0
T	1.1058682, 0	1.2238848, 0	
T+1	1.1058682, 0	1.2238848, 0	

TABLE C4

	SCATTER	XI-SCATTER	TRANSPORT	ABSORPTION	FISSION
N	X-SECTION	X-SECTION	X-SECTION	X-SECTION	X-SECTION
0	6.6087753,-2	5.7111826,-2	3.9022610,-2	6.6235457,-5	1.4318619,-4
1	1.1211400,-1	8.3378293,-2	5.0540146,-2	6.0847608,-5	1.2720728,-4
2	1.8633565,-1	1.2880054,-1	1.1122002,-1	5.7552352,-5	1.1974295,-4
3	1.9957772,-1	1.6895060,-1	7.7375032,-2	5.7928456,-5	1.1942934,-4
4	3.0369273,-1	2.3337740,-1	1.6062409,-1	5.7934700,-5	1.1046234,-4
5	4.4297596,-1	3.0195863,-1	2.4435422,-1	6.1784111,-5	1.0882901,-4
6	4.8667045,-1	3.7262877,-1	2.6327607,-1	6.6462680,-5	1.1608427,-4
7	5.8890813,-1	4.9046240,-1	2.8059310,-1	7.5057153,-5	1.3422244,-4
8	7.0483466,-1	6.0281792,-1	2.9984395,-1	8.0369625,-5	1.4147771,-4
9	1.1658786, 0	1.0677261, 0	4.6066223,-1	1.4062225,-4	2.5030672,-4
10	1.2629195, 0	1.1648830, 0	4.8910105,-1	2.6656395,-4	4.0266734,-4
11	1.2694193, 0	1.1913829, 0	4.9911210,-1	6.7967994,-4	8.9239789,-4
12	1.2894136, 0	1.1913828, 0	4.9910638,-1	2.8131465,-3	3.3918375,-3
13	1.2908748, 0	1.1955045, 0	5.0174549,-1	5.9669704,-3	6.0581483,-3
14	1.3203714, 0	1.2190638, 0	5.0768537,-1	3.4470910,-3	2.0532406,-3
15	1.3262863, 0	1.2190657, 0	5.6071043,-1	7.0579877,-3	6.7836751,-3
16	1.6148705, 0	1.2472358, 0	7.9916460,-1	1.3025058,-2	1.4140941,-2
17	2.1479226, 0	1.3106459, 0	1.2405756, 0	2.0486256,-2	2.1387601,-2
18	2.9271780, 0	1.3851546, 0	2.2975691, 0	4.0165655,-2	4.4972324,-2
T	2.8384683, 0	1.3365897, 0	2.0223802, 0	3.6481296,-2	3.8740087,-2
T+1	2.8384683, 0	1.3365897, 0	2.0223802, 0	3.6481296,-2	3.8740087,-2

N	EXTRAPOLATION		TOTAL		X/R/S		V/Z		Z	
	DISTANCE		BUCKLING		BUCKLING		BUCKLING		BUCKLING	
0	1.8173286,	1	2.4759392,-3		1.3656287,-3		1.1103104,-3		0.0000000,	0
1	1.4041225,	1	2.2910021,-3		1.5571027,-3		1.3338224,-3		0.0000000,	0
2	6.3849341,	0	4.0109422,-3		2.0367336,-3		1.9742086,-3		0.0000000,	0
3	2.1756789,	0	3.5349445,-3		1.8390462,-3		1.6958982,-3		0.0000000,	0
4	4.4217787,	0	4.4087138,-3		2.1955370,-3		2.2131769,-3		0.0000000,	0
5	2.9069289,	0	4.7596581,-3		2.3311247,-3		2.4285335,-3		0.0000000,	0
6	2.6980068,	0	4.8114895,-3		2.3508055,-3		2.4606840,-3		0.0000000,	0
7	2.5314522,	0	4.8534469,-3		2.3666737,-3		2.4867732,-3		0.0000000,	0
8	2.3689308,	0	4.8949491,-3		2.3823143,-3		2.5126348,-3		0.0000000,	0
9	1.5418741,	0	5.1150620,-3		2.4643590,-3		2.6507029,-3		0.0000000,	0
10	1.4518737,	0	5.1399527,-3		2.4735420,-3		2.6664106,-3		0.0000000,	0
11	1.4215919,	0	5.1483704,-3		2.4766433,-3		2.6717271,-3		0.0000000,	0
12	1.4155655,	0	5.1500482,-3		2.4772612,-3		2.6727870,-3		0.0000000,	0
13	1.3994141,	0	5.1545492,-3		2.4789183,-3		2.6756308,-3		0.0000000,	0
14	1.3900506,	0	5.1571614,-3		2.4798797,-3		2.6772816,-3		0.0000000,	0
15	1.2513904,	0	5.1960900,-3		2.4941833,-3		2.7019066,-3		0.0000000,	0
16	8.7479566,-1		5.3041895,-3		2.5336615,-3		2.7705280,-3		0.0000000,	0
17	5.6341402,-1		5.3962760,-3		2.5670157,-3		2.8292603,-3		0.0000000,	0
18	3.0392669,-1		5.4749597,-3		2.5953169,-3		2.8796429,-3		0.0000000,	0
T	3.4509362,-1		5.4623563,-3		2.5907958,-3		2.8715604,-3		0.0000000,	0
T+1	3.4509362,-1		5.4623563,-3		2.5907958,-3		2.8715604,-3		0.0000000,	0

N	EXPANSION		SMALLNESS		TOTAL		RADIAL		LONGITUDINAL	
	PARAMETER		PARAMETER		LEAKAGE		LEAKAGE		LEAKAGE	
0	5.6575436,-1		1.3406402,-1		1.7233999,-2		9.4926255,-3		7.7413740,-3	
1	2.2975100,-1		5.7500635,-2		1.6942786,-2		9.1035944,-3		7.8391915,-3	
2	1.1300975,-1		2.8835157,-2		1.1525793,-2		5.8276098,-3		5.6981841,-3	
3	8.8696481,-2		2.2723153,-2		1.4467988,-2		7.4936367,-3		6.9743216,-3	
4	4.7763441,-2		1.2325379,-2		9.0420074,-3		4.4711875,-3		4.5708199,-3	
5	2.4249025,-2		6.2794790,-3		6.5442424,-3		3.1719274,-3		3.3723150,-3	
6	2.0309113,-2		5.2626706,-3		6.1658383,-3		2.9783098,-3		3.1875285,-3	
7	1.3990882,-2		3.6292621,-3		5.8863376,-3		2.8308807,-3		3.0554568,-3	
8	9.8508711,-3		2.5571082,-3		5.6050456,-3		2.6835098,-3		2.9215357,-3	
9	3.7621788,-3		9.7758862,-4		3.9467536,-3		1.8510675,-3		2.0956861,-3	
10	3.2212501,-3		8.3710599,-4		3.7597350,-3		1.7576607,-3		2.0020742,-3	
11	3.0933115,-3		8.0387581,-4		3.6936026,-3		1.7251909,-3		1.9684117,-3	
12	3.0841380,-3		8.0149308,-4		3.6758643,-3		1.7173698,-3		1.9584944,-3	
13	3.0649027,-3		7.9649685,-4		3.6333792,-3		1.6978683,-3		1.9355108,-3	
14	2.9427531,-3		7.6476864,-4		3.6243799,-3		1.6912780,-3		1.9331019,-3	
15	2.9227525,-3		7.5957339,-4		3.2870345,-3		1.5313416,-3		1.7556928,-3	
16	2.0015477,-3		5.2024817,-4		2.3861154,-3		1.1004309,-3		1.2856844,-3	
17	1.1476561,-3		2.9834477,-4		1.6128316,-3		7.3359332,-4		8.7923828,-4	
18	6.2179216,-4		1.6165535,-4		9.1339713,-4		4.0974853,-4		5.0364860,-4	
T	6.6087531,-4		1.7181518,-4		1.0326108,-3		4.6375009,-4		5.6886071,-4	
T+1	6.6087531,-4		1.7181518,-4		1.0326108,-3		4.6375009,-4		5.6886071,-4	

N	LETHARGY	SLOWING DOWN PARAMETER V	SLOWING DOWN PARAMETER W	SLOWING DOWN DENSITY
0	0.0000000, 0	7.6750786, -1	2.3249213, -1	0.0000000, 0
1	5.0000000, -1	8.3061061, -1	1.6938938, -1	1.7407157, -2
2	1.0000000, 0	9.1748807, -1	8.2511924, -2	1.1846064, -1
3	1.5000000, 0	9.2082955, -1	7.9170443, -2	3.0510687, -1
4	2.0000000, 0	9.6247095, -1	3.7529043, -2	5.0578293, -1
5	2.5000000, 0	9.7859111, -1	2.1408885, -2	6.7339541, -1
6	3.0000000, 0	9.8384831, -1	1.6151688, -2	7.7842779, -1
7	3.5000000, 0	9.8729131, -1	1.2008681, -2	8.3532705, -1
8	4.0000000, 0	9.9065672, -1	9.3432739, -3	8.6342116, -1
9	6.0000000, 0	9.9618648, -1	3.8135126, -3	8.8481251, -1
10	8.0000000, 0	9.9655550, -1	3.4444928, -3	8.7859626, -1
11	1.0000000, 1	9.9634265, -1	3.6573410, -3	8.7240477, -1
12	1.2000000, 1	9.9458288, -1	5.4171159, -3	8.6453428, -1
13	1.4000000, 1	9.9203360, -1	7.9663991, -3	8.5305567, -1
14	1.5500000, 1	9.9423271, -1	5.7672858, -3	8.4430681, -1
15	1.6500000, 1	9.9158538, -1	8.4146112, -3	8.3834435, -1
16	1.7500000, 1	9.8779454, -1	1.2205451, -2	8.2975400, -1
17	1.8500000, 1	9.8341836, -1	1.6581632, -2	8.1790911, -1
T	1.9554883, 1	9.7269936, -1	2.7300633, -2	7.9924705, -1
T+1	1.9554883, 1	0.0000000, 0	0.0000000, 0	0.0000000, 0

N	FLOX	LEAKAGE SPECTRUM	ABSORPTION SPECTRUM	FISSION SPECTRUM
0	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0
1	1.0438662, 0	1.7686002, -2	6.3516764, -5	1.3278739, -4
2	3.5174228, 0	4.0541091, -2	2.0243595, -4	4.2118659, -4
3	4.2444741, 0	6.1409002, -2	2.4587593, -4	5.0691478, -4
4	3.8413643, 0	3.4733645, -2	2.2254829, -4	4.2432612, -4
5	3.1565271, 0	2.0657078, -2	1.9502322, -4	3.4352172, -4
6	2.4202911, 0	1.4923124, -2	1.6087597, -4	2.8095774, -4
7	1.8816728, 0	1.1076161, -2	1.4123300, -4	2.5256272, -4
8	1.4731229, 0	8.2569215, -3	1.1839434, -4	2.0841407, -4
9	8.2567998, -1	3.2587555, -3	1.1610898, -4	2.0667325, -4
10	7.5165894, -1	2.8260309, -3	2.0036464, -4	3.0266770, -4
11	7.2958668, -1	2.6948032, -3	4.9588543, -4	6.5108161, -4
12	7.2172556, -1	2.6529652, -3	2.0303197, -3	2.4479758, -3
13	7.0786839, -1	2.5719543, -3	4.2238297, -3	4.2883717, -3
14	6.8859189, -1	2.4957186, -3	2.3736389, -3	1.4138449, -3
15	6.8190794, -1	2.2414549, -3	4.8128979, -3	4.6258419, -3
16	6.5715436, -1	1.5680461, -3	8.5594740, -3	9.2927815, -3
17	6.1370262, -1	9.8979898, -4	1.2572469, -2	1.3125626, -2
T	5.8164973, -1	6.0061779, -4	2.1219336, -2	2.2533161, -2
T+1	2.1305353, 1	2.2000138, -2	7.7724692, -1	8.2537127, -1

CALCULATED REACTIVITY	8.8259103,-1	
POWER LEVEL 17	1.2700337,-2	
POWER LEVEL T	2.1309897,-2	
POWER LEVEL T+1	2.3516843,-1	
BALANCE CHECK DISCREPANCY	-9.9843537,-5	

LETHARGY INDEX	19.	
LETHARGY AT INDEX	1.9554883, 1	

TWO-GROUP RESULTS		
	FAST	SLOW
DIFFUSION COEFFICIENT, ONE-GROUP BUCKLING	1.3060656, 0	2.0559462,-1
DIFFUSION COEFFICIENT, TWO-GROUP BUCKLING	1.4098853, 0	1.8904127,-1
SIGMA ABSORPTION	2.4315250,-3	3.6481295,-2
NU SIGMA FISSION	2.5627582,-3	3.8740087,-2
FLUX	2.2327412, 1	2.1305353, 1
MULTIPLICATION	1.0539715, 0	1.0619164, 0
SIGMA LEAKAGE	6.5597895,-3	1.0326107,-3
DIFFUSION AREA, ONE-GROUP BUCKLING	3.4164980, 1	5.6356172, 0
DIFFUSION AREA, TWO-GROUP BUCKLING	3.6880771, 1	5.1818683, 0
BUCKLING	4.6527112,-3	5.4623563,-3
EXTRAPOLATION DISTANCE	3.3495227, 0	3.4509362,-1

SLOWING DOWN X-SECTION	3.5796672,-2	
AVERAGE BUCKLING	5.0225573,-3	
AVERAGE EXTRAPOLATION DISTANCE	1.8824962, 0	
ABSORPTION ESCAPE PROBABILITY	9.3639446,-1	
REACTIVITY, ONE-GROUP BUCKLING	8.8259118,-1	
REACTIVITY, TWO-GROUP BUCKLING	8.8259118,-1	

MULTIGROUP CONSTANTS

N	ENERGY	LETHARGY	SLOWING DOWN DENSITY
1	1.0000000, 2	1.1512829, 1	8.6645142, -1
2	1.0000000, 0	1.6117999, 1	8.4062238, -1
GROUP	MULTIPLICATION	BUCKLING	EXTRAPOLATION DISTANCE
1	1.4555278, 0	4.4897725, -3	4.0554376, 0
2	9.6815134, -1	5.1553490, -3	1.3965462, 0
3	1.0613005, 0	5.4488925, -3	3.8926940, -1
GROUP	SIGMA LEAKAGE	FLUX	SIGMA ABSORPTION
1	7.6877354, -3	1.6877715, 1	2.0860153, -4
2	3.6315330, -3	3.2532821, 0	4.3135000, -3
3	1.1444862, -3	2.3501768, 1	3.4634960, -2
GROUP	SOURCE TERM	NU SIGMA FISSION	SLOWING DOWN X-SECTION
1	9.9999911, -1	3.0362534, -4	5.1337007, -2
2	8.5086441, -7	4.1761208, -3	2.5839209, -1
3	0.0000000, 0	3.6758102, -2	0.0000000, 0
GROUP	ABSORPTION ESCAPE PROBABILITY	DIFFUSION COEFFICIENT ONE-GROUP BUCKLING	DIFFUSION COEFFICIENT MULTIGROUP BUCKLING
1	9.9595306, -1	1.5306414, 0	1.7122772, 0
2	9.8358047, -1	7.2304450, -1	7.0442039, -1
3	0.0000000, 0	2.2786918, -1	2.1004053, -1
GROUP	DIFFUSION AREA ONE-GROUP BUCKLING	DIFFUSION AREA MULTIGROUP BUCKLING	
1	2.9694894, 1	3.3218682, 1	
2	2.7522996, 0	2.6814061, 0	
3	6.5791669, 0	6.0644081, 0	
REACTIVITY, ONE-GROUP BUCKLING		8.8255151, -1	
REACTIVITY, MULTIGROUP BUCKLING		8.8255151, -1	

PHOTON PRODUCTION PARAMETERS

ASSUMES NU = 2.46

P	ENERGY	LETHARGY	GROUP FLUX
1	1.0000000, 6	2.3024893, 0	6.4625321, 0
2	1.0000000, 3	9.2102446, 0	8.7363048, 0
3	5.0000000, -1	1.6811146, 1	5.4041127, 0
4	9.9999999, -5	1.9554883, 1	1.7244628, 0
5			2.1305353, 1

ELEMENT -1.130 *DRALLOY

GROUP	ABSORPTION CROSS SECTION	FISSION CROSS SECTION
1	5.6121800, -5	4.7647164, -5
2	1.1397156, -4	8.8131232, -5
3	2.4591223, -3	1.4485356, -3
4	9.9467359, -3	8.3238399, -3
5	1.8808694, -2	1.5748003, -2

ELEMENT 2.510 *WATER

GROUP	ABSORPTION CROSS SECTION	FISSION CROSS SECTION
1	2.0977298, -6	
2	1.9875249, -5	
3	1.1121065, -3	
4	9.3525976, -3	
5	1.7556520, -2	

ELEMENT 5.110 *ALUMINUM

GROUP	ABSORPTION CROSS SECTION	FISSION CROSS SECTION
1	1.6359412, -8	
2	1.5499965, -7	
3	8.6644370, -6	
4	6.6976897, -5	
5	1.1608182, -4	

FINE RADIAL POWER

ZONE	3	CODE	0.0000000, 0	LATTICE	RADIUS	POWER
				32	3.5000000, 0	0.0000000, 0
				31	3.3500000, 0	0.0000000, 0
				30	3.2000000, 0	0.0000000, 0
				29	3.0500000, 0	0.0000000, 0
				28	2.9000000, 0	0.0000000, 0
				27	2.7500001, 0	0.0000000, 0
				26	2.6000001, 0	0.0000000, 0
				25	2.4500001, 0	0.0000000, 0
				24	2.3000001, 0	0.0000000, 0
				23	2.1500002, 0	0.0000000, 0
				22	2.0000000, 0	0.0000000, 0
ZONE	2	CODE	1.0000000, 0	LATTICE	RADIUS	POWER
				21	2.0000000, 0	9.9680601, -1
				20	1.9600000, 0	9.9673686, -1
				19	1.9200000, 0	9.9667048, -1
				18	1.8800000, 0	9.9736250, -1
				17	1.8400000, 0	9.9806913, -1
				16	1.8000000, 0	9.9904699, -1
				15	1.7600000, 0	1.0003032, 0
				14	1.7200000, 0	1.0018458, 0
				13	1.6800000, 0	1.0036830, 0
				12	1.6400000, 0	1.0058242, 0
				11	1.5999999, 0	1.0082791, 0
ZONE	1	CODE	0.0000000, 0	LATTICE	RADIUS	POWER
				10	1.5999999, 0	0.0000000, 0
				9	1.4399999, 0	0.0000000, 0
				8	1.2800000, 0	0.0000000, 0
				7	1.1200000, 0	0.0000000, 0
				6	9.6000000, -1	0.0000000, 0
				5	8.0000001, -1	0.0000000, 0
				4	6.4000001, -1	0.0000000, 0
				3	4.8000001, -1	0.0000000, 0
				2	3.2000002, -1	0.0000000, 0
				1	1.6000002, -1	0.0000000, 0

```
*****  
* UNCLASSIFIED *  
* W.B.HENDERSON EXT.736 *  
* THIS IS AT LEVEL 1 THERMAL *  
* CALCULATED FOR CORE/END CASE AVG.CORE *  
*****
```

PROGRAM I2

P3 APPROXIMATION TO THE SOLUTION OF THE TRANSPORT EQUATION

BY WEIL METHOD

INTERMEDIATE PROGRAM

CASE NUMBER 3.00000

DATA INPUT

INPUT TYPE B

NUMBER OF MATERIALS 2

NUMBER OF ZONES 3

NUMBER OF RADII 10

MATERIAL NUMBER 1

SIGMA ABSR 1.8648197,-1

SIGMA SCAT0 1.1071330,-2

SIGMA SCAT1 2.1381594,-4

SIGMA SCAT2 0.0000000, 0

MATERIAL NUMBER 2

SIGMA ABSR 1.9539445,-2

SIGMA SCAT0 3.1578092, 0

SIGMA SCAT1 9.0823721,-1

SIGMA SCAT2 1.2999999,-1

ZONE DATA ORDERED FROM OUTER-MOST TO INNER-MOST ZONE

OUTER RADIUS OF ZONE	MATERIAL NUMBER	SOURCE TERM OF ZONE
3.2500000	2	1.0000000
2.0000000	1	0.0000000
1.6000000	2	1.0000000

OUTPUT

AVERAGE FLUX WITHIN A ZONE
ORDERED FROM OUTER-MOST TO INNER-MOST ZONE
-----141.61983
-----120.86109
-----134.01045

AVERAGE NON-MODERATOR FLUX
-----120.86109

AVERAGE MODERATOR FLUX
-----139.48445

CELL CORRECTION
-----0.8664844

ABSORPTION CHECK
-----T.A. 28.659112
-----T.S. 28.659178

FLUX AND RADIAL CURRENT		
RADIUS	FLUX	CURRENT
3.2500000	1.4833436, 2	2.0223379, -5
3.1250000	1.4808206, 2	-4.3178923, -1
3.0000000	1.4748892, 2	-8.8298485, -1
2.8750000	1.4651429, 2	-1.3569092, 0
2.7500000	1.4511973, 2	-1.8574881, 0
2.6250000	1.4325746, 2	-2.3893605, 0
2.5000000	1.4085440, 2	-2.9580783, 0
2.3750000	1.3778174, 2	-3.5704113, 0
2.2500000	1.3378979, 2	-4.2348457, 0
2.1250000	1.2836447, 2	-4.9624412, 0
2.0000000	1.2040719, 2	-5.7684247, 0
1.8750000	1.2040740, 2	-4.9788515, 0
1.7500000	1.2044005, 2	-4.1749674, 0
1.6250000	1.2050587, 2	-3.3556172, 0
1.5000000	1.2060568, 2	-2.5195548, 0
1.3750000	1.2074032, 2	-1.6654338, 0
1.2500001	1.2091073, 2	-7.9179641, -1
1.1250001	1.2111794, 2	1.0293831, -1
1.0000001	1.2136302, 2	1.0204941, 0
0.8750001	1.2164717, 2	1.9627484, 0
0.7500000	1.2197166, 2	2.9317561, 0
0.6250000	1.2814750, 2	2.6097671, 0
0.5000000	1.3205404, 2	2.3002863, 0
0.3750000	1.3487527, 2	1.9989489, 0
0.2500000	1.3707661, 2	1.7035949, 0
0.1250000	1.3884321, 2	1.4129280, 0
0.0000000	1.4025024, 2	1.1259943, 0
0.4800000	1.4132924, 2	8.4197923, -1
0.3200000	1.4209407, 2	5.6012665, -1
0.1600000	1.4255109, 2	2.7970642, -1

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*****
* UNCLASSIFIED *
* W.B.HENDERSON EXT.736 *
* THIS I2 AT LEVEL SIXTEEN *
* CALCULATED FOR CORE/END CASE AVG.CORE *
*****
```

PROGRAM 12

P3 APPROXIMATION TO THE SOLUTION OF THE TRANSPORT EQUATION

BY WEIL METHOD

INTERMEDIATE PROGRAM

CASE NUMBER 3.00000

DATA INPUT

INPUT TYPE B

NUMBER OF MATERIALS 2

NUMBER OF ZONES 3

NUMBER OF RADII 10

MATERIAL NUMBER 1

SIGMA ABSR 6.2742830,-2

SIGMA SCAT0 1.0836709,-2

SIGMA SCAT1 2.0744220,-4

SIGMA SCAT2 0.0000000, 0

MATERIAL NUMBER 2

SIGMA ABSR 6.6107795,-3

SIGMA SCAT0 1.8218130, 0

SIGMA SCAT1 9.2091649,-1

SIGMA SCAT2 2.3999999,-1

ZONE DATA ORDERED FROM OUTER-MOST TO INNER-MOST ZONE

OUTER RADIUS OF ZONE	MATERIAL NUMBER	SOURCE TERM OF ZONE
3.2500000	2	1.0000000
2.0000000	1	0.0000000
1.6000000	2	1.0000000

OUTPUT

AVERAGE FLUX WITHIN A ZONE
ORDERED FROM OUTER-MOST TO INNER-MOST ZONE

388.02335
376.16027
383.99810

AVERAGE NON-MODERATOR FLUX

376.16027

AVERAGE MODERATOR FLUX

386.89376

CELL CORRECTION

0.9722572

ABSORPTION CHECK

T.A. 28.659148
T.S. 28.659178

FLUX AND RADIAL CURRENT		
RADIUS	FLUX	CURRENT
3.2500000	3.9221593, 2	1.2639611, -6
3.1250000	3.9193027, 2	-4.7062752, -1
3.0000000	3.9150949, 2	-9.6154519, -1
2.8750000	3.9091432, 2	-1.4755034, 0
2.7500000	3.9010237, 2	-2.0157706, 0
2.6250000	3.8902131, 2	-2.5862551, 0
2.5000000	3.8760009, 2	-3.1916674, 0
2.3750000	3.8573622, 2	-3.8377432, 0
2.2500000	3.8327656, 2	-4.5315454, 0
2.1250000	3.7998718, 2	-5.2818863, 0
2.0000000	3.7550582, 2	-6.0999208, 0
1.9600000	3.7561021, 2	-5.2722507, 0
1.9200000	3.7572541, 2	-4.4294524, 0
1.8800000	3.7585171, 2	-3.5705447, 0
1.8400000	3.7598940, 2	-2.6944608, 0
1.8000000	3.7613880, 2	-1.8000411, 0
1.7600001	3.7630027, 2	-8.8602172, -1
1.7200001	3.7647418, 2	4.8977279, -2
1.6800001	3.7666091, 2	1.0064665, 0
1.6400001	3.7686090, 2	1.9881035, 0
1.6000000	3.7707432, 2	2.9957267, 0
1.4400000	3.8042807, 2	2.6903728, 0
1.2800000	3.8282308, 2	2.3874566, 0
1.1200000	3.8458531, 2	2.0862739, 0
0.9600000	3.8591158, 2	1.7863604, 0
0.8000000	3.8692095, 2	1.4873950, 0
0.6400000	3.8768550, 2	1.1891430, 0
0.4800000	3.8824874, 2	8.9142157, -1
0.3200000	3.8863665, 2	5.9407839, -1
0.1600000	3.8886428, 2	2.9697929, -1

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*****  
* UNCLASSIFIED *  
* W.B.HENDERSON EXT.736 *  
* THIS I2 AT LEVEL SEVENTEEN *  
* CALCULATED FOR CORE/END CASE AVG.CORE *  
*****
```

PROGRAM I2

P3 APPROXIMATION TO THE SOLUTION OF THE TRANSPORT EQUATION

BY WEIL METHOD

INTERMEDIATE PROGRAM

CASE NUMBER 3.00000

DATA INPUT

INPUT TYPE B

NUMBER OF MATERIALS 2

NUMBER OF ZONES 3

NUMBER OF RADII 10

MATERIAL NUMBER 1

SIGMA ABSR 9.2052196,-2

SIGMA SCATO 1.0605532,-2

SIGMA SCAT1 2.0185741,-4

SIGMA SCAT2 0.0000000, 0

MATERIAL NUMBER 2

SIGMA ABSR 1.1518749,-2

SIGMA SCATO 2.4157374, 0

SIGMA SCAT1 1.0210160, 0

SIGMA SCAT2 1.9999999,-1

ZONE DATA ORDERED FROM OUTER-MOST TO INNER-MOST ZONE

OUTER RADIUS OF ZONE	MATERIAL NUMBER	SOURCE TERM OF ZONE
3.2500000	2	1.0000000
2.0000000	1	0.0000000
1.6000000	2	1.0000000

OUTPUT

AVERAGE FLUX WITHIN A ZONE :
ORDERED FROM OUTER-MOST TO INNER-MOST ZONE
-----249.75657
-----235.50296
-----244.90201

AVERAGE NON-MODERATOR FLUX
-----235.50296

AVERAGE MODERATOR FLUX
-----248.39426

CELL CORRECTION
-----0.9481015

ABSORPTION CHECK
-----T.A. 28.659175
-----T.S. 28.659178

FLUX AND RADIAL CURRENT		
RADIUS	FLUX	CURRENT
3.2500000	2.5444927, 2	-9.8308094, -7
3.1250000	2.5421964, 2	-4.2755879, -1
3.0000000	2.5379517, 2	-8.7375564, -1
2.8750000	2.5313772, 2	-1.3412971, 0
2.7500000	2.5220877, 2	-1.8333938, 0
2.6250000	2.5095990, 2	-2.3538794, 0
2.5000000	2.4931975, 2	-2.9073765, 0
2.3750000	2.4717291, 2	-3.4995350, 0
2.2500000	2.4432279, 2	-4.1373783, 0
2.1250000	2.4042393, 2	-4.8298208, 0
2.0000000	2.3485781, 2	-5.5884658, 0
1.9600000	2.3424922, 2	-4.8287598, 0
1.9200000	2.3505526, 2	-4.0550516, 0
1.8800000	2.3517629, 2	-3.2664085, 0
1.8400000	2.3531270, 2	-2.4618174, 0
1.8000000	2.3546493, 2	-1.6401780, 0
1.7600001	2.3563343, 2	-8.0029267, -1
1.7200001	2.3581867, 2	5.9145800, -2
1.6800001	2.3602119, 2	9.3956603, -1
1.6400001	2.3624152, 2	1.8425343, 0
1.6000000	2.3648031, 2	2.7697762, 0
1.4400000	2.4075576, 2	2.4808111, 0
1.2800000	2.4359070, 2	2.1971085, 0
1.1200000	2.4561139, 2	1.9169211, 0
0.9600000	2.4713068, 2	1.6392510, 0
0.8000000	2.4830547, 2	1.3634733, 0
0.6400000	2.4921487, 2	1.0891480, 0
0.4800000	2.4989897, 2	8.1592829, -1
0.3200000	2.5037810, 2	5.4351331, -1
0.1600000	2.5066247, 2	2.7162592, -1

 CORE OR END COMPOSITION

 COMPOSITION INPUT

CASE NUMBER	AVG. CORE	
C2-INPUT UNITS	C.G.S.	
C3-THERMAL BASE SET T=T+1		
C4-SLOWING DOWN MODEL	MODIFIED AGE	
C5-GROUP DIVISION	N=T	
C8-G FACTOR APPLICATION	ALL SIGMAS	
C17-PHOTON PRODUCTION CALCULATION		YES
C19-PRINT OUT		LONG
C21-ADJOINT CALCULATION		NO
C22-MULTI GROUP CALCULATION		YES
C31-CLEAR INPUT AFTER CALCULATION		YES
C32-RERUN THIS COMPOSITION IN REACTIVITY MATCH		YES

 BEHRENS INPUT

C6-BEHRENS CALCULATION	CALCULATE F/R, F/Z
C10-G FACTORS IN BEHRENS CORRECTION	YES
C11-MODERATOR X-SECTION IN BEHRENS CORRECTION	SIGMA TOTAL

D1	D2	D3	M
FUEL ZONE I.D.	FUEL ZONE O.D.	CELL DIAMETER	NUMBER OF CELLS
3.1999999, 0	4.0000000, 0	6.5000000, 0	0.0000000, 0

 I2 INPUT

C7-I2 CALCULATION	YES
C9-LEAKAGE TERM ADDED TO SIGMA A	NO
C12-I2 AT THERMAL	YES, TYPE B
C13-I2 AT LEVEL 16	YES, TYPE B
C14-I2 AT LEVEL 17	YES, TYPE B
C20-FINE RADIAL POWER CALCULATION	YES
C30-G RECIPE	G CELL=1

TERRALL INPUT

C18-TERRALL METHOD	NO	TPF
ESTAR E*		
SLOWING DOWN CUT-OFF (eV)		FUEL TEMPERATURE DEGREES F
0.000000, 0		0.000000, 0

BUCKLING GEOMETRY

C16-GEOMETRY	CYLINDER		
SAVINGS ON H	S/Z	3.9685362, 0	HEIGHT H 5.0000000, 1
SAVINGS ON D	S/R	1.1898314, 1	DIAMETER D 7.0000000, 1

VOLUME GEOMETRY

DCO	DCI	L	VOC
OUTER DIAMETER	INNER DIAMETER	LENGTH	COMPOSITION VOLUME
0.000000, 0	0.000000, 0	0.000000, 0	0.000000, 0

CSP	TPM
CODE NUMBER OF SPECTRUM	MODERATOR TEMPERATURE DEGREES F
0.9420	6.8000000, 1

TABLE 3M,I2 MATERIAL NUMBER 1

C28-FUEL YES

GEOMETRY FOR VOLUME CALCULATION

OUTER RADIUS		INNER RADIUS		LENGTH		MATERIAL VOLUME	
0.0000000, 0		0.0000000, 0		0.0000000, 0		0.0000000, 0	
CODE	WEIGHT	F OR N		SIGMA/S2,I+1	SIGMA/S2,16	SIGMA/S2,17	
-1.130	0.000000, 0	6.999999, -3		0.0000000, 0	0.0000000, 0	0.0000000, 0	
5.110	0.000000, 0	2.299999, -2		0.0000000, 0	0.0000000, 0	0.0000000, 0	

TABLE 3M,I2 MATERIAL NUMBER 2

C28-FUEL NO

GEOMETRY FOR VOLUME CALCULATION

OUTER RADIUS		INNER RADIUS		LENGTH		MATERIAL VOLUME	
0.0000000, 0		0.0000000, 0		0.0000000, 0		0.0000000, 0	
CODE	WEIGHT	F OR N		SIGMA/S2,I+1	SIGMA/S2,16	SIGMA/S2,17	
2.510	0.000000, 0	1.000000, 0		1.299999, -1	2.399999, -1	1.999999, -1	

TABLE M1 MODERATOR

ELEMENT	CODE	WEIGHT	F/H OR N/H	G/T+1	G/16	G/17
*WATER	2.510	0.000000	0 8.6366862,-1	1.018540	1.003797	1.007126

TABLE F1 FUEL

ELEMENT	CODE	WEIGHT	F/H OR N/H	G/T+1	G/16	G/17
*ORALLOY	-1.130	0.000000	0 3.5431254,-4	0.882549	0.975248	0.954857
*ALUMINUM	5.110	0.000000	0 1.2678816,-2	0.882549	0.975948	0.954857

HYDRAULIC DIAMETER			FUEL	8.0000001,-1	MODERATOR	5.0680555, 0
BEHRENS CROSS SECTIONS			ATTENUATION FACTORS			
N	SIGMA/S,MOD	SIGMA/A,MOD	SIGMA/A,FUEL	X-FUEL	Y-MOD	
0	7.3406384,-2	1.1080379,-6	5.5514335,-4	4.4411469,-4	3.7203324,-1	
1	1.2545818,-1	1.4208439,-6	5.0696100,-4	4.0556880,-4	6.3583624,-1	
2	2.1154385,-1	1.8239671,-6	4.7590222,-4	3.8072178,-4	1.0721252, 0	
3	2.2355580,-1	2.3350303,-6	4.7526520,-4	3.8021216,-4	1.1330050, 0	
4	3.4234068,-1	3.0179166,-6	4.7019193,-4	3.7615355,-4	1.7350168, 0	
5	4.2949708,-1	3.8550029,-6	4.9665462,-4	3.9732376,-4	2.5314984, 0	
6	5.4721123,-1	4.9564323,-6	5.2824620,-4	4.2259697,-4	2.7733220, 0	
7	6.6566244,-1	6.3662620,-6	5.2071584,-4	4.7257268,-4	3.3736464, 0	
8	7.9245529,-1	8.1726063,-6	6.2234862,-4	4.9787890,-4	4.0162487, 0	
9	1.3196465, 0	2.2248874,-5	1.0292446,-3	8.2339570,-4	6.6881549, 0	
10	1.4297561, 0	6.0358333,-5	1.8145380,-3	1.4516304,-3	7.2463895, 0	
11	1.4597860, 0	1.6433326,-4	4.5483587,-3	3.6386870,-3	7.3991096, 0	
12	1.4597860, 0	4.4718035,-4	2.0574323,-2	1.6459458,-2	7.4005430, 0	
13	1.4614543, 0	1.2137752,-3	4.1648242,-2	3.3319154,-2	7.4128834, 0	
14	1.4948209, 0	2.2843646,-3	1.2175613,-2	9.7404905,-3	7.5874127, 0	
15	1.5014942, 0	4.3858920,-3	2.7117262,-2	2.1693809,-2	7.6318840, 0	
16	1.8287296, 0	6.6358777,-3	6.1233769,-2	4.8987016,-2	9.3017343, 0	
17	2.4329514, 0	1.1600829,-2	8.7896726,-2	7.0317381,-2	1.2389126, 1	
18	3.3169505, 0	2.0855186,-2	1.8930563,-1	1.5144451,-1	1.6916184, 1	
T	3.2163544, 0	1.9201702,-2	1.6457945,-1	1.3166356,-1	1.6401525, 1	
T+1	3.2163544, 0	1.9901702,-2	1.6457945,-1	1.3166356,-1	1.6401525, 1	
BEHRENS FACTOR			BEHRENS FACTOR	SOURCE SPECTRUM		
N	F/R		F/Z			
0	1.0002137, 0		1.0036695, 0		0.0000000, 0	
1	1.0006217, 0		1.0065282, 0		8.7378149,-2	
2	1.0017464, 0		1.0117060, 0		3.7532886,-1	
3	1.0019462, 0		1.0124713, 0		4.7365445,-1	
4	1.0044424, 0		1.0205601, 0		4.2566089,-1	
5	1.0090015, 0		1.0325176, 0		3.0059730,-1	
6	1.0106157, 0		1.0363776, 0		1.5546837,-1	
7	1.0149831, 0		1.0463199, 0		9.8710099,-2	
8	1.0200970, 0		1.0574019, 0		3.2979099,-2	
9	1.0436866, 0		1.1057892, 0		1.6243999,-4	
10	1.0487805, 0		1.1160244, 0		2.2580000,-5	
11	1.0500762, 0		1.1185872, 0		3.0299999,-6	
12	1.0494512, 0		1.1171026, 0		4.7000000,-7	
13	1.0487346, 0		1.1153659, 0		0.0000000, 0	
14	1.0514919, 0		1.1213192, 0		0.0000000, 0	
15	1.0512819, 0		1.1206838, 0		0.0000000, 0	
16	1.0646269, 0		1.1469365, 0		0.0000000, 0	
17	1.0899925, 0		1.1973083, 0		0.0000000, 0	
18	1.1191373, 0		1.2542488, 0		0.0000000, 0	
T	1.1173246, 0		1.2509427, 0			
T+1	1.1173246, 0		1.2509427, 0			

TABLE C4

N	SCATTER	XI-SCATTER	TRANSPORT	ABSORPTION	FISSION
	X-SECTION	X-SECTION	X-SECTION	X-SECTION	X-SECTION
0	6.4918505,-2	5.5914885,-2	3.8388444,-2	7.6640429,-5	1.6606209,-4
1	1.0998209,-1	8.1623728,-2	4.9658949,-2	7.0341823,-5	1.4753034,-4
2	1.8462783,-1	1.2608277,-1	1.0905190,-1	6.6455703,-5	1.3887348,-4
3	1.9574690,-1	1.6538685,-1	7.5930084,-2	6.6810245,-5	1.3850977,-4
4	2.9751821,-1	2.2843235,-1	1.5744647,-1	6.6708388,-5	1.2811017,-4
5	4.3394596,-1	2.9556037,-1	2.3946769,-1	7.1039058,-5	1.2621589,-4
6	4.7699825,-1	3.7159816,-1	2.5810749,-1	7.6297241,-5	1.3463028,-4
7	5.7664562,-1	4.8004201,-1	2.7488608,-1	8.6031437,-5	1.5566627,-4
8	6.9083609,-1	5.9005898,-1	2.9444053,-1	9.1904061,-5	1.6408066,-4
9	1.1413122, 0	1.0450166, 0	4.5109947,-1	1.5953397,-4	2.9029656,-4
10	1.2362651, 0	1.1401042, 0	4.7891095,-1	2.9950804,-4	4.6699881,-4
11	1.2622010, 0	1.1660400, 0	4.8870894,-1	7.6201344,-4	1.0349703,-3
12	1.2621943, 0	1.1660400, 0	4.8870231,-1	3.1911412,-3	3.9337287,-3
13	1.2638224, 0	1.1700739, 0	4.9128329,-1	6.7263567,-3	7.0260182,-3
14	1.2925007, 0	1.1931324, 0	4.9710599,-1	3.6328520,-3	2.3812732,-3
15	1.2982944, 0	1.1931346, 0	5.4900716,-1	7.4848906,-3	7.8674575,-3
16	1.5806582, 0	1.2208021, 0	7.8244435,-1	1.4079282,-2	1.6465088,-2
17	2.1026444, 0	1.2828929, 0	1.2145149, 0	2.2002352,-2	2.5003507,-2
18	2.8660398, 0	1.3561295, 0	2.2496254, 0	4.3820266,-2	5.3319490,-2
T	2.7791965, 0	1.3085834, 0	1.9802119, 0	3.9625817,-2	4.5930508,-2
T+1	2.7791965, 0	1.3085834, 0	1.9802119, 0	3.9625817,-2	4.5930508,-2

N	EXTRAPOLATION		TOTAL		X/R/S		V/Z		Z	
	DISTANCE		BUCKLING		BUCKLING		BUCKLING		BUCKLING	
0	1.8471296,	1	2.4496103,-	-3	1.3532057,-	-3	1.0964046,-	-3	0.0000000,	0
1	1.4287353,	1	2.8633633,-	-3	1.5446006,-	-3	1.3187626,-	-3	0.0000000,	0
2	6.5112782,	0	3.9872823,-	-3	2.0271089,-	-3	1.9601733,-	-3	0.0000000,	0
3	9.3490662,	0	3.5083107,-	-3	1.8277257,-	-3	1.6805850,-	-3	0.0000000,	0
4	4.5107333,	0	4.3893772,-	-3	2.1879455,-	-3	2.2014316,-	-3	0.0000000,	0
5	2.9661172,	0	4.7451336,-	-3	2.3255939,-	-3	2.4195396,-	-3	0.0000000,	0
6	2.7519155,	0	4.7980307,-	-3	2.3457034,-	-3	2.4523273,-	-3	0.0000000,	0
7	2.5838983,	0	4.8401743,-	-3	2.3616602,-	-3	2.4785141,-	-3	0.0000000,	0
8	2.4122979,	0	4.8838207,-	-3	2.3781259,-	-3	2.5056948,-	-3	0.0000000,	0
9	1.5744837,	0	5.1060902,-	-3	2.4610444,-	-3	2.6450458,-	-3	0.0000000,	0
10	1.4826470,	0	5.1314205,-	-3	2.4703963,-	-3	2.6610241,-	-3	0.0000000,	0
11	1.4515672,	0	5.1400377,-	-3	2.4735733,-	-3	2.6664643,-	-3	0.0000000,	0
12	1.4444184,	0	5.1420230,-	-3	2.4743049,-	-3	2.6677180,-	-3	0.0000000,	0
13	1.4266791,	0	5.1469547,-	-3	2.4761219,-	-3	2.6708328,-	-3	0.0000000,	0
14	1.4189032,	0	5.1491188,-	-3	2.4769189,-	-3	2.6721999,-	-3	0.0000000,	0
15	1.2767477,	0	5.1889364,-	-3	2.4915583,-	-3	2.6973781,-	-3	0.0000000,	0
16	8.9200113,-	-1	5.2991737,-	-3	2.5318375,-	-3	2.7673362,-	-3	0.0000000,	0
17	5.7459769,-	-1	5.3929250,-	-3	2.5658064,-	-3	2.8271186,-	-3	0.0000000,	0
18	3.0979586,-	-1	5.4731600,-	-3	2.5946715,-	-3	2.8784884,-	-3	0.0000000,	0
T	3.5176093,-	-1	5.4603193,-	-3	2.5900647,-	-3	2.8702546,-	-3	0.0000000,	0
T+1	3.5176093,-	-1	5.4603193,-	-3	2.5900647,-	-3	2.8702546,-	-3	0.0000000,	0

N	EXPANSION		SMALLNESS		TOTAL		RADIAL		LONGITUDINAL	
	PARAMETER		PARAMETER		LEAKAGE		LEAKAGE		LEAKAGE	
0	5.7987605,-	-1	1.3710005,-	-1	1.7265612,-	-2	9.5230864,-	-3	7.7425261,-	-3
1	2.3641614,-	-1	5.9103794,-	-2	1.7029689,-	-2	9.1615171,-	-3	7.8681722,-	-3
2	1.1688803,-	-1	2.9805513,-	-2	1.1672349,-	-2	5.9052852,-	-3	5.7670643,-	-3
3	9.1498048,-	-2	2.3429962,-	-2	1.4613289,-	-2	7.5749721,-	-3	7.0383176,-	-3
4	4.9565679,-	-2	1.2781294,-	-2	9.1835058,-	-3	4.5410990,-	-3	4.6424068,-	-3
5	2.5190394,-	-2	6.5222280,-	-3	6.6630293,-	-3	3.2272044,-	-3	3.4358249,-	-3
6	2.1080966,-	-2	5.4619752,-	-3	6.2785515,-	-3	3.0300354,-	-3	3.2485161,-	-3
7	1.4551690,-	-2	3.7743884,-	-3	6.0020248,-	-3	2.8829809,-	-3	3.1190438,-	-3
8	1.0230435,-	-2	2.6554678,-	-3	5.7085112,-	-3	2.7285065,-	-3	2.9800047,-	-3
9	3.9188456,-	-3	1.0182712,-	-3	4.0474236,-	-3	1.8924535,-	-3	2.1549700,-	-3
10	3.3558608,-	-3	8.7206763,-	-4	3.8592551,-	-3	1.7981566,-	-3	2.0610985,-	-3
11	3.2224413,-	-3	8.3741539,-	-4	3.7919051,-	-3	1.7650623,-	-3	2.0268428,-	-3
12	3.2113548,-	-3	8.3453590,-	-4	3.7710272,-	-3	1.7558680,-	-3	2.0151592,-	-3
13	3.1893661,-	-3	8.2882473,-	-4	3.7241494,-	-3	1.7344483,-	-3	1.9897010,-	-3
14	3.0650203,-	-3	7.9652740,-	-4	3.7207191,-	-3	1.7301778,-	-3	1.9905413,-	-3
15	3.0432577,-	-3	7.9087467,-	-4	3.3733858,-	-3	1.5660471,-	-3	1.8073386,-	-3
16	2.0831511,-	-3	5.4145139,-	-4	2.4536057,-	-3	1.1267894,-	-3	1.3268163,-	-3
17	1.1946781,-	-3	3.1056617,-	-4	1.6655234,-	-3	7.5351908,-	-4	9.1200432,-	-4
18	6.4638895,-	-4	1.6804941,-	-4	9.4657367,-	-4	4.2195240,-	-4	5.2462127,-	-4
T	6.8719919,-	-4	1.7865811,-	-4	1.0698633,-	-3	4.7746771,-	-4	5.9239562,-	-4
T+1	6.8719919,-	-4	1.7865811,-	-4	1.0698633,-	-3	4.7746771,-	-4	5.9239562,-	-4

N	LETHARGY	SLOWING DOWN PARAMETER...W	SLOWING DOWN PARAMETER...W	SLOWING DOWN DENSITY
0	0.0000000, 0	7.6326876, -1	2.3673123, -1	0.0000000, 0
1	5.0000000, -1	8.2678910, -1	1.7321089, -1	1.7311203, -2
2	1.0000000, 0	9.1482607, -1	8.5173927, -2	1.1795097, -1
3	1.5000000, 0	9.1847421, -1	8.1525780, -2	3.0384656, -1
4	2.0000000, 0	9.6108164, -1	3.8918353, -2	5.0378567, -1
5	2.5000000, 0	9.7772348, -1	2.2276513, -2	6.7089672, -1
6	3.0000000, 0	9.8318614, -1	1.6813859, -2	7.7558910, -1
7	3.5000000, 0	9.8747648, -1	1.2523517, -2	8.3230515, -1
8	4.0000000, 0	9.9026546, -1	9.7345337, -3	8.6013902, -1
9	6.0000000, 0	9.9592041, -1	4.0095895, -3	8.8105314, -1
10	8.0000000, 0	9.9636556, -1	3.6344379, -3	8.7452634, -1
11	1.0000000, 1	9.9610973, -1	3.8202610, -3	8.6799670, -1
12	1.2000000, 1	9.9406465, -1	5.9353411, -3	8.5952188, -1
13	1.4000000, 1	9.9114757, -1	8.8524222, -3	8.4692345, -1
14	1.5500000, 1	9.9387451, -1	6.1254873, -3	8.3745309, -1
15	1.6500000, 1	9.9098145, -1	9.0185478, -3	8.3114034, -1
16	1.7500000, 1	9.8663830, -1	1.3361692, -2	8.2190150, -1
17	1.8500000, 1	9.8188535, -1	1.8114641, -2	8.0908238, -1
T	1.9554883, 1	9.6983895, -1	3.0161045, -2	7.8880362, -1
T+1	1.9554883, 1	0.0000000, 0	0.0000000, 0	0.0000000, 0

N	FLUX	LEAKAGE SPECTRUM	ABSORPTION SPECTRUM	FISSION SPECTRUM
0	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0
1	1.0604271, 0	1.8058744, -2	7.4592378, -5	1.5644517, -4
2	3.5791190, 0	4.1776728, -2	2.3785287, -4	4.9704471, -4
3	4.3178439, 0	6.3097904, -2	2.8847621, -4	5.9806360, -4
4	3.9104532, 0	3.5911669, -2	2.6086002, -4	5.0096886, -4
5	3.2137343, 0	2.1413206, -2	2.2830065, -4	4.0562436, -4
6	2.4634212, 0	1.5466717, -2	1.8795224, -4	3.3165111, -4
7	1.9151566, 0	1.1494817, -2	1.6476368, -4	2.9812529, -4
8	1.4988739, 0	8.5563384, -3	1.3775260, -4	2.4593622, -4
9	8.3987396, -1	3.3993257, -3	1.3398843, -4	2.4381252, -4
10	7.6429014, -1	2.9495906, -3	2.2891104, -4	3.5692258, -4
11	7.4150364, -1	2.8117114, -3	5.6503574, -4	7.6743427, -4
12	7.3275425, -1	2.7632362, -3	2.9383222, -3	2.8824564, -3
13	7.1741291, -1	2.6717529, -3	4.8255751, -3	5.0405561, -3
14	6.9759503, -1	2.5955551, -3	2.5342595, -3	1.6611643, -3
15	6.9031993, -1	2.3287154, -3	5.1669692, -3	5.4310627, -3
16	6.6425137, -1	1.6298110, -3	9.3521829, -3	1.0936957, -2
17	6.1924586, -1	1.0313684, -3	1.3624865, -2	1.5483318, -2
T	5.8461114, -1	6.2545402, -4	2.3165694, -2	2.6851486, -2
T+1	1.9382981, 1	2.0737141, -2	7.6806648, -1	8.9027018, -1

CALCULATED REACTIVITY	9.5780906,-1	
POWER LEVEL 17	1.3792036,-2	
POWER LEVEL T	2.3312718,-2	
POWER LEVEL T+1	2.2948607,-1	
BALANCE CHECK DISCREPANCY	-9.9895691,-5	
LETHARGY INDEX	19	
LETHARGY AT INDEX	1.9554883, 1	
TWO-GROUP RESULTS		
	FAST	SLOW
DIFFUSION COEFFICIENT, ONE-GROUP BUCKLING	1.3375656, 0	2.1440584,-1
DIFFUSION COEFFICIENT, TWO-GROUP BUCKLING	1.4394929, 0	1.9593420,-1
SIGMA ABSORPTION	2.6347589,-3	3.9625816,-2
NU SIGMA FISSION	2.9769676,-3	4.5930507,-2
FLUX	2.2687137, 1	1.9382981, 1
MULTIPLICATION	1.1298823, 0	1.1591056, 0
SIGMA LEAKAGE	6.6743163,-3	1.0698633,-3
DIFFUSION AREA, ONE-GROUP BUCKLING	3.5760422, 1	5.4107614, 0
DIFFUSION AREA, TWO-GROUP BUCKLING	3.8485496, 1	4.9446098, 0
BUCKLING	4.6365744,-3	5.4603193,-3
EXTRAPOLATION DISTANCE	3.4176930, 0	3.5176093,-1
SLOWING DOWN X-SECTION	3.4768759,-2	
AVERAGE BUCKLING	4.9898981,-3	
AVERAGE EXTRAPOLATION DISTANCE	2.0051249, 0	
ABSORPTION ESCAPE PROBABILITY	9.2955853,-1	
REACTIVITY, ONE-GROUP BUCKLING	9.5780916,-1	
REACTIVITY, TWO-GROUP BUCKLING	9.5780916,-1	

MULTIGROUP CONSTANTS

N	ENERGY	LETHARGY	SLOWING DOWN DENSITY
1	1.0000000, 2	1.1512829, 1	8.6158622, -1
2	1.0000000, 0	1.6117999, 1	8.3355182, -1
GROUP	MULTIPLICATION	BUCKLING	EXTRAPOLATION DISTANCE
1	1.4902972, 0	4.4721371, -3	4.1342531, 0
2	1.0119041, 0	5.1475091, -3	1.4246865, 0
3	1.1581581, 0	5.4452025, -3	4.0136472, -1
GROUP	SIGMA LEAKAGE	FLUX	SIGMA ABSORPTION
1	7.8065638, -3	1.7170264, 1	2.3609636, -4
2	3.7250501, -3	3.2986426, 0	4.7857980, -3
3	1.1957620, -3	2.1601212, 1	3.7405359, -2
GROUP	SOURCE TERM	NU SIGMA FISSION	SLOWING DOWN X-SECTION
1	9.9999911, -1	3.5185375, -4	5.0178973, -2
2	8.5086441, -7	4.8427687, -3	2.5269539, -1
3	0.0000000, 0	4.3321320, -2	0.0000000, 0
GROUP	ABSORPTION ESCAPE PROBABILITY	DIFFUSION COEFFICIENT ONE-GROUP BUCKLING	DIFFUSION COEFFICIENT MULTIGROUP BUCKLING
1	9.9531694, -1	1.5644733, 0	1.7456002, 0
2	9.8141302, -1	7.4651816, -1	7.2366072, -1
3	0.0000000, 0	2.3963652, -1	2.1959917, -1
GROUP	DIFFUSION AREA ONE-GROUP BUCKLING	DIFFUSION AREA MULTIGROUP BUCKLING	
1	3.1031859, 1	3.4624572, 1	
2	2.8993114, 0	2.8105381, 0	
3	6.4064756, 0	5.8707945, 0	
REACTIVITY, ONE-GROUP BUCKLING		9.5775747, -1	
REACTIVITY, MULTIGROUP BUCKLING		9.5775747, -1	

PHOTON PRODUCTION PARAMETERS			ASSUMES NU = 2.46
P	ENERGY	LETHARGY	GROUP FLUX
1	1.0000000, 6	2.3024893, 0	6.5754292, 0
2	1.0000000, 3	9.2102446, 0	8.8889130, 0
3	5.0000000, -1	1.6811146, 1	5.4823268, 0
4	9.9999999, -5	1.9554883, 1	1.7404694, 0
5			1.9382981, 1
ELEMENT -1.130 *ORALLOY			
GROUP	ABSORPTION CROSS SECTION	FISSION CROSS SECTION	
1	6.5087442, -5	5.5258238, -5	
2	1.3213969, -4	1.0218167, -4	
3	2.8505038, -3	1.6789914, -3	
4	1.1656824, -2	2.7550784, -3	
5	2.2299714, -2	1.8670938, -2	
ELEMENT 2.510 *WATER			
GROUP	ABSORPTION CROSS SECTION	FISSION CROSS SECTION	
1	2.0532977, -6		
2	1.9441810, -5		
3	1.0870258, -3		
4	9.1456779, -3		
5	1.7188476, -2		
ELEMENT 5.110 *ALUMINUM			
GROUP	ABSORPTION CROSS SECTION	FISSION CROSS SECTION	
1	1.8975004, -8		
2	1.7966631, -7		
3	1.0036841, -5		
4	7.8468514, -5		
5	1.3762739, -4		

FINE RADIAL POWER

ZONE 3	CODE	0.0000000, 0	LATTICE	RADIUS	POWER
			32	3.2500000, 0	0.0000000, 0
			31	3.1250000, 0	0.0000000, 0
			30	3.0000000, 0	0.0000000, 0
			29	2.8750000, 0	0.0000000, 0
			28	2.7500000, 0	0.0000000, 0
			27	2.6250000, 0	0.0000000, 0
			26	2.5000000, 0	0.0000000, 0
			25	2.3750000, 0	0.0000000, 0
			24	2.2500000, 0	0.0000000, 0
			23	2.1250000, 0	0.0000000, 0
			22	2.0000000, 0	0.0000000, 0
ZONE 2	CODE	1.0000000, 0	LATTICE	RADIUS	POWER
			21	2.0000000, 0	9.9840270, -1
			20	1.9600000, 0	9.9641343, -1
			19	1.9200000, 0	9.9667813, -1
			18	1.8800000, 0	9.9720255, -1
			17	1.8400000, 0	9.9799298, -1
			16	1.8000000, 0	9.9905616, -1
			15	1.7600000, 0	1.0003994, 0
			14	1.7200000, 0	1.0020306, 0
			13	1.6800000, 0	1.0039584, 0
			12	1.6400000, 0	1.0061922, 0
			11	1.5999999, 0	1.0087417, 0
ZONE 1	CODE	0.0000000, 0	LATTICE	RADIUS	POWER
			10	1.5999999, 0	0.0000000, 0
			9	1.4399999, 0	0.0000000, 0
			8	1.2800000, 0	0.0000000, 0
			7	1.1200000, 0	0.0000000, 0
			6	0.6000000, -1	0.0000000, 0
			5	0.0000000, -1	0.0000000, 0
			4	6.4000001, -1	0.0000000, 0
			3	4.8000001, -1	0.0000000, 0
			2	3.2000002, -1	0.0000000, 0
			1	1.6000002, -1	0.0000000, 0

CORE OR END COMPOSITION

COMPOSITION INPUT

CASE NUMBER	END	
C2-INPUT UNITS	C.G.S.	
C3-THERMAL BASE	SET T=T+1	
C4-SLOWING DOWN MODEL	MODIFIED AGE	
C5-GROUP DIVISION	N=T	
C8-G FACTOR APPLICATION	ALL SIGMAS	
C17-PHOTON PRODUCTION CALCULATION		NO
C19-PRINT OUT		LONG
C21-ADJOINT CALCULATION		NO
C22-MULTI GROUP CALCULATION		NO
C31-CLEAR INPUT AFTER CALCULATION		YES
C32-RERUN THIS COMPOSITION IN REACTIVITY MATCH		YES

BEHRENS INPUT

C6-BEHRENS CALCULATION	CALCULATE F/R, F/Z
C10-G FACTORS IN BEHRENS CORRECTION	NO
C11-MODERATOR X-SECTION IN BEHRENS CORRECTION	SIGMA TOTAL

D1	D2	D3	M
FUEL ZONE I.O.	FUEL ZONE O.O.	CELL DIAMETER	NUMBER OF CELLS
3.1999999, 0	4.0000000, 0	6.5000000, 0	0.0000000, 0

I2 INPUT

C7-I2 CALCULATION	NO, G FACTORS SET=1
C9-LEAKAGE TERM ADDED TO SIGMA A	NO
C12-I2 AT THERMAL	NO, G FACTORS SET=1
C13-I2 AT LEVEL 16	NO, G FACTORS SET=1
C14-I2 AT LEVEL 17	NO, G FACTORS SET=1
C20-FINE RADIAL POWER CALCULATION	NO
C30-G RECIPE	G CELL=1

 TERRALL INPUT

C18-TERRALL METHOD NO
 ESTAR E* IPF
 SLOWING DOWN CUT-OFF (eV) FUEL TEMPERATURE DEGREES F
 0.0000000, 0 0.0000000, 0

 BUCKLING GEOMETRY

C16-GEOMETRY CYLINDER
 SAVINGS ON H S/Z 3.9685362, 0 HEIGHT H 5.0000000, 1
 SAVINGS ON D S/R 1.1898314, 1 DIAMETER D 7.0000000, 1

 VOLUME GEOMETRY

DCO	DCI	L	VOC
OUTER DIAMETER	INNER DIAMETER	LENGTH	COMPOSITION VOLUME
0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0

CSP TPM
 CODE NUMBER OF SPECTRUM MODERATOR TEMPERATURE DEGREES F
 0.9420 6.8000000, 1

TABLE M1 MODERATOR

ELEMENT	CODE	WEIGHT	F/H OR N/H	G/T+1	G/16	G/17
*WATER	2.510	0.000000	0-8.8244799,-1	1.000000	1.000000	1.000000

TABLE F1 FUEL

ELEMENT	CODE	WEIGHT	F/H OR N/H	G/T+1	G/16	G/17
NITROGEN	6.300	0.000000	0 1.0000000,-5	1.000000	1.000000	1.000000

HYDRAULIC DIAMETER			FUEL	8.0000001, -1	MODERATOR	5.0680555, 0
BEHRENS CROSS SECTIONS			ATTENUATION FACTORS			
N	SIGMA/S.MOD	SIGMA/A.MOD	SIGMA/A.FUEL	X-FUEL	Y-MOD	
0	7.5002511, -2	1.1321308, -6	6.9363346, -9	5.5490678, -9	3.8012262, -1	
1	1.2818611, -1	1.4517383, -6	8.8945045, -9	7.1156037, -9	6.4966168, -1	
2	2.1614360, -1	1.8636269, -6	1.1418061, -8	9.1344496, -9	1.0954372, 0	
3	2.2841674, -1	2.3858025, -6	1.4617325, -8	1.1693860, -8	1.1576408, 0	
4	3.4978445, -1	3.0835373, -6	1.8892203, -8	1.5113763, -8	1.7727426, 0	
5	5.1035800, -1	3.9388250, -6	2.4132377, -8	1.9305902, -8	2.5865426, 0	
6	5.5910964, -1	5.0642036, -6	3.1027342, -8	2.4821873, -8	2.8336243, 0	
7	6.8513641, -1	6.5046882, -6	3.9852897, -8	3.1882318, -8	3.4470020, 0	
8	8.0968622, -1	8.3503092, -6	5.1160639, -8	4.0928512, -8	4.1035769, 0	
9	1.3483406, 0	2.2732647, -5	1.3927829, -7	1.1142263, -7	6.8335803, 0	
10	1.4608443, 0	6.1670747, -5	3.7784408, -7	3.0227526, -7	7.4039529, 0	
11	1.4915272, 0	1.6790648, -4	1.0287287, -6	8.2298302, -7	7.5599938, 0	
12	1.4915272, 0	4.5690371, -4	2.7993557, -6	2.2394846, -6	7.5614585, 0	
13	1.4932318, 0	1.2401671, -3	7.5982513, -6	6.0786011, -6	7.5740670, 0	
14	1.5273239, 0	2.3340352, -3	1.4300157, -5	1.1440125, -5	7.7523912, 0	
15	1.5341423, 0	4.4812575, -3	2.7455750, -5	2.1964600, -5	7.7978296, 0	
16	1.8614260, 0	6.7545223, -3	4.1383579, -5	3.3106864, -5	9.4680426, 0	
17	2.4682644, 0	1.1769209, -2	7.2107542, -5	5.7686034, -5	1.2568948, 1	
18	3.3273842, 0	2.0920788, -2	1.2817740, -4	1.0254192, -4	1.6989395, 1	
T	3.2264717, 0	1.9964305, -2	1.2229760, -4	9.7838086, -5	1.6453117, 1	
T+1	3.2264717, 0	1.9964305, -2	1.2229760, -4	9.7838086, -5	1.6453117, 1	

BEHRENS FACTOR		BEHRENS FACTOR	SOURCE SPECTRUM
N	F/R	F/Z	
0	1.0002232, 0	1.0037557, 0	0.0000000, 0
1	1.0006491, 0	1.0066865, 0	8.7378149, -2
2	1.0018224, 0	1.0120024, 0	3.7532886, -1
3	1.0020307, 0	1.0127888, 0	4.7365445, -1
4	1.0046301, 0	1.0211044, 0	4.2566089, -1
5	1.0093644, 0	1.0334014, 0	3.0059730, -1
6	1.0110371, 0	1.0373703, 0	1.5546837, -1
7	1.0155541, 0	1.0475875, 0	9.8710099, -2
8	1.0208294, 0	1.0582644, 0	3.2979099, -2
9	1.0450559, 0	1.1085612, 0	1.6243999, -4
10	1.0503033, 0	1.1191091, 0	2.2580000, -5
11	1.0517428, 0	1.1219987, 0	3.0299999, -6
12	1.0517563, 0	1.1220256, 0	4.7000000, -7
13	1.0518724, 0	1.1222587, 0	0.0000000, 0
14	1.0535189, 0	1.1255620, 0	0.0000000, 0
15	1.0539382, 0	1.1264028, 0	0.0000000, 0
16	1.0694127, 0	1.1573974, 0	0.0000000, 0
17	1.0682136, 0	1.2150116, 0	0.0000000, 0
18	1.1390981, 0	1.2967806, 0	0.0000000, 0
T	1.1343014, 0	1.2871872, 0	
T+1	1.1343014, 0	1.2871872, 0	

TABLE C4

	SCATTER	XI-SCATTER	TRANSPORT	ABSORPTION	FISSION
N	X-SECTION	X-SECTION	X-SECTION	X-SECTION	X-SECTION
0	6.4795617,-2	5.7912441,-2	3.8000484,-2	2.7873155,-7	0.0000000, 0
1	1.1672932,-1	8.3270906,-2	4.9484403,-2	1.2550335,-6	0.0000000, 0
2	1.8669445,-1	1.2867377,-1	1.1013857,-1	1.6111127,-6	0.0000000, 0
3	1.9729287,-1	1.6877662,-1	7.6276277,-2	2.0625356,-6	0.0000000, 0
4	3.0211985,-1	2.3326025,-1	1.5931425,-1	2.6657300,-6	0.0000000, 0
5	4.4679370,-1	3.0180526,-1	2.4263335,-1	3.4051296,-6	0.0000000, 0
6	4.8291126,-1	3.7936317,-1	2.6090115,-1	4.3780238,-6	0.0000000, 0
7	5.8744449,-1	4.9036868,-1	2.7916181,-1	5.6233284,-6	0.0000000, 0
8	6.9934009,-1	6.0243446,-1	2.9447995,-1	7.2188749,-6	0.0000000, 0
9	1.1645730, 0	1.0676553, 0	4.5938100,-1	1.9652462,-5	0.0000000, 0
10	1.2617434, 0	1.1648219, 0	4.8724619,-1	5.3314602,-5	0.0000000, 0
11	1.2882777, 0	1.1913264, 0	4.9798998,-1	1.4515581,-4	0.0000000, 0
12	1.2882849, 0	1.1913274, 0	4.9799683,-1	3.9499504,-4	0.0000000, 0
13	1.2897570, 0	1.1954496, 0	5.0064672,-1	1.0721293,-3	0.0000000, 0
14	1.3192021, 0	1.2190051, 0	5.0653642,-1	2.0177825,-3	0.0000000, 0
15	1.3250910, 0	1.2190051, 0	5.5953615,-1	3.8740647,-3	0.0000000, 0
16	1.6077560, 0	1.2425605, 0	7.9509031,-1	5.8393109,-3	0.0000000, 0
17	2.1318648, 0	1.3014492, 0	1.2308663, 0	1.0174527,-2	0.0000000, 0
18	2.8738663, 0	1.3603386, 0	2.2555321, 0	1.8086103,-2	0.0000000, 0
T	2.7867117, 0	1.3126390, 0	1.9852344, 0	1.7259217,-2	0.0000000, 0
T+1	2.7867117, 0	1.3126390, 0	1.9852344, 0	1.7259217,-2	0.0000000, 0

N	EXTRAPOLATION		TOTAL		X/R/S		V/Z		Z	
	DISTANCE		BUCKLING		BUCKLING		BUCKLING		BUCKLING	
0	1.8696648,	1	2.4299857,-3		1.3439238,-3		1.0860619,-3		0.0000000,	0
1	1.4357695,	1	2.8555393,-3		1.5410553,-3		1.3144840,-3		0.0000000,	0
2	6.4508696,	0	3.9985675,-3		2.0317022,-3		1.9668653,-3		0.0000000,	0
3	9.3195707,	0	3.5125847,-3		1.8229626,-3		1.6836151,-3		0.0000000,	0
4	4.4596642,	0	4.4004622,-3		2.1922990,-3		2.2081631,-3		0.0000000,	0
5	2.9282455,	0	4.7544191,-3		2.3291305,-3		2.4252886,-3		0.0000000,	0
6	2.7232078,	0	4.8051905,-3		2.3484183,-3		2.4567721,-3		0.0000000,	0
7	2.5450676,	0	4.8499970,-3		2.3653711,-3		2.4846259,-3		0.0000000,	0
8	2.4126687,	0	4.8837257,-3		2.3780901,-3		2.5056356,-3		0.0000000,	0
9	1.5465802,	0	5.1137657,-3		2.4638803,-3		2.6498854,-3		0.0000000,	0
10	1.4559440,	0	5.1388228,-3		2.4731256,-3		2.6656972,-3		0.0000000,	0
11	1.4263197,	0	5.1470547,-3		2.4761587,-3		2.6708260,-3		0.0000000,	0
12	1.4255851,	0	5.1472591,-3		2.4762340,-3		2.6710251,-3		0.0000000,	0
13	1.4161317,	0	5.1498206,-3		2.4772931,-3		2.6726874,-3		0.0000000,	0
14	1.3970978,	0	5.1551951,-3		2.4791561,-3		2.6760390,-3		0.0000000,	0
15	1.2610704,	0	5.1933574,-3		2.4931808,-3		2.7001766,-3		0.0000000,	0
16	8.8769415,-1		5.3006034,-3		2.5323575,-3		2.7682459,-3		0.0000000,	0
17	5.7250330,-1		5.3935523,-3		2.5660328,-3		2.8275195,-3		0.0000000,	0
18	3.1249749,-1		5.4723320,-3		2.5943747,-3		2.8779573,-3		0.0000000,	0
T	3.5480761,-1		5.4593890,-3		2.5897307,-3		2.8696582,-3		0.0000000,	0
T+1	3.5480761,-1		5.4593890,-3		2.5897307,-3		2.8696582,-3		0.0000000,	0

N	EXPANSION		SMALLNESS		TOTAL		RADIAL		LONGITUDINAL	
	PARAMETER		PARAMETER		LEAKAGE		LEAKAGE		LEAKAGE	
0	5.7876114,-1		1.3686086,-1		1.7313039,-2		9.5600300,-3		7.7530096,-3	
1	2.3289115,-1		5.8256376,-2		1.7074916,-2		9.1893359,-3		7.8855803,-3	
2	1.1471867,-1		2.9262888,-2		1.1608296,-2		5.8689276,-3		5.7393686,-3	
3	9.0264824,-2		2.3118913,-2		1.4591994,-2		7.5610062,-3		7.0309885,-3	
4	4.8209440,-2		1.2434379,-2		9.1108437,-3		4.5019536,-3		4.6088901,-3	
5	2.4469212,-2		6.3362650,-3		6.5969156,-3		3.1929590,-3		3.4039566,-3	
6	2.0604724,-2		5.3390081,-3		6.2279863,-3		3.0037749,-3		3.2242114,-3	
7	1.4053985,-2		3.6455979,-3		5.9306374,-3		2.8464099,-3		3.0842275,-3	
8	9.9853998,-3		2.5919711,-3		5.7160600,-3		2.7310444,-3		2.9850155,-3	
9	3.7764461,-3		9.7973550,-4		3.9898332,-3		1.8636699,-3		2.1261633,-3	
10	3.2276379,-3		8.3876510,-4		3.8037343,-3		1.7704328,-3		2.0333015,-3	
11	3.1005729,-3		8.0576188,-4		3.7402001,-3		1.7390635,-3		2.0011366,-3	
12	3.0994592,-3		8.0547262,-4		3.7384989,-3		1.7382454,-3		2.0002535,-3	
13	3.0907256,-3		8.0320419,-4		3.7162842,-3		1.7276131,-3		1.9886710,-3	
14	2.9532137,-3		7.6748582,-4		3.6788571,-3		1.7085301,-3		1.9703269,-3	
15	2.9404989,-3		7.6418308,-4		3.3480310,-3		1.5518182,-3		1.7962128,-3	
16	2.0358043,-3		5.2914922,-4		2.4578939,-3		1.1258797,-3		1.3320141,-3	
17	1.1754929,-3		3.0557980,-4		1.6787588,-3		7.5650658,-4		9.2225224,-4	
18	6.5431991,-4		1.7011109,-4		9.8021145,-4		4.3317270,-4		5.4703874,-4	
T	6.9437968,-4		1.8052468,-4		1.1035652,-3		4.8885597,-4		6.1470924,-4	
T+1	6.9437968,-4		1.8052468,-4		1.1035652,-3		4.8885597,-4		6.1470924,-4	

N	LETHARGY	SLOWING DOWN PARAMETER	SLOWING DOWN PARAMETER	SLOWING DOWN DENSITY
		U	W	
0	0.0000000, 0	7.6705444, -1	2.3294555, -1	0.0000000, 0
1	5.0000000, -1	8.2382891, -1	1.7017108, -1	1.7387515, -2
2	1.0000000, 0	9.1723979, -1	8.2760207, -2	1.1839213, -1
3	1.5000000, 0	9.2041227, -1	7.9587727, -2	3.0493137, -1
4	2.0000000, 0	9.6239893, -1	3.7601061, -2	5.0551543, -1
5	2.5000000, 0	9.7859856, -1	2.1401435, -2	6.7311695, -1
6	3.0000000, 0	9.8383704, -1	1.6162954, -2	7.7815113, -1
7	3.5000000, 0	9.8803909, -1	1.1960908, -2	8.3513084, -1
8	4.0000000, 0	9.9058915, -1	9.4108432, -3	8.6315239, -1
9	6.0000000, 0	9.9625863, -1	3.7413686, -3	8.8455051, -1
10	8.0000000, 0	9.9669964, -1	3.3003538, -3	8.7852595, -1
11	1.0000000, 1	9.9674923, -1	3.2507628, -3	8.7281470, -1
12	1.2000000, 1	9.9654234, -1	3.4576579, -3	8.6698314, -1
13	1.4000000, 1	9.9601044, -1	3.9895549, -3	8.6055265, -1
14	1.5500000, 1	9.9534854, -1	4.6514570, -3	8.5499500, -1
15	1.6500000, 1	9.9411031, -1	5.8896839, -3	8.5050191, -1
16	1.7500000, 1	9.9336678, -1	6.6332146, -3	8.4519415, -1
17	1.8500000, 1	9.9097444, -1	9.0255513, -3	8.3860653, -1
T	1.9554883, 1	9.8620378, -1	1.3796210, -2	8.2858502, -1
T+1	1.9554883, 1	0.0000000, 0	0.0000000, 0	0.0000000, 0

N	FLUX	LEAKAGE SPECTRUM	ABSORPTION SPECTRUM	FISSION SPECTRUM
0	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0
1	1.0440330, 0	1.7826776, -2	1.3102964, -6	0.0000000, 0
2	3.5194470, 0	4.0854783, -2	5.6702260, -6	0.0000000, 0
3	4.2459668, 0	6.1957126, -2	8.7574579, -6	0.0000000, 0
4	3.8419023, 0	3.5002971, -2	1.0241474, -5	0.0000000, 0
5	3.1572522, 0	2.0828126, -2	1.0750853, -5	0.0000000, 0
6	2.4212404, 0	1.5079452, -2	1.0600248, -5	0.0000000, 0
7	1.8815870, 0	1.1159010, -2	1.0580781, -5	0.0000000, 0
8	1.4735181, 0	8.4227183, -3	1.0637143, -5	0.0000000, 0
9	8.2555007, -1	3.2938071, -3	1.6224092, -5	0.0000000, 0
10	7.5174497, -1	2.8594381, -3	4.0078984, -5	0.0000000, 0
11	7.3026198, -1	2.7313259, -3	1.0600177, -4	0.0000000, 0
12	7.2522957, -1	2.7112699, -3	2.8646209, -4	0.0000000, 0
13	7.1698498, -1	2.6645199, -3	7.6870068, -4	0.0000000, 0
14	6.9812506, -1	2.5683023, -3	1.4086645, -3	0.0000000, 0
15	6.9359242, -1	2.3221689, -3	2.6870219, -3	0.0000000, 0
16	6.7569164, -1	1.6607784, -3	3.9455736, -3	0.0000000, 0
17	6.3654787, -1	1.0719678, -3	6.4969228, -3	0.0000000, 0
T	6.2252734, -1	6.8699951, -4	1.0744334, -2	0.0000000, 0
T+1	4.5123065, 1	4.9796245, -2	7.7878878, -1	0.0000000, 0

CALCULATED REACTIVITY	0.0000000, 0	
POWER LEVEL 17	0.0000000, 0	
POWER LEVEL T	0.0000000, 0	
POWER LEVEL T+1	0.0000000, 0	
BALANCE CHECK DISCREPANCY	-9.9836086, -5	
LETHARGY INDEX	19	
LETHARGY AT INDEX	1.9554883, 1	
TWO-GROUP RESULTS		
	FAST	SLOW
DIFFUSION COEFFICIENT, ONE-GROUP BUCKLING	1.2798711, 0	2.1362535, -1
DIFFUSION COEFFICIENT, TWO-GROUP BUCKLING	1.4230527, 0	2.0214078, -1
SIGMA ABSORPTION	1.0256808, -3	1.7252216, -2
NU SIGMA FISSION	0.0000000, 0	0.0000000, 0
FLUX	2.2444265, 1	4.5123065, 1
MULTIPLICATION	0.0000000, 0	0.0000000, 0
SIGMA LEAKAGE	6.6116732, -3	1.1035651, -3
DIFFUSION AREA, ONE-GROUP BUCKLING	3.3731300, 1	1.2377465, 1
DIFFUSION AREA, TWO-GROUP BUCKLING	3.7504885, 1	1.1712048, 1
BUCKLING	4.6461201, -3	5.4593890, -3
EXTRAPOLATION DISTANCE	3.3773221, 0	3.5480761, -1
SLOWING DOWN X-SECTION	3.6917448, -2	
AVERAGE BUCKLING	5.1658904, -3	
AVERAGE EXTRAPOLATION DISTANCE	1.3588152, 0	
ABSORPTION ESCAPE PROBABILITY	9.7296795, -1	
REACTIVITY, ONE-GROUP BUCKLING	0.0000000, 0	
REACTIVITY, TWO-GROUP BUCKLING	0.0000000, 0	

SIDE COMPOSITION

CASE NUMBER	SIDE
C2-INPUT	C.G.S.
C3-THERMAL BASE	SET T=T+1
C4-SLOWING DOWN MODEL	MODIFIED AGE
C5-GROUP DIVISION	N=T
C7-G FACTORS	SET G-FACTORS=1
C16-GEOMETRY	CYLINDER
C17-PHOTON PRODUCTION	NO
C19-OUTPUT	LONG
C21-ADJOINT CALCULATION	NO
C22-MULTIGROUP CALCULATION	YES
C31-CLEAR THIS INPUT	YES
C32-RERUN THIS COMPOSITION IN MATCH	YES

CASE NUMBER OF REFERENCE

CORE OR END

COMPOSITION FOR BUCKLING

CORE 2

VOLUME GEOMETRY

DCO	DCI	L	VOC
OUTER DIAMETER	INNER DIAMETER	LENGTH	COMPOSITION VOLUME
0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0

CSP	TPM
CODE NUMBER OF SPECTRUM	SIDE TEMPERATURE DEGREES F
0.942	6.8000000, 1

TABLE M1 MODERATOR

ELEMENT	CODE	WEIGHT	F/H OR N/H	G/T+1	G/16	G/17
*WATER	2.510	0.000000, 0	1.000000, 0	1.000000	1.000000	1.000000

TABLE F1 FUEL

ELEMENT	CODE	WEIGHT	F/H OR N/H	G/T+1	G/16	G/17
---------	------	--------	------------	-------	------	------

N	BEHRENS FACTOR	BEHRENS FACTOR	SOURCE SPECTRUM
	F/R	F/Z	
0	1.0000000, 0	1.0000000, 0	0.0000000, 0
1	1.0000000, 0	1.0000000, 0	8.7378149, -2
2	1.0000000, 0	1.0000000, 0	3.7532886, -1
3	1.0000000, 0	1.0000000, 0	4.7365445, -1
4	1.0000000, 0	1.0000000, 0	4.2566089, -1
5	1.0000000, 0	1.0000000, 0	3.0059730, -1
6	1.0000000, 0	1.0000000, 0	1.5546837, -1
7	1.0000000, 0	1.0000000, 0	9.8710092, -2
8	1.0000000, 0	1.0000000, 0	3.2979099, -2
9	1.0000000, 0	1.0000000, 0	1.6243999, -4
10	1.0000000, 0	1.0000000, 0	2.2580000, -5
11	1.0000000, 0	1.0000000, 0	3.0299999, -6
12	1.0000000, 0	1.0000000, 0	4.7000000, -7
13	1.0000000, 0	1.0000000, 0	0.0000000, 0
14	1.0000000, 0	1.0000000, 0	0.0000000, 0
15	1.0000000, 0	1.0000000, 0	0.0000000, 0
16	1.0000000, 0	1.0000000, 0	0.0000000, 0
17	1.0000000, 0	1.0000000, 0	0.0000000, 0
18	1.0000000, 0	1.0000000, 0	0.0000000, 0
T	1.0000000, 0	1.0000000, 0	
T+1	1.0000000, 0	1.0000000, 0	

TABLE C4

N	SCATTER	XI-SCATTER	TRANSPORT	ABSORPTION	FISSION
	X-SECTION	X-SECTION	X-SECTION	X-SECTION	X-SECTION
0	7.3466386, -2	6.4604293, -2	4.3042835, -2	1.1080380, -6	0.0000000, 0
1	1.2545818, -1	9.4360573, -2	5.6055786, -2	1.4208439, -6	0.0000000, 0
2	2.1154385, -1	1.4581177, -1	1.2479085, -1	1.8239671, -6	0.0000000, 0
3	2.2355581, -1	1.9125700, -1	8.6419336, -2	2.3350303, -6	0.0000000, 0
4	3.4234069, -1	2.6432972, -1	1.8051297, -1	3.0179166, -6	0.0000000, 0
5	4.9949709, -1	3.4200702, -1	2.7494028, -1	3.8550030, -6	0.0000000, 0
6	5.4721124, -1	4.2989449, -1	2.9562753, -1	4.9564324, -6	0.0000000, 0
7	6.6566246, -1	5.5568633, -1	3.1631479, -1	6.3662621, -6	0.0000000, 0
8	7.9245530, -1	6.8267938, -1	3.3366539, -1	8.1726064, -6	0.0000000, 0
9	1.3196466, 0	1.2098707, 0	5.2051801, -1	2.2248874, -5	0.0000000, 0
10	1.4297562, 0	1.3199802, 0	5.5288355, -1	6.0358334, -5	0.0000000, 0
11	1.4597861, 0	1.3500101, 0	5.6422817, -1	1.6433327, -4	0.0000000, 0
12	1.4597861, 0	1.3500101, 0	5.6422817, -1	4.4718035, -4	0.0000000, 0
13	1.4614544, 0	1.3546815, 0	5.6723117, -1	1.2137752, -3	0.0000000, 0
14	1.4948209, 0	1.3813747, 0	5.7390447, -1	2.2843646, -3	0.0000000, 0
15	1.5014942, 0	1.3813747, 0	6.3396424, -1	4.3858920, -3	0.0000000, 0
16	1.8218130, 0	1.4080679, 0	9.0089656, -1	6.6107795, -3	0.0000000, 0
17	2.4157374, 0	1.4748010, 0	1.3947213, 0	1.1518749, -2	0.0000000, 0
18	3.2565742, 0	1.5415341, 0	2.5558768, 0	2.0475573, -2	0.0000000, 0
T	3.1578092, 0	1.4874803, 0	2.2495720, 0	1.9539445, -2	0.0000000, 0
T+1	3.1578092, 0	1.4874803, 0	2.2495720, 0	1.9539445, -2	0.0000000, 0

N	EXTRAPOLATION DISTANCE	LONGITUDINAL BUCKLING	LEAKAGE
0	1.8173286, 1	1.1103104, -3	8.5982709, -3
1	1.4041225, 1	1.3338994, -3	7.9317747, -3
2	6.3849341, 0	1.9742086, -3	5.2733024, -3
3	9.1756789, 0	1.6958982, -3	6.5411766, -3
4	4.4217787, 0	2.2131769, -3	4.0867605, -3
5	2.9069289, 0	2.4285335, -3	2.9442750, -3
6	2.6980068, 0	2.4606840, -3	2.7744852, -3
7	2.5314592, 0	2.4867732, -3	2.6205152, -3
8	2.3689308, 0	2.5126348, -3	2.5100728, -3
9	1.5418741, 0	2.6507029, -3	1.6974050, -3
10	1.4518737, 0	2.6664106, -3	1.6074027, -3
11	1.4215919, 0	2.6717271, -3	1.5779367, -3
12	1.4155655, 0	2.6727870, -3	1.5777720, -3
13	1.3994141, 0	2.6756308, -3	1.5689768, -3
14	1.3900506, 0	2.6772816, -3	1.5488450, -3
15	1.2513904, 0	2.7019066, -3	1.4108801, -3
16	8.7479566, -1	2.7705280, -3	1.0176329, -3
17	5.6341402, -1	2.8292603, -3	6.7064420, -4
18	5.6341402, -1	2.8796429, -3	3.7257362, -4
T	3.4509362, -1	2.8715604, -3	4.2183331, -4
T+1	3.4509362, -1	2.8715604, -3	4.2183331, -4

N	LETHARGY	SLOWING DOWN	SLOWING DOWN	SLOWING DOWN
		PARAMETER W	PARAMETER W	DENSITY
0	0.0000000, 0	8.8252804, -1	1.1747195, -1	0.0000000, 0
1	5.0000000, -1	9.2244693, -1	7.7553063, -2	1.9767175, -2
2	1.0000000, 0	9.6508549, -1	3.4914508, -2	1.2896477, -1
3	1.5000000, 0	9.6621863, -1	3.3081367, -2	3.3016098, -1
4	2.0000000, 0	9.8476348, -1	1.5236511, -2	5.4464595, -1
5	2.5000000, 0	9.9145358, -1	8.5464119, -3	7.2033315, -1
6	3.0000000, 0	9.9357613, -1	6.4238682, -3	8.3058468, -1
7	3.5000000, 0	9.9529496, -1	4.7050341, -3	8.9138112, -1
8	4.0000000, 0	9.9632478, -1	3.6752149, -3	9.2226114, -1
9	6.0000000, 0	9.9858065, -1	1.4193430, -3	9.5054258, -1
10	8.0000000, 0	9.9873812, -1	1.2618750, -3	9.4818169, -1
11	1.0000000, 1	9.9871110, -1	1.2888208, -3	9.4579175, -1
12	1.2000000, 1	9.9850229, -1	1.4977082, -3	9.4316363, -1
13	1.4000000, 1	9.9795003, -1	2.0492601, -3	9.3982490, -1
14	1.5500000, 1	9.9723275, -1	2.7672424, -3	9.3643645, -1
15	1.6500000, 1	9.9582116, -1	4.1788369, -3	9.3319095, -1
16	1.7500000, 1	9.9461154, -1	5.3884536, -3	9.2873889, -1
17	1.8500000, 1	9.9180264, -1	8.1973597, -3	9.2245581, -1
T	1.9554883, 1	9.8675817, -1	1.3241820, -2	9.1209711, -1
T+1	1.9554883, 1	0.0000000, 0	0.0000000, 0	0.0000000, 0

N	FLUX	LEAKAGE	ABSORPTION	FISSION
		SPECTRUM	SPECTRUM	SPECTRUM
0	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0
1	1.0474276, 0	8.3079603, -3	1.4882312, -6	0.0000000, 0
2	3.3377721, 0	1.7601081, -2	6.0879866, -6	0.0000000, 0
3	4.0637681, 0	2.6581825, -2	9.4890220, -6	0.0000000, 0
4	3.6148895, 0	1.4773187, -2	1.0909435, -5	0.0000000, 0
5	2.9596033, 0	8.7138864, -3	1.1409280, -5	0.0000000, 0
6	2.2789749, 0	6.3229823, -3	1.1295585, -5	0.0000000, 0
7	1.7733615, 0	4.6471210, -3	1.1289684, -5	0.0000000, 0
8	1.3941090, 0	3.4993152, -3	1.1393504, -5	0.0000000, 0
9	7.8467528, -1	1.3319117, -3	1.7458142, -5	0.0000000, 0
10	7.1744082, -1	1.1532163, -3	4.3303533, -5	0.0000000, 0
11	6.9968046, -1	1.1040515, -3	1.1498078, -4	0.0000000, 0
12	6.9758845, -1	1.1006355, -3	3.1194785, -4	0.0000000, 0
13	6.9233860, -1	1.0862632, -3	8.4034344, -4	0.0000000, 0
14	6.7602591, -1	1.0470593, -3	1.5442897, -3	0.0000000, 0
15	6.7272934, -1	9.4914049, -4	2.9505182, -3	0.0000000, 0
16	6.5602971, -1	6.6759743, -4	4.3368678, -3	0.0000000, 0
17	6.2035086, -1	4.1603471, -4	7.1456659, -3	0.0000000, 0
T	6.0506298, -1	2.5523572, -4	1.1822595, -2	0.0000000, 0
T+1	4.5693320, 1	1.9274964, -2	8.9282213, -1	0.0000000, 0

CALCULATED REACTIVITY	0.0000000, 0
POWER LEVEL 17	0.0000000, 0
POWER LEVEL T	0.0000000, 0
POWER LEVEL T+1	0.0000000, 0
BALANCE CHECK DISCREPANCY	-9.9925493, -5
LETHARGY INDEX	19
LETHARGY AT INDEX	1.9554883, 1
TWO-GROUP RESULTS	
	FAST SLOW
DIFFUSION COEFFICIENT, ONE-GROUP BUCKLING	1.0854958, 0 1.5664797, -1
DIFFUSION COEFFICIENT, TWO-GROUP BUCKLING	1.2368278, 0 1.4690037, -1
SIGMA ABSORPTION	1.1804399, -3 1.9539445, -2
NU SIGMA FISSION	0.0000000, 0 0.0000000, 0
FLUX	2.1421197, 1 4.5693320, 1
MULTIPLICATION	0.0000000, 0 0.0000000, 0
SIGMA LEAKAGE	2.9231040, -3 4.2183331, -4
DIFFUSION AREA, ONE-GROUP BUCKLING	2.4805877, 1 8.0170121, 0
DIFFUSION AREA, TWO-GROUP BUCKLING	2.8264133, 1 7.5181447, 0
BUCKLING	2.3633880, -3 2.8715603, -3
EXTRAPOLATION DISTANCE	3.3432572, 0 3.4509362, -1
SLOWING DOWN X-SECTION	4.2579183, -2
AVERAGE BUCKLING	2.6928744, -3
AVERAGE EXTRAPOLATION DISTANCE	1.3020289, 0
ABSORPTION ESCAPE PROBABILITY	9.7302445, -1
REACTIVITY, ONE-GROUP BUCKLING	0.0000000, 0
REACTIVITY, TWO-GROUP BUCKLING	0.0000000, 0

MULTIGROUP CONSTANTS

N	ENERGY	LETHARGY	SLOWING DOWN DENSITY
1	1.0000000, 2	1.1512829, 1	2.4380380, -1
2	1.0000000, 0	1.6117999, 1	9.3443074, -1
GROUP	MULTIPLICATION	BUCKLING	EXTRAPOLATION DISTANCE
1	0.0000000, 0	2.2596830, -3	4.0763925, 0
2	0.0000000, 0	2.6761580, -3	1.3964228, 0
3	0.0000000, 0	2.8673462, -3	3.6662701, -1
GROUP	SIGMA LEAKAGE	FLUX	SIGMA ABSORPTION
1	3.4653804, -3	1.6041747, 1	3.5430946, -5
2	1.5604064, -3	3.1733233, 0	1.3562235, -3
3	4.4570288, -4	4.7899447, 1	1.9065694, -2
GROUP	SOURCE TERM	NU SIGMA FISSION	SLOWING DOWN X-SECTION
1	9.9999911, -1	0.0000000, 0	5.8834225, -2
2	8.5086441, -7	0.0000000, 0	2.9446439, -1
3	0.0000000, 0	0.0000000, 0	0.0000000, 0
GROUP	ABSORPTION ESCAPE PROBABILITY	DIFFUSION COEFFICIENT ONE-GROUP BUCKLING	DIFFUSION COEFFICIENT MULTIGROUP BUCKLING
1	9.9939814, -1	1.2868703, 0	1.5335692, 0
2	9.9541515, -1	5.7945752, -1	5.8307708, -1
3	0.0000000, 0	1.6551193, -1	1.5544089, -1
GROUP	DIFFUSION AREA ONE-GROUP BUCKLING	DIFFUSION AREA MULTIGROUP BUCKLING	
1	2.1859654, 1	2.6050250, 1	
2	1.9588133, 0	1.9710490, 0	
3	8.6811386, 0	8.1529103, 0	
REACTIVITY, ONE-GROUP BUCKLING		0.0000000, 0	
REACTIVITY, MULTIGROUP BUCKLING		0.0000000, 0	

 CONTROL COMPOSITION

CASE NUMBER R00
 C2-INPUT C.G.S.
 C3-THERMAL BASE SET T=T+1
 C7-I2 CALCULATION SET G-FACTORS=1
 C15-TRANSMISSION CALCULATION YES
 C16-GEOMETRY CYLINDER
 C17-PHOTON PRODUCTION YES
 C19-OUTPUT LONG
 C22-MULTIGROUP CALCULATION YES
 C31-CLEAR THIS INPUT YES
 C32-RERUN THIS COMPOSITION IN MATCH NO

 CASE NUMBER OF REFERENCE

CORE, END OR SIDE
 COMPOSITION FOR BUCKLING
 AND FLUX

 CORE 1

 VOLUME GEOMETRY

DCO	DCI	L	VOC
OUTER DIAMETER	INNER DIAMETER	LENGTH	COMPOSITION VOLUME
0.000000, 0	0.000000, 0	0.000000, 0	0.000000, 0

TABLE M1 MODERATOR

ELEMENT	CODE	WEIGHT	F/H OR N/H	G/T+1	G/16	G/17
*BOR CARBIDE	8.050	0.000000	0.5.000000	-1.1.000000	1.000000	1.000000

TABLE F1 FUEL

ELEMENT	CODE	WEIGHT	F/H OR N/H	G/T+1	G/16	G/17
---------	------	--------	------------	-------	------	------

N	BEHRENS FACTOR	BEHRENS FACTOR	SOURCE SPECTRUM
	F/R	F/Z	
0	1.0000000, 0	1.0000000, 0	0.0000000, 0
1	1.0000000, 0	1.0000000, 0	0.0000000, 0
2	1.0000000, 0	1.0000000, 0	0.0000000, 0
3	1.0000000, 0	1.0000000, 0	0.0000000, 0
4	1.0000000, 0	1.0000000, 0	0.0000000, 0
5	1.0000000, 0	1.0000000, 0	0.0000000, 0
6	1.0000000, 0	1.0000000, 0	0.0000000, 0
7	1.0000000, 0	1.0000000, 0	0.0000000, 0
8	1.0000000, 0	1.0000000, 0	0.0000000, 0
9	1.0000000, 0	1.0000000, 0	0.0000000, 0
10	1.0000000, 0	1.0000000, 0	0.0000000, 0
11	1.0000000, 0	1.0000000, 0	0.0000000, 0
12	1.0000000, 0	1.0000000, 0	0.0000000, 0
13	1.0000000, 0	1.0000000, 0	0.0000000, 0
14	1.0000000, 0	1.0000000, 0	0.0000000, 0
15	1.0000000, 0	1.0000000, 0	0.0000000, 0
16	1.0000000, 0	1.0000000, 0	0.0000000, 0
17	1.0000000, 0	1.0000000, 0	0.0000000, 0
18	1.0000000, 0	1.0000000, 0	0.0000000, 0
T	1.0000000, 0	1.0000000, 0	
T+1	1.0000000, 0	1.0000000, 0	

TABLE C4

N	SCATTER	XI-SCATTER	TRANSPORT	ABSORPTION	FISSION
	X-SECTION	X-SECTION	X-SECTION	X-SECTION	X-SECTION
0	2.4359454, -1	4.2374223, -2	2.2861378, -1	2.0847590, -3	0.0000000, 0
1	2.3467630, -1	4.0957115, -2	2.2019496, -1	2.6732994, -3	0.0000000, 0
2	2.4496657, -1	4.2592240, -2	2.2990898, -1	3.4317704, -3	0.0000000, 0
3	2.4496657, -1	4.2592240, -2	2.2990898, -1	4.3933293, -3	0.0000000, 0
4	2.4976870, -1	4.3355298, -2	2.3444219, -1	5.6781709, -3	0.0000000, 0
5	2.5868694, -1	4.4772406, -2	2.4286101, -1	7.2531379, -3	0.0000000, 0
6	2.6650755, -1	4.6015101, -2	2.5024366, -1	9.3254630, -3	0.0000000, 0
7	2.7213290, -1	4.6908969, -2	2.5555399, -1	1.1978039, -2	0.0000000, 0
8	2.7720944, -1	4.7715630, -2	2.6034624, -1	1.5376652, -2	0.0000000, 0
9	2.8406962, -1	4.8805714, -2	2.6682226, -1	4.1860967, -2	0.0000000, 0
10	2.8406962, -1	4.8805714, -2	2.6682226, -1	1.1356341, -1	0.0000000, 0
11	2.8406962, -1	4.8805714, -2	2.6682226, -1	3.0919091, -1	0.0000000, 0
12	2.8406962, -1	4.8805714, -2	2.6682226, -1	8.4136400, -1	0.0000000, 0
13	2.8406962, -1	4.8805714, -2	2.6682226, -1	2.2837023, 0	0.0000000, 0
14	2.8544165, -1	4.9023730, -2	2.6811746, -1	4.2980023, 0	0.0000000, 0
15	2.8544165, -1	4.9023730, -2	2.6811746, -1	8.2519986, 0	0.0000000, 0
16	2.8544165, -1	4.9023730, -2	2.6811746, -1	1.2438095, 1	0.0000000, 0
17	2.8544165, -1	4.9023730, -2	2.6811746, -1	2.1672376, 1	0.0000000, 0
18	2.8681369, -1	4.9241747, -2	2.6941266, -1	3.8524525, 1	0.0000000, 0
T	2.8375405, -1	4.8755569, -2	2.6652436, -1	3.6757833, 1	0.0000000, 0
T+1	2.8375405, -1	4.8755569, -2	2.6652436, -1	3.6757833, 1	0.0000000, 0

N	EXTRAPOLATION DISTANCE	LONGITUDINAL BUCKLING	LEAKAGE
0	1.8861090, 1	1.0786068, -3	1.5584650, -3
1	1.4610113, 1	1.2993005, -3	1.9433012, -3
2	6.6778122, 0	1.9419009, -3	2.7740559, -3
3	9.5771446, 0	1.6607555, -3	2.3626962, -3
4	4.6280722, 0	2.1860811, -3	3.0347019, -3
5	3.0442350, 0	2.4077457, -3	3.2088625, -3
6	2.8230036, 0	2.4413724, -3	3.1351602, -3
7	2.6531640, 0	2.4676679, -3	3.0746074, -3
8	2.4692679, 0	2.4966217, -3	3.0182739, -3
9	1.6175997, 0	2.6375938, -3	2.8482206, -3
10	1.5233393, 0	2.6539264, -3	2.3256452, -3
11	1.4911942, 0	2.6595309, -3	1.5390452, -3
12	1.4825009, 0	2.6610496, -3	8.0042191, -4
13	1.4625923, 0	2.6645326, -3	3.4823328, -4
14	1.4570177, 0	2.6655091, -3	1.9458601, -4
15	1.3102073, 0	2.6914199, -3	1.0529668, -4
16	9.1465653, -1	2.7631417, -3	7.2487944, -5
17	5.8929861, -1	2.8243071, -3	4.2908593, -5
18	5.8929861, -1	2.8769763, -3	2.4720153, -5
T	3.6050067, -1	2.8685442, -3	2.5825739, -5
T+1	3.6050067, -1	2.8685442, -3	2.5825739, -5

N	LETHARGY	FLUX	LEAKAGE SPECTRUM	ABSORPTION SPECTRUM
0	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0
1	5.0000000, -1	1.0820895, 0	2.1028259, -3	2.8927492, -3
2	1.0000000, 0	3.6599158, 0	1.0152811, -2	1.2559991, -2
3	1.5000000, 0	4.4139212, 0	1.0428755, -2	1.9391809, -2
4	2.0000000, 0	4.0010261, 0	1.2141921, -2	2.2718510, -2
5	2.5000000, 0	3.2887560, 0	1.0553165, -2	2.3853801, -2
6	3.0000000, 0	2.5199300, 0	7.9003843, -3	2.3499514, -2
7	3.5000000, 0	1.9590229, 0	6.0232264, -3	2.3465253, -2
8	4.0000000, 0	1.5325822, 0	4.6257530, -3	2.3565984, -2
9	6.0000000, 0	8.5843894, -1	2.4450235, -3	3.5935084, -2
10	8.0000000, 0	7.8079538, -1	1.8158530, -3	8.8669791, -2
11	1.0000000, 1	7.5705106, -1	1.1651358, -3	2.3407330, -1
12	1.2000000, 1	7.4709471, -1	5.9799097, -4	6.2857859, -1
13	1.4000000, 1	7.2974403, -1	2.5412116, -4	1.6665181, 0
14	1.5500000, 1	7.0920768, -1	1.3800189, -4	3.0481762, 0
15	1.6500000, 1	7.0113532, -1	7.3827224, -5	5.7857677, 0
16	1.7500000, 1	6.7329429, -1	4.8805719, -5	8.3744987, 0
17	1.8500000, 1	6.2619778, -1	2.6869265, -5	1.3571193, 1
T	1.9554883, 1	5.8812783, -1	1.5188836, -5	2.1618305, 1
T+1	1.9554883, 1	1.7347548, 1	4.4801325, -4	6.3765829, 2

CALCULATED REACTIVITY	0.0000000, 0
POWER LEVEL 17	0.0000000, 0
POWER LEVEL T	0.0000000, 0
POWER LEVEL J+1	0.0000000, 0
BALANCE CHECK DISCREPANCY	0.0000000, 0
LETHARGY INDEX	19
LETHARGY AT INDEX	1.2554883, 1
TWO-GROUP RESULTS	
	FAST SLOW
DIFFUSION COEFFICIENT, ONE-GROUP BUCKLING	4.2107316, -1 5.2181803, -3
DIFFUSION COEFFICIENT, TWO-GROUP BUCKLING	4.5152479, -1 4.7320245, -3
SIGMA ABSORPTION	2.0858625, 0 3.6757833, 1
NU SIGMA FISSION	0.0000000, 0 0.0000000, 0
FLUX	2.3156393, 1 1.7747548, 1
MULTIPLICATION	0.0000000, 0 0.0000000, 0
SIGMA LEAKAGE	2.0839689, -3 2.5825739, -5
DIFFUSION AREA, ONE-GROUP BUCKLING	2.0187004, -1 1.4196104, -4
DIFFUSION AREA, TWO-GROUP BUCKLING	2.1646910, -1 1.2873512, -4
BUCKLING	4.6154030, -3 5.4576511, -3
EXTRAPOLATION DISTANCE	3.5076990, 0 3.6050067, -1
SLOWING DOWN X-SECTION	0.0000000, 0
AVERAGE BUCKLING	4.9491848, -3
AVERAGE EXTRAPOLATION DISTANCE	2.1597764, 0
ABSORPTION ESCAPE PROBABILITY	0.0000000, 0
REACTIVITY, ONE-GROUP BUCKLING	0.0000000, 0
REACTIVITY, TWO-GROUP BUCKLING	0.0000000, 0

MULTIGROUP CONSTANTS			
N	ENERGY	LETHARGY	SLOWING DOWN DENSITY
1	0.0000000, 0	1.1512829, 1	0.0000000, 0
2	0.0000000, 0	1.6117999, 1	0.0000000, 0
3	0.0000000, 0		
GROUP	MULTIPLICATION	BUCKLING	EXTRAPOLATION DISTANCE
1	0.0000000, 0	4.4490632, -3	4.2381139, 0
2	0.0000000, 0	5.1371951, -3	1.4618104, 0
3	0.0000000, 0	5.4403165, -3	4.1744413, -1
GROUP	SIGMA LEAKAGE	FLUX	SIGMA ABSORPTION
1	2.6524425, -3	1.7553170, 1	6.5900679, -2
2	4.5924814, -4	3.3573543, 0	2.5378562, 0
3	3.0736584, -5	1.9593417, 1	3.4515780, 1
GROUP	SOURCE TERM	NU SIGMA FISSION	SLOWING DOWN X-SECTION
1	0.0000000, 0	0.0000000, 0	0.0000000, 0
2	0.0000000, 0	0.0000000, 0	0.0000000, 0
3	0.0000000, 0	0.0000000, 0	0.0000000, 0
GROUP	ABSORPTION ESCAPE PROBABILITY	DIFFUSION COEFFICIENT ONE-GROUP BUCKLING	DIFFUSION COEFFICIENT MULTIGROUP BUCKLING
1	0.0000000, 0	5.3523512, -1	5.9617999, -1
2	0.0000000, 0	9.2934103, -2	8.9532933, -2
3	0.0000000, 0	6.2104325, -3	5.6497787, -3
GROUP	DIFFUSION AREA ONE-GROUP BUCKLING	DIFFUSION AREA MULTIGROUP BUCKLING	
1	8.1324672, 0	9.0466440, 0	
2	3.6619136, -2	3.5278961, -2	
3	1.7993023, -4	1.6368682, -4	
REACTIVITY, ONE-GROUP BUCKLING		0.0000000, 0	
REACTIVITY, MULTIGROUP BUCKLING		0.0000000, 0	

PHOTON PRODUCTION PARAMETERS			ASSUMES NU = 2.46
P	ENERGY	LETHARGY	GROUP FLUX
1	1.0000000, 6	2.3024893, 0	6.7233151, 0
2	1.0000000, 3	9.2102446, 0	9.0886753, 0
3	5.0000000, -1	1.6811146, 1	5.5837655, 0
4	9.9999999, -5	1.9554883, 1	1.7606382, 0
5			1.7347548, 1
ELEMENT 8.050 *BOR CARBIDE			
GROUP	ABSORPTION CROSS SECTION	FISSION CROSS SECTION	
1	4.4736694, -3		
2	4.2323587, -2		
3	2.3637207, 0		
4	1.9701859, 1		
5	3.6757833, 1		

TRANSMISSION GEOMETRY

C15-TRANSMISSION CALCULATION ROD

ROD DIAMETER	DD	2.0000000, 0
CHANNEL DIAMETER	DCH	2.5399999, 0

TRANSMISSION FRACTIONS

TWO-GROUP TRANSMISSIONS

FAST	7.0404141, -1
SLOW	2.1288287, -1

LEVEL	TRANSMISSION
0	9.9672586, -1
1	9.9580477, -1
2	9.9461984, -1
3	9.9312100, -1
4	9.9112413, -1
5	9.8868554, -1
6	9.8549216, -1
7	9.8142977, -1
8	9.7626573, -1
9	9.3753733, -1
10	8.4472195, -1
11	6.5831810, -1
12	4.0980599, -1
13	2.5520097, -1
14	2.2545839, -1
15	2.1622900, -1
16	2.1424008, -1
17	2.1320272, -1
T	2.1288287, -1
T+1	2.1288287, -1

MULTIGROUP TRANSMISSION

GROUP	TRANSMISSION
1	9.1926799,-1
2	2.9534507,-1
3	2.1451217,-1
4	2.1288287,-1

```

*****
* UNCLASSIFIED *
* W.B.HENDERSON EXT.736 *
* GEORGE CASE GEORGE SAMPLE TEST CASE *
*****

```

```

*****
* THIS IS RADIAL F2 CALCULATION NUMBER 1 OF ITERATION 1 *
* REFERENCE CORE = AVG.CORE *
* RADIAL F2 = RAD *
* LONGITUDINAL F2 = LONG *
*****

```

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-----
F2 CASE RAD
-----

```

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-----
CTN24 USE TWO-GROUP BUCKLING
-----

```

```

-----
CTN25 COMPUTE BUCKLING FROM REFERENCE COMPOSITION AVG.CORE
-----

```

```

-----
CTN26 USE FAST (T1) AND SLOW (T2) TRANSMISSION FRACTIONS
FROM REFERENCE COMPOSITION ROD
-----

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-----
CTN27 TERRALL METHOD-NOT AVAILABLE
-----

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UNCLASSIFIED

CASE RAD 8/5/59 K=0.95763, F=1.757, H= 50.000, D= 0.000

CO= 3, C1=0, C2=1, C3=1, C4=1, C5=0, C6=0, C7=0, C8=2, C9=1, P= 0

S/H 3.2685363, S/O 0.0000000, R/O 1.0000000, R/N 0.0000000

A1- 0.7040414, A1+ 0.0000000, A2- 0.2128829, A2+ 0.0000000

A1 1.0000550, B1 1.0004043, A2 1.0015063, B2 1.0034037

ALPHA 0 CORE 1 CORE 2

REGIONAL DATA

RADIUS INTERVALS MATERIAL K1 SQ. K2 SQ.

24.740 25 CORE 1 2.3525365, -3 2.8702546, -3

35.000 10 CORE 2 2.3525365, -3 2.8702546, -3

45.000 10 SIDE 2.3525365, -3 2.8702546, -3

MATERIAL DATA

MATERIAL CORE 1 CORE 2 SIDE

DIFFUSION 1 1.4777205, 0 1.4098853, 0 1.2368278, 0 0.0000000, 0

DIFFUSION 2 2.0456507, -1 1.8904127, -1 1.4690037, -1 0.0000000, 0

ABSORPTION 1 2.8864023, -3 2.4315250, -3 1.1804399, -3 0.0000000, 0

ABSORPTION 2 4.3571612, -2 3.6481295, -2 1.9539445, -2 0.0000000, 0

FISSION 1 3.4899848, -3 2.5627582, -3 0.0000000, 0 0.0000000, 0

FISSION 2 5.4953161, -2 3.8740087, -2 0.0000000, 0 0.0000000, 0

SCATTER 3.3477935, -2 3.5796672, -2 4.2579183, -2 0.0000000, 0

SOURCE 1 0.0000000, 0 0.0000000, 0 0.0000000, 0 0.0000000, 0

SOURCE 2 0.0000000, 0 0.0000000, 0 0.0000000, 0 0.0000000, 0

MATERIAL

DIFFUSION 1 0.0000000, 0

DIFFUSION 2 0.0000000, 0

ABSORPTION 1 0.0000000, 0

ABSORPTION 2 0.0000000, 0

FISSION 1 0.0000000, 0

FISSION 2 0.0000000, 0

SCATTER 0.0000000, 0

SOURCE 1 0.0000000, 0

SOURCE 2 0.0000000, 0

UNCLASSIFIED

ITERATION	REACTIVITY	P	V CORE
1	5.3841505, 2	22	1.9226528, 5
2	9.1684783, -1		
3	9.3520137, -1		
4	9.4486354, -1		
5	9.5020458, -1		
6	9.5325511, -1		
7	9.5503307, -1		
8	9.5608168, -1		
9	9.5670439, -1		
10	9.5707556, -1		
11	9.5729729, -1		
12	9.5742987, -1		
13	9.5750921, -1		
14	9.5755670, -1		
15	9.5758513, -1		
16	9.5760217, -1		
17	9.5761234, -1		
18	9.5761846, -1		
19	9.5762210, -1		
20	9.5762429, -1		
21	9.5762559, -1		
22	9.5762640, -1		

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RADIUS	FISSION DENSITY	FAST FLUX	SLOW FLUX
1.0000000, 0	8.1918311, -1	1.9448688, 0	6.6737737, -1
1.0009495, 0	8.2023144, -1	1.9449773, 0	6.6838262, -1
1.9495999, 0	1.2904650, 0	2.0117303, 0	1.1181374, 0
2.8991999, 0	1.5111675, 0	2.0566309, 0	1.3283664, 0
3.8487999, 0	1.6297038, 0	2.0879583, 0	1.4408195, 0
4.7983299, 0	1.6964451, 0	2.1085462, 0	1.5039484, 0
5.7479999, 0	1.7334479, 0	2.1198840, 0	1.5389533, 0
6.6975298, 0	1.7516758, 0	2.1229645, 0	1.5563561, 0
7.6471998, 0	1.7570222, 0	2.1185331, 0	1.5617993, 0
8.5967998, 0	1.7528417, 0	2.1071851, 0	1.5584838, 0
9.5463998, 0	1.7411410, 0	2.0894145, 0	1.5483158, 0
1.0495999, 1	1.7231820, 0	2.0656428, 0	1.5324867, 0
1.1445999, 1	1.6998036, 0	2.0362384, 0	1.5117831, 0
1.2395199, 1	1.6716007, 0	2.0015310, 0	1.4867584, 0
1.3344799, 1	1.6390285, 0	1.9618213, 0	1.4578329, 0
1.4294399, 1	1.6024655, 0	1.9173881, 0	1.4253545, 0
1.5243999, 1	1.5622558, 0	1.8684936, 0	1.3896387, 0
1.6193599, 1	1.5187409, 0	1.8153855, 0	1.3509294, 0
1.7143199, 1	1.4722900, 0	1.7582976, 0	1.3097782, 0
1.8092799, 1	1.4233348, 0	1.6974481, 0	1.2663781, 0
1.9042399, 1	1.3724161, 0	1.6330332, 0	1.2213088, 0
1.9991999, 1	1.3202527, 0	1.5652183, 0	1.1752536, 0
2.0941599, 1	1.2678452, 0	1.4941204, 0	1.1291713, 0
2.1891199, 1	1.2166389, 0	1.4197808, 0	1.0844546, 0
2.2840799, 1	1.1687754, 0	1.3421229, 0	1.0431760, 0
2.3790399, 1	1.1274892, 0	1.2608830, 0	1.0084750, 0
2.4739050, 1	1.0977522, 0	1.1755917, 0	9.8518173, -1
2.4739999, 1	1.0977320, 0	1.1755037, 0	9.8516781, -1
2.4739999, 1	7.7613298, -1	1.1755037, 0	9.8516781, -1
2.4741025, 1	7.7611626, -1	1.1754041, 0	9.8515151, -1
2.5765999, 1	7.4847704, -1	1.0800713, 0	9.5360554, -1
2.6791999, 1	7.0863433, -1	9.9085746, -1	9.0494181, -1
2.7817999, 1	6.6251676, -1	9.0639118, -1	8.4737050, -1
2.8843999, 1	6.1381978, -1	8.2568060, -1	7.8601819, -1
2.9869999, 1	5.6501682, -1	7.4800741, -1	7.2431977, -1
3.0895999, 1	5.1801751, -1	6.7278994, -1	6.6492907, -1
3.1921999, 1	4.7466519, -1	5.9947953, -1	6.1040684, -1
3.2947999, 1	4.3719779, -1	5.2746475, -1	5.6385841, -1
3.3973999, 1	4.0878359, -1	4.5596080, -1	5.2967474, -1
3.4998974, 1	3.9426385, -1	3.8393129, -1	5.1455459, -1
3.5000000, 1	3.9426005, -1	3.8385806, -1	5.1455423, -1
3.5000000, 1	0.0000000, 0	3.8385806, -1	5.1455423, -1
3.5000999, 1	0.0000000, 0	3.8377687, -1	5.1455376, -1
3.5999999, 1	0.0000000, 0	3.1086190, -1	4.9345349, -1
3.6999999, 1	0.0000000, 0	2.5143630, -1	4.5018510, -1
3.7999999, 1	0.0000000, 0	2.0295634, -1	3.9651957, -1
3.8999999, 1	0.0000000, 0	1.6329430, -1	3.3936494, -1
3.9999999, 1	0.0000000, 0	1.3071997, -1	2.8245522, -1

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4.0999999, 1	0.0000000, 0	1.0382151, -1	2.2743584, -1
4.1999999, 1	0.0000000, 0	8.1441516, -2	1.7454409, -1
4.2999999, 1	0.0000000, 0	6.2624991, -2	1.2300703, -1
4.3999999, 1	0.0000000, 0	4.6576904, -2	7.1233765, -2
4.4999000, 1	0.0000000, 0	3.2640088, -2	1.6901586, -2
4.5000000, 1	0.0000000, 0	3.2626899, -2	1.6844254, -2

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MATERIAL	VOLUME	FAST FLUX	SLOW FLUX
CORE 1	4.9923823, -1	1.7148362, 0	1.2827863, 0
CORE 2	5.0076179, -1	7.3585686, -1	7.1807399, -1
SIDE	6.5359478, -1	1.4918693, -1	2.7121457, -1

```

*****
* UNCLASSIFIED *
* W.B.HENDERSON EXT.736 *
* GEORGE CASE GEORGE SAMPLE TEST CASE *
*****

```

```

*****
* THIS IS *
* LONGITUDINAL F2 CALCULATION NUMBER 1 OF ITERATION 1 *
* REFERENCE CORE = AVG.CORE *
* RADIAL F2 = RAD *
* LONGITUDINAL F2 = LONG *
*****

```

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-----
F2 CASE LONG
-----

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```

CTN24 USE TWO-GROUP BUCKLING
-----

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```

CTN25 COMPUTE BUCKLING FROM REFERENCE COMPOSITION AVG.CORE
-----

```

```

CTN26 USE F2 DATA AND CONTROLS
-----

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CTN27 TERRALL METHOD-NOT AVAILABLE
-----

```

UNCLASSIFIED

CASE LONG 8/5/59 K=0.95741, F=1.291, H= 0.000, D= 70.000

C0= 3, C1=0, C2=0, C3=1, C4=1, C5=0, C6=0, C7=0, C8=1, C9=1, P= 0

S/H 0.0000000, S/D 11.828315, R/O 0.0000000, R/N 35.000000

A1- 0.0000000, A1+ 0.0000000, A2- 0.0000000, A2+ 0.0000000

A1 1.0003514, B1 1.0003514, A2 1.0024735, B2 1.0024735

ALPHA 0

REGIONAL DATA

RADIUS INTERVALS		MATERIAL	K1 SQ.	K2 SQ.
10.000	10	END	2.2840378,-3	2.5900647,-3
60.000	50	AVG. CORE	2.2040370,-3	2.5900647,-3
75.000	15	END	2.2840378,-3	2.5900647,-3

MATERIAL DATA

MATERIAL	END	AVG. CORE		
DIFFUSION 1	1.4230527, 0	1.4394929, 0	0.0000000, 0	0.0000000, 0
DIFFUSION 2	2.0214078,-1	1.9593420,-1	0.0000000, 0	0.0000000, 0
ABSORPTION 1	1.0256808,-3	2.6347589,-3	0.0000000, 0	0.0000000, 0
ABSORPTION 2	1.7259216,-2	3.9625816,-2	0.0000000, 0	0.0000000, 0
FISSION 1	0.0000000, 0	2.9769676,-3	0.0000000, 0	0.0000000, 0
FISSION 2	0.0000000, 0	4.5930507,-2	0.0000000, 0	0.0000000, 0
SCATTER	3.6917448,-2	3.4768759,-2	0.0000000, 0	0.0000000, 0
SOURCE 1	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0
SOURCE 2	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0

MATERIAL

DIFFUSION 1	0.0000000, 0
DIFFUSION 2	0.0000000, 0
ABSORPTION 1	0.0000000, 0
ABSORPTION 2	0.0000000, 0
FISSION 1	0.0000000, 0
FISSION 2	0.0000000, 0
SCATTER	0.0000000, 0
SOURCE 1	0.0000000, 0
SOURCE 2	0.0000000, 0

UNCLASSIFIED

ITERATION	REACTIVITY	P	V CORE
1	4.6439333, -1	18	1.9242250, 5
2	9.4334632, -1		
3	9.5004913, -1		
4	9.5346130, -1		
5	9.5527113, -1		
6	9.5624754, -1		
7	9.5677786, -1		
8	9.5706674, -1		
9	9.5722424, -1		
10	9.5731012, -1		
11	9.5735710, -1		
12	9.5738270, -1		
13	9.5739666, -1		
14	9.5740430, -1		
15	9.5740845, -1		
16	9.5741072, -1		
17	9.5741197, -1		
18	9.5741266, -1		

UNCLASSIFIED

RADIUS	FISSION DENSITY	FAST FLUX	SLOW FLUX
0.0000000, 0	0.0000000, 0	3.7852692, -2	2.0858169, -2
0.9999999, -4	0.0000000, 0	3.7865992, -2	2.0909762, -2
1.0000000, 0	0.0000000, 0	5.1699863, -2	6.9915517, -2
2.0000000, 0	0.0000000, 0	6.7043401, -2	1.1568052, -1
3.0000000, 0	0.0000000, 0	8.4327659, -2	1.5937791, -1
4.0000000, 0	0.0000000, 0	1.0405296, -1	2.0169516, -1
5.0000000, 0	0.0000000, 0	1.2679032, -1	2.4275255, -1
6.0000000, 0	0.0000000, 0	1.5319790, -1	2.8200941, -1
7.0000000, 0	0.0000000, 0	1.8404013, -1	3.1809636, -1
8.0000000, 0	0.0000000, 0	2.2020982, -1	3.4855527, -1
9.0000000, 0	0.0000000, 0	2.6275396, -1	3.6945991, -1
9.9999999, 0	0.0000000, 0	3.1285015, -1	3.7488170, -1
1.0000000, 1	0.0000000, 0	3.1290482, -1	3.7487505, -1
1.0000000, 1	5.5397019, -1	3.1290482, -1	3.7487505, -1
1.0000999, 1	5.5396547, -1	3.1295886, -1	3.7486817, -1
1.0999999, 1	5.6391432, -1	3.6477826, -1	3.7860620, -1
1.1999999, 1	5.9155517, -1	4.1355661, -1	3.9516130, -1
1.2999999, 1	6.2957175, -1	4.5996226, -1	4.1927138, -1
1.3999999, 1	6.7338012, -1	5.0440324, -1	4.4764017, -1
1.4999999, 1	7.2009040, -1	5.4709435, -1	4.7819236, -1
1.5999999, 1	7.6786424, -1	5.8813194, -1	5.0961037, -1
1.6999999, 1	8.1551672, -1	6.2754037, -1	5.4104741, -1
1.7999999, 1	8.6226974, -1	6.6530079, -1	5.7194966, -1
1.8999999, 1	9.0759933, -1	7.0136918, -1	6.0194624, -1
1.9999999, 1	9.5114113, -1	7.3568753, -1	6.3078097, -1
2.0999999, 1	9.9263182, -1	7.6819086, -1	6.5827026, -1
2.1999999, 1	1.0318730, 0	7.9881164, -1	6.8427696, -1
2.2999999, 1	1.0687090, 0	8.2748264, -1	7.0869436, -1
2.3999999, 1	1.1030129, 0	8.5413865, -1	7.3143620, -1
2.4999999, 1	1.1346783, 0	8.7871771, -1	7.5243055, -1
2.5999999, 1	1.1636139, 0	9.0116190, -1	7.7161610, -1
2.6999999, 1	1.1897407, 0	9.2141783, -1	7.8893989, -1
2.7999999, 1	1.2129898, 0	9.3943702, -1	8.0435593, -1
2.8999999, 1	1.2333014, 0	9.5517617, -1	8.1782437, -1
2.9999999, 1	1.2506241, 0	9.6859737, -1	8.2931104, -1
3.0999999, 1	1.2649146, 0	9.7966825, -1	8.3878713, -1
3.1999999, 1	1.2761374, 0	9.8836205, -1	8.4622910, -1
3.2999999, 1	1.2842650, 0	9.9465779, -1	8.5161658, -1
3.3999999, 1	1.2892773, 0	9.9854023, -1	8.5494228, -1
3.4999999, 1	1.2911620, 0	1.0000000, 0	8.5619208, -1
3.5999999, 1	1.2899147, 0	9.9903360, -1	8.5536494, -1
3.6999999, 1	1.2855383, 0	9.9564338, -1	8.5246291, -1
3.7999999, 1	1.2780436, 0	9.8983757, -1	8.4749318, -1
3.8999999, 1	1.2674493, 0	9.8163022, -1	8.4046803, -1
3.9999999, 1	1.2537815, 0	9.7104122, -1	8.3140489, -1
4.0999999, 1	1.2370743, 0	9.5809618, -1	8.2032642, -1
4.1999999, 1	1.2173697, 0	9.4282632, -1	8.0726049, -1
4.2999999, 1	1.1947177, 0	9.2526845, -1	7.9224047, -1
4.3999999, 1	1.1691770, 0	9.0546474, -1	7.7530547, -1

UNCLASSIFIED

4.49999999	1	1.1408156	0	8.8346255	-1	7.5650087	-1
4.59999999	1	1.1097119	0	8.5931415	-1	7.3587924	-1
4.69999999	1	1.0759568	0	8.3307631	-1	7.1350178	-1
4.79999999	1	1.0396573	0	8.0480977	-1	6.8944087	-1
4.89999999	1	1.0009419	0	7.7457844	-1	6.6378402	-1
4.99999999	1	9.5996991	-1	7.4244807	-1	6.3664050	-1
5.09999999	1	9.1694584	-1	7.0848444	-1	6.0815207	-1
5.19999999	1	8.7214403	-1	6.7275021	-1	5.7851032	-1
5.29999999	1	8.2594736	-1	6.3530033	-1	5.4798480	-1
5.39999999	1	7.7891034	-1	5.9617432	-1	5.1696848	-1
5.49999999	1	7.3186102	-1	5.5538440	-1	4.8605122	-1
5.59999999	1	6.8606554	-1	5.1282597	-1	4.5613844	-1
5.69999999	1	6.4349401	-1	4.6859662	-1	4.2864273	-1
5.79999999	1	6.0724946	-1	4.2224616	-1	4.0572310	-1
5.89999999	1	5.8226037	-1	3.7339596	-1	3.9113417	-1
5.99999999	1	5.7639461	-1	3.2131296	-1	3.9032577	-1
6.00000000	1	5.7640459	-1	3.2125852	-1	3.9033642	-1
6.00000000	1	0.0000000	0	3.2125852	-1	3.9033642	-1
6.00009999	1	0.0000000	0	3.2120344	-1	3.9034674	-1
6.09999999	1	0.0000000	0	2.7081941	-1	3.8849608	-1
6.19999999	1	0.0000000	0	2.2822050	-1	3.7136769	-1
6.29999999	1	0.0000000	0	1.9222794	-1	3.4522889	-1
6.39999999	1	0.0000000	0	1.6179985	-1	3.1435359	-1
6.49999999	1	0.0000000	0	1.3605541	-1	2.8158278	-1
6.59999999	1	0.0000000	0	1.1424940	-1	2.4873532	-1
6.69999999	1	0.0000000	0	9.5750593	-2	2.1690401	-1
6.79999999	1	0.0000000	0	8.0023500	-2	1.8666707	-1
6.89999999	1	0.0000000	0	6.6612862	-2	1.5823677	-1
6.99999999	1	0.0000000	0	5.5130485	-2	1.3156124	-1
7.09999999	1	0.0000000	0	4.5243981	-2	1.0639084	-1
7.19999999	1	0.0000000	0	3.6667164	-2	8.2316863	-2
7.29999999	1	0.0000000	0	2.9151760	-2	5.8787873	-2
7.39999999	1	0.0000000	0	2.2480219	-2	3.5106528	-2
7.49999999	1	0.0000000	0	1.6465113	-2	1.0433172	-2
7.50000000	1	0.0000000	0	1.6459330	-2	1.0407429	-2

UNCLASSIFIED

MATERIAL	VOLUME	FAST FLUX	SLOW FLUX
END	4.9999999, -1	1.2531126, -1	2.1726121, -1
AVG. CORE	1.0000000, 0	7.6422045, -1	6.6378341, -1

```
*****
* REACTIVITY MATCH CONTINUES *
*****
* K(C)= 9.5780916, -1 *
* S(R)= 1.1898314, 1 *
* S(Z)= 3.9685362, 0 *
*****
* K(R)= 9.5762788, -1 *
* S(Z)= 3.9685362, 0 *
*****
* K(Z)= 9.5741362, -1 *
* S(R)= 1.1898314, 1 *
*****
```

```

*****
* UNCLASSIFIED *
* W.B.HENDERSON EXT.736 *
* GEORGE CASE GEORGE SAMPLE TEST CASE *
*****

```

```

*****
* THIS IS RADIAL F2 CALCULATION NUMBER 2 OF ITERATION 1 *
* REFERENCE CORE = AVG.CORE *
* RADIAL F2 = RAD *
* LONGITUDINAL F2 = LONG *
*****

```

```

*****
F2 CASE RAD
*****

```

```

CTN24 USE TWO-GROUP BUCKLING

```

```

CTN25 COMPUTE BUCKLING FROM REFERENCE COMPOSITION AVG.CORE

```

```

CTN26 USE FAST (CT1) AND SLOW (CT2) TRANSMISSION FRACTIONS
FROM REFERENCE COMPOSITION ROD

```

```

CTN27 TERRALL METHOD-NOT AVAILABLE

```

UNCLASSIFIED

CASE RAD 8/5/59 K=0.94607, F=1.758, H= 50.000, D= 0.000

C0= 3, C1=0, C2=1, C3=1, C4=1, C5=0, C6=0, C7=0, C8=2, C9=1, P= 0

S/H 1.9842681, S/D 0.0000000, R/O 1.0000000, R/N 0.0000000

A1- 0.7040414, A1+ 0.0000000, A2- 0.2128829, A2+ 0.0000000

A1 1.0000558, B1 1.0004043, A2 1.0015063, B2 1.0034037

ALPHA 0 CORE 1 CORE 2

REGIONAL DATA

RADIUS INTERVALS		MATERIAL	K1 SQ.	K2 SQ.
24.740	25	CORE 1	2.6696477,-3	3.3020702,-3
35.000	10	CORE 2	2.6696477,-3	3.3020702,-3
45.000	10	SIDE	2.6696477,-3	3.3020702,-3

MATERIAL DATA

MATERIAL	CORE 1	CORE 2	SIDE
DIFFUSION 1	1.4777205, 0	1.4098853, 0	1.2368278, 0 0.0000000, 0
DIFFUSION 2	2.0456507,-1	1.8904127,-1	1.4690037,-1 0.0000000, 0
ABSORPTION 1	2.8864023,-3	2.4315250,-3	1.1804399,-3 0.0000000, 0
ABSORPTION 2	4.3571612,-2	3.6481295,-2	1.9539445,-2 0.0000000, 0
FISSION 1	3.4899848,-3	2.5627582,-3	0.0000000, 0 0.0000000, 0
FISSION 2	5.4953161,-2	3.8740087,-2	0.0000000, 0 0.0000000, 0
SCATTER	3.3477935,-2	3.5796672,-2	4.2579183,-2 0.0000000, 0
SOURCE 1	0.0000000, 0	0.0000000, 0	0.0000000, 0 0.0000000, 0
SOURCE 2	0.0000000, 0	0.0000000, 0	0.0000000, 0 0.0000000, 0

MATERIAL

DIFFUSION 1	0.0000000, 0
DIFFUSION 2	0.0000000, 0
ABSORPTION 1	0.0000000, 0
ABSORPTION 2	0.0000000, 0
FISSION 1	0.0000000, 0
FISSION 2	0.0000000, 0
SCATTER	0.0000000, 0
SOURCE 1	0.0000000, 0
SOURCE 2	0.0000000, 0

UNCLASSIFIED

ITERATION	REACTIVITY	P	V CORE
1	5.3195275, 2	22	1.9226528, 5
2	9.0569772, -1		
3	9.2380326, -1		
4	9.3335960, -1		
5	9.3865611, -1		
6	9.4168977, -1		
7	9.4346304, -1		
8	9.4451215, -1		
9	9.4513715, -1		
10	9.4551086, -1		
11	9.4573485, -1		
12	9.4590928, -1		
13	9.4594991, -1		
14	9.4599837, -1		
15	9.4602748, -1		
16	9.4604494, -1		
17	9.4605550, -1		
18	9.4606176, -1		
19	9.4606558, -1		
20	9.4606787, -1		
21	9.4606919, -1		
22	9.4607003, -1		

UNCLASSIFIED

RADIUS	FISSION DENSITY	FAST FLUX	SLOW FLUX
1.0000000, 0	8.1997919, -1	1.9497106, 0	6.6807948, -1
1.0009495, 0	8.2102832, -1	1.9498194, 0	6.6908579, -1
1.9495999, 0	1.2915472, 0	2.0168679, 0	1.1192356, 0
2.8991999, 0	1.5123594, 0	2.0620436, 0	1.3296179, 0
3.8487999, 0	1.6309557, 0	2.0936037, 0	1.4421491, 0
4.7983222, 0	1.6977401, 0	2.1143758, 0	1.5053275, 0
5.7479999, 0	1.7347773, 0	2.1258500, 0	1.5403678, 0
6.6975998, 0	1.7530318, 0	2.1290215, 0	1.5577958, 0
7.6471998, 0	1.7583956, 0	2.1246391, 0	1.5632543, 0
8.5967998, 0	1.7542221, 0	2.1133017, 0	1.5599437, 0
9.5463998, 0	1.7425169, 0	2.0955060, 0	1.5497695, 0
1.0495999, 1	1.7245415, 0	2.0716764, 0	1.5339230, 0
1.1445599, 1	1.7011344, 0	2.0421837, 0	1.5131904, 0
1.2395199, 1	1.6728907, 0	2.0073598, 0	1.4881254, 0
1.3344799, 1	1.6402658, 0	1.9675074, 0	1.4591486, 0
1.4294399, 1	1.6036386, 0	1.9229070, 0	1.4266079, 0
1.5243999, 1	1.5633533, 0	1.8738226, 0	1.3908194, 0
1.6193599, 1	1.5197520, 0	1.8205034, 0	1.3520972, 0
1.7143199, 1	1.4732039, 0	1.7631850, 0	1.3107832, 0
1.8092799, 1	1.4241410, 0	1.7020864, 0	1.2672805, 0
1.9042399, 1	1.3731039, 0	1.6374053, 0	1.2220987, 0
1.9991999, 1	1.3208113, 0	1.5693079, 0	1.1759214, 0
2.0941599, 1	1.2682638, 0	1.4979112, 0	1.1297075, 0
2.1891199, 1	1.2169066, 0	1.4232562, 0	1.0848500, 0
2.2840799, 1	1.1688826, 0	1.3452642, 0	1.0434236, 0
2.3790399, 1	1.1274294, 0	1.2636671, 0	1.0085718, 0
2.4739050, 1	1.0975268, 0	1.1779876, 0	9.8513448, -1
2.4739999, 1	1.0975064, 0	1.1778992, 0	9.8512042, -1
2.4739999, 1	7.7597784, -1	1.1778992, 0	9.8512042, -1
2.4741025, 1	7.7596098, -1	1.1777991, 0	9.8510395, -1
2.5765999, 1	7.4818079, -1	1.0820448, 0	9.5338120, -1
2.6791999, 1	7.0820418, -1	9.9247160, -1	9.0454123, -1
2.7817999, 1	6.6196655, -1	9.0769112, -1	8.4680700, -1
2.8843999, 1	6.1316318, -1	8.2670045, -1	7.8530713, -1
2.9869999, 1	5.6426395, -1	7.4877376, -1	7.2347328, -1
3.0895999, 1	5.1717334, -1	6.7332366, -1	6.6395330, -1
3.1921999, 1	4.7372833, -1	5.9979641, -1	6.0930033, -1
3.2947999, 1	4.3615965, -1	5.2757496, -1	5.6261121, -1
3.3973999, 1	4.0762791, -1	4.5586724, -1	5.2826815, -1
3.4998974, 1	3.9296720, -1	3.8362637, -1	5.1296281, -1
3.5000000, 1	3.9296324, -1	3.8355292, -1	5.1296225, -1
3.5000000, 1	0.0000000, 0	3.8355292, -1	5.1296225, -1
3.5000999, 1	0.0000000, 0	3.8347130, -1	5.1296153, -1
3.5999999, 1	0.0000000, 0	3.1037998, -1	4.9165185, -1
3.6999999, 1	0.0000000, 0	2.5086159, -1	4.4828524, -1
3.7999999, 1	0.0000000, 0	2.0234840, -1	3.9462475, -1
3.8999999, 1	0.0000000, 0	1.6269470, -1	3.3756300, -1
3.9999999, 1	0.0000000, 0	1.3015709, -1	2.8081756, -1

UNCLASSIFIED

4.0999999, 1	0.0000000, 0	1.0331424, -1	2.2601953, -1
4.1999999, 1	0.0000000, 0	3.1001969, -2	1.7339535, -1
4.2999999, 1	0.0000000, 0	6.2260565, -2	1.2216519, -1
4.3999999, 1	0.0000000, 0	4.6291793, -2	7.0735266, -2
4.4999000, 1	0.0000000, 0	3.2436306, -2	1.6783250, -2
4.5000000, 1	0.0000000, 0	3.2423199, -2	1.6726320, -2

UNCLASSIFIED			
MATERIAL	VOLUME	FAST FLUX	SLOW FLUX
CORE 1	4.9923823,-1	1.7194623, 0	1.2836620, 0
CORE 2	5.0076179,-1	7.3663998,-1	7.1720095,-1
SIDE	6.5359478,-1	1.4872440,-1	2.6986981,-1

```

*****
* UNCLASSIFIED *
* W.B.HENDERSON EXT.736 *
* GEORGE CASE GEORGE SAMPLE TEST CASE *
*****

```

```

*****
* THIS IS RADIAL F2 CALCULATION NUMBER 3 OF ITERATION 1 *
* REFERENCE CORE = AVG.CORE *
* RADIAL F2 = RAD *
* LONGITUDINAL F2 = LONG *
*****

```

```

-----
F2 CASE RAD
-----

```

```

CTN24 USE TWO-GROUP BUCKLING
-----

```

```

CTN25 COMPUTE BUCKLING FROM REFERENCE COMPOSITION AVG.CORE
-----

```

```

CTN26 USE FAST (T1) AND SLOW (T2) TRANSMISSION FRACTIONS
FROM REFERENCE COMPOSITION ROD
-----

```

```

CTN27 TERRALL METHOD-NOT AVAILABLE
-----

```

UNCLASSIFIED

CASE RAD 8/5/59 K=0.93230, F=1.760, H= 50.000, D= 0.000

C0= 3, C1=0, C2=1, C3=1, C4=1, C5=0, C6=0, C7=0, C8=2, C9=1, P= 0

S/H 0.0000000, S/D 0.0000000, R/D 1.0000000, R/N 0.0000000

A1- 0.7040414, A1+ 0.0000000, A2- 0.2128829, A2+ 0.0000000

A1 1.0000558, B1 1.0004043, A2 1.0015063, B2 1.0034037

ALPHA 0 CORE 1 CORE 2

REGIONAL DATA

RADIUS INTERVALS		MATERIAL	K1 SQ.	K2 SQ.
24.740	25	CORE 1	3.0554805,-3	3.8392014,-3
35.000	10	CORE 2	3.0554805,-3	3.8392014,-3
45.000	10	SIDE	3.0554805,-3	3.8392014,-3

MATERIAL DATA

MATERIAL	CORE 1	CORE 2	SIDE
DIFFUSION 1	1.4777205, 0	1.4098853, 0	1.2368278, 0
DIFFUSION 2	2.0456507,-1	1.8904127,-1	1.4690037,-1
ABSORPTION 1	2.8864023,-3	2.4315250,-3	1.1804399,-3
ABSORPTION 2	4.3571612,-2	3.6481295,-2	1.9539445,-2
FISSION 1	3.4899848,-3	2.5627582,-3	0.0000000, 0
FISSION 2	5.4953161,-2	3.8740087,-2	0.0000000, 0
SCATTER	3.3477935,-2	3.5796672,-2	4.2579183,-2
SOURCE 1	0.0000000, 0	0.0000000, 0	0.0000000, 0
SOURCE 2	0.0000000, 0	0.0000000, 0	0.0000000, 0

MATERIAL	
DIFFUSION 1	0.0000000, 0
DIFFUSION 2	0.0000000, 0
ABSORPTION 1	0.0000000, 0
ABSORPTION 2	0.0000000, 0
FISSION 1	0.0000000, 0
FISSION 2	0.0000000, 0
SCATTER	0.0000000, 0
SOURCE 1	0.0000000, 0
SOURCE 2	0.0000000, 0

UNCLASSIFIED

ITERATION	REACTIVITY	P	V CORE
1	5.2425296, 2	22	1.9226528, 5
2	8.9241135, -1		
3	9.1021968, -1		
4	9.1964846, -1		
5	9.2489101, -1		
6	9.2790380, -1		
7	9.2967111, -1		
8	9.3072059, -1		
9	9.3134807, -1		
10	9.3172483, -1		
11	9.3195151, -1		
12	9.3208804, -1		
13	9.3217034, -1		
14	9.3221928, -1		
15	9.3224991, -1		
16	9.3226792, -1		
17	9.3227881, -1		
18	9.3228539, -1		
19	9.3228936, -1		
20	9.3229174, -1		
21	9.3229320, -1		
22	9.3229407, -1		

UNCLASSIFIED

RADIUS	FISSION DENSITY	FAST FLUX	SLOW FLUX
1.0000000, 0	8.2093890, -1	1.9556737, 0	6.6892199, -1
1.0009495, 0	8.2198898, -1	1.9557828, 0	6.6992956, -1
1.9495999, 0	1.2928487, 0	2.0231933, 0	1.1205544, 0
2.8991999, 0	1.5137894, 0	2.0687054, 0	1.3311187, 0
3.8487999, 0	1.6324551, 0	2.1005497, 0	1.4437414, 0
4.7983999, 0	1.6992894, 0	2.1215469, 0	1.5069776, 0
5.7479999, 0	1.7363667, 0	2.1331974, 0	1.5420594, 0
6.6975298, 0	1.7546523, 0	2.1364699, 0	1.5595170, 0
7.6471998, 0	1.7600369, 0	2.1321474, 0	1.5649936, 0
8.5967998, 0	1.7558719, 0	2.1208226, 0	1.5616890, 0
9.5463998, 0	1.7441617, 0	2.1029963, 0	1.5515077, 0
1.0495999, 1	1.7261670, 0	2.0790960, 0	1.5356405, 0
1.1445599, 1	1.7027260, 0	2.0494956, 0	1.5148736, 0
1.2395199, 1	1.6744339, 0	2.0145296, 0	1.4897608, 0
1.3344799, 1	1.6417464, 0	1.9745030, 0	1.4607228, 0
1.4294399, 1	1.6050426, 0	1.9296987, 0	1.4281081, 0
1.5243999, 1	1.5646672, 0	1.8803827, 0	1.3922327, 0
1.6193599, 1	1.5209626, 0	1.8268061, 0	1.3534114, 0
1.7143199, 1	1.4742983, 0	1.7692062, 0	1.3119863, 0
1.8092799, 1	1.4251062, 0	1.7078039, 0	1.2683605, 0
1.9042399, 1	1.3739269, 0	1.6427981, 0	1.2230437, 0
1.9991999, 1	1.3214786, 0	1.5743559, 0	1.1767191, 0
2.0941599, 1	1.2687618, 0	1.5025949, 0	1.1303459, 0
2.1891199, 1	1.2172214, 0	1.4275554, 0	1.0853174, 0
2.2840799, 1	1.1690010, 0	1.3491563, 0	1.0437099, 0
2.3790399, 1	1.1273416, 0	1.2671243, 0	1.0086717, 0
2.4739050, 1	1.0972317, 0	1.1809725, 0	9.8505342, -1
2.4739999, 1	1.0972112, 0	1.1808837, 0	9.8503921, -1
2.4739999, 1	7.7577465, -1	1.1808837, 0	9.8503921, -1
2.4741025, 1	7.7575764, -1	1.1807830, 0	9.8502256, -1
2.5765999, 1	7.4781695, -1	1.0845135, 0	9.5309981, -1
2.6791999, 1	7.0768555, -1	9.9450208, -1	9.0405639, -1
2.7817999, 1	6.6130824, -1	9.0933919, -1	8.4613249, -1
2.8843999, 1	6.1238075, -1	8.2800830, -1	7.8446021, -1
2.9869999, 1	5.6336908, -1	7.4977426, -1	7.2246772, -1
3.0895999, 1	5.1617143, -1	6.7404274, -1	6.6279571, -1
3.1921999, 1	4.7261702, -1	6.0025376, -1	6.0798805, -1
3.2947999, 1	4.3492766, -1	5.2778352, -1	5.6113089, -1
3.3973999, 1	4.0625419, -1	4.5583114, -1	5.2659525, -1
3.4998974, 1	3.9142126, -1	3.8333708, -1	5.1106319, -1
3.5000000, 1	3.9141711, -1	3.8326336, -1	5.1106239, -1
3.5000000, 1	0.0000000, 0	3.8326336, -1	5.1106239, -1
3.5000599, 1	0.0000000, 0	3.8318144, -1	5.1106137, -1
3.5999999, 1	0.0000000, 0	3.0986144, -1	4.8951156, -1
3.6999999, 1	0.0000000, 0	2.5021881, -1	4.4603091, -1
3.7999999, 1	0.0000000, 0	2.0165584, -1	3.9237642, -1
3.8999999, 1	0.0000000, 0	1.6200442, -1	3.3542420, -1
3.9999999, 1	0.0000000, 0	1.2950482, -1	2.7887309, -1

UNCLASSIFIED

4.0999999, 1	0.0000000, 0	1.0272387, -1	2.2433748, -1
4.1999999, 1	0.0000000, 0	8.0488981, -2	1.7203098, -1
4.2999999, 1	0.0000000, 0	6.1834541, -2	1.2116549, -1
4.3999999, 1	0.0000000, 0	4.5958291, -2	7.0143542, -2
4.4999000, 1	0.0000000, 0	3.2198139, -2	1.6642937, -2
4.5000000, 1	0.0000000, 0	3.2185128, -2	1.6586482, -2

UNCLASSIFIED			
MATERIAL	VOLUME	FAST FLUX	SLOW FLUX
CORE 1	4.9923823,-1	1.7251651, 0	1.2847064, 0
CORE 2	5.0076179,-1	7.3766364,-1	7.1615983,-1
SIDE	6.5359478,-1	1.4819703,-1	2.6827287,-1

```

*****
* UNCLASSIFIED *
* W.B.HENDERSON EXT.736 *
* GEORGE CASE GEORGE SAMPLE TEST CASE *
*****

```

```

*****
* THIS IS *
* LONGITUDINAL F2 CALCULATION NUMBER 2 OF ITERATION 1 *
* REFERENCE CORE = AVG.CORE *
* RADIAL F2 = RAD *
* LONGITUDINAL F2 = LONG *
*****

```

```

*****
F2 CASE LONG
*****

```

```

CTN24 USE TWO-GROUP BUCKLING

```

```

CTN25 COMPUTE BUCKLING FROM REFERENCE COMPOSITION AVG.CORE

```

```

CTN26 USE F2 DATA AND CONTROLS

```

```

CTN27 TERRALL METHOD- NOT AVAILABLE

```


UNCLASSIFIED

CASE LONG 8/5/59 K=0.93378, F=1.293, H= 0.000, D= 70.000

C0= 3, C1=0, C2=0, C3=1, C4=1, C5=0, C6=0, C7=0, C8=1, C9=1, P= 0

S/H 0.0000000, S/D 5.9491575, R/O 0.0000000, R/N 35.000000

R1- 0.0000000, R1+ 0.0000000, A2- 0.0000000, A2+ 0.0000000

R1 1.0003514, B1 1.0003514, A2 1.0024735, B2 1.0024735

ALPHA 0

REGIONAL DATA

RADIUS INTERVALS		MATERIAL	K1 SQ.	K2 SQ.
10.000	10	END	2.9376391,-3	3.3899729,-3
60.000	50	AVG.CORE	2.9376391,-3	3.3899729,-3
75.000	15	END	2.9376391,-3	3.3899729,-3

MATERIAL DATA

MATERIAL	END	AVG.CORE		
DIFFUSION 1	1.4230527, 0	1.4394929, 0	0.0000000, 0	0.0000000, 0
DIFFUSION 2	2.0214078,-1	1.9593420,-1	0.0000000, 0	0.0000000, 0
ABSORPTION 1	1.0256808,-3	2.6347589,-3	0.0000000, 0	0.0000000, 0
ABSORPTION 2	1.7259216,-2	3.9625816,-2	0.0000000, 0	0.0000000, 0
FISSION 1	0.0000000, 0	2.9769676,-3	0.0000000, 0	0.0000000, 0
FISSION 2	0.0000000, 0	4.5930507,-2	0.0000000, 0	0.0000000, 0
SCATTER	3.6917448,-2	3.4768759,-2	0.0000000, 0	0.0000000, 0
SOURCE 1	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0
SOURCE 2	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0

MATERIAL

DIFFUSION 1	0.0000000, 0
DIFFUSION 2	0.0000000, 0
ABSORPTION 1	0.0000000, 0
ABSORPTION 2	0.0000000, 0
FISSION 1	0.0000000, 0
FISSION 2	0.0000000, 0
SCATTER	0.0000000, 0
SOURCE 1	0.0000000, 0
SOURCE 2	0.0000000, 0

UNCLASSIFIED

ITERATION	REACTIVITY	P	V CORE
1	4.5288254, 1	18	1.9242250, 5
2	9.1993346, -1		
3	9.2648154, -1		
4	9.2983426, -1		
5	9.3162472, -1		
6	9.3259754, -1		
7	9.3313001, -1		
8	9.3342224, -1		
9	9.3358284, -1		
10	9.3367110, -1		
11	9.3371961, -1		
12	9.3374635, -1		
13	9.3376100, -1		
14	9.3376912, -1		
15	9.3377356, -1		
16	9.3377596, -1		
17	9.3377734, -1		
18	9.3377806, -1		

UNCLASSIFIED

RADIUS	FISSION DENSITY	FAST FLUX	SLOW FLUX
0.0000000, 0	0.0000000, 0	3.7142426, -2	2.0428917, -2
0.9999999, -4	0.0000000, 0	3.7155477, -2	2.0479448, -2
1.0000000, 0	0.0000000, 0	5.0741722, -2	6.8478529, -2
2.0000000, 0	0.0000000, 0	6.5842811, -2	1.1333915, -1
3.0000000, 0	0.0000000, 0	8.2892901, -2	1.5623611, -1
4.0000000, 0	0.0000000, 0	1.0239668, -1	1.9786354, -1
5.0000000, 0	0.0000000, 0	1.2493149, -1	2.3835480, -1
6.0000000, 0	0.0000000, 0	1.5116437, -1	2.7718878, -1
7.0000000, 0	0.0000000, 0	1.8187184, -1	3.1302190, -1
8.0000000, 0	0.0000000, 0	2.1796286, -1	3.4342694, -1
9.0000000, 0	0.0000000, 0	2.6050575, -1	3.6451165, -1
9.9999999, 0	0.0000000, 0	3.1070572, -1	3.7037978, -1
1.0000000, 1	0.0000000, 0	3.1076058, -1	3.7037372, -1
1.0000000, 1	5.5016528, -1	3.1076058, -1	3.7037372, -1
1.0000000, 1	5.5016140, -1	3.1081479, -1	3.7036746, -1
1.0999999, 1	5.6086760, -1	3.6279571, -1	3.7459776, -1
1.1999999, 1	5.8911340, -1	4.1171888, -1	3.9147611, -1
1.2999999, 1	6.2762249, -1	4.5826054, -1	4.1579385, -1
1.3999999, 1	6.7184195, -1	5.0283271, -1	4.4429257, -1
1.4999999, 1	7.1890467, -1	5.4565194, -1	4.7492308, -1
1.5999999, 1	7.6698837, -1	5.8691513, -1	5.0638563, -1
1.6999999, 1	8.1491918, -1	6.2634654, -1	5.3784541, -1
1.7999999, 1	8.6192638, -1	6.6422692, -1	5.6875663, -1
1.8999999, 1	9.0749084, -1	7.0041170, -1	5.9875367, -1
1.9999999, 1	9.5125111, -1	7.3484226, -1	6.2758376, -1
2.0999999, 1	9.9294567, -1	7.6745300, -1	6.5506552, -1
2.1999999, 1	1.0323770, 0	7.9817584, -1	6.8106321, -1
2.2999999, 1	1.0693898, 0	8.2694293, -1	7.0547096, -1
2.3999999, 1	1.1038573, 0	8.5368856, -1	7.2820296, -1
2.4999999, 1	1.1356727, 0	8.7835031, -1	7.4918758, -1
2.5999999, 1	1.1647446, 0	9.0086977, -1	7.6836363, -1
2.6999999, 1	1.1909934, 0	9.2119316, -1	7.8567819, -1
2.7999999, 1	1.2143499, 0	9.3927165, -1	8.0108525, -1
2.8999999, 1	1.2347539, 0	9.5506162, -1	8.1454491, -1
2.9999999, 1	1.2521537, 0	9.6852489, -1	8.2602294, -1
3.0999999, 1	1.2665057, 0	9.7962885, -1	8.3549048, -1
3.1999999, 1	1.2777742, 0	9.8834656, -1	8.4292397, -1
3.2999999, 1	1.2859312, 0	9.9465688, -1	8.4830496, -1
3.3999999, 1	1.2909567, 0	9.9854449, -1	8.5162018, -1
3.4999999, 1	1.2928384, 0	1.0000000, 0	8.5286148, -1
3.5999999, 1	1.2915716, 0	9.9901984, -1	8.5202582, -1
3.6999999, 1	1.2871596, 0	9.9560648, -1	8.4911531, -1
3.7999999, 1	1.2796132, 0	9.8976818, -1	8.4413717, -1
3.8999999, 1	1.2689511, 0	9.8151917, -1	8.3710373, -1
3.9999999, 1	1.2551999, 0	9.7087951, -1	8.2803253, -1
4.0999999, 1	1.2383939, 0	9.5787501, -1	8.1694625, -1
4.1999999, 1	1.2185754, 0	9.4253718, -1	8.0387289, -1
4.2999999, 1	1.1957948, 0	9.2490313, -1	7.8884587, -1
4.3999999, 1	1.1701114, 0	9.0501539, -1	7.7190438, -1

UNCLASSIFIED

4.4999999, 1	1.1415933, 0	8.8292170, -1	7.5309383, -1
4.5999999, 1	1.1103195, 0	8.5867479, -1	7.3246676, -1
4.6999999, 1	1.0763812, 0	8.3233191, -1	7.1008424, -1
4.7999999, 1	1.0398855, 0	8.0395434, -1	6.8601832, -1
4.8999999, 1	1.0009608, 0	7.7360656, -1	6.6035597, -1
4.9999999, 1	9.5976576, -1	7.4135494, -1	6.3320547, -1
5.0999999, 1	9.1650378, -1	7.0726588, -1	6.0470694, -1
5.1999999, 1	8.7144622, -1	6.7140275, -1	5.7504936, -1
5.2999999, 1	8.2497425, -1	6.3382116, -1	5.4449820, -1
5.3999999, 1	7.7763414, -1	5.9456136, -1	5.1344008, -1
5.4999999, 1	7.3024516, -1	5.5363611, -1	4.8245523, -1
5.5999999, 1	6.8405919, -1	5.1101117, -1	4.5243446, -1
5.6999999, 1	6.4102511, -1	4.6657397, -1	4.2476841, -1
5.7999999, 1	6.0421531, -1	4.2000309, -1	4.0145755, -1
5.8999999, 1	5.7851479, -1	3.7108674, -1	3.8658662, -1
5.9999000, 1	5.7173251, -1	3.1884517, -1	3.8515846, -1
6.0000000, 1	5.7174143, -1	3.1879056, -1	3.8516834, -1
6.0000000, 1	0.0000000, 0	3.1879056, -1	3.8516834, -1
6.0000999, 1	0.0000000, 0	3.1873530, -1	3.8517789, -1
6.0999999, 1	0.0000000, 0	2.6824105, -1	3.8272122, -1
6.1999999, 1	0.0000000, 0	2.2563244, -1	3.6525507, -1
6.2999999, 1	0.0000000, 0	1.8970273, -1	3.3900561, -1
6.3999999, 1	0.0000000, 0	1.5938837, -1	3.0820453, -1
6.4999999, 1	0.0000000, 0	1.3379204, -1	2.7565394, -1
6.5999999, 1	0.0000000, 0	1.1215606, -1	2.4313898, -1
6.6999999, 1	0.0000000, 0	9.3839992, -2	2.1172465, -1
6.7999999, 1	0.0000000, 0	7.8301661, -2	1.8196735, -1
6.8999999, 1	0.0000000, 0	6.5081122, -2	1.5406326, -1
6.9999999, 1	0.0000000, 0	5.3787036, -2	1.2794977, -1
7.0999999, 1	0.0000000, 0	4.4085090, -2	1.0337141, -1
7.1999999, 1	0.0000000, 0	3.5688099, -2	7.9918177, -2
7.2999999, 1	0.0000000, 0	2.8347504, -2	5.7041646, -2
7.3999999, 1	0.0000000, 0	2.1846018, -2	3.4051652, -2
7.4999000, 1	0.0000000, 0	1.5996723, -2	1.0119145, -2
7.5000000, 1	0.0000000, 0	1.5991104, -2	1.0094177, -2

UNCLASSIFIED			
MATERIAL	VOLUME	FAST FLUX	SLOW FLUX
END	4.9999999, -1	1.2358147, -1	2.1318139, -1
AVG. CORE	1.0000000, 0	7.6337589, -1	6.6033702, -1

```

*****
* UNCLASSIFIED *
* W.B.HENDERSON EXT.736 *
* GEORGE CASE GEORGE SAMPLE TEST CASE *
*****

```

```

*****
* THIS IS *
* LONGITUDINAL F2 CALCULATION NUMBER 3 OF ITERATION 1 *
* REFERENCE CORE = AVG.CORE *
* RADIAL F2 = RAD *
* LONGITUDINAL F2 = LONG *
*****

```

```

*****
F2 CASE LONG
*****

```

```

CTN24 USE TWO-GROUP BUCKLING

```

```

CTN25 COMPUTE BUCKLING FROM REFERENCE COMPOSITION AVG.CORE

```

```

CTN26 USE F2 DATA AND CONTROLS

```

```

CTN27 TERRALL METHOD-NOT AVAILABLE

```

UNCLASSIFIED

CASE LONG 8/5/59 K=0.90006, F=1.295, H= 0.000, D= 70.000

CD= 3, C1=0, C2=0, C3=1, C4=1, C5=0, C6=0, C7=0, C8=1, C9=1, P= 0

S/H 0.000000, S/D 0.000000, R/O 0.000000, R/N 35.000000

A1- 0.000000, A1+ 0.000000, A2- 0.000000, A2+ 0.000000

A1 1.0003514, B1 1.0003514, A2 1.0024735, B2 1.0024735

ALPHA 0

REGIONAL DATA

RADIUS INTERVALS		MATERIAL	K1 SQ.	K2 SQ.
10.000	10	END	3.9178976, -3	4.6269364, -3
60.000	50	AVG. CORE	3.9178976, -3	4.6269364, -3
75.000	15	END	3.9178976, -3	4.6269364, -3

MATERIAL DATA

MATERIAL	END	AVG. CORE				
DIFFUSION 1	1.4230527, 0	1.4394929, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0
DIFFUSION 2	2.0214078, -1	1.9593420, -1	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0
ABSORPTION 1	1.0256808, -3	2.6347589, -3	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0
ABSORPTION 2	1.7259216, -2	3.9625816, -2	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0
FISSION 1	0.0000000, 0	2.9769676, -3	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0
FISSION 2	0.0000000, 0	4.5930507, -2	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0
SCATTER	3.6917448, -2	3.4768759, -2	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0
SOURCE 1	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0
SOURCE 2	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0

MATERIAL

DIFFUSION 1	0.0000000, 0
DIFFUSION 2	0.0000000, 0
ABSORPTION 1	0.0000000, 0
ABSORPTION 2	0.0000000, 0
FISSION 1	0.0000000, 0
FISSION 2	0.0000000, 0
SCATTER	0.0000000, 0
SOURCE 1	0.0000000, 0
SOURCE 2	0.0000000, 0

UNCLASSIFIED

ITERATION	REACTIVITY	P	V CORE
1	4.3646232, 1	18	1.9242250, 5
2	8.8653675, -1		
3	8.9286185, -1		
4	8.9612738, -1		
5	8.9788810, -1		
6	8.9885488, -1		
7	8.9938969, -1		
8	8.9968641, -1		
9	8.9985132, -1		
10	8.9994301, -1		
11	8.9999397, -1		
12	9.0002229, -1		
13	9.0003805, -1		
14	9.0004682, -1		
15	9.0005168, -1		
16	9.0005443, -1		
17	9.0005593, -1		
18	9.0005673, -1		

UNCLASSIFIED

RADIUS	FISSION DENSITY	FAST FLUX	SLOW FLUX
0.0000000, 0	0.0000000, 0	3.6118115, -2	1.9804643, -2
0.9999999, -4	0.0000000, 0	3.6130805, -2	1.9853631, -2
1.0000000, 0	0.0000000, 0	4.9360191, -2	6.6388200, -2
2.0000000, 0	0.0000000, 0	6.4111552, -2	1.0993164, -1
3.0000000, 0	0.0000000, 0	8.0823513, -2	1.5166109, -1
4.0000000, 0	0.0000000, 0	1.0000714, -1	1.9228042, -1
5.0000000, 0	0.0000000, 0	1.2224910, -1	2.3194220, -1
6.0000000, 0	0.0000000, 0	1.4822956, -1	2.7015425, -1
7.0000000, 0	0.0000000, 0	1.7874305, -1	3.0561111, -1
8.0000000, 0	0.0000000, 0	2.1472270, -1	3.3593149, -1
9.0000000, 0	0.0000000, 0	2.5726879, -1	3.5727344, -1
9.9990000, 0	0.0000000, 0	3.0762810, -1	3.6378854, -1
1.0000000, 1	0.0000000, 0	3.0768321, -1	3.6378334, -1
1.0000000, 1	5.4465381, -1	3.0768321, -1	3.6378334, -1
1.0000999, 1	5.4465119, -1	3.0773768, -1	3.6377797, -1
1.0099999, 1	5.5646444, -1	3.5995101, -1	3.6871659, -1
1.1999999, 1	5.8559514, -1	4.0908274, -1	3.8605562, -1
1.2999999, 1	6.2482464, -1	4.5582056, -1	4.1066474, -1
1.3999999, 1	6.6964527, -1	5.0058222, -1	4.3934109, -1
1.4999999, 1	7.1722310, -1	5.4358672, -1	4.7007383, -1
1.5999999, 1	7.6575937, -1	5.8493166, -1	5.0158940, -1
1.6999999, 1	8.1409639, -1	6.2464107, -1	5.3307060, -1
1.7999999, 1	8.6147435, -1	6.6269507, -1	5.6398340, -1
1.8999999, 1	9.0738107, -1	6.9904823, -1	5.9396992, -1
1.9999999, 1	9.5145954, -1	7.3364104, -1	6.2278247, -1
2.0999999, 1	9.9345078, -1	7.6640699, -1	6.5024290, -1
2.1999999, 1	1.0331586, 0	7.9727708, -1	6.7621751, -1
2.2999999, 1	1.0704283, 0	8.2618267, -1	7.0060168, -1
2.3999999, 1	1.1051330, 0	8.5305729, -1	7.2331036, -1
2.4999999, 1	1.1371657, 0	8.7783776, -1	7.4427231, -1
2.5999999, 1	1.1664346, 0	9.0046507, -1	7.6342654, -1
2.6999999, 1	1.1928595, 0	9.2088482, -1	7.8072021, -1
2.7999999, 1	1.2163706, 0	9.3904767, -1	7.9610728, -1
2.8999999, 1	1.2369071, 0	9.5490954, -1	8.0954784, -1
2.9999999, 1	1.2544168, 0	9.6843184, -1	8.2100757, -1
3.0999999, 1	1.2688558, 0	9.7958164, -1	8.3045758, -1
3.1999999, 1	1.2801878, 0	9.8833175, -1	8.3787420, -1
3.2999999, 1	1.2883847, 0	9.9466082, -1	8.4323897, -1
3.3999999, 1	1.2934263, 0	9.9855339, -1	8.4653863, -1
3.4999999, 1	1.2953000, 0	1.0000000, 0	8.4776498, -1
3.5999999, 1	1.2940014, 0	9.9899710, -1	8.4691503, -1
3.6999999, 1	1.2895336, 0	9.9554722, -1	8.4399092, -1
3.7999999, 1	1.2819077, 0	9.8965876, -1	8.3899993, -1
3.8999999, 1	1.2711428, 0	9.8134616, -1	8.3195450, -1
3.9999999, 1	1.2572657, 0	9.7062971, -1	8.2287223, -1
4.0999999, 1	1.2403112, 0	9.5753558, -1	8.1177596, -1
4.1999999, 1	1.2203222, 0	9.4209571, -1	7.9869379, -1
4.2999999, 1	1.1973497, 0	9.2434766, -1	7.8365928, -1
4.3999999, 1	1.1714534, 0	9.0433448, -1	7.6671168, -1

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4.4999999, 1	1.1427024, 0	8.8210454, -1	7.4789647, -1
4.5999999, 1	1.1111759, 0	8.5771118, -1	7.2726613, -1
4.6999999, 1	1.0769657, 0	8.3121243, -1	7.0488151, -1
4.7999999, 1	1.0401723, 0	8.0267032, -1	6.8091423, -1
4.8999999, 1	1.0009447, 0	7.7215015, -1	6.5515037, -1
4.9999999, 1	2.5941981, -1	7.3971924, -1	6.2799677, -1
5.0999999, 1	9.1580624, -1	7.0544496, -1	5.9949111, -1
5.1999999, 1	8.7037271, -1	6.6939172, -1	5.6981854, -1
5.2999999, 1	8.2349266, -1	6.3161618, -1	5.3923848, -1
5.3999999, 1	7.7570537, -1	5.9215966, -1	5.0812820, -1
5.4999999, 1	7.2781538, -1	5.5103587, -1	4.7705361, -1
5.5999999, 1	6.8105322, -1	5.0821120, -1	4.4688386, -1
5.6999999, 1	6.3733627, -1	4.6357304, -1	4.1897711, -1
5.7999999, 1	5.9268118, -1	4.1687832, -1	3.9251814, -1
5.8999999, 1	5.7293813, -1	3.6767158, -1	3.7982241, -1
5.9999999, 1	5.6479796, -1	3.1520321, -1	3.7748813, -1
6.0000000, 1	5.6480532, -1	3.1514834, -1	3.7749687, -1
6.0000000, 1	0.0000000, 0	3.1514834, -1	3.7749687, -1
6.0000000, 1	0.0000000, 0	3.1509283, -1	3.7750533, -1
6.0999999, 1	0.0000000, 0	2.6444872, -1	3.7417964, -1
6.1999999, 1	0.0000000, 0	2.2183700, -1	3.5624059, -1
6.2999999, 1	0.0000000, 0	1.8600929, -1	3.2985182, -1
6.3999999, 1	0.0000000, 0	1.5586995, -1	2.9918139, -1
6.4999999, 1	0.0000000, 0	1.3049728, -1	2.6697311, -1
6.5999999, 1	0.0000000, 0	1.0911536, -1	2.3496180, -1
6.6999999, 1	0.0000000, 0	9.1070309, -2	2.0417119, -1
6.7999999, 1	0.0000000, 0	7.5810281, -2	1.7512545, -1
6.8999999, 1	0.0000000, 0	6.2868615, -2	1.4799719, -1
6.9999999, 1	0.0000000, 0	5.1849538, -2	1.2270818, -1
7.0999999, 1	0.0000000, 0	4.2416075, -2	9.8994619, -2
7.1999999, 1	0.0000000, 0	3.4279741, -2	7.6444921, -2
7.2999999, 1	0.0000000, 0	2.7191720, -2	5.4515371, -2
7.3999999, 1	0.0000000, 0	2.0935250, -2	3.2526612, -2
7.4999999, 1	0.0000000, 0	1.5324300, -2	9.6654216, -3
7.5000000, 1	0.0000000, 0	1.5318918, -2	9.6415731, -3

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MATERIAL	VOLUME	FAST FLUX	SLOW FLUX
END	4.9999999, -1	1.2107374, -1	2.0721688, -1
AVG.CORE	1.0000000, 0	7.6214128, -1	6.5513347, -1

```
*****
* SAVINGS ARE ADJUSTED FOR NEXT ITERATION *
*      S(Z)      = 3.8929443, 0      *
*      S(R)      = 1.1842681, 1      *
*****
```

 CORE OR END COMPOSITION

 COMPOSITION INPUT

CASE NUMBER	CORE 1	
C2-INPUT UNITS	C.G.S.	
C3-THERMAL BASE	SET T=T+1	
C4-SLOWING DOWN MODEL	MODIFIED AGE	
C5-GROUP DIVISION	N=T	
C8-G FACTOR APPLICATION	ALL SIGMAS	
C17-PHOTON PRODUCTION CALCULATION		YES
C19-PRINT OUT		LONG
C21-ADJOINT CALCULATION		NO
C22-MULTI GROUP CALCULATION		YES
C31-CLEAR INPUT AFTER CALCULATION		NO
C32-RERUN THIS COMPOSITION IN REACTIVITY MATCH		YES

 BEHRENS INPUT

C6-BEHRENS CALCULATION	CALCULATE F/R, F/Z
C10-G FACTORS IN BEHRENS CORRECTION	YES
C11-MODERATOR X-SECTION IN BEHRENS CORRECTION	SIGMA TOTAL

D1	D2	D3	M
FUEL ZONE I.D.	FUEL ZONE O.D.	CELL DIAMETER	NUMBER OF CELLS
3.1999999, 0	4.0000000, 0	6.0000000, 0	0.0000000, 0

 I2 INPUT

C7-I2 CALCULATION	YES
C9-LEAKAGE TERM ADDED TO SIGMA A	NO
C12-I2 AT THERMAL	YES, TYPE B
C13-I2 AT LEVEL 16	YES, TYPE B
C14-I2 AT LEVEL 17	YES, TYPE B
C20-FINE RADIAL POWER CALCULATION	YES
C30-G RECIPE	G CELL=1

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 TERRALL INPUT

C18-TERRALL METHOD NO
 ESTAR E* TPF
 SLOWING DOWN CUT-OFF (eV) FUEL TEMPERATURE DEGREES F
 0.000000, 0 0.000000, 0

 BUCKLING GEOMETRY

C16-GEOMETRY CYLINDER
 SAVINGS ON H S/Z 3.8929443, 0 HEIGHT H 5.0000000, 1
 SAVINGS ON D S/R 1.1842681, 1 DIAMETER D 7.0000000, 1

 VOLUME GEOMETRY

DCO DCI L VOC
 OUTER DIAMETER INNER DIAMETER LENGTH COMPOSITION VOLUME
 0.0000000, 0 0.0000000, 0 0.0000000, 0 0.0000000, 0

CSP TPM
 CODE NUMBER OF SPECTRUM MODERATOR TEMPERATURE DEGREES F
 0.9420 6.8000000, 1

TABLE 3M,12 MATERIAL NUMBER 1

C28-FUEL YES

GEOMETRY FOR VOLUME CALCULATION

OUTER RADIUS	INNER RADIUS	LENGTH	MATERIAL VOLUME
0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0

CODE	WEIGHT	F OR N	SIGMA/S2,T+1	SIGMA/S2,16	SIGMA/S2,17
-1.130	0.000000, 0	6.9999999,-3	0.0000000, 0	0.0000000, 0	0.0000000, 0
5.110	0.000000, 0	9.2999999,-2	0.0000000, 0	0.0000000, 0	0.0000000, 0

TABLE 3M,12 MATERIAL NUMBER 2

C28-FUEL NO

GEOMETRY FOR VOLUME CALCULATION

OUTER RADIUS	INNER RADIUS	LENGTH	MATERIAL VOLUME
0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0

CODE	WEIGHT	F OR N	SIGMA/S2,T+1	SIGMA/S2,16	SIGMA/S2,17
2.510	0.000000, 0	1.0000000, 0	1.2999999,-1	2.3999999,-1	1.9999999,-1

TABLE M1 MODERATOR

ELEMENT	CODE	WEIGHT	F/H OR N/H	G/T+1	G/16	G/17
*WATER	2.510	0.000000, 0	8.3999998, -1	1.019102	1.003923	1.007338

TABLE F1 FUEL

ELEMENT	CODE	WEIGHT	F/H OR N/H	G/T+1	G/16	G/17
*ORALLOY	-1.130	0.000000, 0	1.1200000, -3	0.899717	0.979405	0.961477
*ALUMINUM	5.110	0.000000, 0	1.4880000, -2	0.899717	0.979405	0.961477

HYDRAULIC DIAMETER			FUEL	8.0000001, -1	MODERATOR	4.1999999, 0
BEHRENS CROSS SECTIONS			ATTENUATION FACTORS			
N	SIGMA/S, MOD	SIGMA/R, MOD	SIGMA/R, FUEL	X-FUEL	Y-MOD	
0	7.3406384, -2	1.1080379, -6	5.5514335, -4	4.4411469, -4	3.0831145, -1	
1	1.2545818, -1	1.4208439, -6	5.0696100, -4	4.0556880, -4	5.2693032, -1	
2	2.1154385, -1	1.8239671, -6	4.7590223, -4	3.8072179, -4	8.8849183, -1	
3	2.2355580, -1	2.3350303, -6	4.7526519, -4	3.8021216, -4	9.3894418, -1	
4	3.4234068, -1	3.0179166, -6	4.7019193, -4	3.7615354, -4	1.4378435, 0	
5	4.9949708, -1	3.8550029, -6	4.9665470, -4	3.9732376, -4	2.0979038, 0	
6	5.4721123, -1	4.9564323, -6	5.2824621, -4	4.2259697, -4	2.2983079, 0	
7	6.6566244, -1	6.3662620, -6	5.9071584, -4	4.7257268, -4	2.7958089, 0	
8	7.9245529, -1	8.1726063, -6	6.2234862, -4	4.9787890, -4	3.3283464, 0	
9	1.3196465, 0	2.2248874, -5	1.0292446, -3	8.2339571, -4	5.5426090, 0	
10	1.4297561, 0	6.0358332, -5	1.8145380, -3	1.4516304, -3	6.0052292, 0	
11	1.4597860, 0	1.6433326, -4	4.5483587, -3	3.6386870, -3	6.1317914, 0	
12	1.4597860, 0	4.4718035, -4	2.0574323, -2	1.6459458, -2	6.1329793, 0	
13	1.4614543, 0	1.2137752, -3	4.1648942, -2	3.3319154, -2	6.1432061, 0	
14	1.4948209, 0	2.2843646, -3	1.2175612, -2	9.7404904, -3	6.2878420, 0	
15	1.5014942, 0	4.3858919, -3	2.7117261, -2	2.1693809, -2	6.3246963, 0	
16	1.8289597, 0	6.6367124, -3	6.1450645, -2	4.9160516, -2	7.7095048, 0	
17	2.4334630, 0	1.1603268, -2	8.8506114, -2	7.0804892, -2	1.0269278, 1	
18	3.3187796, 0	2.0866687, -2	1.9298820, -1	1.5439056, -1	1.4026514, 1	
T	3.2181281, 0	1.9912677, -2	1.6778102, -1	1.3422481, -1	1.3599771, 1	
T+1	3.2181281, 0	1.9912677, -2	1.6778102, -1	1.3422481, -1	1.3599771, 1	

N	BEHRENS FACTOR		BEHRENS FACTOR		SOURCE SPECTRUM
	F/R		F/Z		
0	1.0002023, 0		1.0041469, 0		0.0000000, 0
1	1.0005893, 0		1.0073313, 0		8.7378149, -2
2	1.0016617, 0		1.0130300, 0		3.7532886, -1
3	1.0018530, 0		1.0138669, 0		4.7365445, -1
4	1.0042639, 0		1.0226614, 0		4.2566089, -1
5	1.0087620, 0		1.0356045, 0		3.0059730, -1
6	1.0103825, 0		1.0397884, 0		1.5546837, -1
7	1.0148342, 0		1.0506036, 0		9.8710099, -2
8	1.0201612, 0		1.0627428, 0		3.2979099, -2
9	1.0458654, 0		1.1167524, 0		1.6243999, -4
10	1.0515720, 0		1.1283274, 0		2.2580000, -5
11	1.0530353, 0		1.1312372, 0		3.0299999, -6
12	1.0523743, 0		1.1295949, 0		4.7000000, -7
13	1.0516225, 0		1.1276787, 0		0.0000000, 0
14	1.0546492, 0		1.1343534, 0		0.0000000, 0
15	1.0544525, 0		1.1336712, 0		0.0000000, 0
16	1.0696601, 0		1.1636078, 0		0.0000000, 0
17	1.0986199, 0		1.2210814, 0		0.0000000, 0
18	1.1319166, 0		1.2857706, 0		0.0000000, 0
T	1.1298277, 0		1.2820395, 0		
T+1	1.1298277, 0		1.2820395, 0		

TABLE C4

	SCATTER	XL-SCATTER	TRANSPORT	ABSORPTION	FISSION
N	X-SECTION	X-SECTION	X-SECTION	X-SECTION	X-SECTION
0	6.3444914,-2	5.4406308,-2	3.7580390,-2	8.9753691,-5	1.9489231,-4
1	1.0729527,-1	7.9412470,-2	4.8548388,-2	8.2307271,-5	1.7314324,-4
2	1.7995491,-1	1.2265760,-1	1.0631244,-1	7.7676491,-5	1.6298346,-4
3	1.9091897,-1	1.6089551,-1	7.4109033,-2	7.8003859,-5	1.6255661,-4
4	2.8973653,-1	2.2220017,-1	1.5344187,-1	7.7765759,-5	1.5035152,-4
5	4.2256556,-1	2.8749671,-1	2.3330926,-1	8.2702957,-5	1.4812837,-4
6	4.6480850,-1	3.6147727,-1	2.5159360,-1	8.8682799,-5	1.5800360,-4
7	5.6119130,-1	4.6690931,-1	2.6769360,-1	9.9862198,-5	1.8269166,-4
8	6.7319387,-1	5.7397905,-1	2.8763065,-1	1.0644077,-4	1.9256689,-4
9	1.1103513, 0	1.0163961, 0	4.3904764,-1	1.8336819,-4	3.4069526,-4
10	1.2026729, 0	1.1088757, 0	4.6606849,-1	3.4102708,-4	5.4807499,-4
11	1.2278980, 0	1.1341008, 0	4.7559797,-1	8.6577735,-4	1.2146526,-3
12	1.2278902, 0	1.1341007, 0	4.7559018,-1	3.6675232,-3	4.6166678,-3
13	1.2292766, 0	1.1380240, 0	4.7809790,-1	7.6834021,-3	8.2458129,-3
14	1.2573757, 0	1.1604515, 0	4.8377232,-1	3.8669644,-3	2.7946887,-3
15	1.2630167, 0	1.1604541, 0	5.3425766,-1	8.0229111,-3	9.2333356,-3
16	1.5380243, 0	1.1875123, 0	7.6138737,-1	1.5406941,-2	1.9392050,-2
17	2.0457404, 0	1.2480140, 0	1.1817628, 0	2.3907724,-2	2.9547838,-2
18	2.7893227, 0	1.3197084, 0	2.1894649, 0	4.8406131,-2	6.3793645,-2
T	2.7048213, 0	1.2734407, 0	1.9272984, 0	4.3571613,-2	5.4953161,-2
T+1	2.7048213, 0	1.2734407, 0	1.9272984, 0	4.3571613,-2	5.4953161,-2

EXTRAPOLATION		TOTAL	X/R/5	V/Z	Z
N	DISTANCE	BUCKLING	BUCKLING	BUCKLING	BUCKLING
0	1.8861090, 1	2.4215006, -3	1.3394763, -3	1.0820243, -3	0.0000000, 0
1	1.4610113, 1	2.8350213, -3	1.5312015, -3	1.3038198, -3	0.0000000, 0
2	6.6778122, 0	3.9688800, -3	2.0187168, -3	1.9501632, -3	0.0000000, 0
3	9.5771446, 0	3.4838585, -3	1.8165700, -3	1.6672885, -3	0.0000000, 0
4	4.6280722, 0	4.3786544, -3	2.1827026, -3	2.1959518, -3	0.0000000, 0
5	3.0442350, 0	4.7426549, -3	2.3234980, -3	2.4121562, -3	0.0000000, 0
6	2.8230036, 0	4.7972676, -3	2.3442438, -3	2.4530238, -3	0.0000000, 0
7	2.6531640, 0	4.8398677, -3	2.3603594, -3	2.4795083, -3	0.0000000, 0
8	2.4692679, 0	4.8866683, -3	2.3779969, -3	2.5086714, -3	0.0000000, 0
9	1.6175927, 0	5.1129956, -3	2.4623159, -3	2.6506797, -3	0.0000000, 0
10	1.5233393, 0	5.1390570, -3	2.4719228, -3	2.6671341, -3	0.0000000, 0
11	1.4911942, 0	5.1479925, -3	2.4752119, -3	2.6727805, -3	0.0000000, 0
12	1.4825009, 0	5.1504131, -3	2.4761025, -3	2.6743106, -3	0.0000000, 0
13	1.4625923, 0	5.1559637, -3	2.4781440, -3	2.6778196, -3	0.0000000, 0
14	1.4570177, 0	5.1575195, -3	2.4787160, -3	2.6788034, -3	0.0000000, 0
15	1.3102073, 0	5.1987624, -3	2.4938535, -3	2.7049088, -3	0.0000000, 0
16	9.1465653, -1	5.3125094, -3	2.5353353, -3	2.7771741, -3	0.0000000, 0
17	5.8929861, -1	5.4090453, -3	2.5702367, -3	2.8388086, -3	0.0000000, 0
18	3.1748923, -1	5.4918352, -3	2.5999493, -3	2.8918859, -3	0.0000000, 0
T	3.6050067, -1	5.4786016, -3	2.5952134, -3	2.8833882, -3	0.0000000, 0
T+1	3.6050067, -1	5.4786016, -3	2.5952134, -3	2.8833882, -3	0.0000000, 0

EXPANSION		SMALLNESS	TOTAL	RADIAL	LONGITUDINAL
N	PARAMETER	PARAMETER	LEAKAGE	LEAKAGE	LEAKAGE
0	5.9987817, -1	1.4137646, -1	1.7335701, -2	9.5725402, -3	7.7631610, -3
1	2.4588334, -1	6.1374813, -2	1.7176338, -2	9.2483212, -3	7.9280175, -3
2	1.2245195, -1	3.1195427, -2	1.1896339, -2	6.0173542, -3	5.8789855, -3
3	9.5500916, -2	2.4438698, -2	1.4838863, -2	7.6931997, -3	7.1456638, -3
4	5.2131600, -2	1.3437205, -2	9.3971451, -3	4.6417101, -3	4.7554349, -3
5	2.6549928, -2	6.8726738, -3	6.8404772, -3	3.3063752, -3	3.5341020, -3
6	2.2196276, -2	5.7498748, -3	6.4466345, -3	3.1040335, -3	3.3426010, -3
7	1.5362329, -2	3.9841104, -3	6.1725972, -3	2.9569258, -3	3.2156714, -3
8	1.0779415, -2	2.7977072, -3	5.8605514, -3	2.7920879, -3	3.0684635, -3
9	4.1458264, -3	1.0772089, -3	4.1894196, -3	1.9490551, -3	2.2403645, -3
10	3.5509297, -3	9.2272892, -4	3.9989809, -3	1.8533305, -3	2.1456503, -3
11	3.4695813, -3	8.8601970, -4	3.9297844, -3	1.8193364, -3	2.1104479, -3
12	3.3957248, -3	8.8242097, -4	3.9046110, -3	1.8082766, -3	2.0963344, -3
13	3.3697565, -3	8.7567658, -4	3.8517170, -3	1.7842556, -3	2.0674613, -3
14	3.2422278, -3	8.4255452, -4	3.8557099, -3	1.7830722, -3	2.0726376, -3
15	3.2179683, -3	8.3625361, -4	3.4944915, -3	1.6132521, -3	1.8812393, -3
16	2.2014845, -3	5.7219719, -4	2.5475193, -3	1.1624044, -3	1.3851148, -3
17	1.2627796, -3	3.2826596, -4	1.7380611, -3	7.8023609, -4	9.5782506, -4
18	6.8198636, -4	1.7730303, -4	9.9197409, -4	4.3825349, -4	5.5372061, -4
T	7.2529064, -4	1.8855993, -4	1.7208280, -3	4.9578329, -4	6.2504477, -4
T+1	7.2529064, -4	1.8855993, -4	1.1208280, -3	4.9578329, -4	6.2504477, -4

N	LETHARGY		SLOWING DOWN		SLOWING DOWN		SLOWING DOWN	
	PARAMETER		U		W		DENSITY	
0	0.0000000, 0	7.5741295, -1	2.4258704, -1	0.0000000, 0				
1	5.0000000, -1	8.2147049, -1	1.7852950, -1	1.7177950, -2				
2	1.0000000, 0	9.1106089, -1	8.8939100, -2	1.1723604, -1				
3	1.5000000, 0	9.1515462, -1	8.4845378, -2	3.0207552, -1				
4	2.0000000, 0	9.5910258, -1	4.0897414, -2	5.0097582, -1				
5	2.5000000, 0	9.7648534, -1	2.3514650, -2	6.6737572, -1				
6	3.0000000, 0	9.8224160, -1	1.7758399, -2	7.7158600, -1				
7	3.5000000, 0	9.8674408, -1	1.3255916, -2	8.2724394, -1				
8	4.0000000, 0	9.8971112, -1	1.0288879, -2	8.5550994, -1				
9	6.0000000, 0	9.9571619, -1	4.2838081, -3	8.7575764, -1				
10	8.0000000, 0	9.9610137, -1	3.8986280, -3	8.6880314, -1				
11	1.0000000, 1	9.9578929, -1	4.2107030, -3	8.6181265, -1				
12	1.2000000, 1	9.9336750, -1	6.6324919, -3	8.5253286, -1				
13	1.4000000, 1	9.8996561, -1	1.0034382, -2	8.3846541, -1				
14	1.5500000, 1	9.9338911, -1	6.6108852, -3	8.2804968, -1				
15	1.6500000, 1	9.9017263, -1	9.8273679, -3	8.2127711, -1				
16	1.7500000, 1	9.8510580, -1	1.4894194, -2	8.1120053, -1				
17	1.8500000, 1	9.7986449, -1	2.0135506, -2	7.9713410, -1				
T	1.9554883, 1	9.6609414, -1	3.3905856, -2	7.7481205, -1				
T+1	1.9554883, 1	0.0000000, 0	0.0000000, 0	0.0000000, 0				

N	FLUX		LEAKAGE		ABSORPTION		FISSION	
	SPECTRUM		SPECTRUM		SPECTRUM		SPECTRUM	
0	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0
1	1.0815650, 0	1.8577327, -2	8.9020666, -5	1.8726567, -4				
2	3.6586124, 0	4.3524096, -2	2.8418817, -4	5.9629331, -4				
3	4.4122602, 0	6.5472927, -2	3.4417332, -4	7.1724209, -4				
4	3.9997253, 0	3.7585999, -2	3.1104168, -4	6.0136482, -4				
5	3.2877296, 0	2.2489640, -2	2.7190496, -4	4.8700606, -4				
6	2.5196833, 0	1.6239609, -2	2.2339936, -4	3.9802423, -4				
7	1.9583468, 0	1.2088086, -2	1.9556482, -4	3.5777364, -4				
8	1.5326201, 0	8.9784829, -3	1.6306940, -4	2.9501635, -4				
9	8.5869829, -1	3.5949338, -3	1.5734794, -4	2.9235002, -4				
10	7.8048479, -1	3.1210638, -3	2.6615963, -4	4.2775323, -4				
11	7.5671121, -1	2.9737119, -3	6.5514343, -4	9.1914130, -4				
12	7.4674043, -1	2.9157309, -3	2.7386879, -3	3.4474525, -3				
13	7.2937998, -1	2.8093653, -3	5.6041197, -3	6.0143309, -3				
14	7.0884093, -1	2.7330850, -3	2.7410626, -3	1.9809897, -3				
15	7.0076541, -1	2.4488187, -3	5.6221786, -3	6.4704022, -3				
16	6.7293479, -1	1.7143143, -3	1.0367867, -2	1.3049585, -2				
17	6.2586106, -1	1.0877848, -3	1.4962913, -2	1.8492841, -2				
T	5.8781013, -1	6.5883409, -4	2.5611835, -2	3.2302025, -2				
T+1	1.7336534, 1	1.9431274, -2	7.5538077, -1	9.5269738, -1				

CALCULATED REACTIVITY	1.0334710, 0
POWER LEVEL 17	1.5260430, -2
POWER LEVEL T	2.5923628, -2
POWER LEVEL T+1	9.2184232, -1
BALANCE CHECK DISCREPANCY	-9.9880790, -5

LETHARGY INDEX	19
LETHARGY AT INDEX	1.9554883, 1

----- TWO-GROUP RESULTS -----

	FAST	SLOW
DIFFUSION COEFFICIENT, ONE-GROUP BUCKLING	1.3775992, 0	2.2565496, -1
DIFFUSION COEFFICIENT, TWO-GROUP BUCKLING	1.4774395, 0	2.0458286, -1
SIGMA ABSORPTION	2.8860821, -3	4.3571612, -2
NU SIGMA FISSION	3.4896037, -3	5.4953161, -2
FLUX	2.3146952, 1	1.7336534, 1
MULTIPLICATION	1.2091144, 0	1.2612147, 0
SIGMA LEAKAGE	6.8425346, -3	1.1208280, -3
DIFFUSION AREA, ONE-GROUP BUCKLING	3.7888090, 1	5.1789445, 0
DIFFUSION AREA, TWO-GROUP BUCKLING	4.0633994, 1	4.6953246, 0
BUCKLING	4.6313466, -3	5.4786016, -3
EXTRAPOLATION DISTANCE	3.5077737, 0	3.6050067, -1
SLOWING DOWN X-SECTION	3.3473609, -2	
AVERAGE BUCKLING	4.9669992, -3	
AVERAGE EXTRAPOLATION DISTANCE	2.1599943, 0	
ABSORPTION ESCAPE PROBABILITY	9.2062412, -1	
REACTIVITY, ONE-GROUP BUCKLING	1.0334711, 0	
REACTIVITY, TWO-GROUP BUCKLING	1.0334711, 0	

MULTIGROUP CONSTANTS

N	ENERGY	LETHARGY	SLOWING DOWN DENSITY
1	1.0000000, 2	1.1512829, 1	8.5479328, -1
2	1.0000000, 0	1.6117999, 1	8.2386424, -1
GROUP	MULTIPLICATION	BUCKLING	EXTRAPOLATION DISTANCE
1	1.5240854, 0	4.4641061, -3	4.2381106, 0
2	1.0560950, 0	5.1561816, -3	1.4618108, 0
3	1.2599323, 0	5.4611572, -3	4.1744942, -1
GROUP	SIGMA LEAKAGE	FLUX	SIGMA ABSORPTION
1	7.9834978, -3	1.7546593, 1	2.7064455, -4
2	3.8563150, -3	3.3556888, 0	5.3808434, -3
3	1.2660773, -3	1.9581204, 1	4.0823813, -2
GROUP	SOURCE TERM	NU SIGMA FISSION	SLOWING DOWN X-SECTION
1	9.9999911, -1	4.1248543, -4	4.8715625, -2
2	8.5086441, -7	5.6826822, -3	2.4551269, -1
3	0.0000000, 0	5.1435243, -2	0.0000000, 0
GROUP	ABSORPTION ESCAPE PROBABILITY	DIFFUSION COEFFICIENT ONE-GROUP BUCKLING	DIFFUSION COEFFICIENT MULTIGROUP BUCKLING
1	9.9447509, -1	1.6073077, 0	1.7883754, 0
2	9.7855328, -1	7.7638712, -1	7.4790130, -1
3	0.0000000, 0	2.5489778, -1	2.3183315, -1
GROUP	DIFFUSION AREA ONE-GROUP BUCKLING	DIFFUSION AREA MULTIGROUP BUCKLING	
1	3.2811392, 1	3.6507687, 1	
2	3.0944882, 0	2.9809508, 0	
3	6.2438502, 0	5.6788706, 0	
REACTIVITY, ONE-GROUP BUCKLING		1.0334021, 0	
REACTIVITY, MULTIGROUP BUCKLING		1.0334021, 0	

PHOTON PRODUCTION PARAMETERS

ASSUMES NU = 2.46

P	ENERGY	LETHARGY	GROUP FLUX
1	1.0000000, -6	2.3024893, 0	6.7208771, 0
2	1.0000000, -3	9.2102446, 0	9.0853260, 0
3	5.0000000, -1	1.6811146, 1	5.5810551, 0
4	9.9999999, -5	1.9554883, 1	1.7596948, 0
5			1.7336534, 1

ELEMENT -1.130 *ORALLOY

GROUP	ABSORPTION CROSS SECTION	FISSION CROSS SECTION
1	7.6386449, -5	6.4849768, -5
2	1.5501431, -4	1.1987271, -4
3	3.3429309, -3	1.9688817, -3
4	1.3799520, -2	1.1548290, -2
5	2.6680301, -2	2.2338683, -2

ELEMENT 2.510 *WATER

GROUP	ABSORPTION CROSS SECTION	FISSION CROSS SECTION
1	1.9973093, -6	
2	1.8894777, -5	
3	1.0553960, -3	
4	8.8855199, -3	
5	1.6726649, -2	

ELEMENT 5.110 *ALUMINUM

GROUP	ABSORPTION CROSS SECTION	FISSION CROSS SECTION
1	2.2272418, -8	
2	2.1069965, -7	
3	1.1760082, -5	
4	9.2872329, -5	
5	1.6466311, -4	

FINE RADIAL POWER

ZONE 3	CODE 0.0000000, 0	LATTICE	RADIUS	POWER
		32	3.0000000, 0	0.0000000, 0
		31	2.9000000, 0	0.0000000, 0
		30	2.8000000, 0	0.0000000, 0
		29	2.7000000, 0	0.0000000, 0
		28	2.6000000, 0	0.0000000, 0
		27	2.5000000, 0	0.0000000, 0
		26	2.4000000, 0	0.0000000, 0
		25	2.3000000, 0	0.0000000, 0
		24	2.2000000, 0	0.0000000, 0
		23	2.1000000, 0	0.0000000, 0
		22	2.0000000, 0	0.0000000, 0
ZONE 2	CODE 1.0000000, 0	LATTICE	RADIUS	POWER
		21	2.0000000, 0	9.9985187, -1
		20	1.9600000, 0	9.9597163, -1
		19	1.9200000, 0	9.9634705, -1
		18	1.8800000, 0	9.9698401, -1
		17	1.8400000, 0	9.9788890, -1
		16	1.8000000, 0	9.9906867, -1
		15	1.7600000, 0	1.0005307, 0
		14	1.7200000, 0	1.0022832, 0
		13	1.6800000, 0	1.0043348, 0
		12	1.6400000, 0	1.0066950, 0
		11	1.5999999, 0	1.0093742, 0
ZONE 1	CODE 0.0000000, 0	LATTICE	RADIUS	POWER
		10	1.5999999, 0	0.0000000, 0
		9	1.4399999, 0	0.0000000, 0
		8	1.2800000, 0	0.0000000, 0
		7	1.1200000, 0	0.0000000, 0
		6	9.6000000, -1	0.0000000, 0
		5	8.0000001, -1	0.0000000, 0
		4	6.4000001, -1	0.0000000, 0
		3	4.8000001, -1	0.0000000, 0
		2	3.2000002, -1	0.0000000, 0
		1	1.6000002, -1	0.0000000, 0

 CORE OR END COMPOSITION

 COMPOSITION INPUT

CASE NUMBER	CORE 2	
C2-INPUT UNITS	C.G.S.	
C3-THERMAL BASE	SET T=T+1	
C4-SLOWING DOWN MODEL	MODIFIED AGE	
C5-GROUP DIVISION	N=T	
C8-G FACTOR APPLICATION	ALL SIGMAS	
C17-PHOTON PRODUCTION CALCULATION		YES
C19-PRINT OUT		LONG
C21-ADJOINT CALCULATION		NO
C22-MULTI GROUP CALCULATION		YES
C31-CLEAR INPUT AFTER CALCULATION		NO
C32-RERUN THIS COMPOSITION IN REACTIVITY MATCH		YES

 BEHRENS INPUT

C6-BEHRENS CALCULATION	CALCULATE F/R, F/2
C10-G FACTORS IN BEHRENS CORRECTION	YES
C11-MODERATOR X-SECTION IN BEHRENS CORRECTION	SIGMA TOTAL

D1	D2	D3	M
FUEL ZONE I.D.	FUEL ZONE O.D.	CELL DIAMETER	NUMBER OF CELLS
3.1999992, 0	4.0000000, 0	7.0000000, 0	0.0000000, 0

 I2 INPUT

C7-I2 CALCULATION	YES
C9-LEAKAGE TERM ADDED TO SIGMA A	NO
C12-I2 AT THERMAL	YES, TYPE B
C13-I2 AT LEVEL 16	YES, TYPE B
C14-I2 AT LEVEL 17	YES, TYPE B
C20-FINE RADIAL POWER CALCULATION	YES
C30-G RECIPE	G CELL=1

TERRALL INPUT

C18-TERRALL METHOD NO

ESIAE*

TPF

SLOWING DOWN CUT-OFF (eV)

FUEL TEMPERATURE DEGREES F

0.000000, 0

0.000000, 0

BUCKLING GEOMETRY

C16-GEOMETRY CYLINDER

SAVINGS ON H S/Z 3.8929443, 0 HEIGHT H 5.0000000, 1

SAVINGS ON D S/R 1.1842681, 1 DIAMETER D 7.0000000, 1

VOLUME GEOMETRY

DCO

DCI

L

VOC

OUTER DIAMETER INNER DIAMETER LENGTH COMPOSITION VOLUME

0.0000000, 0

0.0000000, 0

0.0000000, 0

0.0000000, 0

CSP

TPM

CODE NUMBER OF SPECTRUM

MODERATOR TEMPERATURE DEGREES F

0.9420

6.8000000, 1

TABLE 3M.12 MATERIAL NUMBER 1

C28-FUEL YES

GEOMETRY FOR VOLUME CALCULATION

OUTER RADIUS		INNER RADIUS		LENGTH		MATERIAL VOLUME	
0.000000, 0		0.000000, 0		0.000000, 0		0.000000, 0	
CODE	WEIGHT	F OR N	SIGMA/S2,T+1	SIGMA/S2,16	SIGMA/S2,17		
-1.130	0.000000, 0	6.999999, -3	0.000000, 0	0.000000, 0	0.000000, 0		
5.110	0.000000, 0	9.222222, -2	0.000000, 0	0.000000, 0	0.000000, 0		

TABLE 3M.12 MATERIAL NUMBER 2

C28-FUEL NO

GEOMETRY FOR VOLUME CALCULATION

OUTER RADIUS		INNER RADIUS		LENGTH		MATERIAL VOLUME	
0.000000, 0		0.000000, 0		0.000000, 0		0.000000, 0	
CODE	WEIGHT	F OR N	SIGMA/S2,T+1	SIGMA/S2,16	SIGMA/S2,17		
2.510	0.000000, 0	1.000000, 0	1.299999, -1	2.399999, -1	1.999999, -1		

TABLE M1 MODERATOR

ELEMENT	CODE	WEIGHT	F/H OR N/H	G/T+1	G/16	G/17
*WATER	2.510	0.000000, 0	8.8244897, -1	1.018208	1.003717	1.007026

TABLE F1 FUEL

ELEMENT	CODE	WEIGHT	F/H OR N/H	G/T+1	G/16	G/17
*ORALLOY	-1.130	0.000000, 0	8.2285715, -4	0.863311	0.972099	0.947260
*ALUMINUM	5.110	0.000000, 0	1.0932244, -2	0.863311	0.972099	0.947260

HYDRAULIC DIAMETER			FUEL 8.0000001,-1		MODERATOR 6.0055555, 0	
BEHRENS CROSS SECTIONS				ATTENUATION FACTORS		
N	SIGMA/S,MOD	SIGMA/A,MOD	SIGMA/A,FUEL	X-FUEL	Y-MOD	
0	7.3406384,-2	1.1080379,-6	5.5514334,-4	4.4411468,-4	4.4085276,-1	
1	1.2545618,-1	1.4208439,-6	5.0696100,-4	4.0556880,-4	7.5345461,-1	
2	2.1154385,-1	1.8239671,-6	4.7590222,-4	3.8072178,-4	1.2704493, 0	
3	2.2355580,-1	2.3350303,-6	4.7526520,-4	3.8021216,-4	1.3425208, 0	
4	3.4234068,-1	3.0179165,-6	4.7019192,-4	3.7615354,-4	2.0559640, 0	
5	4.9949708,-1	3.8550029,-6	4.9665462,-4	3.9732376,-4	2.9997809, 0	
6	5.4721122,-1	4.9564323,-6	5.2824619,-4	4.2259696,-4	3.2863371, 0	
7	6.6566244,-1	6.3662620,-6	5.9071583,-4	4.7257267,-4	3.9977109, 0	
8	7.9245529,-1	8.1726062,-6	6.2234861,-4	4.9787889,-4	4.7591832, 0	
9	1.3196465, 0	2.2248874,-5	1.0292446,-3	8.2339570,-4	7.9253444, 0	
10	1.4297561, 0	6.0358332,-5	1.8145380,-3	1.4516304,-3	8.5868424, 0	
11	1.4597860, 0	1.6433326,-4	4.5483586,-3	3.6386869,-3	8.7678130, 0	
12	1.4597860, 0	4.4718035,-4	2.0574323,-2	1.6459458,-2	8.7695116, 0	
13	1.4614543, 0	1.2137752,-3	4.1648942,-2	3.3319153,-2	8.7841347, 0	
14	1.4948209, 0	2.2843646,-3	1.2175612,-2	9.7404903,-3	8.9909487, 0	
15	1.5014942, 0	4.3858919,-3	2.7117261,-2	2.1693809,-2	9.0436466, 0	
16	1.8285841, 0	6.6353496,-3	6.0992246,-2	4.8793797,-2	1.1021512, 1	
17	2.4327092, 0	1.1599674,-2	8.7197335,-2	6.9757868,-2	1.4679432, 1	
18	3.3158708, 0	2.0848398,-2	1.8517922,-1	1.4814338,-1	2.0038852, 1	
T	3.2153075, 0	1.9895224,-2	1.6099200,-1	1.2879360,-1	1.9429189, 1	
T+1	3.2153075, 0	1.9895224,-2	1.6099200,-1	1.2879360,-1	1.9429189, 1	

BEHRENS FACTOR		BEHRENS FACTOR		SOURCE SPECTRUM	
N	F/R	N	F/Z		
0	1.0002229, 0	1	1.0032675, 0	0.0000000, 0	
1	1.0006473, 0	1	1.0058509, 0	8.7378149,-2	
2	1.0018097, 0	1	1.0105841, 0	3.7532886,-1	
3	1.0020150, 0	1	1.0112876, 0	4.7365445,-1	
4	1.0045540, 0	1	1.0187536, 0	4.2566089,-1	
5	1.0090763, 0	1	1.0297939, 0	3.0059730,-1	
6	1.0106468, 0	1	1.0333429, 0	1.5546837,-1	
7	1.0148284, 0	1	1.0424360, 0	9.8710099,-2	
8	1.0196224, 0	1	1.0524878, 0	3.2979099,-2	
9	1.0409447, 0	1	1.0956568, 0	1.6243999,-4	
10	1.0454653, 0	1	1.1047068, 0	2.2580000,-5	
11	1.0466085, 0	1	1.1069664, 0	3.0299999,-6	
12	1.0460263, 0	1	1.1056268, 0	4.7000000,-7	
13	1.0453543, 0	1	1.1040561, 0	0.0000000, 0	
14	1.0478484, 0	1	1.1093658, 0	0.0000000, 0	
15	1.0476354, 0	1	1.1087782, 0	0.0000000, 0	
16	1.0593647, 0	1	1.1318873, 0	0.0000000, 0	
17	1.0817010, 0	1	1.1762891, 0	0.0000000, 0	
18	1.1074716, 0	1	1.2268588, 0	0.0000000, 0	
T	1.1058682, 0	1	1.2238048, 0		
T+1	1.1058682, 0	1	1.2238048, 0		

TABLE C4

	SCATTER	MI-SCATTER	TRANSPORT	ABSORPTION	FISSION
N	X-SECTION	X-SECTION	X-SECTION	X-SECTION	X-SECTION
0	6.6087753,-2	5.7111896,-2	3.9029610,-2	6.6235457,-5	1.4318619,-4
1	1.1211400,-1	8.3378293,-2	5.0540146,-2	6.0847608,-5	1.2720728,-4
2	1.8633565,-1	1.2880054,-1	1.1122002,-1	5.7552352,-5	1.1974295,-4
3	1.9957772,-1	1.6895060,-1	7.7375032,-2	5.7928456,-5	1.1942934,-4
4	3.0369273,-1	2.3337740,-1	1.6062400,-1	5.7934700,-5	1.1046234,-4
5	4.4297596,-1	3.0195863,-1	2.4435422,-1	6.1784111,-5	1.0882901,-4
6	4.8667045,-1	3.7962877,-1	2.6327607,-1	6.6462680,-5	1.1608427,-4
7	5.8890813,-1	4.9046240,-1	2.8059310,-1	7.5057153,-5	1.3422244,-4
8	7.0483466,-1	6.0281792,-1	2.9284395,-1	8.0369625,-5	1.4147771,-4
9	1.1658786, 0	1.0677261, 0	4.6066223,-1	1.4062225,-4	2.5030672,-4
10	1.2629195, 0	1.1648830, 0	4.8910105,-1	2.6656395,-4	4.0266734,-4
11	1.2894193, 0	1.1913829, 0	4.9911210,-1	6.7967994,-4	8.9239789,-4
12	1.2894136, 0	1.1913828, 0	4.9910638,-1	2.8131465,-3	3.3918375,-3
13	1.2908748, 0	1.1955045, 0	5.0174549,-1	5.9669704,-3	6.0581483,-3
14	1.3203714, 0	1.2190638, 0	5.0768537,-1	3.4470910,-3	2.0532406,-3
15	1.3262863, 0	1.2190657, 0	5.6071043,-1	7.0579877,-3	6.7836751,-3
16	1.6148705, 0	1.2472358, 0	7.9916460,-1	1.3025058,-2	1.4140941,-2
17	2.1479226, 0	1.3106459, 0	1.2405756, 0	2.0486256,-2	2.1387601,-2
18	2.9271780, 0	1.3851546, 0	2.2975691, 0	4.0165655,-2	4.4972324,-2
T	2.8384683, 0	1.3365897, 0	2.0223802, 0	3.6481296,-2	3.8740087,-2
T+1	2.8384683, 0	1.3365897, 0	2.0223802, 0	3.6481296,-2	3.8740087,-2

EXTRAPOLATION			TOTAL		X/R/S		Y/Z		Z	
N	DISTANCE		BUCKLING		BUCKLING		BUCKLING		BUCKLING	
0	1.8173286, 1		2.4818466, -3		1.3679668, -3		1.1138797, -3		0.0000000, 0	
1	1.4041225, 1		2.8985502, -3		1.5599497, -3		1.3386005, -3		0.0000000, 0	
2	6.3849341, 0		4.0236716, -3		2.0409934, -3		1.9826782, -3		0.0000000, 0	
3	9.1756789, 0		3.5453408, -3		1.8427009, -3		1.7026399, -3		0.0000000, 0	
4	4.4217787, 0		4.4235366, -3		2.2003048, -3		2.2232318, -3		0.0000000, 0	
5	2.9069289, 0		4.7764342, -3		2.3363412, -3		2.4400930, -3		0.0000000, 0	
6	2.6980668, 0		4.8285623, -3		2.3560882, -3		2.4724740, -3		0.0000000, 0	
7	2.5314522, 0		4.8707616, -3		2.3720101, -3		2.4987515, -3		0.0000000, 0	
8	2.3689308, 0		4.9125045, -3		2.3877037, -3		2.5248007, -3		0.0000000, 0	
9	1.5418741, 0		5.1339152, -3		2.4700224, -3		2.6638865, -3		0.0000000, 0	
10	1.4518737, 0		5.1589559, -3		2.4792441, -3		2.6797117, -3		0.0000000, 0	
11	1.4215919, 0		5.1674242, -3		2.4823561, -3		2.6850680, -3		0.0000000, 0	
12	1.4155655, 0		5.1691120, -3		2.4829761, -3		2.6861359, -3		0.0000000, 0	
13	1.3994141, 0		5.1736401, -3		2.4846390, -3		2.6890011, -3		0.0000000, 0	
14	1.3900506, 0		5.1762681, -3		2.4856038, -3		2.6906642, -3		0.0000000, 0	
15	1.2513904, 0		5.2154315, -3		2.4995569, -3		2.7154746, -3		0.0000000, 0	
16	8.7479566, -1		5.3241896, -3		2.5395729, -3		2.7846167, -3		0.0000000, 0	
17	5.6341402, -1		5.4168443, -3		2.5730443, -3		2.8438000, -3		0.0000000, 0	
18	3.0392669, -1		5.4960186, -3		2.6014454, -3		2.8945732, -3		0.0000000, 0	
T	3.4509362, -1		5.4833362, -3		2.5969084, -3		2.8864278, -3		0.0000000, 0	
T+1	3.4509362, -1		5.4833362, -3		2.5969084, -3		2.8864278, -3		0.0000000, 0	

EXPANSION		SMALLNESS		TOTAL		RADIAL		LONGITUDINAL	
N	PARAMETER		PARAMETER		LEAKAGE		LEAKAGE		LEAKAGE
0	5.6710422, -1		1.3435483, -1		1.7268212, -2		9.5050655, -3		7.7631465, -3
1	2.3035065, -1		5.7645062, -2		1.6982235, -2		9.1176496, -3		7.8645863, -3
2	1.1336841, -1		2.8924945, -2		1.1560752, -2		5.8389517, -3		5.7218006, -3
3	8.8957338, -2		2.2788993, -2		1.4508278, -2		7.5073546, -3		7.0009239, -3
4	4.7944096, -2		1.2366488, -2		9.0717943, -3		4.4805569, -3		4.5912373, -3
5	2.4334494, -2		6.3015219, -3		6.5671328, -3		3.1788998, -3		3.3882330, -3
6	2.0381177, -2		5.2812807, -3		6.1875931, -3		2.9849010, -3		3.2026921, -3
7	1.4040774, -2		3.6421792, -3		5.9072792, -3		2.8371874, -3		3.0700918, -3
8	9.8862006, -3		2.5662639, -3		5.6251419, -3		2.6895231, -3		2.9356187, -3
9	3.7760460, -3		9.8118973, -4		3.9614000, -3		1.8553099, -3		2.1060901, -3
10	3.2331596, -3		8.4019923, -4		3.7737439, -3		1.7616985, -3		2.0120454, -3
11	3.1047597, -3		8.0684936, -4		3.7073827, -3		1.7291571, -3		1.9782256, -3
12	3.0955545, -3		8.0445841, -4		3.6895795, -3		1.7213186, -3		1.9682609, -3
13	3.0762542, -3		7.9944531, -4		3.6469418, -3		1.7017737, -3		1.9451681, -3
14	2.9536556, -3		7.6760061, -4		3.6379199, -3		1.6951693, -3		1.9427505, -3
15	2.9336320, -3		7.6239938, -4		3.2993739, -3		1.5348762, -3		1.7644976, -3
16	2.0090948, -3		5.2220917, -4		2.3952114, -3		1.1029940, -3		1.2922174, -3
17	1.1520304, -3		2.9948171, -4		1.6190697, -3		7.3531470, -4		8.8375501, -4
18	6.2418382, -4		1.6227708, -4		9.1697530, -4		4.1071579, -4		5.0625951, -4
T	6.6341362, -4		1.7247502, -4		1.0366492, -3		4.6484380, -4		5.7180544, -4
T+1	6.6341362, -4		1.7247502, -4		1.0366492, -3		4.6484380, -4		5.7180544, -4

N	LETHARGY	SLOWING DOWN PARAMETER V	SLOWING DOWN PARAMETER W	SLOWING DOWN DENSITY
0	0.0000000, 0	7.6715515, -1	2.3284484, -1	0.0000000, 0
1	5.0000000, -1	8.3028430, -1	1.6271569, -1	1.7398257, -2
2	1.0000000, 0	9.1725965, -1	8.2740344, -2	1.1841695, -1
3	1.5000000, 0	9.2062740, -1	7.9372599, -2	3.0499867, -1
4	2.0000000, 0	9.6235274, -1	3.7647254, -2	5.0561161, -1
5	2.5000000, 0	9.7851852, -1	2.1481476, -2	6.7318164, -1
6	3.0000000, 0	9.8379284, -1	1.6207158, -2	7.7818553, -1
7	3.5000000, 0	9.8724963, -1	1.2050360, -2	8.3513289, -1
8	4.0000000, 0	9.9062401, -1	9.3759894, -3	8.6314238, -1
9	6.0000000, 0	9.9617286, -1	3.8271322, -3	8.8449618, -1
10	8.0000000, 0	9.9654356, -1	3.4564360, -3	8.7825976, -1
11	1.0000000, 1	9.9633118, -1	3.6688148, -3	8.7205024, -1
12	1.2000000, 1	9.9457149, -1	5.4285004, -3	8.6416321, -1
13	1.4000000, 1	9.9202243, -1	7.9775601, -3	8.5267033, -1
14	1.5500000, 1	9.9422173, -1	5.7782679, -3	8.4391138, -1
15	1.6500000, 1	9.9157543, -1	8.4245651, -3	8.3794355, -1
16	1.7500000, 1	9.8778744, -1	1.2212559, -2	8.2934965, -1
17	1.8500000, 1	9.8341376, -1	1.6586236, -2	8.1750574, -1
T	1.9554883, 1	9.7269650, -1	2.7303494, -2	7.9884975, -1
T+1	1.9554883, 1	0.0000000, 0	0.0000000, 0	0.0000000, 0

N	FLUX	LEAKAGE SPECTRUM	ABSORPTION SPECTRUM	FISSION SPECTRUM
0	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0
1	1.0433745, 0	1.7718832, -2	6.3486844, -5	1.3272483, -4
2	3.5162360, 0	4.0650334, -2	2.0236765, -4	4.2104447, -4
3	4.2429527, 0	6.1557939, -2	2.4578769, -4	5.0673307, -4
4	3.8401860, 0	3.4837377, -2	2.2248002, -4	4.2419596, -4
5	3.1556002, 0	2.0723245, -2	1.9496595, -4	3.4342085, -4
6	2.4195269, 0	1.4971048, -2	1.6082517, -4	2.8086903, -4
7	1.8810633, 0	1.1111966, -2	1.4118725, -4	2.5248092, -4
8	1.4726162, 0	8.2836751, -3	1.1835361, -4	2.0834237, -4
9	8.2537356, -1	3.2696349, -3	1.1606589, -4	2.0659655, -4
10	7.5136005, -1	2.8354404, -3	2.0028550, -4	3.0254815, -4
11	7.2928179, -1	2.7037267, -3	4.9567819, -4	6.5080953, -4
12	7.2140753, -1	2.6616904, -3	2.0294251, -3	2.4468971, -3
13	7.0754067, -1	2.5803597, -3	4.2218742, -3	4.2863863, -3
14	6.8826179, -1	2.5038412, -3	2.3725010, -3	1.4131671, -3
15	6.8157460, -1	2.2487694, -3	4.8105452, -3	4.6235806, -3
16	6.5682539, -1	1.5732452, -3	8.5552412, -3	9.2881862, -3
17	6.1339709, -1	9.9313266, -4	1.2566210, -2	1.3119092, -2
T	5.8135889, -1	6.0266525, -4	2.1208725, -2	2.2521894, -2
T+1	2.1292470, 1	2.2072823, -2	7.7677692, -1	8.2487218, -1

CALCULATED REACTIVITY	8.8206452,-1
POWER LEVEL 17	1.2701602,-2
POWER LEVEL T	2.1311972,-2
POWER LEVEL T+1	9.3516080,-1
BALANCE CHECK DISCREPANCY	-9.9888240,-5

LETHARGY INDEX	19
LETHARGY AT INDEX	1.9554883, 1

TWO-GROUP RESULTS

	FAST	SLOW
DIFFUSION COEFFICIENT, ONE-GROUP BUCKLING	1.3055990, 0	2.0565138,-1
DIFFUSION COEFFICIENT, TWO-GROUP BUCKLING	1.4096080, 0	1.8905446,-1
SIGMA ABSORPTION	2.4312930,-3	3.6481295,-2
NU SIGMA FISSION	2.5625103,-3	3.8740087,-2
FLUX	2.2318874, 1	2.1292470, 1
MULTIPLICATION	1.0539745, 0	1.0619164, 0
SIGMA LEAKAGE	6.5812744,-3	1.0366492,-3
DIFFUSION AREA, ONE-GROUP BUCKLING	3.4156662, 1	5.6371733, 0
DIFFUSION AREA, TWO-GROUP BUCKLING	3.6877714, 1	5.1822300, 0
BUCKLING	4.6688682,-3	5.4833362,-3
EXTRAPOLATION DISTANCE	3.3495782, 0	3.4509362,-1
SLOWING DOWN X-SECTION	3.5792563,-2	
AVERAGE BUCKLING	5.0408082,-3	
AVERAGE EXTRAPOLATION DISTANCE	1.8826915, 0	
ABSORPTION ESCAPE PROBABILITY	9.3639355,-1	
REACTIVITY, ONE-GROUP BUCKLING	8.8206463,-1	
REACTIVITY, TWO-GROUP BUCKLING	8.8206463,-1	

MULTIGROUP CONSTANTS			
N	ENERGY	LETHARGY	SLOWING DOWN DENSITY
1	1.0000000, 2	1.1512822, 1	8.6608438, -1
2	1.0000000, 0	1.6117999, 1	8.4022326, -1
GROUP	MULTIPLICATION	BUCKLING	EXTRAPOLATION DISTANCE
1	1.4555381, 0	4.5050408, -3	4.0554234, 0
2	9.6815370, -1	5.1744446, -3	1.3965464, 0
3	1.0613004, 0	5.4627768, -3	3.8227395, -1
GROUP	SIGMA LEAKAGE	FLUX	SIGMA ABSORPTION
1	7.7122981, -3	1.6871762, 1	2.0859135, -4
2	3.6450930, -3	3.2517842, 0	4.3134879, -3
3	1.1409518, -3	2.3487799, 1	3.4634772, -2
GROUP	SOURCE TERM	NU SIGMA FISSION	SLOWING DOWN X-SECTION
1	9.9999911, -1	3.0361267, -4	5.1333366, -2
2	8.5086441, -7	4.1761193, -3	2.5838938, -1
3	0.0000000, 0	3.6757901, -2	0.0000000, 0
GROUP	ABSORPTION ESCAPE PROBABILITY	DIFFUSION COEFFICIENT ONE-GROUP BUCKLING	DIFFUSION COEFFICIENT MULTIGROUP BUCKLING
1	9.9595297, -1	1.5299722, 0	1.7119263, 0
2	9.8358029, -1	7.2311666, -1	7.0444138, -1
3	0.0000000, 0	2.2793005, -1	2.1005461, -1
GROUP	DIFFUSION AREA ONE-GROUP BUCKLING	DIFFUSION AREA MULTIGROUP BUCKLING	
1	2.9684015, 1	3.3214228, 1	
2	2.7526133, 0	2.6815240, 0	
3	6.5809599, 0	6.0648474, 0	
REACTIVITY, ONE-GROUP BUCKLING		8.8202487, -1	
REACTIVITY, MULTIGROUP BUCKLING		8.8202487, -1	

PHOTON PRODUCTION PARAMETERS

ASSUMES NU = 2.46

P	ENERGY	LETHARGY	GROUP FLUX
1	1.0000000,-6	2.3024893, 0	6.4603041, 0
2	1.0000000, 3	9.2102446, 0	8.7332880, 0
3	5.0000000,-1	1.6311146, 1	5.4016761, 0
4	9.9999999,-5	1.9554883, 1	1.7236072, 0
5			2.1292470, 1

ELEMENT -1.130 *DRALLOY

GROUP	ABSORPTION CROSS SECTION	FISSION CROSS SECTION
1	5.6121761,-5	4.7647085,-5
2	1.1326903,-4	8.8129342,-5
3	2.4590997,-3	1.4485200,-3
4	9.2467232,-3	8.3238292,-3
5	1.8808694,-2	1.5748003,-2

ELEMENT 2.510 *WATER

GROUP	ABSORPTION CROSS SECTION	FISSION CROSS SECTION
1	2.0977465,-6	
2	1.9874472,-5	
3	1.1120810,-3	
4	9.3525855,-3	
5	1.7556520,-2	

ELEMENT 5.110 *ALUMINUM

GROUP	ABSORPTION CROSS SECTION	FISSION CROSS SECTION
1	1.6359542,-8	
2	1.5499359,-7	
3	8.6642380,-6	
4	6.6976819,-5	
5	1.1608182,-4	

FINE RADIAL POWER

ZONE	3	CODE	0.0000000, 0	LATTICE	RADIUS	POWER
				32	3.5000000, 0	0.0000000, 0
				31	3.3500000, 0	0.0000000, 0
				30	3.2000000, 0	0.0000000, 0
				29	3.0500000, 0	0.0000000, 0
				28	2.9000000, 0	0.0000000, 0
				27	2.7500001, 0	0.0000000, 0
				26	2.6000001, 0	0.0000000, 0
				25	2.4500001, 0	0.0000000, 0
				24	2.3000001, 0	0.0000000, 0
				23	2.1500002, 0	0.0000000, 0
				22	2.0000000, 0	0.0000000, 0
ZONE	2	CODE	1.0000000, 0	LATTICE	RADIUS	POWER
				21	2.0000000, 0	9.9680603, -1
				20	1.9600000, 0	9.9673689, -1
				19	1.9200000, 0	9.9692050, -1
				18	1.8800000, 0	9.9736254, -1
				17	1.8400000, 0	9.9806915, -1
				16	1.8000000, 0	9.9904700, -1
				15	1.7600000, 0	1.0003032, 0
				14	1.7200000, 0	1.0018458, 0
				13	1.6800000, 0	1.0036830, 0
				12	1.6400000, 0	1.0058241, 0
				11	1.5999999, 0	1.0082790, 0
ZONE	1	CODE	0.0000000, 0	LATTICE	RADIUS	POWER
				10	1.5999999, 0	0.0000000, 0
				9	1.4399999, 0	0.0000000, 0
				8	1.2800000, 0	0.0000000, 0
				7	1.1200000, 0	0.0000000, 0
				6	9.6000000, -1	0.0000000, 0
				5	8.0000001, -1	0.0000000, 0
				4	6.4000001, -1	0.0000000, 0
				3	4.8000001, -1	0.0000000, 0
				2	3.2000002, -1	0.0000000, 0
				1	1.6000002, -1	0.0000000, 0

 CORE OR END COMPOSITION

 COMPOSITION INPUT

CASE NUMBER	AVG.CORE	
C2-INPUT UNITS	C.G.S.	
C3-THERMAL BASE SET T=T+1		
C4-SLOWING DOWN MODEL	MODIFIED AGE	
C5-GROUP DIVISION	N=T	
C8-G FACTOR APPLICATION	ALL SIGMAS	
C17-PHOTON PRODUCTION CALCULATION		YES
C19-PRINT OUT		LONG
C21-ADJOINT CALCULATION		NO
C22-MULTI GROUP CALCULATION		YES
C31-CLEAR INPUT AFTER CALCULATION		YES
C32-RERUN THIS COMPOSITION IN REACTIVITY MATCH		YES

 BEHRENS INPUT

C6-BEHRENS CALCULATION		CALCULATE F/R, F/2
C10-G FACTORS IN BEHRENS CORRECTION		YES
C11-MODERATOR X-SECTION IN BEHRENS CORRECTION		SIGMA TOTAL

D1	D2	D3	M
FUEL ZONE I.D.	FUEL ZONE O.D.	CELL DIAMETER	NUMBER OF CELLS
3.1999999, 0	4.0000000, 0	6.5000000, 0	0.0000000, 0

 I2 INPUT

C7-I2 CALCULATION	YES
C9-LEAKAGE TERM ADDED TO SIGMA A	NO
C12-I2 AT THERMAL	YES, TYPE B
C13-I2 AT LEVEL 16	YES, TYPE B
C14-I2 AT LEVEL 17	YES, TYPE B
C20-FINE RADIAL POWER CALCULATION	YES
C30-G RECIPE	G CELL=1

TERRALL INPUT

C18-TERRALL METHOD NO

ESTAR E*

TPF

SLOWING DOWN CUT-OFF (eV)

FUEL TEMPERATURE DEGREES F

0.000000, 0

0.000000, 0

BUCKLING GEOMETRY

C16-GEOMETRY CYLINDER

SAVINGS ON H S/Z 3.8929443, 0 HEIGHT H 5.0000000, 1

SAVINGS ON D S/R 1.1842681, 1 DIAMETER D 7.0000000, 1

VOLUME GEOMETRY

DCO

DCI

L

VOC

OUTER DIAMETER INNER DIAMETER LENGTH COMPOSITION VOLUME

0.000000, 0 0.000000, 0 0.000000, 0 0.000000, 0

CSP

TPM

CODE NUMBER OF SPECTRUM

MODERATOR TEMPERATURE DEGREES F

0.9420

6.8000000, 1

TABLE 3M, I2 MATERIAL NUMBER 1

C28-FUEL YES

GEOMETRY FOR VOLUME CALCULATION

OUTER RADIUS	INNER RADIUS	LENGTH	MATERIAL VOLUME
0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0

CODE	WEIGHT	F OR N	SIGMA/S2,T+1	SIGMA/S2,16	SIGMA/S2,17
-1.130	0.000000, 0	6.9999999, -3	0.0000000, 0	0.0000000, 0	0.0000000, 0
5.110	0.000000, 0	9.2999999, -2	0.0000000, 0	0.0000000, 0	0.0000000, 0

TABLE 3M, I2 MATERIAL NUMBER 2

C28-FUEL NO

GEOMETRY FOR VOLUME CALCULATION

OUTER RADIUS	INNER RADIUS	LENGTH	MATERIAL VOLUME
0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0

CODE	WEIGHT	F OR N	SIGMA/S2,T+1	SIGMA/S2,16	SIGMA/S2,17
2.510	0.000000, 0	1.0000000, 0	1.2999999, -1	2.3999999, -1	1.9999999, -1

TABLE M1 MODERATOR

ELEMENT	CODE	WEIGHT	F/H OR N/H	G/T+1	G/16	G/17
*WATER	2.510	0.000000, 0	8.6366862, -1	1.018540	1.003797	1.007126

TABLE F1 FUEL

ELEMENT	CODE	WEIGHT	F/H OR N/H	G/T+1	G/16	G/17
*ORALLOY	-1.130	0.000000, 0	2.5431254, -4	0.882549	0.975948	0.954857
*ALUMINUM	5.110	0.000000, 0	1.2678816, -2	0.882549	0.975948	0.954857

HYDRAULIC DIAMETER		FUEL 8.0000001,-1		MODERATOR 5.0680555, 0	
BEHRENS CROSS SECTIONS				ATTENUATION FACTORS	
N	SIGMA/S,MOD	SIGMA/A,MOD	SIGMA/A,FUEL	X-FUEL	Y-MOD
0	7.3406384,-2	1.1080379,-6	5.5514335,-4	4.4411469,-4	3.7203324,-1
1	1.2545818,-1	1.4208439,-6	5.0696100,-4	4.0556880,-4	6.3583624,-1
2	2.1154385,-1	1.8239671,-6	4.7590222,-4	3.8072178,-4	1.0721252, 0
3	2.2355580,-1	2.3350303,-6	4.7526520,-4	3.8021216,-4	1.1330050, 0
4	3.4234068,-1	3.0179166,-6	4.7019193,-4	3.7615355,-4	1.7350168, 0
5	4.9949708,-1	3.8550029,-6	4.9665469,-4	3.9732376,-4	2.5314984, 0
6	5.4721123,-1	4.9564323,-6	5.2824620,-4	4.2259697,-4	2.7733220, 0
7	6.6566244,-1	6.3662620,-6	5.9071584,-4	4.7257268,-4	3.3736464, 0
8	7.9245529,-1	8.1726063,-6	6.2234862,-4	4.9787890,-4	4.0162487, 0
9	1.3196465, 0	2.2248874,-5	1.0292446,-3	8.2339570,-4	6.6881549, 0
10	1.4297561, 0	6.0358333,-5	1.8145380,-3	1.4516304,-3	7.2463895, 0
11	1.4597860, 0	1.6433326,-4	4.5483587,-3	3.6386870,-3	7.3991096, 0
12	1.4597860, 0	4.4718035,-4	2.0574323,-2	1.6459458,-2	7.4005430, 0
13	1.4614543, 0	1.2137752,-3	4.1648942,-2	3.3319154,-2	7.4128834, 0
14	1.4948209, 0	2.2843646,-3	1.2175613,-2	9.7404905,-3	7.5874127, 0
15	1.5014942, 0	4.3858920,-3	2.7117262,-2	2.1693809,-2	7.6318840, 0
16	1.8287296, 0	6.6358777,-3	6.1233769,-2	4.8987016,-2	9.3017343, 0
17	2.4329514, 0	1.1600829,-2	8.7896726,-2	7.0317381,-2	1.2389126, 1
18	3.3169505, 0	2.0855186,-2	1.8930563,-1	1.5144451,-1	1.6916184, 1
T	3.2163544, 0	1.9901702,-2	1.6457945,-1	1.3166356,-1	1.6401525, 1
T+1	3.2163544, 0	1.9901702,-2	1.6457945,-1	1.3166356,-1	1.6401525, 1

	BEHRENS FACTOR		BEHRENS FACTOR		SOURCE SPECTRUM
N	F/R		F/Z		
0	1.0002137, 0		1.0036695, 0		0.0000000, 0
1	1.0006217, 0		1.0065282, 0		9.7378149,-2
2	1.0017464, 0		1.0117060, 0		3.7532886,-1
3	1.0019462, 0		1.0124713, 0		4.7365445,-1
4	1.0044424, 0		1.0205601, 0		4.2566089,-1
5	1.0090015, 0		1.0325176, 0		3.0059730,-1
6	1.0106157, 0		1.0363776, 0		1.5546837,-1
7	1.0149831, 0		1.0463199, 0		9.8710099,-2
8	1.0200970, 0		1.0574019, 0		3.2979099,-2
9	1.0436866, 0		1.1057892, 0		1.6243999,-4
10	1.0487805, 0		1.1160244, 0		2.2580000,-5
11	1.0500762, 0		1.1185872, 0		3.0299999,-6
12	1.0494512, 0		1.1171026, 0		4.7000000,-7
13	1.0487346, 0		1.1153659, 0		0.0000000, 0
14	1.0514919, 0		1.1213192, 0		0.0000000, 0
15	1.0512819, 0		1.1206838, 0		0.0000000, 0
16	1.0646269, 0		1.1469365, 0		0.0000000, 0
17	1.0899925, 0		1.1973083, 0		0.0000000, 0
18	1.1191373, 0		1.2542488, 0		0.0000000, 0
T	1.1173246, 0		1.2509427, 0		
T+1	1.1173246, 0		1.2509427, 0		

TABLE C4

N	SCATTER	XI-SCATTER	TRANSPORT	ABSORPTION	FISSION
	X-SECTION	X-SECTION	X-SECTION	X-SECTION	X-SECTION
0	6.4918505,-2	5.5914885,-2	3.8388444,-2	7.6640429,-5	1.6606209,-4
1	1.0998209,-1	8.1623728,-2	4.9658949,-2	7.0341823,-5	1.4757034,-4
2	1.8462783,-1	1.2608277,-1	1.0905190,-1	6.6455703,-5	1.3887348,-4
3	1.9574690,-1	1.6538685,-1	7.5930084,-2	6.6810245,-5	1.3850977,-4
4	2.9751821,-1	2.2843235,-1	1.5744647,-1	6.6708388,-5	1.2811017,-4
5	4.3394596,-1	2.9556037,-1	2.3946769,-1	7.1039058,-5	1.2621589,-4
6	4.7629825,-1	3.7153816,-1	2.5810749,-1	7.6227241,-5	1.3463028,-4
7	5.7664562,-1	4.8004201,-1	2.7488608,-1	8.6031437,-5	1.5566627,-4
8	6.9083609,-1	5.2005828,-1	2.9444053,-1	9.1204061,-5	1.6408066,-4
9	1.1413122, 0	1.0450166, 0	4.5109947,-1	1.5953397,-4	2.9029656,-4
10	1.2362651, 0	1.1401042, 0	4.7821025,-1	2.2950804,-4	4.6629881,-4
11	1.2622010, 0	1.1660400, 0	4.8870894,-1	7.6201344,-4	1.0349703,-3
12	1.2621943, 0	1.1660400, 0	4.8870231,-1	3.1911412,-3	3.9337287,-3
13	1.2636224, 0	1.1700739, 0	4.9128329,-1	6.7263567,-3	7.0260182,-3
14	1.2925007, 0	1.1931324, 0	4.9710599,-1	3.6328520,-3	2.3812732,-3
15	1.2982944, 0	1.1931346, 0	5.4900716,-1	7.4848906,-3	7.8674575,-3
16	1.5808582, 0	1.2208021, 0	7.8244435,-1	1.4079282,-2	1.6465088,-2
17	2.1026444, 0	1.2828929, 0	1.2145149, 0	2.2002352,-2	2.5003507,-2
18	2.8660398, 0	1.3561295, 0	2.2496254, 0	4.3820266,-2	5.3319490,-2
T	2.7791965, 0	1.3085834, 0	1.9802119, 0	3.9625817,-2	4.5930508,-2
T+1	2.7791965, 0	1.3085834, 0	1.9802119, 0	3.9625817,-2	4.5930508,-2

N	EXTRAPOLATION		TOTAL		X/R/5		Y/2		Z	
	DISTANCE		BUCKLING		BUCKLING		BUCKLING		BUCKLING	
0	1.8471296,	1	2.4554190,-	-3	1.3555119,-	-3	1.0999070,-	-3	0.0000000,	0
1	1.4287353,	1	2.8707973,-	-3	1.5474133,-	-3	1.3233839,-	-3	0.0000000,	0
2	6.5112782,	0	3.9998911,-	-3	2.0313385,-	-3	1.9685526,-	-3	0.0000000,	0
3	9.3490662,	0	3.5185821,-	-3	1.8313466,-	-3	1.6872355,-	-3	0.0000000,	0
4	4.5107333,	0	4.4040952,-	-3	2.1926886,-	-3	2.2114065,-	-3	0.0000000,	0
5	2.9661172,	0	4.7618268,-	-3	2.3307919,-	-3	2.4310349,-	-3	0.0000000,	0
6	2.7519155,	0	4.8150262,-	-3	2.3509689,-	-3	2.4640572,-	-3	0.0000000,	0
7	2.5838983,	0	4.8574124,-	-3	2.3669796,-	-3	2.4904328,-	-3	0.0000000,	0
8	2.4122979,	0	4.9013114,-	-3	2.3835010,-	-3	2.5178103,-	-3	0.0000000,	0
9	1.5744837,	0	5.1248905,-	-3	2.4667033,-	-3	2.6581872,-	-3	0.0000000,	0
10	1.4826470,	0	5.1503724,-	-3	2.4760875,-	-3	2.6742849,-	-3	0.0000000,	0
11	1.4515672,	0	5.1590414,-	-3	2.4792756,-	-3	2.6797658,-	-3	0.0000000,	0
12	1.4444184,	0	5.1610387,-	-3	2.4800097,-	-3	2.6810289,-	-3	0.0000000,	0
13	1.4266791,	0	5.1659929,-	-3	2.4818329,-	-3	2.6841670,-	-3	0.0000000,	0
14	1.4189032,	0	5.1681771,-	-3	2.4826327,-	-3	2.6855444,-	-3	0.0000000,	0
15	1.2767477,	0	5.2082347,-	-3	2.4973228,-	-3	2.7109118,-	-3	0.0000000,	0
16	8.9200113,-	-1	5.3191431,-	-3	2.5377425,-	-3	2.7814006,-	-3	0.0000000,	0
17	5.7459769,-	-1	5.4134725,-	-3	2.5718307,-	-3	2.8416418,-	-3	0.0000000,	0
18	3.0979586,-	-1	5.4942076,-	-3	2.6007978,-	-3	2.8934097,-	-3	0.0000000,	0
T	3.5176093,-	-1	5.4812866,-	-3	2.5961747,-	-3	2.8851118,-	-3	0.0000000,	0
T+1	3.5176093,-	-1	5.4812866,-	-3	2.5961747,-	-3	2.8851118,-	-3	0.0000000,	0

N	EXPANSION		SMALLNESS		TOTAL		RADIAL		LONGITUDINAL	
	PARAMETER		PARAMETER		LEAKAGE		LEAKAGE		LEAKAGE	
0	5.8125109,-	-1	1.3739492,-	-1	1.7299577,-	-2	9.5354589,-	-3	7.7641185,-	-3
1	2.3702994,-	-1	5.9251250,-	-2	1.7069018,-	-2	9.1755521,-	-3	7.8934666,-	-3
2	1.1725766,-	-1	2.9897929,-	-2	1.1707580,-	-2	5.9167256,-	-3	5.7908548,-	-3
3	9.1765929,-	-2	2.3497511,-	-2	1.4653743,-	-2	7.5887333,-	-3	7.0650102,-	-3
4	4.9731877,-	-2	1.2823795,-	-2	9.2136630,-	-3	4.5505866,-	-3	4.6630764,-	-3
5	2.5279012,-	-2	6.5450760,-	-3	6.6862926,-	-3	3.2342853,-	-3	3.4520073,-	-3
6	2.1155639,-	-2	5.4812542,-	-3	6.3006693,-	-3	3.0367300,-	-3	3.2639393,-	-3
7	1.4803515,-	-2	3.7877978,-	-3	6.0233491,-	-3	2.8893939,-	-3	3.1339552,-	-3
8	1.0267074,-	-2	2.6649616,-	-3	5.7289604,-	-3	2.7346131,-	-3	2.9943473,-	-3
9	3.9332745,-	-3	1.0220179,-	-3	4.0624433,-	-3	1.8967871,-	-3	2.1656581,-	-3
10	3.3682550,-	-3	8.7528663,-	-4	3.8736367,-	-3	1.8022841,-	-3	2.0713525,-	-3
11	3.2343553,-	-3	8.4050981,-	-4	3.8060546,-	-3	1.7691171,-	-3	2.0369374,-	-3
12	3.2232308,-	-3	8.3762044,-	-4	3.7851005,-	-3	1.7599023,-	-3	2.0251981,-	-3
13	3.2010677,-	-3	8.3188999,-	-4	3.7380543,-	-3	1.7384352,-	-3	1.9996191,-	-3
14	3.0763648,-	-3	7.9947404,-	-4	3.7346222,-	-3	1.7341557,-	-3	2.0004664,-	-3
15	3.0545760,-	-3	7.9381454,-	-4	3.3860538,-	-3	1.5696596,-	-3	1.8163942,-	-3
16	2.0910013,-	-3	5.4349108,-	-4	2.4629670,-	-3	1.1294128,-	-3	1.3335541,-	-3
17	1.1992299,-	-3	3.1174921,-	-4	1.6719742,-	-3	7.5528676,-	-4	9.1668753,-	-4
18	6.4887471,-	-4	1.6869559,-	-4	9.5028866,-	-4	4.2294833,-	-4	5.2734033,-	-4
T	6.8983798,-	-4	1.7934407,-	-4	1.0740550,-	-3	4.7859360,-	-4	5.9546146,-	-4
T+1	6.8983798,-	-4	1.7934407,-	-4	1.0740550,-	-3	4.7859360,-	-4	5.9546146,-	-4

N	LETHARGY		SLOWING DOWN		SLOWING DOWN		SLOWING DOWN	
			PARAMETER	W	PARAMETER	W	DENSITY	
0	0.0000000	0	7.6291504	-1	2.3708495	-1	0.0000000	0
1	5.0000000	-1	8.2645985	-1	1.7354014	-1	1.7302944	-2
2	1.0000000	0	9.1459228	-1	8.5407719	-2	1.1790657	-1
3	1.5000000	0	9.1826791	-1	8.1732086	-2	3.0373643	-1
4	2.0000000	0	9.6095971	-1	3.9040282	-2	5.0361105	-1
5	2.5000000	0	9.7764824	-1	2.2351756	-2	6.7067841	-1
6	3.0000000	0	9.8312861	-1	1.6871385	-2	7.7534139	-1
7	3.5000000	0	9.8743317	-1	1.2566827	-2	8.3203585	-1
8	4.0000000	0	9.9023147	-1	9.7685232	-3	8.5985360	-1
9	6.0000000	0	9.9597615	-1	4.0238439	-3	8.8072883	-1
10	8.0000000	0	9.9635303	-1	3.6469697	-3	8.7418112	-1
11	1.0000000	1	9.9602770	-1	3.9022937	-3	8.6763276	-1
12	1.2000000	1	9.9405273	-1	5.9472620	-3	8.5914094	-1
13	1.4000000	1	9.9114590	-1	8.8940972	-3	8.4652815	-1
14	1.5500000	1	9.9386300	-1	6.1369985	-3	8.3704765	-1
15	1.6500000	1	9.9097102	-1	9.0289786	-3	8.3072885	-1
16	1.7500000	1	9.8663084	-1	1.3369150	-2	8.2148724	-1
17	1.8500000	1	9.8188051	-1	1.8119484	-2	8.0866961	-1
T	1.9554883	1	9.6983592	-1	3.0164070	-2	7.8839793	-1
T+1	1.9554883	1	0.0000000	0	0.0000000	0	0.0000000	0

N	FLUX		LEAKAGE		ABSORPTION		FISSION	
			SPECTRUM		SPECTRUM		SPECTRUM	
0	0.0000000	0	0.0000000	0	0.0000000	0	0.0000000	0
1	1.0599212	0	1.8091815	-2	7.4556791	-5	1.5637053	-4
2	3.5778823	0	4.1888345	-2	2.3777068	-4	4.9687296	-4
3	4.3162626	0	6.3249405	-2	2.8837056	-4	5.9784458	-4
4	3.9092225	0	3.6018258	-2	2.6077793	-4	5.0081119	-4
5	3.2127649	0	2.1481486	-2	2.2823179	-4	4.0550200	-4
6	2.4626217	0	1.5516165	-2	1.8789124	-4	3.3154346	-4
7	1.9145187	0	1.1531814	-2	1.6470879	-4	2.9802598	-4
8	1.4983434	0	8.5839504	-3	1.3770384	-4	2.4584919	-4
9	8.3955290	-1	3.4106360	-3	1.3393721	-4	2.4371931	-4
10	7.6397883	-1	2.9593764	-3	2.2881780	-4	3.5677720	-4
11	7.4115378	-1	2.8209859	-3	5.6472200	-4	7.6710322	-4
12	7.3242071	-1	2.7722860	-3	2.3372579	-3	2.8811444	-3
13	7.1706961	-1	2.6804452	-3	4.8232660	-3	5.0381441	-3
14	6.9724923	-1	2.6039624	-3	2.5330032	-3	1.6603409	-3
15	6.8997090	-1	2.3362786	-3	5.1643567	-3	5.4283167	-3
16	6.6391155	-1	1.6351922	-3	9.3473985	-3	1.0931362	-2
17	6.1892688	-1	1.0348298	-3	1.3617847	-2	1.5475342	-2
T	5.8430864	-1	0.2757965	-4	2.3153707	-2	2.6837592	-2
T+1	1.9371017	1	2.0805539	-2	7.6759240	-1	8.8972067	-1

CALCULATED REACTIVITY	9.5722607,-1
POWER LEVEL 17	1.3793347,-2
POWER LEVEL T	2.3314866,-2
POWER LEVEL T+1	9.2947809,-1
BALANCE CHECK DISCREPANCY	-9.9903142,-5

LETHARGY INDEX	19
LETHARGY AT INDEX	1.9554883, 1

TWO-GROUP RESULTS

	FAST	SLOW
DIFFUSION COEFFICIENT, ONE-GROUP BUCKLING	1.3371016, 0	2.1446981,-1
DIFFUSION COEFFICIENT, TWO-GROUP BUCKLING	1.4392141, 0	1.9594944,-1
SIGMA ABSORPTION	2.6344837,-3	3.9625816,-2
NU SIGMA FISSION	2.9766635,-3	4.5930507,-2
FLUX	2.2678213, 1	1.9371017, 1
MULTIPLICATION	1.1298849, 0	1.1591056, 0
SIGMA LEAKAGE	6.6961440,-3	1.0740550,-3
DIFFUSION AREA, ONE-GROUP BUCKLING	3.5752302, 1	5.4123758, 0
DIFFUSION AREA, TWO-GROUP BUCKLING	3.8482653, 1	4.9449943, 0
BUCKLING	4.6526391,-3	5.4812866,-3
EXTRAPOLATION DISTANCE	3.4177564, 0	3.5176093,-1
SLOWING DOWN X-SECTION	3.4764552,-2	
AVERAGE BUCKLING	5.0079543,-3	
AVERAGE EXTRAPOLATION DISTANCE	2.0053298, 0	
ABSORPTION ESCAPE PROBABILITY	9.2955745,-1	
REACTIVITY, ONE-GROUP BUCKLING	9.5722617,-1	
REACTIVITY, TWO-GROUP BUCKLING	9.5722617,-1	

MULTIGROUP CONSTANTS			
N	ENERGY	LETHARGY	SLOWING DOWN DENSITY
1	1.0000000, 2	1.1512829, 1	8.6120242, -1
2	1.0000000, 0	1.6117999, 1	8.3314264, -1
GROUP	MULTIPLICATION	BUCKLING	EXTRAPOLATION DISTANCE
1	1.4903080, 0	4.4873076, -3	4.1342434, 0
2	1.0119063, 0	5.1665576, -3	1.4246868, 0
3	1.1581580, 0	5.4660738, -3	4.0136958, -1
GROUP	SIGMA LEAKAGE	FLUX	SIGMA ABSORPTION
1	7.8314525, -3	1.7164043, 1	2.3608421, -4
2	3.7389625, -3	3.2970730, 0	4.7857857, -3
3	1.2004336, -3	2.1588114, 1	3.7405144, -2
GROUP	SOURCE TERM	NU SIGMA FISSION	SLOWING DOWN X-SECTION
1	9.9999911, -1	3.5183821, -4	5.0175204, -2
2	8.5086441, -7	4.8427669, -3	2.5269159, -1
3	0.0000000, 0	4.3321067, -2	0.0000000, 0
GROUP	ABSORPTION ESCAPE PROBABILITY	DIFFUSION COEFFICIENT ONE-GROUP BUCKLING	DIFFUSION COEFFICIENT MULTIGROUP BUCKLING
1	9.9531684, -1	1.5638024, 0	1.7452452, 0
2	9.8141279, -1	7.4660463, -1	7.2368543, -1
3	0.0000000, 0	2.3970535, -1	2.1961534, -1
GROUP	DIFFUSION AREA ONE-GROUP BUCKLING	DIFFUSION AREA MULTIGROUP BUCKLING	
1	3.1020877, 1	3.4620127, 1	
2	2.8996902, 0	2.8106757, 0	
3	6.4083524, 0	5.8712602, 0	
REACTIVITY, ONE-GROUP BUCKLING		9.5717437, -1	
REACTIVITY, MULTIGROUP BUCKLING		9.5717437, -1	

PHOTON PRODUCTION PARAMETERS

ASSUMES NU = 2.46

P	ENERGY	LETHARGY	GROUP FLUX
1	1.0000000, 6	2.3024893, 0	6.5731112, 0
2	1.0000000, 3	9.2102446, 0	8.8857538, 0
3	5.0000000, -1	1.6811146, 1	5.4797729, 0
4	9.9999999, -5	1.9554883, 1	1.7395760, 0
5			1.9371017, 1

ELEMENT -1.130 *ORALLOY

GROUP	ABSORPTION CROSS SECTION	FISSION CROSS SECTION
1	6.5087398, -5	5.5258147, -5
2	1.3213662, -4	1.0217938, -4
3	2.8504764, -3	1.6789725, -3
4	1.1656808, -2	9.7550650, -3
5	2.2299714, -2	1.8670938, -2

ELEMENT 2.510 *WATER

GROUP	ABSORPTION CROSS SECTION	FISSION CROSS SECTION
1	2.0533139, -6	
2	1.9441016, -5	
3	1.0869996, -3	
4	9.1456653, -3	
5	1.7188476, -2	

ELEMENT 5.110 *ALUMINUM

GROUP	ABSORPTION CROSS SECTION	FISSION CROSS SECTION
1	1.8975153, -8	
2	1.7965897, -7	
3	1.0036600, -5	
4	7.8468417, -5	
5	1.3762739, -4	

FINE RADIAL POWER

ZONE	3	CODE	0.0000000, 0	LATTICE	RADIUS	POWER
				32	3.2500000, 0	0.0000000, 0
				31	3.1250000, 0	0.0000000, 0
				30	3.0000000, 0	0.0000000, 0
				29	2.8750000, 0	0.0000000, 0
				28	2.7500000, 0	0.0000000, 0
				27	2.6250000, 0	0.0000000, 0
				26	2.5000000, 0	0.0000000, 0
				25	2.3750000, 0	0.0000000, 0
				24	2.2500000, 0	0.0000000, 0
				23	2.1250000, 0	0.0000000, 0
				22	2.0000000, 0	0.0000000, 0
ZONE	2	CODE	1.0000000, 0	LATTICE	RADIUS	POWER
				21	2.0000000, 0	9.9840271, -1
				20	1.9600000, 0	9.9641344, -1
				19	1.9200000, 0	9.9667815, -1
				18	1.8800000, 0	9.9720256, -1
				17	1.8400000, 0	9.9792299, -1
				16	1.8000000, 0	9.9865616, -1
				15	1.7600000, 0	1.0003994, 0
				14	1.7200000, 0	1.0020306, 0
				13	1.6800000, 0	1.0039584, 0
				12	1.6400000, 0	1.0061921, 0
				11	1.5999999, 0	1.0087416, 0
ZONE	1	CODE	0.0000000, 0	LATTICE	RADIUS	POWER
				10	1.5999999, 0	0.0000000, 0
				9	1.4999999, 0	0.0000000, 0
				8	1.2800000, 0	0.0000000, 0
				7	1.1200000, 0	0.0000000, 0
				6	0.6000000, -1	0.0000000, 0
				5	0.0000001, -1	0.0000000, 0
				4	0.4000001, -1	0.0000000, 0
				3	0.8000001, -1	0.0000000, 0
				2	0.2000002, -1	0.0000000, 0
				1	1.6000002, -1	0.0000000, 0

 CORE OR END COMPOSITION

 COMPOSITION INPUT

CASE NUMBER	END	
C2-INPUT UNITS	C.G.S.	
C3-THERMAL BASE	SET T=T+1	
C4-SLOWING DOWN MODEL	MODIFIED AGE	
C5-GROUP DIVISION	NET	
C8-G FACTOR APPLICATION	ALL SIGMAS	
C17-PHOTON PRODUCTION CALCULATION		NO
C19-PRINT OUT		LONG
C21-ADJOINT CALCULATION		NO
C22-MULTI GROUP CALCULATION		NO
C31-CLEAR INPUT AFTER CALCULATION		YES
C32-RERUN THIS COMPOSITION IN REACTIVITY MATCH		YES

 BEHRENS INPUT

C6-BEHRENS CALCULATION	CALCULATE F/R, F/2
C10-G FACTORS IN BEHRENS CORRECTION	NO
C11-MODERATOR X-SECTION IN BEHRENS CORRECTION	SIGMA TOTAL

D1	D2	D3	M
FUEL ZONE I.D.	FUEL ZONE O.D.	CELL DIAMETER	NUMBER OF CELLS
3.1999999, 0	4.0000000, 0	6.5000000, 0	0.0000000, 0

 I2 INPUT

C7-I2 CALCULATION	NO, G FACTORS SET=1
C9-LEAKAGE TERM ADDED TO SIGMA A	NO
C12-I2 AT THERMAL	NO, G FACTORS SET=1
C13-I2 AT LEVEL 16	NO, G FACTORS SET=1
C14-I2 AT LEVEL 17	NO, G FACTORS SET=1
C20-FINE RADIAL POWER CALCULATION	NO
C30-G RECIPE	G CELL=1

TERRALL INPUT

C18-TERRALL METHOD NO

ESTAR E*

TPF

SLOWING DOWN CUT-OFF (EV)

FUEL TEMPERATURE DEGREES F

0.000000, 0

0.000000, 0

BUCKLING GEOMETRY

C16-GEOMETRY CYLINDER

SAVINGS ON H S/2

3.8929443, 0

HEIGHT

H

5.0000000, 1

SAVINGS ON D S/2

1.1842681, 1

DIAMETER

D

7.0000000, 1

VOLUME GEOMETRY

DCO

DCI

L

VOC

OUTER DIAMETER

INNER DIAMETER

LENGTH

COMPOSITION VOLUME

0.0000000, 0

0.0000000, 0

0.0000000, 0

0.0000000, 0

CSP

TPM

CODE NUMBER OF SPECTRUM

MODERATOR TEMPERATURE DEGREES F

0.9420

6.8000000, 1

TABLE M1 MODERATOR

ELEMENT	CODE	WEIGHT	F/H OR N/H	G/T+1	G/16	G/17
*WATER	2.510	0.000000	0.8244792	-1	1.000000	1.000000

TABLE F1 FUEL

ELEMENT	CODE	WEIGHT	F/H OR N/H	G/T+1	G/16	G/17
NITROGEN	6.300	0.000000	0.1000000	-5	1.000000	1.000000

HYDRAULIC DIAMETER			FUEL	8.0000001, -1	Moderator	5.0680555, 0
BEHRENS CROSS SECTIONS			ATTENUATION FACTORS			
N	SIGMA/S, MOD	SIGMA/A, MOD	SIGMA/R, FUEL	X-FUEL	Y-MOD	
0	7.5002511, -2	1.1321308, -6	6.9363346, -9	5.5490678, -9	3.8012262, -1	
1	1.2818611, -1	1.4517383, -6	8.8945045, -9	7.1156037, -9	6.4966168, -1	
2	2.1614360, -1	1.8636269, -6	1.1418061, -8	9.1344496, -9	1.0954372, 0	
3	2.2841674, -1	2.3858025, -6	1.4617325, -8	1.1693860, -8	1.1576408, 0	
4	3.4978445, -1	3.0835373, -6	1.8892203, -8	1.5113763, -8	1.7727426, 0	
5	5.1035800, -1	3.9388250, -6	2.4132377, -8	1.9305902, -8	2.5865426, 0	
6	5.5910964, -1	5.0642036, -6	3.1027342, -8	2.4821873, -8	2.8336243, 0	
7	6.8013641, -1	6.5046882, -6	3.9852897, -8	3.1882318, -8	3.4470020, 0	
8	8.0968622, -1	8.3503092, -6	5.1160639, -8	4.0928512, -8	4.1035769, 0	
9	1.3483406, 0	2.2732647, -5	1.3927829, -7	1.1142263, -7	6.8335803, 0	
10	1.4608443, 0	6.1670747, -5	3.7784408, -7	3.0227526, -7	7.4039529, 0	
11	1.4915272, 0	1.6790648, -4	1.0287287, -6	8.2298302, -7	7.5592938, 0	
12	1.4915272, 0	4.5690371, -4	2.7993557, -6	2.2394846, -6	7.5614585, 0	
13	1.4932318, 0	1.2401671, -3	7.5982513, -6	6.0786011, -6	7.5740670, 0	
14	1.5273239, 0	2.3340352, -3	1.4300157, -5	1.1440125, -5	7.7523912, 0	
15	1.5341423, 0	4.4812575, -3	2.7455750, -5	2.1964600, -5	7.7978296, 0	
16	1.8614260, 0	6.7545223, -3	4.1383579, -5	3.3106864, -5	9.4680426, 0	
17	2.4682644, 0	1.1769209, -2	7.2107542, -5	5.7686034, -5	1.2568948, 1	
18	3.3273842, 0	2.0920788, -2	1.2817740, -4	1.0254192, -4	1.6969395, 1	
T	3.2264717, 0	1.9964305, -2	1.2229760, -4	9.7838086, -5	1.6453117, 1	
T+1	3.2264717, 0	1.9964305, -2	1.2229760, -4	9.7838086, -5	1.6453117, 1	

N	BEHRENS FACTOR	BEHRENS FACTOR	SOURCE SPECTRUM
	F/R	F/Z	
0	1.0002232, 0	1.0037557, 0	0.0000000, 0
1	1.0006491, 0	1.0066865, 0	8.7378149, -2
2	1.0018224, 0	1.0120024, 0	3.7532886, -1
3	1.0020307, 0	1.0127888, 0	4.7365445, -1
4	1.0046301, 0	1.0211044, 0	4.2566089, -1
5	1.0093644, 0	1.0334014, 0	3.0059730, -1
6	1.0110371, 0	1.0373703, 0	1.5546837, -1
7	1.0155541, 0	1.0475875, 0	9.8710099, -2
8	1.0208294, 0	1.0589644, 0	3.2979099, -2
9	1.0450559, 0	1.1085612, 0	1.6243999, -4
10	1.0503033, 0	1.1191091, 0	2.2580000, -5
11	1.0517428, 0	1.1219987, 0	3.0299999, -6
12	1.0517563, 0	1.1220256, 0	4.7000000, -7
13	1.0518724, 0	1.1222587, 0	0.0000000, 0
14	1.0535189, 0	1.1255620, 0	0.0000000, 0
15	1.0539382, 0	1.1264028, 0	0.0000000, 0
16	1.0694127, 0	1.1573974, 0	0.0000000, 0
17	1.0982136, 0	1.2150116, 0	0.0000000, 0
18	1.1390981, 0	1.2967806, 0	0.0000000, 0
T	1.1343014, 0	1.2871872, 0	
T+1	1.1343014, 0	1.2871872, 0	

TABLE C4

	SCATTER	XI-SCATTER	TRANSPORT	ABSORPTION	EMISSION
N	X-SECTION	X-SECTION	X-SECTION	X-SECTION	X-SECTION
0	6.4795617,-2	5.7012441,-2	3.8000484,-2	9.7873155,-7	0.0000000, 0
1	1.1072932,-1	8.3270906,-2	4.9484403,-2	1.2550335,-6	0.0000000, 0
2	1.8669445,-1	1.2867377,-1	1.1013857,-1	1.6111127,-6	0.0000000, 0
3	1.9729287,-1	1.6877662,-1	7.6276277,-2	2.0625356,-6	0.0000000, 0
4	3.0211985,-1	2.3326025,-1	1.5931425,-1	2.6657300,-6	0.0000000, 0
5	4.4079370,-1	3.0180526,-1	2.4263335,-1	3.4051296,-6	0.0000000, 0
6	4.8291126,-1	3.7936317,-1	2.6090115,-1	4.3780238,-6	0.0000000, 0
7	5.8744449,-1	4.9036868,-1	2.7916181,-1	5.6233284,-6	0.0000000, 0
8	6.9934009,-1	6.0243446,-1	2.9447995,-1	7.2188749,-6	0.0000000, 0
9	1.1645730, 0	1.0676553, 0	4.5938100,-1	1.9652462,-5	0.0000000, 0
10	1.2617434, 0	1.1648219, 0	4.8794619,-1	5.3314602,-5	0.0000000, 0
11	1.2882777, 0	1.1913264, 0	4.9798998,-1	1.4515581,-4	0.0000000, 0
12	1.2882849, 0	1.1913274, 0	4.9799683,-1	3.9499504,-4	0.0000000, 0
13	1.2897570, 0	1.1954496, 0	5.0064672,-1	1.0721293,-3	0.0000000, 0
14	1.3192021, 0	1.2190051, 0	5.0653642,-1	2.0177825,-3	0.0000000, 0
15	1.3250910, 0	1.2190051, 0	5.5953615,-1	3.8740647,-3	0.0000000, 0
16	1.6077560, 0	1.2425605, 0	7.9509031,-1	5.8393109,-3	0.0000000, 0
17	2.1318648, 0	1.3014492, 0	1.2308663, 0	1.0174527,-2	0.0000000, 0
18	2.8738663, 0	1.3603386, 0	2.2555321, 0	1.8086103,-2	0.0000000, 0
T	2.7867117, 0	1.3126390, 0	1.9852344, 0	1.7259217,-2	0.0000000, 0
T+1	2.7867117, 0	1.3126390, 0	1.9852344, 0	1.7259217,-2	0.0000000, 0

EXTRAPOLATION		TOTAL	X/R'S	V/2	Z
N	DISTANCE	BUCKLING	BUCKLING	BUCKLING	BUCKLING
0	1.8696648, 1	2.4357213, -3	1.3462063, -3	1.0895149, -3	0.0000000, 0
1	1.4357695, 1	2.8629412, -3	1.5438583, -3	1.3190829, -3	0.0000000, 0
2	6.4508696, 0	4.0112338, -3	2.0359462, -3	1.9752875, -3	0.0000000, 0
3	9.3145707, 0	3.5238807, -3	1.8335972, -3	1.6902835, -3	0.0000000, 0
4	4.4596642, 0	4.4152402, -3	2.1970563, -3	2.2181839, -3	0.0000000, 0
5	2.9282495, 0	4.7711653, -3	2.3343403, -3	2.4368249, -3	0.0000000, 0
6	2.7232078, 0	4.8222271, -3	2.3536930, -3	2.4685341, -3	0.0000000, 0
7	2.5450676, 0	4.8672218, -3	2.3707031, -3	2.4965887, -3	0.0000000, 0
8	2.4126687, 0	4.9012158, -3	2.3834651, -3	2.5177507, -3	0.0000000, 0
9	1.5465802, 0	5.1326119, -3	2.4625490, -3	2.6630629, -3	0.0000000, 0
10	1.4559440, 0	5.1578192, -3	2.4788262, -3	2.6789930, -3	0.0000000, 0
11	1.4263197, 0	5.1661006, -3	2.4818698, -3	2.6842307, -3	0.0000000, 0
12	1.4255851, 0	5.1663062, -3	2.4819454, -3	2.6843608, -3	0.0000000, 0
13	1.4161317, 0	5.1689534, -3	2.4829179, -3	2.6860355, -3	0.0000000, 0
14	1.3970978, 0	5.1742900, -3	2.4848776, -3	2.6894123, -3	0.0000000, 0
15	1.2610704, 0	5.2126824, -3	2.4989509, -3	2.7137314, -3	0.0000000, 0
16	8.8709415, -1	5.3205816, -3	2.5382643, -3	2.7823172, -3	0.0000000, 0
17	5.7250330, -1	5.4141037, -3	2.5720579, -3	2.8420458, -3	0.0000000, 0
18	3.1249749, -1	5.4933744, -3	2.6004998, -3	2.8928745, -3	0.0000000, 0
T	3.5480761, -1	5.4803504, -3	2.5958395, -3	2.8845108, -3	0.0000000, 0
T+1	3.5480761, -1	5.4803504, -3	2.5958395, -3	2.8845108, -3	0.0000000, 0

EXPANSION		SMALLNESS	TOTAL	RADIAL	LONGITUDINAL
N	PARAMETER	PARAMETER	LEAKAGE	LEAKAGE	LEAKAGE
0	5.8012720, -1	1.3715392, -1	1.7346898, -2	9.5723889, -3	7.7745092, -3
1	2.3349483, -1	5.8401572, -2	1.7114299, -2	9.2034051, -3	7.9108948, -3
2	1.1508206, -1	2.9353812, -2	1.1643422, -2	5.8803237, -3	5.7630987, -3
3	9.0529331, -2	2.3185639, -2	1.4632448, -2	7.5747609, -3	7.0576875, -3
4	4.8371342, -2	1.2475801, -2	9.1408269, -3	4.5113767, -3	4.6294502, -3
5	2.4555398, -2	6.3584911, -3	6.6199849, -3	3.1999733, -3	3.4200116, -3
6	2.0677777, -2	5.3578719, -3	6.2499530, -3	3.0104175, -3	3.2395355, -3
7	1.4104101, -2	3.6585673, -3	5.9517424, -3	2.8527490, -3	3.0989933, -3
8	1.0021160, -2	2.6012382, -3	5.7365402, -3	2.7371574, -3	2.9993828, -3
9	3.7843416, -3	9.8334392, -4	4.0046575, -3	1.8679406, -3	2.1367169, -3
10	3.2395693, -3	8.4186403, -4	3.8179262, -3	1.7744994, -3	2.0434267, -3
11	3.1120461, -3	8.0874193, -4	3.7541732, -3	1.7430612, -3	2.0111120, -3
12	3.1109286, -3	8.0845167, -4	3.7524660, -3	1.7422412, -3	2.0102247, -3
13	3.1021664, -3	8.0617579, -4	3.7301732, -3	1.7315854, -3	1.9985878, -3
14	2.9641524, -3	7.7032718, -4	3.6926195, -3	1.7124606, -3	1.9801589, -3
15	2.9514407, -3	7.6702528, -4	3.3606170, -3	1.5553992, -3	1.8052177, -3
16	2.0434773, -3	5.3114292, -4	2.4672810, -3	1.1285014, -3	1.3387796, -3
17	1.1799719, -3	3.0674394, -4	1.6852697, -3	7.5828134, -4	9.2698843, -4
18	6.5683593, -4	1.7076514, -4	9.8406878, -4	4.3419504, -4	5.4987374, -4
T	6.9704577, -4	1.8121773, -4	1.1078988, -3	4.9000864, -4	6.1789022, -4
T+1	6.9704577, -4	1.8121773, -4	1.1078988, -3	4.9000864, -4	6.1789022, -4

N	LETHARGY	SLOWING DOWN PARAMETER V	SLOWING DOWN PARAMETER W	SLOWING DOWN DENSITY
0	0.0000000, 0	7.6670518, -1	2.3329481, -1	0.0000000, 0
1	5.0000000, -1	8.2950334, -1	1.7042665, -1	1.7379336, -2
2	1.0000000, 0	9.1701018, -1	8.2989819, -2	1.1834834, -1
3	1.5000000, 0	9.2020925, -1	7.9790748, -2	3.0482289, -1
4	2.0000000, 0	9.6227990, -1	3.7720099, -2	5.0534341, -1
5	2.5000000, 0	9.7852537, -1	2.1474622, -2	6.7299217, -1
6	3.0000000, 0	9.8378099, -1	1.6219004, -2	7.7790760, -1
7	3.5000000, 0	9.8799706, -1	1.2002930, -2	8.3486619, -1
8	4.0000000, 0	9.9055579, -1	9.4442069, -3	8.6287193, -1
9	6.0000000, 0	9.9624486, -1	3.7551373, -3	8.8423182, -1
10	8.0000000, 0	9.9668755, -1	3.3124461, -3	8.7818679, -1
11	1.0000000, 1	9.9673758, -1	3.2624155, -3	8.7245703, -1
12	1.2000000, 1	9.9653070, -1	3.4692957, -3	8.6660767, -1
13	1.4000000, 1	9.9599891, -1	4.0010809, -3	8.6016003, -1
14	1.5500000, 1	9.9533736, -1	4.6626329, -3	8.5459037, -1
15	1.6500000, 1	9.9410010, -1	5.8998912, -3	8.5009023, -1
16	1.7500000, 1	9.9335934, -1	6.6406577, -3	8.4477767, -1
17	1.8500000, 1	9.9096953, -1	9.0304687, -3	8.3818811, -1
T	1.9554883, 1	9.8620057, -1	1.3799421, -2	8.2816805, -1
T+1	1.9554883, 1	0.0000000, 0	0.0000000, 0	0.0000000, 0

N	FLUX	LEAKAGE SPECTRUM	ABSORPTION SPECTRUM	FISSION SPECTRUM
0	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0
1	1.0435419, 0	1.7859490, -2	1.3096801, -6	0.0000000, 0
2	3.5182539, 0	4.0964516, -2	5.6683037, -6	0.0000000, 0
3	4.2444383, 0	6.2106525, -2	8.7543054, -6	0.0000000, 0
4	3.8407174, 0	3.5107334, -2	1.0238316, -5	0.0000000, 0
5	3.1563197, 0	2.0894789, -2	1.0747678, -5	0.0000000, 0
6	2.4204709, 0	1.5127829, -2	1.0596879, -5	0.0000000, 0
7	1.8809737, 0	1.1195071, -2	1.0577333, -5	0.0000000, 0
8	1.4730073, 0	8.4499662, -3	1.0633456, -5	0.0000000, 0
9	8.2524129, -1	3.3048087, -3	1.6218023, -5	0.0000000, 0
10	7.5144563, -1	2.8689639, -3	4.0063025, -5	0.0000000, 0
11	7.2995419, -1	2.7403744, -3	1.0595709, -4	0.0000000, 0
12	7.2490702, -1	2.7201889, -3	2.8633468, -4	0.0000000, 0
13	7.1664957, -1	2.6732270, -3	7.6834107, -4	0.0000000, 0
14	6.9778683, -1	2.5766613, -3	1.4079821, -3	0.0000000, 0
15	6.9324965, -1	2.3297466, -3	2.6856940, -3	0.0000000, 0
16	6.7535363, -1	1.8662871, -3	3.9435998, -3	0.0000000, 0
17	6.3622610, -1	1.0755831, -3	6.4936489, -3	0.0000000, 0
T	6.2221204, -1	6.8934800, -4	1.0738892, -2	0.0000000, 0
T+1	4.5089716, 1	4.9954845, -2	7.7821321, -1	0.0000000, 0

CALCULATED REACTIVITY	0.0000000, 0	
POWER LEVEL 17	0.0000000, 0	
POWER LEVEL T	0.0000000, 0	
POWER LEVEL T+1	0.0000000, 0	
BALANCE CHECK DISCREPANCY	-9.9873339, -5	
LETHARGY INDEX	19	
LETHARGY AT INDEX	1.9554883, 1	
TWO-GROUP RESULTS		
	FAST	SLOW
DIFFUSION COEFFICIENT, ONE-GROUP BUCKLING	1.2793347, 0	2.1367477, -1
DIFFUSION COEFFICIENT, TWO-GROUP BUCKLING	1.4227759, 0	2.0215839, -1
SIGMA ABSORPTION	1.0255677, -3	1.7259216, -2
NU SIGMA FISSION	0.0000000, 0	0.0000000, 0
FLUX	2.2435606, 1	4.5082716, 1
MULTIPLICATION	0.0000000, 0	0.0000000, 0
SIGMA LEAKAGE	6.6333218, -3	1.1078988, -3
DIFFUSION AREA, ONE-GROUP BUCKLING	3.3721120, 1	1.2380328, 1
DIFFUSION AREA, TWO-GROUP BUCKLING	3.7501989, 1	1.1713068, 1
BUCKLING	4.6622391, -3	5.4803504, -3
EXTRAPOLATION DISTANCE	3.3773822, 0	3.5480761, -1
SLOWING DOWN X-SECTION	3.6913111, -2	
AVERAGE BUCKLING	5.1849773, -3	
AVERAGE EXTRAPOLATION DISTANCE	1.3590722, 0	
ABSORPTION ESCAPE PROBABILITY	9.7296775, -1	
REACTIVITY, ONE-GROUP BUCKLING	0.0000000, 0	
REACTIVITY, TWO-GROUP BUCKLING	0.0000000, 0	

SIDE COMPOSITION

CASE NUMBER	SIDE
C2-INPUT	C.G.S.
C3-THERMAL BASE	SET T=T+1
C4-SLOWING DOWN MODEL	MODIFIED AGE
C5-GROUP DIVISION	N=T
C7-G FACTORS	SET G-FACTORS=1
C16-GEOMETRY	CYLINDER
C17-PHOTON PRODUCTION	NO
C19-OUTPUT	LONG
C21-ADJOINT CALCULATION	NO
C22-MULTIGROUP CALCULATION	YES
C31-CLEAR THIS INPUT	YES
C32-RERUN THIS COMPOSITION IN MATCH	YES

CASE NUMBER OF REFERENCE

CORE OR END

COMPOSITION FOR BUCKLING

CORE 2

VOLUME GEOMETRY

DCO	DCI	L	VOC
OUTER DIAMETER	INNER DIAMETER	LENGTH	COMPOSITION VOLUME
0.000000, 0	0.000000, 0	0.000000, 0	0.000000, 0

CSP

CODE NUMBER OF SPECTRUM -

0.942

TPM

SIDE TEMPERATURE DEGREES F

6.800000, 1

TABLE M1 MODERATOR

ELEMENT	CODE	WEIGHT	F/H OR N/H	G/T+1	G/16	G/17
*WATER	2.510	0.000000, 0	1.0000000, 0	1.000000	1.000000	1.000000

TABLE F1 FUEL

ELEMENT	CODE	WEIGHT	F/H OR N/H	G/T+1	G/16	G/17
---------	------	--------	------------	-------	------	------

N	BEHRENS FACTOR	BEHRENS FACTOR	SOURCE SPECTRUM
	F/R	F/Z	
0	1.0000000, 0	1.0000000, 0	0.0000000, 0
1	1.0000000, 0	1.0000000, 0	8.7378149, -2
2	1.0000000, 0	1.0000000, 0	3.7532886, -1
3	1.0000000, 0	1.0000000, 0	4.7365445, -1
4	1.0000000, 0	1.0000000, 0	4.2366089, -1
5	1.0000000, 0	1.0000000, 0	3.0059730, -1
6	1.0000000, 0	1.0000000, 0	1.5546837, -1
7	1.0000000, 0	1.0000000, 0	9.8710092, -2
8	1.0000000, 0	1.0000000, 0	3.2979099, -2
9	1.0000000, 0	1.0000000, 0	1.6243992, -4
10	1.0000000, 0	1.0000000, 0	2.2580000, -5
11	1.0000000, 0	1.0000000, 0	3.0292992, -6
12	1.0000000, 0	1.0000000, 0	4.7000000, -7
13	1.0000000, 0	1.0000000, 0	0.0000000, 0
14	1.0000000, 0	1.0000000, 0	0.0000000, 0
15	1.0000000, 0	1.0000000, 0	0.0000000, 0
16	1.0000000, 0	1.0000000, 0	0.0000000, 0
17	1.0000000, 0	1.0000000, 0	0.0000000, 0
18	1.0000000, 0	1.0000000, 0	0.0000000, 0
T	1.0000000, 0	1.0000000, 0	
T+1	1.0000000, 0	1.0000000, 0	

TABLE C4

N	SCATTER	XI-SCATTER	TRANSPORT	ABSORPTION	FISSION
	X-SECTION	X-SECTION	X-SECTION	X-SECTION	X-SECTION
0	7.3406386, -2	6.4604293, -2	4.3042835, -2	1.1080380, -6	0.0000000, 0
1	1.2545818, -1	9.4360573, -2	5.6055786, -2	1.4208439, -6	0.0000000, 0
2	2.1154385, -1	1.4581177, -1	1.2479085, -1	1.8239671, -6	0.0000000, 0
3	2.2355581, -1	1.9125700, -1	8.6419336, -2	2.3350303, -6	0.0000000, 0
4	3.4234089, -1	2.6432972, -1	1.8051297, -1	3.0179166, -6	0.0000000, 0
5	4.9949709, -1	3.4200702, -1	2.7494028, -1	3.8550030, -6	0.0000000, 0
6	5.4721124, -1	4.2989449, -1	2.9562753, -1	4.9564324, -6	0.0000000, 0
7	6.6566246, -1	5.5568633, -1	3.1631479, -1	6.3662621, -6	0.0000000, 0
8	7.9245530, -1	6.8267938, -1	3.3366539, -1	8.1726064, -6	0.0000000, 0
9	1.3196466, 0	1.2098707, 0	5.2051801, -1	2.2248874, -5	0.0000000, 0
10	1.4297562, 0	1.3199802, 0	5.5288355, -1	6.0358334, -5	0.0000000, 0
11	1.4597861, 0	1.3500101, 0	5.6422817, -1	1.6433327, -4	0.0000000, 0
12	1.4597861, 0	1.3500101, 0	5.6422817, -1	4.4718035, -4	0.0000000, 0
13	1.4614544, 0	1.3546815, 0	5.6723117, -1	1.2137752, -3	0.0000000, 0
14	1.4948209, 0	1.3813747, 0	5.7390447, -1	2.2843646, -3	0.0000000, 0
15	1.5014942, 0	1.3813747, 0	6.3396424, -1	4.3858920, -3	0.0000000, 0
16	1.8218130, 0	1.4080679, 0	9.0089656, -1	6.6107795, -3	0.0000000, 0
17	2.4157374, 0	1.4748010, 0	1.3947213, 0	1.1518749, -2	0.0000000, 0
18	3.2565742, 0	1.5415341, 0	2.5558768, 0	2.0475573, -2	0.0000000, 0
T	3.1578092, 0	1.4874803, 0	2.2495720, 0	1.9539445, -2	0.0000000, 0
T+1	3.1578092, 0	1.4874803, 0	2.2495720, 0	1.9539445, -2	0.0000000, 0

N	EXTRAPOLATION DISTANCE	LONGITUDINAL BUCKLING	LEAKAGE
0	1.8173286, 1	1.1138797, -3	8.6259120, -3
1	1.4041225, 1	1.3386005, -3	7.9597292, -3
2	6.3849341, 0	1.9826782, -3	5.2959255, -3
3	9.1756789, 0	1.7026399, -3	6.5671797, -3
4	4.4217787, 0	2.2232318, -3	4.1053274, -3
5	2.9069289, 0	2.44009, -3	2.9582894, -3
6	2.6980068, 0	2.4724740, -3	2.7877789, -3
7	2.5314592, 0	2.4987515, -3	2.6331377, -3
8	2.3689308, 0	2.5248007, -3	2.5222263, -3
9	1.5418741, 0	2.6638865, -3	1.7058473, -3
10	1.4518737, 0	2.6797117, -3	1.6154210, -3
11	1.4215919, 0	2.6850680, -3	1.5858160, -3
12	1.4155655, 0	2.6861359, -3	1.5856520, -3
13	1.4094141, 0	2.6890011, -3	1.5768170, -3
14	1.3900506, 0	2.6906642, -3	1.5565870, -3
15	1.2513904, 0	2.7154746, -3	1.4179650, -3
16	8.7479566, -1	2.7846167, -3	1.0228078, -3
17	5.6341402, -1	2.8438000, -3	6.7409068, -4
18	5.6341402, -1	2.8945732, -3	3.7450533, -4
T	3.4509362, -1	2.8864278, -3	4.2401734, -4
T+1	3.4509362, -1	2.8864278, -3	4.2401734, -4

N	LETHARGY	SLOWING DOWN PARAMETER, W	SLOWING DOWN PARAMETER, W	SLOWING DOWN DENSITY
0	0.0000000, 0	8.8219492, -1	1.1780507, -1	0.0000000, 0
1	5.0000000, -1	2.2219492, -1	7.7805079, -2	1.2760553, -2
2	1.0000000, 0	9.6494100, -1	3.5058997, -2	1.2893358, -1
3	1.5000000, 0	2.6679153, -1	3.3208467, -2	3.3008692, -1
4	2.0000000, 0	9.8469537, -1	1.5304629, -2	5.4453089, -1
5	2.5000000, 0	9.2141331, -1	8.5866898, -3	7.2019203, -1
6	3.0000000, 0	9.9354559, -1	6.4544007, -3	8.3042631, -1
7	3.5000000, 0	2.2527246, -1	4.7275349, -3	8.9121012, -1
8	4.0000000, 0	9.9630711, -1	3.6928802, -3	9.2208071, -1
9	6.0000000, 0	2.2857370, -1	1.4262244, -3	9.5033962, -1
10	8.0000000, 0	9.9873206, -1	1.2679323, -3	9.4796694, -1
11	1.0000000, 1	2.2870528, -1	1.2947171, -3	9.4556631, -1
12	1.2000000, 1	9.9849647, -1	1.5035271, -3	9.4292783, -1
13	1.4000000, 1	2.2794427, -1	2.0557269, -3	9.3957906, -1
14	1.5500000, 1	9.9722718, -1	2.7728155, -3	9.3618352, -1
15	1.6500000, 1	9.9581606, -1	4.1839331, -3	9.3293392, -1
16	1.7500000, 1	9.9460791, -1	5.3920894, -3	9.2847903, -1
17	1.8500000, 1	9.9180034, -1	8.1996545, -3	9.2219498, -1
T	1.9554883, 1	9.8675674, -1	1.3243257, -2	9.1183740, -1
T+1	1.9554883, 1	0.0000000, 0	0.0000000, 0	0.0000000, 0

N	FLUX	LEAKAGE SPECTRUM	ABSORPTION SPECTRUM	FISSION SPECTRUM
0	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0
1	1.0470768, 0	8.3344478, -3	1.4877327, -6	0.0000000, 0
2	3.3370659, 0	1.7672853, -2	6.0866987, -6	0.0000000, 0
3	4.0628526, 0	2.6681529, -2	2.4869006, -6	0.0000000, 0
4	3.6142109, 0	1.4837519, -2	1.0907387, -5	0.0000000, 0
5	2.9590740, 0	8.7537376, -3	1.1407239, -5	0.0000000, 0
6	2.2785388, 0	6.3520626, -3	1.1293424, -5	0.0000000, 0
7	1.7730152, 0	4.6685932, -3	1.1287479, -5	0.0000000, 0
8	1.3938210, 0	3.5155320, -3	1.1391150, -5	0.0000000, 0
9	7.6450231, -1	1.3382411, -3	1.7454293, -5	0.0000000, 0
10	7.1727396, -1	1.1586995, -3	4.3293462, -5	0.0000000, 0
11	6.9950961, -1	1.1092935, -3	1.1495270, -4	0.0000000, 0
12	6.9740999, -1	1.1058496, -3	3.1186805, -4	0.0000000, 0
13	6.9215349, -1	1.0913994, -3	8.4011877, -4	0.0000000, 0
14	6.7583955, -1	1.0520031, -3	1.5438639, -3	0.0000000, 0
15	6.7254061, -1	9.5363909, -4	2.9496905, -3	0.0000000, 0
16	6.5584377, -1	6.7080213, -4	4.3356385, -3	0.0000000, 0
17	6.2017402, -1	4.1805352, -4	7.1436288, -3	0.0000000, 0
T	6.0488981, -1	2.5648377, -4	1.1819211, -2	0.0000000, 0
T+1	4.5675312, 1	1.9367124, -2	8.9247027, -1	0.0000000, 0

CALCULATED REACTIVITY	0.0000000, 0
POWER LEVEL 17	0.0000000, 0
POWER LEVEL T	0.0000000, 0
POWER LEVEL T+1	0.0000000, 0
BALANCE CHECK DISCREPANCY	-9.9903142, -5
LETHARGY INDEX	19
LETHARGY AT INDEX	1.9554883, 1
TWO-GROUP RESULTS	
	FAST SLOW
DIFFUSION COEFFICIENT, ONE-GROUP BUCKLING	1.0849401, 0 1.5667470, -1
DIFFUSION COEFFICIENT, TWO-GROUP BUCKLING	1.2365771, 0 1.4690037, -1
SIGMA ABSORPTION	1.1803790, -3 1.9539445, -2
NU SIGMA FISSION	0.0000000, 0 0.0000000, 0
FLUX	2.1416276, -1 4.5675312, 1
MULTIPLICATION	0.0000000, 0 0.0000000, 0
SIGMA LEAKAGE	2.9362330, -3 4.2401733, -4
DIFFUSION AREA, ONE-GROUP BUCKLING	2.4794540, 1 8.0183801, 0
DIFFUSION AREA, TWO-GROUP BUCKLING	2.8259956, 1 7.5181446, 0
BUCKLING	2.3744843, -3 2.8864278, -3
EXTRAPOLATION DISTANCE	3.3432617, 0 3.4509362, -1
SLOWING DOWN X-SECTION	4.2576840, -2
AVERAGE BUCKLING	2.7063548, -3
AVERAGE EXTRAPOLATION DISTANCE	1.3021375, 0
ABSORPTION ESCAPE PROBABILITY	9.7302436, -1
REACTIVITY, ONE-GROUP BUCKLING	0.0000000, 0
REACTIVITY, TWO-GROUP BUCKLING	0.0000000, 0

MULTIGROUP CONSTANTS

N	ENERGY	LETHARGY	SLOWING DOWN DENSITY
1	1.0000000, 2	1.1512829, 1	2.4357053, -1
2	1.0000000, 0	1.6117999, 1	9.3417527, -1
GROUP	MULTIPLICATION	BUCKLING	EXTRAPOLATION DISTANCE
1	0.0000000, 0	2.2700620, -3	4.0763551, 0
2	0.0000000, 0	2.6895322, -3	1.3964229, 0
3	0.0000000, 0	2.8821804, -3	3.6662932, -1
GROUP	SIGMA LEAKAGE	FLUX	SIGMA ABSORPTION
1	3.4806808, -3	1.6038296, 1	3.5430021, -5
2	1.5682046, -3	3.1724790, 0	1.3562863, -3
3	4.4800864, -4	4.7880814, 1	1.9065644, -2
GROUP	SOURCE TERM	NU SIGMA FISSION	SLOWING DOWN X-SECTION
1	2.9999911, -1	0.0000000, 0	5.8832341, -2
2	6.5006441, -7	0.0000000, 0	2.9446223, -1
3	0.0000000, 0	0.0000000, 0	0.0000000, 0
GROUP	ABSORPTION ESCAPE PROBABILITY	DIFFUSION COEFFICIENT ONE-GROUP BUCKLING	DIFFUSION COEFFICIENT MULTIGROUP BUCKLING
1	9.9939814, -1	1.2861132, 0	1.5332976, 0
2	9.9541514, -1	5.7945267, -1	5.8307708, -1
3	0.0000000, 0	1.6553950, -1	1.5544087, -1
GROUP	DIFFUSION AREA ONE-GROUP BUCKLING	DIFFUSION AREA MULTIGROUP BUCKLING	
1	2.1847505, 1	2.6046470, 1	
2	1.9588113, 0	1.9710634, 0	
3	8.6826072, 0	8.1529304, 0	
REACTIVITY, ONE-GROUP BUCKLING		0.0000000, 0	
REACTIVITY, MULTIGROUP BUCKLING		0.0000000, 0	

```

*****
* UNCLASSIFIED *
* W.B.HENDERSON EXT.736 *
* GEORGE CASE GEORGE SAMPLE TEST CASE *
*****

```

```

*****
* THIS IS RADIAL F2 CALCULATION NUMBER 1 OF ITERATION 2 *
* REFERENCE CORE = AVG.CORE *
* RADIAL F2 = RAD *
* LONGITUDINAL F2 = LONG *
*****

```

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-----
F2 CASE RAD
-----

```

```

-----
CTN24 USE TWO-GROUP BUCKLING
-----

```

```

-----
CTN25 COMPUTE BUCKLING FROM REFERENCE COMPOSITION AVG.CORE
-----

```

```

-----
CTN26 USE FAST CT1 AND SLOW CT2 TRANSMISSION FRACTIONS
FROM REFERENCE COMPOSITION ROD
-----

```

```

-----
CTN27 TERRALL METHOD-NOT AVAILABLE
-----

```


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CASE RAD 8/5/59 K=0.95723, F=1.757, H= 50.000, D= 0.000

CO= 3, C1=0, C2=1, C3=1, C4=1, C5=0, C6=0, C7=0, C8=2, C9=1, P= 0

S/H 3.8929443, S/D 0.0000000, R/D 1.0000000, R/N 0.0000000

A1- 0.7040414, A1+ 0.0000000, A2- 0.2128829, A2+ 0.0000000

A1 1.0000558, B1 1.0004043, A2 1.0015061, B2 1.0034037

ALPHA 0 CORE 1 CORE 2

REGIONAL DATA

RADIUS INTERVALS		MATERIAL	K1 SQ.	K2 SQ.
24.740	25	CORE 1	2.3635479, -3	2.8851118, -3
35.000	10	CORE 2	2.3635479, -3	2.8851118, -3
45.000	10	SIDE	2.3635479, -3	2.8851118, -3

MATERIAL DATA

MATERIAL	CORE 1	CORE 2	SIDE
DIFFUSION 1	1.4774395, 0	1.4096080, 0	1.2365771, 0
DIFFUSION 2	2.0458286, -1	1.8905446, -1	1.4690037, -1
ABSORPTION 1	2.8860821, -3	2.4312830, -3	1.1803790, -3
ABSORPTION 2	4.3571612, -2	3.6481295, -2	1.9539445, -2
FISSION 1	3.4896037, -3	2.5625103, -3	0.0000000, 0
FISSION 2	5.4953161, -2	3.8740087, -2	0.0000000, 0
SCATTER	3.3473609, -2	3.5792563, -2	4.2576840, -2
SOURCE 1	0.0000000, 0	0.0000000, 0	0.0000000, 0
SOURCE 2	0.0000000, 0	0.0000000, 0	0.0000000, 0

MATERIAL

DIFFUSION 1	0.0000000, 0
DIFFUSION 2	0.0000000, 0
ABSORPTION 1	0.0000000, 0
ABSORPTION 2	0.0000000, 0
FISSION 1	0.0000000, 0
FISSION 2	0.0000000, 0
SCATTER	0.0000000, 0
SOURCE 1	0.0000000, 0
SOURCE 2	0.0000000, 0

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ITERATION	REACTIVITY	P	V CORE
1	5.3819323,-1	2	22 1.9226528, 5
2	9.1946822,-1		
3	9.3481235,-1		
4	9.4447103,-1		
5	9.4981054,-1		
6	9.5286056,-1		
7	9.5463832,-1		
8	9.5568700,-1		
9	9.5630979,-1		
10	9.5668105,-1		
11	9.5690284,-1		
12	9.5703554,-1		
13	9.5711491,-1		
14	9.5716241,-1		
15	9.5719089,-1		
16	9.5720794,-1		
17	9.5721813,-1		
18	9.5722424,-1		
19	9.5722793,-1		
20	9.5723005,-1		
21	9.5723144,-1		
22	9.5723219,-1		

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RADIUS	FISSION DENSITY	FAST FLUX	SLOW FLUX
1.0000000, 0	8.1922595, -1	1.9452389, 0	6.6741827, -1
1.0009495, 0	8.2027424, -1	1.9453475, 0	6.6842348, -1
1.9495999, 0	1.2904894, 0	2.0121303, 0	1.1181646, 0
2.6991999, 0	1.5111874, 0	2.0570529, 0	1.3283907, 0
3.8487999, 0	1.6297243, 0	2.0883975, 0	1.4408449, 0
4.7983999, 0	1.6964682, 0	2.1089985, 0	1.5039764, 0
5.7479999, 0	1.7334742, 0	2.1203460, 0	1.5389843, 0
6.6975998, 0	1.7517054, 0	2.1234332, 0	1.5563901, 0
7.6471998, 0	1.7570548, 0	2.1190055, 0	1.5618359, 0
8.5967998, 0	1.7528767, 0	2.1076590, 0	1.5585226, 0
9.5463998, 0	1.7411779, 0	2.0898875, 0	1.5483562, 0
1.0495992, 1	1.7232203, 0	2.0661128, 0	1.5325282, 0
1.1445599, 1	1.6998426, 0	2.0367035, 0	1.5118251, 0
1.2395199, 1	1.6716399, 0	2.0019894, 0	1.4868005, 0
1.3344799, 1	1.6390675, 0	1.9622712, 0	1.4578748, 0
1.4294399, 1	1.6025038, 0	1.9178280, 0	1.4253956, 0
1.5243999, 1	1.5622929, 0	1.8689220, 0	1.3896785, 0
1.6193599, 1	1.5187764, 0	1.8158010, 0	1.3510375, 0
1.7143199, 1	1.4723236, 0	1.7586990, 0	1.3098145, 0
1.8092799, 1	1.4233662, 0	1.6978341, 0	1.2664122, 0
1.9042399, 1	1.3724450, 0	1.6334027, 0	1.2213405, 0
1.9991999, 1	1.3202788, 0	1.5655701, 0	1.1752827, 0
2.0941599, 1	1.2678685, 0	1.4944531, 0	1.1291979, 0
2.1891199, 1	1.2166595, 0	1.4200935, 0	1.0844786, 0
2.2840799, 1	1.1687935, 0	1.3424140, 0	1.0431979, 0
2.3790399, 1	1.1275054, 0	1.2611510, 0	1.0084955, 0
2.4739050, 1	1.0977676, 0	1.1758343, 0	9.8520215, -1
2.4739999, 1	1.0977474, 0	1.1757463, 0	9.8518824, -1
2.4739999, 1	7.7614475, -1	1.1757463, 0	9.8518824, -1
2.4741025, 1	7.7612803, -1	1.1756466, 0	9.8517194, -1
2.5765999, 1	7.4847812, -1	1.0802806, 0	9.5361245, -1
2.6791999, 1	7.0862593, -1	9.9103711, -1	9.0493851, -1
2.7817999, 1	6.6250006, -1	9.0654379, -1	8.4735430, -1
2.8843999, 1	6.1379580, -1	8.2580818, -1	7.8599233, -1
2.9869999, 1	5.6498640, -1	7.4811154, -1	7.2428537, -1
3.0895999, 1	5.1798146, -1	6.7287181, -1	6.6488716, -1
3.1921999, 1	4.7462421, -1	5.9953998, -1	6.1035840, -1
3.2947999, 1	4.3715262, -1	5.2750424, -1	5.6380455, -1
3.3973999, 1	4.0873514, -1	4.5597920, -1	5.2961686, -1
3.4998974, 1	3.9421341, -1	3.8392771, -1	5.1449472, -1
3.5000000, 1	3.9420961, -1	3.8385445, -1	5.1449436, -1
3.5000000, 1	0.0000000, 0	3.8385445, -1	5.1449436, -1
3.5000999, 1	0.0000000, 0	3.8377305, -1	5.1449388, -1
3.5999999, 1	0.0000000, 0	3.1084667, -1	4.9337833, -1
3.6999999, 1	0.0000000, 0	2.5141416, -1	4.5010146, -1
3.7999999, 1	0.0000000, 0	2.0293068, -1	3.9643336, -1
3.8999999, 1	0.0000000, 0	1.6326751, -1	3.3928101, -1
3.9999999, 1	0.0000000, 0	1.3069370, -1	2.8237746, -1

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4.0999999, 1	0.0000000, 0	1.0379687, -1	2.2736738, -1
4.1999999, 1	0.0000000, 0	8.1419206, -2	1.7448756, -1
4.2999999, 1	0.0000000, 0	6.2605435, -2	1.2296478, -1
4.3999999, 1	0.0000000, 0	4.6560311, -2	7.1208191, -2
4.4999999, 1	0.0000000, 0	3.2626519, -2	1.6895396, -2
4.5000000, 1	0.0000000, 0	3.2613333, -2	1.6838086, -2

UNCLASSIFIED			
MATERIAL	VOLUME	FAST FLUX	SLOW FLUX
CORE 1	4.9923823,-1	1.7152194, 0	1.2828185, 0
CORE 2	5.0076179,-1	7.3595919,-1	7.1804196,-1
SIDE	6.5359478,-1	1.4916612,-1	2.7115265,-1

```

*****
* UNCLASSIFIED *
* W.B.HENDERSON EXT.736 *
* GEORGE CASE GEORGE SAMPLE TEST CASE *
*****

```

```

*****
* THIS IS *
* LONGITUDINAL F2 CALCULATION NUMBER 1 OF ITERATION 2 *
* REFERENCE CORE = AVG.CORE *
* RADIAL F2 = RAD *
* LONGITUDINAL F2 = LONG *
*****

```

```

-----
F2 CASE LONG
-----

```

```

-----
CTN24 USE TWO-GROUP BUCKLING
-----

```

```

-----
CTN25 COMPUTE BUCKLING FROM REFERENCE COMPOSITION AVG.CORE
-----

```

```

-----
CTN26 USE F2 DATA AND CONTROLS
-----

```

```

-----
CTN27 TERRALL METHOD-NOT AVAILABLE
-----

```

UNCLASSIFIED

CASE LONG 8/5/59 K=0.95724, F=1.291, H= 0.000, D= 70.000
 C0= 3, C1=0, C2=0, C3=1, C4=1, C5=0, C6=0, C7=0, C8=1, C9=1, P= 0
 S/H 0.000000, S/D 11.842682, R/O 0.000000, R/N 35.000000
 A1- 0.000000, A1+ 0.000000, A2- 0.000000, A2+ 0.000000
 A1 1.0003514, B1 1.0003514, A2 1.0024733, B2 1.0024733
 ALPHA 0

REGIONAL DATA

RADIUS INTERVALS		MATERIAL	K1 SQ.	K2 SQ.
10.000	10	END	2.2890912, -3	2.5961747, -3
60.000	50	AVG. CORE	2.2890912, -3	2.5961747, -3
75.000	15	END	2.2890912, -3	2.5961747, -3

MATERIAL DATA

	END	AVG. CORE		
DIFFUSION 1	1.4227759, 0	1.4392141, 0	0.0000000, 0	0.0000000, 0
DIFFUSION 2	2.0215839, -1	1.9594944, -1	0.0000000, 0	0.0000000, 0
ABSORPTION 1	1.0255677, -3	2.6344837, -3	0.0000000, 0	0.0000000, 0
ABSORPTION 2	1.7259216, -2	3.9625816, -2	0.0000000, 0	0.0000000, 0
FISSION 1	0.0000000, 0	2.9766635, -3	0.0000000, 0	0.0000000, 0
FISSION 2	0.0000000, 0	4.5930507, -2	0.0000000, 0	0.0000000, 0
SCATTER	3.6913111, -2	3.4764552, -2	0.0000000, 0	0.0000000, 0
SOURCE 1	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0
SOURCE 2	0.0000000, 0	0.0000000, 0	0.0000000, 0	0.0000000, 0

MATERIAL

DIFFUSION 1	0.0000000, 0
DIFFUSION 2	0.0000000, 0
ABSORPTION 1	0.0000000, 0
ABSORPTION 2	0.0000000, 0
FISSION 1	0.0000000, 0
FISSION 2	0.0000000, 0
SCATTER	0.0000000, 0
SOURCE 1	0.0000000, 0
SOURCE 2	0.0000000, 0

UNCLASSIFIED				
ITERATION	REACTIVITY	P	V	CORE
1	4.6430712, -1	18	1.9242250, 5	
2	9.4317035, -1			
3	9.4987183, -1			
4	9.5328350, -1			
5	9.5509324, -1			
6	9.5606354, -1			
7	9.5659994, -1			
8	9.5688882, -1			
9	9.5704647, -1			
10	9.5713245, -1			
11	9.5717935, -1			
12	9.5720493, -1			
13	9.5721895, -1			
14	9.5722656, -1			
15	9.5723073, -1			
16	9.5723299, -1			
17	9.5723428, -1			
18	9.5723492, -1			

UNCLASSIFIED			
RADIUS	FISSION DENSITY	FAST FLUX	SLOW FLUX
0.0000000, 0	0.0000000, 0	3.7839156, -2	2.0851284, -2
0.9999998, -4	0.0000000, 0	3.7852453, -2	2.0902856, -2
1.0000000, 0	0.0000000, 0	5.1683718, -2	6.9888611, -2
2.0000000, 0	0.0000000, 0	6.7024545, -2	1.1563601, -1
3.0000000, 0	0.0000000, 0	8.4306024, -2	1.5931768, -1
4.0000000, 0	0.0000000, 0	1.0402852, -1	2.0162080, -1
5.0000000, 0	0.0000000, 0	1.2676310, -1	2.4266560, -1
6.0000000, 0	0.0000000, 0	1.5316801, -1	2.8121160, -1
7.0000000, 0	0.0000000, 0	1.8400781, -1	3.1798990, -1
8.0000000, 0	0.0000000, 0	2.2017542, -1	3.4844315, -1
9.0000000, 0	0.0000000, 0	2.6271807, -1	3.6934631, -1
9.9990000, 0	0.0000000, 0	3.1281358, -1	3.7477250, -1
1.0000000, 1	0.0000000, 0	3.1286825, -1	3.7476586, -1
1.0000000, 1	5.5389858, -1	3.1286825, -1	3.7476506, -1
1.0000000, 1	5.5389387, -1	3.1292228, -1	3.7475899, -1
1.0999999, 1	5.6385621, -1	3.6474316, -1	3.7850576, -1
1.1999999, 1	5.9150620, -1	4.1352297, -1	3.9506451, -1
1.2999999, 1	6.2952931, -1	4.5993008, -1	4.1917515, -1
1.3999999, 1	6.7334259, -1	5.0437254, -1	4.4754270, -1
1.4999999, 1	7.2005681, -1	5.4706514, -1	4.7809261, -1
1.5999999, 1	7.6783403, -1	5.8810425, -1	5.0950780, -1
1.6999999, 1	8.1548953, -1	6.2751422, -1	5.4094178, -1
1.7999999, 1	8.6224538, -1	6.6527620, -1	5.7184091, -1
1.8999999, 1	9.0757765, -1	7.0134617, -1	6.0183441, -1
1.9999999, 1	9.5112200, -1	7.3566611, -1	6.3066618, -1
2.0999999, 1	9.9261520, -1	7.6817103, -1	6.5815267, -1
2.1999999, 1	1.0318588, 0	7.9879342, -1	6.8415680, -1
2.2999999, 1	1.0686972, 0	8.2746600, -1	7.0857185, -1
2.3999999, 1	1.1030035, 0	8.5412359, -1	7.3131158, -1
2.4999999, 1	1.1346712, 0	8.7870422, -1	7.5230406, -1
2.5999999, 1	1.1636091, 0	9.0114995, -1	7.7148801, -1
2.6999999, 1	1.1897381, 0	9.2140740, -1	7.8881046, -1
2.7999999, 1	1.2129893, 0	9.3942806, -1	8.0422542, -1
2.8999999, 1	1.2333029, 0	9.5516862, -1	8.1769303, -1
2.9999999, 1	1.2506276, 0	9.6859121, -1	8.2917913, -1
3.0999999, 1	1.2649199, 0	9.7966340, -1	8.3865492, -1
3.1999999, 1	1.2761446, 0	9.8835850, -1	8.4609685, -1
3.2999999, 1	1.2842738, 0	9.9465546, -1	8.5148657, -1
3.3999999, 1	1.2892877, 0	9.9853909, -1	8.5481078, -1
3.4999999, 1	1.2911739, 0	1.0000000, 0	8.5606136, -1
3.5999999, 1	1.2899279, 0	9.9903465, -1	8.5523526, -1
3.6999999, 1	1.2855527, 0	9.9564544, -1	8.5233452, -1
3.7999999, 1	1.2780592, 0	9.8984056, -1	8.4736634, -1
3.8999999, 1	1.2674659, 0	9.8163408, -1	8.4034300, -1
3.9999999, 1	1.2537990, 0	9.7104589, -1	8.3128194, -1
4.0999999, 1	1.2370926, 0	9.5810156, -1	8.2020577, -1
4.1999999, 1	1.2173886, 0	9.4283235, -1	8.0714240, -1
4.2999999, 1	1.1947372, 0	9.2527506, -1	7.9212518, -1
4.3999999, 1	1.1691970, 0	9.0547187, -1	7.7519320, -1

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4.4999999, 1	1.1408358, 0	8.8347011, -1	7.5639186, -1
4.5999999, 1	1.1097323, 0	8.5932207, -1	7.3577369, -1
4.6999999, 1	1.0759773, 0	8.3308453, -1	7.1339990, -1
4.7999999, 1	1.0396778, 0	8.0481825, -1	6.8934287, -1
4.8999999, 1	1.0009623, 0	7.7458710, -1	6.6369007, -1
4.9999999, 1	9.5999000, -1	7.4245686, -1	6.3655077, -1
5.0999999, 1	9.1696552, -1	7.0849330, -1	6.0866670, -1
5.1999999, 1	8.7216319, -1	6.7275910, -1	5.7842939, -1
5.2999999, 1	8.2596579, -1	6.3530915, -1	5.4790831, -1
5.3999999, 1	7.7822778, -1	5.9618303, -1	5.1689633, -1
5.4999999, 1	7.3187709, -1	5.5539291, -1	4.8598316, -1
5.5999999, 1	6.8607972, -1	5.1290419, -1	4.5607394, -1
5.6999999, 1	6.4350545, -1	4.6860447, -1	4.2858081, -1
5.7999999, 1	6.0725682, -1	4.2225347, -1	4.0573209, -1
5.8999999, 1	5.8226159, -1	3.7340253, -1	3.9107127, -1
5.9999000, 1	5.7638607, -1	3.2131851, -1	3.9025636, -1
6.0000000, 1	5.7639604, -1	3.2126406, -1	3.9026700, -1
6.0000000, 1	0.0000000, 0	3.2126406, -1	3.9026700, -1
6.0000999, 1	0.0000000, 0	3.2120897, -1	3.9027731, -1
6.0999999, 1	0.0000000, 0	2.7081855, -1	3.8842206, -1
6.1999999, 1	0.0000000, 0	2.2821514, -1	3.7129232, -1
6.2999999, 1	0.0000000, 0	1.9221955, -1	3.4515454, -1
6.3999999, 1	0.0000000, 0	1.6178954, -1	3.1428200, -1
6.4999999, 1	0.0000000, 0	1.3604404, -1	2.8151515, -1
6.5999999, 1	0.0000000, 0	1.1423761, -1	2.4867247, -1
6.6999999, 1	0.0000000, 0	9.5738850, -2	2.1684652, -1
6.7999999, 1	0.0000000, 0	8.0012141, -2	1.8661532, -1
6.8999999, 1	0.0000000, 0	6.6602130, -2	1.5819101, -1
6.9999999, 1	0.0000000, 0	5.5120539, -2	1.3152170, -1
7.0999999, 1	0.0000000, 0	4.5234926, -2	1.0635773, -1
7.1999999, 1	0.0000000, 0	3.6659061, -2	8.2290474, -2
7.2999999, 1	0.0000000, 0	2.9144634, -2	5.8768621, -2
7.3999999, 1	0.0000000, 0	2.2474071, -2	3.5095032, -2
7.4999000, 1	0.0000000, 0	1.6459923, -2	1.0430329, -2
7.5000000, 1	0.0000000, 0	1.6454141, -2	1.0404596, -2

UNCLASSIFIED			
MATERIAL	VOLUME	FAST FLUX	SLOW FLUX
END	4.9999999, -1	1.2529574, -1	2.1720010, -1
AVG. CORE	1.0000000, 0	7.6421492, -1	6.6367588, -1

```
*****
*-----REACTIVITY MATCH COMPLETED-----*
*****
*          K(CZ)= 9.5722617, -1          *
*          S(CZ)= 1.1842681, 1           *
*          S(CZ)= 3.8929443, 0           *
*****
*          K(CZ)= 9.5723324, -1          *
*          S(CZ)= 3.8929443, 0           *
*****
*          K(CZ)= 9.5723571, -1          *
*          S(CZ)= 1.1842681, 1           *
*****
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