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ARGONNE NATIONAL LABORATORY
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RE-34, AN IBM-704 REACTOR SHIELDING PROGRAM

by

M. K. Butler and J. M. Cook

Applied Mathematics Division

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DISCLAIMER

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HISTORY AND ACKNOWLEDGMENTS

The problem which this program solves was originally proposed in 1955 by J. W. Butler and M. Grotenhuis. At this time the Laboratory did not have a computing machine with a sufficiently large memory to adequately solve the problem; consequently, when the IBM-704 was installed in November of 1957 the problem was reviewed and the program described in this report prepared.

J. Heestand assisted the authors by checking the machine program, while J. W. Butler and M. Grotenhuis, in addition to being very patient, contributed advice and assistance throughout the development of the program.

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ABSTRACT

An IBM-704 shielding program is described which solves, by a finite difference method, the multigroup diffusion equation system in slab, cylindrical, or spherical geometry, with a prescribed source distribution given for the highest energy group. A wide choice of boundary conditions has been made available at the outer boundaries and either continuity of flux and current or the "black boundary" condition may be specified at each regional interface.

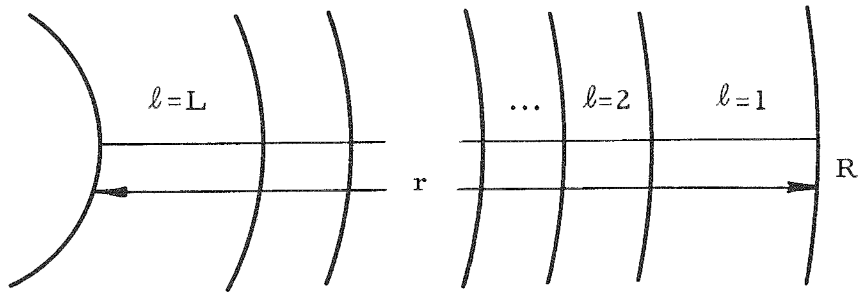
The machine time required to process an average problem is approximately 1-2 minutes. This includes reading in the program deck.

I. INTRODUCTION

The purpose of this report is to present the IBM-704 program for solving the one-dimensional multigroup diffusion equation system of reactor shielding problems.

The problem originator specifies certain problem parameters, such as the outer boundary, energy group divisions, geometrical and material properties of each region, and the source distribution for the highest energy group which enable the program to solve the diffusion equation system printing the flux distributions, the integrals of the fluxes, neutron leakages and balance checks for each region, as well as the value of the current at the outer boundary and at any regional interface where a "black" sheet has been inserted.

The outer edge of the reactor shield is designated as R and the reactor or the reactor shield whichever is being considered is divided into L regions, ($1 \leq L \leq 100$), numbered from R inward to the inner boundary which may be at the center of the reactor or at the beginning of any shield region.



Each region, ℓ , is divided into H_ℓ sub-intervals of equal thickness, Δ_ℓ. The lattice points in each region, designated by integers, are numbered from the outer edge of the region inward, h_ℓ, $(0 \leq h_\ell \leq H_\ell)$. It is at these points that the source for the highestenergy group is specified, the fluxes and lower energy group sources are computed, and numerical integration is performed, $\left(\sum_{\ell=1}^{L} H_\ell + L \leq 1000 \right)$.

The neutron energy spectrum is divided into a set of J energy groups, $(J \geq 1)$. In the numerical solution of the problem the set of J diffusion equations of the form

$$\nabla (D \nabla \phi) - \sigma\phi + S = 0,$$

is replaced by a set of J coupled difference equations, where

D is the diffusion coefficient $\left(= \frac{1}{3\sigma_{tr}} \right)$,

σ is the removal cross section $(= \sigma_{elastic} + \sigma_{capture} + DB^2)$,*

ϕ is the neutron flux,

and S is the source term prescribed as input data point by point for $j = 1$, and computed for the lower energy groups, $j \neq 1$, as $S_j = s_{j-1}\sigma_{j-1}\phi_{j-1}$, where s_{j-1} is the transfer fraction for the j-1st energy group.

Before describing the boundary conditions available it will be helpful to distinguish the inner and outer edges from the interior regional boundaries. This has been done by referring to only the inner and outer boundaries of the problem as boundaries and applying the term interfaces to the interior boundaries.

At the inner edge of the problem, (the point of minimum r value), any of three boundary conditions may be employed. The derivative of the flux may be set equal to zero, the flux value, k, may be specified, or if $r \neq 0$, the "black boundary" condition, $-\frac{1}{\phi}\frac{d\phi}{dr} = \frac{1}{d}$, may be imposed.

*This is not the usual removal cross section as defined for shielding work.

At each interface the problem originator has two choices; he may elect the standard boundary condition of continuity of flux and current or a "black boundary" condition may be chosen. The "black boundary" condition may be written as

$$-\frac{1}{\phi}\frac{d\phi}{dr} = \frac{1}{d} \text{ for the inner region,}$$

and

$$\frac{1}{\phi}\frac{d\phi}{dr} = \frac{1}{d} \text{ for the outer region.}$$

At the outer boundary, $(r = R)$, the flux may be set equal to zero, the derivative of the flux may be set equal to zero, or the "black boundary" condition may be applied.

These boundary conditions are specified and applied at each boundary and on both sides of each interface. Obviously, if an interface is a "black boundary" to one of its adjacent regions, it is a "black boundary" to the other, or if the continuity condition is used for one adjacent region it must be used for the other.

The input data may be divided into three categories - the general problem parameters, the point-by-point source distribution for the highest energy group, and the group-region parameters. Included in the general problem parameters are such items as the problem number, the geometry (N), J, L, R, and the interval size (Δ_ℓ), and number of intervals (H_ℓ), included in each region. The group-region parameters for each region and each energy group consist of the boundary condition indicators for both the outer (d_0), and the inner (d_I) boundaries of the region, D, σ, and s. A more detailed description of the input is provided in Section III.

No description of the IBM-704 computer will be attempted here, instead the reader is referred to the IBM-704 Data Processing System Reference Manual, IBM Form A22-6500-0.

II. DESCRIPTION OF NUMERICAL METHOD

We are to solve the diffusion equation $D\nabla^2\Phi - \sigma\Phi + Q = 0$ for three different reactor shapes: slab (N = 1), cylinder (N = 2), and sphere (N = 3).

$$\Phi = \phi(r)\ \psi(\theta_1, \cdots \theta_{N=1},), \text{ where } \nabla^2\Phi = (\nabla^2\phi)\psi + \phi\cdot(\nabla^2\psi), \text{ and } \nabla^2\psi = -\mathcal{L}\psi$$

The $\mathcal{L}$ corresponds to neutron leakage out of the reactor in directions parallel to the surfaces r = constant. If we consider it as a form of absorption, add it to σ, and factor out ψ; the diffusion equation becomes an ordinary differential equation $D\nabla^2\phi - \Sigma\phi + S = 0$ in r, with $\nabla^2 = \frac{1}{r^{N-1}}\frac{d}{dr} r^{N-1}\frac{d}{dr}$ and $\Sigma = \sigma + D\mathcal{L}$. The range of r is from b_0 to b_L with $0 \leq b_0 < b_L$. The boundary conditions are of the form $A_0 = A_1\phi(b_0) + A_2\phi'(b_0)$ and $0 = \phi(b_L) + d\phi'(b_L)$.

We use the following difference approximation to the differential operators (see ANL-5437, Sec. V, note (6)):

$$\left[\frac{d\phi}{dr}\right]_{r_n} = \frac{1}{2\Delta r}\left[\left(1+\frac{1}{2n}\right)^{N-1}\phi_{n+1} + \left(\left(1-\frac{1}{2n}\right)^{N-1} - \left(1+\frac{1}{2n}\right)^{N-1}\right)\phi_n - \left(1-\frac{1}{2n}\right)^{N-1}\phi_{n-1}\right]$$

$$\left[\nabla^2\phi\right]_{r_n} = \frac{1}{(\Delta r)^2}\left[\left(1+\frac{1}{2n}\right)^{N-1}\phi_{n+1} - \left(\left(1+\frac{1}{2n}\right)^{N-1} + \left(1-\frac{1}{2n}\right)^{N-1}\right)\phi_n + \left(1-\frac{1}{2n}\right)^{N-1}\phi_{n-1}\right] \quad \text{if } r_n \neq 0$$

$$= \frac{N}{(\Delta r)^2}\left[\phi_{-1} - 2\phi_0 + \phi_1\right] \quad \text{if } r_n = 0$$

where

$$n = n_{\ell,h\ell} = r_n / \Delta_\ell r \text{ need not be integral.}$$

The differential system to be solved is given by

(b_1) $D_\ell \nabla^2\phi(r) - \Sigma_\ell\phi(r) + S(r) = 0$ $\qquad b_{\ell-1} < r < b_\ell$, $1 \leq \ell \leq L$

(b_2) $D_\ell \left[\frac{d\phi}{dr}\right]_{b_\ell -} = D_{\ell+1}\left[\frac{d\phi}{dr}\right]_{b_\ell +}$ $\qquad 1 \leq \ell < L$

(b_3) $\phi(b_\ell -) = \phi(b_\ell +)$ $\qquad 1 \leq \ell < L$

(b_4^*) $\phi(b_L) + d\phi'(b_L) = 0$

(b_5) $A_1\phi(b_0) + A_2\phi'(b_0) = A_0$

We replace this system by the following difference system

$$(c_1)\ \frac{D_\ell}{(\Delta_\ell r)^2}\Big[p_\ell(h_\ell)\,\phi_\ell(h_\ell+1)-\big(p_\ell(h_\ell)+q_\ell(h_\ell)\big)\phi_\ell(h_\ell)+q_\ell(h_\ell)\,\phi_\ell(h_\ell-1)\Big]$$

$$-\Sigma_\ell\phi_\ell(h_\ell)+S_\ell(h_\ell)=0 \qquad 0<h_\ell<H_\ell,\quad 1\le \ell\le L$$

$$(c_2)\ \frac{D_\ell}{\Delta_\ell r}\Big[p_\ell(H_\ell)\,\phi_\ell(H_\ell+1)+\big(q_\ell(H_\ell)-p_\ell(H_\ell)\big)\,\phi_\ell(H_\ell)-q_\ell(H_\ell)\,\phi_\ell(H_\ell-1)\Big]=$$

$$\frac{D_{\ell+1}}{\Delta_{\ell+1} r}\Big[p_{\ell+1}(0)\,\phi_{\ell+1}(1)+\big(q_{\ell+1}(0)-p_{\ell+1}(0)\big)\phi_{\ell+1}(0)-q_{\ell+1}(0)\phi_{\ell+1}(-1)\Big]$$

$$(c_3)\ \phi_\ell(H_\ell)=\phi_{\ell+1}(0)$$

$$(c_4^*)\ (d+\Delta_L r)\,\phi_L(H_L)-d\phi_L(H_L-1)=0$$

$$(c_5)\ a_0\phi_1(0)+a_1\phi_1(1)=a_2,$$

where functions of n_{ℓ,h_ℓ} are written as $f_{n_{\ell,h_\ell}}=f_\ell(h_\ell)$, and the derivative $\phi'(b_L)$ in the extrapolated end-point condition (C_4^*) is approximated by $(\phi_L(H_L)-\phi_L(H_L-1))/\Delta_L r$. The quantities p and q are defined by

$$p_\ell(h_\ell)=\left(1+\frac{1}{2n_{\ell,h_\ell}}\right)^{N-1} \quad\text{and}\quad q_\ell(h_\ell)=\left(1-\frac{1}{2n_{\ell,h_\ell}}\right)^{N-1}$$

The fictitious fluxes $\phi_\ell(-1)$ and $\phi_\ell(H_\ell+1)$ are defined outside of the ℓ^{th} region R_ℓ by using (c_1) to extend across the boundary.

We now use (c_1) on (c_2) to eliminate these extensions. Then let $\lambda_\ell=(\Delta_\ell r)^2/D_\ell$ and $k_\ell(h_\ell)=p_\ell(h_\ell)+q_\ell(h_\ell)+\lambda_\ell\Sigma_\ell$, and (c) becomes:

$$(d_1)\ p_\ell(h_\ell)\,\phi_\ell(h_\ell+1)-k_\ell(h_\ell)\,\phi_\ell(h_\ell)+q_\ell(h_\ell)\phi_\ell(h_\ell-1)+\lambda_\ell S_\ell(h_\ell)=0$$

$$0<h_\ell<H_\ell, \qquad 1\le \ell\le L$$

$$(d_2)\ \Delta_\ell r\cdot\lambda_{\ell+1}\,[-2q_\ell(H_\ell)\phi_\ell(H_\ell-1)+\big(k_\ell(H_\ell)+q_\ell(H_\ell)-p_\ell(H_\ell)\big)\,\phi_\ell(H_\ell)$$

$$-\lambda_\ell S_\ell(H_\ell)]=\Delta_{\ell+1} r\cdot\lambda_\ell\,[(q_{\ell+1}(0)-p_{\ell+1}(0)-k_{\ell+1}(0))\ \phi_{\ell+1}(0)$$

$$+2p_{\ell+1}(0)\phi_{\ell+1}(1)+\lambda_{\ell+1}S_{\ell+1}(0)]$$

$$(d_3)\ \phi_\ell(H_\ell)=\phi_{\ell+1}(0)$$

$$(d_4^*)\ (d+\Delta_L r)\,\phi_L(H_L)-d\phi_L(H_L-1)=0$$

$$(d_5)\ a_0\phi_1(0)+a_1\phi_1(1)=a_2$$

Omission of the boundary condition (d_5) gives a system which has a unique solution for each assigned value of $\phi_L(H_L)$. The difference X of any two such solutions is a solution of the following system:

$$(e_1)\ p_\ell(h_\ell)X_\ell(h_\ell+1) - k_\ell(h_\ell)X_\ell(h_\ell) + q_\ell(h_\ell)X_\ell(h_\ell-1) = 0$$

$$0 < h_\ell < H_\ell, \quad 1 \leq \ell \leq L$$

$$(e_2)\Delta_\ell r\cdot\lambda_{\ell+1}\left[-2q_\ell(H_\ell)X_\ell(H_\ell-1) + \left(k_\ell(H_\ell) + q_\ell(H_\ell) - p_\ell(H_\ell)\right)X_\ell(H_\ell)\right] =$$

$$\Delta_{\ell+1}r\cdot\lambda_\ell\left[\left(q_{\ell+1}(0) - p_{\ell+1}(0) - k_{\ell+1}(0)\right)X_{\ell+1}(0) + 2p_{\ell+1}(0)X_{\ell+1}(1)\right]$$

$$1 \leq \ell < L$$

$$(e_3)\ X_\ell(H_\ell) = X_{\ell+1}(0)$$

$$(e_4^*)\ (d+\Delta_L r)X_L(H_L) - dX_L(H_L-1) = 0$$

In order to keep the quantities of the problem in range, it is simpler to solve for certain auxiliary functions.

Set $u_\ell(h) = X_\ell(h+1)/X_\ell(h)$. Then from (e_1) we get

$$p_\ell(h_\ell)\frac{X_\ell(h_\ell+1)}{X_\ell(h_\ell)} - k_\ell(h_\ell) + q_\ell(h_\ell)\frac{X_\ell(h_\ell-1)}{X_\ell(h_\ell)} = 0$$

or

$$u_\ell(h_\ell-1) = q_\ell(h_\ell)/\left(k_\ell(h_\ell) - p_\ell(h_\ell)u_\ell(h_\ell)\right) \quad .$$

From (e_2) we get

$$\Delta_\ell r\cdot\lambda_{\ell+1}\left[-2q_\ell(H_\ell)/u_\ell(H_\ell-1) + k_\ell(H_\ell) + q_\ell(H_\ell) - p_\ell(H_\ell)\right] =$$

$$\Delta_{\ell+1}r\cdot\lambda_\ell\left[q_{\ell+1}(0) - p_{\ell+1}(0) - k_{\ell+1}(0) + 2p_{\ell+1}(0)u_{\ell+1}(0)\right];$$

and from (e_4), $u_L(H_L-1) = d/(d+\Delta_L r)$. So u is determined by the system

$$(f_1)\ u_\ell(h_\ell-1) = q_\ell(h_\ell)/\left(k_\ell(h_\ell) - p_\ell(h_\ell)\,u_\ell(h_\ell)\right) \qquad \begin{matrix} 0 < h_\ell < H_\ell \\ 1 \leq \ell \leq L \end{matrix}$$

$$(f_2)\ u_\ell(H_\ell-1) = 2q_\ell(H_\ell)\Big/\Big[k_\ell(H_\ell) + q_\ell(H_\ell) - p_\ell(H_\ell)$$

$$+\frac{\Delta_{\ell+1}r\cdot\lambda_\ell}{\Delta_\ell r\cdot\lambda_{\ell+1}}\left(k_{\ell+1}(0) + p_{\ell+1}(0) - q_{\ell+1}(0) - 2p_{\ell+1}(0)u_{\ell+1}(0)\right)\Big] \quad 1\leq\ell< L$$

$$(f_3^*)\ u_L(H_L-1) = d/(d+\Delta_L r).$$

Now set $v_\ell(h_\ell-1) = \phi_\ell(h_\ell) - u_\ell(h_\ell-1)\phi_\ell(h_\ell-1)$.

To express it in terms of $u_\ell(h_\ell-1)$, $v_\ell(h_\ell)$, and $S_\ell(h_\ell)$ we proceed as follows:

$$v_\ell(h_\ell-1) = \frac{1}{X_\ell(h_\ell-1)}\Big(X_\ell(h_\ell-1)\ \phi_\ell(h_\ell) - X_\ell\ (h_\ell)\ \phi_\ell\ (h_\ell-1)\Big)$$

$$= \frac{1}{X_\ell(h_\ell-1)}\Big(\big(k_\ell(h_\ell)X_\ell(h_\ell) - p_\ell\ (h_\ell)X_\ell(h_\ell+1)\big)\ \phi_\ell(h_\ell)$$

$$-X_\ell(h_\ell)\big(k_\ell(h_\ell)\ \phi_\ell(h_\ell) - p_\ell(h_\ell)\ \phi_\ell(h_\ell+1) - \lambda_\ell S_\ell(h_\ell)\big)\Big)/q_\ell(h_\ell)$$

(where we have solved (e_1) and (d_1) for $X_\ell(h_\ell-1)$ and $\phi_\ell(h_\ell-1)$ to insert in the first equality)

$$v_\ell\ (h_\ell-1) = \frac{1}{X_\ell(h_\ell-1)}\Big(p_\ell(h_\ell)\big(X_\ell(h_\ell)\phi_\ell\ (h_\ell+1) - X_\ell(h_\ell+1)\ \phi_\ell\ (h_\ell)\big)$$

$$+\lambda_\ell X_\ell(h_\ell)S_\ell\ (h_\ell)\Big)/q_\ell(h_\ell)$$

$$= u_\ell(h_\ell-1)\big(p_\ell(h_\ell\ \ v_\ell(h_\ell) + \lambda_\ell S_\ell(h_\ell)\big)/q_\ell(h_\ell).$$

To carry v inwards across an interface, we follow the same procedure, using (e_2) and (d_2) instead of (e_1) and (d_1):

$$v_\ell\ (H_\ell-1) = \frac{1}{X_\ell(H_\ell-1)}\ \Big(X_\ell(H_\ell-1)\ \phi_\ell(H_\ell) - X_\ell(H_\ell)\ \phi_\ell(H_\ell-1)\Big)$$

$$= \frac{1}{X_\ell(H_\ell-1)}\ \Bigg(\ \Big[k_\ell(H_\ell) + q_\ell(H_\ell) - p_\ell(H_\ell) + \frac{\Delta_{\ell+1} r\cdot\lambda_\ell}{\Delta_\ell r\cdot\lambda_{\ell+1}}\big(p_{\ell+1}(0)$$

$$+k_{\ell+1}(0) - q_{\ell+1}(0)\big)\Big]\ \ X_{\ell+1}(0)\,\phi_\ell\ (H_\ell) - X_\ell(H_\ell)\Big[k_\ell(H_\ell) + q_\ell(H_\ell)$$

$$-p_\ell(H_\ell) + \frac{\Delta_{\ell+1} r\cdot\lambda_\ell}{\Delta_\ell r\cdot\lambda_{\ell+1}}\big(p_{\ell+1}(0) + k_{\ell+1}(0) - q_{\ell+1}(0)\big)\Big]\ \ \phi_{\ell+1}(0)$$

$$-\frac{\Delta_{\ell+1} r\cdot\lambda_\ell}{\Delta_\ell r\cdot\lambda_{\ell+1}}\ 2p_{\ell+1}(0)\ X_{\ell+1}(1)\,\phi_\ell(H_\ell) - X_\ell(H_\ell)\ \Big[-\lambda_\ell S_\ell(H_\ell)$$

$$-\frac{\Delta_{\ell+1} r\cdot\lambda_\ell}{\Delta_\ell r\cdot\lambda_{\ell+1}}\ \big(-2p_{\ell+1}(0)\ \phi_{\ell+1}(1) - \lambda_{\ell+1}S_{\ell+1}(0)\big)\Big]\Bigg)\Big/\ 2q_\ell(H_\ell)$$

$$= \frac{1}{X_\ell(H_\ell-1)}\Bigg(p_{\ell+1}(0)\frac{\Delta_{\ell+1} r\cdot\lambda_\ell}{\Delta_\ell r\cdot\lambda_{\ell+1}}\Big[X_{\ell+1}(0)\ \ \phi_{\ell+1}(1) - X_{\ell+1}(1)\ \phi_{\ell+1}(0)\Big]$$

$$+X_{\ell+1}(0)\Big[\ \frac{\lambda_\ell}{2}\ S_\ell(H_\ell) + \frac{\Delta_{\ell+1} r\cdot\lambda_\ell}{\Delta_\ell r\cdot\lambda_{\ell+1}}\ \frac{\lambda_{\ell+1}}{2}\ \ S_{\ell+1}(0)\Big]\Bigg)\Big/\ \ q_\ell(H_\ell)$$

$$= \frac{u_\ell(H_\ell-1)}{q_\ell(H_\ell)}\Bigg(\ p_{\ell+1}(0)\ \frac{\Delta_{\ell+1} r\cdot\lambda_\ell}{\Delta_\ell r\cdot\lambda_{\ell+1}}v_{\ell+1}(0) + \frac{\lambda_\ell}{2}\ S_\ell(H_\ell) +$$

$$\frac{\Delta_{\ell+1} r\cdot\lambda_\ell}{2\,\Delta_\ell\ r}\ \ S_{\ell+1}(0)\Bigg) \qquad \text{for } 1\leq\ell<L$$

(where we have used (d_3) and (e_3)).

At the extrapolated end-point $v_L(H_L-1) =$

$$\frac{1}{X_L(H_L-1)}\left(X_L(H_L-1)\phi_L(H_L) - X_L(H_L)\phi_L(H_L-1)\right) = 0$$ because both

X and ϕ obey the same homogeneous linear condition on their values at H_L-1 and H_L.

So v is determined by the system:

$$(g_1)\ v_\ell(h_\ell-1) = u_\ell(h_\ell-1)\left(p_\ell(h_\ell)v_\ell(h_\ell) + \lambda_\ell S_\ell(h_\ell)\right)/q_\ell(h_\ell) \qquad 0 < h_\ell < H_\ell, \quad 1 \leq \ell \leq L$$

$$(g_2)\ v_\ell(H_\ell-1) = \frac{u_\ell(H_\ell-1)\lambda_\ell}{2q_\ell(H_\ell)}\left(p_{\ell+1}(0)\frac{2\Delta_{\ell+1}r}{\Delta_\ell r\cdot\lambda_{\ell+1}}v_{\ell+1}(0) + S_\ell(H_\ell) + \frac{\Delta_{\ell+1}r}{\Delta_\ell r}S_{\ell+1}(0)\right) \qquad 1 \leq \ell \leq L$$

$$(g_3^*)\ v_L(H_L-1) = 0$$

After u and v have been found from the systems (f) and (g), then ϕ is found by means of the following system:

$$(h_1)\ \phi_\ell(h_\ell+1) = v_\ell(h_\ell) + u_\ell(h_\ell)\ \phi_\ell(h_\ell), \quad 0 \leq h_\ell < H_\ell, \quad 1 \leq \ell \leq L$$

$$(h_2)\ \phi_1(0) = \left(a_2 - a_1v_1(0)\right)/(a_1u_1(0) + a_0),$$

where (h_1) is obtained by solving for $\phi_\ell(h_\ell+1)$ in the definition of v, and (h_2) by solving for $\phi_1(0)$ in (h_1) (evaluated at $h_1=0$) and (c_5), considered as a set of simultaneous linear equations in $\phi_1(0)$ and $\phi_1(1)$.

Instead of approximating the derivative $\phi'(b_L)$ by the two-point formula $\left(\phi_L(H_L) - \phi_L(H_L-1)\right)/\Delta_L r$ for the extrapolated end-point condition (c_4^*), it would be more consistent with the rest of the calculation to use the three-point formula

$$\left[\frac{d\phi}{dr}\right]_{b_L} = \frac{1}{2\Delta_L r}\left(p_L(H_L)\ \phi_L(H_L+1) + \left(q_L(H_L) - p_L(H_L)\right)\phi_L(H_L) - q_L(H_L)\phi_L(H_L-1)\right).$$

If (d_1), evaluated at $\ell = L$ and $h_\ell = H_L$, is used to eliminate the fictitious flux $\phi_L(H_L+1)$, we get

$$\left[\frac{d\phi}{dr}\right]_{b_L} = \frac{1}{2\Delta_L r}\left(\left(k_L(H_L) + q_L(H_L) - p_L(H_L)\right)\phi_L(H_L) - 2q_L(H_L)\phi_L(H_L-1) - \lambda_L S_L(H_L)\right).$$

The corresponding expression for X is

$$\left[\frac{dX}{dr}\right]_{b_L} = \frac{1}{2\Delta_L r}\Big(\big(k_L(H_L) + q_L(H_L) - p_L(H_L)\big)\, X_L(H_L) - 2q_L(H_L)X_L(H_L-1)\Big).$$

Now the general boundary condition

$$(b_4)\; B_0\phi(b_L) + B_1\,\phi'(b_L) = 0$$

is expressed in difference form as

$$(c_4')\quad \Big(2\Delta_L r B_0 + B_1\big(k_L(H_L) + q_L(H_L) - p_L(H_L)\big)\Big)\phi_L(H_L) - 2B_1 q_L(H_L)\phi_L(H_L-1) = \lambda_L B_1 S_L(H_L).$$

For X it is

$$(e_4)\quad \Big(2\Delta_L r B_0 + B_1\big(k_L(H_L) + q_L(H_L) - p_L(H_L)\big)\Big)X_L(H_L) - 2B_1 q_L(H_L)X_L(H_L-1) = 0\;.$$

Then the initial value for u is given by

$$(f_3)\quad u_L(H_L-1) = 2B_1 q_L(H_L)\Big/\Big(2\Delta_L r B_0 + \big(k_L(H_L) + q_L(H_L) - p_L(H_L)\big)\,B_1\Big),$$

and that for v by

$$(g_3)\quad v_L(H_L-1) = \lambda_L B_1 S_L(H_L)\Big/\Big(2\Delta_L r B_0 + \big(k_L(H_L) + q_L(H_L) - p_L(H_L)\big)\,B_1\Big)\;.$$

To check the computations we integrate the diffusion equation over each region R_ℓ.

$$\int_{R_\ell} (D_\ell\,\nabla\phi - \Sigma_\ell\phi + S)\,\frac{N\pi^{\frac{N}{2}}}{\Gamma\left(\frac{N}{2}+1\right)}\; r^{N-1}\,dr = 0$$

i.e.

$$0 = \left[\frac{N\pi^{\frac{N}{2}}D_\ell}{\Gamma\left(\frac{N}{2}+1\right)}\, r^{N-1}\,\frac{d}{dr}\,\phi\right]_{b_{\ell-1}}^{b_\ell} - \Sigma_\ell\frac{N\pi^{\frac{N}{2}}}{\Gamma\left(\frac{N}{2}+1\right)}\int_{b_{\ell-1}}^{b_\ell}\phi\cdot r^{N-1}\,dr + \frac{N\pi^{\frac{N}{2}}}{\Gamma\left(\frac{N}{2}+1\right)}\int_{b_{\ell-1}}^{b_\ell} S\cdot r^{N-1}\,dr$$

or

$$(i_1)\quad E_\ell - E_\ell' - \Sigma_\ell\frac{N\pi^{\frac{N}{2}}}{\Gamma\left(\frac{N}{2}+1\right)}\int_{b_{\ell-1}}^{b_\ell}\phi\cdot r\;dr + \frac{N\pi^{\frac{N}{2}}}{\Gamma\left(\frac{N}{2}+1\right)}\int_{b_{\ell-1}}^{b_\ell} S\cdot r^{N-1}\,dr = 0$$

where E_ℓ and E'_ℓ are the leakages radially outward thru the inner and outer interfaces (respectively) of R_ℓ. All integrals are computed trapezoidally, and the E's are given a difference approximation which makes (i_1) an algebraic identity as follows:

$$\int_{b_{\ell-1}}^{b_\ell} \nabla^2\phi \cdot r^{N-1}\,dr = \frac{\Delta_\ell r}{2}\,(r^{N-1}\nabla^2\phi)_{n_\ell(0)} + (r^{N-1}\nabla^2\phi)_{n_\ell(1)}\Delta_\ell r + \cdots$$

$$\cdots + \Delta_\ell r(r^{N-1}\nabla^2\phi)_{n_\ell(H_\ell-1)} + \frac{\Delta_\ell r}{2}\,(r^{N-1}\nabla^2\phi)_{n_\ell(H_\ell)} \quad .$$

But
$$(r^{N-1}\nabla^2\phi)_{n_\ell(h)} = \left(n_\ell(h)\Delta_\ell r\right)^{N-1}\frac{1}{(\Delta_\ell r)^2}\Big[p_\ell(h)\phi_\ell(h+1) - \left(p_\ell(h)+q_\ell(h)\right)\phi_\ell(h) + q_\ell(h)\,\phi_\ell(h-1)\Big]$$
$$= (\Delta_\ell r)^{N-3}\left[\left(n_\ell(h)+\tfrac{1}{2}\right)^{N-1}\left(\phi_\ell(h+1)-\phi_\ell(h)\right) - \left(n_\ell(h)-\tfrac{1}{2}\right)^{N-1}\left(\phi_\ell(h)-\phi_\ell(h-1)\right)\right]$$
$$= (\Delta_\ell r)^{N-3}\left[\left(n_\ell(h)+\tfrac{1}{2}\right)^{N-1}\left(\phi_\ell(h+1)-\phi_\ell(h)\right)\right]_{h-1}^{h}$$

Therefore

$$\sum_{h=1}^{H_\ell-1}\left(r^{N-1}\nabla^2\phi\right)_{n_\ell(h)}\Delta_\ell r = -(\Delta_\ell r)^{N-2}\left(n_\ell(0)+\tfrac{1}{2}\right)^{N-1}\left(\phi_\ell(1)-\phi_\ell(0)\right) + (\Delta_\ell r)^{N-2}\left(n_\ell(H_\ell)-\tfrac{1}{2}\right)^{N-1}\left(\phi_\ell(H_\ell)-\phi_\ell(H_\ell-1)\right),$$

and

$$\int_{b_{\ell-1}}^{b_\ell}\nabla^2\phi r^{N-1}dr = \left[\frac{\Delta_\ell r}{2}\left(r^{N-1}\nabla^2\phi\right)_{n_\ell(0)} - (\Delta_\ell r)^{N-2}\left(n_\ell(0)+\tfrac{1}{2}\right)^{N-1}\left(\phi_\ell(1)-\phi_\ell(0)\right)\right]$$
$$+\Big[\tfrac{1}{2}(\Delta_\ell r)^{N-2}\left(n_\ell(H_\ell)-\tfrac{1}{2}\right)^{N-1}\left(\phi_\ell(H_\ell)-\phi_\ell(H_\ell-1)\right) + \tfrac{1}{2}(\Delta_\ell r)^{N-2}\left(n_\ell(H_\ell)+\tfrac{1}{2}\right)^{N-1}\left(\phi_\ell(H_\ell+1)-\phi_\ell(H_\ell)\right)\Big].$$

So $$E'_\ell = -D_\ell \frac{N\pi^{\frac{N}{2}}}{\Gamma\left(\frac{N}{2}+1\right)} \frac{1}{2\Delta_\ell r}\left[(\Delta_\ell r)^{N-1}\left(n_\ell(H_\ell)-\tfrac{1}{2}\right)^{N-1}\left(\phi_\ell(H_\ell)-\phi_\ell(H_\ell-1)\right)\right.$$
$$\left.+(\Delta_\ell r)^{N-1}\left(n_\ell(H_\ell)+\tfrac{1}{2}\right)^{N-1}\left(\phi_\ell(H_\ell+1)-\phi_\ell(H_\ell)\right)\right]$$
$$= -D_\ell \frac{N\pi^{\frac{N}{2}}}{\Gamma\left(\frac{N}{2}+1\right)} r_\ell(H_\ell)^{N-1}\left[q_\ell(H_\ell)\left(\phi_\ell(H_\ell)-\phi_\ell(H_\ell-1)\right)+p_\ell(H_\ell)\left(\phi_\ell(H_\ell+1)-\phi_\ell(H_\ell)\right)\right]\frac{1}{2\Delta_\ell r}$$
$$= -D_\ell \frac{N\pi^{\frac{N}{2}}}{\Gamma\left(\frac{N}{2}+1\right)} r_\ell(H_\ell)^{N-1}\left[\left(k_\ell(H_\ell)+q_\ell(H_\ell)-p_\ell(H_\ell)\right)\phi_\ell(H_\ell)-2q_\ell(H_\ell)\,\phi_\ell(H_\ell-1)-\lambda_\ell S_\ell(H_\ell)\right]\frac{1}{2\Delta_\ell r}\ \left(\text{by } (d_1)\right).$$

Similarly, if $b_0 > 0$, then

$$E_\ell = -D_\ell \frac{N\pi^{\frac{N}{2}}}{\Gamma\left(\frac{N}{2}+1\right)} r_\ell(0)^{N-1}\left[\left(q_\ell(0)-p_\ell(0)-k_\ell(0)\right)\phi_\ell(0)+2p_\ell(0)\,\phi_\ell(1)\right.$$
$$\left.+\lambda_\ell S_\ell(0)\right]\frac{1}{2\Delta_\ell r}$$

On the other hand, if $b_0 = 0$, then we must use the formula

$$\left[\nabla^2\phi\right]_0 = \frac{N}{(\Delta_1 r)^2}\left[\phi_1(-1) - 2\phi_1(0) + \phi_1(1)\right]$$
$$= \frac{2N}{(\Delta_1 r)^2}\left[\phi_1(1) - \phi_1(0)\right] \qquad \left(\text{since } \phi_1(-1) = \phi_1(+1)\right).$$

Therefore

$$E_1 = D_1 \frac{N\pi^{\frac{N}{2}}}{\Gamma\left(\frac{N}{2}+1\right)}\left[\frac{\Delta_1 r}{2}\left(r^{N-1}\nabla^2\phi\right)_{r=0} - \frac{(\Delta_1 r)^{N-2}}{2^{N-1}}\left(\phi_1(1)-\phi_1(0)\right)\right]$$
$$= D_1 \frac{N\pi^{\frac{N}{2}}}{\Gamma\left(\frac{N}{2}+1\right)}\left[0 + \frac{(\Delta_1 r)^{N-2}}{2^{N-1}}\left(\phi_1(0)-\phi_1(1)\right)\right]$$
$$= D_1 \frac{N\pi^{\frac{N}{2}}}{\Gamma\left(\frac{N}{2}+1\right)} \frac{(\Delta_1 r)^{N-2}}{2^{N-1}}\left(\phi_1(0)-\phi_1(1)\right).$$

III. PREPARATION OF INPUT DATA

This program has been designed to accept the problem input from the standard SHARE symbolic coding form, (IBM Form 12-6809-1), and will be described in that format here. The input sheet for a sample problem has been included in Appendix A. SHARE subroutine NY INP1 is used.

In the listing that follows the quantities are listed either with or without a decimal point. If a decimal point is included it indicates the quantity specified must either contain its decimal point or be written in the standard floating point notation as a fraction and E followed by the base 10 exponent. For example, π may be written 3.14159 or .314159E1 or 31.4159E-1. In addition, when quantities are listed successively on a card, (or line), a comma must be used to separate items. The last item on the card, (or line), must not be followed by a comma.

LOCATION	OPERATION	ADDRESS, TAG, DECREMENT
1000	DEC	XX.YYYYY, J, L, N, R., P Here, XX.YYYYY is the problem number, XX = the problem originator's code number and YYYYY = the chronological problem identification. J = the number of energy groups included in the problem. L = the number of regions into which the problem is divided. N = the geometry of the problem, N=1 for a slab, N=2 for a cylinder, and N=3 for a sphere. R is the outer edge, (cm.), of the problem. P is the total number of intervals.

$$P = \sum_{\ell=1}^{L} H_\ell$$

LOCATION	OPERATION	ADDRESS, TAG, DECREMENT
	DEC	Δ_L., Δ_{L-1}., Δ_{L-2}., ..., Δ_1.

The Δ_ℓ value is the size of the interval spacing, (cm.), in region ℓ.

These values are given from the innermost region, ℓ=L, to the outermost, ℓ=1.

LOCATION	OPERATION	ADDRESS, TAG, DECREMENT
1106	DEC	$H_L, H_{L-1}, H_{L-2}, \ldots, H_1$

The H_ℓ value is the number of intervals into which region ℓ is subdivided for the solution. These are given from the innermost region, (ℓ =L), outward through region 1, the outermost region.

1206	DEC	$S_{L,H}., S_{L,H-1}., \ldots, S_{L,1}., S_{L,0}., S_{L-1,H}.,$ $\ldots, S_{\ell,h}., \ldots, S_{2,0}., S_{1,H}., S_{1,H-1}., \ldots, S_{1,0}.$

These are the lattice point source values to be used as the source value in the diffusion equation for the highest energy group, j = 1.

	TRA	3,4

This card always follows the specified general problem parameters and point source values.

Next, in ascending energy group order, the group-region parameters must be listed for each region from innermost, ℓ = L, to outermost, ℓ = 1. These are, in the SHARE coding form format:

LOCATION	OPERATION	ADDRESS, TAG, DECREMENT
2999	DEC	k., $d_0(L)$., D(L)., σ(L)., s(L)., $d_I(L)$.

These are the parameters for region L. k is the value to be used as the value of the flux at the inner edge of the region if the boundary condition, inner edge ϕ = k, was chosen. Otherwise, it is irrelevant and may be given as zero. d_0 is the boundary condition at the outer edge of the region and here the choice of interface boundary conditions is indicated. $d_0 > 0$ indicates d_0 is the extrapolation distance, (cm.), to be used for the "black boundary" condition. $d_0 < 0$, usually given as -1, is used if the flux and current are to be continuous across the interface. D (cm.) is

LOCATION	OPERATION	ADDRESS, TAG, DECREMENT
		the diffusion coefficient, σ (cm.$^{-1}$), the removal cross section, s, the transfer fraction, and d_I, the boundary condition at the inner boundary of the problem. If $d_I > 0$, then d_I represents the extrapolation distance of the "black boundary" condition and r at this boundary must be greater than zero. If $d_I=0$ the flux at this boundary is set equal to the value of k specified, or if $d_I < 0$, the derivative of the flux is set to zero.
		For regions ℓ=L-1, L-2,..., 2 the group-region input can be described generally as:
3ccc	DEC	$d_0(\ell)$., $D(\ell)$., $\sigma(\ell)$., $s(\ell)$., $d_I(\ell)$.
ccc=000+5(L-ℓ)		These parameters are as described for region L, except that since d_0 and d_I apply only to interior regions they can never equal zero and hence, no value of k is permitted. If d_0 or $d_I > 0$ their values are taken as the appropriate extrapolation distance value, d, (cm.), for the "black boundary" while if d_0 or $d_I < 0$, usually given as -1, the continuity of flux and current is preserved across the interface.
		For region $\ell = 1$ the only change comes in the specification of d_0 since this is the boundary condition indicator for the outer edge, r=R. Here, the value of $d_0 > 0$ corresponds to the "black boundary" extrapolation distance, d, (cm.), as before, d_0=0 indicates the flux is to go to zero at r=R, and $d_0 < 0$, usually given as -1, requires the cell condition, that is, the derivative of the flux equal zero at r=R. Obviously, in the case of a one region problem the description of the ℓ = L group-region parameters must be altered to permit d_0 to specify the r=R boundary condition rather than the interface condition.

LOCATION	OPERATION	ADDRESS, TAG, DECREMENT
		The group-region parameters for all regions for energy group 1 are followed by
	TRA	3,4

After this the group-region parameters for the next group are enumerated in the same manner, until the group-region parameters have been given for all J energy groups.

IV. OPERATING INSTRUCTIONS

This program requires an IBM 704 equipped with the 8K memory and input and output may be on or off-line determined by sense switch settings. No tapes are required although both an input and output tape may be used.

The standard 72-72 board is used in the card reader, the SHARE 2 board in the on-line printer. If tapes are available, tape 2 may be used as a BCD output unit, tape 3 for the BCD input unit. Sense switch 1 is down if card rather than tape input is to be used and sense switches 3 and 5 are down if on-line rather than tape output is desired.

A. Operating Procedure:

1. Mount tapes, if required, set tape selector switches and ready tape units.

2. Ready the printer.

3. Ready the binary program deck followed by problem input, if on cards, in card reader.

4. Clear and load cards.

5. STOP 6662_8. Problems are completed.

B. Program Stops (Octal):

4653 Illegal operation code specified on input data card.
5171 Out-of-range input data.
5452 Illegal punch in problem input card.
7766 "Black boundary" condition requested at inner edge and r=0.

C. Off-line Printing:

Tape 2, the output, should be printed on single space, off-line. An end of file follows each problem so that the paper may be restored, if desired.

V. OUTPUT INFORMATION

All of the input information is printed as well as the problem solution so that the problem originator will have a complete record of the problem for later reference and checking, if desired.

The problem solution provides a listing for each energy group, $j = 1,2,..,J$, of the radius and flux value at each lattice point from $r=R-\Delta_L H_L-\Delta_{L-1}H_{L-1}-\ldots-\Delta_1 H_1$, in steps of Δ_ℓ through each regionto $r = R$.

The integral of the flux, the leakage, and the value of the neutron balance check equation for each region is given, as is the value of the current at the outer boundary, $(r=R)$. In addition, if a "black boundary" condition was imposed at an interface the value of the current at this interface is computed and printed. If the current was not computed a zero is printed in that position.

An output listing for a sample problem is included as AppendixB. SHARE subroutine NY OUT1 is used.

APPENDIX A

Sample Problem Input

Share Symbolic Coding Form

Problem: RE 34 TEST PROBLEM

Coder: M. BUTLER | Date: 2-12-58 | Page 1 Of 1

H	Location	Op	Address, Tag Decrement	Identification
	1000	DEC	99.91234, 3, 3, 2, 30., 30	RE34T000
		DEC	1., 1., 1.	RE34T001
	1106	DEC	10, 5, 15	RE34T002
	1206	DEC	1., .95, .93, .90, .85, .83, .8, .79, .77, .75, .73	RE34T003
		DEC	.7, .6, .5, .4, .3, .2, .15, .14, .13, .12, .11, .1	RE34T004
		DEC	.08, .05, .03, .02, .01, .005, .001, .0005, .0003, .0002	RE34T005
		TRA	3, 4	RE34T006
	2999	DEC	0, -1., .06, .21, .2380952, -1.	RE34T007
	3005	DEC	-1., .025, .18, .3888889, -1.	RE34T008
	3010	DEC	0, .10, .24, .125, -1.	RE34T009
		TRA	3, 4	RE34T010
	2999	DEC	0, -1., .08, .19, .0263158, -1.	RE34T011
	3005	DEC	-1., .03, .16, .0625, -1.	RE34T012
	3010	DEC	0, .12, .22, .03636364, -1.	RE34T013
		TRA	3, 4	RE34T014
	2999	DEC	0, -1., .04, .33, 0, -1.	RE34T015
	3005	DEC	-1., .06, .30, 0, -1.	RE34T016
	3010	DEC	0, .08, .36, 0, -1.	RE34T017
		TRA	3, 4	RE34T018

APPENDIX B

Sample Problem Output

R.E. 34 PROBLEM 99.91234

J= 3 L= 3 N= 2 R= 30.000 P= 30

MESH SPACING

1.000000	1.000000	1.000000

POINTS PER REGION

10	5	15

POINT-WISE SOURCES

1.0000E 00	9.5000E-01	9.3000E-01	9.0000E-01	8.5000E-01	8.3000E-01	8.0000E-01	7.9000E-01	7.7000E-01	7.5000E-01
7.3000E-01	7.0000E-01	6.0000E-01	5.0000E-01	4.0000E-01	3.0000E-01	2.0000E-01	1.5000E-01	1.4000E-01	1.3000E-01
1.2000E-01	1.1000E-01	10.0000E-02	8.0000E-02	5.0000E-02	3.0000E-02	2.0000E-02	10.0000E-03	5.0000E-03	10.0000E-04
5.0000E-04	3.0000E-04	2.0000E-04							

GROUP-REGION PARAMETERS

K= 0.

D OUT	DIFF. COEF.	SIGMA	TRANSFER	D IN
-1.0000E 00	6.0000E-02	2.1000E-01	2.3810E-01	-1.0000E 00
-1.0000E 00	2.5000E-02	1.8000E-01	3.8889E-01	-1.0000E 00
0.	10.0000E-02	2.4000E-01	1.2500E-01	-1.0000E 00

J= 1

RADIUS	FLUX	FLUX INTEGRAL	LEAKAGE	CURRENT	BAL CK
0.	4.6214E 00				
1.000	4.4985E 00				
2.000	4.3986E 00				
3.000	4.2548E 00				

4.000	4.0593E 00				
5.000	3.9436E 00				
6.000	3.8208E 00				
7.000	3.7536E 00				
8.000	3.6680E 00				
9.000	3.5969E 00				
10.000	3.6176E 00	1.2002E 03	-1.0076E 00	0.	1.9073E-06
10.000	3.6176E 00				
11.000	3.2986E 00				
12.000	2.7680E 00				
13.000	2.2124E 00				
14.000	1.6294E 00				
15.000	8.2801E-01	9.1340E 02	4.2268E 00	0.	3.8147E-06
15.000	8.2801E-01				
16.000	6.2975E-01				
17.000	5.5155E-01				
18.000	5.0084E-01				
19.000	4.5483E-01				
20.000	4.0300E-01				
21.000	3.2168E-01				

```
 22.000  2.1683E-01

 23.000  1.3657E-01

 24.000  8.6896E-02

 25.000  4.7627E-02

 26.000  2.3921E-02

 27.000  8.3812E-03

 28.000  3.3373E-03

 29.000  1.4272E-03

 30.000  0.           4.4174E 02  4.5304E-02  2.4034E-04  -0.


GROUP-REGION  PARAMETERS
 K=    0.
    D OUT     DIFF. COEF.   SIGMA       TRANSFER       D IN
 -1.0000E 00  8.0000E-02  1.9000E-01  2.6316E-02 -1.0000E 00
 -1.0000E 00  3.0000E-02  1.6000E-01  6.2500E-02 -1.0000E 00
  0.          1.2000E-01  2.2000E-01  3.6364E-02 -1.0000E 00


  RADIUS        FLUX     FLUX INTEGRAL  LEAKAGE     CURRENT    BAL  CK

     0.      1.1882E 00

     1.000   1.1716E 00

     2.000   1.1467E 00

     3.000   1.1112E 00
```

4.000	1.0687E 00				
5.000	1.0368E 00				
6.000	1.0084E 00				
7.000	9.9090E-01				
8.000	9.8264E-01				
9.000	1.0142E 00				
10.000	1.1946E 00	3.2802E 02	-2.3093E 00	0.	-4.7684E-07
10.000	1.1946E 00				
11.000	1.3756E 00				
12.000	1.1964E 00				
13.000	9.5645E-01				
14.000	6.7546E-01				
15.000	2.2117E-01	3.7077E 02	2.3054E 00	0.	4.7684E-07
15.000	2.2117E-01				
16.000	1.1994E-01				
17.000	8.5389E-02				
18.000	7.0943E-02				
19.000	6.1999E-02				
20.000	5.3472E-02				
21.000	4.2711E-02				

22.000	3.0382E-02					
23.000	2.0063E-02					
24.000	1.2766E-02					
25.000	7.4132E-03					
26.000	3.9214E-03					
27.000	1.7474E-03					
28.000	7.4047E-04					
29.000	2.8291E-04					
30.000	0.	7.0688E 01	6.2927E-03	3.3384E-05	8.3447E-07	

GROUP-REGION PARAMETERS

K= 0.

D OUT	DIFF. COEF.	SIGMA	TRANSFER	D IN
-1.0000E 00	4.0000E-02	3.3000E-01	0.	-1.0000E 00
-1.0000E 00	6.0000E-02	3.0000E-01	0.	-1.0000E 00
0.	8.0000E-02	3.6000E-01	0.	-1.0000E 00

J= 3

RADIUS	FLUX	FLUX INTEGRAL	LEAKAGE	CURRENT	BAL CK
0.	1.7903E-02				
1.000	1.7697E-02				
2.000	1.7329E-02				
3.000	1.6804E-02				
4.000	1.6192E-02				

5.000	1.5706E-02				
6.000	1.5293E-02				
7.000	1.5048E-02				
8.000	1.5101E-02				
9.000	1.6800E-02				
10.000	2.9523E-02	5.4210E 00	-1.4880E-01	0.	2.9802E-08
10.000	2.9523E-02				
11.000	4.2599E-02				
12.000	3.8977E-02				
13.000	3.1316E-02				
14.000	2.1499E-02				
15.000	7.4552E-03	1.1611E 01	7.5600E-02	0.	1.4901E-07
15.000	7.4552E-03				
16.000	3.2831E-03				
17.000	2.0602E-03				
18.000	1.6181E-03				
19.000	1.3823E-03				
20.000	1.1784E-03				
21.000	9.4131E-04				
22.000	6.8087E-04				

23.000	4.5709E-04				
24.000	2.9239E-04				
25.000	1.7277E-04				
26.000	9.3293E-05				
27.000	4.3974E-05				
28.000	1.9172E-05				
29.000	7.2512E-06				
30.000	0.	1.7805E 00	1.0752E-04	5.7043E-07	2.2352E-08

APPENDIX C

SHARE Assembly Program Listing

```
                      04573           ORG 2427                                                   RE34SR00
                      04573    INP1   LIB                                                        RE34LIB3
                      00613           ORG 395                                                    RE34SR02
                      00613    OUT1   LIB                                                        RE34LIB4
                      06654           ORG 3500                                                   RE340000
                      06654   P       HED                                                        RE340001
                      04573    INP1   SYN I$INP1                                                 RE340002
                      00613    OUT1   SYN O$OUT1                                                 RE340003
06654   0 76600 0 00361               WPR              SELECT PRINTER                            RE340004
06655   0 76000 0 00165               SWT 5    IS SENSE SWITCH 5 DOWN  TAPE OUTPUT OR NOT        RE340005
06656   0 02000 0 10153               TRA TAPE                                                   RE340006
06657   0 76000 0 00361               SPR 1        SENSE PRINTER EXIT HUB ONE                    RE340007
06660   0 07400 4 04573    IO         TSX INP1,4 READ IN PROBLEM PARAMETERS AND SOURCES          RE340008
06661   0 00000 0 01750                   1000,0,0                                               RE340009
06662   0 42000 0 04622               HPR INP1+23                                                RE340010
06663   0 50000 0 04402               CLA 2306 1 GOES TO J                                       RE340011
06664   0 60100 0 17527               STO 8023                                                   RE340012
06665   0 50000 0 01752               CLA 1002 SET UP PRINT ORDER FOR PROBLEM PARAMETERS,MESH SPACINGS RE340013
06666   0 76700 0 00022               ALS 18                                                     RE340014
06667   0 40000 0 10147               ADD PD1                                                    RE340015
06670   0 60100 0 06711               STO IO+25                                                  RE340016
06671   0 50000 0 01752               CLA 1002 SET UP PRINT ORDER FOR POINTS PER REGION          RE340017
06672   0 76700 0 00022               ALS 18                                                     RE340018
06673   0 40000 0 10150               ADD PD2                                                    RE340019
06674   0 60100 0 06713               STO IO+27                                                  RE340020
06675   0 50000 0 01752               CLA 1002 SET UP PRINT ORDER FOR GROUP 1 SOURCES            RE340021
06676   0 40000 0 01755               ADD 1005                                                   RE340022
06677   0 76700 0 00022               ALS 18                                                     RE340023
06700   0 40000 0 10151               ADD PD3                                                    RE340024
06701   0 60100 0 06715               STO IO+29                                                  RE340025
06702   0 50000 0 01752               CLA 1002 SET UP PRINT ORDER FOR GROUP-REGION PARAMETERS    RE340026
06703   0 76700 0 00002               ALS 2                                                      RE340027
06704   0 40000 0 01752               ADD 1002                                                   RE340028
06705   0 76700 0 00022               ALS 18                                                     RE340029
06706   0 40000 0 10152               ADD PD4                                                    RE340030
06707   0 60100 0 06755               STO I1+20                                                  RE340031
06710   0 07400 4 10022               TSX P1,4 PRINT PROBLEM PARAMETERS, MESH SPACINGS           RE340032
06711   0 01755 0 01750                   1000,0,1005                                            RE340033
06712   0 07400 4 10046               TSX P2,4 PRINT POINTS PER REGION                           RE340034
```

```
06713  0 02121 0 02122              1106,0,1105                                      RE340035
06714  0 07400 4 10055          TSX P3,4 PRINT GROUP ONE SOURCES                     RE340036
06715  0 02265 0 02266              1206,0,1205                                      RE340037
06716  0 50000 0 04407          CLA 2311 2 GOES TO ALPHA N                           RE340038
06717  0 60100 0 17500          STO 8000                                             RE340039
06720  0 50000 0 04403          CLA 2307                                             RE340040
06721  0 34000 0 01753          CAS 1003                                             RE340041
06722  0 02000 0 06731          TRA I1 SLAB                                          RE340042
06723  0 02000 0 07177          TRA CYL CYLINDER                                     RE340043
06724  0 40200 0 01753          SUB 1003                                             RE340044
06725  0 40000 0 04402          ADD 2306                                             RE340045
06726 -0 10000 0 07233          TNZ I10 N GREATER THAN 3                             RE340046
06727  0 50000 0 04567          CLA 2423 SPHERE                                      RE340047
06730  0 60100 0 17500          STO 8000                                             RE340048
06731  0 50000 0 01752    I1    CLA 1002                                             RE340049
06732  0 76000 0 00006          COM                                                  RE340050
06733  0 40000 0 04402          ADD 2306                                             RE340051
06734  0 73400 1 00000          PAX 0,1 BAR L GOES TO A REGISTER                     RE340052
06735  0 50000 0 01755          CLA 1005                                             RE340053
06736  0 40000 0 01752          ADD 1002                                             RE340054
06737  0 76000 0 00006          COM                                                  RE340055
06740  0 40000 0 04402          ADD 2306                                             RE340056
06741  0 73400 2 00000          PAX 0,2 BAR P+L GOES TO B REGISTER                   RE340057
06742  0 50000 0 01752          CLA 1002                                             RE340058
06743  0 76700 0 00002          ALS 2                                                RE340059
06744  0 40000 0 01752          ADD 1002                                             RE340060
06745  0 76000 0 00006          COM                                                  RE340061
06746  0 40000 0 04402          ADD 2306                                             RE340062
06747  0 73400 4 00000          PAX 0,4 BAR 5L GOES TO C REGISTER                    RE340063
06750 -0 63400 4 17520          SXD 8016,4 SAVE C REGISTER                           RE340064
06751  0 07400 4 04573          TSX INP1,4 READ IN GROUP-REGION PARAMETERS           RE340065
06752  0 00000 0 05667              2999,0,0                                         RE340066
06753  0 42000 0 04622          HPR INP1+23                                          RE340067
06754  0 07400 4 10065          TSX P4,4 PRINT GROUP-REGION PARAMETERS               RE340068
06755  0 05667 0 05667              2999,0,2999                                      RE340069
06756  0 07400 4 10112          TSX P5,4 PRINT J AND FORMAT                          RE340070
06757  0 17527 0 17527              8023,0,8023                                      RE340071
06760 -0 53400 4 17520          LXD 8016,4 REPLACE C REGISTER                        RE340072
06761  0 50000 0 17501    I2    CLA 8001                                             RE340073
06762  0 60100 0 17520          STO 8016 G1 OF L-1 GOES TO TEMP 1                    RE340074
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06763  0 50000 1 02121          CLA 1105,1                               RE340075
06764  0 60100 0 17505          STO 8005 H SUB L GOES TO H               RE340076
06765  0 56000 1 01755          LDQ 1005,1 COMPUTE G2                    RE340077
06766  0 26000 1 01755          FMP 1005,1 DELTA SQUARED                 RE340078
06767  0 24000 4 05664          FDH 2996,4 DIVIDED BY D                  RE340079
06770 -0 60000 0 17501          STQ 8001                                 RE340080
06771  0 26000 0 04405          FMP 2309 TIMES 1/2                       RE340081
06772  0 60100 0 17502          STO 8002                                 RE340082
06773  0 56000 0 17501          LDQ 8001 COMPUTE G1                      RE340083
06774  0 26000 4 05665          FMP 2997,4                               RE340084
06775  0 60100 0 17501          STO 8001                                 RE340085
06776  0 50000 4 05663          CLA 2995,4 COMPUTE G4                    RE340086
06777  0 24000 1 01755          FDH 1005,1                               RE340087
07000 -0 60000 0 17504          STQ 8004                                 RE340088
07001  0 50000 0 04406          CLA 2310 1 GOES TO QL,0                  RE340089
07002  0 60100 0 17511          STO 8009                                 RE340090
07003 -0 63400 4 17521          SXD 8017,4                               RE340091
07004  0 50000 0 01753          CLA 1003 CALCULATION OF QL,0             RE340092
07005  0 40200 0 04402          SUB 2306                                 RE340093
07006  0 73400 4 00000          PAX 0,4 N-1 GOES TO C REG                RE340094
07007  0 10000 0 07023          TZE I3                                   RE340095
07010  0 50200 1 01755          CLS 1005,1 -DELTA                        RE340096
07011  0 24000 0 01754          FDH 1004 DIVIDED BY R                    RE340097
07012  0 26000 0 04405          FMP 2309 TIMES 1/2                       RE340098
07013  0 30000 0 04406          FAD 2310 PLUS 1                          RE340099
07014  0 60100 0 17511          STO 8009                                 RE340100
07015  0 60100 0 17522          STO 8018                                 RE340101
07016 -2 00001 4 07023          TNX I3,4,1                               RE340102
07017  0 56000 0 17511          LDQ 8009                                 RE340103
07020  0 26000 0 17522          FMP 8018                                 RE340104
07021  0 60100 0 17511          STO 8009                                 RE340105
07022  0 02000 0 07016          TRA I2+29                                RE340106
07023  0 56000 0 17501    I3    LDQ 8001 CALCULATION OF F1               RE340107
07024  0 26000 0 04405          FMP 2309                                 RE340108
07025  0 30000 0 17511          FAD 8009                                 RE340109
07026  0 60100 0 17513          STO 8011                                 RE340110
07027 -0 53400 4 17521          LXD 8017,4                               RE340111
07030 -0 75400 1 00000          PXD 0,1                                  RE340112
07031  0 77100 0 00022          ARS 18                                   RE340113
07032  0 40000 0 01752          ADD 1002                                 RE340114
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07033  0 76700 0 00030         ALS 24                                                   RE340115
07034  0 10000 0 07211         TZE I4 GO TO I4 IF REGION 1                              RE340116
07035  0 50000 1 01755         CLA 1005,1 COMPUTE G3                                    RE340117
07036  0 24000 1 01756         FDH 1006,1                                               RE340118
07037  0 26000 4 05671         FMP 3001,4                                               RE340119
07040  0 24000 4 05664         FDH 2996,4                                               RE340120
07041 -0 60000 0 17503         STQ 8003                                                 RE340121
07042  0 50000 4 05674         CLA 3004,4                                               RE340122
07043  0 12000 0 07216         TPL I6 GO TO I6 IF DI, L-1 ZERO OR POSITIVE              RE340123
07044  0 56000 0 17520   I5    LDQ 8016 COMPUTE U L,1                                   RE340124
07045  0 26000 0 04405         FMP 2309                                                 RE340125
07046  0 30000 0 17514         FAD 8012                       PLUS F2                   RE340126
07047  0 76500 0 00043         LRS 35                                                   RE340127
07050  0 26000 0 17503         FMP 8003                                                 RE340128
07051  0 30000 0 17513         FAD 8011                                                 RE340129
07052  0 60100 0 17521         STO 8017                                                 RE340130
07053  0 50000 0 17511         CLA 8009                                                 RE340131
07054  0 24000 0 17521         FDH 8017                                                 RE340132
07055 -0 60000 2 13556         STQ 5998,2                                               RE340133
07056  0 50000 1 01756         CLA 1006,1 COMPUTE V L,1                                 RE340134
07057  0 24000 1 01755         FDH 1005,1                                               RE340135
07060  0 26000 2 02266         FMP 1206,2                                               RE340136
07061  0 30000 2 02265         FAD 1205,2                                               RE340137
07062  0 76500 0 00043         LRS 35                                                   RE340138
07063  0 26000 0 17502         FMP 8002                                                 RE340139
07064  0 60100 0 17521         STO 8017                                                 RE340140
07065  0 56000 0 17515         LDQ 8013                                                 RE340141
07066  0 26000 0 17503         FMP 8003                                                 RE340142
07067  0 30000 0 17521         FAD 8017                                                 RE340143
07070  0 76500 0 00043         LRS 35                                                   RE340144
07071  0 26000 2 13556         FMP 5998,2                                               RE340145
07072  0 24000 0 17511         FDH 8009                                                 RE340146
07073 -0 60000 2 15526         STQ 6998,2                                               RE340147
07074  1 00001 2 07075   I8    TXI I8+1,2,1 B REGISTER PLUS 1 GOES TO B REGISTER        RE340148
07075  0 50000 1 01755         CLA 1005,1                                               RE340149
07076  0 24000 0 04407         FDH 2311                                                 RE340150
07077  0 50000 0 01754         CLA 1004 R-DELTA R GOES TO R                             RE340151
07100  0 30200 1 01755         FSB 1005,1                                               RE340152
07101  0 60100 0 01754         STO 1004                                                 RE340153
07102  0 04000 0 07104         TLQ I8+8                                                 RE340154
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07103  0 02000 0 07305        TRA 016 R EQUAL ZERO                                             RE340155
07104  0 50000 0 04406        CLA 2310 COMPUTE P L,H AND Q L,H                                 RE340156
07105  0 60100 0 17511        STO 8009                                                         RE340157
07106  0 60100 0 17512        STO 8010                                                         RE340158
07107 -0 63400 4 17521        SXD 8017,4                                                       RE340159
07110  0 50000 0 01753        CLA 1003                                                         RE340160
07111  0 40200 0 04402        SUB 2306                                                         RE340161
07112  0 73400 4 00000        PAX 0,4                                                          RE340162
07113  0 10000 0 07137        TZE I8+35                                                        RE340163
07114  0 50200 1 01755        CLS 1005,1                                                       RE340164
07115  0 24000 0 01754        FDH 1004                                                         RE340165
07116  0 26000 0 04405        FMP 2309                                                         RE340166
07117  0 60100 0 17520        STO 8016                                                         RE340167
07120  0 30000 0 04406        FAD 2310                                                         RE340168
07121  0 60100 0 17511        STO 8009                                                         RE340169
07122  0 60100 0 17522        STO 8018                                                         RE340170
07123  0 50000 0 04406        CLA 2310                                                         RE340171
07124  0 30200 0 17520        FSB 8016                                                         RE340172
07125  0 60100 0 17512        STO 8010                                                         RE340173
07126  0 60100 0 17520        STO 8016                                                         RE340174
07127 -2 00001 4 07137        TNX I8+35,4,1                                                    RE340175
07130  0 56000 0 17511        LDQ 8009                                                         RE340176
07131  0 26000 0 17522        FMP 8018                                                         RE340177
07132  0 60100 0 17511        STO 8009                                                         RE340178
07133  0 56000 0 17512        LDQ 8010                                                         RE340179
07134  0 26000 0 17520        FMP 8016                                                         RE340180
07135  0 60100 0 17512        STO 8010                                                         RE340181
07136  0 02000 0 07127        TRA I8+27                                                        RE340182
07137 -0 53400 4 17521        LXD 8017,4                                                       RE340183
07140  0 50000 0 04406        CLA 2310 COMPUTE F2                                              RE340184
07141  0 30200 2 13557        FSB 5999,2                                                       RE340185
07142  0 76500 0 00043        LRS 35                                                           RE340186
07143  0 26000 0 17512        FMP 8010                                                         RE340187
07144  0 60100 0 17514        STO 8012                                                         RE340188
07145  0 56000 2 15527        LDQ 6999,2                    COMPUTE F3                         RE340189
07146  0 26000 0 17512        FMP 8010                                                         RE340190
07147  0 60100 0 17515        STO 8013                                                         RE340191
07150  0 50000 0 17505        CLA 8005 H-1 GOES TO H                                           RE340192
07151  0 40200 0 04402        SUB 2306                                                         RE340193
07152  0 60100 0 17505        STO 8005                                                         RE340194
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07153  0 10000 0 07201          TZE I9                                      RE340195
07154  0 50000 0 17511          CLA 8009 COMPUTE U L, H+1                   RE340196
07155  0 30000 0 17501          FAD 8001                                    RE340197
07156  0 30000 0 17514          FAD 8012                                    RE340198
07157  0 60100 0 17520          STO 8016                                    RE340199
07160  0 50000 0 17511          CLA 8009                                    RE340200
07161  0 24000 0 17520          FDH 8016                                    RE340201
07162 -0 60000 2 13556          STQ 5998,2                                  RE340202
07163  0 50000 2 13556          CLA 5998,2          COMPUTE  V  L,H+1       RE340203
07164  0 24000 0 17511          FDH 8009                                    RE340204
07165 -0 60000 0 17520          STQ 8016                                    RE340205
07166  0 50000 0 17502          CLA 8002                                    RE340206
07167  0 30000 0 17502          FAD 8002                                    RE340207
07170  0 76500 0 00043          LRS 35                                      RE340208
07171  0 26000 2 02265          FMP 1205,2                                  RE340209
07172  0 30000 0 17515          FAD 8013                                    RE340210
07173  0 76500 0 00043          LRS 35                                      RE340211
07174  0 26000 0 17520          FMP 8016                                    RE340212
07175  0 60100 2 15526          STO 6998,2                                  RE340213
07176  0 02000 0 07074          TRA I8                                      RE340214
07177  0 50000 0 04566    CYL   CLA 2422                                    RE340215
07200  0 02000 0 06730          TRA I1-1                                    RE340216
07201 -0 75400 1 00000    I9    PXD 0,1 TEST FOR LAST REGION                RE340217
07202  0 77100 0 00022          ARS 18                                      RE340218
07203  0 40000 0 04402          ADD 2306                                    RE340219
07204  0 76700 0 00030          ALS 24                                      RE340220
07205  0 10000 0 07305          TZE 016                                     RE340221
07206  1 00005 4 07207          TXI I9+6,4,5 C REG PLUS 5 GOES TO C REG     RE340222
07207  1 00001 2 07210          TXI I9+7,2,1 B REG PLUS 1 GOES TO B REG     RE340223
07210  1 00001 1 06761          TXI I2,1,1 A REG PLUS 1 GOES TO A REG       RE340224
07211  0 50000 4 05663    I4    CLA 2995,4 IS D O OF REGION 1 POSITIVE      RE340225
07212  0 12000 0 07216          TPL I6                                      RE340226
07213  0 50000 0 17511          CLA 8009                                    RE340227
07214  0 24000 0 17513          FDH 8011                                    RE340228
07215  0 02000 0 07225          TRA I7-1                                    RE340229
07216  0 56000 0 17504    I6    LDQ 8004 COMPUTE U L,1                      RE340230
07217  0 26000 0 17513          FMP 8011                                    RE340231
07220  0 30000 0 04406          FAD 2310                                    RE340232
07221  0 60100 0 17520          STO 8016                                    RE340233
07222  0 56000 0 17511          LDQ 8009                                    RE340234
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07223  0 26000 0 17504        FMP 8004                                                 RE340235
07224  0 24000 0 17520        FDH 8016                                                 RE340236
07225 -0 60000 2 13556        STQ 5998,2                                               RE340237
07226  0 26000 0 17502  I7    FMP 8002                                                 RE340238
07227  0 24000 0 17511        FDH 8009                                                 RE340239
07230  0 26000 2 02265        FMP 1205,2                                               RE340240
07231  0 60100 2 15526        STO 6998,2                                               RE340241
07232  0 02000 0 07074        TRA I8                                                   RE340242
07233  0 50000 0 04404  I10   CLA 2308 3 GOES TO TEMP 1                                RE340243
07234  0 60100 0 17520        STO 8016                 ALPHA N CALCULATION             RE340244
07235  0 53400 4 04404        LXA 2308,4               3 GOES TO C REGISTER            RE340245
07236  0 56000 0 04566        LDQ 2422 2 PI GOES TO MQ                                 RE340246
07237  0 26000 4 04571        FMP 2425,4 TIMES ALPHA N-2                               RE340247
07240  0 24000 4 04412        FDH 2314,4 DIVIDED BY N-2                                RE340248
07241 -0 60000 4 04573        STQ 2427,4 GOES TO ALPHA N                               RE340249
07242 -0 60000 0 17500        STQ 8000                                                 RE340250
07243  0 50000 0 17520        CLA 8016                                                 RE340251
07244  0 40000 0 04402        ADD 2306                                                 RE340252
07245  0 60100 0 17520        STO 8016                                                 RE340253
07246  0 40200 0 01753        SUB 1003 IS THIS N OF PROBLEM                            RE340254
07247  0 10000 0 06731        TZE I1 YES                                               RE340255
07250  2 00001 4 07236        TIX I10+3,4,1 NO                                         RE340256
07251  0 00000 0 07251        HTR I10+14 N GREATER THAN 6                              RE340257
07252  0 50000 0 04406  OO    CLA 2310 COMPUTE P L,H                                   RE340258
07253  0 60100 0 17512        STO 8010                                                 RE340259
07254 -0 63400 4 17521        SXD 8017,4                                               RE340260
07255  0 50000 0 01753        CLA 1003                                                 RE340261
07256  0 40200 0 04402        SUB 2306                                                 RE340262
07257  0 73400 4 00000        PAX 0,4                                                  RE340263
07260  0 10000 0 07274        TZE OO+18                                                RE340264
07261  0 50000 1 01755        CLA 1005,1                                               RE340265
07262  0 24000 0 01754        FDH 1004                                                 RE340266
07263  0 26000 0 04405        FMP 2309                                                 RE340267
07264  0 30000 0 04406        FAD 2310                                                 RE340268
07265  0 60100 0 17512        STO 8010                                                 RE340269
07266  0 60100 0 17522        STO 8018                                                 RE340270
07267 -2 00001 4 07274        TNX OO+18,4,1                                            RE340271
07270  0 56000 0 17512        LDQ 8010                                                 RE340272
07271  0 26000 0 17522        FMP 8018                                                 RE340273
07272  0 60100 0 17512        STO 8010                                                 RE340274
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07273  0 02000 0 07267          TRA 00+13                                             RE340275
07274 -0 53400 4 17521          LXD 8017,4 COMPUTE F2                                 RE340276
07275  0 50000 0 04406          CLA 2310                                              RE340277
07276  0 30200 2 13557          FSB 5999,2                                            RE340278
07277  0 76500 0 00043          LRS 35                                                RE340279
07300  0 26000 0 17512          FMP 8010                                              RE340280
07301  0 60100 0 17514          STO 8012                                              RE340281
07302  0 56000 0 17512          LDQ 8010 COMPUTE F3                                   RE340282
07303  0 26000 2 15527          FMP 6999,2                                            RE340283
07304  0 60100 0 17515          STO 8013                                              RE340284
07305 -0 75400 0 00000T  016    PXD 0,0 ZERO TO INTEGRALS                             RE340285
07306  0 60100 0 17506          STO 8006                                              RE340286
07307  0 60100 0 17525          STO 8021                                              RE340287
07310  0 50000 1 02121          CLA 1105,1 H L GOES TO H                              RE340288
07311  0 60100 0 17505          STO 8005                                              RE340289
07312  0 56000 1 01755          LDQ 1005,1 COMPUTE G2                                 RE340290
07313  0 26000 1 01755          FMP 1005,1                                            RE340291
07314  0 24000 4 05664          FDH 2996,4                                            RE340292
07315  0 26000 0 04405          FMP 2309                                              RE340293
07316  0 60100 0 17502          STO 8002                                              RE340294
07317  0 76500 0 00043          LRS 35 COMPUTE G1/2                                   RE340295
07320  0 26000 4 05665          FMP 2997,4                                            RE340296
07321  0 60100 0 17501          STO 8001                                              RE340297
07322 -3 77776 1 07741          TXL 03,1,32766            IS THIS INNERMOST REGION    RE340298
07323  0 50000 4 05667   01     CLA 2999,4 YES, IS DI EQUAL ZERO                      RE340299
07324 -0 10000 0 07723          TNZ 02                                                RE340300
07325  0 50000 0 05667          CLA 2999 K GOES TO FLUX L,H                           RE340301
07326  0 60100 0 17507          STO 8007                                              RE340302
07327  0 50000 0 17507   06     CLA 8007                  COMPUTE F4, F5              RE340303
07330  0 60100 0 17517          STO 8015                                              RE340304
07331  0 50000 2 02265          CLA 1205,2                                            RE340305
07332  0 60100 0 17516          STO 8014                                              RE340306
07333 -0 63400 4 17521          SXD 8017,4                SAVE C INDEX                RE340307
07334  0 50000 0 01753          CLA 1003                                              RE340308
07335  0 40200 0 04402          SUB 2306                                              RE340309
07336  0 73400 4 00000          PAX 0,4                                               RE340310
07337  0 10000 0 07347          TZE 06+16                                             RE340311
07340  0 56000 0 01754          LDQ 1004                                              RE340312
07341  0 26000 0 17517          FMP 8015                                              RE340313
07342  0 60100 0 17517          STO 8015                                              RE340314
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07343  0 56000 0 01754          LDQ 1004                                                RE340315
07344  0 26000 0 17516          FMP 8014                                                RE340316
07345  0 60100 0 17516          STO 8014                                                RE340317
07346  2 00001 4 07340          TIX 06+9,4,1                                            RE340318
07347 -0 53400 4 17521          LXD 8017,4                                              RE340319
07350  0 50000 0 01754          CLA 1004                                                RE340320
07351  0 30200 1 01755          FSB 1005,1                                              RE340321
07352  0 60100 0 17522          STO 8018                                                RE340322
07353  0 76100 0 00000          NOP                                                     RE340323
07354  0 76100 0 00000          NOP                                                     RE340324
07355  0 50000 0 17505          CLA 8005 ACCUMULATE INTEGRALS                           RE340325
07356  0 10000 0 07361          TZE 06+26 IS THIS INNER EDGE OF REGION                  RE340326
07357  0 40200 1 02121          SUB 1105,1                                              RE340327
07360 -0 10000 0 07367          TNZ 06+32 IS THIS OUTER EDGE OF REGION                  RE340328
07361  0 56000 0 17517          LDQ 8015                                                RE340329
07362  0 26000 0 04405          FMP 2309                                                RE340330
07363  0 60100 0 17517          STO 8015                                                RE340331
07364  0 56000 0 17516          LDQ 8014                                                RE340332
07365  0 26000 0 04405          FMP 2309                                                RE340333
07366  0 60100 0 17516          STO 8014                                                RE340334
07367  0 50000 0 17517          CLA 8015                                                RE340335
07370  0 30000 0 17506          FAD 8006                                                RE340336
07371  0 60100 0 17506          STO 8006                                                RE340337
07372  0 50000 0 17516          CLA 8014                                                RE340338
07373  0 30000 0 17525          FAD 8021                                                RE340339
07374  0 60100 0 17525          STO 8021                                                RE340340
07375  0 50000 0 17505          CLA 8005                                                RE340341
07376  0 40200 1 02121          SUB 1105,1                                              RE340342
07377  0 40000 0 04402          ADD 2306                                                RE340343
07400 -0 10000 0 07435          TNZ 07+1                                                RE340344
07401 -3 77776 1 07667          TXL 012,1,32766                                         RE340345
07402  0 50000 0 01753          CLA 1003                                                RE340346
07403  0 40200 0 04402          SUB 2306                                                RE340347
07404  0 10000 0 07667          TZE 012                                                 RE340348
07405  0 50000 1 01755          CLA 1005,1                                              RE340349
07406  0 24000 0 04407          FDH 2311                                                RE340350
07407  0 50000 0 17522          CLA 8018                                                RE340351
07410  0 04000 0 07667          TLQ 012                                                 RE340352
07411  0 50000 0 17510          CLA 8008 FOR R OF 0, COMPUTE EI FOR INNERMOST REGION    RE340353
07412  0 30200 0 17507          FSB 8007                                                RE340354
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07413  0 24000 0 04407        FDH 2311                                                  RE340355
07414  0 26000 0 17500        FMP 8000                                                  RE340356
07415  0 76500 0 00043        LRS 35                                                    RE340357
07416  0 26000 4 05664        FMP 2996,4                                                RE340358
07417  0 60100 0 17523        STO 8019                                                  RE340359
07420  0 50000 1 01755        CLA 1005,1                                                RE340360
07421  0 24000 0 04407        FDH 2311                                                  RE340361
07422 -0 60000 0 17520        STQ 8016                                                  RE340362
07423 -0 63400 4 17521        SXD 8017,4                                                RE340363
07424  0 50000 0 01753        CLA 1003                                                  RE340364
07425  0 40200 0 04403        SUB 2307                                                  RE340365
07426  0 73400 4 00000        PAX 0,4                                                   RE340366
07427  0 10000 0 07434        TZE 07                                                    RE340367
07430  0 56000 0 17523        LDQ 8019 DELTA/2 TIMES E0                                 RE340368
07431  0 26000 0 17520        FMP 8016                                                  RE340369
07432  0 60100 0 17523        STO 8019                                                  RE340370
07433  2 00001 4 07426        TIX 06+63,4,1                                             RE340371
07434 -0 53400 4 17521   07   LXD 8017,4                                                RE340372
07435  0 50000 2 02265        CLA 1205,2 S L,H GOES TO S+                               RE340373
07436  0 60100 0 04415        STO 2317                                                  RE340374
07437  0 56000 0 17507        LDQ 8007 COMPUTE POINT SOURCE FOR NEXT GROUP              RE340375
07440  0 26000 4 05665        FMP 2997,4                                                RE340376
07441  0 76500 0 00043        LRS 35                                                    RE340377
07442  0 26000 4 05666        FMP 2998,4                                                RE340378
07443  0 60100 2 02265        STO 1205,2                                                RE340379
07444  0 50000 0 17505        CLA 8005 IS H ZERO                                        RE340380
07445  0 10000 0 07473        TZE 08                                                    RE340381
07446  0 40200 0 04402        SUB 2306 H-1 GOES TO H                                    RE340382
07447  0 60100 0 17505        STO 8005                                                  RE340383
07450  1 77777 2 07451        TXI 09,2,32767            B REG-1 GOES TO B REG           RE340384
07451 -0 63400 4 17520   09   SXD 8016,4                                                RE340385
07452  0 50000 0 01754        CLA 1004                                                  RE340386
07453  0 60100 0 17521        STO 8017                                                  RE340387
07454  0 50000 0 17507        CLA 8007                                                  RE340388
07455  0 60100 0 17522        STO 8018                                                  RE340389
07456  0 07400 4 10137        TSX P6,4 PRINT R, FLUX                                    RE340390
07457  0 17522 0 17521            8017,0,8018                                           RE340391
07460 -0 53400 4 17520        LXD 8016,4                                                RE340392
07461  0 50000 0 17507        CLA 8007 FLUX GOES TO FLUX +                              RE340393
07462  0 60100 0 17510        STO 8008                                                  RE340394
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07463  0 50000 0 01754          CLA 1004 R PLUS DELTA R GOES TO R          RE340395
07464  0 30000 1 01755          FAD 1005,1                                 RE340396
07465  0 60100 0 01754          STO 1004                                   RE340397
07466  0 56000 0 17510          LDQ 8008                                   RE340398
07467  0 26000 2 13556          FMP 5998,2 COMPUTE FLUX                    RE340399
07470  0 30000 2 15526          FAD 6998,2                                 RE340400
07471  0 60100 0 17507          STO 8007                                   RE340401
07472  0 02000 0 07327          TRA 06                                     RE340402
07473  0 50000 0 17523    08    CLA 8019 EO GOES TO EI                     RE340403
07474  0 60100 0 17524          STO 8020                                   RE340404
07475  0 50000 0 04406          CLA 2310 COMPUTE Q L,0                     RE340405
07476  0 60100 0 17511          STO 8009                                   RE340406
07477 -0 63400 4 17521          SXD 8017,4                                 RE340407
07500  0 50000 0 01753          CLA 1003                                   RE340408
07501  0 40200 0 04402          SUB 2306                                   RE340409
07502  0 73400 4 00000          PAX 0,4                                    RE340410
07503  0 10000 0 07516          TZE 08+19                                  RE340411
07504  0 50200 1 01755          CLS 1005,1                                 RE340412
07505  0 24000 0 01754          FDH 1004                                   RE340413
07506  0 26000 0 04405          FMP 2309                                   RE340414
07507  0 30000 0 04406          FAD 2310                                   RE340415
07510  0 60100 0 17511          STO 8009                                   RE340416
07511  0 60100 0 17522          STO 8018                                   RE340417
07512 -2 00001 4 07517          TNX 08+20,4,1                              RE340418
07513  0 56000 0 17511          LDQ 8009                                   RE340419
07514  0 26000 0 17522          FMP 8018                                   RE340420
07515  0 60100 0 17511          STO 8009                                   RE340421
07516  0 02000 0 07512          TRA 08+15                                  RE340422
07517 -0 53400 4 17521          LXD 8017,4                                 RE340423
07520  0 56000 0 04415          LDQ 2317 COMPUTE EO                        RE340424
07521  0 26000 0 17502          FMP 8002                                   RE340425
07522  0 60100 0 17522          STO 8018                                   RE340426
07523  0 50000 0 17511          CLA 8009                                   RE340427
07524  0 30000 0 17501          FAD 8001                                   RE340428
07525  0 76500 0 00043          LRS 35                                     RE340429
07526  0 26000 0 17507          FMP 8007                                   RE340430
07527  0 60100 0 17521          STO 8017                                   RE340431
07530  0 56000 0 17511          LDQ 8009                                   RE340432
07531  0 26000 0 17510          FMP 8008                                   RE340433
07532  0 30200 0 17521          FSB 8017                                   RE340434
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07533  0 30000 0 17522        FAD 8018                                                      RE340435
07534  0 24000 1 01755        FDH 1005,1                                                    RE340436
07535  0 26000 4 05664        FMP 2996,4                                                    RE340437
07536  0 76500 0 00043        LRS 35                                                        RE340438
07537  0 26000 0 17500        FMP 8000                                                      RE340439
07540  0 60100 0 17523        STO 8019                                                      RE340440
07541 -0 63400 4 17521        SXD 8017,4                                                    RE340441
07542  0 50000 0 01753        CLA 1003                                                      RE340442
07543  0 40200 0 04402        SUB 2306                                                      RE340443
07544  0 73400 4 00000        PAX 0,4                                                       RE340444
07545  0 10000 0 07552        TZE O8+47                                                     RE340445
07546  0 56000 0 17523        LDQ 8019                                                      RE340446
07547  0 26000 0 01754        FMP 1004                                                      RE340447
07550  0 60100 0 17523        STO 8019                                                      RE340448
07551  2 00001 4 07546        TIX O8+43,4,1                                                 RE340449
07552 -0 53400 4 17521        LXD 8017,4                                                    RE340450
07553  0 56000 0 17525        LDQ 8021 ALPHA N TIMES THE SOURCE INTEGRAL                    RE340451
07554  0 26000 0 17500        FMP 8000                                                      RE340452
07555  0 76500 0 00043        LRS 35                                                        RE340453
07556  0 26000 1 01755        FMP 1005,1    TIMES DELTA  R                                  RE340454
07557  0 60100 0 17525        STO 8021                                                      RE340455
07560  0 56000 0 17506        LDQ 8006 ALPHA N TIMES THE FLUX INTEGRAL                      RE340456
07561  0 26000 0 17500        FMP 8000                                                      RE340457
07562  0 76500 0 00043        LRS 35                                                        RE340458
07563  0 26000 1 01755        FMP 1005,1    TIMES DELTA  R                                  RE340459
07564  0 60100 0 17506        STO 8006                                                      RE340460
07565  0 76500 0 00043        LRS 35 COMPUTE BALANCE CHECK                                  RE340461
07566  0 26000 4 05665        FMP 2997,4                                                    RE340462
07567  0 76000 0 00002        CHS                                                           RE340463
07570  0 30000 0 17524        FAD 8020                                                      RE340464
07571  0 30200 0 17523        FSB 8019                                                      RE340465
07572  0 30000 0 17525        FAD 8021                                                      RE340466
07573  0 60100 0 17526        STO 8022                                                      RE340467
07574 -0 75400 1 00000        PXD 0,1                         IS L EQUAL TO 1               RE340468
07575  0 77100 0 00022        ARS 18                                                        RE340469
07576  0 40000 0 01752        ADD 1002                                                      RE340470
07577  0 76700 0 00030        ALS 24                                                        RE340471
07600  0 10000 0 07603        TZE O10                                                       RE340472
07601  0 50000 4 05663        CLA 2995,4 IS DO POSITIVE                                     RE340473
07602 -0 12000 0 07664        TMI O15                                                       RE340474
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07603   0 56000 0 17502   010   LDQ 8002 COMPUTE CURRENT                                          RE340475
07604   0 26000 0 04415         FMP 2317                                                          RE340476
07605   0 60100 0 17520         STO 8016                                                          RE340477
07606   0 56000 0 17511         LDQ 8009                                                          RE340478
07607   0 26000 0 17510         FMP 8008                                                          RE340479
07610   0 60100 0 17521         STO 8017                                                          RE340480
07611   0 50200 0 17511         CLS 8009                                                          RE340481
07612   0 30200 0 17501         FSB 8001                                                          RE340482
07613   0 76500 0 00043         LRS 35                                                            RE340483
07614   0 26000 0 17507         FMP 8007                                                          RE340484
07615   0 30000 0 17520         FAD 8016                                                          RE340485
07616   0 30000 0 17521         FAD 8017                                                          RE340486
07617   0 24000 1 01755         FDH 1005,1                                                        RE340487
07620   0 26000 4 05664         FMP 2996,4                                                        RE340488
07621   0 60100 0 17530         STO 8024                                                          RE340489
07622  -0 63400 4 17521   011   SXD 8017,4 PRINT R, FLUX, INTEGRAL FLUX, LEAKAGE, CURRENT, B.C.   RE340490
07623   0 50000 0 01754         CLA 1004                                                          RE340491
07624   0 60100 0 17531         STO 8025                                                          RE340492
07625   0 50000 0 17507         CLA 8007                                                          RE340493
07626   0 60100 0 17532         STO 8026                                                          RE340494
07627   0 50000 0 17506         CLA 8006                                                          RE340495
07630   0 60100 0 17533         STO 8027                                                          RE340496
07631   0 50000 0 17523         CLA 8019                                                          RE340497
07632   0 60100 0 17534         STO 8028                                                          RE340498
07633   0 50000 0 17530         CLA 8024                                                          RE340499
07634   0 60100 0 17535         STO 8029                                                          RE340500
07635   0 50000 0 17526         CLA 8022                                                          RE340501
07636   0 60100 0 17536         STO 8030                                                          RE340502
07637   0 07400 4 10143         TSX P7,4                                                          RE340503
07640   0 17536 0 17531             8025,0,8030                                                   RE340504
07641  -0 53400 4 17521         LXD 8017,4                                                        RE340505
07642  -0 75400 1 00000   013   PXD 0,1 IS L EQUAL 1                                              RE340506
07643   0 77100 0 00022         ARS 18                                                            RE340507
07644   0 40000 0 01752         ADD 1002                                                          RE340508
07645   0 76700 0 00030         ALS 24                                                            RE340509
07646   0 10000 0 07654         TZE 014                                                           RE340510
07647   0 50000 0 17507         CLA 8007 FLUX GOES TO FLUX +                                      RE340511
07650   0 60100 0 17510         STO 8008                                                          RE340512
07651   1 77777 1 07652         TXI 013+8,1,32767             A REG-1 GOES TO A REG               RE340513
07652   1 77777 2 07653         TXI 013+9,2,32767             B REG-1 GOES TO B REG               RE340514
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07653  1 77773 4 07252          TXI 00,4,32763              C REG-5 GOES TO C REG         RE340515
07654  0 50000 0 17527   014    CLA 8023 IS THIS LAST GROUP                               RE340516
07655  0 40200 0 01751          SUB 1001                                                  RE340517
07656  0 10000 0 07663          TZE OMEGA                                                 RE340518
07657  0 50000 0 17527          CLA 8023                                                  RE340519
07660  0 40000 0 04402          ADD 2306                                                  RE340520
07661  0 60100 0 17527          STO 8023                                                  RE340521
07662  0 02000 0 06731          TRA I1                                                    RE340522
07663  0 02000 0 06654   OMEGA  TRA I0-4                                                  RE340523
07664 -0 75400 0 00000T  015    PXD 0,0                                                   RE340524
07665  0 60100 0 17530          STO 8024                                                  RE340525
07666  0 02000 0 07622          TRA 011                                                   RE340526
07667  0 56000 0 04415   012    LDQ 2317 R NOT 0, COMPUTE EI FOR INNERMOST REGION         RE340527
07670  0 26000 0 17502          FMP 8002                                                  RE340528
07671  0 60100 0 17520          STO 8016                                                  RE340529
07672  0 56000 0 17507          LDQ 8007                                                  RE340530
07673  0 26000 0 17512          FMP 8010                                                  RE340531
07674  0 60100 0 17521          STO 8017                                                  RE340532
07675  0 50000 0 17512          CLA 8010                                                  RE340533
07676  0 30000 0 17501          FAD 8001                                                  RE340534
07677  0 76500 0 00043          LRS 35                                                    RE340535
07700  0 26000 0 17510          FMP 8008                                                  RE340536
07701  0 30200 0 17520          FSB 8016                                                  RE340537
07702  0 30200 0 17521          FSB 8017                                                  RE340538
07703  0 24000 1 01755          FDH 1005,1                                                RE340539
07704  0 26000 4 05664          FMP 2996,4                                                RE340540
07705  0 76500 0 00043          LRS 35                                                    RE340541
07706  0 26000 0 17500          FMP 8000                                                  RE340542
07707  0 60100 0 17523          STO 8019                                                  RE340543
07710 -0 63400 4 17521          SXD 8017,4                                                RE340544
07711  0 50000 0 01753          CLA 1003                                                  RE340545
07712  0 40200 0 04402          SUB 2306                                                  RE340546
07713  0 73400 4 00000          PAX 0,4                                                   RE340547
07714  0 10000 0 07721          TZE 012+26                                                RE340548
07715  0 56000 0 17523          LDQ 8019                                                  RE340549
07716  0 26000 0 01754          FMP 1004                                                  RE340550
07717  0 60100 0 17523          STO 8019                                                  RE340551
07720  2 00001 4 07715          TIX 012+22,4,1                                            RE340552
07721 -0 53400 4 17521          LXD 8017,4                                                RE340553
07722  0 02000 0 07434          TRA 07                                                    RE340554
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07723  0 12000 0 07765   02    TPL CHECK                                              RE340555
07724  0 50000 1 01755         CLA 1005,1 IS R EQUAL ZERO                             RE340556
07725  0 24000 0 04407         FDH 2311                                               RE340557
07726  0 50000 0 01754         CLA 1004                                               RE340558
07727  0 04000 0 07731         TLQ 02+6                                               RE340559
07730  0 02000 0 07775         TRA 05                                                 RE340560
07731  0 50000 0 17514         CLA 8012 COMPUTE FLUX AT INNER EDGE                    RE340561
07732  0 30000 0 17501         FAD 8001                                               RE340562
07733  0 60100 0 17520         STO 8016                                               RE340563
07734  0 56000 0 17502         LDQ 8002                                               RE340564
07735  0 26000 2 02265         FMP 1205,2                                             RE340565
07736  0 30000 0 17515         FAD 8013                                               RE340566
07737  0 24000 0 17520         FDH 8016                                               RE340567
07740  0 02000 0 07326         TRA 06-1                                               RE340568
07741  0 50000 4 05656   03    CLA 2990,4                                             RE340569
07742  0 12000 0 07746         TPL 04                                                 RE340570
07743  0 50000 0 17510         CLA 8008 FLUX AT ZERO, I+1 GOES TO FLUX AT H,I         RE340571
07744  0 60100 0 17507         STO 8007 CONTINUITY CONDITION FLUX AT INTERFACE        RE340572
07745  0 02000 0 07327         TRA 06                                                 RE340573
07746  0 50000 4 05667   04    CLA 2999,4                                             RE340574
07747  0 10000 0 07772         TZE CHECK+5                                            RE340575
07750  0 50000 1 01755         CLA 1005,1 BLACK BOUNDARY CONDITION                    RE340576
07751  0 24000 4 05667         FDH 2999,4 FLUX AT INTERFACE                           RE340577
07752 -0 60000 0 17520         STQ 8016                                               RE340578
07753  0 50000 0 17520         CLA 8016                                               RE340579
07754  0 30000 0 17501         FAD 8001                                               RE340580
07755  0 30000 0 17514         FAD 8012                                               RE340581
07756  0 60100 0 17520         STO 8016                                               RE340582
07757  0 56000 0 17502         LDQ 8002                                               RE340583
07760  0 26000 2 02265         FMP 1205,2                                             RE340584
07761  0 30000 0 17515         FAD 8013                                               RE340585
07762  0 24000 0 17520         FDH 8016                                               RE340586
07763 -0 60000 0 17507         STQ 8007                                               RE340587
07764  0 02000 0 07327         TRA 06                                                 RE340588
07765  0 50000 1 01755   CHECK CLA 1005,1 IS R EQUAL ZERO                             RE340589
07766  0 24000 0 04407         FDH 2311                                               RE340590
07767  0 50000 0 01754         CLA 1004                                               RE340591
07770  0 04000 0 07746         TLQ 04                                                 RE340592
07771  0 00000 0 07771         HTR CHECK+4                                            RE340593
07772 -0 75400 0 00000T        PXD 0,0                                                RE340594
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07773  0 60100 0 17507          STO 8007                                                   RE340595
07774  0 02000 0 07327          TRA 06                                                     RE340596
07775 -0 63400 4 17521    05    SXD 8017,4 COMPUTE FLUX AT R EQUAL ZERO                    RE340597
07776  0 50000 0 01753          CLA 1003 FOR DERIVATIVE OF FLUX EQUAL ZERO                 RE340598
07777  0 76000 0 00006          COM                          BOUNDARY CONDITION            RE340599
10000  0 40000 0 04402          ADD 2306                                                   RE340600
10001  0 73400 4 00000          PAX 0,4                                                    RE340601
10002  0 50000 0 04406          CLA 2310                                                   RE340602
10003  0 30200 2 13557          FSB 5999,2                                                 RE340603
10004  0 76500 0 00043          LRS 35                                                     RE340604
10005  0 26000 4 04405          FMP 2309,4                                                 RE340605
10006  0 30000 0 17501          FAD 8001                                                   RE340606
10007  0 60100 0 17520          STO 8016                                                   RE340607
10010  0 56000 2 15527          LDQ 6999,2                                                 RE340608
10011  0 26000 4 04405          FMP 2309,4                                                 RE340609
10012  0 60100 0 17522          STO 8018                                                   RE340610
10013  0 56000 2 02265          LDQ 1205,2                                                 RE340611
10014  0 26000 0 17502          FMP 8002                                                   RE340612
10015  0 30000 0 17522          FAD 8018                                                   RE340613
10016  0 24000 0 17520          FDH 8016                                                   RE340614
10017 -0 60000 0 17507          STQ 8007                                                   RE340615
10020 -0 53400 4 17521          LXD 8017,4                                                 RE340616
10021  0 02000 0 07327          TRA 06                                                     RE340617
10022  0 02000 0 00613    P1    TRA OUT1                                                   RE340618
10023  010730513325             BCD  17HR.E. 34  PROBLEM F8.5//6H   J= I3,6H   L= I3,6H   N= I1,6RE340619
10024  336003046060
10025  475146224325
10026  446026103305
10027  616106306060
10030  604113603103
10031  730630606060
10032  431360310373
10033  063060606045
10034  136031017306
10035  306060605113             BCD 9H   R= F9.3,6H   P= I4//13HMESH  SPACING/(10F12.6)   RE340620
10036  602611330373
10037  063060606047
10040  136031046161
10041  010330442562
10042  306060624721
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10043   233145276174
10044   010026010233
10045   063460606060
10046   0 02000 0 00613   P2     TRA OUT1                                              RE340621
10047   616101113047             BCD 6//19HPOINTS  PER  REGION/(10I12)                 RE340622
10050   463145636260
10051   604725516060
10052   512527314645
10053   617401003101
10054   023460606060
10055   0 02000 0 00613   P3     TRA OUT1                                              RE340623
10056   616101113047             BCD 7//19HPOINT-WISE  SOURCES/(1P10E12.4)             RE340624
10057   463145634066
10060   316225606062
10061   466451232562
10062   617401470100
10063   250102330434
10064   606060606060
10065   0 02000 0 00613   P4     TRA OUT1                                              RE340625
10066   616102043027             BCD  //24HGROUP-REGION  PARAMETERS/4H K= 1PE12.4/58H     D OUT   RE340626
10067   514664474051
10070   252721464560
10071   604721512144
10072   256325516261
10073   043060421360
10074   014725010233
10075   046105103060
10076   606060602460
10077   466463606060
10100   602431262633             BCD   DIFF. COEF.   SIGMA      TRANSFER       D IN /(1P5E12.4)   RE340627
10101   602346252633
10102   606060623127
10103   442160606060
10104   606063512145
10105   622625516060
10106   606060602460
10107   314560617401
10110   470525010233
10111   043460606060
10112   0 02000 0 00613   P5     TRA OUT1                                              RE340628
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10113  616101001030          BCD  //108H  RADIUS        FLUX    FLUX INTEGRAL  LEAKAGE     CURRRE340629
10114  606051212431
10115  646260606060
10116  606060264364
10117  676060606026
10120  436467603145
10121  632527512143
10122  606043252142
10123  212725606060
10124  606023645151
10125  254563606060          BCD  ENT    BAL  CK                                      J= I3/   RE340630
10126  602221436060
10127  234260606060
10130  606060606060
10131  606060606060
10132  606060606060
10133  606060606060
10134  606060606060
10135  606060411360
10136  310361606060
10137  0 02000 0 00613  P6    TRA OUT1                                                          RE340631
10140  260100330373           BCD 3F10.3,1PE12.4                                                RE340632
10141  014725010233
10142  046060606060
10143  0 02000 0 00613  P7    TRA OUT1                                                          RE340633
10144  260100330373           BCD 3F10.3,1P5E12.4                                               RE340634
10145  014705250102
10146  330460606060
10147  0 01755 0 01750  PD1       1000,0,1005                                                   RE340635
10150  0 02121 0 02122  PD2       1106,0,1105                                                   RE340636
10151  0 02265 0 02266  PD3       1206,0,1205                                                   RE340637
10152  0 05667 0 05667  PD4       2999,0,2999                                                   RE340638
10153  0 77000 0 00202  TAPE  WEF 2    WRITE END OF FILE TAPE 2                                 RE340639
10154  0 02000 0 06660        TRA IO                                                            RE340640
04402 +000000000001     2306  DEC 1,2,3,.5,1.0,2.0,3.0,4.0,5.0,6.0,7.0                          RE340641
04403 +000000000002
04404 +000000000003
04405 +200400000000
04406 +201400000000
04407 +202400000000
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04410 +202600000000
04411 +203400000000
04412 +203500000000
04413 +203600000000
04414 +203700000000
04565 +202400000000       2421  DEC 2.0.6.2831853,12.5663706          RE340642
04566 +203622077324
04567 +204622077324
                 06660        END IO                                RE340643
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