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INCORPORATION OF EPITHERMAL PROTON CHEMICAL BINDING EFFECTS IN HAMMER

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MASTER

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I. Introduction

This reports those changes to the hydrogen epithermal library in HAMMER, and those changes to the HAMMER program[1,2] itself, which are required to incorporate the effects of the chemical binding and thermal motion of the protons in water on the epithermal neutron flux and reaction rates. The changes to the hydrogen epithermal library required are changes to the slowing-down power $\xi\sigma_s$, the Greuling-Goertzel parameter γ, and the P-1 component of the scattering cross-section σ_{s1}. These changes are based on the kernel developed by Cady, Kirouac and McInerney.[3]

The changes to the HAMMER program which are required consist of changes to the program to ensure that the slowing-down power $\xi\sigma_s$ and the Greuling-Goertzel parameter γ for hydrogen are used in all of the subroutines (HAMMER at present assumes in certain of its subroutines that the hydrogen slowing-down power $\xi\sigma_s$ is equal to the P-0 component of the scattering cross-section σ_{s0}, and that the parameter γ for hydrogen is equal to unity). In addition, changes are required to modify the Dancoff factor used in the Pu-240 1 eV resonance treatment and the cosine current calculation of the lattice escape probabilities used in the resonance absorption calculation. These changes are along the lines discussed in references 7 and 8.

Another approach to obtaining cross-sections for hydrogen which account for epithermal chemical binding effects is to obtain values of $\xi\sigma_s$ by multigroup so as to reproduce the Corngold asymptotic expansion fluxes exactly for plain water, and to leave the value of the Greuling-Goertzel parameter γ equal to unity. This is the approach used by J. Hardy, Jr.[6] as suggested by E. M. Gelbard. However, by also varying γ (as is done in the method presented here), one would hope to get better accuracy in cases of heavy absorption. Moreover, this is more consistent with the changes made in the resonance absorption treatment for the Pu-240 1 eV resonance.

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The changes to the HAMMER hydrogen epithermal library will first be presented, and a comparison of fluxes as calculated with these hydrogen cross-sections and parameters to fluxes as calculated by the Corngold asymptotic expansion[4,5] will be presented. This comparison acts as a check on the correctness of the hydrogen cross-sections and parameters obtained. (The comparisons do not check σ_{s1}.)

II. The Changes to the HAMMER Epithermal Library

The formulae used for the values of $\xi\sigma_s$ and γ for hydrogen are derived in reference 8. These formulae are:

$$\xi\sigma_s(E) = \left(1 - \frac{1}{2}\frac{kT^*}{E}\right)^2 \sigma \tag{1}$$

and

$$\gamma(E) = 1 - \frac{1}{2}\frac{kT^*}{E} \tag{2}$$

Here σ is the asymptotic value of the hydrogen scattering cross-section, and was taken as 20.4 barns in the computations; E is the neutron energy and T* is the effective temperature associated with the short collision time approximation[9]. The value of T* used in the computations corresponds to a moderator temperature of 500°F (= 533°K) in a Nelkin kernel model.[10] The value of T* obtained is 1453°K. One should note that the values of the hydrogen epithermal library parameters are therefore dependent on the water temperature, and that the calculated parameters correspond to a water temperature of 500°F. The temperature dependence of the parameters is rather weak, however, since T* depends rather weakly on T. (At room temperature T* is 1360°K, while at 533°K, T* is 1453°K.)

The value of $\sigma_{s1}(E)$ is the same as in an effective temperature kernel model, and is given by

$$\sigma_{s1}(E) = \frac{2}{3}\sigma\left[1 - \frac{1}{2}\frac{kT^*}{E} + \frac{5}{\sqrt{\pi}}\left(\frac{kT^*}{E}\right)^{\frac{3}{2}} - \frac{9}{4}\left(\frac{kT^*}{E}\right)^{2}\right] \tag{3}$$

This formula was taken from the Cady, Kirouac and McInerney article.[3]

The value of $\sigma_{so}(E)$ is also the same as that for an effective temperature kernel and the formula for $\sigma_{so}(E)$,

$$\sigma_{so}(E) = \sigma\left(1 + \frac{1}{2}\frac{kT^*}{E}\right), \tag{4}$$

is also taken from reference 3.

Group averages of the various parameters were obtained by taking the arithmetic average of the quantity at the upper and lower energies bounding the multigroup. For example,

$$\overline{\sigma_{s,j}} = \frac{1}{2}\left[\sigma_{so}(E_{j+1}) + \sigma_{so}(E_j)\right]$$

where E_j and E_{j+1} are the energies bounding the jth multigroup.

The chemical binding effects were included for energies up to and including group 36; for energies greater than the upper cutpoint of this group, chemical binding effects were neglected and the values of the parameters used in the previous library for hydrogen were used.

The hydrogen cross-sections obtained are given in Table I. The isotope identity number is 2001001, and the cross-sections are on tape N35838. Note that the cross-sections in Table I are not in the same format as a printout of the HAMMER epithermal library -- some columns have been omitted and others have been rearranged. The column labelled "age number" is what we have denoted by γ. The omitted parameters (inelastic scattering, fission cross-section, neutrons per fission) are all zero for hydrogen.

III. Verification of the Hydrogen Cross-Section Changes

In order to verify the cross-section changes made, the neutron fluxes in a medium composed of plain water (with oxygen scattering effects neglected) were computed by means of the Corngold asymptotic expansion and compared to the fluxes obtained by running a HAMMER problem using the new hydrogen library. In addition, water poisoned with a $\frac{1}{v}$ absorber was considered. Five terms in the Corngold asymptotic expansion were used. It turns out that to this order the expansion is identical to an expansion derived in a much simpler fashion by Parks[11] (see also pages 103 ff of reference 5). The

TABLE I. Hydrogen cross-sections including binding effects.

IDENT=2001001, MASS= 1.0081 H1 CADY MODEL (BUSLIK) 6/74

GRP	SIGMA-SO	SIGMA-G	AGE NUMBER	PARTIAL CROSS SECTIONS (BARNS) SIGMA-S1	XI*SIGMA-SO
1	1.050000E+00	0.	1.000000E+00	7.000000E-01	1.050000E+00
2	1.300000E+00	0.	1.000000E+00	8.670000E-01	1.300000E+00
3	1.550000E+00	0.	1.000000E+00	1.033000E+00	1.550000E+00
4	1.850000E+00	0.	1.000000E+00	1.233000E+00	1.850000E+00
5	2.150000E+00	0.	1.000000E+00	1.433000E+00	2.150000E+00
6	2.500000E+00	0.	1.000000E+00	1.667000E+00	2.500000E+00
7	2.900000E+00	0.	1.000000E+00	1.933000E+00	2.900000E+00
8	3.350000E+00	0.	1.000000E+00	2.233000E+00	3.350000E+00
9	3.850000E+00	0.	1.000000E+00	2.567000E+00	3.850000E+00
10	4.400000E+00	1.000000E+04	1.000000E+00	2.933000E+00	4.400000E+00
11	5.050000E+00	1.000000E+04	1.000000E+00	3.367000E+00	5.050000E+00
12	5.750000E+00	1.000000E+04	1.000000E+00	3.834000E+00	5.750000E+00
13	6.500000E+00	1.000000E+04	1.000000E+00	4.334000E+00	6.500000E+00
14	7.350000E+00	1.000000E+04	1.000000E+00	4.900000E+00	7.350000E+00
15	8.250000E+00	1.000000E+04	1.000000E+00	5.500000E+00	8.250000E+00
16	9.300000E+00	1.000000E+04	1.000000E+00	6.200000E+00	9.300000E+00
17	1.045000E+01	1.000000E+04	1.000000E+00	6.967000E+00	1.045000E+01
18	1.160000E+01	1.000000E+04	1.000000E+00	7.734000E+00	1.160000E+01
19	1.270000E+01	2.000000E+04	1.000000E+00	8.467000E+00	1.270000E+01
20	1.375000E+01	2.000000E+04	1.000000E+00	9.167000E+00	1.375000E+01
21	1.520000E+01	2.000000E+04	1.000000E+00	1.013000E+01	1.520000E+01
22	1.680000E+01	3.000000E+04	1.000000E+00	1.120000E+01	1.680000E+01
23	1.810000E+01	4.000000E+04	1.000000E+00	1.207000E+01	1.810000E+01
24	1.880000E+01	5.000000E+04	1.000000E+00	1.253000E+01	1.880000E+01
25	1.930000E+01	6.000000E+04	1.000000E+00	1.287000E+01	1.930000E+01
26	1.960000E+01	8.000000E+04	1.000000E+00	1.307000E+01	1.960000E+01
27	1.980000E+01	1.000000E+05	1.000000E+00	1.320000E+01	1.980000E+01
28	1.990000E+01	1.300000E+05	1.000000E+00	1.327000E+01	1.990000E+01
29	2.000000E+01	1.700000E+05	1.000000E+00	1.333000E+01	2.000000E+01
30	2.010000E+01	2.200000E+05	1.000000E+00	1.340000E+01	2.010000E+01
31	2.020000E+01	2.800000E+05	1.000000E+00	1.347000E+01	2.020000E+01
32	2.030000E+01	3.600000E+05	1.000000E+00	1.353000E+01	2.030000E+01
33	2.030000E+01	4.400000E+05	1.000000E+00	1.353000E+01	2.030000E+01
34	2.040000E+01	4.900000E+05	1.000000E+00	1.360000E+01	2.040000E+01
35	2.040000E+01	5.600000E+05	1.000000E+00	1.360000E+01	2.040000E+01
36	2.041900E+01	6.300000E+05	9.990900E-01	1.355600E+01	2.036300E+01
37	2.042400E+01	7.200000E+05	9.988400E-01	1.355700E+01	2.035200E+01
38	2.043100E+01	8.100000E+05	9.985100E-01	1.354500E+01	2.033900E+01
39	2.043900E+01	9.200000E+05	9.980800E-01	1.353000E+01	2.032200E+01
40	2.045000E+01	1.040000E+02	9.975300E-01	1.351200E+01	2.030000E+01
41	2.046500E+01	1.180000E+02	9.968400E-01	1.348900E+01	2.027100E+01
42	2.048300E+01	1.340000E+02	9.959400E-01	1.346100E+01	2.023500E+01
43	2.050600E+01	1.520000E+02	9.947800E-01	1.342500E+01	2.018800E+01
44	2.053700E+01	1.720000E+02	9.933000E-01	1.338100E+01	2.012800E+01
45	2.057500E+01	1.950000E+02	9.914000E-01	1.332700E+01	2.005100E+01
46	2.062500E+01	2.210000E+02	9.889600E-01	1.325100E+01	1.995200E+01
47	2.068900E+01	2.500000E+02	9.858200E-01	1.318100E+01	1.982600E+01
48	2.077100E+01	2.840000E+02	9.817900E-01	1.308400E+01	1.966400E+01
49	2.087700E+01	3.220000E+02	9.766200E-01	1.295800E+01	1.945700E+01
50	2.101300E+01	3.640000E+02	9.699800E-01	1.283200E+01	1.919400E+01
51	2.118800E+01	4.130000E+02	9.613600E-01	1.265800E+01	1.885500E+01
52	2.141200E+01	4.680000E+02	9.504100E-01	1.247900E+01	1.842800E+01
53	2.173400E+01	5.370000E+02	9.345300E-01	1.222700E+01	1.782200E+01
54	2.218800E+01	6.220000E+02	9.123600E-01	1.190500E+01	1.698400E+01

CAPTURE INTEGRAL = 1.33403E+01 FISSION INTEGRAL = 0.

expansion, to the order given, may be written in the form

$$E\phi(E) = 1 - \frac{3\alpha}{\rho} + \frac{6\alpha^2+1}{\rho^2} - \frac{10\alpha^3 + \frac{45}{8}\alpha}{\rho^3} + \left[\frac{15}{4} + \frac{43}{4}\alpha^2 + 15\alpha^4 - \frac{1}{\alpha}\frac{B_{av}}{T^{*3}}\right]\frac{1}{\rho^4} \tag{5}$$

where

$$\alpha = \frac{\Sigma_a(kT^*)}{\Sigma}, \quad \rho = \sqrt{\frac{E}{kT^*}}, \quad B_{av}^2 = \int_0^\infty (\hbar\omega)^2 f(\omega)\,d\omega \tag{6}$$

and the effective temperature is given by

$$kT^* = \frac{1}{2}\int_0^\infty f(\omega)\hbar\omega \coth\frac{\hbar\omega}{2kT}\,d\omega.$$

Here $f(\omega)$ is the phonon frequency spectrum; for the Nelkin model it is given by

$$f(\omega) = \sum_{i=1}^{4} \frac{1}{A_i}\,\delta(\omega-\omega_i) \tag{7}$$

where

$A_1 = 18$		$\hbar\omega_1 = 0$	
$A_2 = 2.32$		$\hbar\omega_2 = .06$	eV
$A_3 = 5.84$		$\hbar\omega_3 = .205$	eV
$A_4 = 2.92$		$\hbar\omega_4 = .481$	eV

(8)

It is assumed that the absorption cross-section has a $\frac{1}{v}$ energy dependence; the quantity Σ is the asymptotic macroscopic scattering cross-section of hydrogen (= 20.4 N^H, where N^H is the atom density of hydrogen). The quantity B_{av}^2 is computed to be

$$B_{av}^2 = .087981,$$

in a Nelkin model.

Computations of $E\phi(E)$ from Eq. (5) were first performed corresponding to room temperature water; these were compared to computations done by J. Hardy and reported in reference 6 (a larger version of Figure 1 of

reference 6 was obtained directly from J. Hardy.) The purpose of this comparison was to verify our use of the Corngold asymptotic expansion. J. Hardy, Jr. used seven terms in the expansion, while we used five terms. Agreement within .2% was obtained. Calculations for both a plain water case and water poisoned such that the absorption cross-section (including the hydrogen absorption) was 6 barns per hydrogen atom at .0253 eV were performed.

Calculations of epithermal fluxes by the Corngold asymptotic expansion were then performed at reactor operating temperature (more precisely, $500^{\circ}F = 533^{\circ}K$). The calculations were for plain water and for water poisoned with a $\frac{1}{v}$ absorber such that the poison absorption cross-section per hydrogen atom was 6 barns at .0253 eV. The results are compared to similar cases at room temperature in Figure 1. The effects of moderator temperature on the epithermal flux is seen to be fairly small.

Comparison of epithermal fluxes as calculated by the Corngold asymptotic expansion, and by the HAMMER program with the new hydrogen library representing hydrogen bound in water, are presented in Figure 2. The same figure shows the fluxes as calculated with the old hydrogen library which corresponds to a free proton at rest model. These comparisons are for the case of plain water; Figure 3 gives a similar comparison for the case of water poisoned with a $\frac{1}{v}$ absorber, with the poison absorption being 6 barns per hydrogen atom at .0253 eV. The fluxes calculated using the new HAMMER hydrogen cross-section set agree rather well with the Corngold expansion fluxes, and represent a considerable improvement over those calculated with the old HAMMER hydrogen cross-section set.

IV. The Changes to the HAMMER Program

In addition to the changes to the HAMMER epithermal library, it is necessary to make changes to the HAMMER program in order that chemical binding effects be taken into account properly.

The first of these changes is in the subroutine SØRE to ensure that the library values of $\xi\sigma_s$ and ν for hydrogen are used in the heterogeneous part

of the slowing-down calculation. Originally, HAMMER treated the slowing-down density due to hydrogen everywhere by the equation

$$\frac{dq_H}{du} + q_H = \Sigma_{sH}\phi,$$

where q_H is the slowing-down density due to hydrogen, Σ_{sH} is the scattering cross-section due to hydrogen, and ϕ is the flux per unit lethargy. (See reference 2 for a good description of the HAMMER code from the viewpoint of the physical approximations and numerical techniques used.)

HAMMER was later modified so that in that part of the above-thermal calculation where the homogeneous slowing-down calculation is done the slowing-down density due to hydrogen is treated by

$$\gamma_H \frac{dq_H}{du} + q_H = \xi_H \Sigma_{sH}\phi$$

The homogeneous slowing-down calculation is done in subroutine SLODON. However, the SØRE subroutine was left unmodified.

The primary reason that the changes in the subroutine SØRE are important is that the regionwise multigroup fluxes and slowing-down densities calculated in the heterogeneous part of the calculation are used in the calculation of the resonance absorption probability. In particular (see Eq. (73) of reference 2), the resonance absorption probability for a resonance with resonance integral I is given by

$$A = 1 - \exp\left\{-(N_o I \Phi_o V_o)/\sum_n q_{ni} V_n\right\}$$

where q_{ni} is the slowing-down density in the nth region at the lower energy limit of the ith multigroup (before the ith multigroup resonance absorption depletes the slowing-down density), and is due to all isotopes, both hydrogen and heavy elements. The quantity $\Phi_o V_o$ is the integral of the ith multigroup flux over the regions containing the resonance isotope, and N_o is the number density of the resonance absorber averaged over these regions. Consequently, the resonance absorption probability is affected directly by the slowing-down densities and fluxes entering into the heterogeneous part of the above-thermal HAMMER calculation.

In addition to the changes in the SØRE subroutine, changes must be made to the Dancoff factor calculation and the calculation of the collision probability calculations used in the resonance integral calculation for the Pu-240 1 eV resonance. In point of fact, the changes are made for all resonances which occur in multigroups 53 and 54. They are made only on option in the program. The option is used whenever the 30th element on the batch control card is a 1. (This sets a flag ICADY equal to unity in the program.)

Before discussing these changes in detail, it should be pointed out that the older version of HAMMER did not recalculate the Dancoff factor in each multigroup, but rather used the Dancoff factor calculated in a given multogroup in all succeeding multigroups. Thus the Dancoff factor, if it was calculated at all, was calculated only once per problem. Whether or not the collision probabilities used in the resonance integral calculation are obtained from a formula using a Dancoff factor or whether they are calculated by the method of cosine currents depends on whether the flux across the lattice cell is sufficiently flat (see reference 2 here). If the flux is sufficiently flat, then a parameter KEY is set equal to unity, and the Dancoff factor method is used when the resonance absorber is in the fuel pellet. However, once the parameter KEY is set equal to unity it is not reset in any succeeding multigroup, and moreover the collision probability table is not recalculated in the succeeding multigroup. This had to be changed in order to modify the resonance integral calculation for the Pu-240 1 eV resonance so that proton chemical binding effects could be taken into account. Changes were therefore made to the subroutine FLUX so that the Dancoff factor would be recalculated in each multigroup.

In accordance with the method described in references 7 and 8, the modifications to the Dancoff factor are made by computing the "optical thickness" $\Sigma\Delta r$ of each region external to the fuel pellet stack with $\Sigma = \frac{\xi_H \Sigma_{sH}}{\nu_H} + \Sigma_a$, where the value of $\xi_H \Sigma_{sH}$ and ν_H are the values appropriate to hydrogen for that group; here Δr is the difference between the outer and inner radii for the particular region, and Σ_a is the absorption cross-section

for the given region. The change is made only if there is a 1 in column 30 of the batch control card in the input to HAMMER. Under these circumstances, it affects all resonances in multigroups 53 and 54. This change occurs in the subroutine DANC. The change implicitly assumes that the resonances in question are wide with respect to scattering from all isotopes except hydrogen.

As mentioned earlier, if the flux is not sufficiently flat across the lattice cell the Dancoff factor is not used to calculate the table of collision probabilities used in the resonance integral calculation. Instead a method of cosine currents is used. Here the collision probability calculation was modified by using $\gamma_H \Sigma_{sH}/\gamma_H$ as the cross-section in each region (except in the region containing the resonance absorber) where previously the quantity Σ_s, the scattering cross-section of all materials, appeared. This change occurs in the subroutine PTBL.

The appendix gives, along with some comments, a Fortran listing of the subroutines which have been changed. This is a preliminary version of the program.

In an early version of the program there were certain indications of errors in the resonance integral calculation performed for the Pu-240 1 eV resonance. These errors could have been associated with the coarseness of the energy mesh used in the numerical calculation of the resonance integral, or possibly some sort of numerical instability (see reference 12). Later work indicated that the numerical instability problem is not serious, and that the use of a finer mesh in the resonance integral calculation was sufficient. The changes to the subroutine GRID which are required to permit a finer mesh in the resonance integral calculation are included in the appendix.

Concerning limitations on the use of the new program and the new hydrogen library, one should probably use the new library at all times; the use of the ICADY = 1 option (activated by putting a 1 in column 30 of the batch control card) should be used only if the principal moderator is hydrogen.

APPENDIX I

This appendix gives a Fortran listing of those subroutines which have been changed, with some explanatory comments. The new cards added to the source are readily identifiable since they are labelled with the identification "HAMMER". The deleted cards are not shown, however.

The changes to the subroutine RTBLIB consist in:

(1) Setting the flag ICADY by equating it to ICNTRL (158), which (see LINK 1 of the HAMMER program) is equal to the item in column 30 of the batch control card.

(2) Computing the parameter $\frac{\xi_H \bar{\sigma}_{sH}}{\nu_H}$ for each mixture. For the Mth mixture this variable is called CDYC(M). If, in any mixture M, the hydrogen concentration is so low that the value of $N^H \nu_H \xi_H \sigma_{sH}$ is less than .0001, CDYC(M) is set equal to zero.

(3) A labelled common block CADY is used to transmit CDYC(M) and ICADY to other subroutines where they are required.

The changes to the subroutine SØRE consist in:

(1) The computation of ν for hydrogen from the ratio of $(N\nu\xi\sigma_s)_H$ to $(N\xi\sigma_s)_H$.

(2) The kernel $P_{n'i}$ (see eq. (44) of reference 2) is modified to use the library value of ν and $\xi\Sigma_s$ for hydrogen. This kernel expresses the effect of in-group scattering in the equation determining the fluxes in the various regions of the cell. It is denoted by GRP(N) in the program.

(3) The slowing-down density due to hydrogen (called ETA(N) in the program) is computed with ν and $\xi\Sigma_s$ for hydrogen used where unity and Σ_s were used previously. The equation is now completely analogous to the equation for Q(N), the nonhydrogenous slowing-down density.

(4) The source term ($S_{n'i}$ of eq. (48) of reference 2) is modified also to use the γ and $\xi\Sigma_s$ for hydrogen. This term is denoted by SØR(N) in the program.

The source $S_{n'i}$ and the kernel $P_{n'i}$ discussed above occur in eq. (40) of reference 2,

$$\phi_{ni} = \sum_{n'} T_{nn'i}(P_{n'i}\,\phi_{n'i} + S_{n'i})$$

where n and n' are region indices and i is a group index. This equation determines the regionwise fluxes.

A change to the subroutine FLUX is made so that the flat flux flag KEY is initialized to zero in each group and is reset to 1 only if the flat flux criterion is met. Certain indices MDØNE(I) are reset to zero in each group. This ensures that the collision probability tables will be recalculated in each group.

Changes to PTBL are made. They consist of

(1) Defining IGCDY as IG, the group index. This index is transmitted to DANC through the labelled common block CADY.

(2) The cross-section XT(N) used in regions not containing the resonance absorber for the collision probability calculation when the method of cosine currents is used is set equal to CDYC(M) instead of the scattering cross-section for groups 53 and 54 if ICADY = 1.

Changes to DANC are made, to the calculation of the moderator optical thickness SL, for groups 53 and 54, if ICADY = 1. In such cases the optical thickness SL is computed with CDYC(M) instead of the scattering cross-section SSC(M).

Changes to subroutine GRID have been made so that more than 501 mesh points (in lethargy) can be used per resonance. The mesh for all resonances in multigroup 53 is changed to half that used in other multigroups. These changes reduce the mesh error in the treatment of the 1 eV resonance of Pu-240 to an acceptable level (about 1%).

```
      SUBROUTINE FLUX(IG)                                                FLUX
CFLUX  ======HAMMER===BNL-SRL LATTICE ANALYSIS PROGRAM=========HAMLET    FLUX
CFLUX ITERATE ON SPATIAL DISTRIBUTION OF FLUX                            FLUX
      DIMENSION CNTRL(200),BTTL(9),LNK(10)                               FLUX
      COMMON CNTRL                                                       FLUX
      EQUIVALENCE                                                        FLUX
     X(CNTRL(  1),IDBCH),(CNTRL(  2),NCASE),(CNTRL(  3),NFLOG),         FLUX
     1(CNTRL(4),BTTL(1)),(CNTRL( 13), NTIN),(CNTRL(14),NTOUT),          FLUX
     2(CNTRL( 15),NTPUN),(CNTRL(16),NCHAIN),(CNTRL( 17),LIB1),          FLUX
     3(CNTRL( 18), LIB2),(CNTRL( 19), LIB3),(CNTRL( 20),INT1),          FLUX
     4(CNTRL( 21), INT2),(CNTRL( 22), NSC1),(CNTRL( 23),LNK(1)),        FLUX
     5(CNTRL( 33),NTHCS),(CNTRL( 34),NEPCS),(CNTRL( 35),KLIB1),         FLUX
     6(CNTRL( 36),KLIB2),(CNTRL( 37),KLIB3),(CNTRL(129),NCPRN),         FLUX
     7(CNTRL(130),NCPPT),(CNTRL(141),NTHRN),(CNTRL(142),NTHPT),         FLUX
     8(CNTRL(143),NTHPN),(CNTRL(153),NEPRN),(CNTRL(154),NEPPT),         FLUX
     9(CNTRL(155),NEPPN),(CNTRL(156),NEPSG),(CNTRL(157),NEPAG),         FLUX
     A(CNTRL(165),NFGRN),(CNTRL(166),NFGPT),(CNTRL(167),NFGPN),         FLUX
     B(CNTRL(168),NFGPB),(CNTRL(169),NFGJO),(CNTRL(177),NEDRN),         FLUX
     C(CNTRL(178),NEDPT),(CNTRL(179),NEDPA),(CNTRL(180),NEDNB),         FLUX
     D(CNTRL(181),NEDFW),(CNTRL(182),NEDRB),(CNTRL(183),NEDAX),         FLUX
     E(CNTRL(184),NEDNU)                                                FLUX
      DIMENSION LIMP(600),HOL(9),NPT(20),THT(20),MXAS(20),              FLUX
     1ILHI(20),ARBP(20),DEGC(20),WSTBA(18),WSTBB(18),                   FLUX
     2CONCTA(18,10),LIMT(10),RIN(20),RAD(20),ROUT(20),VOL(20),          FLUX
     3MTBL(20),REGV(20),FISD(20),HOLID(3,18)                            FLUX
      COMMON LIMP                                                       FLUX
      EQUIVALENCE                                                       FLUX
     1(LIMP(  1),    IDENT),(LIMP(  2),       NX),(LIMP(  3),       MX),FLUX
     2(LIMP(  4),      NRX),(LIMP(  5),     ISOX),(LIMP(  6),    ISCXE),FLUX
     3(LIMP(  7),    NGEOM),(LIMP(  8),    NP1B1),(LIMP(  9),     NBCT),FLUX
     4(LIMP( 10),      NXP),(LIMP( 11),     BSQD),(LIMP( 12),    HOL(1)),FLUX
     5(LIMP( 21),  NPT(1)),(LIMP( 41),   THT(1)),(LIMP( 61),   MXAS(1)),FLUX
     6(LIMP( 81), ILHI(1)),(LIMP(101), ARBP(1)),(LIMP(121), DEGC(1)),   FLUX
     7(LIMP(141),WSTBA(1)),(LIMP(159),WSTBB(1)),(LIMP(177),CONCTA(1,1)),FLUX
     8(LIMP(357), LIMT(1)),(LIMP(367),  RIN(1)),(LIMP(387),  RAD(1)),   FLUX
     9(LIMP(407), ROUT(1)),(LIMP(427),  VOL(1)),(LIMP(447), MTBL(1)),   FLUX
     A(LIMP(467), REGV(1)),(LIMP(487), FISD(1)),(LIMP(507),HOLID(1,1))  FLUX
      DIMENSION LOUT(1100),HOLA(9),BALT(18,4,5),FOIL(20,4,5),           FLUX
     1FOGX(4,6),FOX(20,4),DUMB(20),OTGC(5),CTGA(30,6)                   FLUX
      COMMON LOLT                                                       FLUX
      EQUIVALENCE (         LOUT(1),ID),(LOUT(2),HOLA(1)),              FLUX
     1(LOUT(11),BALT(1,1,1)),(LOUT(371),FOIL(1,1,1)),                   FLUX
     2(LOUT(771),FOGX(1,1)),(LOLT(795),FOX(1,1)),(LOUT(875),DUMB(1)),   FLUX
     3(LOUT(895),OTGC(1)),(LOUT(900),CTGA(1))                           FLUX
      DIMENSION ERASE(3500)                                             FLUX
      COMMON ERASE                                                      FLUX
      DIMENSION SSC(10),S1(10),SIGABS(10),SIGIN(10),SIGX(10),C(10),     FLUX
     1AN(10),SD(10),PROB(25,10),SIGY(18,54),GNU(18,54),SIGA(18,54),     FLUX
     2NRIG(18),ER(200  ),GMN(200  ),GMGM(200  ),GMF(200  ),SPIN(200  ), FLUX
     3AMASS(18),SIGP(18),JONE(18),JTWO(18),DZERO(18),DONE(18),DTWO(18), FLUX
     4ETA(20),Q(20),FS(54),FX(20),DEL(54),F(20,54),MDONE(18),P(18,54),   FLUX
     5PF(18,54),PZ(1001),PZ1(1001),A1(18),EEK(55),TEMP(18),SIGEFY(18),  FLUX
     6CT(18,10)                                                         FLUX
      COMMON IX,SIGY,GNU,SIGA,P,PF,F,DEL,FS,SSC,S1,SIGABS,SIGIN,SIGX,   FLUX
     1C,AN,SD,PROB,NRIG,ER,GMN,GMGM,GMF,SPIN,AMASS,SIGP,JONE,JTWO,      FLUX
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     2DZERO,DONE,DTWO,ETA,O,ESC,MDONE,KEY,MCURR,PZ,PZ1,DELSIG,A1,EBK,     FLUX
     3TEMP,SIGEFY,NDONE                                                  FLUX
      DIMENSION DATA(185),DZ(18),GRP(20),SOR(20),T(20,20),XT(20),V1(20),  FLUX
     1V2(20),V3(20),V4(20),V5(20),CP(20),CN(20),CP2(20),CN2(20),Y(21),    FLUX
     2F1(20),F2(20),S2(20),Q1(20),QC(20),TO(20),T1(20)                    FLUX
      EQUIVALENCE (ERASE(1),DATA(1),DZ(1),GRP(1)),                        FLUX
     1(ERASE(21),SOR(1)),(ERASE(41),T(1)),(ERASE(441),XT(1)),             FLUX
     2(ERASE(461),V1(1)),(ERASE(481),V2(1)),(ERASE(501),V3(1)),           FLUX
     3(ERASE(521),V4(1)),(ERASE(541),V5(1)),(ERASE(561),CP(1)),           FLUX
     4(ERASE(581),CN(1)),(ERASE(601),CP2(1)),(ERASE(621),CN2(1)),         FLUX
     5(ERASE(641),Y(1)),(ERASE(441),F1(1)),(ERASE(461),F2(1)),            FLUX
     6(ERASE(481),S2(1)),(ERASE(501),Q1(1)),(ERASE(481),QO(1)),           FLUX
     7(ERASE(461),TO(1)),(ERASE(441),T1(1))                               FLUX
      EQUIVALENCE (FX(1),FISD(1)),(CT(1),CONCTA(1)),(LIB2,NLIB2)          FLUX
      COMMON NLIB                                                         FLUX
      ITCNT=0                                                             FLUX
      XNORM=0.                                                            FLUX
      DO9999N=1,NX                                                        FLUX
      XNORM=XNORM+SOR(N)*VOL(N)                                           FLUX
      M=MTBL(N)                                                           FLUX
      Q1(N)=(SSC(M)-S1(M)*SIGIN(M)+SIGABS(M)-GRP(N))*VOL(N)               FLUX
9999  CONTINUE                                                            FLUX
      IF(IG-1) 5,1,5                                                      FLUX
1     ITMX=0                                                              FLUX
      RMX=1.                                                              FLUX
      IGI=1                                                               FLUX
      IGR=1                                                               FLUX
      EPSF=0.1                                                            FLUX
      ITMAX=100                                                           FLUX
      EPS=1.E-3                                                           FLUX
      DO 3 N=1,NX                                                         FLUX
3     F1(N)=SCF(N)                                                        FLUX
      GO TO 20                                                            FLUX
5     DO 6 N=1,NX                                                         FLUX
6     F1(N)=F(N,IG-1)                                                     FLUX
20    RNORM=0.0                                                           FLUX
      DO 30 N=1,NX                                                        FLUX
30    RNORM=RNORM+Q1(N)*F1(N)                                             FLUX
      RNORM=XNORM/RNORM                                                   FLUX
      DO 40 N=1,NX                                                        FLUX
      F1(N)=F1(N)*RNORM                                                   FLUX
      S2(N)=SCR(N)*F1(N)+GRP(N)                                           FLUX
40    CONTINUE                                                            FLUX
45    RNORM=0.0                                                           FLUX
      DO  53 N=1,NX                                                       FLUX
      F2(N)=0.0                                                           FLUX
      DO 50 M=1,NX                                                        FLUX
      DUMMY=DUMMY                                                         FLUX
50    F2(N)=F2(N)+T(N,M)*S2(M)                                            FLUX
53    RNORM=RNORM+Q1(N)*F2(N)                                             FLUX
      RNORM=XNORM/RNORM                                                   FLUX
      DO 55 N=1,NX                                                        FLUX
55    F2(N)=F2(N)*RNORM                                                   FLUX
      DO 60 N=1,NX                                                        FLUX
      DUMMY=DUMMY                                                         FLUX
```

```
      IF(ABS((F1(N)-F2(N))/F2(N))-EPS) 60,60,70                          FLUX
   60 CONTINUE                                                          FLUX
      GO TO 90                                                          FLUX
   70 DO 80 N=1,NX                                                      FLUX
      S2(N)=SCR(N)*F2(N)*GRP(N)                                         FLUX
      F1(N)=F2(N)                                                       FLUX
   80 CONTINUE                                                          FLUX
      ITCNT=ITCNT+1                                                     FLUX
      IF(ITCNT-ITMAX) 45,90,90                                          FLUX
   90 IF(ITCNT-ITMX)92,92,91                                            FLUX
   91 ITMX=ITCNT                                                        FLUX
      IGI=IG                                                            FLUX
   92 IF(ABS(RNORM-1.)-ABS(RMX-1.))94,94,93                             FLUX
   93 RMX=RNORM                                                         FLUX
      IGR=IG                                                            FLUX
   94 CONTINUE                                                          FLUX
      DO100N=1,NX                                                       FLUX
  100 F(N,IG)=F2(N)                                                     FLUX
      KEY=0                                                             HAMMER
  105 IF(NX-1) 125,125,110                                              FLUX
  110 DO120N=2,NX                                                       FLUX
      IF(ABS(F2(N)/F2(1)-1.)-EPSF)120,120,130                           FLUX
  120 CONTINUE                                                          FLUX
  125 KEY=1                                                             FLUX
  130 DO140I=1,ISOX                                                     FLUX
      SIGEFY(I)=0.                                                      FLUX
  140 MDONE(I)=0                                                        FLUX
      MCURR=0                                                           FLUX
      NDONE=0                                                           FLUX
      REWIND4SC1                                                        FLUX
  150 IF(54-IG)152,151,152                                              FLUX
  151 WRITE(NTOLT,160)ITMX,IGI,RMX,IGR                                  FLUX
  160 FORMAT(59H0MAXIMUM ITERATIONS ON THE  FLUX SHAPE IN ANY MACRO GROL FLUX
     1P = I5,6H GROUP I2/39H MAXIMUM RENORMALIZATION IN ANY GROUP =     FLUX
     1F9.5,6H GROUP I2)                                                 FLUX
  152 RETURN                                                            FLUX
      END                                                               FLUX
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ION
SIGNED OVER THE LOOP BEGINNING AT LINE    92
SIGNED OVER THE LOOP BEGINNING AT LINE    95
SIGNED OVER THE LOOP BEGINNING AT LINE   102
SIGNED OVER THE LOOP BEGINNING AT LINE   107
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      SUBROUTINE RTBLIB(I6)                                                 RTBLI
C     RTBLIB                                                                RTBLI
      DIMENSION CNTRL(200),BTTL(9),LNK(10)                                  RTBLI
      COMMON CNTRL                                                          RTBLI
      EQUIVALENCE                                                           RTBLI
     X(CNTRL(  1),IDBCM),(CNTRL(  2),NCASE),(CNTRL(  3),NFLOG),            RTBLI
     1(CNTRL(4),BTTL(1)),(CNTRL( 13),NTIN),(CNTRL(14),NTOUT),               RTBLI
     2(CNTRL( 15),NTPUN),(CNTRL(16),NCHAIN),(CNTRL( 17),LIB1),              RTBLI
     3(CNTRL( 18), LIB2),(CNTRL( 19), LIB3),(CNTRL( 20),INT1),              RTBLI
     4(CNTRL( 21), INT2),(CNTRL( 22), NSC1),(CNTRL( 23),LNK(1)),            RTBLI
     5(CNTRL( 33),NTHCS),(CNTRL( 34),NEPCS),(CNTRL( 35),KLIB1),             RTBLI
     6(CNTRL( 36),KLIB2),(CNTRL( 37),KLIB3),(CNTRL(129),NCPRN),             RTBLI
     7(CNTRL(130),NCPPT),(CNTRL(141),NTHRN),(CNTRL(142),NTHPT),             RTBLI
     8(CNTRL(143),NTHPN),(CNTRL(153),NEPRN),(CNTRL(154),NEPPT),             RTBLI
     9(CNTRL(155),NEPPN),(CNTRL(156),NEPSG),(CNTRL(157),NEPAG),             RTBLI
     A(CNTRL(165),NFGRN),(CNTRL(166),NFGPT),(CNTRL(167),NFGPN),             RTBLI
     B(CNTRL(168),NFGPB),(CNTRL(169),NFGJO),(CNTRL(177),NEDRN),             RTBLI
     C(CNTRL(178),NEDPT),(CNTRL(179),NEDPN),(CNTRL(180),NEDNB),             RTBLI
     D(CNTRL(181),NEDFW),(CNTRL(182),NEDRB),(CNTRL(183),NEDAX),             RTBLI
     E(CNTRL(184),NEDNU)                                                    RTBLI
      DIMENSION LIMP(600),HDL(9),NPT(20),THT(20),MXAS(20),                  RTBLI
     1ILHI(20),NRHP(20),DEGC(20),WSTBA(18),WSTBB(18),                       RTBLI
     2CONCTA(18,10),LIMT(10),RIN(20),RAD(20),ROUT(20),VOL(20),              RTBLI
     3MTBL(20),REGV(20),FISD(20),HOLID(3,18)                                RTBLI
      COMMON LIMP                                                           RTBLI
      EQUIVALENCE                                                           RTBLI
     1(LIMP(  1),    IDENT),(LIMP(  2),       NX),(LIMP(  3),       MX),   RTBLI
     2(LIMP(  4),      NRX),(LIMP(  5),     ISOX),(LIMP(  6),    ISOXE),   RTBLI
     3(LIMP(  7),    NGEOM),(LIMP(  8),   NP1B1),(LIMP(  9),     NBCT),   RTBLI
     4(LIMP( 10),      NXP),(LIMP( 11),     BSQD),(LIMP( 12),  HOL(1)),    RTBLI
     5(LIMP( 21),  NPT(1)),(LIMP( 41),  THT(1)),(LIMP( 61), MXAS(1)),       RTBLI
     6(LIMP( 81), ILHI(1)),(LIMP(101), NRHP(1)),(LIMP(121), DEGC(1)),       RTBLI
     7(LIMP(141),WSTBA(1)),(LIMP(159),WSTBB(1)),(LIMP(177),CONCTA(1,1)),    RTBLI
     8(LIMP(357), LIMT(1)),(LIMP(367),  RIN(1)),(LIMP(387), RAD(1)),        RTBLI
     9(LIMP(407), ROUT(1)),(LIMP(427),  VOL(1)),(LIMP(447), MTBL(1)),       RTBLI
     A(LIMP(467), REGV(1)),(LIMP(487), FISD(1)),(LIMP(507),HOLID(1,1))      RTBLI
      DIMENSION LOUT(1100),HOLA(9),BALT(18,4,5),FOIL(20,4,5),               RTBLI
     1FOGX(4,6),FOX(20,4),DUMB(20),OTGC(5),OTGA(30,6)                       RTBLI
      COMMON LOUT                                                           RTBLI
      EQUIVALENCE (         LOUT(1),ID),(LOUT(2),HOLA(1)),                  RTBLI
     1(LOUT(11),BALT(1,1,1)),(LOUT(371),FOIL(1,1,1)),                       RTBLI
     2(LOUT(771),FOGX(1,1)),(LOUT(795),FOX(1,1)),(LOUT(875),DUMB(1)),       RTBLI
     3(LOUT(895),OTGC(1)),(LOUT(900),OTGA(1))                               RTBLI
      DIMENSION ERASE(3500)                                                 RTBLI
      COMMON ERASE                                                          RTBLI
      DIMENSION SSC(10),S1(10),SIGABS(10),SIGIN(10),SIGX(10),C(10),         RTBLI
     1A1(10),SD(10),PROB(25,10),SIGV(18,54),GNU(18,54),SIGA(18,54),         RTBLI
     2NRIG(18),ER(200  ),GMN(200  ),GMGM(200  ),GMF(200  ),SPIN(200  ),     RTBLI
     3AMASS(18),SIGP(18),JONE(18),JTWO(18),DZERO(18),DONE(18),DTWO(18),     RTBLI
     4ETA(20),Q(20),FS(54),FX(20),DEL(54),F(20,54),MDONE(18),P(18,54),      RTBLI
     5PF(18,54),PZ(1001),PZ1(1001),A1(18),EBK(55),TEMP(18),SIGEFV(18),      RTBLI
     6CT(18,10)                                                             RTBLI
      COMMON IX,SIGV,GNU,SIGA,P,PF,F,DEL,FS,SSC,S1,SIGABS,SIGIN,SIGX,       RTBLI
     1C,A1,SD,PROB,NRIG,ER,GMN,GMGM,GMF,SPIN,AMASS,SIGP,JONE,JTWO,          RTBLI
     2DZERO,DONE,DTWO,ETA,Q,ESC,MDONE,KEY,MCURR,PZ,PZ1,DELSIG,A1,EBK,       RTBLI
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INE  RTBLIB                                  CDC 6600 FTN V3.0-P261 OPT=2  11/20/74

      SIGMP,SIGEPY,NDONE                                                    RTBLIB
       DIMENSION DATA(165),DZ(18),GRP(20),SOR(20),T(20,20),XT(20),V1(20),   RTBLIB
      1V2(20),V3(20),V4(20),V5(20),CP(20),CN(20),CP2(20),CN2(20),W(21),     RTBLIB
      2F1(20),F2(20),S2(20),Q1(20),QO(20),TO(20),T1(20)                     RTBLIB
       EQUIVALENCE (ERASE(1),DATA(1),DZ(1),GRP(1)),                         RTBLIB
      1(ERASE(21),SOR(1)),(ERASE(41),T(1)),(ERASE(441),XT(1)),              RTBLIB
      2(ERASE(461),V1(1)),(ERASE(481),V2(1)),(ERASE(501),V3(1)),            RTBLIB
      3(ERASE(521),V4(1)),(ERASE(541),V5(1)),(ERASE(561),CP(1)),            RTBLIB
      4(ERASE(581),CN(1)),(ERASE(601),CP2(1)),(ERASE(621),CN2(1)),          RTBLIB
      5(ERASE(641),Y(1)),(ERASE(441),F1(1)),(ERASE(461),F2(1)),             RTBLIB
      6(ERASE(481),S2(1)),(ERASE(501),Q1(1)),(ERASE(481),QO(1)),            RTBLIB
      7(ERASE(461),TO(1)),(ERASE(441),T1(1))                                RTBLIB
       EQUIVALENCE (FX(1),FISD(1)),(CX(1),CONCTA(1)),(LIB2,NLIB2)           RTBLIB
       COMMON NLIB                                                          RTBLIB
       DIMENSION THFLX(630),ANH(10),SDH(10),S1H(10)                         RTBLIB
       COMMON THFLX,ANH,SDH,S1H                                             RTBLIB
       DIMENSIONLOCR(20)                                                    RTBLIB
       EQUIVALENCE (ERASE(3441),LOCR(1))                                    RTBLIB
       COMMON/CREG2/OS0(18,54),OS1(18,54),OXS0(18,54)                       RTBLIB
       DIMENSION ABSSIG(18),FISSIG(18),GNUSIG(18),SGSIG(54)                 RTBLIB
       EQUIVALENCE                                                          RTBLIB
      1(SGSIG(1),ABSSIG(1)),(SGSIG(19),FISSIG(1)),(SGSIG(37),GNUSIG(1))     RTBLIB
       COMMON/CADY/CDYC(10),IGCDY,ICADY                                     HAMMER
       DIMENSION ICNTRL(200)                                                HAMMER
       EQUIVALENCE (ICNTRL(1),CNTRL(1))                                     HAMMER
       ICADY=ICNTRL(158)                                                    HAMMER
       IF(IG.EQ.1) WRITE(NTOJT,1111) ICADY                                  HAMMER
 1111  FORMAT(*0   ICADY=*,I4)                                              HAMMER
       ISOX=ISOX+ISOXC                                                      RTBLIB
       DO51=1,348                                                           RTBLIB
    5  SSC(I)=0.                                                            RTBLIB
       DO 6 I=1,30                                                          RTBLIB
    6  ANH(I)=0.0                                                           RTBLIB
       IFOUND=0                                                             RTBLIB
       NRED=0                                                               RTBLIB
       NL=0                                                                 RTBLIB
   10  NRED=NRED+1                                                          RTBLIB
       READ(LIB2)IFL,WDX,NIN,NR ,(DATA(I),I=1,IFL)                          RTBLIB
       IF(WDX)140,140,20                                                    RTBLIB
   20  DO1101=1,ISOX                                                        RTBLIB
       IF(WDX.NE.WSTBA(I)) GO TO 110                                        RTBLIB
   30  SIGY(I,IG)=DATA(5)                                                   RTBLIB
       GNU(I,IG)=DATA(9)                                                    RTBLIB
       SIGA(I,IG)=DATA(5)+DATA(3)                                           RTBLIB
       FISSIG(I) = SIGY(I,IG)                                               RTBLIB
       GNUSIG(I) = GNU(I,IG)                                                RTBLIB
       ABSSIG(I) = SIGA(I,IG)                                               RTBLIB
       OS0(I,IG)=DATA(2)+DATA(4)                                            RTBLIB
       OS1(I,IG)=DATA(7)                                                    RTBLIB
       OXS0(I,IG)=DATA(9)                                                   RTBLIB
       NP1(I)=NR                                                            RTBLIB
       IF(NR)31,34,31                                                       RTBLIB
   31  NRR=IABS(NR)                                                         RTBLIB
       LOCR(I)=NL                                                           RTBLIB
       DO33I=1,NRR                                                          RTBLIB
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UTINE  RTBLIB                    CDC 6600 FTN V3.0-P261 OPT=2  11/20/74
                                                                RTBLIB
      NL=NL+1                                                   RTBLIB
      IF(NL-200)36,36,35                                        RTBLIB
   35 NR(3(I)=ISIGN(N-1,NRIG(I))                                RTBLIB
      GO TO 37                                                  RTBLIB
   36 LOC=NIN*10+(N-1)*5                                        RTBLIB
      ER(NL)=DATA(LOC)                                          RTBLIB
      GMN(NL)=DATA(LOC+1)                                       RTBLIB
      GMGM(NL)=DATA(LOC+2)                                      RTBLIB
      GMF(NL)=DATA(LOC+3)                                       RTBLIB
   33 SPIN(NL)=DATA(LOC+4)                                      RTBLIB
   34 AMASS(I)=DATA(1)                                          RTBLIB
      SIGP(I)=DATA(2)                                           RTBLIB
      DO100M=1,MX                                               RTBLIB
      IF(CT(I,M))40,100,40                                      RTBLIB
   40 SSC(M)=SSC(M)+DATA(2)*CT(I,M)                             RTBLIB
      SIGABS(M)=SIGABS(M)+(DATA(3)+DATA(5))*CT(I,M)             RTBLIB
      SIGIN(M)=SIGIN(M)+DATA(4)*CT(I,M)                         RTBLIB
      SIGX(M)=SIGX(M)+DATA(5)*CT(I,M)*DATA(8)                   RTBLI
      WDP = AMOD(WDX,10000.)                                    RTBLI
      IF(WDP.NE.1001.) GO TO 60                                 RTBLI
   50 C(M)=C(M)+DATA(2)*CT(I,M)                                 RTBLI
      ANH(M)=ANH(M)+DATA(6)*DATA(9)*CT(I,M)                     RTBLI
      SDH(M)=SDH(M)+DATA(9)*CT(I,M)                             RTBLI
      S1H(M)=S1H(M)+DATA(7)*CT(I,M)                             RTBLI
      GOTO70                                                    RTBLI
   60 AN(M)=AN(M)+DATA(6)*DATA(9)*CT(I,M)                       RTBLI
      SD(M)=SD(M)+DATA(9)*CT(I,M)                               RTBLI
   70 S1(M)=S1(M)+DATA(7)*CT(I,M)                               RTBLI
      IF(NIN)100,100,80                                         RTBLI
   80 LOW=IG*NIN+1                                              RTBLI
      DO90N=LOW,IG                                              RTBLI
   90 PROH(N,M)=PROH(N,M)+DATA(N+9)*CT(I,M)                     RTBLI
  100 CONTINUE                                                  RTBLI
      IFOUND=IFOUND+1                                           RTBLI
      IF(ISOX-IFOUND)120,120,110                                RTBLI
  110 CONTINUE                                                  RTBLI
      GOTO10                                                    RTBLI
  120 NSKIP=NLIB-NREC+1                                         RTBLI
      DO130N=1,NSKIP                                            RTBLI
  130 READ(LIB2)                                                RTBLI
      GOTO150                                                   RTBLI
  140  IF(ISOX-ISOXF-IFOUND)150,150,141                         RTBLI
  141 CALL STOPIT(301)                                          RTBLI
  150 ISOX=ISOX-ISOXC                                           RTBLI
      NECS = (IG-1)*3                                           RTBLI
      CALL WRITEC(SGSIG,NECS,54)                                RTBLI
      DO 160 M=1,MX                                             HAMME
      CDYC(M)=SDH(M)**2/ANH(M)                                  HAMME
      IF(ANH(M).LE..0001) CDYC(M)=0.0                           HAMME
  160 CONTINUE                                                  HAMME
      IF(IG.GE.53.AND.ICARY.EQ.1)                               HAMMI
     1WRITE(NOUT,1114) IG                                       HAMMI
      IF(IG.GE.53.AND.ICARY.EQ.1)                               HAMMI
     1WRITE(NOUT,1113)                                          HAMMI
      IF(IG.GE.53.AND.ICARY.EQ.1)                               HAMMI
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ROUTINE  RTBL1R                                  CDC 6600 FTN V3.0-P261 OPT=2  11/20/
          1WRITE(NTOUT,1112) (CDYC(M),M=1,MX)                                    HAMM
      1112 FORMAT(5E20.8)                                                        HAMM
      1114 FORMAT(*  IG=*I10)                                                    HAMM
      1113 FORMAT(* CDYC(M),M=1,MX*)                                             HAMM
           RETURN                                                                RTBL
           END                                                                   RTBL
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```
      SUBROUTINE SORE(IG)                                                    SORE
CSORE                                                                        SORE
      DIMENSION CNTRL(200),BTTL(9),LNK(10)                                   SORE
      COMMON CNTRL                                                           SORE
      EQUIVALENCE                                                            SORE
     X(CNTRL(  1),IDBCH),(CNTRL(  2),NCASE),(CNTRL(  3),NFLOG),             SORE
     1(CNTRL(4),BTTL(1)),(CNTRL( 13), NTIN),(CNTRL(14),NTOUT),              SORE
     2(CNTRL( 15),NTPUN),(CNTRL(16),NCHAIN),(CNTRL( 17),LIB1),              SORE
     3(CNTRL( 18), LIB2),(CNTRL( 19), LIB3),(CNTRL( 20),INT1),              SORE
     4(CNTRL( 21), INT2),(CNTRL( 22), NSC1),(CNTRL( 23),LNK(1)),            SORE
     5(CNTRL( 33),NTHCS),(CNTRL( 34),NEPCS),(CNTRL( 35),KLIB1),            SORE
     6(CNTRL( 36),KLIB2),(CNTRL( 37),KLIB3),(CNTRL(129),NCPRN),            SORE
     7(CNTRL(130),NCPPT),(CNTRL(141),NTHRN),(CNTRL(142),NTHPT),            SORE
     8(CNTRL(143),NTHPN),(CNTRL(153),NEPRN),(CNTRL(154),NEPPT),            SORE
     9(CNTRL(155),NEPPN),(CNTRL(156),NEPSG),(CNTRL(157),NEPAG),            SORE
     A(CNTRL(165),NFGRN),(CNTRL(166),NFGPT),(CNTRL(167),NFGPN),            SORE
     B(CNTRL(168),NFGPB),(CNTRL(169),NFGJO),(CNTRL(177),NEDRN),            SORE
     C(CNTRL(178),NEDPT),(CNTRL(179),NEDPN),(CNTRL(180),NEDNB),            SORE
     D(CNTRL(181),NEDFW),(CNTRL(182),NEDRB),(CNTRL(183),NEDAX),            SORE
     E(CNTRL(184),NEDNU)                                                    SORE
      DIMENSION LIMP(600),HOL(9),NPT(20),THT(20),MXAS(20),                   SORE
     1ILHI(20),NRBP(20),DEGC(20),WSTBA(18),WSTBB(18),                        SORE
     2CONCTA(18,10),LIMT(10),RIN(20),RAD(20),ROUT(20),VOL(20),               SORE
     3MTBL(20),REGV(20),FISD(20),HOLID(3,18)                                SORE
      COMMON LIMP                                                            SORE
      EQUIVALENCE                                                            SORE
     1(LIMP(  1),   IDENT),(LIMP(  2),      NX),(LIMP(  3),      MX),       SORE
     2(LIMP(  4),     NRX),(LIMP(  5),    ISOX),(LIMP(  6),   ISCXE),       SORE
     3(LIMP(  7),   NGEOM),(LIMP(  8),   NRBI),(LIMP(  9),    NEC),        SORE
     4(LIMP( 10),     NXP),(LIMP( 11),     BSQD),(LIMP( 12),   HCL(1)),     SORE
     5(LIMP( 21),  NPT(1)),(LIMP( 41),    THT(1)),(LIMP( 61),  MXAS(1)),    SORE
     6(LIMP( 81), ILHI(1)),(LIMP(101), NRBP(1)),(LIMP(121), DEGC(1)),       SORE
     7(LIMP(141),WSTBA(1)),(LIMP(159),WSTBB(1)),(LIMP(177),CONCTA(1,1)),    SORE
     8(LIMP(357), LIMT(1)),(LIMP(367),  RIN(1)),(LIMP(387),  RAD(1)),       SORE
     9(LIMP(407), ROUT(1)),(LIMP(427),  VCL(1)),(LIMP(447),  MTBL(1)),      SORE
     A(LIMP(467), REGV(1)),(LIMP(487), FISD(1)),(LIMP(507),HOLID(1,1))      SORE
      DIMENSION LOUT(1100),HOLA(9),BALT(18,4,5),FOIL(20,4,5),                SORE
     1FOGX(4,6),FOX(20,4),DUMB(20),OTGC(5),OTGA(30,6)                        SORE
      COMMON LOUT                                                            SORE
      EQUIVALENCE (        LOUT(1),ID),(LOUT(2),HOLA(1)),                    SORE
     1(LOUT(11),BALT(1,1,1)),(LOUT(371),FOIL(1,1,1)),                        SORE
     2(LOUT(771),FOGX(1,1)),(LOUT(795),FOX(1,1)),(LOUT(875),DUMB(1)),        SORE
     3(LOUT(895),OTGC(1)),(LOUT(900),OTGA(1))                                SORE
      DIMENSION ERASE(3500)                                                  SORE
      COMMON ERASE                                                           SORE
      DIMENSION SSC(10),S1(10),SIGABS(10),SIGIN(10),SIGX(10),C(10),          SORE
     1AN(10),SD(10),PROB(25,10),SIGY(18,54),GNU(18,54),SIGA(18,54),          SORE
     2NRIG(18),ER(200  ),GMN(200  ),GMGM(200  ),GMF(200  ),SPIN(200  ),      SORE
     3AMASS(18),SIGP(18),JONE(18),JTWO(18),DZERO(18),DONE(18),DTWO(18),      SORE
     4ETA(20),Q(20),FS(54),FX(20),DEL(54),F(20,54),MDONE(18),P(18,54),       SORE
     5PF(18,54),PZ(1001),PZ1(1001),A1(18),EBK(55),TEMP(18),SIGEFY(18),       SORE
     6CT(18,10)                                                              SORE
      COMMON IX,SIGY,GNU,SIGA,P,PF,F,DEL,FS,SSC,S1,SIGABS,SIGIN,SIGX,        SORE
     1C,AN,SD,PROB,NRIG,ER,GMN,GMGM,GMF,SPIN,AMASS,SIGP,JONE,JTWO,           SORE
     2DZERO,DONE,DTWO,ETA,Q,ESC,MDONE,KEY,MCURR,PZ,PZ1,DELSIG,A1,EBK,        SORE
```

```
      3TEMP,SIGEFY,NDONE                                                SORE
       DIMENSION DATA(165),DZ(18),GRP(20),SOR(20),T(20,20),XT(20),V1(20), SORE
      1V2(20),V3(20),V4(20),V5(20),CP(20),CN(20),CP2(20),CN2(20),Y(21),  SORE
      2F1(20),F2(20),S2(20),D1(20),QC(20),TO(20),T1(20)                 SORE
       EQUIVALENCE (ERASE(1),DATA(1),DZ(1),GRP(1)),                     SORE
      1(ERASE(21),SOR(1)),(ERASE(41),T(1)),(ERASE(441),XT(1)),          SORE
      2(ERASE(461),V1(1)),(ERASE(481),V2(1)),(ERASE(501),V3(1)),        SORE
      3(ERASE(521),V4(1)),(ERASE(541),V5(1)),(ERASE(561),CP(1)),        SORE
      4(ERASE(581),CN(1)),(ERASE(601),CP2(1)),(ERASE(621),CN2(1)),      SORE
      5(ERASE(641),Y(1)),(ERASE(441),F1(1)),(ERASE(461),F2(1)),         SORE
      6(ERASE(481),S2(1)),(ERASE(501),C1(1)),(ERASE(481),QO(1)),        SORE
      7(ERASE(461),TO(1)),(ERASE(441),T1(1))                            SORE
       EQUIVALENCE (FX(1),FISD(1)),(CT(1),CONCTA(1)),(LIB2,NLIB2)       SORE
       COMMON NLIB                                                      SORE
       COMMON THFLX(630),ANH(10),SDH(10),S1H(10)                        HAMMER
       DIMENSION ANH(10),ANBH(10),SDH1(10)                              HAMMER
       DIMENSION                  ANB(10),AN(10),C1(10),SD1(10)         SORE
       COMMON/DAVE/RXREM(20,3)                                          SORE
       DIMENSION FSUM(20),ENNP(20)                                      SORE
       IF(IG-1)10,10,30                                                 SORE
   10  A=0.                                                             SORE
       DO11N=1,NX                                                       SORE
   11   A=A+FX(N)*VOL(N)                                                SORE
       IF(A)12,12,14                                                    SORE
   12  A=0.                                                             SORE
       DO13N=1,NX                                                       SORE
   13  A=A+VOL(N)                                                       SORE
       DO 18N=1,NX                                                      SORE
   18  FX(N)=1./A                                                       SORE
       GOTO16                                                           SORE
   14   DO15N=1,NX                                                      SORE
   15   FX(N)=FX(N)/A                                                   SORE
   16   DO20N=1,NX                                                      SORE
       G(N)=0.                                                          SORE
       ETA(N)=0.                                                        SORE
       SOR(N)=FS(1)*FX(N)                                               SORE
       M=MTBL(N)                                                        SORE
       IF(SD(M))100,101,100                                             SORE
  101  ANB(M)=0.0                                                       SORE
       GO TO 402                                                        HAMMER
  100  ANB(M)=AN(M)/SD(M)                                               SORE
  402  CONTINUE                                                         HAMMER
       IF(SDH(M)) 400,401,400                                           HAMMER
  401  ANBH(M)=0.0                                                      HAMMER
       GO TO 102                                                        HAMMER
  400  ANBH(M)=ANH(M)/SDH(M)                                            HAMMER
  102  C1(M)=C(M)                                                       SORE
       SDH1(M)=SDH(M)                                                   HAMMER
       SD1(M)=SD(M)                                                     SORE
   20  GRP(N)=-2.*SDH(M)/(2.*ANBH(M)*DEL(1))+SSC(M)*S1(M)*SD(M)/(ANB(M) HAMMER
      1*DEL(1)/2.)*PROB(1,M)                                            HAMMER
       DO 1011 N=1,NX                                                   SORE
       FSUM(N) = 0.0                                                    SORE
  1011 ENNP(N) = 0.0                                                    SORE
       RETURN                                                           SORE
```

```
      30 DO40N=1,NX                                                          SORE
         M=MTBL(N)                                                           SORE
         ETA(N)=ESC*ETA(N)*(2.*AMBH(M)*DEL(IG-1))/(2.*AMBH(M)*DEL(IG-1))     HAMMER
        1*2.*DEL(IG-1)*SD1(M)*F(N,IG-1)/(2.*AMBH(M)*DEL(IG-1))               HAMMER
         Q(N)=ESC*Q(N)*(2.*AMB(M)-DEL(IG-1))/(2.*AMB(M)+DEL(IG-1))           SORE
        1+2.*DEL(IG-1)*SD1(M)*F(N,IG-1)/(2.*AMB(M)*DEL(IG-1))                SORE
         IF(IG.EQ.55) GO TO 40                                               SORE
         IF(SD(M))200,201,200                                                SORE
     201 AM(M)=0.0                                                           SORE
         GO TO 302                                                           HAMMER
     200 AM(M)=AM(M)/SD(M)                                                   SORE
     302 CONTINUE                                                            HAMMER
         IF(SDH(M)) 300,301,300                                              HAMMER
     301 AMH(M)=0.0                                                          HAMMER
         GO TO 202                                                           HAMMER
     300 AMH(M)=AMH(M)/SDH(M)                                                HAMMER
     202 GRP(N)=SSC(M)*S1(M)-2.*SDH(M)/(2.*AMH(M)*DEL(IG))-SD(M)/(AM(M)*     HAMMER
        1DEL(IG)/2.)                                                         HAMMER
         SOR(N)=ETA(N)*2./(2.*AMH(M)*DEL(IG))*Q(N)/(AM(M)*DEL(IG)/2.)        HAMMER
        1+FS(IG)*FX(N)                                                       HAMMER
      40 CONTINUE                                                            SORE
         IF(IG.LT.11) GO TO 1001                                             SORE
         IF(IG.GT.25) GO TO 1002                                             SORE
         DO 1003 N=1,NX                                                      SORE
         M = MTBL(N)                                                         SORE
         DO 1004 J=1,10                                                      SORE
         ENNP(N) = ENNP(N) + PROB(J,M)*F(N,J)*DEL(J)                         SORE
         IF(IG.NE.11) GO TO 1004                                             SORE
         FSUM(N) = FSUM(N) + F(N,J)*DEL(J)                                   SORE
    1004 CONTINUE                                                            SORE
         IF(IG.NE.11) GO TO 1003                                             SORE
         RXREM(N,1) = (Q(N)*ETA(N))/FSUM(N)                                  SORE
    1003 CONTINUE                                                            SORE
         GO TO 1001                                                          SORE
    1002 IF(IG.GT.26) GO TO 1005                                             SORE
         DO 1006 N=1,NX                                                      SORE
    1006 RXREM(N,1) = RXREM(N,1)*ENNP(N)/FSUM(N)                             SORE
         DO 1012 N=1,NX                                                      SORE
         FSUM(N) = 0.0                                                       SORE
         DO 1007 J=11,25                                                     SORE
    1007 FSUM(N) = FSUM(N) + F(N,J)*DEL(J)                                   SORE
    1012 RXREM(N,2) = (Q(N)*ETA(N))/FSUM(N)                                  SORE
    1005 IF(IG.EQ.55) GO TO 1008                                             SORE
         GO TO 1001                                                          SORE
    1008 DO 1009 N=1,NX                                                      SORE
         FSUM(N) = 0.0                                                       SORE
         DO 1010 J=26,54                                                     SORE
    1010 FSUM(N) = FSUM(N) + F(N,J)*DEL(J)                                   SORE
    1009 RXREM(N,3) = (Q(N)*ETA(N))/FSUM(N)                                  SORE
         GO TO 80                                                            SORE
    1001 CONTINUE                                                            SORE
         DO50M=1,MX                                                          SORE
         AMB(M)=AM(M)                                                        SORE
         C1(M)=C(M)                                                          SORE
         AMBH(M)=AMH(M)                                                      HAMMER
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```
      SDH1(M)=SDH(M)                                                    HAMMER
   50 SD1(M)=SD(M)                                                      SORE
      IF(IG-25)60,60,80                                                 SORE
   60 IG1=IG+1                                                          SORE
      DO70N=1,NX                                                        SORE
      M=MTBL(N)                                                         SORE
      GRP(N)=GRP(N)+PROB(IG,M)                                          SORE
      DO70I=1,IG1                                                       SORE
   70 SOR(N)=SOR(N)+PROB(I,M)*F(N,I)/DEL(IG)*DEL(I)                     SORE
   80 RETURN                                                            SORE
      END
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IS MADE BY THE OPTIMIZER
VARIANT RLIST REMOVED FROM THE LOOP STARTING AT LINE     83

ION
SIGNED OVER THE LOOP BEGINNING AT LINE     77
SIGNED OVER THE LOOP BEGINNING AT LINE     81
SIGNED OVER THE LOOP BEGINNING AT LINE     86
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      SUBROUTINE PTBL(I3,J)                                                 PTBL
CPTBL  =====SHAMMER===BVL-SRL LATTICE ANALYSIS PROGRAM==========SHAMLET PTBL
CPTBL                                                                       PTBL
      DIMENSION CNTRL(200),BTTL(9),LNK(10)                                  PTBL
      COMMON CNTRL                                                          PTBL
      EQUIVALENCE                                                           PTBL
     X(CNTRL(  1),IDBCH),(CNTRL(  2),NCASE),(CNTRL(  3),NFLOG),            PTBL
     1(CNTRL(4),BTTL(1)),(CNTRL( 13),NTIN),(CNTRL(14),NTOUT),               PTBL
     2(CNTRL( 15),NTPUN),(CNTRL(16),NCHAIN),(CNTRL( 17),LIB1),              PTBL
     3(CNTRL( 18), LIB2),(CNTRL( 19), LIB3),(CNTRL( 20),INT1),              PTBL
     4(CNTRL( 21), INT2),(CNTRL( 22), NSC1),(CNTRL( 23),LNK(1)),            PTBL
     5(CNTRL( 33),NTHCS),(CNTRL( 34),NEPCS),(CNTRL( 35),KLIB1),            PTBL
     6(CNTRL( 36),KLIB2),(CNTRL( 37),KLIB3),(CNTRL(129),NCPRN),            PTBL
     7(CNTRL(130),NCPPT),(CNTRL(141),NTHRN),(CNTRL(142),NTHPT),            PTBL
     8(CNTRL(143),NTHPN),(CNTRL(153),NEPRN),(CNTRL(154),NEPPT),            PTBL
     9(CNTRL(155),NEPPN),(CNTRL(156),NEPSG),(CNTRL(157),NEPAG),            PTBL
     A(CNTRL(165),NFGRN),(CNTRL(166),NFGPT),(CNTRL(167),NFGPN),            PTBL
     B(CNTRL(168),NFGPB),(CNTRL(169),NFGJO),(CNTRL(177),NEDRN),            PTBL
     C(CNTRL(178),NEDPT),(CNTRL(179),NEDPN),(CNTRL(180),NEDNB),            PTBL
     D(CNTRL(181),NEDFN),(CNTRL(182),NEDRB),(CNTRL(183),NEDAX),            PTBL
     E(CNTRL(184),NEDNU)                                                    PTBL
      DIMENSION LIMP(600),HOL(9),NPT(20),THT(20),MXAS(20),                  PTBL
     1ILHI(20),NRBP(20),DEGC(20),WSTBA(18),WSTBB(18),                       PTBL
     2CONCTA(18,10),LIMT(10),RIN(20),RAD(20),ROUT(20),VOL(20),              PTBL
     3MTBL(20),REGV(20),FISD(20),HOLID(3,18)                                PTBL
      COMMON LIMP                                                           PTBL
      EQUIVALENCE                                                           PTBL
     1(LIMP(  1),    IDENT),(LIMP(  2),       NX),(LIMP(  3),       MX),   PTBL
     2(LIMP(  4),      NRX),(LIMP(  5),     ISOX),(LIMP(  6),    ISOXE),   PTBL
     3(LIMP(  7),    NGEOM),(LIMP(  8),    NP1B1),(LIMP(  9),     NBCT),   PTBL
     4(LIMP( 10),      NXP),(LIMP( 11),     BSQD),(LIMP( 12),  HOL(1)),     PTBL
     5(LIMP( 21),  NPT(1)),(LIMP( 41),   THT(1)),(LIMP( 61), MXAS(1)),      PTBL
     6(LIMP( 81), ILHI(1)),(LIMP(101), NRBP(1)),(LIMP(121), DEGC(1)),       PTBL
     7(LIMP(141),WSTBA(1)),(LIMP(159),WSTBB(1)),(LIMP(177),CONCTA(1,1)),    PTBL
     8(LIMP(357), LIMT(1)),(LIMP(367),  RIN(1)),(LIMP(387), RAD(1)),        PTBL
     9(LIMP(407), ROUT(1)),(LIMP(427),  VOL(1)),(LIMP(447), MTBL(1)),       PTBL
     A(LIMP(467), REGV(1)),(LIMP(487), FISD(1)),(LIMP(507),HOLID(1,1))      PTBL
      DIMENSION LOUT(1100),HOLA(9),BALT(18,4,5),FOIL(20,4,5),               PTBL
     1FOGX(4,6),FOX(20,4),DUMB(20),OTGC(5),OTGA(30,6)                       PTBL
      COMMON LOUT                                                           PTBL
      EQUIVALENCE (         LOUT(1),ID),(LOUT(2),HOLA(1)),                  PTBL
     1(LOUT(11),BALT(1,1,1)),(LOUT(371),FOIL(1,1,1)),                       PTBL
     2(LOUT(771),FOGA(1,1)),(LOUT(795),FOX(1,1)),(LOUT(875),DUMB(1)),       PTBL
     3(LOUT(895),OTGC(1)),(LOUT(900),OTGA(1))                               PTBL
      DIMENSION ERASE(3500)                                                 PTBL
      COMMON ERASE                                                          PTBL
      DIMENSION SSC(10),S1(10),SIGABS(10),SIGIN(10),SIGX(10),C(10),         PTBL
     1AJ(10),SD(10),PROB(45,10),SIGY(18,54),GNU(18,54),SIGA(18,54),         PTBL
     2NRIG(18),ER(200  ),GMN(200  ),GMGM(200  ),GMF(200  ),SPIN(200  ),     PTBL
     3AMASS(18),SIGP(18),JONE(18),JTWO(18),DZERO(18),DONE(18),DTWO(18),     PTBL
     4ETA(20),D(20),FS(54),FX(20),DEL(54),F(20,54),MDONE(18),P(18,54),      PTBL
     5PF(18,54),PZ(1001),PZ1(1001),A1(18),EBK(55),TEMP(18),SIGEFY(18),      PTBL
     6CT(18,10)                                                             PTBL
      COMMON IX,SIGY,GNU,SIGA,P,PF,F,DEL,FS,SSC,S1,SIGABS,SIGIN,SIGX,       PTBL
     1C,AJ,SD,PROB,NRIG,ER,GMN,GMGM,GMF,SPIN,AMASS,SIGP,JONE,JTWO,          PTBL
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ROUTINE  PTBL                                   CDC 6600 FTN V3.0-P261 OPT=2  11/20/
     2DZERO,DONE,DTWO,ETA,Q,ESC,MDONE,KEY,MCURR,PZ,PZ1,DELSIG,A1,EBK,     PTBL
     3TEMP,SIGEFY,NDONE                                                   PTBL
      DIMENSION DATA(165),DZ(18),GRP(20),SOR(20),T(20,20),XT(20),V1(20),  PTBL
     1V2(20),V3(20),V4(20),V5(20),CP(20),CN(20),CP2(20),CN2(20),Y(21),    PTBL
     2F1(20),F2(20),S2(20),Q1(20),QQ(20),TO(20),T1(20)                    PTBL
      EQUIVALENCE (ERASE(1),DATA(1),DZ(1),GRP(1)),                        PTBL
     1(ERASE(21),SOR(1)),(ERASE(41),T(1)),(ERASE(441),XT(1)),             PTBL
     2(ERASE(461),V1(1)),(ERASE(481),V2(1)),(ERASE(501),V3(1)),           PTBL
     3(ERASE(521),V4(1)),(ERASE(541),V5(1)),(ERASE(561),CP(1)),           PTBL
     4(ERASE(581),CN(1)),(ERASE(601),CP2(1)),(ERASE(621),CN2(1)),         PTBL
     5(ERASE(641),Y(1)),(ERASE(441),F1(1)),(ERASE(461),F2(1)),            PTBL
     6(ERASE(461),S2(1)),(ERASE(501),Q1(1)),(ERASE(481),QQ(1)),           PTBL
     7(ERASE(461),TO(1)),(ERASE(441),T1(1))                               PTBL
      EQUIVALENCE (FX(1),FISD(1)),(CT(1),CONCTA(1)),(LIB2,NLIB2)          PTBL
      COMMON NLIB                                                         PTBL
      COMMON/CADY/CDYC(10),IGCDY,ICADY                                    HAMM
      IGCDY=IG                                                            HAMM
      SIGPZ=SIGP(J)                                                       PTBL
      J1=JONE(J)                                                          PTBL
      IF(J1)20,10,20                                                      PTBL
   10 SIGM1=0.                                                            PTBL
      GOTO30                                                              PTBL
   20 SIGM1=SIGP(J1)*DONE(J )/DZERO(J)                                    PTBL
   30 J2=JTWO(J)                                                          PTBL
      IF(J2)50,40,50                                                      PTBL
   40 SIGM2=0.                                                            PTBL
      GOTO60                                                              PTBL
   50 SIGM2=SIGP(J2)*DTWO(J )/DZERO(J)                                    PTBL
   60 SIGT=(SIGPZ+SIGM1+SIGM2)*DZERO(J)                                   PTBL
      FLX=0.                                                              PTBL
      VO=0.                                                               PTBL
      DO110N=1,NX                                                         PTBL
      QQ(N)=0.                                                            PTBL
      M=MTBL(N)                                                           PTBL
      IF(CT(J,M))80,70,90                                                 PTBL
   70 XT(N)=SSC(M)                                                        PTBL
      IF(IG.GE.53.AND.ICADY.EQ.1) XT(N)=CDYC(M)                           HAMM
      GOTO110                                                             PTBL
   80 XT(N)=SIGT                                                          PTBL
      DO90NR=1,NRX                                                        PTBL
      IF(N-NRBP(NR))100,100,90                                            PTBL
   90 CONTINUE                                                            PTBL
      NR=NRX                                                              PTBL
  100 RMAX=THT(NR)                                                        PTBL
      QQ(N)=VOL(N)                                                        PTBL
      VO=VO+VOL(N)                                                        PTBL
  130 FLX=FLX+VOL(N)*F(N,IG)                                              PTBL
  110 CONTINUE                                                            PTBL
      IF(NRIG(J))160,160,<C0                                              PTBL
  160 CALLPZCALC                                                          PTBL
      PO=0.                                                               PTBL
      P1=0.                                                               PTBL
      DO120N=1,NX                                                         PTBL
      IF(QQ(N))170,180,170                                                PTBL
  170 PO=PO+TO(N)                                                         PTBL
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      GOTO120                                                          PTB
  180 P1=P1+TO(N)*F(N,IG)                                              PTB
  120 CONTINUE                                                         PTB
      PO=PO/VC                                                         PTB
      IF(KEY)121,122,121                                               PTB
  121 P1=1.-PO                                                         PTB
      GOTO123                                                          PTB
  122 P1=P1/FLX                                                        PTB
  123 A1(J)=P1*PO                                                      PTB
      SIGEFY(J)=SIGT*(P1/PO)                                           PTB
      GOTO415                                                          PTB
  200 DELSIG=0.02/RMAX                                                 PTB
      TEST=RMAX-THT(1)                                                 PTB
      CALLDANC(C1)                                                     PTB
      IF(IG.EQ.53) WRITE(6,500) IG,C1,KEY                              HAM
  500 FORMAT(1H0,*IG=*,I3,*C1= *,E20.8,*KEY= *,I3)                     HAM
      SIG =0.                                                          PTB
      PZ1(1)=1.                                                        PTB
      PZ(1)=0.                                                         PTB
      DO310N=2,1001                                                    PTB
      SIG =SIG +DELSIG                                                 PTB
      IF(KEY)210,230,210                                               PTB
  210 IF(TEST)230,220,230                                              PTB
  220 ARG=SIG *RMAX                                                    PTB
      IF(NGEOM-1)221,221,222                                           PTB
  221 ARG=ARG*ARG                                                      PTB
      CALLESCAPE(1.,   ARG,P1,PO)                                      PTB
      PZ1(N)=P1+P1                                                     PTB
      GOTO223                                                          PTB
  222 CALLESCAPE(0,ARG,P1,PO)                                          PTB
      PZ1(N)=P1                                                        PTB
  223 PZ1(N)=PZ1(N)*(1.+C1)/(1.+(1.-2.*ARG*PZ1(N))*C1)                 PTB
      GOTO310                                                          PTB
  230 DO250K=1,NX                                                      PTB
      IF(QO(K))240,250,240                                             PTB
  240 XT(K)=SIG                                                        PTB
  250 CONTINUE                                                         PTB
  260 CALLPZCALC                                                       PTB
      PZ(N)=0.                                                         PTB
  270 PZ1(N)=0.                                                        PTB
      IF(KEY)305,275,305                                               PTB
  275 DO300K=1,NX                                                      PTB
      IF(QO(K))290,260,290                                             PTB
  280 PZ1(N)=PZ1(N)+TO(K)*F(K,IG)                                      PTB
      GOTO301                                                          PTB
  290 PZ(N)=PZ(N)+TO(K)                                                PTB
  300 CONTINUE                                                         PTB
      PZ1(N)=PZ1(N)/FLX                                                PTB
      PZ(N)=PZ(N)/VC                                                   PTB
      GOTO310                                                          PTB
  305 DO307K=1,NX                                                      PTB
      IF(QO(K))306,307,306                                             PTB
  306 PZ(N)=PZ(N)+TO(K)                                                PTB
  307 CONTINUE                                                         PTB
      PZ(N)=PZ(N)/VC                                                   PTB
```

```
      PZ1(N)=1.-PZ(N)                                                   PTBL
      CONTINUE                                                          PTBL
      CALL PCALC(P1,P0,SIGT)                                            PTBL
      IF(KEY)190,320,190                                                PTBL
  190 A1(J)=1.                                                          PTBL
      SIGEFY(J)=SIGT*(1.-P0)/P0                                         PTBL
      GOTO334                                                           PTBL
  320 A1(J)=P0+P1                                                       PTBL
  330 SIGEFY(J)=SIGT*P1/P0                                              PTBL
  334 NDONE=NDONE+1                                                     PTBL
  335 DO370I=1,ISOX                                                     PTBL
      DO360M=1,MX                                                       PTBL
      IF(CT(J,M))350,340,350                                            PTBL
  340 IF(CT(I,M))370,360,370                                            PTBL
  350 IF(CT(I,M))360,370,360                                            PTBL
  360 CONTINUE                                                          PTBL
      IF(NRIG(J))367,367,365                                            PTBL
  365 MDONE(I)=NDONE                                                    PTBL
  367 CONTINUE                                                          PTBL
      SIGEFY(I)=SIGEFY(J)                                               PTBL
      A1(I)=A1(J)                                                       PTBL
  370 CONTINUE                                                          PTBL
      IF(NRIG(J))415,375,375                                            PTBL
  375 MC=MCURR                                                          PTBL
      ND=NDONE                                                          PTBL
      IF(MC+1-ND)380,400,400                                            PTBL
  380 MD=MDONE(1)                                                       PTBL
      M1=ND+1-MD                                                        PTBL
      DO390M=1,M1                                                       PTBL
  390 READ(NSC1)                                                        PTBL
  400 MCURR=NDONE                                                       PTBL
      IF(KEY)420,410,420                                                PTBL
  410 WRITE(NSC1) DELSI3,PZ1,PZ                                         PTBL
  415 RETURN                                                            PTBL
  420 WRITE(NSC1) DELSI3,PZ1                                            PTBL
      RETURN                                                            PTBL
      END                                                               PTBL
```

```
      SUBROUTINE DANC(C1)                                                    DA
CDANC  ******HAMMEN***BNL-SRL LATTICE ANALYSIS PROGRAM**************HAMLET DA
CDANC DANCOFF CORRECTION FOR SINGLE RODS                                     DA
      DIMENSION CNTRL(200),BTTL(9),LNK(10)                                   DA
      COMMON CNTRL                                                           DA
      EQUIVALENCE                                                            DA
     X(CNTRL(  1),IDBCM),(CNTRL(  2),NCASE),(CNTRL(  3),NFLOG),             DA
     1(CNTRL(4),BTTL(1)),(CNTRL(13),NTIN),(CNTRL(14),NTOUT),                 DA
     2(CNTRL( 15),NTPUN),(CNTRL(16),NCHAIN),(CNTRL( 17),LIB1),               DA
     3(CNTRL( 18), LIB2),(CNTRL( 19), LIB3),(CNTRL( 20),INT1),               DA
     4(CNTRL( 21), INT2),(CNTRL( 22), NSC1),(CNTRL( 23),LNK(1)),             DA
     5(CNTRL( 33),NTHCS),(CNTRL( 34),NEPCS),(CNTRL( 35),KLIB1),              DA
     6(CNTRL( 36),KLIB2),(CNTRL( 37),KLIB3),(CNTRL(129),NCPRN),              DA
     7(CNTRL(130),NCPPT),(CNTRL(141),NTMRN),(CNTRL(142),NTMPT),              DA
     8(CNTRL(143),NTHPN),(CNTRL(153),NEPRN),(CNTRL(154),NEPPT),              DA
     9(CNTRL(155),NEPPN),(CNTRL(156),NEPSG),(CNTRL(157),NEPAG),              DA
     A(CNTRL(165),NFGRN),(CNTRL(166),NFGPT),(CNTRL(167),NFGPN),              DA
     B(CNTRL(168),NFGPB),(CNTRL(169),NFGJO),(CNTRL(177),NEDRN),              DA
     C(CNTRL(178),NEDPT),(CNTRL(179),NEDPN),(CNTRL(180),NEDNB),              DA
     D(CNTRL(181),NEDFW),(CNTRL(182),NEDRB),(CNTRL(183),NEDAX),              DA
     E(CNTRL(184),NEDNU)                                                     DA
      DIMENSION LIMP(600),HOL(9),NPT(20),THT(20),MXAS(20),                   DA
     1ILHI(20),NRHP(20),DEGC(20),WSTBA(18),WSTBB(18),                        DA
     2CONCTA(18,10),LIMT(10),RIN(20),RAD(20),ROUT(20),VOL(20),               DA
     3MTBL(20),REGV(20),FISD(20),HOLID(3,18)                                 DA
      COMMON LIMP                                                            DA
      EQUIVALENCE                                                            DA
     1(LIMP(  1),    IDENT),(LIMP(  2),       NX),(LIMP(  3),       MX),    DA
     2(LIMP(  4),      NRX),(LIMP(  5),     ISOX),(LIMP(  6),    ISOXE),    DA
     3(LIMP(  7),    NGEOM),(LIMP(  8),    NP1B1),(LIMP(  9),     NBCT),    DA
     4(LIMP( 10),      NXP),(LIMP( 11),     BSQD),(LIMP( 12),   HOL(1)),    DA
     5(LIMP( 21),  NPT(1)),(LIMP( 41),  THT(1)),(LIMP( 61), MXAS(1)),        DA
     6(LIMP( 81), ILHI(1)),(LIMP(101), NRHP(1)),(LIMP(121), DEGC(1)),        DA
     7(LIMP(141),WSTBA(1)),(LIMP(159),WSTBB(1)),(LIMP(177),CONCTA(1,1)),     DA
     8(LIMP(357), LIMT(1)),(LIMP(367),  RIN(1)),(LIMP(387), RAD(1)),         DA
     9(LIMP(407), ROUT(1)),(LIMP(427),  VOL(1)),(LIMP(447), MTBL(1)),        DA
     A(LIMP(467), REGV(1)),(LIMP(487), FISD(1)),(LIMP(507),HOLID(1,1))       DA
      DIMENSION LOUT(1100),HOLA(9),BALT(18,4,5),FOIL(20,4,5),                DA
     1FOGX(4,6),FOX(20,4),DUMB(20),OTGC(5),OTGA(30,6)                        DA
      COMMON LOUT                                                            DA
      EQUIVALENCE (         LOUT(1),ID),(LOUT(2),HOLA(1)),                   DA
     1(LOUT(11),BALT(1,1,1)),(LOUT(371),FOIL(1,1,1)),                        DA
     2(LOUT(771),FOGX(1,1)),(LOUT(795),FOX(1,1)),(LOUT(875),DUMB(1)),        DA
     3(LOUT(895),OTGC(1)),(LOUT(900),OTGA(1))                                DA
      DIMENSION ERASE(3500)                                                  DA
      COMMON ERASE                                                           DA
      DIMENSION SSC(10),S1(10),SIGABS(10),SIGIN(10),SIGX(10),C(10),          DA
     1AN(10),SD(10),PROB(25,10),SIGY(18,54),GNU(18,54),SIGA(18,54),          DA
     2NRIG(18),ER(200  ),GMN(200  ),GMGM(200  ),GMF(200  ),SPIN(200  ),      DA
     3AMASS(18),SIGP(18),JONE(18),JTWO(18),DZERO(18),DONE(18),DTWO(18),      DA
     4ETA(20),Q(20),FS(54),FX(20),DEL(54),F(20,54),MDONE(18),P(18,54),        DA
     5PF(18,54),PZ(1001),FZ1(1001),A1(18),E9K(55),TEMP(18),SIGEFF(18),       DA
     6CT(18,10)                                                              DA
      COMMON IX,SIGY,GNU,SIGA,P,PF,F,DEL,FS,SSC,S1,SIGABS,SIGIN,SIGX,        DA
     1C,AN,SD,PROB,NRIG,ER,GMN,GMGM,GMF,SPIN,AMASS,SIGP,JONE,JTWO,           DA
```

```
     2DZERO,DONE,DTWO,ETA,Q,ESC,MDONE,KEY,MCURR,PZ,PZ1,DELSIG,A1,EBK,     DANC
     3TEMP,SIGEFY,NDONE                                                   DANC
      DIMENSION DATA(165),DZ(18),GRP(20),SOR(20),T(20,20),XT(20),V1(20),  DANC
     1V2(20),V3(20),V4(20),V5(20),CP(20),CN(20),CP2(20),CN2(20),Y(21),    DANC
     2F1(20),F2(20),S2(20),Q1(20),QD(20),TD(20),T1(20)                    DANC
      EQUIVALENCE (ERASE(1),DATA(1),DZ(1),GRP(1)),                        DANC
     1(ERASE(21),SOR(1)),(ERASE(41),T(1)),(ERASE(441),XT(1)),             DANC
     2(ERASE(461),V1(1)),(ERASE(481),V2(1)),(ERASE(501),V3(1)),           DANC
     3(ERASE(521),V4(1)),(ERASE(541),V5(1)),(ERASE(561),CP(1)),           DANC
     4(ERASE(581),CN(1)),(ERASE(601),CP2(1)),(ERASE(621),CN2(1)),         DANC
     5(ERASE(641),Y(1)),(ERASE(441),F1(1)),(ERASE(461),F2(1)),            DANC
     6(ERASE(481),S2(1)),(ERASE(501),Q1(1)),(ERASE(481),QD(1)),           DANC
     7(ERASE(461),TD(1)),(ERASE(441),T1(1))                               DANC
      EQUIVALENCE (FX(1),FISD(1)),(CT(1),CONCTA(1)),(LIB2,NLIB2)          DANC
      COMMON NLIB                                                         DANC
      COMMON/CADY/CDYC(10),IGCDY,ICADY                                    HAMMER
      IG=IGCDY                                                            HAMMER
      IF(NRX+1)200,200,1                                                  DANC
    1 NX=NX                                                               DANC
      IF(NGEOM-2)10,10,20                                                 DANC
   10 C2=0.95231261                                                       DANC
      C3=0.12                                                             DANC
      GOTO3                                                               DANC
   20 C2=0.8862269                                                        DANC
      C3=0.0                                                              DANC
   35 LOW=NP1(1)+1                                                        DANC
      SL=0.0                                                              DANC
      IF(LOW-NX)35,35,45                                                  DANC
   35 DO40N=LOW,NX                                                        DANC
      M=MTBL(N)                                                           DANC
      IF(IG.LT.53.OR.ICADY.NE.1)                                          HAMMER
     1SL=SL+      (ROUT(N)-ROUT(N-1))*(SSC(M)+SIGIN(M)+SIGABS(M))        HAMMER
      IF(IG.GE.53.AND.ICADY.EQ.1)                                         HAMMER
     1SL=SL+(ROUT(N)-ROUT(N-1))*(CDYC(M)+                                 HAMMER
     2SIGIN(M)+SIGABS(M))                                                 HAMMER
   40 CONTINUE                                                            HAMMER
   45 IF(NGEOM-1)70,70,73                                                 DANC
   70 SL=SL+2.                                                            DANC
      IF(SL-1.)71,71,72                                                   DANC
   71 C1=1.-SL*(2.+SL*(ALOG(SL)-.9228-SL*(.332-.0354*SL)))                DANC
      GOTO111                                                             DANC
   72 C1=EXP(-SL)*(2.+6.16/(SL+3.)**2)/(SL+3.)                            DANC
      GOTO111                                                             DANC
   73 CONTINUE                                                            DANC
      VMOF=(ROUT(NX)/ROUT(LOW-1))                                         DANC
      SL=SL+2.*(VMOF+1.)                                                  DANC
      VMOF=VMOF**2-1.                                                     DANC
      VMOF=(C2*SQRT(VMOF+1.)-1.)/VMOF-C3                                  DANC
      IF(VMOF)51,51,52                                                    DANC
   52 C2=VMOF*SL                                                          DANC
      IF(C2-20.)50,60,60                                                  DANC
   51 C2=0.                                                               DANC
   50 C1=EXP(-C2)/(1.+SL-C2)                                              DANC
      GOTO111                                                             DANC
   60 C1=0.                                                               DANC
```

```
SUBROUTINE  DAMP                                  CDC 6600 FTN V3.0-P261 OPT=2  11/21
                                                                                DAM
      111 IF(NEPRT)110,113,110                                                  DAM
      110 WRITE(NTOUT,112)C1                                                    DAM
      112 FORMAT(1H 75X2HC=1PE16.6)                                             DAM
      113 RETURN                                                                DAM
      200 C1=1.0                                                                DAM
          GOTO111                                                               DAM
          END
```

```
      SUBROUTINE GRID (IOUT)                                                    GRID
GRID                                                                            GRID
     /COMPUTES MESH NEEDED FOR CROSS SECTION CALCULATION/                       GRID
                                                                                GRID
      DIMENSION DUMY(1900)                                                      GRID
      COMMON DUMY                                                               GRID
      EQUIVALENCE(NOUT,DUMY(14))                                                GRID
      DIMENSION                                EZERO(1),GAMN(1),GMGM(1),G       GRID
     1FG(1),R(1),GAMMA(1),EONE(1),EPSIL(1),SIGOM(1),XI(1),MESH(1),ALPHA(       GRID
     2S),TERM(3),IVAL(3),HVAL(1001,3),SIGAZ(5),SIGSZ(5),F(5),AMU(5),           GRID
     3SUB(5),RI(1),DRI(1),SPIN(1),TAPS(1)                                       GRID
      COMMON MMSH,MIHV,NPG,SLAST,CYLT,HEAD,TEMP,IGEOM,ARAR,C,S                  GRID
     1,AZERO,SIGPZ,G,NNR,IABS,DZERO,AMOD1,SIGM1,IMOD1,AMOD2,SIGM2,IMOD2,        GRID
     2EZERO,GAMN,GMGM,GFG,R,GAMMA,EONE,EPSIL,SIGOM,XI,MESH,ALPHA,TERM,IV        GRID
     3AL,HVAL,SIGAZ,SIGSZ,F,AMU,SUB,I,DINK,SPIN,RI,DRI                          GRID
     4,TAPS,RNAR,S2,S3,S4,T1,T2,T3,T4                                           GRID
      COMMON/JJD/EPIL                                                           GRID
      COMMON/CADY/CDYC(10),IGCDY,ICADY                                          HAMMER
                                                                                GRID
        THE CONSTANT 8.6164E-5 DEFINES KAPPA                                    GRID
        THE CONSTANT 273.0 DEFINES THE MESH REFERENCE TEMPERATURE TZERO         GRID
                                                                                GRID
      NNX=1                                                                     GRID
      SAP=5                                                                     GRID
      B1=8.6164E-5*273.0/AZERO                                                  GRID
      B2=1.0/(B1*AZERO*AZERO)                                                   GRID
      JG=1                                                                      GRID
      IG=JG                                                                     GRID
      GAMMA(JG)=GAMN(JG)*GMGM(JG)*GFG(JG)                                       GRID
      GMGM(JG)=GMGM(JG)*GFG(JG)                                                 GRID
      GFG(JG)=GFG(JG)/GMGM(JG)                                                  GRID
      IF(R(JG))70,70,60                                                         GRID
   60 RP=R(JG)                                                                  GRID
      GO TO 80                                                                  GRID
   70 RP=0.0+0.5*SQRT(B1*EZERO(JG))/GAMMA(JG)                                   GRID
   80 NSN=0.5*RP*SQRT(B2*EZERO(JG))+1.0                                         GRID
      FNSN=NSN                                                                  GRID
      EPSIL(JG)=2.0/(AZERO*FNSN)                                                GRID
      IF(IGCDY.EQ.53) EPSIL(JG)=0.5*EPSIL(JG)                                   HAMMER
      SIGOM(JG)=2.6E+6*SPIN(JG)/EZERO(JG)*GAMN(JG)/GAMMA(JG)                    GRID
      XONE=5*SQRT(SIGOM(JG)/SIGPZ)                                              GRID
      XI(JG)=GAMMA(JG)/(2.0*SQRT(8.6164E-5*EZERO(JG)*TEMP/AZERO))               GRID
      IF(1000/XI(IG)-XONE/2.0)100,100,120                                       GRID
  100 EONE(JG)=EZERO(JG)+GAMMA(JG)*XONE/2.0                                     GRID
      SAP=777.0                                                                 GRID
      GO TO 140                                                                 GRID
  120 EONE(JG)=EZERO(JG)+20.0*GAMMA(JG)/XI(JG)                                  GRID
  140 ZONE=(EONE(JG)-EZERO(JG))/EZERO(JG)                                       GRID
      CUT=AMAX1(EPILL/EZERO(JG),0.428571428571)                                 GRID
      IF (ZONE- (1.0-CUT)) 160,160,180                                          GRID
  160 MESH(IG)=1+2* INT(0.5*(ALOG(EONE(IG)/(2.*EZERO(IG)-EONE(IG)))             GRID
     1  /EPSIL(IG)    ))                                                       GRID
      EONE(IG)=2.*EZERO(IG)/(1.+EXP(-EPSIL(IG)*FLOAT(MESH(IG)-1)))             GRID
      GO TO 200                                                                 GRID
  180 MESH(IG)=1+2* INT(0.5*(ALOG(1.0/CUT     *EONE(IG)/EZERO(IG))              GRID
```

```
      /(EPSIL(IG)    ))                                                    GRID
      EZERO(IG)=EZERO(IG)*EXP(EPSIL(IG)*FLOAT(MESH(IG)-1))*CUT             GRID
  320 IF (MMSH-MESH(IG)) 420,320,320                                       GRID
C                                                                          GRID
C     MESH EXCEEDS STORAGE LIMITS                                          GRID
  321 CONTINUE                                                             NAMME-
      ITEMP=1                                                              NAMME-
      IF(ITEMP.EQ.1) GO TO 316                                             NAMME-
      GO TO (221,222),NYX                                                  NAMME-
  316 IF(MESH(IG).GT.MMSH) WRITE(NOUT,317) MESH(IG),MMSH                   NAMME-
  317 FORMAT(*0 NUMBER OF MESH PTS FOR THIS RESONANCE **,I20  ,* THIS      NAMME-
     1 IS MAX NUMBER=*,I20  )                                              NAMME-
      WRITE( NOUT,325) EZERO,GAMN,GMGM,GFG,SPIN,R,S                        NAMME-
  325 FORMAT(*0 THIS RESONANCE IS AT*E24.8/* IT HAS WIDTHS*3E20.8/         NAMME-
     1*  SPIN,R,S ARE *3E20.8)                                            NAMME-
      GO TO 320                                                            NAMME-
  221 M(JG)=MP                                                             GRID
      WRITE(NOUT,223)EZERO,GAMN,GMGM,GFG,SPIN,R,S                          GRID
  223 FORMAT(14H0RESONANCE AT E20.8, 14H, WITH WIDTHS 3E20.8/6H SPIN F20   GRID
     1.8, 4H, R E20.8, 4H, S E20.8/30H CANNOT BE PROCESSED PROPERLY.//)    GRID
      NYX=2                                                                GRID
  222 IF(M(JG)-2)300,300,500                                               GRID
  500 M(JG)=M(JG)-1.                                                       GRID
      GOTO 320                                                             GRID
  300 MESH(IG)=MMSH                                                        GRID
      IF(ZONE-0.57142857)301,301,302                                       GRID
  301 EPSIL(IG)=ALOG((EONE(IG)/(2.*EZERO(IG)-EONE(IG)))/(FLOAT(MMSH-3))    GRID
      GOTO 320                                                             GRID
  302 EPSIL(IG)=ALOG(2.3333333*EONE(IG)/EZERO(IG))/(FLOAT(MMSH-3))         GRID
  320 CONTINUE                                                             GRID
      RETURN                                                               GRID
      END                                                                  GRID
```

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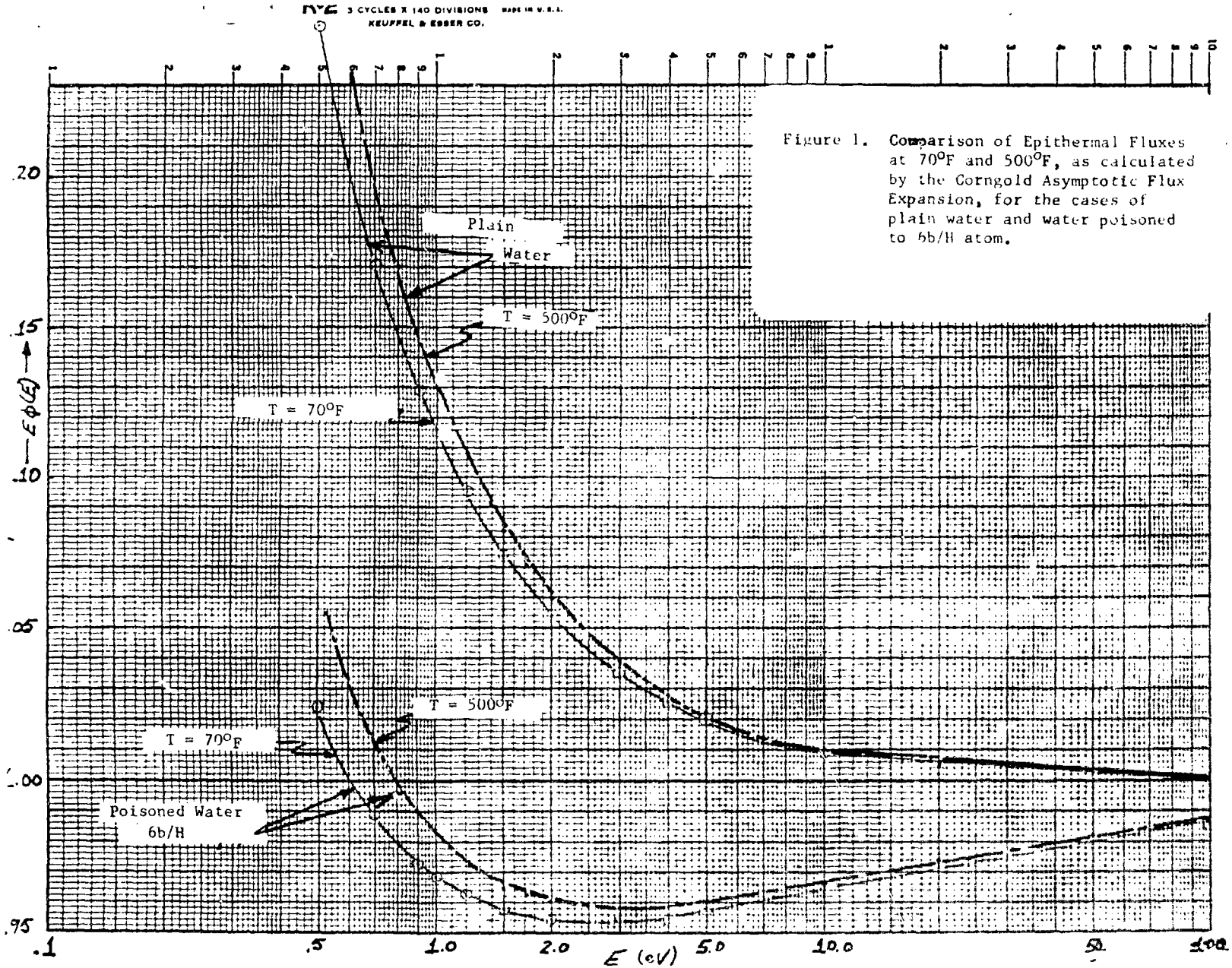

Figure 1. Comparison of Epithermal Fluxes at 70°F and 500°F, as calculated by the Corngold Asymptotic Flux Expansion, for the cases of plain water and water poisoned to 6b/H atom.

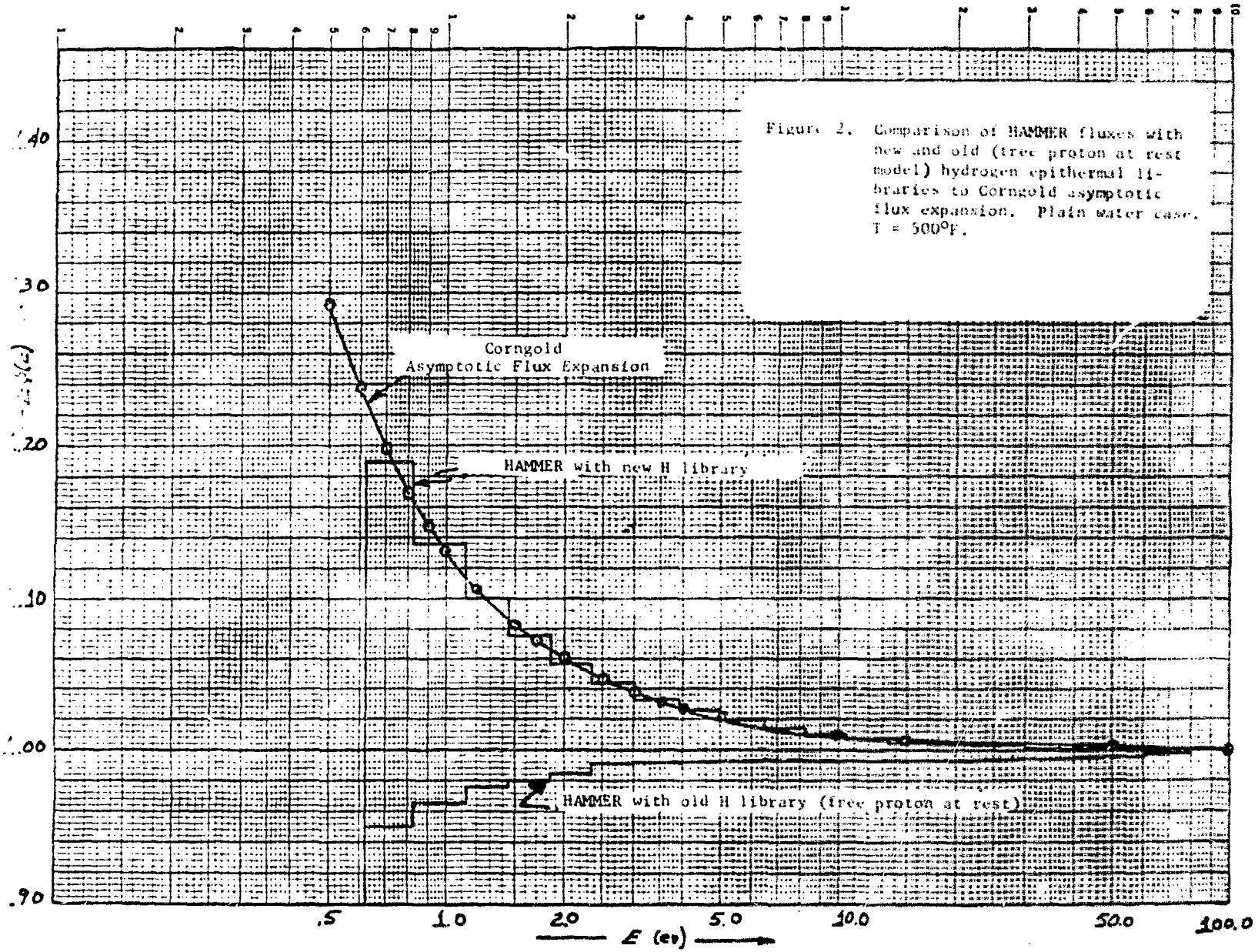

Figure 2. Comparison of HAMMER fluxes with new and old (free proton at rest model) hydrogen epithermal libraries to Corngold asymptotic flux expansion. Plain water case. T = 500°F.

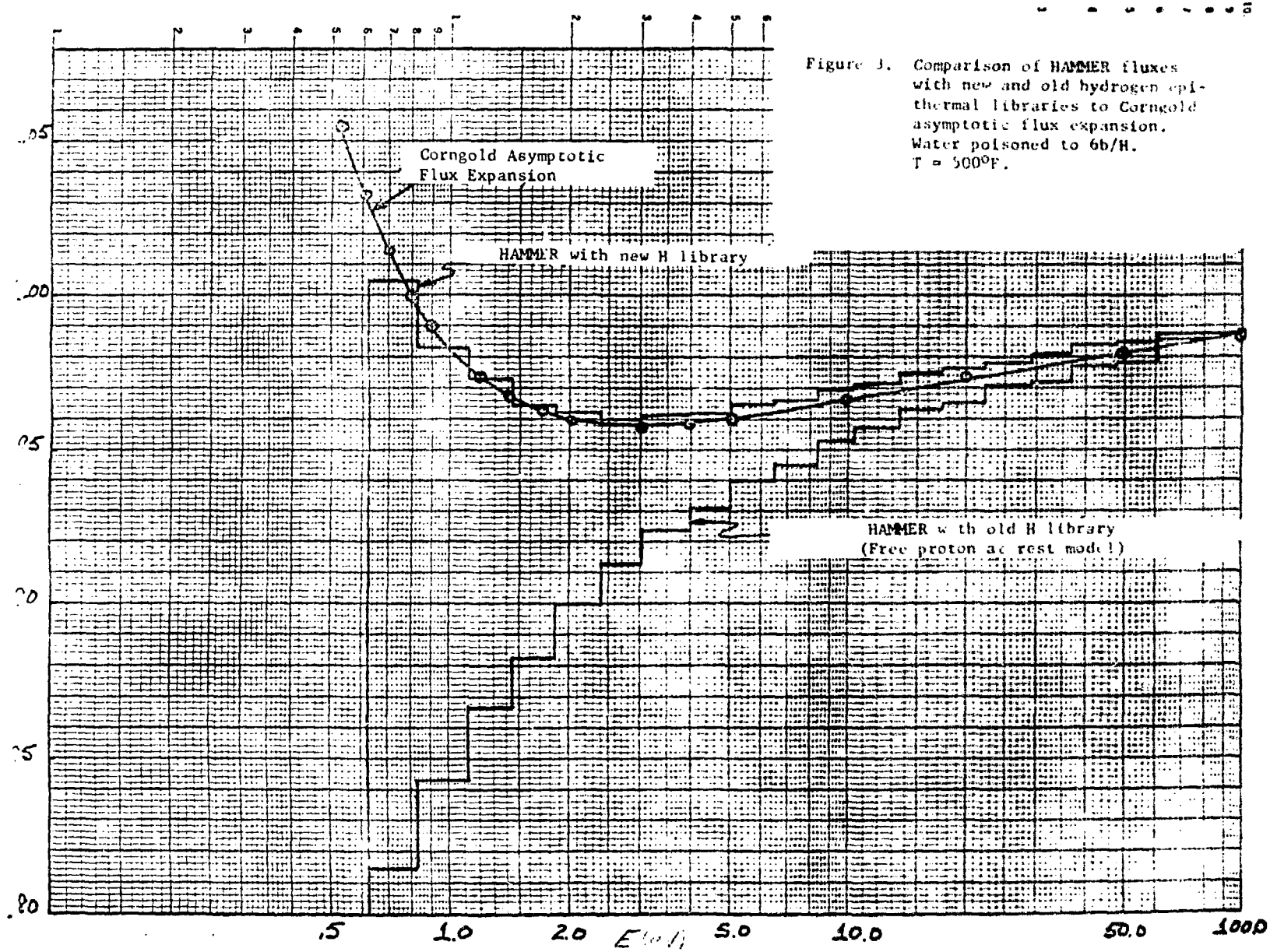

Figure 3. Comparison of HAMMER fluxes with new and old hydrogen epithermal libraries to Corngold asymptotic flux expansion. Water poisoned to 6b/H. T = 500°F.