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MODIFIED GRAY: AN IMPROVED THREE-PHASE EQUATION OF STATE FOR METALS

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An improved version of the GRAY three-phase equation of state for metals is presented in this report. The Grover model for liquid metals is modified by employing a single continuous representation of the specific heat thereby eliminating the somewhat artificial hot liquid region. A soft sphere representation is incorporated into the modified van der Waals equation of state for the vapor region yielding a model which is physically realistic at high temperatures and more compatible with the Grover model.

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20. A continuous and thermodynamically consistent join procedure is inserted between the Grover liquid and van der Walls vapor regions. This new join procedure does not distort the van der Waals model in the vicinity of the critical point and allows the vapor to limit correctly at high temperatures and volumes.

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Mr. Robert A. Cecil, a scientific programming consultant to Systems, Science and Software (S^3), performed all of the programming required to incorporate the modified GRAY equation of state into the RIP code and performed the necessary test calculations. Mr. John R. Triplett of the S^3 scientific staff participated in the numerous technical discussions which led to the development of modified GRAY.

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1. INTRODUCTION

The RIP[1] material response code for x-ray interactions includes three equations of state for compacted (non-porous) material: (1) modified PUFF; (2) RIP mixed phase; (3) GRAY. A recent sensitivity study[2] performed by Systems, Science and Software (S^3) indicated that substantial differences in radiation-induced impulse were calculated depending on which equation of state was used. Furthermore, John J. Ruminer[3] of Lawrence Livermore Laboratories (L^3), has determined that mixed-phase effects must be properly modeled in order to obtain a reasonable degree of accuracy when predicting the response of porous or tamped metals. In view of Ruminer's results and those of another study by Oswald, McLean, Schallhorn, and Oldham[4] at Harry Diamond Laboratories (HDL), which demonstrated the necessity of accounting for the melt regime when modeling material response to pulsed energy deposition, it was decided that the GRAY three-phase equation of state was the most appropriate for describing the response of metals to a wide variety of radiation threat conditions.

GRAY is a three-phase equation of state for metals developed by E. B. Royce[5] at L^3. Material near normal density, in the solid-liquid region, is described by a scaling law equation of state for metals developed by Grover.[6] The scaling law equation of state includes a Gruneisen description of the solid[7] referenced to the experimental Hugoniot. Material in the liquid-vapor region is treated according to an equation of state developed by Young and Alder;[8] their van der Waals model uses an analytic representation of the classical hard-sphere equation of state with a van der Waals attractive term added. The complete equation of state, as described in Reference 5, is developed by analytically joining the Grover scaling law and the Young-Alder models at a volume in the range 1.3 to 1.5 times normal volume. This is accomplished by adding correction terms to the Young-Alder equation of state employed on the low density side of the join volume. Young[9] recently introduced a modification of the original GRAY equation of state which permits calculation of the pressure in the mixed phase liquid-vapor region; however, the basic physical models and the join procedure were not altered.

A substantially modified GRAY equation of state has been developed and is presented in this report. A critique of the original GRAY equation of state which illustrates the need for improvement is presented in Section 2. A continuous model for the liquid phase is discussed in Section 3.1 and a soft sphere model for the vapor region is developed in Section 3.2. The liquid and vapor regions are connected via an improved join procedure which is discussed in Section 3.3. The results of calculations performed with the modified GRAY equation of state are presented in Section 4 and a summary is given in Section 5.

2. CRITIQUE OF THE GRAY EQUATION OF STATE

The latest L^3 version of GRAY is a complete three-phase equation of state for metals and was, until recently, the most sophisticated equation of state available in the RIP code. However, a quick inspection of the procedure used to join the Grover liquid equation of state and the Young-Alder modified van der Waals model, as presented in Reference 5, reveals the following problems:

1. The slope of the equation of state is discontinuous at the join volume.

2. A correction term, quadratic in temperature, added to the caloric equation of state in the van der Waals region prevents the model from approaching the correct ideal gas limit at high volumes.

3. At high temperatures the correction terms dominate the van der Waals model in the vicinity of the join volume.

The first two of these problems are due to the rather crude nature of the join procedure. However, the third problem is more fundamental because it indicates that the discrepancy between the two models is actually quite large, even in the region of the join volume.

The primary source of the discrepancy between the Grover and Young-Alder models is the dramatically different behavior of their atomic components (related to thermal motion and ions of atoms) of pressure and energy. This discrepancy is best illustrated by comparing the atomic components of the specific heats at constant volume and the atomic components of the Gruneisen coefficients. The scaled temperature dependence of the specific heat divided by the gas constant and the scaled temperature dependence of the Gruneisen coefficient, both as represented by the Grover liquid equation of state, are presented in Figure 1 and Figure 2, respectively. The notation employed in these figures is defined below:

T = temperature

T_m = melt temperature (a function of specific volume)

C_v = specific heat at constant volume

R = gas constant

γ = Gruneisen coefficient

The specific heat variation shall be discussed first.

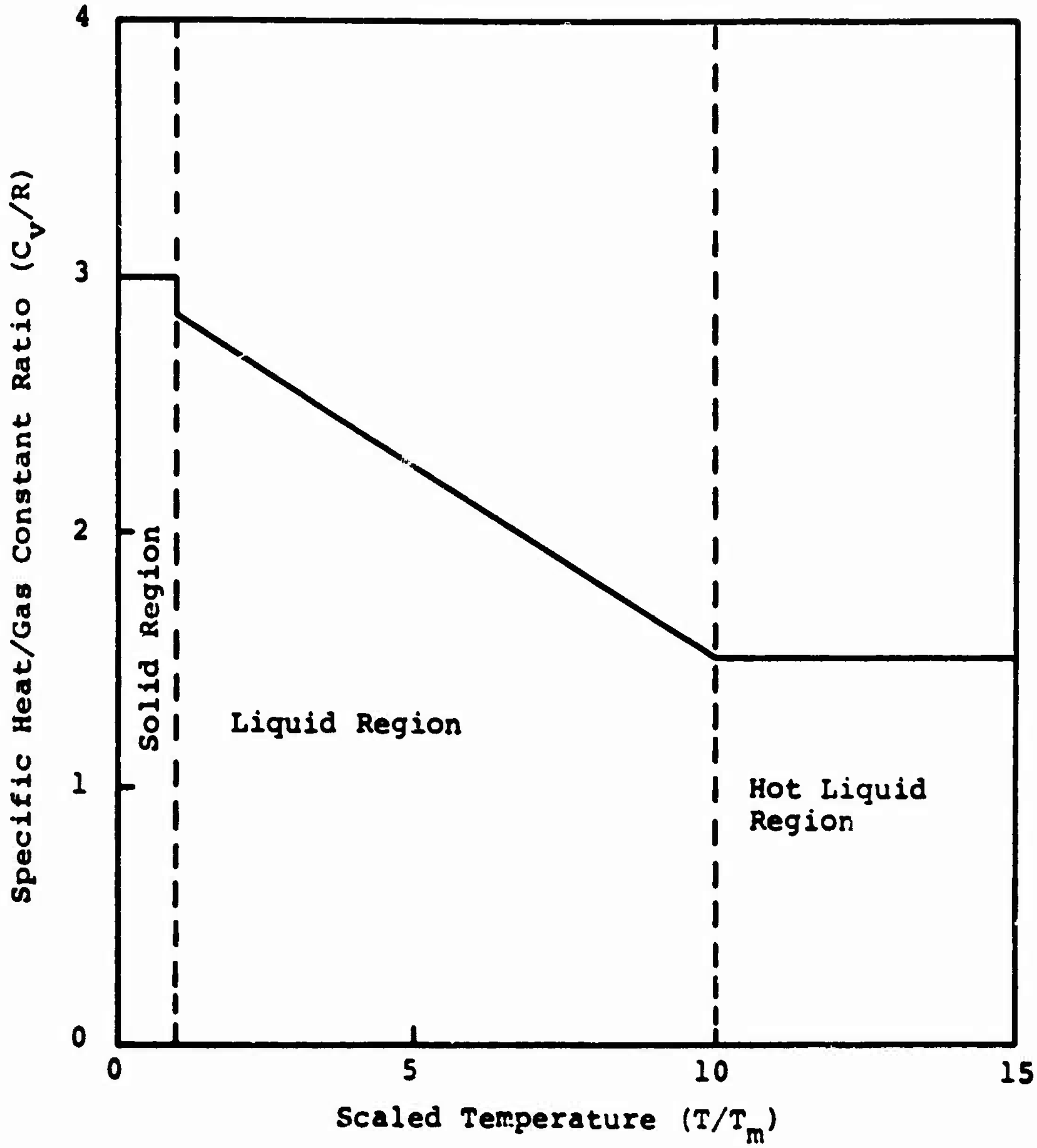

Figure 1. Specific heat divided by the gas constant versus scaled temperature in the Grover equation of state.

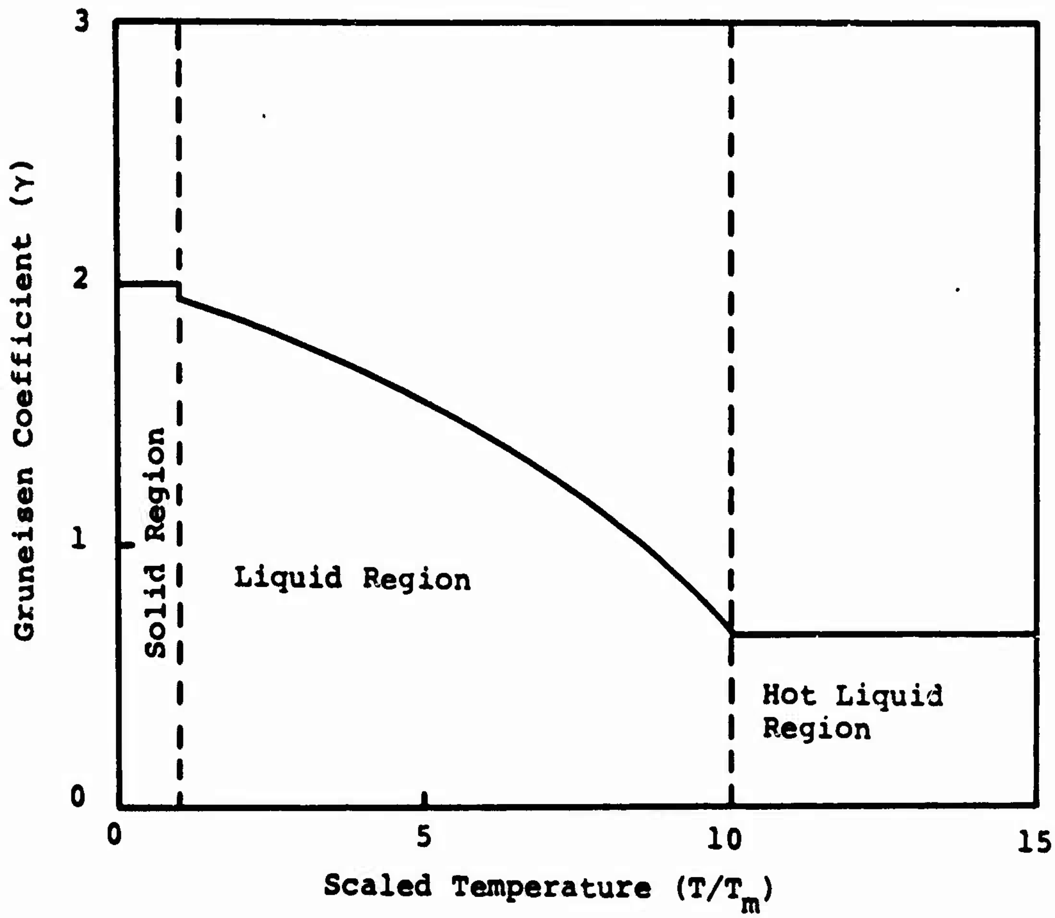

Figure 2. Gruneisen coefficient versus scaled temperature in the Grover equation of state.

Note from Figure 1 that the specific heat in the Grover liquid equation of state has a constant value of 3R in the solid region, drops discontinuously to 2.85R at the melt temperature, decreases linearly to 3R/2 in the liquid region, and has a constant value of 3R/2 in the hot liquid region. However, the Young-Alder model has a temperature independent specific heat of 3R/2 for all volumes. The join volume, v_j, employed in the present version of the GRAY equation of state is the zero pressure intercept of the boundary between the so-called liquid and hot liquid regions. This particular join volume was chosen for two reasons: (1) Continuity between the Grover and Young-Alder models could be achieved by adding a single set of correction terms to the Young-Alder model. If a smaller join volume were selected it would be necessary to add a second set of correction terms to the Young-Alder model in order to insure continuity with the liquid region of the Grover equation of state at positive pressures; (2) the specific heats of both the Grover and Young-Alder models are 3R/2 at the selected join volume. Unfortunately, at the volume, v_j, there is a large discrepancy between the Gruneisen coefficients of the two models; this point is discussed in the following paragraph.

The Gruneisen coefficient, γ, in the Grover equation of state is plotted as a function of the normalized temperature, T/T_m, in Figure 2. The small variations of the solid or lattice Gruneisen coefficient, γ_s, with volume are not included in Figure 2; additionally, the fact that the value of the solid Gruneisen coefficient, γ_o, at ambient volume and temperature is material dependent ($\gamma_o = 2.0 \pm 1.0$) is ignored for convenience of presentation. The significant observation depicted in Figure 2 is that γ is a decreasing function of the scaled temperature until the boundary between the liquid and hot liquid region ($T/T_m = 10$) is reached; a slope discontinuity occurs at that point and the ideal gas value, $\gamma = 2/3$, is maintained for further increases in scaled temperature. The behavior of the Gruneisen coefficient in the Young-Alder model is totally unrelated to that in the Grover equation of state. In particular, the Young-Alder Gruneisen parameter is independent of temperature and the functional form of the volume dependence is

$$\gamma = \frac{2}{3}\left[\frac{1 + \left(\frac{v_b}{v}\right) + \left(\frac{v_b}{v}\right)^2 - \left(\frac{v_b}{v}\right)^3}{\left(1 - \frac{v_b}{v}\right)^3}\right] \tag{1}$$

where v is the volume and v_b is the hard sphere volume. At the join volume currently used in the GRAY equation of state, γ has a constant value of about 4.6 (there is some variation with material) which is more than twice the maximum value of γ occurring in the Grover scaling law.

On the basis of the critique of the GRAY equation of state presented in the paragraphs above it was decided that several modifications would lead to substantial improvement. In Section 3.1 a new form of the Grover liquid equation of state is developed; the new form is mathematically continuous from $T/T_m = 1$ to $T/T_m \to \infty$ where the ideal gas limit ($c_v = 3R/2$, $\gamma = 2/3$) is reached. The advantage of the new functional form is that the artificial distinction between the liquid and hot liquid regions is eliminated while preserving the Grover scaling law in the low temperature range where it is meaningful to within a few percent. Also, additional flexibility is gained with respect to selection of the join volume. In Section 3.2 incorporation of a soft sphere model into the Young-Alder region is discussed and the required thermal and caloric state relations are developed; the advantage of this modification is that the Gruneisen parameter approaches the correct ideal gas limit at any volume provided the singularity in Equation (1) is avoided. Additionally the location of the liquid-vapor mixed phase boundary may be correlated with experimental data through judicious selection of the temperature dependence of the soft sphere diameter. A new join procedure which is continuous in slope, thermodynamically consistent, and free of incorrect limiting behavior is presented in Section 3.3.

3. THE MODIFIED GRAY EQUATION OF STATE

3.1 A CONTINUOUS FORM OF THE GROVER LIQUID EQUATION OF STATE

The Grover liquid metal equation of state is developed and discussed in Reference 6. The equation of state is based on the observations that a corrected entropy of melting (2.32 cal/g-atom deg) can be considered constant for all metals and that the liquid specific heat has a universal linear dependence on the scaled temperature (T/T_m); both of these observations are supported by experimental data. The Lindemann law which establishes the volume dependence of the melting temperature is used in conjunction with the above observations to develop an approximate equation of state for liquid metals. However, as noted in Section 2, the linear scaling of the specific heat breaks down at $T/T_m = 10$ where the ideal gas limit is reached. For scaled temperatures above 10, an ideal gas equation of state with additive "effective" pressure and internal energy components at zero temperature (determined by continuity requirements) is introduced. In the following paragraphs a modified form of the Grover liquid equation of state is presented. The modification is based on the introduction of a functional form of the liquid specific heat which has a hyperbolic dependence on the scaled temperature. This new functional form closely approximates the Grover scaling law in the lower range of temperatures for which experimental correlation is available and approaches the ideal gas limit continuously; thus the need for a somewhat artificial "hot liquid" region is eliminated. The procedures employed to develop the new equation of state are identical to those presented by Grover in Reference 6 except that the functional form of the liquid specific heat is hyperbolic rather than linear.

The specific heat employed by Grover has the form

$$C_v = 3R-\alpha(T/T_m) \quad , \quad \alpha = 0.15R \quad , \quad T > T_m \tag{2}$$

Because Equation (2) becomes unrealistic at $T/T_m > 10$ we select instead the following relation:

$$C_v = 3R/2 \left[1 + \left(\alpha \frac{T}{T_m} + 1\right)^{-1}\right] , \quad \alpha = .1, \; T > T_m \tag{3}$$

Equations (2) and (3) are plotted for comparison in Figure 3. Note that for scaled temperatures below 4.0, the maximum value for which data are reported in Reference 6, the hyperbolic form departs from the Grover scaling law by no more than

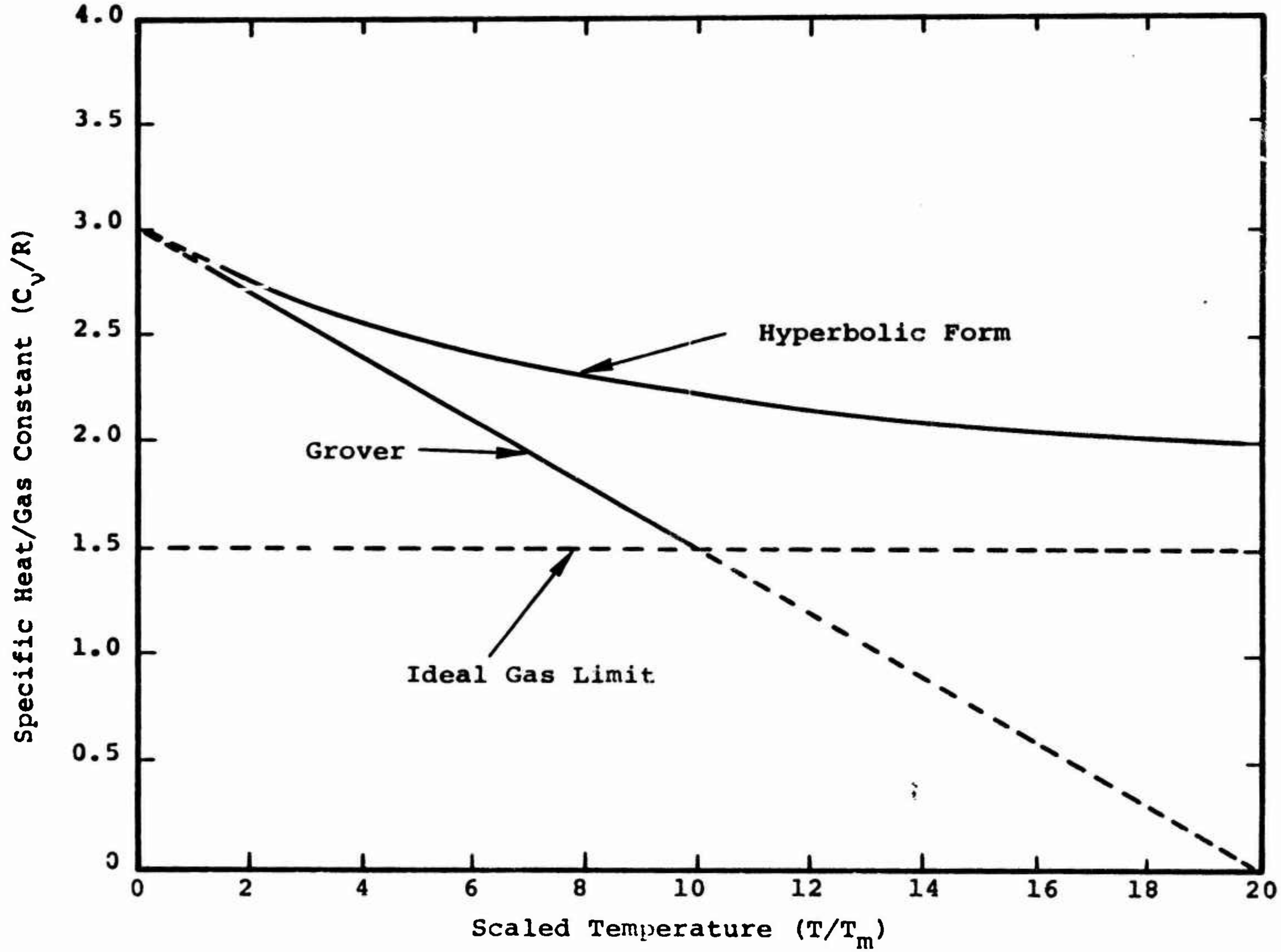

Figure 3. Comparison of Grover and hyperbolic specific heat dependence on scaled temperature.

6 percent. At higher temperatures the hyperbolic form has the advantage of approaching the ideal gas limit continuously.

In order to obtain an expression for the entropy in the liquid region we employ the thermodynamic relation

$$\left.\frac{\partial S}{\partial T}\right|_v = \frac{C_v}{T} \tag{4}$$

Substituting Equation (3) into the above expression and integrating with respect to temperature yields

$$S_\ell = 3R \ \ell n \ T - \frac{3R}{2} \ \ell n \left(\alpha \frac{T}{T_m} + 1\right) + f(v) \tag{5}$$

where S_ℓ is the entropy in the liquid region and f(v) is an undetermined function of volume. Since the specific heat in the solid is 3R, Equation (4) also yields

$$S_s = 3R \ \ell n \ T + h(v) \tag{6}$$

where S_s is the entropy of the solid and h(v) is another undetermined function of volume. Solving Equation (6) for 3R ℓn T and substituting the result into Equation (5) yields

$$S_\ell = S_s - \frac{3R}{2} \ \ell n \left(\alpha \frac{T}{T_m} + 1\right) + f(v) - h(v) \tag{7}$$

This expression for the liquid entropy is consistent with experimental data on the entropy of melting presented by Grover[6] if we take

$$f(v) - h(v) = \Delta s \tag{8}$$

where Δs is the "corrected" entropy of melting. Thus, the entropy in the liquid region, Equation (7), becomes

$$S_\ell = S_s - \frac{3R}{2} \ \ell n \left(\alpha \frac{T}{T_m} + 1\right) + \Delta s \tag{9}$$

Following Grover's procedure we obtain the entropy in the two-phase melt region, S_m, by adding the solid and liquid components;

$$S_m = \nu S_\ell + (1-\nu) S_s \tag{10}$$

where ν is the liquid fraction in the melt region which is assumed to be linear in T.

$$\nu = \frac{T - T_s(v)}{\Delta T(v)}$$

where

$$\Delta T(v) = T_\ell(v) - T_s(v)$$

is the temperature change for melting at constant volume, $T_\ell(v)$ is the liquidus temperature and $T_s(v)$ is the solidus temperature. It should be noted that Equation (10) is based on the following definition of the melt temperature

$$T_m = \frac{T_s + T_\ell}{2}$$

Substitution of Equation (9) into Equation (10) yields

$$S_m = S_s + \nu \left[\Delta S - \frac{3R}{2} \ln \alpha \left(\frac{T}{T_m} + 1 \right) \right] \tag{11}$$

Noting that in the melt region $T \doteq T_m$, we obtain the following approximate expression for the melt entropy

$$S_m = S_s + \nu(\Delta S - .143R) \tag{12}$$

With Equation (12) and (9) for the entropy in the melt and liquid regions respectively, the following thermodynamic relation may be solved for the Helmholtz free energy, A:

$$S = - \left(\frac{\partial A}{\partial T} \right)_V \tag{13}$$

Having obtained the Helmholtz free energy, expressions for the energy and pressure are trivial to derive. The melt region will be treated first.

Equation (13) may be integrated to obtain

$$A = E_o(v) - \int S dT \tag{14}$$

where $E_o(v)$ is the cold compression energy. Substituting Equation (12) into the above relation and performing the indicated integration yields

$$A_m = E_o(v) - \int S_s dT - \int_{T_s}^{T} \nu(\Delta S - .143R) dT$$

or, combining the first two terms

$$A_m = A_s - \int_{T_s}^{T} \nu(\Delta S - .143R) dT \tag{15}$$

where A_s is the Helmholtz free energy of the solid. Since

$$\nu = \frac{T - T_s}{\Delta T} \tag{16}$$

Equation (15) becomes

$$A_m = A_s - (\Delta S - .143R) \int_{T_s}^{T} \left(\frac{T}{\Delta T} - \frac{T_s}{\Delta T} \right) dT$$

which, after integration, yields

$$A_m = A_s - (\Delta S - .143R) \left[\frac{T^2}{2\Delta T} - \frac{TT_s}{\Delta T} \right]_{T_s}^{T} \tag{17}$$

Expanding the expression in brackets and employing Equation (16) yields the following expression for the free energy in the melt region:

$$A_m = A_s - \nu^2\left(\frac{\Delta T}{2}\right)(\Delta S - .143R) \tag{18}$$

The energy in the melt region is immediately obtained from the definition of the Helmholtz free energy, $A \equiv E-TS$, and Equations (12) and (18):

$$E_m = A_s + TS_s + \nu\left[T - \nu\left(\frac{\Delta T}{2}\right)\right](\Delta S - .143R)$$

or, more concisely

$$E_m = E_s + \nu\left[T - \nu\left(\frac{\Delta T}{2}\right)\right](\Delta S - .143R) \tag{19}$$

where E_s is the extrapolated energy in the solid.

The pressure in the melt region is obtained from the thermodynamic relation

$$P = -\left(\frac{\partial A}{\partial v}\right)_T \tag{20}$$

Substitution of Equation (18) into the above equation yields

$$P_m = -\left(\frac{\partial A_s}{\partial v}\right)_T + (\Delta S - .143R)\frac{\partial}{\partial v}\left(\frac{\nu^2 \Delta T}{2}\right) \tag{21}$$

or

$$P_m = P_s + (\Delta S - .143R)\frac{\partial}{\partial v}\left(\frac{\nu^2 \Delta T}{2}\right) \tag{22}$$

Expressing ν^2 in terms of temperature and evaluating the partial derivative in Equation (22) yields

$$\frac{\partial}{\partial V}\left(\frac{\nu^2 \Delta T}{2}\right) = -\nu \frac{dT_s}{dV} - \frac{\nu^2}{2}\frac{d\Delta T}{dV} \tag{23}$$

Noting that

$$\frac{d\Delta T}{dV} \approx 0$$

and

$$\frac{dT_s}{dV} \approx \frac{dT_m}{dV}$$

Equation (23) becomes

$$\frac{\partial}{\partial V}\left(\frac{\nu^2 \Delta T}{2}\right) = -\nu \frac{dT_m}{dV} \tag{24}$$

Now, the volume dependence of the melt temperature is defined according to the Lindemann law:

$$\lambda \equiv + \frac{d \ \ell n \ T_m}{d \ \ell n \ V} \tag{25}$$

An alternate form of this law is

$$\lambda \equiv + \frac{V}{T_m}\frac{dT_m}{dV} \tag{26}$$

Substituting this definition into Equation (24) yields

$$\frac{\partial}{\partial V}\left(\frac{\nu^2 \Delta T}{2}\right) = -\nu\lambda \frac{T_m}{V} \tag{27}$$

Substitution of Equation (27) into Equation (22) yields the final expression for the pressure in the melt region:

$$P_m = P_s - \nu\lambda \frac{T_m}{V} (\Delta S - .143R) \tag{28}$$

In summary, the relations defining the new form of the metal equation of state in the melt region are:

$$S_m = S_s + \nu(\Delta S - .143R) \tag{29}$$

$$A_m = A_s - \nu^2\left(\frac{\Delta T}{2}\right) (\Delta S - .143R) \tag{30}$$

$$E_m = E_s + \nu\left[T - \nu\left(\frac{\Delta T}{2}\right)\right] (\Delta S - .143R) \tag{31}$$

$$P_m = P_s - \nu\lambda \frac{T_m}{V} (\Delta S - .143R) \tag{32}$$

Following essentially the same procedure applied above to obtain the melt region equation of state yields the improved form of the Grover equation of state in the liquid region. Beginning with Equation (9) for the entropy in the liquid region and applying the appropriate thermodynamic relations in sequence yields:

$$S_\ell = S_s - \frac{3R}{2} \ell n \left(\alpha \frac{T}{T_m} + 1\right) + \Delta S \tag{33}$$

$$A_\ell = A_s - \frac{\Delta T}{2} (\Delta S - .143R) - (T - T_m) \left(\Delta S + \frac{3R}{2}\right)$$

$$+ \frac{3RT_m}{2\alpha}\left[\left(\alpha \frac{T}{T_m} + 1\right) \ell n\left(\alpha \frac{T}{T_m} + 1\right) - (\alpha+1)\ell n(\alpha+1)\right] \tag{34}$$

$$E_\ell = E_s + T_m \, \Delta S + .143R\left(\frac{\Delta T}{2}\right)$$

$$+ \frac{3RT_m}{2\alpha}\left[\ell n\left(\alpha \frac{T}{T_m} + 1\right) - (\alpha+1)\ \ell n\ (\alpha+1) - \alpha\left(\frac{T}{T_m} - 1\right)\right] \quad (35)$$

$$P_\ell = P_s - \lambda \frac{T_m}{V} \Delta S$$

$$- \frac{3R}{2\alpha} \lambda \frac{T_m}{V}\left[\ell n\left(\alpha \frac{T}{T_m} + 1\right) - (\alpha+1)\ \ell n\ (\alpha+1) - \alpha\left(\frac{T}{T_m} - 1\right)\right] \quad (36)$$

As mentioned earlier in this section, the above set of equations replace the two sets employed by Grover to represent the liquid and hot liquid regions in Reference 6. This particular feature of the improved form of the Grover equation of state results in substantial flexibility with respect to selection of an appropriate join procedure. The introduction of a soft sphere model into the modified van der Waals equation of state is discussed in the next section.

3.2 A SOFT SPHERE MODEL FOR THE VAN DER WAALS EQUATION OF STATE

The classical van der Walls equation of state has the following functional form:

$$P_v = \frac{RT}{V - V_b} - \frac{a}{V^2} \quad (37)$$

where the subscript v indicates the vapor region. The second term on the right of the equal sign represents the effect of a mean field attractive potential on the pressure in the medium; a is the attractive potential coefficient. The first term on the right of the equal sign is identical to the ideal gas law except for the appearance of V_b, the hard sphere excluded volume, in the denominator; this term has the effect of increasing the pressure at small volumes thereby accounting for the repulsive potential in an approximate manner. The opposing forces included in the van der Waals model cause the appearance of loops on isotherms plotted in Gibbs free energy versus volume space. A procedure for defining the liquid-vapor phase boundary, often referred to as a Maxwell construction, may be applied to the Gibbs free energy. However, experimental evidence indicates that the liquid-vapor phase boundary derived from the van der Waals model is highly inaccurate.

A modified form of the van der Waals model was presented by Young and Alder in Reference 8; this modified form was found to be relatively accurate on the basis of the correlation between theoretical and experimental critical points of metals and was therefore selected to represent the vapor region in the GRAY equation of state. The new equation of state, also referred to as the Young-Alder model, is

$$P_V = \frac{RT}{V} \frac{1 + \eta + \eta^2 - \eta^3}{(1 - \eta)^3} - \frac{a}{V^2} \tag{38}$$

$$\eta = \frac{V_b}{V} . \tag{39}$$

The first term in Equation (38) is an algebraic approximation[10] to the hard sphere pressure calculated by computer experiments.[11] An ideal gas caloric equation of state with a potential energy term,

$$E = \frac{3R}{2} T - \frac{a}{V} \tag{40}$$

is used with the Young-Alder model to complete the description of the vapor region in GRAY.

It was noted in Section 1 that the Gruneisen coefficient for the Young-Alder region in GRAY is given by Equation (1) which is repeated below for convenience:

$$\gamma = \frac{2}{3}\left[\frac{1 + \left(\frac{V_b}{V}\right) + \left(\frac{V_b}{V}\right)^2 - \left(\frac{V_b}{V}\right)^3}{\left(1 - \frac{V_b}{V}\right)^3}\right] . \tag{41}$$

At the join volume between the Grover and Young-Alder models in the GRAY equation of state, Equation (41) yields an unreasonably high value of about 4.6 (there is some variation with material). Additionally, the Young-Alder Gruneisen coefficient is independent of temperature. These unrealistic characteristics may be eliminated by allowing the hard sphere excluded volume, V_b, to vary as a function of temperature such that $V_b \rightarrow 0$ as the temperature approaches infinity. Note by inspection of Equation (41) that setting V_b equal to zero yields the correct ideal gas high temperature limit of $\gamma = 2/3$.

Several techniques for relating the temperature dependence of the sphere diameter to the behavior of a fluid with realistic repulsive forces are available in the open literature; the selection of the most appropriate technique may ultimately depend on the results of experimental definition of metal liquid-vapor phase boundaries. A simplified technique for obtaining the desired relation is discussed in a paper by Anderson, Weeks and Chandler.[12] The technique is called the generalized Rowlinson method and provides that the hard sphere diameter, d, be calculated according to

$$d = \int_0^\infty [1 - e^{-u(r)/kT}]\, dr \tag{42}$$

where r is the distance from the particle center, u(r) is the repulsive potential, and k is the Boltzmann constant. Grover[6] has shown that his liquid scaling law is in close agreement with computer experiments on the liquid phase for particles having the inverse twelve potential which may be expressed algebraically as

$$u(r) = \varepsilon\left(\frac{\sigma}{r}\right)^{12} \quad . \tag{43}$$

It is therefore reasonable to expect that this potential function is most likely to minimize the differences between the Grover and Young-Alder equations of state.

Substitution of the inverse twelve potential into Equation (42), after some manipulation, yields

$$d = 1.0556\left(\frac{\varepsilon\sigma^{12}}{kT}\right)^{1/12} \tag{44}$$

for the soft sphere diameter. The excluded volume, V_b, may be obtained from the soft sphere diameter via the relation

$$V_b = \frac{\pi N_{av} d^3}{6A} \tag{45}$$

which, when combined with Equation (44) yields

$$V_b = \frac{C_1}{T^{1/4}} \tag{46}$$

where

$$C_1 = \left(\frac{\pi N_{av}}{6A}\right) \left(\frac{1.0556\ \varepsilon\sigma^{12}}{k}\right)^{1/4}$$

In order to avoid the singularity at absolute zero in Equation (46) and provide reasonable values for V_b at temperatures well below critical, we introduce the following relation:

$$V_b = V_{b_0} - C_2 T - C_3 T^2 \ ; \ T \leq 2T_{m_0} \tag{47}$$

where

$$V_{b_0} = \frac{1.1\ C_1}{\left(2T_{m_0}\right)^{1/4}}$$

$$C_2 = \frac{V_{b_0}}{T_{m_0}} - \frac{9\ C_1}{4\left(2T_{m_0}\right)^{5/4}}$$

$$C_3 = \frac{5\ C_1}{4\left(2T_{m_0}\right)^{9/4}} - \frac{V_{b_0}}{\left(2T_{m_0}\right)^{2}}$$

This relation is continuous with Equation (46) through the first derivative at twice T_{m0}, the melt temperature at ambient volume.

Before leaving this section, the complete "soft sphere" equation of state will be developed on the basis of the following relations:

$$V_b = V_b(T) \tag{48}$$

$$\lim_{T\to\infty} V_b = 0 \tag{49}$$

$$\lim_{T\to\infty} \left(\frac{dV_b}{dT}\right) = 0 \ . \tag{50}$$

The thermal equation of state is obtained by simply substituting Equation (48) into Equations (38) and (39) yielding

$$P_v = \frac{RT}{V} \frac{1 + \eta + \eta^2 - \eta^3}{(1 - \eta)^3} - \frac{a}{V^2} \ , \quad \eta = \frac{V_b(T)}{V} \ . \tag{51}$$

The caloric equation of state is obtained from the equation of thermodynamic consistency.

$$P - T\left(\frac{\partial P}{\partial T}\right)_V = -\left(\frac{\partial E}{\partial V}\right)_T \ . \tag{52}$$

Substituting Equation (51) into Equation (52) yields

$$\left(\frac{\partial E}{\partial V}\right)_T = \frac{RT^2}{V}\left(\frac{\partial f}{\partial T}\right)_V + \frac{a}{V^2} \tag{53}$$

where

$$f = f(T,V) = \frac{1 + \eta + \eta^2 - \eta^3}{(1 - \eta)^3} \quad . \tag{54}$$

Equation (53) and the thermodynamic relations

$$P = -\left(\frac{\partial A}{\partial V}\right)_T \tag{55}$$

$$S = -\left(\frac{\partial A}{\partial T}\right)_V \tag{56}$$

$$A = E - TS \tag{57}$$

may be solved for the thermal energy E and the Helmholtz free energy A. The solutions are

$$E_V = \frac{3RT}{2} - \frac{2RT^2}{V} \frac{(2 - \eta)}{(1 - \eta)^3} \frac{dV_b}{dT} - \frac{a}{V} + E_S \tag{58}$$

$$A_V = \left[\frac{7 - 6\eta + \eta^2}{2(1 - \eta)^2} - \ln V\right] RT - \frac{3RT}{2} \ln T - \frac{a}{V} + E_S \tag{59}$$

The sublimation energy, E_S, is included in the caloric state relation in order to insure that the zero energy reference is consistent with the solid, melt and liquid regions. The energy is referenced to zero at 300°K and ambient volume.

An improved procedure for joining the modified forms of the Grover and Young-Alder models is presented in the next subsection.

3.3 AN IMPROVED JOIN PROCEDURE

As pointed out in Section 2 of this report, the join procedure in the current version of the GRAY equation of state has a slope discontinuity at the join volume, V_j, and employs correction terms which prevent the Young-Alder model from approaching the correct ideal gas limit at high temperature and volume. These problems may be eliminated by applying a mixing function to the improved forms of the Grover and Young-Alder models presented in Section 3.1 and Section 3.2, respectively.

In order to assure thermodynamic consistency the mixing function is applied initially to the Helmholtz free energy of the two regions to be joined. Letting $f_m = f_m(V)$ represent the mixing function, the Helmholtz free energy in the join region, A_j, may be represented as

$$A_j(T,V) = f_m(V)A_v(T,V) + [1-f_m(V)]A_\ell(T,V) \tag{60}$$

where $V_1 \leq V \leq V_2$ and the quantities A_ℓ and A_v represent the Helmholtz free energy in the liquid and vapor regions, respectively. A schematic illustration of the various regions in the improved GRAY equation of state is presented in Figure 4.

The algebraic form of the mixing function is somewhat arbitrary except for the requirements of continuity which may be expressed mathematically as follows:

$$f_m(V_1) = 0 \tag{61}$$

$$f_m(V_2) = 1 \tag{62}$$

$$\left(\frac{df_m}{dV}\right)_{V=V_1} = 0 \tag{63}$$

$$\left(\frac{df_m}{dV}\right)_{V=V_2} = 0 \ . \tag{64}$$

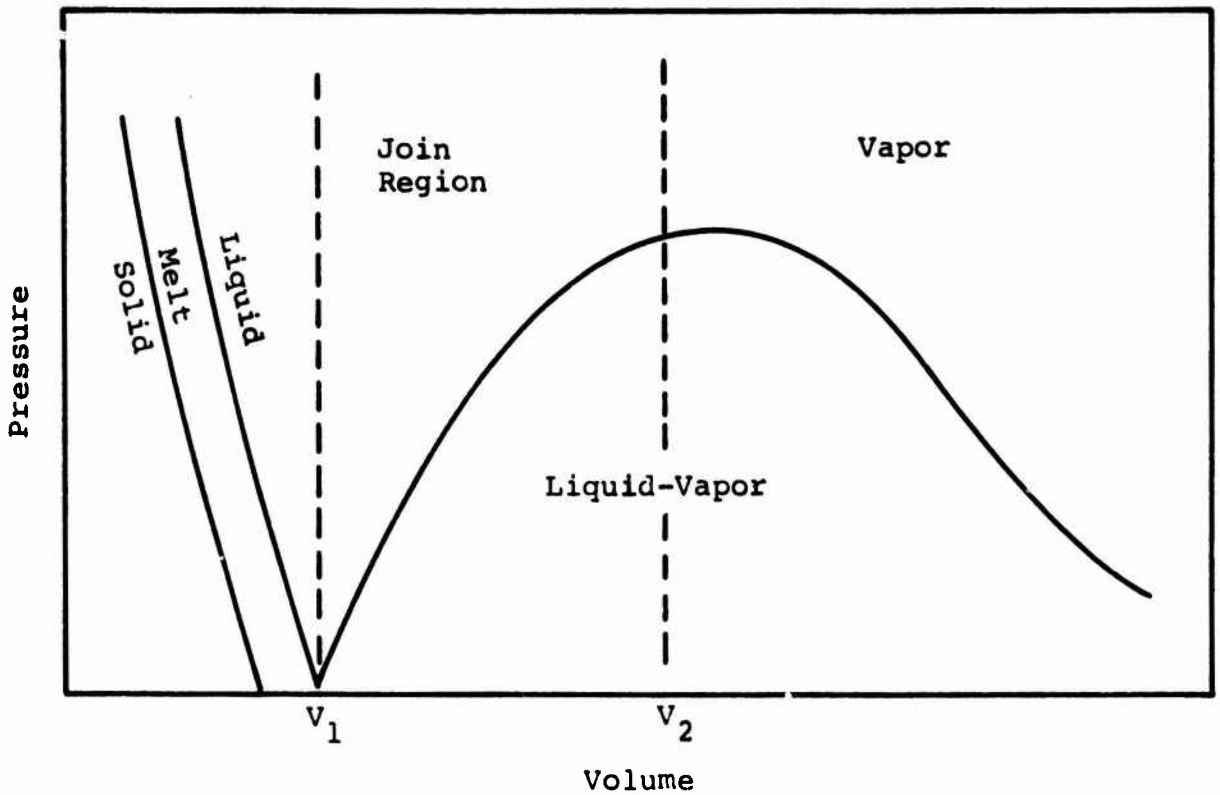

Figure 4. Schematic phase diagram illustrating the various regions in the improved GRAY equation of state

The following trigonometric relation meets all of the above continuity requirements and is therefore an appropriate mixing function.

$$f_m(V) = \frac{1}{2}\left\{\cos\left[\frac{\pi(V_2-V)}{V_2 - V_1}\right] + 1\right\} \quad . \tag{65}$$

Having completed a join between the improved Grover and Young-Alder models it is necessary to obtain thermal and caloric state relations which are applicable within the join region. This task is easily accomplished in a thermodynamically consistent manner because the mixing function has already been applied to the Helmholtz free energy from which all the thermodynamic quantities of interest may be obtained. The pressure in the join region, P_j, is obtained from the relation

$$P_j = -\left(\frac{\partial A_j}{\partial V}\right)_T \quad . \tag{66}$$

Substitution of Equation (60) into Equation (66) yields

$$P_j(T,V) = [A_\ell(T,V) - A_v(T,V)]\,\frac{df_m}{dV} + f_m P_v(T,V) + (1-f_m)P_\ell(T,V) \quad . \tag{67}$$

Similarly, the thermodynamic relations

$$S = -\left(\frac{\partial A}{\partial T}\right)_V \tag{68}$$

and

$$E = A + TS \tag{69}$$

yield the following thermodynamic functions for the entropy, S_j, and the energy, E_j, in the join region when combined with Equation (60).

$$S_j(T,V) = fS_v(T,V) + (1-f)S_\ell(T,V) \tag{70}$$

$$E_j(T,V) = fE_v(T,V) + (1-f)E_\ell(T,V) \quad . \tag{71}$$

Thus the equation of state in the join region is completely defined in terms of the mixing function and thermodynamic state variables in the liquid and vapor regions.

4. DISCUSSION OF RESULTS

The modified GRAY equation of state requires several parameters not specified for the version developed by Royce.[5] A complete description of the input data generation procedures for modified GRAY is presented in Appendix A of this report.

Critical point constants for three metals calculated from the modified GRAY equation of state are compared to estimates by Grosse[13,14,15] and to values calculated from the L^3 version of GRAY in Table 1. The estimates by Grosse were obtained in several ways. One way is to get T_c, the critical temperature, by matching the entropy of vaporization at some T_o to a curve of ΔS_{vap} versus T/T_c obtained from mercury data. Then one reads off the corresponding value of T_o/T_c and calculates T_c. Grosse has also measured the densities of liquid metals from their melting points to their boiling points. These data, combined with the law of rectilinear diameter of Cailletet and Mathias, and T_c obtained above, give the critical density ρ_c. Extrapolation of vapor-pressure curves then yields P_c. Alternatively, T_c can be calculated by requiring the boiling point density divided by ρ_c to equal 4.35, and using the law of rectilinear diameter. Grosse's estimates of the alkali-metal critical constants compare favorably with later experimental data. Note that BRL-GRAY is consistently closer to the estimated values than the L^3 version. Since the critical point lies outside the join region, which is confined to a small range of volume in the modified GRAY equation of state, the critical point constants are determined directly by the parameters of the soft sphere model. This characteristic greatly facilitates the process of fitting available critical point data.

A Maxwell construction was performed on aluminum, iron and uranium to obtain the thermodynamic state variables at a series of temperatures on the liquid-vapor phase boundary. A Maxwell construction involves calculating the Gibbs' free energy along a series of isotherms. Points on an isotherm having equal values of Gibbs' free energy are indicative of liquid-vapor phase equilibrium and are therefore located on the phase boundary. The data are reported in Tables 2, 3, and 4 for aluminum, iron, and uranium respectively. The variable names appearing in these tables are defined below:

TMP = temperature on the line (°K)

VMN = volume on liquid end of tie line (cm^3/gm)

VMX = volume on vapor end of tie line (cm^3/gm)

EVMN = energy at VMN and TMP (ergs/gm)

EVMX = energy at VMX and TMP (ergs/gm)

PRES = pressure on tie line ($dynes/cm^2$)

The volumes which bound the join region of BRL-GRAY are given in Table 5. The procedure for reading these data into modified GRAY is discussed in Appendix A.

TABLE 1. COMPARISON OF CRITICAL CONSTANTS CALCULATED FROM BRL-GRAY AND L^3-GRAY WITH VALUES ESTIMATED BY GROSSE

Element	V_c (cm^3/gm)			T_c (°K)			P_c (kbar)			E_c (10^{10} ergs/gm)
	Grosse	BRL-GRAY	L^3-GRAY	Grosse	BRL-GRAY	L^3-GRAY	Grosse	BRL-GRAY	L^3-GRAY	BRL-GRAY
Al		1.51	1.21	8,550	7,162	11,533		5.32	10.47	0.1277
Fe	0.746	0.533	0.453	6,750	9,289	14,721		9.808	17.50	0.0799
U		0.203	0.183	12,500	12,979	18,759		8.25	12.83	0.0220

TABLE 2. LIQUID-VAPOR PHASE BOUNDARY DATA FOR ALUMINUM

TMP = .66215+04	VMN = .89286+00	VMX = .30303+01	EVMN = .10955+12	EVMX = .13739+12	PRES = .38137+10
TMP = .60814+04	VMN = .76336+00	VMX = .47619+01	EVMN = .10097+12	EVMX = .13951+12	PRES = .26077+10
TMP = .55412+04	VMN = .68966+00	VMX = .76923+01	EVMN = .94147+11	EVMX = .14017+12	PRES = .16766+10
TMP = .50011+04	VMN = .63694+00	VMX = .12500+02	EVMN = .88069+11	EVMX = .13969+12	PRES = .99514+09
TMP = .44609+04	VMN = .59880+00	VMX = .20000+02	EVMN = .82667+11	EVMX = .13844+12	PRES = .53031+09
TMP = .39208+04	VMN = .57143+00	VMX = .33333+02	EVMN = .77690+11	EVMX = .13680+12	PRES = .24016+09
TMP = .33806+04	VMN = .55866+00	VMX = .11111+03	EVMN = .72862+11	EVMX = .13522+12	PRES = .88547+08

TABLE 3. LIQUID-VAPOR PHASE BOUNDARY DATA FOR IRON

TMP = .86711+09	VMN = .31153+00	VMX = .98039+00	EVMN = .68780+11	EVMX = .85220+11	PRES = .73373+10
TMP = .80537+09	VMN = .26882+00	VMX = .19706+01	EVMN = .63895+11	EVMX = .84612+11	PRES = .52920+10
TMP = .74363+09	VMN = .24272+00	VMX = .21739+01	EVMN = .59858+11	EVMX = .87070+11	PRES = .36505+10
TMP = .68189+09	VMN = .22422+00	VMX = .33333+01	EVMN = .56293+11	EVMX = .87053+11	PRES = .23809+10
TMP = .62015+09	VMN = .21053+00	VMX = .52632+01	EVMN = .53102+11	EVMX = .86631+11	PRES = .19931+10
TMP = .55841+09	VMN = .20000+00	VMX = .90909+01	EVMN = .50201+11	EVMX = .85963+11	PRES = .79398+09
TMP = .49667+09	VMN = .19157+00	VMX = .16667+02	EVMN = .47387+11	EVMX = .85093+11	PRES = .38271+09
TMP = .43492+09	VMN = .18315+00	VMX = .33333+02	EVMN = .41571+11	EVMX = .83950+11	PRES = .14720+09
TMP = .37318+09	VMN = .17544+00	VMX = .12500+03	EVMN = .35080+11	EVMX = .82796+11	PRES = .41596+08
TMP = .31144+09	VMN = .16722+00	VMX = .50000+03	EVMN = .27064+11	EVMX = .81501+11	PRES = .83325+07
TMP = .24970+09	VMN = .15798+00	VMX = .50000+04	EVMN = .18645+11	EVMX = .80169+11	PRES = .61619+06

TABLE 4. LIQUID-VAPOR PHASE BOUNDARY DATA FOR URANIUM

TMP = .11955+05	VMN = .11765+00	VMX = .41667+00	EVMN = .18171+11	EVMX = .24021+11	PRES = .58178+10
TMP = .10930+05	VMN = .10040+00	VMX = .67114+00	EVMN = .16365+11	EVMX = .24439+11	PRES = .38923+10
TMP = .99059+04	VMN = .90334-01	VMX = .10879+01	EVMN = .14899+11	EVMX = .24517+11	PRES = .24313+10
TMP = .88814+04	VMN = .83333-01	VMX = .16519+01	EVMN = .13611+11	EVMX = .24399+11	PRES = .13855+10
TMP = .78564+04	VMN = .76247-01	VMX = .34483+01	EVMN = .12465+11	EVMX = .24146+11	PRES = .69505+09
TMP = .68324+04	VMN = .74349-01	VMX = .71429+01	EVMN = .11924+11	EVMX = .23785+11	PRES = .28970+09
TMP = .58080+04	VMN = .71736-01	VMX = .20000+02	EVMN = .10463+11	EVMX = .23360+11	PRES = .91169+08
TMP = .47835+04	VMN = .69735-01	VMX = .50062+02	EVMN = .93831+10	EVMX = .22869+11	PRES = .17069+08
TMP = .37590+04	VMN = .68776-01	VMX = .50000+03	EVMN = .84282+10	EVMX = .22369+11	PRES = .24733+07

TABLE 5. VOLUMES AT BOUNDARIES OF THE JOIN REGION IN BRL-GRAY

Element	V_1 (cm^2/gm)	V_2 (cm^2/gm)
Al	0.4	0.58
Fe	0.14	0.182
U	0.0564	0.0733

5. SUMMARY

Several improvements have been incorporated into a modified version of the GRAY equation of state. The liquid region now exhibits a continuous variation of the specific heat from an appropriate value at the melt temperature to the ideal gas value of 3/2 R as the temperature approaches infinity. A soft sphere model has been introduced in the vapor region yielding the correct ideal gas limit at high temperature. A new join procedure which affects a limited volume range is employed between the liquid and vapor regions. Critical point constants generated from the new equation of state are in closer agreement with estimates by Grosse than those generated with the original version.

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APPENDIX A

DATA GENERATION FOR MODIFIED GRAY

Prior to making a hydrodynamic calculation with the RIP code using the GRAY equation of state, EOS3, preliminary calculations to determine the specific volume limits of the join region and the state variables on the mixed phase boundary must be made for each material in the mesh. Figure A.1 shows a P-V plot of the regions defined by the GRAY equation of state.

The first set of preliminary calculations involves making "driver" runs to determine the specific volume limits of the join region, V_1 and V_2. As previously discussed in the text of this report, the join region connects the liquid and vapor phases. Equations from both of these phases are used in the join region with a weighting function to bias the pressure to the most dominant phase. The weighting function is trigonometric in form and the pressure equation in the join region is written to maintain thermodynamic consistency. Figure A.2 shows a schematic diagram of representative isotherms in the join region. The values of V_1 and V_2 must be chosen such that no pressure maximum and minimum occur along an isotherm within the join region. An example of this behavior is isotherm T_3 in Figure A.2. Maximum and minimum pressures are not allowed in the join region because errors will be introduced in the calculations of the mixed phase boundary state points which follow. Therefore, the determination of V_1 and V_2 becomes a trial and error procedure in which an isotherm driver program is run with trial values of V_1 and V_2 until no isotherms are produced which have a maximum and minimum characteristic.

The isotherm driver may be incorporated temporarily into subroutine ENCALC of the RIP code or it may be written independent of RIP. The driver should essentially consist of a double loop procedure in which the inner loop increments volume and the outer loop increments user selected temperatures. Within the inner loop, subroutine ET should be called to calculate the appropriate specific internal energy for the driver values of specific volume and temperature and then subroutine EOS3 should be called to calculate the pressure and sound speed for the given values of density and specific energy. One coding change is required in subroutine EOS3 when it is used in the isotherm driver runs. The mixed phase flag, MIXFLG, must be set to 0 to bypass the mixed phase region. A comment card exists in the subroutine to indicate where this change must be made. The values of V_1 and V_2 are input to the program through the equation of state constants array in the locations ESTCON (14,N) and ESTCON (15,N) respectively.

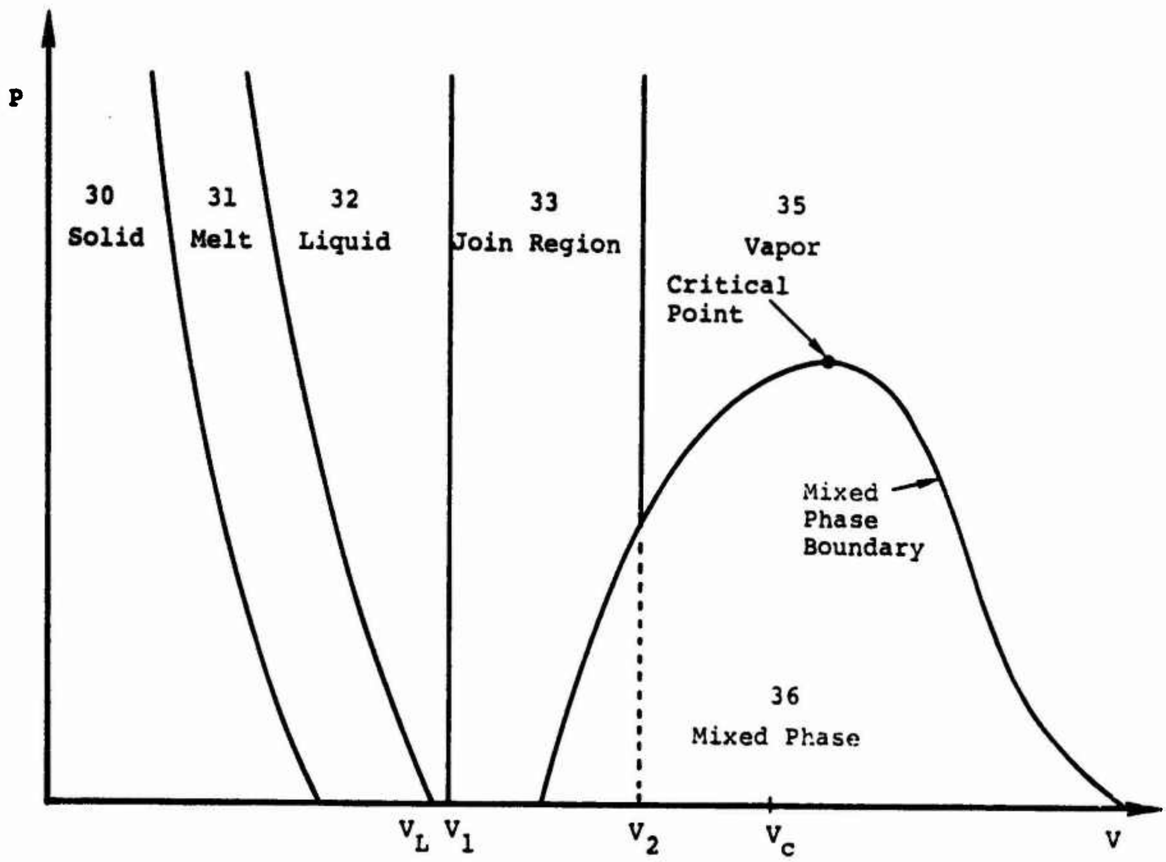

Figure A.1. Schematic diagram of regions in the modified GRAY equation of state.

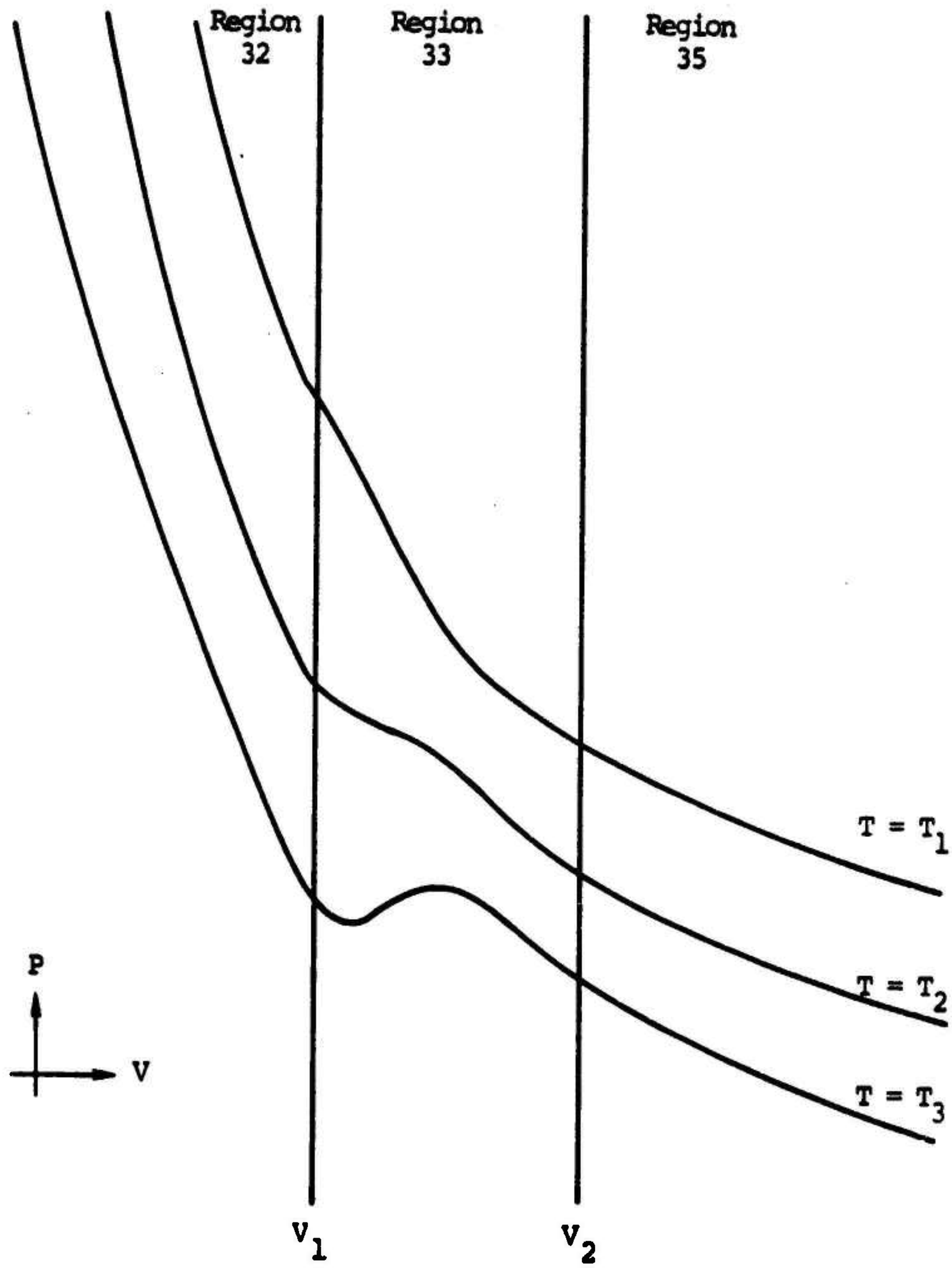

Figure A.2. Schematic diagram of representative isotherms in the join region.

The selected isotherms should range from approximately twice the critical temperature down to 300°K. Driven specific volumes should encompass the trial values of V_1 and V_2. In general, the lower temperature isotherms will display the undesired pressure reversal characteristics. However, the lower temperature isotherms also will produce negative pressures which will not be important with respect to the generation of mixed phase boundary values. The user should attempt to obtain isotherms which give positive pressures in the join region with no pressure minimums or maximums for as low a temperature as possible. In general, this minimum temperature will be in the range of 1000 to 3000 °K. Initial values of V_1 and V_2 should be chosen as follows. V_1 must be larger than the specific volume at which the liquidus intersects the zero pressure line, V_L, and V_2 may be estimated by $1.3 \times V_1$. Subsequent values of V_1 and V_2 are based upon the results of the isotherm driver for the previous values of V_1 and V_2.

Once the limiting values of the join region have been determined the remaining step is to generate the mixed phase boundary values. These values are calculated by the DATGEN and ET subroutines. To activate the DATGEN subroutine, a change to subroutine ENCALC is required. The cells to DATGEN and EXIT, which exist as comment cards in ENCALC, must be activated by removing the "C" in column 1. In addition, the mixed phase flag, MIXFLG, must be set to 0 in subroutine EOS3.

The DATGEN subroutine is based upon the "Main Subroutine" described in Reference 9. The mixed phase boundary state points and the critical point are calculated by this subroutine. Output is in the following form. For each value of temperature, which is automatically selected in the DATGEN subroutine, values of specific volume, specific energy and pressure are calculated on the mixed phase boundary. Two values of specific volume, V_{MAX} and V_{MIN}, and specific energy, E_{MAX} and E_{MIN}, are produced at each temperature. The maximum values correspond to the mixed phase boundary values at the specific volume greater than the critical point and the minimum values correspond to the mixed phase boundary values at the specific volume less then the critical point. Mixed phase boundary values calculated by subroutine DATGEN are used in the /GRAY/COMMON arrays in the hydrodynamics.

The equation of state constants and mixed phase boundary data are loaded into the ESTCON array of /EQST/COMMON and the /GRAY/COMMON arrays respectively. Table A.1 lists the required ESTCON variables.

TABLE A.1. THE ESTCON ARRAY

Location	Symbol	Definition
ESTCON(1,N)	ρ_0	Ambient density (g/cm^3).
ESTCON(2,N) to ESTCON(5,N)	-	Unused.
ESTCON(6,N)	C_0	Bulk sound speed (cm/sec).
ESTCON(7,N)	AMU	Shear modulus (dyne/cm^2).
ESTCON(8,N)	Y_0	Yield strength (dyne/cm^2).
ESTCON(9,N)	σ	Spall strength (dyne/cm^2).
ESTCON(10,N)	E_S	Sublimation energy (erg/g).
ESTCON(11,N)	E_{LV}	Energy at which the matrrial commences to vaporize (erg/g).
ESTCON(12,N)	E_{LM}	Energy at which the material has completed melting (erg/g).
ESTCON(13,N)	E_{SM}	Energy at which the material commences to melt (erg/g).
ESTCON(14,N)	V1	Specific volume at boundary between the join region and the liquid region (cm^3/g).
ESTCON(15,N)	V2	Specific volume at boundary between the join region and the vapor region (cm^3/g).
ESTCON(16,N)	S	Hugoniot parameter $U_s = C + SU_p$ (cm/μsec).
ESTCON(17,N)	λ_0	Lattice gamma $\lambda(V) = \lambda_0 - ax$.
:ON(18,N)	a	See ESTCON(17,N).
ESTCON(19,N)	λ_e	Electronic gamma.
ESTCON(20,N)	g_e	Electronic energy coefficient (mbar cm^3/mole deg^2).
ESTCON(21,N)	T_{MO}	Melting temperature parameter (deg).

TABLE A.1 (Continued)

Location	Symbol	Definition
ESTCON(22,N)	E_{OH}	Energy at $V = V_0$, T = 300°K, P = 0 (mbar cm^2/g).
ESTCON(23,N)	E_∞	Energy difference between E_{OH} and energy at $V = V_0$, T = 0 (mbar cm^3/g). If undefined $E_\infty = -300\ (3\times 8.134E-5 + 150\ g_e)/AW$.
ESTCON(24,N)	AW	Atomic weight (g/mole).
ESTCON(25,N)	V_J	Unused.
ESTCON(26,N)	V_b	Excluded volume for vapor phase (cm^3/g).
ESTCON(27,N)	a_y	Coefficient of attractive potential for vapor [mbar $(cm^3/mole)^2$].
ESTCON(28,N)	T_{crit}	Critical temperature (°K).
ESTCON(29,N)	ΔS	Entropy of melting (mbar cm^3/mole deg).
ESTCON(30,N)	EOSFLG	Equation of state flag. Must have the value of 3.0 to indicate EOS3 is to be used.

Table A.2 lists the /GRAY/COMMON variables that are to be loaded with the mixed phase boundary data generated by subroutine DATGEN.

TABLE A.2. THE GRAY COMMON ARRAYS

Location	Symbol	Definition
TMP(I,N) I=1,20	T	Temperature (°K). Load in descending order starting with the critical temperature
VMX(I,N) I=1,20	V_{MAX}	Specific volumes which are larger than the critical value (cm^3/g). Load in descending order starting with the critical specific volume.

TABLE A.2 (Continued)

Location	Symbol	Definition
VMN(I,N) I=1,20	V_{MIN}	Specific volumes which are smaller than the critical value (cm^3/g). Load in descending order starting with the critical specific volume.
EVMX(I,N) I=1,20	$E_{V_{MAX}}$	Specific energies at corresponding specific volume, V_{MAX} ($mbar/cm^2$). Note: DATGEN units which are $dyne/cm^2$ must be converted to $mbar/cm^2$.
EVMN(I,N) I=1,20	$E_{V_{MIN}}$	Specific energies at corresponding specific volumes, V_{MIN} ($mbar/cm^2$). Note: DATGEN units which are $dyne/cm^2$ must be converted to $mbar/cm^2$.
PRBS(I,N) I=1,20	P	Pressure ($mbar/cm^2$). Load in descending order starting with the critical pressure. Note: DATGEN units which are $dyne/cm^2$ must be converted to $mbar/cm^2$.

The index "N" in the /GRAY/COMMON variables is treated in exactly the same manner as the "N" index in the ESTCON array.

APPENDIX B

LISTING OF MODIFIED GRAY

```
      SUBROUTINE EOS3
C
      COMMON AMASS(10),DELTMI(10),DELTMN(10),MATBND(10),MATLID(10),
     .       RATIO(10),NMTRLS
      COMMON VISCOL(10),VISCOQ(10),COURST,DELTIM,MAXCYL,MODE,NRESRT,TMAX
      COMMON IPLATE,UZERO
      COMMON ALPHA(81),AMU(11),BBTEMP(2),CONVRG,ENERGY(2),MAXPAS,NALPHA,
     .       NFLUID(10),NPE(10),NSCTT(10),SSTART(2),SSTOP(2),NUNIT1,
     .       NUNIT2,NUNIT3,NUNIT4,NFIT(10),NEDGE,NINC,NKFILT,NFUNCT
      COMMON STIME1,STIME2,ENRGY,WIDTH
      COMMON IOUNIT(6)
      COMMON NCYEDT(20),TEDIT(20),NABS(5),NORD(5),IZPLOT(5),LPLOT(5),
     .       IPDT,MOMENT,NDUMP,NFEDIT,NPRINT,TPRINT,NSEDIT
      COMMON ICUTL,ICUTR,IADDL,IADDR,IODEN,DMZ1,DRATIO,ADDMAS,DUM1
      COMMON IVZONE,VWIDTH
      COMMON DELTAM(1000),DISCPT(12),MERROR(2),ITEMP(25),MZONE(10,4),
     .       TEMP(25),DTAVG,DTN,DTNP1,ICOURN,JSAVE,MAPFLG,MAXZ,MAXZP1,
     .       NCYCLE,NSAVE,PDTPOS,PDTNEG,TIME
      COMMON C(1000),E(1000),HRATE(1000,2),IBFLAG(1000),IVFLAG(1000),
     .       OLDRHO(1000),P(1000),Q(1000),RHO(1000),S(1000),SD(1000),
     .       U(1000),X(1000),BLANK(39)
C
      COMMON /EQST/ ESTCON(30,30)
C
      COMMON /GRAY/ TMP(20,30),VMX(20,30),VMN(20,30),EVMX(20,30),
     .       EVMN(20,30),PRES(20,30)
C
      COMMON /TEM/ T(1000)
C
      COMMON /TSAVE/ TOLDJ,EOLDJ
C
      COMMON /EC/ ECON(20,30)
C
      DATA GAMMAF,ALF/1.0556,.1/
C
      DATA BOLTZ,AVNO,PI/1.38E-16,6.02E23,3.1416/
C
C
C
C     *** STATEMENT FUNCTIONS ***
C
      EM(X1,X2,X3)=TEMP(11)+X1*(3.*ECON(5,N)+.5*ECON(2,N)*X1)+X2*
     .       (ECON(3,N)-.5*ECON(4,N)*(1.+X3**2))
C
      PC(X4,X5)=.5*(ESTCON(19,N)-ESTCON(17,N)+ESTCON(18,N)*X4)*ECON(2,N)
     .       /(ECON(1,N)*(1.-X4))*X5**2
C
      T1(X6,X7,X8)=(-X7+SQRT(X7**2-2.*X6*X8))/X6
C
      J=JSAVE
      N=NSAVE
      TOLD=T(J)
      EOLD=E(J)
      IJOIN=0
```

```
      IF (ECON(1,N) .GT. 0.) GO TO 30                                   ESC 390
C                                                                       ESC 400
C     *** INITIALIZATION OF EQUATION OF STATE CONSTANTS ***             ESC 410
C                                                                       ESC 420
      ECON(1,N)=1./ESTCON(1,N)                                          ESC 430
      ECON(2,N)=ESTCON(20,N)/ESTCON(24,N)                               ESC 440
      ECON(3,N)=ESTCON(29,N)/ESTCON(24,N)                               ESC 450
      ECON(4,N)=1.163E-5/ESTCON(24,N)
      ECON(5,N)=8.134E-5/ESTCON(24,N)                                   ESC 470
      ECON(7,N)=4.5E4*ECON(2,N)*ESTCON(1,N)*(ESTCON(17,N)-ESTCON(19,N)) ESC 490
      IF (ESTCON(23,N) .GE. 0.) ESTCON(23,N)=-900.*(8.134E-5+50.*       ESC 500
     .        ESTCON(20,N))/ESTCON(24,N)                                ESC 510
      ECON(12,N)=1.-ESTCON(1,N)*ESTCON(14,N)                           EXV1
      ECON(15,N)=(ALF+1.0)*ALOG(ALF+1.0)
      TEMP(1)=ESTCON(17,N)-1.333
      TEMP(2)=ESTCON(21,N)/(1.0-ECON(12,N))**2
      TEMP(3)=1.+ECON(12,N)*(2.*TEMP(1)+ECON(12,N)*(TEMP(1)*
     .    (2.*ESTCON(17,N)-1.6667)-ESTCON(18,N)))
      ECON(8,N)=TEMP(2)*TEMP(3)                                        TMV1
      TEMP(4)=2.*(ECON(12,N)*ESTCON(18,N)-ESTCON(17,N)+.3333)
      TEMP(5)=1.2*(1.-ECON(12,N))*1.E-12*ESTCON(6,N)**2
      ECON(9,N)=ECON(3,N)*(TEMP(4)*TEMP(2)*TEMP(3))**2/TEMP(5)         TISV1
      TC=ESTCON(28,N)
      VB=ESTCON(26,N)
      SIGMA=(3.*ESTCON(24,N)*VB/(PI*AVNO*4.))**.33333333
      DT=(6.*ESTCON(24,N)*VB/(PI*AVNO))**.33333333
      EPS=BOLTZ*TC*(DT/(GAMMAF*SIGMA))**12
      ECON(6,N)=PI*AVNO*((GAMMAF*SIGMA*(EPS/BOLTZ)**.083333333)**3)/
     .    (6.0*ESTCON(24,N))
      ECON(10,N)=.143*ECON(5,N)*.5*ECON(9,N)
      TEMP(1)=ESTCON(16,N)*ECON(12,N)
      TEMP(2)=.5*(1.E-6*ESTCON(6,N)*ECON(12,N))**2/(1.-TEMP(1))
      TEMP(3)=1.+TEMP(1)*(1.+.5*TEMP(1)*(1.-ESTCON(17,N)/ESTCON(16,N)))
     .    /3.
      ECON(11,N)=TEMP(2)*TEMP(3)+ESTCON(23,N)*(1.+ESTCON(17,N)*        T11V1
     .    ECON(12,N))+ESTCON(22,N)
      TEMP(25)=TEMP(2)*ECON(6,N)
      ECON(17,N)=ESTCON(27,N)/ESTCON(24,N)**2                           ESC 750
      IF (ABS(TMP(1,N)) .LE. 0.) GO TO 22
      DO 20 I1=3,20
      JMAX=I1-1
      IF (ABS(TMP(I1,N)) .LE. 0.) GO TO 21
   20 CONTINUE
   21 ECON(16,N)=VMN(JMAX,N)-PRES(JMAX,N)*(VMN(JMAX-1,N)-VMN(JMAX,N))/  (VMNO)
     .        (PRES(JMAX-1,N)-PRES(JMAX,N))
   22 ECON(14,N)=2.*ESTCON(21,N)
      ECON(18,N)=1.1*ECON(6,N)/(ECON(14,N)**.25)                       (VB01
      ECON(19,N)=2.*ECON(18,N)/ECON(14,N)-2.25*ECON(6,N)/
     .        (ECON(14,N)**1.25)                                        (C21
      ECON(20,N)=1.25*ECON(6,N)/(ECON(14,N)**2.25)-ECON(18,N)/
     .        (ECON(14,N)**2)                                           (C3)
      PRINT 25, (ECON(I,N),I=1,20)
   25 FORMAT (//,7H  ECONS,//,4(4X,1P5E14.6,/),//)
C                                                                       ESC 930
```

```
   30 E(J)=1.E-12*E(J(
      RNU=ESTCON((,N)/RHO(J)
      EX=1.-RNU
C
C     *** FOR DRIVER OR DATGEN RUNS, CHANGE MIXFLG TO 0.  THIS
C         BYPASSES THE MIXED PHASE REGION. ***
C
      MIXFLG=1
      IF (MIXFLG .EQ. 01 GO TO 35
      ITER=0
      V=1.0/RHO(J)
      VOS=1.0/ESTCON(1,N(
      IF (V .LE. ECON(16,N)) GO TO 35
      IMX=(
      DO 7422 I=1,19
      K=I+1
      IF (EVMX(K,N( .GT. EVMX(I,N)) IMX=K
 7422 CONTINUE
      IF (E(J) .LT. 1.2*EVMX(IMX,N)( GO TO 195
   32 EXV2=1.-ESTCON(1,N)*ESTCON(15,N)
      IF (EX .GE. EXV2( GO TO 35
      TEMP(1)=1.5*ECON(5,N(
      TEMP(2(=ESTCON(1,N)/(1.0-EX)
      GO TO 90
   35 TEMP(1(=ESTCON(16,N)*EX
      TEMP(2(=.5*(1.E-6*ESTCON(6,N)*EX(**2/(1.-TEMP(1)(
      TEMP(3(=1.+TEMP(1)*(1.+.5*TEMP(1)*(1.-ESTCON(17,N)/ESTCON(16,N)))(/
     *        3.
      TEMP(11(=TEMP(2(*TEMP(3)+ESTCON(23,N(*(1.+ESTCON(17,N)*EX)+
     *        ESTCON(22,N(
      IF (EX .GT. 0.) GO TO 40
      TEMP(1)=ESTCON(17,N)-1.3333
      TEMP(2)=ESTCON(21,N)/(1.-EX(**2
      TEMP(3(=1.+EX*(2.*TEMP(1)+EX*(TEMP(1)*(2.*ESTCON(17,N)-1.6667)-
     *        ESTCON(18,N))(
      GO TO 50
   40 TEMP(1(=2.*(ESTCON(17,N(-.3333)
      TEMP(2(=ESTCON(21,N)
      TEMP(3(=1.+EX*(TEMP(1)+EX*((ESTCON(17,N)-.3333)*(TEMP(1)+1.)-
     *        ESTCON(18,N)))
   50 TEMP(12(=TEMP(2)*TEMP(3)
      TEMP(14)=2.*(EX*ESTCON(18,N(-ESTCON(17,N)+.3333)
      TEMP(1(=1.2*(1.-EX(*1.E-12*ESTCON(6,N)**2
      TEMP(2(=1.
      IF (EX .GT. 0.) TEMP(2)=1.+EX*(4.*ESTCON(16,N(-1.(
      TEMP(15)=ECON(3,N)*(TEMP(14)*TEMP(12))**2/(TEMP(1)*TEMP(2()
      TEMP(1(=TEMP(12)-.5*TEMP(15(
      TEMP(16)=EM(TEMP(1(,0.,0.)
C
      TEMP(1(=ESTCON(16,N)*EX
      TEMP(2)=ESTCON(1,N(/(1.-EX)
      TEMP(3)=EX*TEMP(2)*(1.E-6*ESTCON(6,N(/(1.-TEMP(1)((**2
      TEMP(4)=1.-EX*((1.+.5*ESTCON(17,N)(-.5*EX*ESTCON(18,N))
      TEMP(19)=TEMP(3(*TEMP(4)+TEMP(2(*(ESTCON(17,N(-EX*ESTCON(18,N)(*
```

```
     .       (E(J)-ESTCON(22,N))                                        ESC1290
C                                                                       ESC1300
      V=1./RHO(J)
      IF (V .GT. V1) GO TO 70
      IF (E(J) .GT. TEMP(16)) GO TO 60                                  ESC1310
C                                                                       ESC1320
C     *** SOLID REGION ***                                              ESC1330
C                                                                       ESC1340
      IVFLAG(J)=30                                                      ESC1350
      TEMP(1)=3.*ECON(5,N)                                              ESC1360
      TEMP(2)=-(E(J)-TEMP(11))                                          ESC1370
      ARG=TEMP(1)**2-2.*ECON(2,N)*TEMP(2)
      IF (ARG .LT. C.) GO TO 55
      TEMP(5)=T1(ECON(2,N),TEMP(1),TEMP(2))                             ESC1380
      T(J)=TEMP(5)
      TEMP(6)=PC(EX,TEMP(5))                                            ESC1390
      P(J)=TEMP(19)+TEMP(6)+ECON(7,N)                                   ESC1400
      GO TO 100                                                         ESC1410
   55 P(J)=0.
      T(J)=0.
      GO TO 100
C                                                                       ESC1420
   60 TEMP(1)=TEMP(12)+.5*TEMP(15)                                      ESC1430
      TEMP(2)=TEMP(1)/TEMP(12)                                          ESC1440
      TEMP(17)=EM(TEMP(1),TEMP(12),TEMP(2))                             ESC1450
      IF (E(J) .GE. TEMP(17)) GO TO 70                                  ESC1460
C                                                                       ESC1470
C     *** MELT REGION ***                                               ESC1480
C                                                                       ESC1490
      IVFLAG(J)=31                                                      ESC1500
      TEMP(1)=(E(J)-TEMP(16))/(TEMP(17)-TEMP(16))                       ESC1510
      TEMP(2)=ECON(3,N)-ECON(4,N)                                       ESC1520
      TEMP(3)=3.*ECON(5,N)+TEMP(1)*TEMP(2)                              ESC1530
      TEMP(4)=-(E(J)-TEMP(11)+.5*TEMP(1)**2*TEMP(15)*TEMP(2))           ESC1540
      ARG=TEMP(3)**2-2.*ECON(2,N)*TEMP(4)
      IF (ARG .LT. C.) GO TO 55
      TEMP(5)=T1(ECON(2,N),TEMP(3),TEMP(4))                             ESC1550
      T(J)=TEMP(5)
      TEMP(2)=ESTCON(1,N)/(1.-EX)                                       ESC1560
      TEMP(3)=TEMP(5)-.5*TEMP(1)*TEMP(15)                               ESC1570
      TEMP(4)=ESTCON(17,N)-ESTCON(18,N)*EX                              ESC1580
      TEMP(6)=PC(EX,TEMP(5))-TEMP(1)*TEMP(2)*(ECON(3,N)-ECON(4,N))*     ESC1590
     .        (TEMP(14)*TEMP(12)+TEMP(3)*TEMP(4))                       ESC1600
      P(J)=TEMP(19)+TEMP(6)+ECON(7,N)                                   ESC1610
      GO TO 100                                                         ESC1620
C                                                                       ESC1630
   70 TEMP(1)=1.5*ECON(5,N)
      TEMP(2)=ESTCON(1,N)/(1.0-EX)
      TEMP(6)=.143*ECON(5,N)*.5*TEMP(15)
      TEMP(10)=2.0*TEMP(1)
      TEMP(13)=TEMP(1)/ALF
      TEMP(22)=.5*ECON(2,N)*TEMP(12)
      TEMP(23)=(TEMP(11)-E(J)+TEMP(6))/TEMP(12)+ECON(3,N)+
     .   TEMP(13)*(ALF-ECON(15,N))
```

```
      GAMMAS=ESTCON(17,N)-ESTCON(18,N)*EX
      V1=ESTCON(14,N)
      V2=ESTCON(15,N)
      V=1.0/RHO(J)
      IJOIN=0
      IF (V .LE. V1) GO TO 79
      IF (V .GE. V2) GO TO 90
      IJOIN=1
C
C     *** JOIN REGION ***
C
      IVFLAG(J)=33
      TEMP(3)=2.0*ECON(5,N)*TEMP(2)
      TEMP(4)=-TEMP(2)*ECON(17,N)
      TEMP(25)=TEMP(2)*ECON(6,N)
      FM=.5*(COS(PI*(V2-V)/(V2-V1))+1.0)
      DFMDV=.5*PI*SIN(PI*(V2-V)/(V2-V1))/(V2-V1)
C     DFMDV=0.
      XV=1.0-ESTCON(1,N)*V
      T17=ESTCON(17,N)-1.333
      T2V=ESTCON(21,N)/(1.0-XV)**2
      T3V=1.0+XV*(2.*T17+XV*(T17*(2.*ESTCON(17,N)-1.6667)-ESTCON(18,N)))
      THV=T2V*T3V
      T4V=2.*(XV*ESTCON(18,N)-ESTCON(17,N)+.3333)
      T5V=1.2*XV*1.E-12*ESTCON(6,N)**2
      ECON9V=ECON(3,N)*((T2V*T4V*T3V)**2)/T5V
      T1V=ESTCON(16,N)*XV
      T2V=.5*(1.E-6*ESTCON(6,N)*XV)**2/(1.0-T1V)
      T3V=1.+T1V*(1.+.5*T1V*(1.-ESTCON(17,N)/ESTCON(16,N)))/3.0
      EOV=T2V*T3V+ESTCON(23,N)*(1.+ESTCON(17,N)*XV)+ESTCON(22,N)
      ITERTJ=0
      IF (TOLD .LT.0.) TOLD=300.
      TJ=TOLD
      ITH=0
      TUP=1.E6
      TLW=300.
   73 IF (TJ .GT. ECON(14,N)) GO TO 731
      VB=ECON(18,N)-TJ*(ECON(19,N)+ECON(20,N)*TJ)
      TEMP(7)=-ECON(19,N)-2.*ECON(20,N)*TJ
      TEMP(8)=-2.*ECON(20,N)
      GO TO 732
  731 VB=ECON(6,N)/(TJ**.25)
      TEMP(7)=-.25*ECON(6,N)/(TJ**1.25)
      TEMP(8)=5.*ECON(6,N)/(16.*TJ**2.25)
  732 ETA=VB/V
      TEMP(5)=(2.0-ETA)/((1.0-ETA)**3)
      EV=TEMP(1)*TJ-2.*ECON(5,N)*TJ**2*(2.-ETA)*TEMP(7)/(V*(1.-ETA)**3)
     *    -ECON(17,N)/V+ESTCON(13,N)*1.E-12
      XX=TJ/THV
      EL=EOV+TEMP(10)*TJ+.5*ECON(2,N)*TJ**2+ECON(3,N)*THV+ECON(4,N)*.5*
     * ECON9V+TEMP(13)*THV*(ALOG(ALF*XX+1.0)-ECON(15,N)-ALF*(XX-1.0))
      FF=-E(J)+FM*EV+(1.-FM)*EL
      IF (FF .GT. 0.) TUP=AMIN1(TUP,TJ)
      IF (FF .LT. 0.) TLW=AMAX1(TLW,TJ)
```

```
      IF (ITM .GT. 0) GO TO 733
      TEMP(11)=TEMP(7)*TEMP(2)                                          DETADT
      TEMP(12)=TEMP(10)+ECON(2,N)*TJ+TEMP(1)      *(1../(ALF*XX+1.0)-1.0)DELDT
      TEMP(14)=TEMP(1)-4.*ECON(5,N)*TJ*TEMP(5)*TEMP(7)/V               (DEVDT)
     .        -2.*ECON(5,N)*TJ*TJ*TEMP(5)*TEMP(8)/V
     .        +2.*ECON(5,N)*TJ*TJ*TEMP(7)*TEMP(7)/(V*V*((.-ETA)**3)
     .        -6.*ECON(5,N)*TJ*TJ*TEMP(7)*TEMP(7)*TEMP(5)/(V*V*(1.-ETA))
      DFFDT=FM*TEMP(14)+(1.-FM)*TEMP((2)
      TJO=TJ
      TJ=TJO-FF/DFFDT
      IF(TJ .LT. 300.) TJ=300.
      IF (ABS((TJ-TJO)/TJO) .LE. 1.E-4) GO TO 75
      ITERTJ=ITERTJ+1
      IF (ITERTJ .GT. 20) GO TO 733
      GO TO 73
  733 TJO=TJ
      ITERTJ=0
      TJ=.5*(TUP+TLW)
      IF (TJ .LT. 300.) TJ=300.
      IF (ABS((TJ-TJO)/TJO) .LE. 1.E-4) GO TO 75
      ITM=ITM+1
      IF (ITM .GT. 20) CALL SPRINT (6HEOS3  ,6HERROR3)
      GO TO 73
C
   75 TL=TJ
      TT=TJ
      GO TO 92
C
C     *** LIQUID REGION ***
C
   74 IVFLAG(J)=32
      ITERT=0
      XX=TOLD/TEMP(12)
   71 F=TEMP(23)+XX*(TEMP(10)+XX*TEMP(22))+TEMP(13)*(ALOG(ALF*XX+1.0)
     .    -ALF*XX)
      DFDX=TEMP(10)+2.*TEMP(22)*XX+TEMP(13)*(ALF/(ALF*XX+1.0)-ALF)
      XXO=XX
      XX=XXO-F/DFDX
      IF (ABS((XX-XXO)/XXO) .LE. 1.E-4) GO TO 72
      ITERT=ITERT+1
      IF (ITERT .GT. 20) CALL SPRINT (6HEOS3  ,6HERROR1)
      GO TO 71
C
   72 TL=XX*TEMP(12)
   77 PCS=0.5*ECON(2,N)*TL**2*(ESTCON(19,N)-GAMMAS)*TEMP(2)
      PRC      =PCS-TEMP(2)*TEMP(12)*ECON(3,N)*(TEMP(14)+GAMMAS)-TEMP(6)
     .    -TEMP(2)*TEMP(12)*(TEMP(14)+GAMMAS)*(ALOG(ALF*XX+1.)-(ALF+1.)*
     .    ALOG(ALF+1.)-ALF*(XX-1.))*TEMP(1)/ALF
      P(J)=TEMP(19)+PRC+ECON(7,N)
      T(J)=TL
      GO TO 100
C
C     *** VAPOR REGION ***
C
```

```
 90 IVFLAG(J)=35
    TEMP(4)=-TEMP(2)*ECON(17,N)
 95 ITERT=0
    TEMP(16)=-E(J)+TEMP(4)
    TEMP(25)=TEMP(2)*ECON(6,N)
    TEMP(17)=ECON(5,N)*TEMP(25)
    TEMP(18)=.5*TEMP(17)*TEMP(25)
    TT=TOLD
    ITH=0
    TUP=1.E6
    TLW=300.
 91 IF (TT .GT. ECON(14,N)) GO TO 911
    VB=ECON(18,N)-TT*(ECON(19,N)+ECON(20,N)*TT)
    TEMP(7)=-ECON(19,N)-2.*ECON(20,N)*TT
    TEMP(8)=-2.*ECON(20,N)
    GO TO 912
911 VB=ECON(6,N)/(TT**.25)
    TEMP(7)=-.25*ECON(6,N)/(TT**1.25)
    TEMP(8)=5.*ECON(6,N)/(16.*TT**2.25)
912 ETA=VB/V
    TEMP(5)=(2.0-ETA)/((1.0-ETA)**3)
    EV=TEMP(1)*TT-2.*ECON(5,N)*TT*TT*TEMP(5)*TEMP(7)/V + ESTCON(10,N)
   .    *1.E-12+TEMP(4)
    F=EV-E(J)
    IF (F   .GT. 0.) TUP=AMIN1(TUP,TT)
    IF (F   .LT. 0.) TLW=AMAX1(TLW,TT)
    IF (ITH .GT. 0) GO TO 913
    DF        =TEMP(1)-4.*ECON(5,N)*TT*TEMP(5)*TEMP(7)/V
   .          -2.*ECON(5,N)*TT*TT*TEMP(5)*TEMP(8)/V
   .          +2.*ECON(5,N)*TT*TT*TEMP(7)*TEMP(7)/(V*V*(1.-ETA)**3)
   .          -6.*ECON(5,N)*TT*TT*TEMP(7)*TEMP(7)*TEMP(5)/(V*V*(1.-ETA))
    TTO=TT
    TT=TTO-F/DF
    IF (TT .LT. 300.) TT=300.
    IF (ABS((TT-TTO)/TTO) .LE. 1.E-3) GO TO 92
    ITERT=ITERT+1
    IF (ITERTJ .GT. 20) GO TO 9.3
    GO TO 91
913 TTO=TT
    ITERTJ=0
    TT=.5*(TUP+TLW)
    IF (TT .LT. 300.) TT=300.
    IF (ABS((TT-TTO)/TTO) .LE. 1.E-4) GO TO 92
    ITH=ITH+1
    IF (ITH .GT. 20) CALL SPRINT (6HEOS3  ,6HERROR2)
    GO TO 91
 92 TEMP(5)=ETA
    PV   =ECON(5,N)*TT*TEMP(2)*(1.0+TEMP(5)*(1.0+TEMP(5)*(1.-TEMP(5))))
   .    /((1.0-TEMP(5))**3)+TEMP(2)*TEMP(4)
 94 IF (IJOIN .NE. 0) GO TO 96
    P(J)=PV
    T(J)=TT
    GO TO 100
C
```

```
C     *** MIXED PHASE REGION ***
C
  195 IVFLAG(J)=36
      ITER=ITER+1
      IF (ITER .GT. 3) CALL SPRINT (6HES03  ,5HERROR1)
      VXM1=VMN(1,N)
      VMM1=VMN(1,N)
      EXM1=EVMN(1,N)
      EVM1=EVMN(1,N)
      EEQM1=EVM1+(EVMX(2,N)-EVMN(2,N))*(V-VMM1)/(VMX(2,N)-VMN(2,N))
C
      DO 197 JJ=2,20
      JM=JJ
      EEQ=EVMN(JJ,N)+(EVMX(JJ,N)-EVMN(JJ,N))*(V-VMN(JJ,N))/
     *   (VMX(JJ,N)-VMN(JJ,N))
      IF (E(J) .LT. EEQ) GO TO 196
      EBH=EVMN(JJ,N)+(EVM1-EVMN(JJ,N))*(V-VMN(JJ,N))/(VMM1-VMN(JJ,N))
      IF (E(J) .GE. EBH) GO TO 32
      EBL=EVMX(JJ,N)+(EVMX(JJ,N)-EXM1)*(V-VMX(JJ,N))/(VMX(JJ,N)-VXM1)
      IF (E(J)-EBL) 199,32,32
  196 EEQM1=EEQ
      VXM1=VMX(JJ,N)
      VMM1=VMN(JJ,N)
      EXM1=EVMX(JJ,N)
      EVM1=EVMN(JJ,N)
      IF (ABS(VMX(JJ+1,N)-VMN(JJ+1,N)) .LE. 0.) GO TO 198
  197 CONTINUE
C
  198 EBL=EVMX(JM,N)*VMX(JM,N)/V
      IF (E(J) .GE. EBL) GO TO 32
C
      SLEN=-EVMN(JM,N)/(1./ECON(16,N)-1./VMN(JM,N))
      EBH=EVMN(JM,N)+SLEN*(1.0/V-1.0/VMN(JM,N))
      IF (E(J) .GE. EBH) GO TO 35
C
      TEMP(1)=TMP(JM-2,N)
      TEMP(2)=TMP(JM-1,N)
      TEMP(3)=(E(J)/EEQM1)*(TEMP(2)-300.)+300.
      GO TO 101
C
  199 TEMP(1)=TMP(JM-1,N)
      TEMP(2)=TMP(JM,N)
      TEMP(4)=(EEQM1-E(J))/(E(J)-EEQ)
      TEMP(3)=(TEMP(2)*TEMP(4)+TEMP(1))/(1.0+TEMP(4))
C
  101 TEMP(5)=ALOG(PRES(JM-1,N)/PRES(JM,N))/(1.0/TEMP(1)-1./TEMP(2))
      P(J)=PRES(JM,N)*EXP(TEMP(5)*(1.0/TEMP(3)-1.0/TEMP(2)))
      IF (P(J) .LE. ESTCON(2,N) /1.E+12) P(J)=0.
      T(J)=TEMP(3)
      GO TO 100
C
C     P(J)=JOIN PRESSURE
C
   96 XV=1.0-V*ESTCON(1,N)
```

```
      TEMP(15)=ESTCON(1,N)/(1.0-XV)
      TEMP(16)=XV*TEMP(15)*(1.E-6*ESTCON(6,N)/(1.0-ESTCON(16,N)*XV))**2
      TEMP(17)=1.0-XV*(1.0+.5*ESTCON(17,N)-.5*XV*ESTCON(18,N))
      GAMMAS=ESTCON(17,N)-XV*ESTCON(18,N)
      PIV=TEMP(16)*TEMP(17)+TEMP(15)*GAMMAS*(E(J)-ESTCON(22,N))
      PCSV=.5*ECON(2,N)*TL**2*(ESTCON(19,N)-GAMMAS)*TEMP(15)
      XXTM=TL/TMV
      TEMP(18)=2.*(XV*ESTCON(18,N)-ESTCON(17,N)+.3333)
      PCTMV=PCSV-TMV*ECON(3,N)*TEMP(15)*(TEMP(18)+GAMMAS)
     *     -.5*ECON(4,N)*ECON9V-TEMP(15)*TMV*(TEMP(18)+GAMMAS)*TEMP(1)*
     *    (ALOG(ALF*XXTM+1.0)-ECON(15,N)-ALF*(XXTM-1.0))/ALF
      PL=PIV+PCTMV+ECON(7,N)
      EOV1=ECON(11,N)
      TO=300.
      TTERM1=0.
      TTERM2=0.
      IF (TT .LE. 0.) GO TO 743
      TTERM1=TT*ALOG(TT)
      TTERM2=TT*ALOG(ABS(TT/TO))
  743 CONTINUE
      TERM1=2.*TT*TEMP(1)+.5*ECON(2,N)*TT*TT-2.*TEMP(1)*TTERM2
     *     -ECON(2,N)*TT*(TT-TO)
      TERM2=2.*TT*TEMP(1)*(ESTCON(17,N)-ESTCON(18,N))+.5*ECON(2,N)*TT*
     *      TT*ESTCON(19,N)
      ASV1=EOV1+TERM1+2.*TT*TEMP(1)*ESTCON(18,N)*(1.0-V1*ESTCON(1,N))
     *     -TERM2*ALOG(V1*ESTCON(1,N))
      AS=EOV+TERM1+2.*TT*TEMP(1)*ESTCON(18,N)*XV-TERM2*ALOG(1.0-XV)
      AV=TT*ECON(5,N)*(ALOG(TEMP(2))+(7.-ETA*(6.+ETA))*.5/((1.-ETA)**2))
     *   -TEMP(1)*TTERM1-ECON(17,N)/V+ESTCON(10,N)*1.E-12
      ETAV1=VB/V1
      AVV1=TT*ECON(5,N)*(ALOG(1./V1)+(7.-ETAV1*(6.+ETAV1))*.5/
     *   ((1.-ETAV1)**2))-TEMP(1)*TTERM1-ECON(17,N)/V)
     *   +ESTCON(10,N)*1.E-12
      XXTM=TL/ECON(8,N)
      ALV1=ASV1+ECON(10,N)-.5*ECON(9,N)*ECON(3,N)-(TL-ECON(8,N))*
     *     (ECON(3,N)+TEMP(1))+2.*TEMP(1)*ECON(8,N)*((ALF*XXTM+1.)*
     *     ALOG(ALF*XXTM+1.)-(ALF+1.)*ALOG(ALF+1.))/ALF
      XX=TL/TMV
      EC1OV=ECON(4,N)*.5*ECON9V
      AL=AS+EC1OV-.5*ECON9V   *ECON(3,N)-(TL-TMV)*
     *     (ECON(3,N)+TEMP(1))+2.*TEMP(1)*TMV*((ALF*XX+1.)*
     *     ALOG(ALF*XX+1.)-(ALF+1.)*ALOG(ALF+1.))/ALF
      P(J)=FM*PV+(1.0-FM)*PL+DFMOV*(AL-AV-ALV1+AVV1)
      T(J)=TL
C
  100 E(J)=1.E+12*E(J)
      P(J)=1.E+12*P(J)
      RETURN
      END
```

APPENDIX C

LISTING OF DATA GENERATION ROUTINES

```
      SUBROUTINE DATGEN
C
      COMMON AMASS(10),DELTMI(10),DELTMN(10),MATBND(10),MATLID(10),
     .       RATIO(10),NMTRLS
      COMMON VISCOL(10),VISCOQ(10),COURST,DELTIM,MAXCYL,MODE,NRESRT,TMAX
      COMMON IPLATE,UZERO
      COMMON ALPHA(81),AMU(11),BBTEMP(2),CONVRG,ENERGY(2),MAXPAS,NALPHA,
     .       NFLUD(10),NPE(10),NSCTT(10),SSTART(2),SSTOP(2),NUNIT1,
     .       NUNIT2,NUNIT3,NUNIT4,NFIT(10),NEDGE,NINC,NKFILT,NFUNCT
      COMMON STIME1,STIME2,ENRGY,WIDTH
      COMMON IOUNIT(6)
      COMMON NCYEDT(20),TEDIT(20),NABS(5),NORD(5),IZPLOT(5),LPLOT(5),
     .       IPDT,MOMENT,NDUMP,NFEDIT,NPRINT,TPRINT,NSEDIT
      COMMON ICUTL,ICUTR,IADDL,IADDR,IDDEN,DHZ1,DRATIO,ADDMAS,DUM1
      COMMON IVZONE,VWIDTH
      COMMON DELTAM(1000),DISCPT(12),MERROR(2),ITEMP(25),MZONE(10,4),
     .       TEMP(25),DTAVG,DTN,DTNP1,ICOURN,JSAVE,MAPFLG,MAXZ,MAXZP1,
     .       NCYCLE,NSAVE,PDTPOS,PDTNEG,TIME
      COMMON C(1000),E(1000),HRATE(1000,2),IBFLAG(1000),IVFLAG(1000),
     .       OLDRHO(1000),P(1000),Q(1000),RHO(1000),S(1000),SD(1000),
     .       U(1000),X(1000),BLANK(39)
C
      COMMON /EQST/ ESTCON(30,30)
      COMMON /TEM/ T(1000)
      COMMON /TSAVE/ TOLDJ,EOLDJ
      DIMENSION TMP(20),VMX(20),VMN(20),EVMX(20),EVMN(20),PRES(20)
C
C     *** CALCULATION OF CRITICAL POINT ***
C
      JAA=11
      JAB=JAA+1
      AJAA=JAA
      NK=9
      NK1=NK-1
      NK2=NK-2
      NK3=NK-3
      N=NSAVE
      JSAVE=1
      JS=JSAVE
      VOS=1./ESTCON(1,N)
      TMO=ESTCON(21,N)
      DELT=2.*TMO
      TJS=DELT
      TOLDJ=TJS
      DELV=3.*VOS/20.
      VIN=VOS
      VCEST=4.5*VOS
      IR=1
      IT=1
  112 IT=IT+1
      RHO(JS)=1./VIN
      VJS=VIN
```

```
      CALL ET (VJS,TJS,EJS)
      E(JS)=EJS
      CALL EOS3
      P1=P(JS)
      JVC=(VCEST-VJS)/DELV
      DO 110 J=1,JVC
      VJS=VJS+DELV
      RHO(JS)=1./VJS
      CALL ET (VJS,TJS,EJS)
      E(JS)=EJS
      CALL EOS3
      P2=P(JS)
      IF((P2-P1)/DELV  .GE. 0.) GO TO 111
  110 P1=P2
      IR=IR+1
      IF(IR-2 .GT. 0 ) GO TO 123
      DELV=0.7*DELV
      GO TO 112
  123 DELT=.5*DELT
      TJS=TJS-DELT
      TOLDJ=TJS
      IR=1
      GO TO 112
  111 IF(IT-100 .GE. 0 ) GO TO 115
      TJS=TJS+.5*DELT
      TOLDJ=TJS
      VIN=VJS-2.*DELV
      GO TO 112
  115 TC=TJS
      VC=VJS
      CALL ET (VJS,TJS,EJS)
      ECC=EJS
      PC=P2
      PRINT 200,TC,VC,PC,ECC
C
C     *** COEXISTENCE CALCULATION ***
C
      DO 100 J=2,JAB
      AJ=J-1
      TJS=TC-AJ*(TC-TMO)/AJAA
      TOLDJ=TJS
      DELRHO=.01*ESTCON(1,N)
      RHO(JS)=0.
      P1=0.
      K1=1
      DO 20 K=1,100
      RHO(JS)=RHO(JS)+DELRHO
      VJS=1./RHO(JS)
      CALL ET (VJS,TJS,EJS)
      E(JS)=EJS
      CALL EOS3
      P2=P(JS)
      IF((P2 .LE. P1) .AND. (K1 .EQ. 2)) GO TO 20
      IF(P2 .GT. P1) GO TO 12
```

```
      PMAX=P1
      K1=2
      GO TO 20
   12 IF(K1 .EQ. 1) GO TO 20
      PMIN=P2
      GO TO 16
   20 P1=P2
   16 PEQ=.5*(PMAX+PMIN)
      IF(PEQ .GT. 0.) GO TO 22
      PEQ=.5*PMAX
   22 DO 25 KIT=1,50
      DO 300 K=1,NK2
      DO 400 L=1,9
      AL=L
      VJS=(10.**(NK-K))/AL
      RHO(J)=1./VJS
      CALL ET (VJS,TJS,EJS)
      E(JS)=EJS
      CALL EOS3
      P1=P(JS)
      IF(P1 .GE. PEQ) GO TO 41
  400 CONTINUE
  300 CONTINUE
      K=NK1
      DO 45 L=10,2500
      AL=L
      VJS=100./AL
      RHO(JS)=1./VJS
      CALL ET (VJS,TJS,EJS)
      E(JS)=EJS
      CALL EOS3
      P1=P(JS)
      IF(P1 .GE. PEQ) GO TO 41
   45 CONTINUE
   41 RHOMIN=RHO(JS)
      SUM2=0.
      IN=1
      IF(K .GT. NK3) GO TO 53
      DO 55 KK=K,NK3
      DELRHO=1./(10.**(NK-KK))
      DO 60 LL=L,10
      AL=LL
      RHO(JS)=AL*DELRHO
      VJS=1./RHO(JS)
      CALL ET (VJS,TJS,EJS)
      E(JS)=EJS
      CALL EOS3
      P1=P(JS)
      F=P1-PEQ
      SUM2=SUM2+F*DELRHO/RHO(JS)**2
      IF(F .LE. 0.) IN=2
   60 CONTINUE
   55 L=1
   53 DO 65 LL=L,2500
```

```
      DELRHO=.01
      AL=LL
      RHO(JS)=AL/100.
      VJS=1./RHO(JS)
      CALL ET (VJS,TJS,EJS)
      E(JS)=EJS
      CALL EOS3
      P1=P(JS)
      F=P1-PEQ
      SUM2=SUM2+F*DELRHO/RHO(JS)**2
      IF(IN .EQ. 2) GO TO 64
      IF(F .GE. 0.) GO TO 65
      IN=2
   64 IF(F .GE. 0.) GO TO 62
   65 CONTINUE
   62 RHOMAX=RHO(JS)
      IF(KIT .GE. 2) GO TO 68
      PEQ1=PEQ
      IF(SUM2 .LT. 0.) GO TO 72
      PEQ2=PEQ1+.1*(PMAX-PEQ1)
   71 PEQ=PEQ2
      SUM1=SUM2
      GO TO 25
   72 IF(PMIN .LE. 0.) PMIN=0.
      PEQ2=PEQ1-.1*(PEQ1-PMIN)
      GO TO 71
   68 IF (ABS(SUM1-SUM2)-1.E-6 .LE. 0.) GO TO 69
      PEQ3=(SUM2*PEQ1/SUM1-PEQ2)/(SUM2/SUM1-1.)
      IF(PEQ3 .LT. 0.) PEQ3=.5*PEQ2
      PEQ=PEQ3
      PEQ1=PEQ2
      PEQ2=PEQ3
      SUM1=SUM2
   25 CONTINUE
   69 VMN(J)=1./RHOMAX
      VM=VMN(J)
      VMX(J)=1./RHOMIN
      VX=VMX(J)
      PRES(J)=PEQ
      TMP(J)=TJS
      CALL ET(VM,TJS,EJS)
      EVMN(J)=EJS
      EM=EVMN(J)
      CALL ET(VX,TJS,EJS)
      EVMX(J)=EJS
      EX=EVMX(J)
      IF(PEQ-1.E-5 .LE. 0.) GO TO 9
  100 PRINT 500,TJS,VM,VX,EM,EX,PEQ
      J=JAB
    9 JMAX=J
      PRINT 500,TJS,VM,VX,EM,EX,PEQ
      VMX(1)=VC
      VMN(1)=VC
      EVMX(1)=ECC
```

```
      EVMN(I)=ECC
      PRES(I)=PC
      TMP(I)=TC
  200 FORMAT(5X,5HTC = ,E10.5,5X,5HVC = ,E10.5,5X,5HPC = ,E10.5,
     25X,5HEC = ,E10.5,///)
  500 FORMAT(5X,6HTMP = ,E10.5,5X,6HVMN = ,E10.5,5X,6HVMX = ,E10.5,5X,
     27HEVMN = ,E10.5,5X,7HEVMX = ,E10.5,5X,7HPRES = ,E10.5,/)
      RETURN
      END
```

```
      SUBROUTINE ENCALC
C
      COMMON AMASS(10),DELTMI(10),DELTMN(10),MATBND(10),MATLID(10),
     .       RATIO(10),NMTRLS
      COMMON VISCOL(10),VISCOU(10),COURST,DELTIM,MAXCYL,MODE,NRESRT,TMAX
      COMMON IPLATE,UZERO
      COMMON ALPHA(81),AMU(11),BBTEMP(2),CONVRG,ENERGY(2),MAXPAS,NALPHA,
     .       NFLUO(10),NPE(10),NSCTT(10),SSTART(2),SSTOP(2),NUNIT1,
     .       NUNIT2,NUNIT3,NUNIT4,NFIT(10),NEDGE,NINC,NKFILT,NFUNCT
      COMMON STIME1,STIME2,ENRGY,WIDTH
      COMMON IOUNIT(6)
      COMMON NCYEDT(20),TEDIT(20),NABS(5),NORD(5),IZPLOT(5),LPLOT(5),
     .       IPDT,MOMENT,NDUMP,NFEDIT,NPRINT,TPRINT,NSEDIT
      COMMON ICUTL,ICUTR,IADOL,IADOR,IODEN,DMZ1,ORATIO,ADDMAS,DUM1
      COMMON IVZONE,VWIDTH
      COMMON DELTAM(1000),DISCPT(12),MERROR(2),ITEMP(25),MZONE(10,4),
     .       TEMP(25),DTAVG,DTN,DTNP1,ICOURN,JSAVE,MAPFLG,MAXZ,MAXZP1,
     .       NCYCLE,NSAVE,POTPOS,POTNEG,TIME
      COMMON C(1000),E(1000),HRATE(1000,2),IBFLAG(1000),IVFLAG(1000),
     .       OLDRHO(1000),P(1000),Q(1000),RHO(1000),S(1000),SD(1000),
     .       U(1000),X(1000),BLANK(39)
C
      COMMON /CEDIT/ DAMAGE(1000),NSPALL(10),SKAPPA(10),SLAMDA(10),
     .       SINITL(10),SFINAL(10),ICOMBZ,ISPALL
C
      COMMON /EQST/ ESTCON(30,30)
C
      COMMON /TEM/ T(1000)
C
      COMMON /TSAVE/ TOLDJ,EOLDJ
C
      SDT1=0.
      SDT2=0.
      SMASS=0.
      FRAC=0.
      FRAC1=1.
      FRAC2=1.
C
C     *** CALCULATE SOURCE TIME STEP ***
C
      IF (MODE .EQ. 1) GO TO 20
      TEMP(1)=TIME-DTNP1
      IF (TEMP(1) .GE. SSTOP(1)) GO TO 10
      IF (TIME .LE. SSTART(1)) GO TO 10
      SDT1=DTNP1
      IF (TIME .GT. SSTOP(1) .AND. TEMP(1) .LT. SSTOP(1)) SDT1=SSTOP(1)-
     .       TEMP(1)
      IF (TIME .GT. SSTART(1) .AND. TEMP(1) .LT. SSTART(1)) SDT1=TIME-
     .       SSTART(1)
   10 IF (TEMP(1) .GE. SSTOP(2)) GO TO 20
      IF (TIME .LE. SSTART(2)) GO TO 20
      SDT2=DTNP1
      IF (TIME .GT. SSTOP(2) .AND. TEMP(1) .LT. SSTOP(2)) SDT2=SSTOP(2)-
     .       TEMP(1)
```

```
      IF (TIME .GT. SSTART(2) .AND. TEMP(1) .LT. SSTART(2)) SOT2=TIME-
     *          SSTART(2)
C
C     *** CALCULATE INTERNAL ENERGY ***
C
   20 M=1
      N=MATLID(M)
      IDONE=0
      IEOS=ESTCON(30,N)
      IF ((MODE .NE. 0 .OR. (MODE .EQ. 0 .AND. NMTRLS .EQ. 1))
     *         .AND. TIME-DTNP1 .GE. AMAX1(SSTOP(1),SSTOP(2))) IDONE=1
C
C     *** MAIN DO LOOP FOR CALCULATING EXTERNAL HEAT SOURCES, INTERNAL
C         ENERGY, DEVIATORIC STRESS COMPONENT, ARTIFICIAL VISCOSITY
C         COMPONENT, PRESSURE, AND STRESS. ***
C
      IF (NFUNCT .NE. 2) GO TO 30
      FRAC1=BOUND(TIME,1)
      FRAC2=BOUND(TIME,2)
   30 DO 160 J=1,MAXZ
      IF (J .LT. MATBNO(M)) GO TO 40
      M=M+1
      N=MATLID(M)
      IEOS=ESTCON(30,N)
   40 IF (ABS(U(J)) .GT. 0.) GO TO 60
      IF (IDONE .EQ. 0) GO TO 60
      J1=J
      DO 50 K=J1,MAXZ
      IF (ABS(U(K)) .GT. 0.) GO TO 60
   50 CONTINUE
      GO TO 170
   60 IF (IBFLAG(J) .EQ. 1 .OR. IBFLAG(J) .EQ. 3) GO TO 160
      NSAVE=N
      JSAVE=J
      EADD=0.
      IF (MODE) 70,80,90
   70 IF (IDONE .EQ. 1 .AND. NCYCLE .NE. 1) GO TO 90
      SMASS=SMASS+DELTAM(J)
C
C           CALCULATE HEAT ADDITION FROM ELECTRON BEAM SOURCE
C
      CALL TBEAM (SMASS,SOT1,FRAC)
      EADD=FRAC*HRATE(J,1)
      GO TO 90
C
C           CALCULATE HEAT ADDITION FROM RADIATION DEPOSITION SOURCES
C
   80 EADD=SOT1*HRATE(J,1)*FRAC1+SOT2*HRATE(J,2)*FRAC2
   90 DU=U(J+1)-U(J)
      ITER=0
      DV=DU*DTNP1/DELTAM(J)
      E(J)=AMAX1(E(J)+EADD-.5*S(J)*DV,0.)
C
C           CALCULATE DEVIATORIC STRESS COMPONENT AND ARTIFICIAL
```

```
C          VISCOSITY PRESSURE COMPONENT
C
      IF (ESTCON(8,N) .GT. 0.) CALL STRESS
      IF (ESTCON(8,N) .LT. 0.) CALL STRES1
      Q(J)=QFUNCT(M)
C
C          CALCULATE PRESSURE, STRESS, AND INTERNAL ENERGY
C
      E(J)=AMAX1(E(J)-(.5*SD(J)+Q(J))*DV,0.)
C
C     *** FOR DATGEN RUNS, REMOVE C FROM THE NEXT THREE CARDS ***
C
C     E(J)=0.
C     CALL DATGEN
C     CALL EXIT
C
      GO TO (110,100,100,110), IEOS
  100 HOLDP=P(J)
      E(J)=AMAX1(E(J)-.5*P(J)*DV,0.)
  110 CALL EOS
      S(J)=P(J)+SD(J)
      GO TO (120,130,130,120), IEOS
  120 E(J)=AMAX1(E(J)-.5*P(J)*DV,0.)
      GO TO 140
  130 EI=AMAX1(E(J)-.5*(P(J)-HOLDP)*DV,0.)
      IF (ABS((EI-E(J))/EI) .LT. 5.E-3) GO TO 140
      ITER=ITER+1
C
C     *******************************************************************
C
C                                ERROR EXIT
C
C          ERROR 1 - ENERGY ITERATION HAS FAILED TO CONVERGE
C
      IF (ITER .GE. 10) CALL SPRINT (6HENCALC,6HERROR1)
C
C     *******************************************************************
C
      E(J)=EI
      HOLDP=P(J)
      GO TO 110
C
  140 CONTINUE
C
C         SET MOMENTUM EDITING FLAGS
C
      TEMP(1)=TIME-DTNP1
      IF (TEMP(1) .GE. SSTOP(1) .AND. TEMP(1) .GE. SSTOP(2)) GO TO 150
      IF (E(J) .GE. ESTCON(10,N)) MZONE(M,1)=J
      IF (E(J) .GE. ESTCON(11,N)) MZONE(M,2)=J
      IF (E(J) .GE. ESTCON(12,N)) MZONE(M,3)=J
      IF (E(J) .GE. ESTCON(13,N)) MZONE(M,4)=J
C
C          CHECK FOR SPALLATION
```

```
C                                                                       ENC1520
  150 IF (ISPALL .NE. 0) CALL SPALL                                     ENC1530
  160 CONTINUE                                                          ENC1540
  170 RETURN                                                            ENC1550
      END                                                               ENC1560
```

```
      SUBROUTINE ET (VJS,TJS,EJS)
C                                                                       ESC  20
      COMMON AMASS(10),DELTMI(10),DELTMN(10),MATBND(10),MATLID(10),     ESC  30
     *       RATIO(10),NMTRLS                                           ESC  40
      COMMON VISCOL(10),VISCOQ(10),COURST,DELTIM,MAXCYL,MODE,NRESRT,TMAX ESC  50
      COMMON IPLATE,UZERO                                               ESC  60
      COMMON ALPHA(8),AMU(1),BBTEMP(2),CONVRG,ENERGY(2),MAXPAS,NALPHA,  ESC  70
     *       NFLUO(10),NPE(10),NSCTT(10),SSTART(2),SSTOP(2),NUNIT1,     ESC  80
     *       NUNIT2,NUNIT3,NUNIT4,NFIT(10),NEDGE,NINC,NKFILT,NFUNCT     ESC  90
      COMMON STIME1,STIME2,ENRGY,WIDTH                                  ESC 100
      COMMON IOUNIT(6)                                                  ESC 110
      COMMON NCYEDT(20),TEDIT(20),NABS(5),NORD(5),IZPLOT(5),LPLOT(5),   ESC 120
     *       IPOT,MOMENT,NDUMP,NFEDIT,NPRINT,TPRINT,NSEDIT              ESC 130
      COMMON ICUTL,ICUTR,IADDL,IADDR,IODEN,OMZ1,DRATIO,ADDMAS,DUM1      ESC 140
      COMMON IVZONE,VWIDTH                                              ESC 150
      COMMON DELTAM(1000),DISCPT(12),NERROR(2),ITEMP(25),MZONE(10,4),   ESC 160
     *       TEMP(25),DTAVG,DTN,DTNP1,ICOURN,JSAVE,MAPFLG,MAXZ,MAXZP1,  ESC 170
     *       NCYCLE,NSAVE,PDTPOS,PDTNEG,TIME                            ESC 180
      COMMON C(1000),E(1000),HRATE(1000,2),IBFLAG(1000),IVFLAG(1000),   ESC 190
     *       OLDRHO(1000),P(1000),Q(1000),RHO(1000),S(1000),SD(1000),   ESC 200
     *       U(1000),X(1000),BLANK(39)                                  ESC 210
C                                                                       ESC 220
      COMMON /EQST/ ESTCON(30,30)                                       ESC 230
C                                                                       ESC 240
      COMMON /GRAY/ TMP(20,30),VMX(20,30),VMN(20,30),EVMX(20,30),
     *   EVMN(20,30),PRES(20,30)
C
      DATA GAMMAF,ALF/1.0556,.1/
C
      DATA BOLTZ,AVNO,PI/1.38E-16,6.02E23,3.1416/
C
C
      COMMON /EC/ ECON(20,30)
C                                                                       ESC 260
      J=JSAVE                                                           ESC 370
      N=NSAVE                                                           ESC 380
      RHO(J)=1./VJS
      TOLD=TJS
      IF (ECON(1,N) .GT. 0.) GO TO 33                                   ESC 390
C                                                                       ESC 400
C     *** INITIALIZATION OF EQUATION OF STATE CONSTANTS ***             ESC 410
C                                                                       ESC 420
      ECON(1,N)=1./ESTCON(1,N)                                          ESC 430
      ECON(2,N)=ESTCON(20,N)/ESTCON(24,N)                               ESC 440
      ECON(3,N)=ESTCON(29,N)/ESTCON(24,N)                               ESC 450
      ECON(4,N)=1.160E-5/ESTCON(24,N)
      ECON(5,N)=8.134E-5/ESTCON(24,N)                                   ESC 470
      ECON(7,N)=4.5E4*ECON(2,N)*ESTCON(1,N)*(ESTCON(17,N)-ESTCON(19,N)) ESC 490
      IF (ESTCON(23,N) .GE. 0.) ESTCON(23,N)=-900.*(8.134E-5*50.*       ESC 500
     *      ESTCON(20,N))/ESTCON(24,N)                                  ESC 510
      ECON(12,N)=1.-ESTCON(1,N)*ESTCON(14,N)                           EXV1
      ECON(15,N)=(ALF+1.0)*ALOG(ALF+1.0)
      TEMP(1)=ESTCON(17,N)-1.333
      TEMP(2)=ESTCON(21,N)/(1.0-ECON(12,N))**2
```

```
      TEMP(3)=1.+ECON(12,N)*(2.*TEMP(1)+ECON(12,N)*(TEMP(1)*
     .     (2.*ESTCON(17,N)-1.667)-ESTCON(18,N)))
      ECON(8,N)=TEMP(2)*TEMP(3)                                          TMV1
      TEMP(4)=2.*(ECON(12,N)*ESTCON(15,N)-ESTCON(17,N)+.3333)
      TEMP(5)=1.2*(1.-ECON(12,N))*1.E-12*ESTCON(6,N)**2
      ECON(9,N)=ECON(3,N)*(TEMP(4)*TEMP(2)*TEMP(3))**2/TEMP(5)           T15V1
      TC=ESTCON(28,N)
      VB=ESTCON(26,N)
      SIGMA=(3.*ESTCON(24,N)*VB/(PI*AVNO*4.))**.33333333
      DT=(6.*ESTCON(24,N)*VB/(PI*AVNO))**.33333333
      EPS=BOLTZ*TC*(DT/(GAMMAF*SIGMA))**12
      ECON(6,N)=PI*AVNO*(((GAMMAF*SIGMA*(EPS/BOLTZ)**.08333333)**3)/
     .     (6.3*ESTCON(24,N))
      ECON(10,N)=.143*ECON(5,N)*.5*ECON(9,N)
      TEMP(1)=ESTCON(16,N)*ECON(12,N)
      TEMP(2)=.5*(1.E-6*ESTCON(6,N)*ECON(12,N))**2/(1.-TEMP(1))
      TEMP(3)=1.+TEMP(1)*(1.+.5*TEMP(1)*(1.-ESTCON(17,N)/ESTCON(16,N)))
     .     /3.
      ECON(11,N)=TEMP(2)*TEMP(3)+ESTCON(23,N)*(1.+ESTCON(17,N)*          T11V1
     .     ECON(12,N))+ESTCON(22,N)
      TEMP(25)=TEMP(2)*ECON(6,N)
      ECON(17,N)=ESTCON(27,N)/ESTCON(24,N)**2                            ESC 750
      IF (ABS(TMP(1,N)) .LE. 0.) GO TO 22
      DO 20 I1=3,20
      JMAX=I1-1
      IF (ABS(TMP(I1,N)) .LE. 0.) GO TO 21
   20 CONTINUE
   21 ECON(16,N)=VMN(JMAX,N)-PRES(JMAX,N)*(VMN(JMAX-1,N)-VMN(JMAX,N))/   (VMNO)
     .          (PRES(JMAX-1,N)-PRES(JMAX,N))
   22 ECON(14,N)=2.*ESTCON(21,N)
      ECON(18,N)=(.1*ECON(6,N)/(ECON(14,N)**.25)                         (VBO)
      ECON(19,N)=2.*ECON(18,N)/ECON(14,N)-2.25*ECON(6,N)/
     .          (ECON(14,N)**1.25)                                       (C2)
      ECON(20,N)=1.25*ECON(6,N)/(ECON(14,N)**2.25)-ECON(18,N)/
     .          (ECON(14,N)**2)                                          (C3)
      PRINT 25, (ECON(I,N),I=1,20)
   25 FORMAT (//,7H  ECONS,//,4(4X,1P5E14.6,/),//)
C                                                                        ESC 930
   30 RNU=ESTCON(1,N)/RHO(J)
      EX=1.-RNU                                                          ESC 960
C                                                                        ESC 970
      TEMP(1)=ESTCON(16,N)*EX                                            ESC 990
      TEMP(2)=.5*(1.E-6*ESTCON(6,N)*EX)**2/(1.-TEMP(1))                  ESC1000
      TEMP(3)=1.+TEMP(1)*(1.+.5*TEMP(1)*(1.-ESTCON(17,N)/ESTCON(16,N)))/ ESC1010
     .          3.                                                       ESC1020
      TEMP(11)=TEMP(2)*TEMP(3)+ESTCON(23,N)*(1.+ESTCON(17,N)*EX)+        ESC1030
     .          ESTCON(22,N)                                             ESC1040
      IF (EX .GT. 0.) GO TO 40                                           ESC1050
      TEMP(1)=ESTCON(17,N)-1.3333                                        ESC1060
      TEMP(2)=ESTCON(21,N)/(1.-EX)**2                                    ESC1070
      TEMP(3)=1.+EX*(2.*TEMP(1)+EX*(TEMP(1)*(2.*ESTCON(17,N)-1.6667)-    ESC1080
     .          ESTCON(18,N)))                                           ESC1090
      GO TO 50                                                           ESC1100
   40 TEMP(1)=2.*(ESTCON(17,N)-.3333)                                    ESC1110
```

```
      TEMP(2(=ESTCON(21,N(                                              ESC((20
      TEMP(3(=1.+EX*(TEMP(1)+EX*((ESTCON(17,N(-.33331*(TEMP(11+1.(-     ESC()30
     *        ESTCON(18,N)))                                            ESC1)40
   50 TEMP(12(=TEMP(2)*TEMP(3)                                          ESC((5C
      TEMP(14(=2.*(EX*ESTCON(18,N1-ESTCON((7,N(+.3333)                  ESC()6C
      TEMP(1)=1.2*((.-EX)*(.E-(2*ESTCON(6,N(**2                         ESC)(70
      TEMP(2(=1.                                                        ESC()80
      IF (EX .GT. 0.( TEMP(2(=1.+EX*(4.*ESTCON()6.N(-(.)                ESC))9C
      TEMP(15(=ECON(3,N(*(TEMP(14)*TEMP()2)(**2/(TEMP(1(*TEMP(211       ESC)20C
      TEMP(11=TEMP((2)-.5*TEMP(15(                                      ESC)2(0
      TM(=TEMP(1(
      V=(./RHO(J)
      IF (V .GT. V(( GO TO 70
C                                                                       ESC(230
      IF (TOLD .GT. TM1( GO TO 60
C                                                                       ESC1320
C     ***  SOL)D REGION ***                                             ESC)330
C                                                                       ESC(340
      (VFLAG(J)=30                                                      ESC)350
      TEMP(()=3.*ECON(5,N)                                              ESC(3o0
      EJS=TEMP(11(+TOLD*(.5*ECON(2,N(*TOLD+TEMP(1))
      GO TO (C0
C                                                                       ESC1420
   60 TEMP(1(=TEMP(12)+.5*TEMP(15(                                      ESC)43C
      TM2=TEMP(()
      (F (TOLD .GT. TM2) GO TO 70
C                                                                       ESC(470
C     *** MELT REG(ON ***                                               ESC(480
C                                                                       ESC(49C
      (VFLAG(J)=3(                                                      ESC150C
      TEMP(1)=(TOLD-TM)1/(TM2-TM1)
      TEMP(2(=ECON(3,N)-ECON(4,N)                                       ESC(520
      TEMP(3)=3.*ECON(5,N(+TEMP(1(*TEMP(2)                              ESC(530
      TEMP(5)=TEMP(()**2
      EJS=.5*ECON(2,N(*TOLD**2+TEMP(3(*TOLD+TEMP()))-TEMP(5)*TEMP(2(*
     *        .5*TEMP(151
      GO TO 1C0                                                         ESC(620
C                                                                       ESC1630
   70 TEMP(1)=1.5*ECON(5,N1
      TEMP(2(=ESTCON((,N)/(1.0-EX)
      TEMP(6(=.)43*ECON(5,N)*.5*TEMP((5(
      TEMP(101=2.?*TEMP(1)
      TEMP(131=TEMP(((/ALF
      TEMP(221=.5*ECON(2,N1*TEMP((2)
      V1=ESTCON(14,N(
      V2=ESTCON(15,N)
      V=(.0/RHO(J(
      IF (V .LE. V() GO TO 74
      IF (V .GE. V2( GO TO 90
C
C     *** JOIN REG(ON ***
C
      IVFLAG(J)=33
      TEMP(3)=2.C*ECON(5,N(*TEMP(2(
```

```
      TEMP(4)=-TEMP(2)*ECON(17,N)
      TEMP(25)=TEMP(2)*ECON(6,N)
      FM=.5*(COS(PI*(V2-V)/(V2-V1))+1.0)
      XV=1.0-ESTCON(1,N)*V
      T17=ESTCON(17,N)-1.333
      T2V=ESTCON(21,N)/(1.0-XV)**2
      T3V=1.0+XV*(2.*T17+XV*(T17*(2.*ESTCON(17,N)-1.6667)-ESTCON(18,N)))
      TMV=T2V*T3V
      T4V=2.*(XV*ESTCON(18,N)-ESTCON(17,N)+.3333)
      T5V=1.2*XV*1.E-12*ESTCON(6,N)**2
      ECON9V=ECON(3,N)*((T2V*T4V+T3V)**2)/T5V
      T1V=ESTCON(16,N)*XV
      T2V=.5*(1.E-6*ESTCON(6,N)*XV)**2/(1.0-T1V)
      T3V=1.+T1V*(1.+.5*T1V*(1.-ESTCON(17,N)/ESTCON(16,N)))/3.0
      EOV=T2V*T3V+ESTCON(23,N)*(1.+ESTCON(17,N)*XV)+ESTCON(22,N)
      IF (TOLD .LT.0.) TOLD=300.
      TJ=TOLD
   73 IF (TJ .GT. ECON(14,N)) GO TO 731
      VB=ECON(18,N)-TJ*(ECON(19,N)+ECON(20,N)*TJ)
      TEMP(7)=-ECON(19,N)-2.*ECON(20,N)*TJ
      TEMP(8)=-2.*ECON(20,N)
      GO TO 732
  731 VB=ECON(6,N)/(TJ**.25)
      TEMP(7)=-.25*ECON(6,N)/(TJ**1.25)
      TEMP(8)=5.*ECON(6,N)/(16.*TJ**2.25)
  732 ETA=VB/V
      TEMP(5)=(2.0-ETA)/((1.0-ETA)**3)
      EV=TEMP(1)*TJ-2.*ECON(5,N)*TJ*TJ*TEMP(5)*TEMP(7)/V + ESTCON(10,N)
     .    *1.E-12+TEMP(4)
      XX=TJ/TMV
      EL=EOV+TEMP(10)*TJ+.5*ECON(2,N)*TJ**2+ECON(3,N)*TMV+ECON(4,N)*.5*
     .  ECON9V+TEMP(13)*TMV*(ALOG(ALF*XX+1.0)-ECON(15,N)-ALF*(XX-1.0))
      EJS=FM*EV+(1.-FM)*EL
      GO TO 100
C
C     *** LIQUID REGION ***
C
   74 IVFLAG(J)=32
      XX=TOLD/TEMP(12)
      TEMP(23)=XX*(TEMP(10)+XX*TEMP(22))+TEMP(13)*(ALOG(ALF*XX+1.)
     .      -ALF*XX)
      EJS=TEMP(12)*(ECON(3,N)+TEMP(13)*(ALF-ECON(15,N))+TEMP(23))+
     .     TEMP(11)+TEMP(6)
      GO TO 100
C
C     *** VAPOR REGION ***
C
   90 IVFLAG(J)=35
      TEMP(4)=-TEMP(2)*ECON(17,N)
      TEMP(25)=TEMP(2)*ECON(6,N)
      TEMP(17)=ECON(5,N)*TEMP(25)
      TEMP(18)=.5*TEMP(17)*TEMP(25)
      TT=TOLD
   91 IF (TT .GT. ECON(14,N)) GO TO 911
```

```
      VB=ECON(18,N)-TT*(ECON(19,N)+ECON(20,N)*TT)
      TEMP(7)=-ECON(19,N)-2.*ECON(20,N)*TT
      TEMP(8)=-2.*ECON(20,N)
      GO TO 912
  911 VB=ECON(6,N)/(TT**.25)
      TEMP(7)=-.25*ECON(6,N)/(TT**1.25)
      TEMP(8)=5.*ECON(6,N)/(16.*TT**2.25)
  912 ETA=VB/V
      TEMP(5)=(2.0-ETA)/((1.0-ETA)**3)
      EV=TEMP(1)*TT-2.*ECON(5,N)*TT*TT*TEMP(5)*TEMP(7)/V + ESTCON(10,N)
     *    *1.E-12+TEMP(4)
      EJS=EV
C
  100 EJS=1.E+12*EJS
      RETURN                                                            ESC2250
      END                                                               ESC2260
```

APPENDIX D

SAMPLE CALCULATION

RIP generation and restart calculations taken from the Uranium study are presented here as a sample problem. It should be noted that in order to print out the temperature at each cycle, the subroutine MEDIT as listed in Reference 17 was modified in the following manner:

The line MED 390

PRINT 130, J, SMASS, X(J), RHO(J), Q(J), PT, P(J), E(J), C(J), was changed to

PRINT 130, J, SMASS, X(J), U(J), RHO(J), T(J), PT, P(J), E(J), C(J),

and the line MED 680

1HJ, 4X, 5HSMASS, 8X, 1HX, 10X, 1HU, 10X, 3HRHO, 8A, 1HQ, 9X, 3HS+Q, 9X, was changed to

1HJ, 4X, 5HSMASS, 8X, 1HX, 10X, 1HU, 10X, 3HRHO, 8X, 1HT, 9X, 3HS+Q, 9X,

D.1 RIP CYCLE 0

SUBROUTINE -CARDS- READS FREE-FORM DATA CARDS INTO BLANK AND NAMED COMMONS IDENTIFIED BY LETTERS AS FOLLOWS

B FOR BLANK COMMON, V FOR NAMED COMMON /EOST/, W FOR NAMED COMMON /BEAM/, X FOR NAMED COMMON /CEDIT/,

Y FOR NAMED COMMON /EOSTAB/, Z FOR NAMED COMMON /FUNCT/

```
B1329=12A
      TEST PROBLEM  -  GRAY  2                                              HOLLERITH CARD
B1=1.        (AMASS)
B11=4.E-3          (DELTMI)
B31=72             (MATBNO)
B41=103      (MATLIO)
B51=0.             (RATIO)
B61=1        (NMTRLS)
B84=0               (MAXCYL)
B88=0               (MODE)
B87=1.       (TMAX)
B182=10.          (BBTEMP)
B185=-200.        (ENERGY)
B219=0.         (SSTART)
B221=1.E-7      (SSTOP)
B240=2             (NFUNCT)
B245=5.-10.20   (IOUNIT)
B291=1,4.3        (NABS)
B296=18,16,18,16,18 (NORD)
B301=0,10,10,20,20   (IZPLOT)
B313=50            (NDUMP)
B315=1             (NPRINT)
V661=19.083969,400.,2.5400E5,200.,-1.E12,4.1.E12,220.,1.549,
      2.07,1.5,.66666667,13.0E-9,1710.,0.,0.,238.,1.0,067596,.025152,
     67.1,1.,9.637E-5,3.
V669=-1.E10      (SPALL)
V670=4.2.044E10
V674=.0564,.0733
V685=0.
V688=1.3043E4        (TC)
X1051=1.1
Z1=0.,1.,0.,0.        (FFUNCT)
Z41=0.,2.E-8,1.E-7,1.   (FTIME)
G441=1.2979E4,1.1955E4,1.0930E4,.99059E4,.88814E4,.78569E4,.68324E4,      (TMP)
      .58080E4,.47835E4,.37590E4
G1041=.20319,.41667,.67114,1.0870,1.8519,3.4483,7.1429,20.,50.,800.       (VMX)
G1641=.20319,.11765,.10040,.090334,.083333,.078247,.074349,.071736,       (VMN)
      .069735,.068776
G2241=2.2033E-2,2.4021E-2,2.4439E-2,2.4517E-2,2.4399E-2,2.4146E-2,        (EVMX)
      2.3785E-2,2.3360E-2,2.2869E-2,2.2364E-2
G2841=2.2033E-2,1.8171E-2,1.6365E-2,1.4899E-2,1.3611E-2,1.2465E-2,        (EVMN)
      1.1424E-2,1.0463E-2,9.3831E-3,8.4282E-3
G3441=8.2467E-3,5.8178E-3,3.8923E-3,2.4313E-3,1.3855E-3,6.9505E-4,        (PRES)
      2.8970E-4,9.1164E-5,1.7069E-5,2.4733E-6
END
```


PRECEDING PAGE BLANK-NOT FILMED

```
*****  NORMAL DATA READS WITHOUT ERRORS  *****

BBODYX   -1   0
   0        0.000
   0              1       92   1.000+00
   1              0        0   0.000
```

```
                    TEST PROBLEM  -  GRAY  2

     THIS CALCULATION USES THE BBODYX SPECTRUM (BBTEMP = 10.0 KEV, ENERGY = 8.360+09 ERGS /CM2).
     AND DASA CROSS SECTION DATA DATED  10/12/70

LAYER  1          MASS =  1.000+00 GM/CM2       NO. OF ZONES = 72

     FRACTIONAL WEIGHTS OF LAYER CONSTITUENTS

     U  = 1.000+00

     PHOTOELECTRIC, FLUORESCENT, AND SCATTERING EFFECTS ARE CALCULATED IN LAYER  1
```

ANGULAR GROUP BOUNDARIES (DEGREES)

.000	48.190	70.529	90.000	109.471	131.810	180.000

ENERGY GROUP BOUNDARIES (KEV)

.000	10.500	21.000	31.500	42.000	52.500	63.000
73.500	84.000	94.500	94.578	94.734	98.358	98.514
105.000	111.062	111.218	114.472	114.628	115.500	126.000
136.500	147.000	157.500	168.000	178.500	189.000	199.500
210.000						

INCIDENT SPECTRUM (NORMALIZED TO UNITY)

	ENERGY	FLUX	SFLUX		ENERGY	FLUX	SFLUX		ENERGY	FLUX	SFLUX
1	.20	8.09-06	4.08-07	21	37.00	1.98-02	5.40-01	41	94.00	1.08-03	9.85-01
2	.60	5.57-05	1.08-05	22	39.00	1.89-02	5.78-01	42	98.00	8.08-04	9.89-01
3	1.40	2.96-04	1.82-04	23	41.00	1.79-02	6.15-01	43	110.00	3.72-04	9.95-01
4	3.00	1.22-03	1.29-03	24	43.00	1.68-02	6.50-01	44	130.00	8.40-05	9.99-01
5	5.00	2.99-03	5.29-03	25	45.00	1.58-02	6.83-01	45	150.00	1.76-05	1.00+00
6	7.00	5.22-03	1.39-02	26	47.00	1.47-02	7.13-01	46	170.00	3.49-06	1.00+00
7	9.00	7.69-03	2.63-02	27	49.00	1.36-02	7.41-01	47	190.00	6.63-07	1.00+00
8	11.00	1.02-02	4.42-02	28	51.00	1.25-02	7.67-01	48	210.00	2.96-07	1.00+00
9	13.00	1.27-02	6.71-02	29	53.00	1.15-02	7.91-01				
10	15.00	1.49-02	9.48-02	30	55.00	1.05-02	8.13-01				
11	17.00	1.69-02	1.27-01	31	57.00	9.57-03	8.33-01				
12	19.00	1.86-02	1.62-01	32	59.00	8.69-03	8.52-01				
13	21.00	1.99-02	2.01-01	33	62.00	7.47-03	8.76-01				
14	23.00	2.09-02	2.42-01	34	66.00	6.04-03	9.03-01				
15	25.00	2.15-02	2.84-01	35	70.00	4.83-03	9.24-01				
16	27.00	2.18-02	3.27-01	36	74.00	3.82-03	9.42-01				
17	29.00	2.19-02	3.71-01	37	78.00	3.00-03	9.55-01				
18	31.00	2.16-02	4.15-01	38	82.00	2.39-03	9.66-01				
19	33.00	2.12-02	4.58-01	39	86.00	1.81-03	9.74-01				
20	35.00	2.06-02	4.99-01	40	90.00	1.37-03	9.80-01				

TOTAL FLUX = 8.360+09 (ERGS/CM2)

HEAT (ERGS/GM)

	NO.	MASS	INTERFACE	ZONE	NO.	MASS	INTERFACE	ZONE		NO.	MASS	INTERFACE	ZONE
* 1 *	1	0.00	4.28+11	3.06+11	26	1.46-01	8.02+09	7.67+09		51	4.55-01	9.36+08	8.96+08
	2	4.00-03	2.45+11	2.12+11	27	1.55-01	7.33+09	7.01+09		52	4.73-01	8.58+08	8.22+08
	3	8.12-03	1.84+11	1.64+11	28	1.64-01	6.70+09	6.41+09		53	4.91-01	7.87+08	7.54+08
	4	1.24-02	1.46+11	1.31+11	29	1.72-01	6.13+09	5.87+09		54	5.10-01	7.22+08	6.91+08
	5	1.67-02	1.18+11	1.06+11	30	1.82-01	5.62+09	5.38+09		55	5.30-01	6.61+08	6.33+08
	6	2.12-02	9.63+10	8.76+10	31	1.91-01	5.15+09	4.93+09		56	5.50-01	6.06+08	5.80+08
	7	2.59-02	7.97+10	7.30+10	32	2.01-01	4.72+09	4.52+09		57	5.70-01	5.55+08	5.31+08
	8	3.07-02	6.68+10	6.15+10	33	2.11-01	4.33+09	4.15+09		58	5.91-01	5.08+08	4.86+08
	9	3.56-02	5.64+10	5.21+10	34	2.21-01	3.97+09	3.81+09		59	6.13-01	4.65+08	4.44+08
	10	4.07-02	4.82+10	4.47+10	35	2.32-01	3.65+09	3.50+09		60	6.36-01	4.25+08	4.06+08
	11	4.59-02	4.15+10	3.86+10	36	2.43-01	3.35+09	3.21+09		61	6.59-01	3.88+08	3.71+08
	12	5.13-02	3.60+10	3.36+10	37	2.55-01	3.08+09	2.95+09		62	6.83-01	3.55+08	3.39+08
	13	5.69-02	3.14+10	2.95+10	38	2.66-01	2.83+09	2.71+09		63	7.08-01	3.24+08	3.10+08
	14	6.26-02	2.77+10	2.60+10	39	2.78-01	2.60+09	2.49+09		64	7.33-01	2.96+08	2.82+08
	15	6.85-02	2.45+10	2.31+10	40	2.91-01	2.39+09	2.29+09		65	7.60-01	2.70+08	2.57+08
	16	7.46-02	2.18+10	2.06+10	41	3.04-01	2.19+09	2.10+09		66	7.87-01	2.46+08	2.34+08
	17	8.08-02	1.95+10	1.84+10	42	3.17-01	2.01+09	1.93+09		67	8.14-01	2.24+08	2.13+08
	18	8.73-02	1.75+10	1.66+10	43	3.30-01	1.85+09	1.77+09		68	8.43-01	2.03+08	1.94+08
	19	9.39-02	1.57+10	1.49+10	44	3.44-01	1.70+09	1.63+09		69	8.73-01	1.85+08	1.76+08
	20	1.01-01	1.42+10	1.35+10	45	3.59-01	1.56+09	1.50+09		70	9.03-01	1.68+08	1.60+08
	21	1.08-01	1.28+10	1.22+10	46	3.74-01	1.43+09	1.38+09		71	9.34-01	1.52+08	1.45+08
	22	1.15-01	1.16+10	1.11+10	47	3.89-01	1.32+09	1.26+09		72	9.67-01	1.38+08	1.31+08
	23	1.23-01	1.06+10	1.01+10	48	4.05-01	1.21+09	1.16+09	* 2 *	73	1.00+00	1.24+08	0.00
	24	1.30-01	9.64+09	9.20+09	49	4.21-01	1.11+09	1.06+09					
	25	1.38-01	8.79+09	8.39+09	50	4.38-01	1.02+09	9.77+08					

SUMMARY (ERGS/CM2)

```
TOTAL ENERGY ABSORBED                           = 8.297+09
TRANSMITTED SECONDARY FLUX (COLLIMATED)         = 2.159+06
REFLECTED SECONDARY FLUX (COLLIMATED)           = 1.029+07
TRANSMITTED PRIMARY FLUX                        = 5.042+07
ENERGY ABSORBED IN FILTER                       = 0.000
UNDISTRIBUTED ENERGY                            = 1.592+03
SUM                                             = 8.360+09
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RIP GEOMETRY DESCRIPTION

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MODE    COURST      DTMPI       TMAX       MAXCYL  MAXZ  MAXZPI  NPRINT   TPRINT    NDUMP

  0   9.0000-01   8.2520-11   1.0000+00       0     72     73       1     0.0000      50

MATERIAL  1 ..........................................................

  AMASS      DELTMI      DELTMN      RATIO       MATBNO

1.000+00   4.000-03    3.328-02    1.030+00       73      ... ZONES   1 TO   72 ...

  RHO        UNUSED      UNUSED      UNUSED      UNUSED      C           AMU         YO

1.908+01   0.000       0.000       0.000       0.000       2.540+05    0.000       0.000

  SPALL      EVV         ELY         ELM         ESM         UNUSED      UNUSED      S

-1.000+10  2.044+10    2.044+10    2.044+10    2.044+10    5.640-02    7.330-02    1.549+00

  GAMMAD     A           GAMMAE      GE          TMO         EOM         EOO         AW

2.070+00   1.503+00    6.667-01    1.300-08    1.710+03    0.000       0.000       2.381+02

  VJ         VB          AY          THETA       DELS        EOSFLG      VISCOL      VISCOQ

0.000      2.515-02    6.710+01    1.309+04    9.637-05    3.000+00    2.500-01    1.600+00
```

RIP CYCLE 0

J	DELTAN	X	U	RHO	C	HRATE
1	4.00-03	0.00	0.00	1.91+01	2.54+05	3.06+18
2	4.12-03	2.10-04	0.00	1.91+01	2.54+05	2.12+18
3	4.25-03	4.26-04	0.00	1.91+01	2.54+05	1.64+18
4	4.37-03	6.48-04	0.00	1.91+01	2.54+05	1.31+18
5	4.51-03	8.77-04	0.00	1.91+01	2.54+05	1.06+18
6	4.64-03	1.11-03	0.00	1.91+01	2.54+05	8.76+17
7	4.78-03	1.36-03	0.00	1.91+01	2.54+05	7.30+17
8	4.93-03	1.61-03	0.00	1.91+01	2.54+05	6.18+17
9	5.08-03	1.87-03	0.00	1.91+01	2.54+05	5.21+17
10	5.23-03	2.13-03	0.00	1.91+01	2.54+05	4.47+17
11	5.39-03	2.41-03	0.00	1.91+01	2.54+05	3.86+17
12	5.55-03	2.69-03	0.00	1.91+01	2.54+05	3.36+17
13	5.72-03	2.98-03	0.00	1.91+01	2.54+05	2.95+17
14	5.90-03	3.28-03	0.00	1.91+01	2.54+05	2.60+17
15	6.07-03	3.59-03	0.00	1.91+01	2.54+05	2.31+17
16	6.26-03	3.91-03	0.00	1.91+01	2.54+05	2.06+17
17	6.45-03	4.23-03	0.00	1.91+01	2.54+05	1.84+17
18	6.64-03	4.57-03	0.00	1.91+01	2.54+05	1.66+17
19	6.84-03	4.92-03	0.00	1.91+01	2.54+05	1.49+17
20	7.05-03	5.28-03	0.00	1.91+01	2.54+05	1.35+17
21	7.27-03	5.65-03	0.00	1.91+01	2.54+05	1.22+17
22	7.49-03	6.03-03	0.00	1.91+01	2.54+05	1.11+17
23	7.71-03	6.42-03	0.00	1.91+01	2.54+05	1.01+17
24	7.95-03	6.83-03	0.00	1.91+01	2.54+05	9.20+16
25	8.19-03	7.24-03	0.00	1.91+01	2.54+05	8.39+16
26	8.43-03	7.67-03	0.00	1.91+01	2.54+05	7.67+16
27	8.69-03	8.11-03	0.00	1.91+01	2.54+05	7.01+16
28	8.95-03	8.57-03	0.00	1.91+01	2.54+05	6.41+16
29	9.22-03	9.04-03	0.00	1.91+01	2.54+05	5.87+16
30	9.50-03	9.52-03	0.00	1.91+01	2.54+05	5.38+16
31	9.79-03	1.00-02	0.00	1.91+01	2.54+05	4.93+16
32	1.01-02	1.05-02	0.00	1.91+01	2.54+05	4.52+16
33	1.04-02	1.11-02	0.00	1.91+01	2.54+05	4.15+16
34	1.07-02	1.16-02	0.00	1.91+01	2.54+05	3.81+16
35	1.10-02	1.22-02	0.00	1.91+01	2.54+05	3.50+16
36	1.14-02	1.27-02	0.00	1.91+01	2.54+05	3.21+16
37	1.17-02	1.33-02	0.00	1.91+01	2.54+05	2.95+16
38	1.21-02	1.40-02	0.00	1.91+01	2.54+05	2.71+16
39	1.24-02	1.46-02	0.00	1.91+01	2.54+05	2.49+16
40	1.28-02	1.52-02	0.00	1.91+01	2.54+05	2.29+16
41	1.32-02	1.59-02	0.00	1.91+01	2.54+05	2.10+16
42	1.36-02	1.66-02	0.00	1.91+01	2.54+05	1.93+16
43	1.40-02	1.73-02	0.00	1.91+01	2.54+05	1.77+16
44	1.44-02	1.80-02	0.00	1.91+01	2.54+05	1.63+16
45	1.49-02	1.88-02	0.00	1.91+01	2.54+05	1.50+16
46	1.53-02	1.96-02	0.00	1.91+01	2.54+05	1.38+16
47	1.58-02	2.04-02	0.00	1.91+01	2.54+05	1.26+16
48	1.63-02	2.12-02	0.00	1.91+01	2.54+05	1.16+16
49	1.68-02	2.21-02	0.00	1.91+01	2.54+05	1.06+16
50	1.73-02	2.29-02	0.00	1.91+01	2.54+05	9.77+15

J	DELTAN	X	U	RHO	C	HRATE
51	1.78-02	2.38-02	0.00	1.91+01	2.54+05	8.96+15
52	1.83-02	2.48-02	0.00	1.91+01	2.54+05	8.22+15
53	1.89-02	2.57-02	0.00	1.91+01	2.54+05	7.59+15
54	1.95-02	2.67-02	0.00	1.91+01	2.54+05	6.91+15
55	2.00-02	2.77-02	0.00	1.91+01	2.54+05	6.33+15
56	2.06-02	2.88-02	0.00	1.91+01	2.54+05	5.80+15
57	2.13-02	2.99-02	0.00	1.91+01	2.54+05	5.31+15
58	2.19-02	3.10-02	0.00	1.91+01	2.54+05	4.86+15
59	2.26-02	3.21-02	0.00	1.91+01	2.54+05	4.44+15
60	2.33-02	3.33-02	0.00	1.91+01	2.54+05	4.06+15
61	2.40-02	3.45-02	0.00	1.91+01	2.54+05	3.71+15
62	2.47-02	3.58-02	0.00	1.91+01	2.54+05	3.39+15
63	2.54-02	3.71-02	0.00	1.91+01	2.54+05	3.10+15
64	2.62-02	3.84-02	0.00	1.91+01	2.54+05	2.82+15
65	2.70-02	3.98-02	0.00	1.91+01	2.54+05	2.57+15
66	2.78-02	4.12-02	0.00	1.91+01	2.54+05	2.34+15
67	2.87-02	4.27-02	0.00	1.91+01	2.54+05	2.13+15
68	2.95-02	4.42-02	0.00	1.91+01	2.54+05	1.94+15
69	3.04-02	4.57-02	0.00	1.91+01	2.54+05	1.76+15
70	3.14-02	4.73-02	0.00	1.91+01	2.54+05	1.60+15
71	3.23-02	4.90-02	0.00	1.91+01	2.54+05	1.45+15
72	3.33-02	5.07-02	0.00	1.91+01	2.54+05	1.31+15
EXT		5.24-02	0.00			

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BLANK   COMMON FOR CYCLE NUMBER      0 WAS WRITTEN ON UNIT 20.

EQST    COMMON FOR CYCLE NUMBER      0 WAS WRITTEN ON UNIT 20.

CELIT   COMMON FOR CYCLE NUMBER      0 WAS WRITTEN ON UNIT 20.

FUNCT   COMMON FOR CYCLE NUMBER      0 WAS WRITTEN ON UNIT 20.

TEM     COMMON FOR CYCLE NUMBER      0 WAS WRITTEN ON UNIT 20.

GRAY    COMMON FOR CYCLE NUMBER      0 WAS WRITTEN ON UNIT 20.

ECONS

   5.240000-02    5.459891-11    4.047459-07    4.884502-08    3.416212-07
   2.687925-01    6.580001-05    1.312742+03    1.147395+02    2.802616-06
  -9.960588-05   -7.633579-02    0.000000       0.000000       1.048412+01
   0.000000       1.183597-03    0.000000       0.000000       0.000000
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TEST PROBLEM - GRAY 2 CYCLE NO. = 1 TIME = 8.25197-11

J	SMASS	X	U	RHO	T	S+Q	P	E	C	IV	IB	J
1	0.000	0.000	0.000	1.908+01	3.020+02	8.152+07	8.152+07	2.086+06	9.879+05	30	0	1
2	4.000-03	2.096-04	0.000	1.908+01	3.014+02	5.632+07	5.632+07	1.441+06	2.541+05	30	0	2
3	8.121-03	4.255-04	0.000	1.908+01	3.011+02	4.364+07	4.364+07	1.116+06	2.541+05	30	0	3
4	1.237-02	6.480-04	0.000	1.908+01	3.009+02	3.485+07	3.455+07	8.916+05	2.541+05	30	0	4
5	1.674-02	8.773-04	0.000	1.908+01	3.007+02	2.828+07	2.826+07	7.247+05	2.541+05	30	0	5
6	2.125-02	1.113-03	0.000	1.908+01	3.006+02	2.339+07	2.339+07	5.987+05	2.541+05	30	0	6
7	2.589-02	1.357-03	0.000	1.908+01	3.005+02	1.944+07	1.944+07	4.969+05	2.541+05	30	0	7
8	3.068-02	1.607-03	0.000	1.908+01	3.004+02	1.639+07	1.639+07	4.180+05	2.541+05	30	0	8
9	3.561-02	1.866-03	0.000	1.908+01	3.003+02	1.393+07	1.393+07	3.550+05	2.541+05	30	0	9
10	4.068-02	2.132-03	0.000	1.908+01	3.003+02	1.198+07	1.198+07	3.093+05	2.541+05	30	0	10
11	4.592-02	2.406-03	0.000	1.908+01	3.003+02	1.040+07	1.040+07	2.629+05	2.541+05	30	0	11
12	5.131-02	2.689-03	0.000	1.908+01	3.002+02	9.004+06	9.004+06	2.290+05	2.541+05	30	0	12
13	5.686-02	2.980-03	0.000	1.908+01	3.002+02	7.957+06	7.957+06	2.008+05	2.541+05	30	0	13
14	6.258-02	3.279-03	0.000	1.908+01	3.002+02	7.034+06	7.034+06	1.772+05	2.541+05	30	0	14
15	6.848-02	3.588-03	0.000	1.908+01	3.002+02	6.235+06	6.235+06	1.572+05	2.541+05	30	0	15
16	7.455-02	3.907-03	0.000	1.908+01	3.001+02	5.661+06	5.661+06	1.401+05	2.541+05	30	0	16
17	8.081-02	4.235-03	0.000	1.908+01	3.001+02	5.087+06	5.087+06	1.255+05	2.541+05	30	0	17
18	8.726-02	4.572-03	0.000	1.908+01	3.001+02	4.480+06	4.480+06	1.128+05	2.541+05	30	0	15
19	9.390-02	4.921-03	0.000	1.908+01	3.001+02	4.175+06	4.175+06	1.017+05	2.541+05	30	0	19
20	1.007-01	5.279-03	0.000	1.908+01	3.001+02	3.592+06	3.592+06	9.190+04	2.541+05	30	0	20
21	1.078-01	5.649-03	0.000	1.908+01	3.001+02	3.420+06	3.420+06	8.328+04	2.541+05	30	0	21
22	1.151-01	6.029-03	0.000	1.908+01	3.001+02	3.065+06	3.065+06	7.562+04	2.541+05	30	0	22
23	1.226-01	6.422-03	0.000	1.908+01	3.001+02	2.817+06	2.817+06	6.878+04	2.541+05	30	0	23
24	1.303-01	6.826-03	0.000	1.908+01	3.001+02	2.614+06	2.614+06	6.266+04	2.541+05	30	0	24
25	1.382-01	7.242-03	0.000	1.908+01	3.001+02	2.344+06	2.344+06	5.716+04	2.541+05	30	0	25
26	1.464-01	7.671-03	0.000	1.908+01	3.001+02	2.334+06	2.334+06	5.220+04	2.541+05	30	0	26
27	1.548-01	8.113-03	0.000	1.908+01	3.000+02	1.883+06	1.883+06	4.772+04	2.541+05	30	0	27
28	1.635-01	8.568-03	0.000	1.908+01	3.000+02	1.963+06	1.963+06	4.366+04	2.541+05	30	0	28
29	1.725-01	9.038-03	0.000	1.908+01	3.000+02	1.764+06	1.764+06	3.997+04	2.541+05	30	0	29
30	1.817-01	9.521-03	0.000	1.908+01	3.000+02	1.523+06	1.523+06	3.662+04	2.541+05	30	0	30
31	1.912-01	1.002-02	0.000	1.908+01	3.000+02	1.514+06	1.514+06	3.357+04	2.541+05	30	0	31
32	2.010-01	1.053-02	0.000	1.908+01	3.000+02	1.313+06	1.313+06	3.079+04	2.541+05	30	0	32
33	2.111-01	1.106-02	0.000	1.908+01	3.000+02	1.122+06	1.122+06	2.825+04	2.541+05	30	0	33
34	2.215-01	1.161-02	0.000	1.908+01	3.000+02	1.123+06	1.123+06	2.593+04	2.541+05	30	0	34
35	2.322-01	1.217-02	0.000	1.908+01	3.000+02	1.059+06	1.059+06	2.381+04	2.541+05	30	0	35
36	2.432-01	1.274-02	0.000	1.908+01	3.000+02	1.001+06	1.001+06	2.186+04	2.541+05	30	0	36
37	2.546-01	1.334-02	0.000	1.908+01	3.000+02	8.949+05	8.949+05	2.008+04	2.541+05	30	0	37
38	2.663-01	1.395-02	0.000	1.908+01	3.000+02	7.393+05	7.393+05	1.845+04	2.541+05	30	0	35
39	2.784-01	1.459-02	0.000	1.908+01	3.000+02	8.641+05	8.641+05	1.695+04	2.541+05	30	0	39
40	2.908-01	1.524-02	0.000	1.908+01	3.000+02	8.037+05	8.037+05	1.557+04	2.541+05	30	0	40
41	3.036-01	1.591-02	0.000	1.908+01	3.000+02	7.977+05	7.977+05	1.431+04	2.541+05	30	0	41
42	3.168-01	1.660-02	0.000	1.908+01	3.000+02	7.624+05	7.524+05	1.315+04	2.541+05	30	0	42
43	3.304-01	1.731-02	0.000	1.908+01	3.000+02	7.656+05	7.656+05	1.208+04	2.541+05	30	0	43
44	3.444-01	1.805-02	0.000	1.908+01	3.000+02	6.906+05	6.906+05	1.110+04	2.541+05	30	0	44
45	3.588-01	1.880-02	0.000	1.908+01	3.000+02	5.085+05	5.085+05	1.019+04	2.541+05	30	0	45
46	3.737-01	1.758-02	0.000	1.908+01	3.000+02	4.945+05	4.945+05	9.364+03	2.541+05	30	0	46
47	3.890-01	2.039-02	0.000	1.908+01	3.000+02	3.544+05	3.544+05	8.600+03	2.541+05	30	0	47
48	4.048-01	2.121-02	0.000	1.908+01	3.000+02	4.737+05	4.737+05	7.896+03	2.541+05	30	0	45
49	4.211-01	2.206-02	0.000	1.908+01	3.000+02	3.933+05	3.933+05	7.248+03	2.541+05	30	0	49
50	4.378-01	2.294-02	0.000	1.908+01	3.000+02	4.251+05	4.251+05	6.652+03	2.541+05	30	0	50

J	SMASS	X	U	RHO	T	S+Q	P	E	C	IV	IB	J
51	4.551-01	2.385-02	0.000	1.908+01	3.000+02	4.404+05	4.404+05	6.104+03	2.541+05	30	0	51
52	4.729-01	2.478-02	0.000	1.908+01	3.000+02	4.022+05	4.022+05	5.599+03	2.541+05	30	0	52
53	4.912-01	2.574-02	0.000	1.908+01	3.000+02	2.924+05	2.924+05	5.134+03	2.541+05	30	0	53
54	5.101-01	2.673-02	0.000	1.908+01	3.000+02	1.839+05	1.839+05	4.706+03	2.541+05	30	0	54
55	5.295-01	2.775-02	0.000	1.908+01	3.000+02	2.786+05	2.786+05	4.312+03	2.541+05	30	0	55
56	5.496-01	2.880-02	0.000	1.908+01	3.000+02	3.011+05	3.011+05	3.949+03	2.541+05	30	0	56
57	5.702-01	2.988-02	0.000	1.908+01	3.000+02	1.597+05	1.597+05	3.616+03	2.541+05	30	0	57
58	5.915-01	3.099-02	0.000	1.908+01	3.000+02	-3.567+04	-3.567+04	3.309+03	2.541+05	30	0	58
59	6.134-01	3.214-02	0.000	1.908+01	3.000+02	2.651+05	2.651+05	3.027+03	2.541+05	30	0	59
6C	6.360-01	3.333-02	0.000	1.908+01	3.000+02	5.485+05	5.485+05	2.767+03	2.541+05	30	0	60
61	6.593-01	3.455-02	0.000	1.908+01	3.000+02	1.355+05	1.355+05	2.528+03	2.541+05	30	0	61
62	6.832-01	3.580-02	0.000	1.908+01	3.000+02	2.920+05	2.920+05	2.309+03	2.541+05	30	0	62
63	7.079-01	3.710-02	0.000	1.908+01	3.000+02	3.759+05	3.759+05	2.108+03	2.541+05	30	0	63
64	7.334-01	3.843-02	0.000	1.908+01	3.000+02	4.604+05	4.604+05	1.922+03	2.541+05	30	0	64
65	7.596-01	3.980-02	0.000	1.908+01	3.000+02	1.603+05	1.603+05	1.752+03	2.541+05	30	0	65
66	7.866-01	4.122-02	0.000	1.908+01	3.000+02	1.724+05	1.724+05	1.596+03	2.541+05	30	0	66
67	8.144-01	4.268-02	0.000	1.908+01	3.000+02	7.515+04	7.515+04	1.453+03	2.541+05	30	0	67
68	8.431-01	4.418-02	0.000	1.908+01	3.000+02	6.995+04	6.995+04	1.321+03	2.541+05	30	0	68
69	8.726-01	4.573-02	0.000	1.908+01	3.000+02	1.570+05	1.570+05	1.200+03	2.541+05	30	0	69
70	9.031-01	4.732-02	0.000	1.908+01	3.000+02	1.526+05	1.526+05	1.089+03	2.541+05	30	0	70
71	9.344-01	4.896-02	0.000	1.908+01	3.000+02	2.770+05	2.770+05	9.860+02	2.541+05	30	0	71
72	9.667-01	5.066-02	0.000	1.908+01	3.000+02	2.183+05	2.183+05	8.908+02	2.541+05	30	0	72
EXT	1.000+00	5.240-02	0.000									EXT

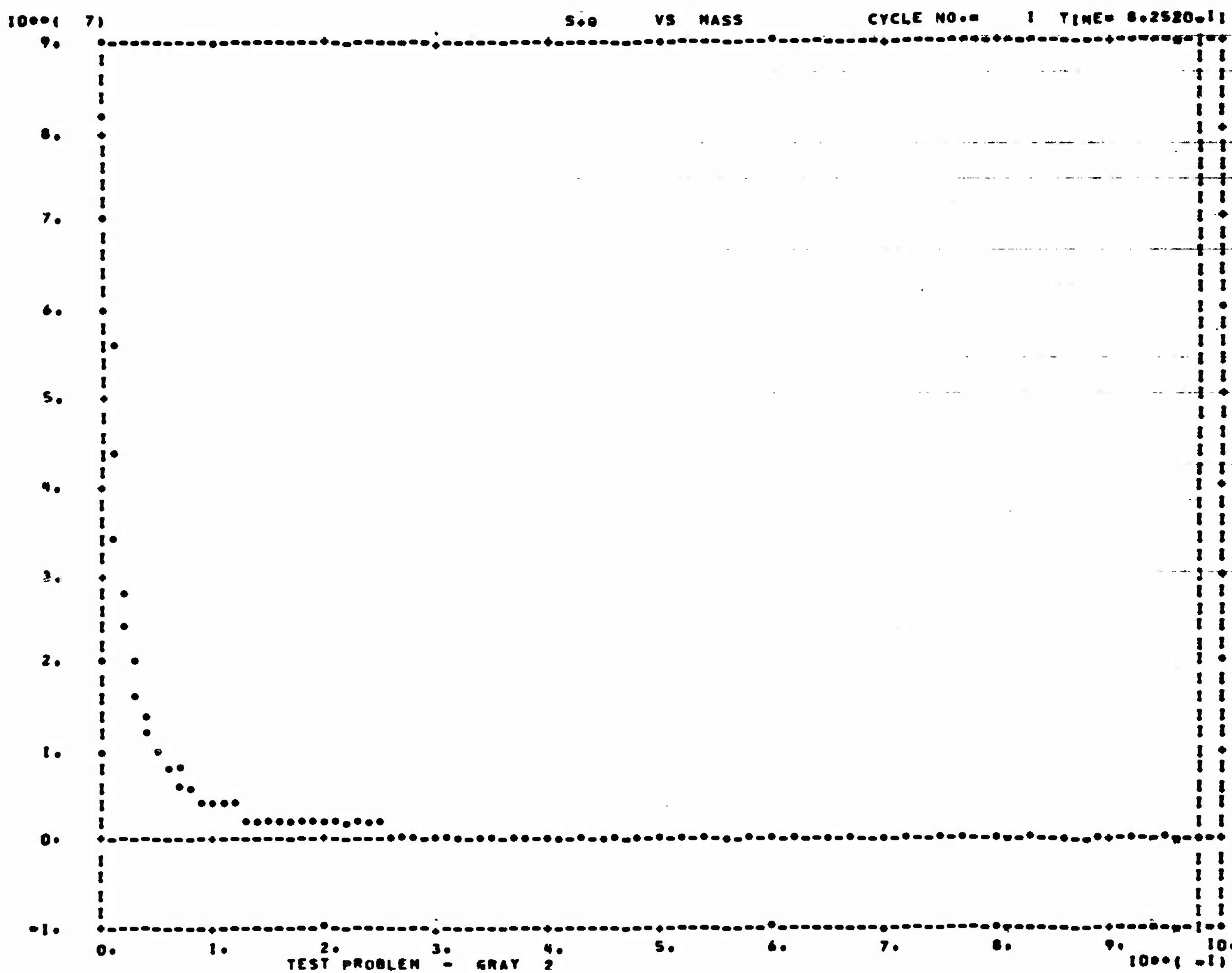
DTNPI	ICOURN
8.2520-11	0

TOTAL MOMENTUM

POS 0.0000
NEG 0.0000

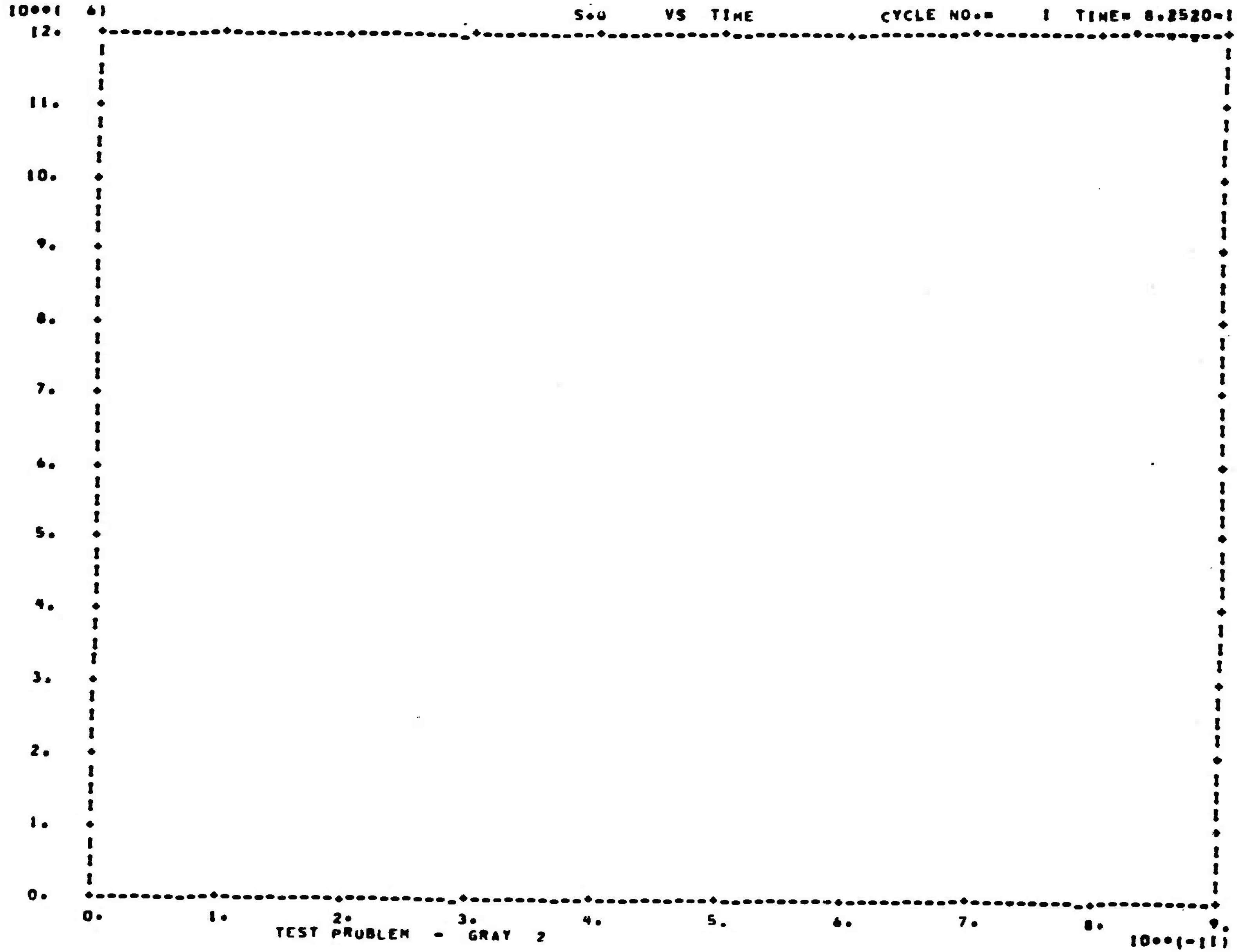
TOTAL MOMENTUM BY LAYER

LAYER 1
PCS 0.0000
NEG 0.0000


10**(7)
S+0 VS MASS
CYCLE NO.= 1 TIME= 8.2520-1
9.
8.
7.
6.
5.
4.
3.
2.
1.
0.
-1.
0. 1. 2. 3. 4. 5. 6. 7. 8. 9. 10.
10**(-1)
TEST PROBLEM - GRAY 2

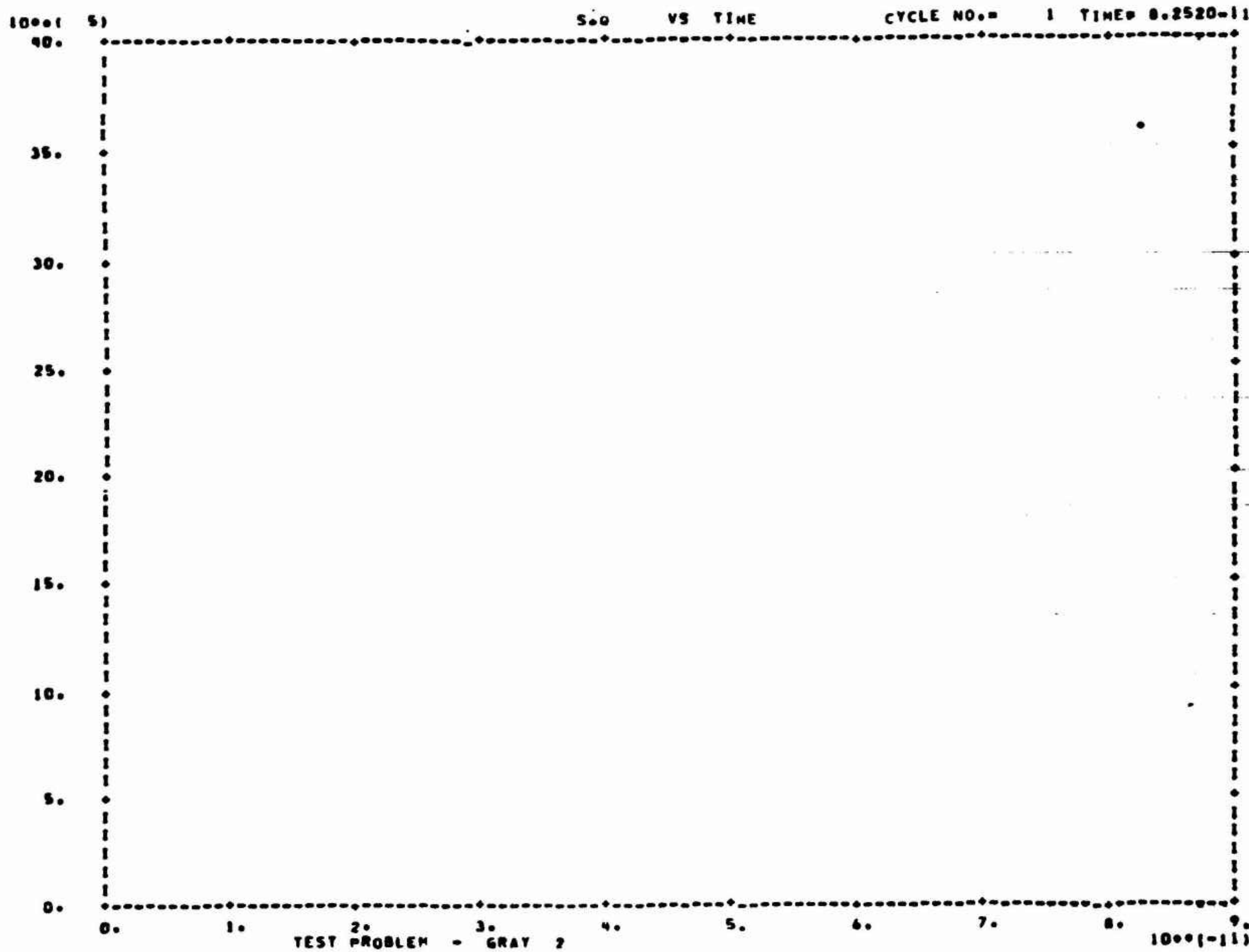
TIME	U	TIME	U	TIME	U	TIME	U	TIME	U
8.2520-11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

TIME	S+Q	TIME	S+Q	TIME	S+Q	TIME	S+Q	TIME	S+Q
8.2520-11	1.1789+07	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000


10**(6)
S+U VS TIME
CYCLE NO.= 1 TIME= 8.2520-11
12.
11.
10.
9.
8.
7.
6.
5.
4.
3.
2.
1.
0.
0.
1.
2.
3.
4.
5.
6.
7.
8.
9.
10**(-11)
TEST PROBLEM - GRAY 2

TIME	U	TIME	U	TIME	U	TIME	U	TIME	U
8.2520-11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

TIME	S+Q	TIME	S+Q	TIME	S+Q	TIME	S+Q	TIME	S+Q
8.2520-11	3.5918+04	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000



BLANK COMMON FOR CYCLE NUMBER 1 WAS WRITTEN ON UNIT 20.

```
EQST   COMMON FOR CYCLE NUMBER      1 WAS WRITTEN ON UNIT 20.

CEDIT  COMMON FOR CYCLE NUMBER      1 WAS WRITTEN ON UNIT 20.

FUNCT  COMMON FOR CYCLE NUMBER      1 WAS WRITTEN ON UNIT 20.

TEM    COMMON FOR CYCLE NUMBER      1 WAS WRITTEN ON UNIT 20.

GRAY   COMMON FOR CYCLE NUMBER      1 WAS WRITTEN ON UNIT 20.

NORMAL EXIT AT CYCLE      1 AND TIME  8.252D-11.


BFIN
       LOAD 4190    1/0 X            -1 GRAY
    CECIL-R=X       4190        005500
       LOAD  BLANK 1/2 20            -1 GRAY
    CECIL-R=20      4175        005500
      GRAY    FIN
```

D.2 RIP RESTART

```
SUBROUTINE -CARDS- READS FREE-FORM DATA CARDS INTO BLANK AND NAMED COMMONS IDENTIFIED BY LETTERS AS FOLLOWS

 B FOR BLANK COMMON, V FOR NAMED COMMON /EQST/, W FOR NAMED COMMON /BEAM/, X FOR NAMED COMMON /CEDIT/,

 Y FOR NAMED COMMON /EQSTAB/, Z FOR NAMED COMMON /FUNCT/

B86=-1    (NRESRT)
B245=5*-10,20     (IOUNIT)
END

              *****  NORMAL DATA READS WITHOUT ERRORS  *****

************************************************

    RESTART FROM CYCLE NUMBER      0.

    TYPE  0 RECORD FOUND FOR CYCLE NUMBER      0 ON UNIT 20.

    CYCLE      0 READ INTO BLANK  COMMON.

    CYCLE      0 READ INTO EQST   COMMON.

    CYCLE      0 READ INTO CEDIT  COMMON.

    CYCLE      0 READ INTO FUNCT  COMMON.

    CYCLE      0 READ INTO TEM    COMMON.

    CYCLE      0 READ INTO GRAY   COMMON.
```


PRECEDING PAGE BLANK-NOT FILMED

```
SUBROUTINE -CARDS- READS FREE-FORM DATA CARDS INTO BLANK AND NAMED COMMONS IDENTIFIED BY LETTERS AS FOLLOWS

 B FOR BLANK COMMON, V FOR NAMED COMMON /CONST/, A FOR NAMED COMMON /BEAM/, X FOR NAMED COMMON /CEDIT/,

 Y FOR NAMED COMMON /EOSTAB/, Z FOR NAMED COMMON /FUNCT/

B84=200     (MAXCYL)
B245=5*-10,20     (IOUNIT)
B313=20      (NDUMP)
B315=10    (NPRINT)
V674=.0569,-.0733    (V1,V2)
END

          *****  NORMAL DATA READS WITHOUT ERRORS  *****
```

ADMASS PRINT

OLD MESH DESCRIPTION

LAYER NO.	TOTAL MASS	ZONE SIZE RATIO	NUMBER OF ZONES	MATERIAL ID	SIZE OF FIRST ZONE	SIZE OF LAST ZONE
1	1.000000+00	1.030291+00	72	103	4.000000-03	3.328322-02

ADMASS OPERATIONS REQUESTED

1. NUMBER OF ZONES CUT FROM THE LEFT END = 0
2. NUMBER OF ZONES CUT FROM THE RIGHT END = 0
3. NUMBER OF ZONES ADDED TO THE LEFT END = 0
4. NUMBER OF ZONES ADDED TO THE RIGHT END = 0

NEW MESH DESCRIPTION

LAYER NO.	TOTAL MASS	ZONE SIZE RATIO	NUMBER OF ZONES	MATERIAL ID	SIZE OF FIRST ZONE	SIZE OF LAST ZONE
1	1.000000+00	1.030291+00	72	103	4.000000-03	3.328322-02

F1P GEOMETRY DESCRIPTION

MODE	CULMST	DTMPI	TMAX	MAXCYL	MAXZ	MAXZP1	NPRINT	TPRINT	NDUMP
0	9.0000-01	8.2520-11	1.0000+00	200	72	73	10	0.0000	20

MATERIAL 1 ••

APASS	DELTMI	DELTMM	RATIO	MATNO			
1.000+00	4.000-03	3.328-02	1.030+00	73	••• ZONES	1 TO	72 •••
RHO	UNUSED	UNUSED	UNUSED	UNUSED	C	AMU	YO
1.908+01	0.000	0.000	0.000	0.000	2.590+05	0.000	0.000
SPALL	EVV	ELV	ELM	ESM	UNUSED	UNUSED	S
-1.000+10	2.644+10	2.644+10	2.644+10	2.644+10	5.690-02	7.330-02	1.549+00
GAMMAC	A	GAMMAE	GE	TMO	EOM	EOO	AW
2.070+00	1.500+00	6.667-01	1.300-08	1.710+03	0.000	0.000	2.381+02
VJ	VB	AT	THETA	DELS	EOSFLG	VISCOL	VISCOQ
0.000	2.515-02	6.712+01	1.364+04	9.637-05	3.000+00	2.500-01	1.600+00

RIP CYCLE 0

J	DELTAM	X	U	RHO	C	HRATE	J	DELTAM	X	U	RHO	C	HRATE
1	4.00-03	0.00	0.00	1.91+01	2.54+05	3.06+18	51	1.78-02	2.38-02	0.00	1.91+01	2.54+05	8.96+15
2	4.12-03	2.10-04	0.00	1.91+01	2.54+05	2.12+18	52	1.83-02	2.48-02	0.00	1.91+01	2.54+05	8.22+15
3	4.25-03	4.26-04	0.00	1.91+01	2.54+05	1.64+18	53	1.89-02	2.57-02	0.00	1.91+01	2.54+05	7.54+15
4	4.37-03	6.48-04	0.00	1.91+01	2.54+05	1.31+18	54	1.95-02	2.67-02	0.00	1.91+01	2.54+05	6.91+15
5	4.51-03	8.77-04	0.00	1.91+01	2.54+05	1.06+18	55	2.00-02	2.77-02	0.00	1.91+01	2.54+05	6.33+15
6	4.64-03	1.11-03	0.00	1.91+01	2.54+05	8.76+17	56	2.06-02	2.88-02	0.00	1.91+01	2.54+05	5.80+15
7	4.78-03	1.36-03	0.00	1.91+01	2.54+05	7.30+17	57	2.13-02	2.99-02	0.00	1.91+01	2.54+05	5.31+15
8	4.93-03	1.61-03	0.00	1.91+01	2.54+05	6.14+17	58	2.19-02	3.10-02	0.00	1.91+01	2.54+05	4.86+15
9	5.08-03	1.87-03	0.00	1.91+01	2.54+05	5.21+17	59	2.26-02	3.21-02	0.00	1.91+01	2.54+05	4.44+15
10	5.23-03	2.13-03	0.00	1.91+01	2.54+05	4.47+17	60	2.33-02	3.33-02	0.00	1.91+01	2.54+05	4.06+15
11	5.39-03	2.41-03	0.00	1.91+01	2.54+05	3.86+17	61	2.40-02	3.45-02	0.00	1.91+01	2.54+05	3.71+15
12	5.55-03	2.69-03	0.00	1.91+01	2.54+05	3.36+17	62	2.47-02	3.58-02	0.00	1.91+01	2.54+05	3.39+15
13	5.72-03	2.98-03	0.00	1.91+01	2.54+05	2.95+17	63	2.54-02	3.71-02	0.00	1.91+01	2.54+05	3.10+15
14	5.90-03	3.28-03	0.00	1.91+01	2.54+05	2.60+17	64	2.62-02	3.84-02	0.00	1.91+01	2.54+05	2.83+15
15	6.07-03	3.59-03	0.00	1.91+01	2.54+05	2.31+17	65	2.70-02	3.98-02	0.00	1.91+01	2.54+05	2.57+15
16	6.26-03	3.91-03	0.00	1.91+01	2.54+05	2.06+17	66	2.78-02	4.12-02	0.00	1.91+01	2.54+05	2.34+15
17	6.45-03	4.23-03	0.00	1.91+01	2.54+05	1.84+17	67	2.87-02	4.27-02	0.00	1.91+01	2.54+05	2.13+15
18	6.64-03	4.57-03	0.00	1.91+01	2.54+05	1.66+17	68	2.95-02	4.42-02	0.00	1.91+01	2.54+05	1.94+15
19	6.84-03	4.92-03	0.00	1.91+01	2.54+05	1.49+17	69	3.04-02	4.57-02	0.00	1.91+01	2.54+05	1.76+15
20	7.05-03	5.28-03	0.00	1.91+01	2.54+05	1.35+17	70	3.14-02	4.73-02	0.00	1.91+01	2.54+05	1.60+15
21	7.27-03	5.65-03	0.00	1.91+01	2.54+05	1.22+17	71	3.23-02	4.90-02	0.00	1.91+01	2.54+05	1.46+15
22	7.49-03	6.03-03	0.00	1.91+01	2.54+05	1.11+17	72	3.33-02	5.07-02	0.00	1.91+01	2.54+05	1.31+15
23	7.71-03	6.42-03	0.00	1.91+01	2.54+05	1.01+17	EXT		5.24-02	0.00			
24	7.95-03	6.83-03	0.00	1.91+01	2.54+05	9.20+16							
25	8.19-03	7.24-03	0.00	1.91+01	2.54+05	8.39+16							
26	8.43-03	7.67-03	0.00	1.91+01	2.54+05	7.67+16							
27	8.69-03	8.11-03	0.00	1.91+01	2.54+05	7.01+16							
28	8.95-03	8.57-03	0.00	1.91+01	2.54+05	6.41+16							
29	9.22-03	9.04-03	0.00	1.91+01	2.54+05	5.87+16							
30	9.50-03	9.52-03	0.00	1.91+01	2.54+05	5.38+16							
31	9.79-03	1.00-02	0.00	1.91+01	2.54+05	4.93+16							
32	1.01-02	1.05-02	0.00	1.91+01	2.54+05	4.52+16							
33	1.04-02	1.11-02	0.00	1.91+01	2.54+05	4.15+16							
34	1.07-02	1.16-02	0.00	1.91+01	2.54+05	3.81+16							
35	1.10-02	1.22-02	0.00	1.91+01	2.54+05	3.50+16							
36	1.14-02	1.27-02	0.00	1.91+01	2.54+05	3.21+16							
37	1.17-02	1.33-02	0.00	1.91+01	2.54+05	2.95+16							
38	1.21-02	1.40-02	0.00	1.91+01	2.54+05	2.71+16							
39	1.24-02	1.46-02	0.00	1.91+01	2.54+05	2.49+16							
40	1.28-02	1.52-02	0.00	1.91+01	2.54+05	2.29+16							
41	1.32-02	1.59-02	0.00	1.91+01	2.54+05	2.10+16							
42	1.36-02	1.66-02	0.00	1.91+01	2.54+05	1.93+16							
43	1.40-02	1.73-02	0.00	1.91+01	2.54+05	1.77+16							
44	1.44-02	1.80-02	0.00	1.91+01	2.54+05	1.63+16							
45	1.49-02	1.88-02	0.00	1.91+01	2.54+05	1.50+16							
46	1.53-02	1.96-02	0.00	1.91+01	2.54+05	1.38+16							
47	1.58-02	2.04-02	0.00	1.91+01	2.54+05	1.26+16							
48	1.63-02	2.12-02	0.00	1.91+01	2.54+05	1.16+16							
49	1.68-02	2.21-02	0.00	1.91+01	2.54+05	1.06+16							
50	1.73-02	2.29-02	0.00	1.91+01	2.54+05	9.77+15							

ECONS

5.240002-02	5.459891-11	4.047459-07	4.884502-08	3.416212-07
2.687925-01	6.500001-05	1.312742+03	1.147395+02	2.802616-06
-9.960580-05	-7.633579-02	0.000000	3.420000+03	1.048412-01
6.661349-02	1.103597-03	3.866369-02	-5.138720-07	4.507645+10

TEST PROBLEM - GRAY 2 CYCLE NO. = 10 TIME = 2.14210-09

J	SMASS	X	U	RHO	T	S+Q	P	E	C	IV	IB	J
1	0.000	-3.761-06	-4.560+03	1.876+01	1.020+03	9.463+09	9.463+09	7.895+08	2.802+05	30	0	1
2	4.000-03	2.095-04	-4.120+02	1.909+01	8.151+02	1.832+10	1.832+10	5.452+08	2.540+05	30	0	2
3	8.171-03	4.259-04	4.793+02	1.909+01	7.027+02	1.694+10	1.686+10	4.235+08	2.546+05	30	0	3
4	1.237-02	6.483-04	4.151+02	1.909+01	6.225+02	1.375+10	1.361+10	3.384+08	2.546+05	30	0	4
5	1.674-02	8.775-04	3.008+02	1.909+01	5.624+02	1.109+10	1.100+10	2.750+08	2.545+05	30	0	5
6	2.125-02	1.114-03	2.214+02	1.909+01	5.163+02	9.082+09	9.015+09	2.264+08	2.544+05	30	0	6
7	2.589-02	1.357-03	1.666+02	1.909+01	4.803+02	7.532+09	7.485+09	1.885+08	2.543+05	30	0	7
8	3.068-02	1.608-03	1.273+02	1.909+01	4.517+02	6.317+09	6.282+09	1.586+08	2.543+05	30	0	8
9	3.561-02	1.866-03	9.844+01	1.909+01	4.290+02	5.351+09	5.325+09	1.347+08	2.543+05	30	0	9
10	4.068-02	2.132-03	7.687+01	1.908+01	4.106+02	4.576+09	4.556+09	1.154+08	2.542+05	30	0	10
11	4.592-02	2.406-03	6.047+01	1.908+01	3.956+02	3.946+09	3.931+09	9.975+07	2.542+05	30	0	11
12	5.131-02	2.689-03	4.833+01	1.908+01	3.833+02	3.430+09	3.419+09	8.686+07	2.542+05	30	0	12
13	5.686-02	2.980-03	3.890+01	1.908+01	3.730+02	3.004+09	2.995+09	7.617+07	2.542+05	30	0	13
14	6.258-02	3.279-03	3.151+01	1.908+01	3.644+02	2.647+09	2.640+09	6.721+07	2.542+05	30	0	14
15	6.848-02	3.588-03	2.587+01	1.908+01	3.572+02	2.346+09	2.341+09	5.963+07	2.542+05	30	0	15
16	7.455-02	3.907-03	2.145+01	1.908+01	3.510+02	2.090+09	2.086+09	5.316+07	2.542+05	30	0	16
17	8.081-02	4.235-03	1.784+01	1.908+01	3.457+02	1.870+09	1.867+09	4.760+07	2.542+05	30	0	17
18	8.726-02	4.572-03	1.503+01	1.908+01	3.410+02	1.679+09	1.676+09	4.278+07	2.542+05	30	0	18
19	9.390-02	4.921-03	1.278+01	1.908+01	3.370+02	1.513+09	1.511+09	3.857+07	2.542+05	30	0	19
20	1.007-01	5.279-03	1.082+01	1.908+01	3.335+02	1.368+09	1.366+09	3.486+07	2.541+05	30	0	20
21	1.078-01	5.649-03	9.307+00	1.908+01	3.303+02	1.239+09	1.237+09	3.159+07	2.541+05	30	0	21
22	1.151-01	6.029-03	7.976+00	1.908+01	3.275+02	1.125+09	1.123+09	2.869+07	2.541+05	30	0	22
23	1.226-01	6.422-03	6.952+00	1.908+01	3.250+02	1.021+09	1.021+09	2.609+07	2.541+05	30	0	23
24	1.303-01	6.826-03	5.990+00	1.908+01	3.228+02	9.304+08	9.304+08	2.377+07	2.541+05	30	0	24
25	1.382-01	7.242-03	5.252+00	1.908+01	3.208+02	8.488+08	8.488+08	2.168+07	2.541+05	30	0	25
26	1.464-01	7.671-03	4.585+00	1.908+01	3.190+02	7.753+08	7.753+08	1.980+07	2.541+05	30	0	26
27	1.548-01	8.113-03	4.048+00	1.908+01	3.174+02	7.085+08	7.085+08	1.810+07	2.541+05	30	0	27
28	1.635-01	8.568-03	3.525+00	1.908+01	3.159+02	6.480+08	6.480+08	1.656+07	2.541+05	30	0	28
29	1.725-01	9.038-03	3.120+00	1.908+01	3.146+02	5.933+08	5.933+08	1.516+07	2.541+05	30	0	29
30	1.817-01	9.521-03	2.781+00	1.908+01	3.133+02	5.438+08	5.438+08	1.389+07	2.541+05	30	0	30
31	1.912-01	1.002-02	2.421+00	1.908+01	3.122+02	4.981+08	4.981+08	1.274+07	2.541+05	30	0	31
32	2.010-01	1.053-02	2.169+00	1.908+01	3.112+02	4.568+08	4.568+08	1.168+07	2.541+05	30	0	32
33	2.111-01	1.106-02	1.913+00	1.908+01	3.103+02	4.191+08	4.191+08	1.072+07	2.541+05	30	0	33
34	2.215-01	1.161-02	1.668+00	1.908+01	3.094+02	3.850+08	3.850+08	9.837+06	2.541+05	30	0	34
35	2.322-01	1.217-02	1.515+00	1.908+01	3.087+02	3.533+08	3.533+08	9.031+06	2.541+05	30	0	35
36	2.432-01	1.274-02	1.323+00	1.908+01	3.080+02	3.245+08	3.245+08	8.294+06	2.541+05	30	0	36
37	2.546-01	1.334-02	1.200+00	1.908+01	3.073+02	2.980+08	2.980+08	7.618+06	2.541+05	30	0	37
38	2.663-01	1.395-02	1.071+00	1.908+01	3.067+02	2.735+08	2.735+08	6.998+06	2.541+05	30	0	38
39	2.[illegible]-01	1.459-02	9.133-01	1.908+01	3.062+02	2.515+08	2.515+08	6.430+06	2.541+05	30	0	39
40	2.[illegible]-01	1.524-02	8.276-01	1.908+01	3.057+02	2.315+08	2.315+08	5.908+06	2.541+05	30	0	40
41	3.036-01	1.591-02	7.522-01	1.908+01	3.052+02	2.124+08	2.124+08	5.428+06	2.541+05	30	0	41
42	3.168-01	1.660-02	6.663-01	1.908+01	3.048+02	1.951+08	1.951+08	4.987+06	2.541+05	30	0	42
43	3.304-01	1.731-02	5.866-01	1.908+01	3.044+02	1.798+08	1.798+08	4.582+06	2.541+05	30	0	43
44	3.444-01	1.805-02	5.352-01	1.908+01	3.043+02	1.648+08	1.648+08	4.210+06	2.541+05	30	0	44
45	3.588-01	1.886-02	4.924-01	1.908+01	3.037+02	1.513+08	1.513+08	3.867+06	2.541+05	30	0	45
46	3.737-01	1.958-02	4.281-01	1.908+01	3.034+02	1.390+08	1.390+08	3.552+06	2.541+05	30	0	46
47	3.890-01	2.039-02	3.905-01	1.908+01	3.031+02	1.275+08	1.275+08	3.262+06	2.541+05	30	0	47
48	4.046-01	2.121-02	3.205-01	1.908+01	3.029+02	1.172+08	1.172+08	2.995+06	2.541+05	30	0	48
49	4.211-01	2.204-02	3.065-01	1.908+01	3.026+02	1.076+08	1.076+08	2.750+06	2.541+05	30	0	49
50	4.376-01	2.294-02	2.834-01	1.908+01	3.024+02	9.879+07	9.879+07	2.524+06	2.541+05	30	0	50

J	SMASS	A	U	RHO	T	S+Q	P	E	C	IV	IB	J
51	4.551-01	2.365-02	2.366-01	1.908+01	3.022+02	9.069+07	9.069+07	2.315+06	2.541+05	30	0	51
52	4.729-01	2.478-02	2.163-01	1.908+01	3.020+02	8.319+07	8.319+07	2.124+06	2.541+05	30	0	52
53	4.912-01	2.574-02	2.000-01	1.908+01	3.019+02	7.620+07	7.620+07	1.947+06	2.541+05	30	0	53
54	5.101-01	2.673-02	1.794-01	1.908+01	3.017+02	6.977+07	6.977+07	1.785+06	2.541+05	30	0	54
55	5.295-01	2.775-02	1.434-01	1.908+01	3.016+02	6.404+07	6.404+07	1.636+06	2.541+05	30	0	55
56	5.496-01	2.880-02	1.331-01	1.908+01	3.014+02	5.870+07	5.870+07	1.498+06	2.541+05	30	0	56
57	5.702-01	2.988-02	1.324-01	1.908+01	3.013+02	5.363+07	5.363+07	1.372+06	2.541+05	30	0	57
58	5.915-01	3.099-02	1.245-01	1.908+01	3.012+02	4.889+07	4.889+07	1.255+06	2.541+05	30	0	58
59	6.134-01	3.214-02	7.183-02	1.908+01	3.011+02	4.502+07	4.502+07	1.148+06	2.541+05	30	0	59
60	6.360-01	3.333-02	6.382-02	1.908+01	3.010+02	4.147+07	4.147+07	1.050+06	2.541+05	30	0	60
61	6.593-01	3.455-02	1.100-01	1.908+01	3.009+02	3.752+07	3.752+07	9.592+05	2.541+05	30	0	61
62	6.832-01	3.580-02	5.728-02	1.908+01	3.008+02	3.444+07	3.444+07	8.760+05	2.541+05	30	0	62
63	7.079-01	3.710-02	5.529-02	1.908+01	3.008+02	3.154+07	3.154+07	7.995+05	2.541+05	30	0	63
64	7.334-01	3.843-02	4.893-02	1.908+01	3.007+02	2.889+07	2.889+07	7.293+05	2.541+05	30	0	64
65	7.596-01	3.980-02	6.997-02	1.908+01	3.006+02	2.607+07	2.607+07	6.647+05	2.541+05	30	0	65
66	7.866-01	4.122-02	4.187-02	1.908+01	3.006+02	2.377+07	2.377+07	6.055+05	2.541+05	30	0	66
67	8.144-01	4.268-02	4.378-02	1.908+01	3.005+02	2.155+07	2.155+07	5.511+05	2.541+05	30	0	67
68	8.431-01	4.418-02	3.401-02	1.908+01	3.005+02	1.960+07	1.960+07	5.011+05	2.541+05	30	0	68
69	8.726-01	4.573-02	2.562-02	1.908+01	3.004+02	1.790+07	1.790+07	4.552+05	2.541+05	30	0	69
70	9.031-01	4.732-02	2.618-02	1.908+01	3.004+02	1.625+07	1.625+07	4.130+05	2.541+05	30	0	70
71	9.344-01	4.896-02	1.779-02	1.908+01	3.004+02	1.486+07	1.486+07	3.740+05	2.541+05	30	0	71
72	9.667-01	5.066-02	2.416-02	1.908+01	3.003+02	1.339+07	1.339+07	3.379+05	2.541+05	30	0	72
EXT	1.000+00	5.240-02	4.324-01									EXT

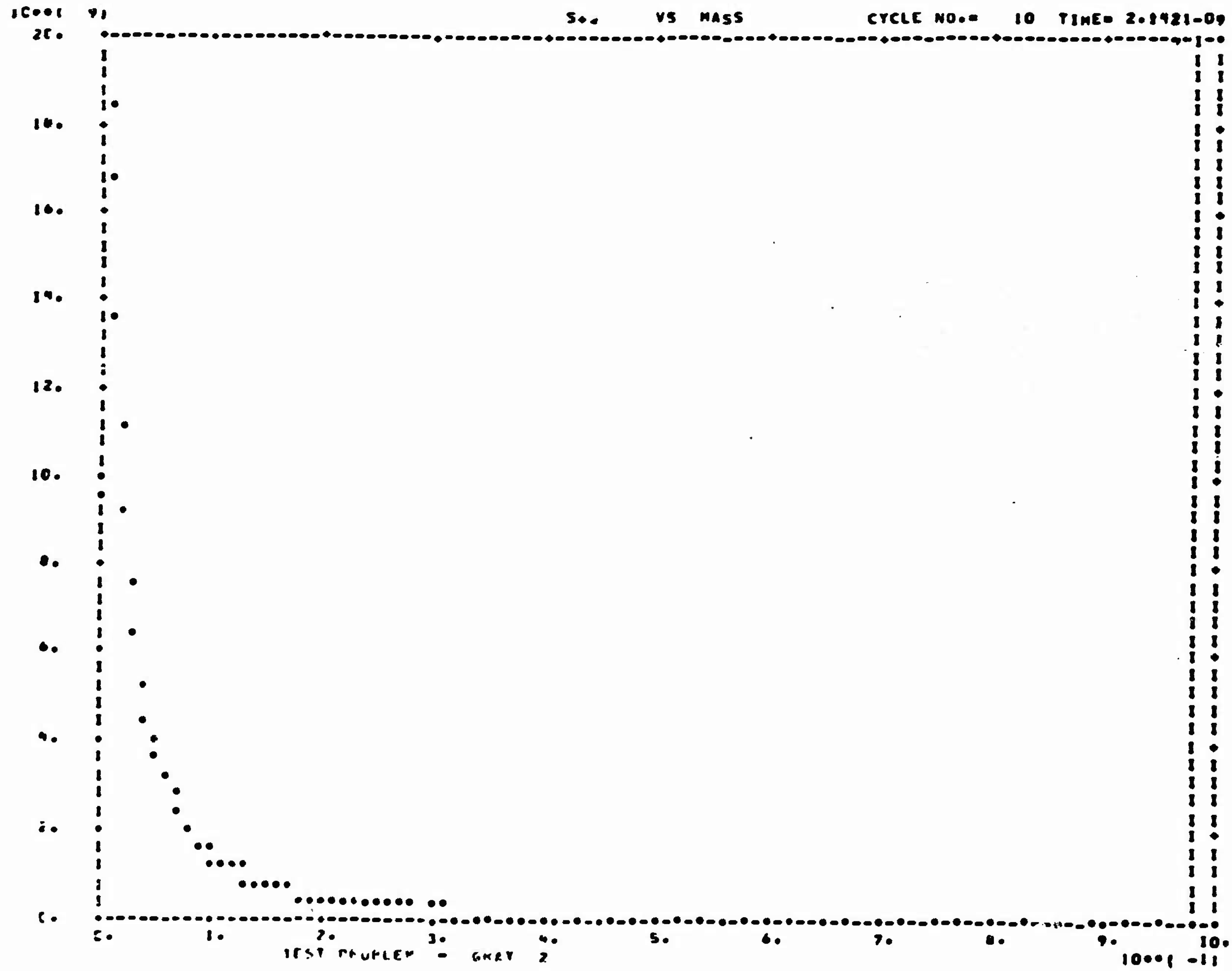
DTNFI	ICOURN
4.2576-10	1

TOTAL MOMENTUM

POS 9.9439+00
NEG -9.9442+00

TOTAL MOMENTUM BY LAYER

LAYER 1
POS 9.9439+00
NEG -9.9442+00



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TEST PROBLEM - GREY 2
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TEST PROBLEM - GRAY 2 CYCLE NO. = 20 TIME = 7.48354-09

J	SMASS	A	U	RHO	T	S+Q	P	E	C	IV	IB	J
1	0.000	-1.396-04	-3.490+04	1.458+01	4.561+03	8.977+09	7.952+09	8.888+09	2.584+05	33	0	1
2	4.000-03	1.347-04	-2.594+04	1.540+01	2.980+03	2.327+10	2.327+10	5.769+09	2.552+05	33	0	2
3	6.171-03	4.073-04	-1.292+04	1.739+01	3.626+03	7.716+10	7.716+10	4.564+09	1.978+05	33	0	3
4	1.237-02	6.464-04	-5.586+03	1.801+01	3.105+03	7.987+10	7.987+10	3.452+09	2.497+05	32	0	4
5	1.674-02	8.893-04	-1.017+03	1.851+01	2.527+03	8.994+10	8.994+10	2.994+09	2.563+05	32	0	5
6	2.125-02	1.133-03	5.396+03	1.905+01	2.111+03	1.117+11	1.117+11	2.565+09	2.638+05	32	0	6
7	2.589-02	1.377-03	9.437+03	1.936+01	1.841+03	1.191+11	1.181+11	2.215+09	2.459+05	31	0	7
8	3.066-02	1.624-03	8.454+03	1.938+01	1.792+03	1.014+11	9.864+10	1.871+09	2.445+05	31	0	8
9	3.561-02	1.478-03	6.911+03	1.930+01	1.705+03	7.830+10	7.604+10	1.575+09	2.938+05	31	0	9
10	4.068-02	2.141-03	4.663+03	1.923+01	1.551+03	6.220+10	6.089+10	1.342+09	2.577+05	30	0	10
11	4.592-02	2.413-03	3.626+03	1.919+01	1.383+03	5.233+10	5.132+10	1.157+09	2.569+05	30	0	11
12	5.131-02	2.694-03	2.821+03	1.916+01	1.244+03	4.442+10	4.368+10	1.005+09	2.563+05	30	0	12
13	5.686-02	2.984-03	2.221+03	1.914+01	1.129+03	3.814+10	3.759+10	8.798+08	2.559+05	30	0	13
14	6.258-02	3.283-03	1.771+03	1.913+01	1.032+03	3.308+10	3.266+10	7.755+08	2.555+05	30	0	14
15	6.846-02	3.591-03	1.430+03	1.912+01	9.501+02	2.895+10	2.862+10	6.875+08	2.553+05	30	0	15
16	7.455-02	3.909-03	1.167+03	1.911+01	8.803+02	2.551+10	2.526+10	6.126+08	2.551+05	30	0	16
17	8.081-02	4.237-03	9.624+02	1.910+01	8.201+02	2.263+10	2.243+10	5.483+08	2.550+05	30	0	17
18	8.726-02	4.574-03	8.012+02	1.910+01	7.678+02	2.018+10	2.003+10	4.926+08	2.548+05	30	0	18
19	9.390-02	4.922-03	6.729+02	1.910+01	7.221+02	1.808+10	1.796+10	4.440+08	2.547+05	30	0	19
20	1.007-01	5.280-03	5.696+02	1.909+01	6.819+02	1.626+10	1.616+10	4.013+08	2.547+05	30	0	20
21	1.078-01	5.650-03	4.854+02	1.909+01	6.463+02	1.467+10	1.459+10	3.636+08	2.546+05	30	0	21
22	1.151-01	6.030-03	4.162+02	1.909+01	6.147+02	1.328+10	1.321+10	3.301+08	2.545+05	30	0	22
23	1.226-01	6.422-03	3.588+02	1.909+01	5.864+02	1.204+10	1.198+10	3.003+08	2.545+05	30	0	23
24	1.303-01	6.826-03	3.107+02	1.909+01	5.610+02	1.094+10	1.089+10	2.735+08	2.544+05	30	0	24
25	1.382-01	7.243-03	2.702+02	1.909+01	5.382+02	9.959+09	9.917+09	2.495+08	2.544+05	30	0	25
26	1.464-01	7.672-03	2.358+02	1.909+01	5.177+02	9.076+09	9.042+09	2.279+08	2.544+05	30	0	26
27	1.548-01	8.114-03	2.064+02	1.909+01	4.991+02	8.286+09	8.255+09	2.083+08	2.544+05	30	0	27
28	1.635-01	8.569-03	1.811+02	1.909+01	4.822+02	7.570+09	7.544+09	1.906+08	2.543+05	30	0	28
29	1.725-01	9.038-03	1.593+02	1.909+01	4.669+02	6.923+09	6.900+09	1.745+08	2.543+05	30	0	29
30	1.817-01	9.521-03	1.404+02	1.909+01	4.529+02	6.335+09	6.315+09	1.598+08	2.543+05	30	0	30
31	1.912-01	1.002-02	1.238+02	1.909+01	4.402+02	5.803+09	5.785+09	1.465+08	2.543+05	30	0	31
32	2.010-01	1.053-02	1.096+02	1.908+01	4.287+02	5.317+09	5.302+09	1.344+08	2.543+05	30	0	32
33	2.111-01	1.106-02	9.692+01	1.908+01	4.181+02	4.675+09	4.861+09	1.233+08	2.542+05	30	0	33
34	2.215-01	1.161-02	8.590+01	1.908+01	4.084+02	4.471+09	4.459+09	1.132+08	2.542+05	30	0	34
35	2.322-01	1.217-02	7.622+01	1.908+01	3.995+02	4.102+09	4.092+09	1.039+08	2.542+05	30	0	35
36	2.433-01	1.274-02	6.770+01	1.908+01	3.914+02	3.765+09	3.756+09	9.542+07	2.542+05	30	0	36
37	2.546-01	1.334-02	6.019+01	1.908+01	3.840+02	3.456+09	3.448+09	8.764+07	2.542+05	30	0	37
38	2.663-01	1.395-02	5.349+01	1.908+01	3.772+02	3.174+09	3.167+09	8.051+07	2.542+05	30	0	38
39	2.784-01	1.459-02	4.763+01	1.908+01	3.709+02	2.915+09	2.908+09	7.397+07	2.542+05	30	0	39
40	2.908-01	1.524-02	4.234+01	1.908+01	3.652+02	2.677+09	2.671+09	6.796+07	2.542+05	30	0	40
41	3.036-01	1.591-02	3.783+01	1.908+01	3.599+02	2.459+09	2.454+09	6.245+07	2.542+05	30	0	41
42	3.168-01	1.660-02	3.374+01	1.908+01	3.550+02	2.259+09	2.254+09	5.738+07	2.542+05	30	0	42
43	3.304-01	1.731-02	3.012+01	1.908+01	3.506+02	2.074+09	2.070+09	5.272+07	2.542+05	30	0	43
44	3.444-01	1.805-02	2.682+01	1.908+01	3.465+02	1.905+09	1.901+09	4.843+07	2.542+05	30	0	44
45	3.588-01	1.880-02	2.397+01	1.908+01	3.427+02	1.750+09	1.747+09	4.449+07	2.542+05	30	0	45
46	3.737-01	1.958-02	2.140+01	1.908+01	3.392+02	1.606+09	1.603+09	4.087+07	2.542+05	30	0	46
47	3.890-01	2.039-02	1.913+01	1.908+01	3.360+02	1.475+09	1.472+09	3.753+07	2.541+05	30	0	47
48	4.048-01	2.121-02	1.690+01	1.908+01	3.331+02	1.354+09	1.352+09	3.446+07	2.541+05	30	0	48
49	4.211-01	2.206-02	1.527+01	1.906+01	3.304+02	1.243+09	1.241+09	3.163+07	2.541+05	30	0	49
50	4.378-01	2.294-02	[illegible]	1.908+01	3.279+02	1.140+09	1.138+09	2.903+07	2.541+05	30	0	50

J	SMASS	A	U	RHO	T	S+Q	P	E	C	IV	IS	J
51	4.551-01	2.346-02	1.217+01	1.908+01	3.256+02	1.096+09	1.099+09	2.669+07	2.541+05	30	0	51
52	4.729-01	2.478-02	1.085+01	1.908+01	3.235+02	9.590+08	9.577+08	2.493+07	2.541+05	30	0	52
53	4.912-01	2.574-02	9.790+00	1.908+01	3.215+02	8.792+08	8.777+08	2.290+07	2.541+05	30	0	53
54	5.101-01	2.673-02	8.567+00	1.906+01	3.197+02	8.096+08	8.096+08	2.059+07	2.541+05	30	0	54
55	5.295-01	2.775-02	7.708+00	1.908+01	3.181+02	7.378+08	7.378+08	1.882+07	2.541+05	30	0	55
56	5.496-01	2.880-02	6.901+00	1.908+01	3.165+02	6.751+08	6.751+08	1.724+07	2.541+05	30	0	56
57	5.702-01	2.986-02	6.209+00	1.908+01	3.151+02	6.184+08	6.184+08	1.578+07	2.541+05	30	0	57
58	5.915-01	3.099-02	5.354+00	1.908+01	3.139+02	5.666+08	5.666+08	1.444+07	2.541+05	30	0	58
59	6.134-01	3.214-02	5.093+00	1.908+01	3.127+02	5.172+08	5.172+08	1.321+07	2.541+05	30	0	59
60	6.360-01	3.333-02	4.271+00	1.908+01	3.116+02	4.733+08	4.733+08	1.208+07	2.541+05	30	0	60
61	6.593-01	3.455-02	3.962+00	1.908+01	3.106+02	4.321+08	4.321+08	1.103+07	2.541+05	30	0	61
62	6.832-01	3.580-02	3.504+00	1.908+01	3.097+02	3.949+08	3.949+08	1.008+07	2.541+05	30	0	62
63	7.079-01	3.710-02	3.070+00	1.908+01	3.088+02	3.602+08	3.602+08	9.198+06	2.541+05	30	0	63
64	7.334-01	3.843-02	2.763+00	1.908+01	3.081+02	3.286+08	3.286+08	8.390+06	2.541+05	30	0	64
65	7.596-01	3.980-02	2.515+00	1.908+01	3.073+02	2.993+08	2.993+08	7.647+06	2.541+05	30	0	65
66	7.866-01	4.122-02	2.219+00	1.908+01	3.067+02	2.727+08	2.727+08	6.966+06	2.541+05	30	0	66
67	8.144-01	4.268-02	1.968+00	1.908+01	3.061+02	2.481+08	2.481+08	6.340+06	2.541+05	30	0	67
68	8.431-01	4.418-02	1.769+00	1.908+01	3.055+02	2.257+08	2.257+08	5.765+06	2.541+05	30	0	68
69	8.726-01	4.573-02	1.525+00	1.908+01	3.050+02	2.051+08	2.051+08	5.236+06	2.541+05	30	0	69
70	9.031-01	4.732-02	1.402+00	1.908+01	3.046+02	1.858+08	1.858+08	4.751+06	2.541+05	30	0	70
71	9.344-01	4.896-02	1.226+00	1.908+01	3.041+02	1.677+08	1.677+08	4.303+06	2.541+05	30	0	71
72	9.667-01	5.066-02	2.042+00	1.908+01	3.037+02	1.265+08	1.265+08	3.887+06	2.541+05	30	0	72
EXT	1.000+00	5.240-02	1.899+01									EXT

DTNP1 ICOURN

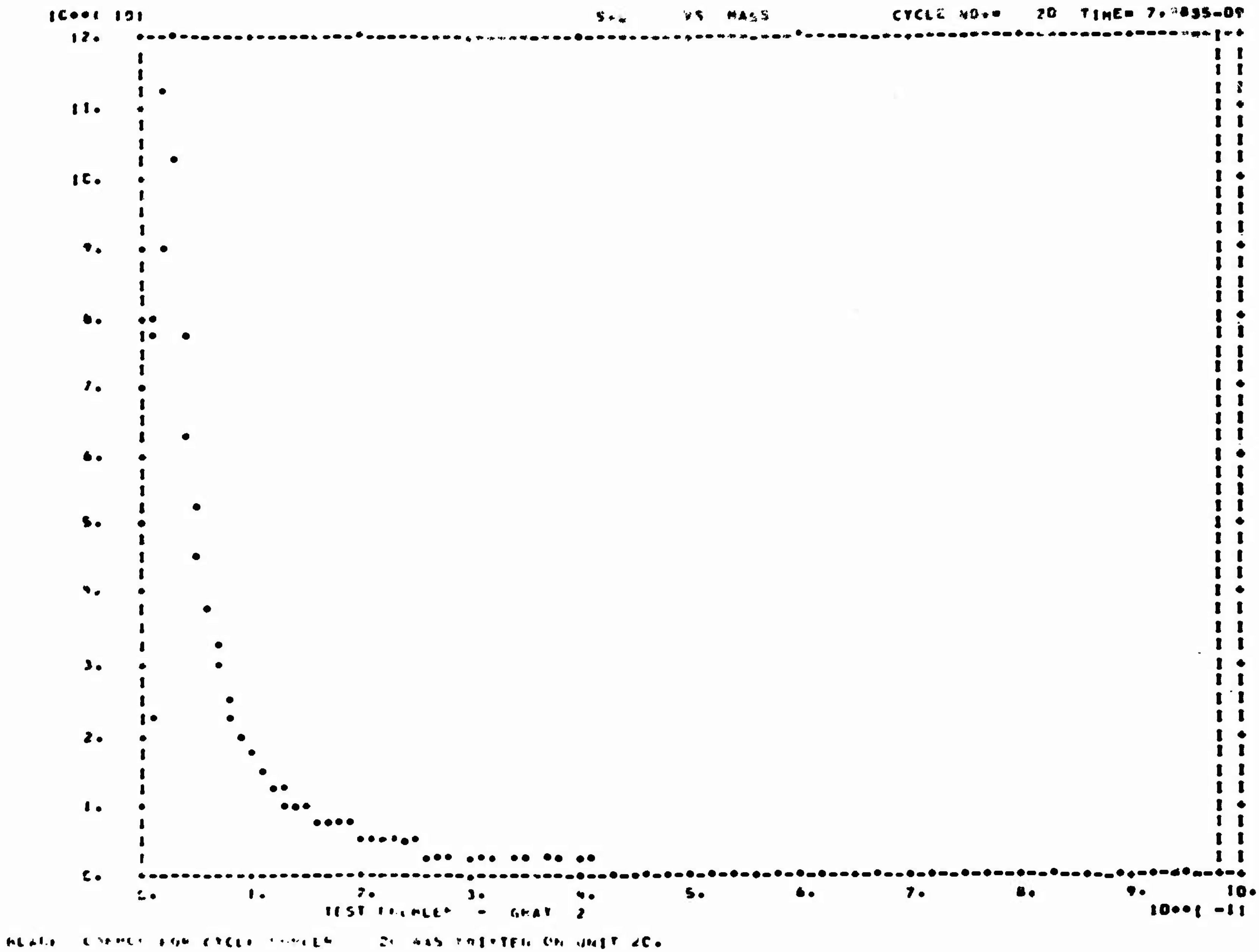
5.5?16-10 5

TOTAL MOMENTUM

POS 2.9916+02
NEG -2.9916+02

TOTAL MOMENTUM BY LAYER

LAYER 1
POS 2.9916+02
NEG -2.9916+02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FAST   COMMON FOR CYCLE NUMBER   20 WAS WRITTEN ON UNIT 20.
CEDIT  COMMON FOR CYCLE NUMBER   20 WAS WRITTEN ON UNIT 20.
FUNCT  COMMON FOR CYCLE NUMBER   20 WAS WRITTEN ON UNIT 20.
TEM    COMMON FOR CYCLE NUMBER   20 WAS WRITTEN ON UNIT 20.
GRAV   COMMON FOR CYCLE NUMBER   20 WAS WRITTEN ON UNIT 20.
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TEST PROBLEM - CRAY 2 CYCLE NO. = 30 TIME = 1.30760-08

J	SMASS	X	U	RHO	T	S+Q	P	E	C	IV	IS	J
1	0.000	-6.064-04	-1.349+05	7.700+00	2.181+04	4.979+10	4.979+10	2.454+10	1.330+05	35	0	1
2	4.000-03	-8.687-05	-5.154+04	1.267+01	1.550+04	8.399+10	8.399+10	1.747+10	2.112+05	35	0	2
3	6.121-03	2.384-04	-3.617+04	1.420+01	1.024+04	8.972+10	8.972+10	1.336+10	2.464+05	33	0	3
4	1.237-02	5.375-04	-2.144+04	1.562+01	8.226+03	1.168+11	1.168+11	1.078+10	2.667+05	33	0	4
5	1.674-02	8.176-04	-1.793+04	1.563+01	5.715+03	7.674+10	7.270+10	8.385+09	2.595+05	33	0	5
6	2.125-02	1.160-03	-2.196+04	1.635+01	5.022+03	8.662+10	8.662+10	6.789+09	2.289+05	33	0	6
7	2.589-02	1.390-03	-4.891+03	1.767+01	5.099+03	1.284+11	1.284+11	5.900+09	2.129+05	33	0	7
8	3.068-02	1.661-03	3.173+03	1.837+01	4.417+03	1.487+11	1.487+11	5.118+09	2.883+05	32	0	8
9	3.561-02	1.929-03	7.113+03	1.875+01	3.802+03	1.528+11	1.528+11	4.418+09	2.628+05	32	0	9
10	4.068-02	2.200-03	8.565+03	1.897+01	3.263+03	1.490+11	1.490+11	3.826+09	2.651+05	32	0	10
11	4.592-02	2.476-03	1.688+04	1.927+01	2.845+03	1.556+11	1.556+11	3.394+09	2.688+05	32	0	11
12	5.131-02	2.756-03	1.445+04	1.959+01	2.514+03	1.688+11	1.688+11	3.081+09	2.731+05	32	0	12
13	5.686-02	3.039-03	1.704+04	1.979+01	2.218+03	1.737+11	1.737+11	2.799+09	2.756+05	32	0	13
14	6.256-02	3.328-03	1.746+04	1.982+01	2.026+03	1.673+11	1.631+11	2.505+09	2.493+05	31	0	14
15	6.848-02	3.626-03	1.430+04	1.965+01	1.918+03	1.384+11	1.334+11	2.178+09	2.471+05	31	0	15
16	7.445-02	3.935-03	1.050+04	1.947+01	1.818+03	1.093+11	1.056+11	1.896+09	2.450+05	31	0	16
17	8.081-02	4.256-03	7.556+03	1.934+01	1.737+03	8.696+10	8.442+10	1.672+09	2.434+05	31	0	17
18	8.726-02	4.590-03	5.999+03	1.925+01	1.674+03	7.000+10	6.849+10	1.491+09	2.922+05	31	0	18
19	9.390-02	4.935-03	4.313+03	1.921+01	1.547+03	6.033+10	5.938+10	1.338+09	2.574+05	30	0	19
20	1.007-01	5.291-03	3.553+03	1.918+01	1.428+03	5.327+10	5.254+10	1.207+09	2.568+05	30	0	20
21	1.078-01	5.659-03	2.963+03	1.916+01	1.323+03	4.739+10	4.681+10	1.092+09	2.564+05	30	0	21
22	1.151-01	6.039-03	2.498+03	1.914+01	1.230+03	4.290+10	4.194+10	9.903+08	2.560+05	30	0	22
23	1.226-01	6.429-03	2.124+03	1.913+01	1.147+03	3.812+10	3.774+10	8.999+08	2.557+05	30	0	23
24	1.303-01	6.832-03	1.815+03	1.912+01	1.072+03	3.439+10	3.408+10	8.193+08	2.555+05	30	0	24
25	1.382-01	7.248-03	1.567+03	1.912+01	1.005+03	3.113+10	3.087+10	7.469+08	2.553+05	30	0	25
26	1.464-01	7.676-03	1.357+03	1.911+01	9.447+02	2.824+10	2.802+10	6.819+08	2.552+05	30	0	26
27	1.548-01	8.117-03	1.181+03	1.911+01	8.699+02	2.567+10	2.549+10	6.231+08	2.551+05	30	0	27
28	1.635-01	8.572-03	1.031+03	1.910+01	8.403+02	2.337+10	2.322+10	5.699+08	2.550+05	30	0	28
29	1.725-01	9.041-03	9.028+02	1.910+01	7.951+02	2.131+10	2.118+10	5.217+08	2.549+05	30	0	29
30	1.817-01	9.524-03	7.927+02	1.910+01	7.540+02	1.946+10	1.934+10	4.779+08	2.548+05	30	0	30
31	1.912-01	1.002-02	6.977+02	1.909+01	7.165+02	1.778+10	1.768+10	4.380+08	2.547+05	30	0	31
32	2.010-01	1.053-02	6.152+02	1.909+01	6.822+02	1.626+10	1.617+10	4.017+08	2.547+05	30	0	32
33	2.111-01	1.106-02	5.434+02	1.909+01	6.510+02	1.488+10	1.481+10	3.685+08	2.546+05	30	0	33
34	2.215-01	1.161-02	4.807+02	1.909+01	6.223+02	1.363+10	1.356+10	3.382+08	2.546+05	30	0	34
35	2.322-01	1.217-02	4.257+02	1.909+01	5.961+02	1.249+10	1.243+10	3.105+08	2.545+05	30	0	35
36	2.432-01	1.275-02	3.775+02	1.909+01	5.721+02	1.145+10	1.140+10	2.851+08	2.545+05	30	0	36
37	2.546-01	1.334-02	3.350+02	1.909+01	5.500+02	1.050+10	1.045+10	2.619+08	2.544+05	30	0	37
38	2.663-01	1.396-02	2.976+02	1.909+01	5.298+02	9.629+09	9.589+09	2.406+08	2.544+05	30	0	38
39	2.784-01	1.459-02	2.646+02	1.909+01	5.112+02	8.835+09	8.799+09	2.210+08	2.544+05	30	0	39
40	2.908-01	1.524-02	2.354+02	1.909+01	4.941+02	8.107+09	8.076+09	2.031+08	2.544+05	30	0	40
41	3.036-01	1.591-02	2.097+02	1.909+01	4.784+02	7.440+09	7.412+09	1.866+08	2.543+05	30	0	41
42	3.166-01	1.660-02	1.868+02	1.909+01	4.640+02	6.828+09	6.803+09	1.714+08	2.543+05	30	0	42
43	3.304-01	1.731-02	1.665+02	1.909+01	4.507+02	6.268+09	6.246+09	1.575+08	2.543+05	30	0	43
44	3.444-01	1.805-02	1.484+02	1.909+01	4.385+02	5.753+09	5.734+09	1.447+08	2.543+05	30	0	44
45	3.588-01	1.880-02	1.324+02	1.909+01	4.273+02	5.280+09	5.263+09	1.329+08	2.543+05	30	0	45
46	3.737-01	1.958-02	1.181+02	1.909+01	4.169+02	4.846+09	4.830+09	1.221+08	2.543+05	30	0	46
47	3.888-01	2.039-02	1.054+02	1.908+01	4.074+02	4.447+09	4.433+09	1.121+08	2.542+05	30	0	47
48	4.041-01	2.121-02	9.402+01	1.908+01	3.986+02	4.080+09	4.068+09	1.030+08	2.542+05	30	0	48
49	4.211-01	2.206-02	[illegible]	1.906+01	3.906+02	3.743+09	3.732+09	9.451+07	2.542+05	30	0	49
50	4.376-01	2.294-02	[illegible]	1.906+01	3.831+02	3.433+09	3.424+09	8.674+07	2.542+05	30	0	50

J	SMASS	X	U	RHO	T	S+Q	P	E	C	IV	IB	J
51	4.551-01	2.385-02	6.695+01	1.908+01	3.763+02	3.148+09	3.140+09	7.950+07	2.542+05	30	0	51
52	4.729-01	2.478-02	5.990+01	1.908+01	3.700+02	2.886+09	2.878+09	7.300+07	2.542+05	30	0	52
53	4.912-01	2.574-02	5.340+01	1.908+01	3.642+02	2.645+09	2.638+09	6.694+07	2.542+05	30	0	53
54	5.101-01	2.673-02	4.769+01	1.908+01	3.588+02	2.423+09	2.417+09	6.136+07	2.542+05	30	0	54
55	5.295-01	2.775-02	4.243+01	1.908+01	3.539+02	2.219+09	2.214+09	5.622+07	2.542+05	30	0	55
56	5.496-01	2.880-02	3.799+01	1.908+01	3.494+02	2.032+09	2.027+09	5.149+07	2.542+05	30	0	56
57	5.702-01	2.988-02	3.385+01	1.908+01	3.452+02	1.860+09	1.856+09	4.714+07	2.542+05	30	0	57
58	5.915-01	3.099-02	3.019+01	1.908+01	3.414+02	1.702+09	1.698+09	4.314+07	2.542+05	30	0	58
59	6.134-01	3.214-02	2.706+01	1.908+01	3.379+02	1.556+09	1.552+09	3.946+07	2.542+05	30	0	59
60	6.360-01	3.333-02	2.416+01	1.908+01	3.346+02	1.422+09	1.419+09	3.608+07	2.541+05	30	0	60
61	6.593-01	3.455-02	2.163+01	1.908+01	3.316+02	1.298+09	1.295+09	3.297+07	2.541+05	30	0	61
62	6.832-01	3.580-02	1.908+01	1.908+01	3.289+02	1.186+09	1.183+09	3.011+07	2.541+05	30	0	62
63	7.079-01	3.710-02	1.716+01	1.908+01	3.264+02	1.083+09	1.080+09	2.748+07	2.541+05	30	0	63
64	7.334-01	3.843-02	1.520+01	1.908+01	3.241+02	9.860+08	9.841+08	2.506+07	2.541+05	30	0	64
65	7.596-01	3.980-02	1.362+01	1.908+01	3.219+02	8.993+08	8.975+08	2.285+07	2.541+05	30	0	65
66	7.866-01	4.122-02	1.216+01	1.908+01	3.200+02	8.187+08	8.171+08	2.081+07	2.541+05	30	0	66
67	8.144-01	4.268-02	1.082+01	1.908+01	3.182+02	7.445+08	7.431+08	1.894+07	2.541+05	30	0	67
68	8.431-01	4.418-02	9.650+00	1.908+01	3.165+02	6.772+08	6.759+08	1.722+07	2.541+05	30	0	68
69	8.726-01	4.573-02	8.517+00	1.908+01	3.150+02	6.135+08	6.135+08	1.564+07	2.541+05	30	0	69
70	9.031-01	4.732-02	7.679+00	1.908+01	3.136+02	5.554+08	5.554+08	1.419+07	2.541+05	30	0	70
71	9.344-01	4.896-02	6.070+00	1.908+01	3.123+02	4.798+08	4.798+08	1.286+07	2.541+05	30	0	71
72	9.667-01	5.066-02	1.999+01	1.908+01	3.111+02	2.670+08	2.670+08	1.161+07	2.541+05	30	0	72
EXT	1.000+00	5.240-02	8.367+01									EXT

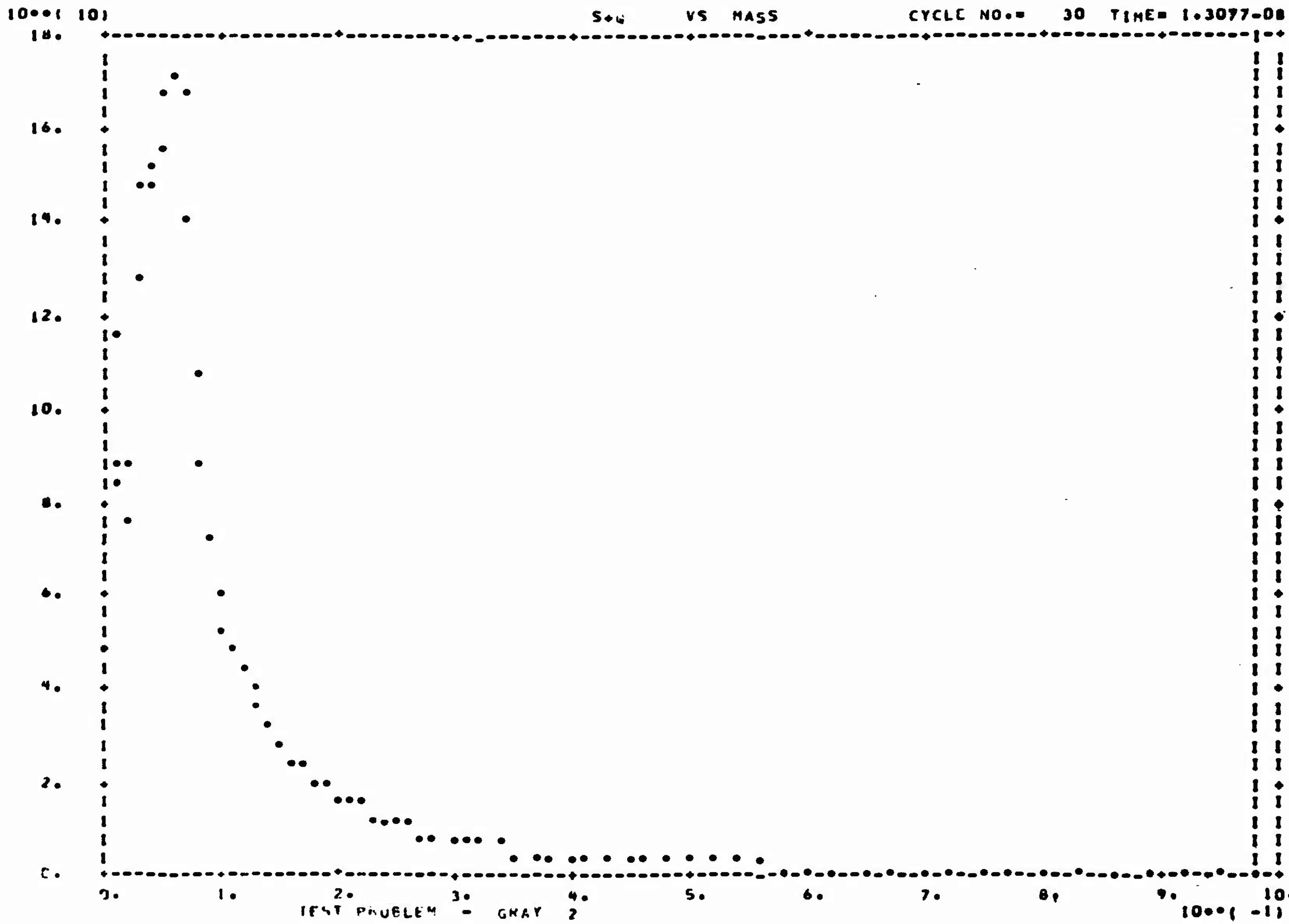
DTMPI	ICOURN
5.4690-10	4

TOTAL MOMENTUM

POS 9.1807+02
NEG -9.1807+02

TOTAL MOMENTUM BY LAYER

LAYER 1
POS 9.1807+02
NEG -9.1807+02


10**(10)
S+G VS MASS
CYCLE NO.= 30 TIME= 1.3077-08
18.
16.
14.
12.
10.
8.
6.
4.
2.
0.
0. 1. 2. 3. 4. 5. 6. 7. 8. 9. 10.
10**(-1)
TEST PROBLEM - GRAY 2

TEST PROBLEM - GRAY 2 CYCLE NO. = 40 TIME = 1.84313-08

J	SMASS	A	U	RHO	T	S+Q	P	E	C	IV	IB	J
1	0.000	-1.744-03	-2.807+05	3.280+00	4.642+04	5.388+10	5.388+10	4.146+10	1.409+05	35	0	1
2	4.000-03	-5.247-04	-1.100+05	7.460+00	3.368+04	1.058+11	1.058+11	3.108+10	1.639+05	35	0	2
3	8.121-03	-6.965-06	-6.341+04	1.083+01	2.563+04	1.250+11	1.250+11	2.466+10	1.896+05	35	0	3
4	1.237-02	3.853-04	-3.226+04	1.358+01	2.147+04	1.809+11	1.809+11	2.088+10	2.333+05	35	0	4
5	1.674-02	7.073-04	-2.651+04	1.401+01	1.457+04	1.596+11	1.596+11	1.638+10	3.234+05	33	0	5
6	2.125-02	1.029-03	-1.258+04	1.559+01	1.133+04	1.759+11	1.759+11	1.395+10	2.643+05	33	0	6
7	2.589-02	1.327-03	-1.039+04	1.594+01	9.030+03	1.516+11	1.516+11	1.138+10	2.703+05	33	0	7
8	3.064-02	1.627-03	-6.249+03	1.677+01	7.971+03	1.759+11	1.759+11	9.681+09	2.569+05	33	0	8
9	3.561-02	1.921-03	-3.002+03	1.697+01	6.702+03	1.511+11	1.506+11	8.071+09	2.398+05	33	0	9
10	4.060-02	2.220-03	-3.468+03	1.753+01	5.980+03	1.515+11	1.515+11	6.968+09	2.204+05	33	0	10
11	4.592-02	2.519-03	1.791+03	1.810+01	5.300+03	1.622+11	1.622+11	6.142+09	2.564+05	32	0	11
12	5.131-02	2.817-03	7.236+03	1.863+01	4.751+03	1.790+11	1.790+11	5.503+09	2.834+05	32	0	12
13	5.686-02	3.115-03	1.239+04	1.910+01	4.283+03	1.962+11	1.962+11	5.001+09	2.696+05	32	0	13
14	6.258-02	3.414-03	1.550+04	1.936+01	3.829+03	1.997+11	1.997+11	4.516+09	2.726+05	32	0	14
15	6.848-02	3.719-03	1.626+04	1.948+01	3.403+03	1.933+11	1.933+11	4.052+09	2.734+05	32	0	15
16	7.455-02	4.031-03	1.713+04	1.967+01	3.059+03	1.956+11	1.956+11	3.702+09	2.756+05	32	0	16
17	8.081-02	4.349-03	1.977+04	1.991+01	2.782+03	2.057+11	2.057+11	3.450+09	2.768+05	32	0	17
18	8.726-02	4.673-03	2.156+04	2.003+01	2.513+03	2.055+11	2.055+11	3.182+09	2.890+05	32	0	18
19	9.390-02	5.005-03	2.153+04	2.003+01	2.251+03	1.985+11	1.958+11	2.896+09	2.794+05	32	0	19
20	1.007-01	5.346-03	1.967+04	1.989+01	2.050+03	1.774+11	1.719+11	2.581+09	2.497+05	31	0	20
21	1.078-01	5.701-03	1.564+04	1.966+01	1.939+03	1.448+11	1.395+11	2.271+09	2.974+05	31	0	21
22	1.151-01	6.070-03	1.168+04	1.948+01	1.646+03	1.171+11	1.135+11	2.016+09	2.456+05	31	0	22
23	1.226-01	6.455-03	8.859+03	1.937+01	1.775+03	9.670+10	9.423+10	1.809+09	2.442+05	31	0	23
24	1.303-01	6.853-03	6.869+03	1.929+01	1.717+03	8.099+10	7.914+10	1.635+09	2.430+05	31	0	24
25	1.382-01	7.265-03	5.349+03	1.923+01	1.667+03	6.790+10	6.660+10	1.483+09	2.420+05	31	0	25
26	1.464-01	7.690-03	4.325+03	1.920+01	1.558+03	5.987+10	5.908+10	1.350+09	2.572+05	30	0	26
27	1.548-01	8.130-03	3.696+03	1.918+01	1.451+03	5.387+10	5.323+10	1.232+09	2.568+05	30	0	27
28	1.635-01	8.583-03	3.186+03	1.916+01	1.354+03	4.866+10	4.814+10	1.126+09	2.564+05	30	0	28
29	1.725-01	9.050-03	2.763+03	1.915+01	1.266+03	4.409+10	4.365+10	1.030+09	2.561+05	30	0	29
30	1.817-01	9.532-03	2.407+03	1.914+01	1.186+03	4.004+10	3.967+10	9.428+08	2.559+05	30	0	30
31	1.912-01	1.003-02	2.105+03	1.913+01	1.113+03	3.643+10	3.611+10	8.637+08	2.557+05	30	0	31
32	2.010-01	1.054-02	1.846+03	1.912+01	1.047+03	3.320+10	3.292+10	7.917+08	2.655+05	30	0	32
33	2.111-01	1.107-02	1.623+03	1.911+01	9.859+02	3.029+10	3.005+10	7.261+08	2.553+05	30	0	33
34	2.215-01	1.161-02	1.431+03	1.911+01	9.302+02	2.766+10	2.745+10	6.662+08	2.552+05	30	0	34
35	2.322-01	1.217-02	1.263+03	1.911+01	8.791+02	2.528+10	2.510+10	6.115+08	2.651+05	30	0	35
36	2.432-01	1.275-02	1.117+03	1.910+01	8.323+02	2.312+10	2.297+10	5.614+08	2.650+05	30	0	36
37	2.546-01	1.334-02	9.688+02	1.910+01	7.894+02	2.116+10	2.103+10	5.156+08	2.649+05	30	0	37
38	2.663-01	1.396-02	6.766+02	1.910+01	7.499+02	1.938+10	1.926+10	4.735+08	2.548+05	30	0	38
39	2.784-01	1.459-02	7.776+02	1.910+01	7.136+02	1.775+10	1.765+10	4.350+08	2.547+05	30	0	39
40	2.908-01	1.524-02	6.909+02	1.909+01	6.803+02	1.627+10	1.617+10	3.994+08	2.547+05	30	0	40
41	3.036-01	1.591-02	6.143+02	1.909+01	6.497+02	1.491+10	1.483+10	3.672+08	2.546+05	30	0	41
42	3.168-01	1.660-02	5.465+02	1.909+01	6.215+02	1.367+10	1.360+10	3.373+08	2.546+05	30	0	42
43	3.304-01	1.732-02	4.864+02	1.909+01	5.955+02	1.253+10	1.247+10	3.099+08	2.545+05	30	0	43
44	3.444-01	1.805-02	4.330+02	1.909+01	5.717+02	1.149+10	1.144+10	2.847+08	2.545+05	30	0	44
45	3.586-01	1.880-02	3.859+02	1.909+01	5.497+02	1.054+10	1.049+10	2.615+08	2.545+05	30	0	45
46	3.737-01	1.958-02	3.439+02	1.909+01	5.294+02	9.665+09	9.620+09	2.402+08	2.544+05	30	0	46
47	3.890-01	2.039-02	3.066+02	1.909+01	5.106+02	8.862+09	8.822+09	2.206+08	2.544+05	30	0	47
48	4.046-01	2.121-02	2.736+02	1.909+01	4.936+02	8.126+09	8.090+09	2.025+08	2.544+05	30	0	48
49	4.211-01	2.207-02	2.439+02	1.909+01	4.776+02	7.449+09	7.417+09	1.859+08	2.543+05	30	0	49
50	4.378-01	2.294-02	2.176+02	1.909+01	4.632+02	6.828+09	6.800+09	1.706+08	2.543+05	30	0	50

J	SMASS	X	U	RHO	T	S+Q	P	E	C	IV	IB	J
51	4.551-01	2.365-02	1.942+02	1.909+01	4.498+02	6.257+09	6.232+09	1.565+08	2.543+05	30	0	51
52	4.729-01	2.478-02	1.734+02	1.909+01	4.375+02	5.735+09	5.712+09	1.436+08	2.543+05	30	0	52
53	4.912-01	2.574-02	1.548+02	1.909+01	4.261+02	5.252+09	5.232+09	1.317+08	2.543+05	30	0	53
54	5.101-01	2.673-02	1.380+02	1.909+01	4.156+02	4.810+09	4.793+09	1.207+08	2.543+05	30	0	54
55	5.295-01	2.775-02	1.232+02	1.909+01	4.059+02	4.403+09	4.387+09	1.106+08	2.542+05	30	0	55
56	5.496-01	2.880-02	1.099+02	1.908+01	3.971+02	4.030+09	4.015+09	1.013+08	2.542+05	30	0	56
57	5.702-01	2.988-02	9.794+01	1.908+01	3.889+02	3.687+09	3.674+09	9.273+07	2.542+05	30	0	57
58	5.915-01	3.099-02	8.748+01	1.908+01	3.813+02	3.372+09	3.360+09	8.486+07	2.542+05	30	0	58
59	6.134-01	3.214-02	7.805+01	1.908+01	3.744+02	3.082+09	3.072+09	7.762+07	2.542+05	30	0	59
60	6.360-01	3.333-02	6.968+01	1.908+01	3.680+02	2.816+09	2.807+09	7.096+07	2.542+05	30	0	60
61	6.593-01	3.455-02	6.225+01	1.908+01	3.622+02	2.571+09	2.563+09	6.484+07	2.542+05	30	0	61
62	6.832-01	3.580-02	5.536+01	1.908+01	3.568+02	2.346+09	2.339+09	5.922+07	2.542+05	30	0	62
63	7.079-01	3.710-02	4.940+01	1.908+01	3.518+02	2.140+09	2.133+09	5.405+07	2.542+05	30	0	63
64	7.334-01	3.843-02	4.389+01	1.908+01	3.473+02	1.952+09	1.947+09	4.930+07	2.542+05	30	0	64
65	7.596-01	3.980-02	3.935+01	1.908+01	3.431+02	1.777+09	1.772+09	4.494+07	2.542+05	30	0	65
66	7.866-01	4.122-02	3.498+01	1.908+01	3.393+02	1.619+09	1.614+09	4.093+07	2.542+05	30	0	66
67	8.144-01	4.268-02	3.114+01	1.908+01	3.357+02	1.472+09	1.468+09	3.725+07	2.541+05	30	0	67
68	8.431-01	4.418-02	2.762+01	1.908+01	3.325+02	1.337+09	1.334+09	3.387+07	2.541+05	30	0	68
69	8.726-01	4.573-02	2.487+01	1.908+01	3.295+02	1.212+09	1.210+09	3.077+07	2.541+05	30	0	69
70	9.031-01	4.732-02	2.349+01	1.908+01	3.268+02	1.078+09	1.078+09	2.791+07	2.541+05	30	0	70
71	9.344-01	4.896-02	3.094+01	1.908+01	3.242+02	8.568+08	8.568+08	2.528+07	2.541+05	30	0	71
72	9.667-01	5.066-02	7.616+01	1.908+01	3.216+02	3.639+08	3.639+08	2.284+07	2.540+05	30	0	72
EXT	1.000+00	5.240-02	1.868+02									EXT

DTHP1	ICOURN
3.2128-10	4

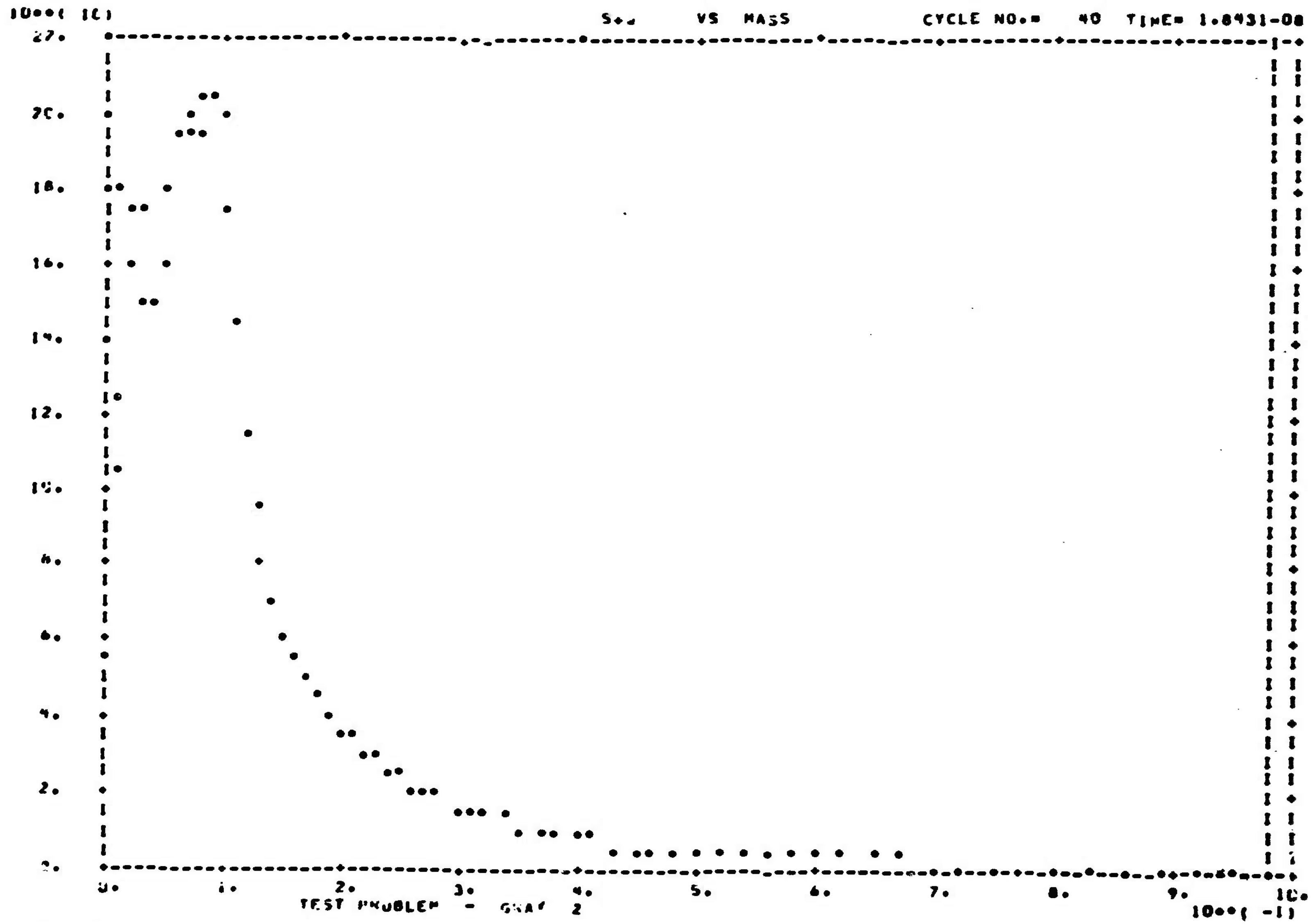
TOTAL MOMENTUM

POS 1.695C+03
NEG -1.695C+03

TOTAL MOMENTUM BY LAYER

LAYER 1

POS 1.695C+03
NEG -1.695C+03



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EASI COMMON FOR CYCLE NUMBER 40 WAS WRITTEN ON UNIT 20.

CEDIT COMMON FOR CYCLE NUMBER 40 WAS WRITTEN ON UNIT 20.

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FUNCT   COMMON FOR CYCLE NUMBER    40 WAS WRITTEN ON UNIT 20.
TEM     COMMON FOR CYCLE NUMBER    40 WAS WRITTEN ON UNIT 20.
GNAV    COMMON FOR CYCLE NUMBER    40 WAS WRITTEN ON UNIT 20.
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TEST PROBLEM - WRAY 2 CYCLE NO. = 50 TIME = 2.2745D-08

J	SMASS	X	U	RHO	T	S+Q	P	E	C	IV	IB	J
1	0.0	-3.223-03	-3.932+05	1.915+00	7.204+04	4.920+10	4.920+10	5.593+10	1.675+05	35	0	1
2	4.003-03	-1.130-03	-1.650+05	5.267+00	5.042+04	1.019+11	1.019+11	4.213+10	1.646+05	35	0	2
3	8.121-03	-3.478-04	-9.567+04	8.220+00	3.986+04	1.394+11	1.394+11	3.441+10	1.801+05	35	0	3
4	1.237-02	1.687-04	-5.509+04	1.053+01	3.177+04	1.631+11	1.601+11	2.846+10	1.991+05	35	0	4
5	1.674-02	5.842-04	-4.270+04	1.244+01	2.534+04	1.740+11	1.740+11	2.371+10	2.175+05	35	0	5
6	2.125-02	9.464-04	-1.650+04	1.364+01	1.954+04	1.620+11	1.615+11	1.964+10	5.808+05	35	0	6
7	2.589-02	1.287-03	-1.704+04	1.504+01	1.435+04	2.074+11	2.074+11	1.676+10	1.445+05	33	0	7
8	3.068-02	1.605-03	-4.807+03	1.596+01	1.164+04	2.081+11	2.081+11	1.428+10	2.720+05	33	0	8
9	3.561-02	1.914-03	1.595+03	1.663+01	1.002+04	2.220+11	2.202+11	1.223+10	2.752+05	33	0	9
10	4.068-02	2.219-03	-6.854+00	1.690+01	8.570+03	1.990+11	1.990+11	1.034+10	2.588+05	33	0	10
11	4.592-02	2.529-03	3.786+03	1.754+01	7.731+03	2.081+11	2.081+11	9.094+09	2.304+05	33	0	11
12	5.131-02	2.836-03	6.651+03	1.792+01	6.814+03	2.017+11	2.013+11	7.965+09	2.580+05	32	0	12
13	5.686-02	3.146-03	6.292+03	1.814+01	6.003+03	1.886+11	1.886+11	6.972+09	2.591+05	32	0	13
14	6.258-02	3.461-03	7.603+03	1.844+01	5.353+03	1.864+11	1.864+11	6.203+09	2.619+05	32	0	14
15	6.848-02	3.781-03	1.060+04	1.880+01	4.839+03	1.940+11	1.940+11	5.616+09	2.663+05	32	0	15
16	7.455-02	4.104-03	1.455+04	1.920+01	4.421+03	2.088+11	2.088+11	5.173+09	2.715+05	32	0	16
17	8.081-02	4.430-03	1.871+04	1.955+01	4.053+03	2.236+11	2.236+11	4.809+09	2.762+05	32	0	17
18	8.726-02	4.760-03	2.067+04	1.971+01	3.674+03	2.229+11	2.227+11	4.407+09	2.778+05	32	0	18
19	9.390-02	5.097-03	2.049+04	1.979+01	3.316+03	2.160+11	2.160+11	4.019+09	2.782+05	32	0	19
20	1.007-01	5.443-03	2.202+04	1.999+01	3.035+03	2.221+11	2.221+11	3.753+09	2.806+05	32	0	20
21	1.078-01	5.796-03	2.415+04	2.015+01	2.782+03	2.268+11	2.268+11	3.516+09	2.825+05	32	0	21
22	1.151-01	6.157-03	2.450+04	2.019+01	2.528+03	2.220+11	2.202+11	3.245+09	2.825+05	32	0	22
23	1.226-01	6.527-03	2.330+04	2.011+01	2.277+03	2.076+11	2.032+11	2.945+09	2.806+05	32	0	23
24	1.303-01	6.911-03	2.035+04	1.992+01	2.065+03	1.824+11	1.766+11	2.625+09	2.503+05	31	0	24
25	1.382-01	7.310-03	1.609+04	1.970+01	1.957+03	1.497+11	1.447+11	2.323+09	2.479+05	31	0	25
26	1.464-01	7.725-03	1.232+04	1.952+01	1.867+03	1.228+11	1.194+11	2.075+09	2.461+05	31	0	26
27	1.548-01	8.158-03	9.608+03	1.940+01	1.797+03	1.026+11	1.002+11	1.870+09	2.446+05	31	0	27
28	1.635-01	8.605-03	7.624+03	1.932+01	1.739+03	8.677+10	8.488+10	1.696+09	2.435+05	31	0	28
29	1.725-01	9.069-03	6.068+03	1.926+01	1.689+03	7.351+10	7.201+10	1.543+09	2.425+05	31	0	29
30	1.817-01	9.548-03	4.828+03	1.922+01	1.609+03	6.336+10	6.247+10	1.407+09	2.576+05	30	0	30
31	1.912-01	1.004-02	4.126+03	1.919+01	1.501+03	5.704+10	5.636+10	1.287+09	2.571+05	30	0	31
32	2.010-01	1.055-02	3.587+03	1.917+01	1.403+03	5.165+10	5.108+10	1.179+09	2.567+05	30	0	32
33	2.111-01	1.108-02	3.133+03	1.916+01	1.313+03	4.688+10	4.641+10	1.080+09	2.564+05	30	0	33
34	2.215-01	1.162-02	2.746+03	1.915+01	1.230+03	4.264+10	4.223+10	9.907+08	2.561+05	30	0	34
35	2.322-01	1.218-02	2.414+03	1.914+01	1.155+03	3.884+10	3.848+10	9.088+08	2.558+05	30	0	35
36	2.432-01	1.276-02	2.126+03	1.913+01	1.086+03	3.542+10	3.511+10	8.341+08	2.556+05	30	0	36
37	2.546-01	1.335-02	1.877+03	1.912+01	1.023+03	3.233+10	3.206+10	7.657+08	2.555+05	30	0	37
38	2.663-01	1.396-02	1.659+03	1.912+01	9.646+02	2.953+10	2.930+10	7.031+08	2.553+05	30	0	38
39	2.784-01	1.459-02	1.469+03	1.911+01	9.112+02	2.700+10	2.680+10	6.457+08	2.552+05	30	0	39
40	2.908-01	1.525-02	1.302+03	1.911+01	8.621+02	2.470+10	2.452+10	5.931+08	2.551+05	30	0	40
41	3.036-01	1.592-02	1.155+03	1.910+01	8.169+02	2.260+10	2.244+10	5.448+08	2.550+05	30	0	41
42	3.166-01	1.661-02	1.026+03	1.910+01	7.753+02	2.069+10	2.055+10	5.005+08	2.549+05	30	0	42
43	3.304-01	1.732-02	9.121+02	1.910+01	7.370+02	1.894+10	1.882+10	4.598+08	2.548+05	30	0	43
44	3.444-01	1.805-02	8.111+02	1.910+01	7.018+02	1.735+10	1.724+10	4.223+08	2.547+05	30	0	44
45	3.588-01	1.881-02	7.217+02	1.910+01	6.693+02	1.589+10	1.580+10	3.879+08	2.547+05	30	0	45
46	3.737-01	1.959-02	6.424+02	1.909+01	6.394+02	1.456+10	1.447+10	3.563+08	2.546+05	30	0	46
47	3.890-01	2.039-02	5.726+02	1.909+01	6.119+02	1.334+10	1.326+10	3.271+08	2.546+05	30	0	47
48	4.046-01	2.122-02	5.101+02	1.909+01	5.865+02	1.222+10	1.215+10	3.004+08	2.545+05	30	0	48
49	4.211-01	2.207-02	4.547+02	1.909+01	5.632+02	1.119+10	1.113+10	2.757+08	2.545+05	30	0	49
50	4.376-01	2.294-02	4.053+02	1.909+01	5.414+02	1.025+10	1.020+10	2.530+08	2.544+05	30	0	50

J	SMASS	X	U	RHO	T	S+Q	P	E	C	IV	IB	J
51	4.551-01	2.385-02	3.615+02	1.909+01	5.218+02	9.389+09	9.341+09	2.321+08	2.544+05	30	0	51
52	4.729-01	2.478-02	3.222+02	1.909+01	5.035+02	8.597+09	8.555+09	2.129+08	2.544+05	30	0	52
53	4.912-01	2.574-02	2.675+02	1.909+01	4.867+02	7.872+09	7.634+09	1.952+08	2.544+05	30	0	53
54	5.101-01	2.673-02	2.565+02	1.909+01	4.712+02	7.204+09	7.170+09	1.789+08	2.543+05	30	0	54
55	5.295-01	2.775-02	2.288+02	1.909+01	4.569+02	6.592+09	6.562+09	1.640+08	2.543+05	30	0	55
56	5.496-01	2.880-02	2.040+02	1.909+01	4.438+02	6.030+09	6.003+09	1.502+08	2.543+05	30	0	56
57	5.702-01	2.988-02	1.819+02	1.909+01	4.317+02	5.514+09	5.490+09	1.375+08	2.543+05	30	0	57
58	5.915-01	3.100-02	1.621+02	1.909+01	4.205+02	5.041+09	5.020+09	1.258+08	2.543+05	30	0	58
59	6.134-01	3.214-02	1.449+02	1.909+01	4.103+02	4.605+09	4.586+09	1.151+08	2.542+05	30	0	59
60	6.360-01	3.333-02	1.292+02	1.909+01	4.008+02	4.207+09	4.190+09	1.052+08	2.542+05	30	0	60
61	6.593-01	3.455-02	1.152+02	1.909+01	3.921+02	3.840+09	3.824+09	9.614+07	2.542+05	30	0	61
62	6.832-01	3.580-02	1.027+02	1.908+01	3.842+02	3.503+09	3.490+09	8.780+07	2.542+05	30	0	62
63	7.079-01	3.710-02	9.146+01	1.908+01	3.768+02	3.194+09	3.182+09	8.013+07	2.542+05	30	0	63
64	7.334-01	3.843-02	8.130+01	1.908+01	3.701+02	2.910+09	2.900+09	7.309+07	2.542+05	30	0	64
65	7.596-01	3.980-02	7.281+01	1.908+01	3.637+02	2.651+09	2.641+09	6.662+07	2.542+05	30	0	65
66	7.866-01	4.122-02	6.459+01	1.908+01	3.582+02	2.414+09	2.405+09	6.068+07	2.542+05	30	0	66
67	8.144-01	4.268-02	5.759+01	1.908+01	3.530+02	2.194+09	2.187+09	5.523+07	2.542+05	30	0	67
68	8.431-01	4.416-02	5.150+01	1.908+01	3.482+02	1.991+09	1.986+09	5.022+07	2.542+05	30	0	68
69	8.726-01	4.573-02	4.691+01	1.908+01	3.438+02	1.792+09	1.792+09	4.562+07	2.542+05	30	0	69
70	9.031-01	4.732-02	4.741+01	1.908+01	3.397+02	1.553+09	1.553+09	4.138+07	2.541+05	30	0	70
71	9.344-01	4.896-02	7.122+01	1.908+01	3.358+02	1.130+09	1.130+09	3.747+07	2.541+05	30	0	71
72	9.667-01	5.066-02	1.523+02	1.907+01	3.320+02	4.162+08	4.162+08	3.385+07	2.539+05	30	0	72
EXT	1.000+00	5.240-02	2.857+02									EXT

DTHP1	ICOURN
5.6980-10	8

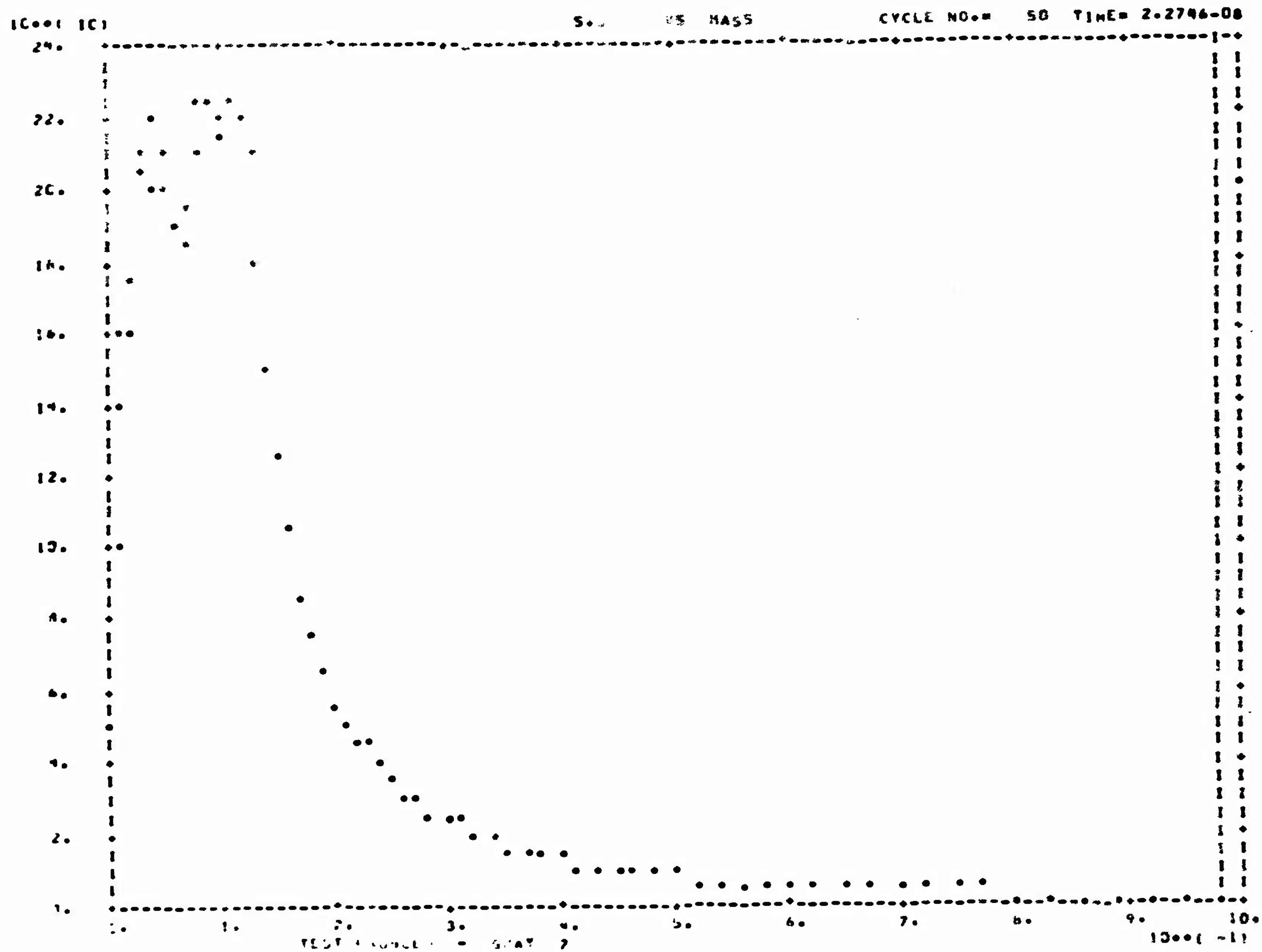
TOTAL MOMENTUM

POS 2.4531+03
NEG -2.4531+03

TOTAL MOMENTUM BY LAYER

LAYER 1

POS 2.4531+03
NEG -2.4531+03



CYCLE NO.= 50 TIME= 2.2796-08
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