KSIG - KANSAS STATE UNIVERSITY ISOTOPE GENERATION MICROCOMPUTER PROGRAM

by

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I. Introduction

During the operation of a nuclear reactor, the nuclear fuel, fuel cladding, and even the reactor vessel, undergo certain nuclear changes. These changes are a result of the fissioning of fissile atoms, the interaction of neutrons with matter, and of radioactive decay of radioactive isotopes. For example, an atom of U-235 could undergo neutron induced fission resulting in an atom of I-135, Y-98 and three neutrons. The atom of I-135 could then undergo beta-decay resulting in an atom of Xe-135. This atom of Xe-135 could then absorb a neutron and release a high energy photon. Figure 1 is an example of this transition chain.

$$^{235}_{92}U + ^{1}_{0}n \xrightarrow{\text{Fission}} ^{135}_{53}I + ^{98}_{39}Y + 3\ ^{1}_{0}n$$

$$^{135}_{53}I \xrightarrow[\text{decay}]{\text{Beta-}} ^{135}_{54}Xe + ^{0}_{-1}\beta$$

$$^{135}_{54}Xe + ^{1}_{0}n \xrightarrow{(n,\gamma)} ^{136}_{54}Xe + ^{0}_{0}\gamma$$

Figure 1. A simple example of a transition chain

The calculations performed to track these transitions are called isotope inventory calculations.

Those interested in isotope inventory calculations include people involved in reactor operations, those who deal with radiation shielding, and those who reprocess spent nuclear fuel.

The interest of those in reactor operations stems from the buildup of nuclear poisons, i.e., those isotopes with a large affinity for the absorption of neutrons (large neutron absorption cross sections, e.g., Xe-135). If these isotopes are allowed to build up they will reduce the number of neutrons available for the fissioning process. Hence, the reactor will sustain poor neutron economy and may not be capable of maintaining a chain reaction. Isotope inventory calculations could estimate the poison value of isotopes such as Xe-135 and could predict a shutdown time which would provide enough reactivity to allow an immediate return to full power.

Shielding considerations require isotope inventory calculations for the life of the nuclear fuel. From operation to long-term storage of spent fuel, shielding calculations are performed based on expected inventories of isotopes whose radioactive decay results in a high energy gamma emission. Special emphasis is on those isotopes whose half-lives are longer than a few minutes.

Finally, those interested in fuel reprocessing like to know the amounts of certain fissile isotopes they have present, as well as the amounts of isotopes which are involved, in a major way, with the chemical reprocessing of spent fuel. If special precautions are not taken in controlling the concentration of the fissile isotopes, the vat containing the reprocessed fuel could become critical or super-critical resulting in costly damage to the facility as well as to those operating the facility.

The methods used in isotope inventory calculations range from simple hand calculations, such as the exponential decay of Co-60, to very complex computer simulations. Among these computer simulations are SANDIA-ORIGEN[1], KORIGEN[2], ORIGEN-S[3], and ORIGEN2[4]. Each of these codes is based on the computer code ORIGEN[5] produced by the Oak Ridge National Lab (ORNL).

The most popular computer code used for isotope inventory calculations is ORIGEN2. ORIGEN2, also produced by ORNL, is a revision and update of the method of calculation that ORIGEN had used, that is, the matrix exponential method [4]. Among the changes made to ORIGEN were, the addition of variable cross sections, variable fission yields, a more flexible input deck, the addition of cross section libraries for more reactor types, and the inclusion of a method for using data generated by more sophisticated codes as an initial data base. The functions of ORIGEN2 include: 1) the calculation of isotopic abundances, 2) the calculation of radioactivity and related parameters, 3) the calculation of inhalation/ingestion hazard, and 4) the calculation of simple neutronic parameters.

The calculation of isotopic abundance is the primary function of ORIGEN2. From that calculation stem all of the other calculations. Once calculated, isotopic abundance can be output in grams, gram-atoms, atom fractions, and weight fractions. These tables can be produced for either the individual isotopes or the total contribution from each element. Further provision is even made for the output of the isotopic composition of each element.

Radioactivity tables are provided for alpha activity, total activity, and photon emission. The alpha and total activity tables are provided in curies, or fraction of total and are provided for both isotopes and elements. The photon emission tables encompass the total energy spectrum of photons and segments it into eighteen groups. Also, a table containing the decay heat of each isotope and/or element is produced.

Inhalation/ingestion hazards are calculated based on the Federal Regulations Guide 10CFR20[6]. The output is the volume of air or water required to dilute the isotope/element to acceptable levels. An option is provided to output the fraction of total dilution required.

The neutronic parameters provided are burnup, infinite multiplication factor, neutron production/destruction, specific power, and neutron flux. The neutronic parameters provided for each isotope/element are neutron absorption rate, neutron induced fission rate, (alpha, n) neutron production, and spontaneous fission neutron production. These are considered simple neutronic parameters because they are calculated for a point reactor, and each parameter is found by multiplying an isotopic abundance by some neutronic scaling factor such as microscopic cross section and neutron flux.

An important feature of ORIGEN2 is its ability to store inventory vectors in permanent files. This allows the output of ORIGEN2 to provide direct input to another code which makes use of isotope inventory data.

Some of the limitations observed in this code are: 1) It requires a large virtual machine to perform the transition calculations; 2) it requires a great deal of computer time to complete these calculations; and 3) it provides a great deal of output. A small job performed required a memory of approximately 870K-bytes of machine storage (2048K-bytes is the maximum permissible for the KSU Computing Facility), 4½ minutes of CPU time and an output of approximately 160 pages. Thus, one can see that operating ORIGEN2 can be a costly procedure.

The objective of this research is to reduce the cost of isotope inventory calculations. This is done by removing the need for a mainframe computer. To do this the size of the job needs to be considerably reduced.

In ORIGEN2 the two major users of space are the code itself and the associated data libraries. By storing those libraries outside of main memory on an external disk, more room is provided for other needs.

Reduction of the size of the code can be achieved by eliminating options which can be performed externally using an isotope inventory generated by the inventory code. Further reduction can be obtained by isolating functions and eliminating the code needed to perform these functions after the function was completed. Such functions could include data input, calculation, and output.

Moving from the mainframe to a microcomputer provides problems other than size. Calculational effort requires much more time on a microcomputer than on the mainframe. To overcome this, approximations can be used and the number of isotopes considered can be reduced by the consideration of subsets of isotopes. Each isotope of concern has a limited number of other isotopes which contribute significantly to its abundance. By considering only these isotopes, the number of calculations required is reduced more than proportionally.

By reducing the size of the job, moving from the mainframe to a microcomputer, and reducing the number of calculations the cost of isotope inventory calculations can be reduced.

II. Development of Equations

To perform isotope inventory calculations one needs to determine three things. First, if given constant power one must determine neutron flux. Second, if given constant flux one must determine a fission product production rate. And finally, given constant initial conditions, constant production rates and constant flux, one must calculate abundances for each isotope of interest.

To calculate a neutron flux from a constant thermal power, one needs several equations which link these two variables. The first of these equations could be the determination of the fission rate [7], R_F,

$$R_F = \frac{m\sigma_f}{A}\phi , \tag{2.1}$$

where m is the mass of the isotope of interest,

σ_f is the microscopic fission cross section of the isotope of interest,

A is the atomic weight of the fissile isotope of interest, and

ϕ is the neutron flux.

Given the fission rate of all fissile isotopes, one can find the total power by summing the products of all the fission rates and the energy released per fission, or,

$$P_{th} = \sum_{i=1}^{N} R_{fi} E_{fi}, \tag{2.2}$$

where P_{th} is the thermal power,

N is the total number of contributing fissile isotopes, and

E_f is the amount of energy released per fission.

E_f can be found by the following empirical relationship [8],

$$E_f = 1.29927 \times 10^{-3} \times Z^2 \sqrt{A} + 33.12, \text{ \{MeV/Fission\}} \qquad (2.3)$$

where Z is the atomic number of the fissile isotope for which E_f is being calculated.

Combining Eq. (2.1) and Eq. (2.2) and solving for neutron flux yields the following equation,

$$\phi = \frac{P_{th}}{\sum_{i=1}^{N} \frac{m_i \sigma_{fi} E_{fi}}{A_i}} . \qquad (2.4)$$

Applying units, as such,

$$\phi = \frac{P_{th} \text{ \{MW/unit\}}}{\sum_{i=1}^{N} \frac{m_i\text{\{g/unit\}} \times \sigma_{fi}\text{\{barns\}} \times E_{fi}\text{\{MeV/Fission\}}}{A_i\text{\{g/mol\}}}} , \qquad (2.5)$$

demonstrates the need for conversion factors. Applying these conversion factors gives

$$\phi = \frac{P_{th}}{\sum_{i=1}^{N} \frac{m_i \sigma_{fi}}{A_i}} \left\{\frac{\text{MW} \times \text{Fission}}{\text{MeV} \times \text{barns} \times \text{mol}}\right\} \times \frac{10^6\text{\{J/MW}\cdot\text{s\}}}{1.6021 \times 10^{-13}\text{\{J/MeV\}}}$$

$$\times \frac{10^{24}\text{\{barns/cm}^2\text{\}}}{6.0225 \times 10^{23} \text{ \{fission/mol\}}} , \qquad (2.6)$$

or,

$$\phi = \frac{P_{th}}{\sum_{i=1}^{N} \frac{m_i \sigma_{fi} E_{fi}}{A_i}} \times 1.036 \times 10^{19} \text{ \{cm}^{-2}\text{ s}^{-1}\text{\}} . \qquad (2.7)$$

Similarly, power can be calculated by rearranging Eq. (2.7) to give,

$$P_{th} = \frac{\phi}{1.036 \times 10^{19}} \sum_{i=1}^{N} \frac{m_i \sigma_{fi} E_{fi}}{A_i} \{MW/unit\}. \quad (2.8)$$

Now that neutron flux is known, one can find the fission product production rate. It is found by multiplying each fission rate by its appropriate fission yield and summing over all contributions, or,

$$Prod = \sum_{i=1}^{N} R_{fi}\ f_{yi}, \quad (2.9)$$

where Prod is the fission product production rate and

f_{yi} is the fission yield.

Combining Eq. (2.1) and Eq. (2.7) gives,

$$Prod = \sum_{i=1}^{N} \frac{m_i \sigma_{fi} f_{yi}}{A_i} \phi\ . \quad (2.10)$$

Applying units and conversion factors gives,

$$Prod = \sum_{i=1}^{N} \frac{m_i\{g/unit\} \times \sigma_{fi}\{barns\} \times f_{yi} \times \phi\{cm^{-2}\ s^{-1}\}}{A_i\{g/mole\}} \quad (2.11)$$

$$\times 10^{-24}\ \{cm^2/barn\},$$

which, upon cancellation of terms, is,

$$Prod = \sum_{i=1}^{N} \frac{m_i \sigma_{fi} f_{yi}}{A_i} \phi \times 10^{-24} \left\{\frac{mole}{unit \cdot sec}\right\} . \quad (2.12$$

To calculate isotopic abundance one must solve the following set of coupled first order differential equations:

$$\frac{dN_1}{dt} + N_1\Omega_1 = Prod_1 ,$$

$$\frac{dN_2}{dt} + N_2\Omega_2 = Prod_2 + \varepsilon_1 N_1 , \quad (2.13)$$

$$\vdots$$

$$\frac{dN_i}{dt} + N_i\Omega_i = Prod_i + \varepsilon_{i-1}N_{i-1} ,$$

where, N_i is the abundance of isotope i (mol),

$Prod_i$ is the rate of production of isotope i,

ε_i is the coupling coefficient between isotope i-1 and isotope i, and

Ω_i is the total transition coefficient of isotope i.

The solution of these equations is called a Bateman equation [9].

The coupling coefficient ε_i is the rate at which one isotope is converted to another. This conversion can be the result of a neutron interaction, for which

$$\varepsilon_i = \sigma_{(n,x)i}\phi, \quad (2.14)$$

where, $\sigma_{(n,x)}$ is the microscopic cross section for the reaction where isotope i absorbs a neutron and emits a particle of type x,

or as a result of radioactive decay, for which

$$\varepsilon_i = \frac{\ln(2)}{T_{\frac{1}{2}i}} F_{xi}, \quad (2.15)$$

where, $T_{\frac{1}{2}i}$ is the radioactive half-life of this isotope, and

F_{xi} is the fraction of decays which results in the emission of particle type x.

The total transition coefficient, Ω_i is the sum of all possible coupling coefficients, which is,

$$\Omega_i = \sigma_{ai}\,\phi + \frac{\ln(2)}{T_{\frac{1}{2}i}}\,, \tag{2.16}$$

where, σ_{ai} is the neutron absorption cross section of isotope i.

If initial amounts and production rates are considered for each isotope in this system of equations, the Bateman solution of these equations becomes quite complex. Instead it is assumed that only the first isotope has a non-zero production rate, and a non-zero initial concentration. All other rates and initial concentrations are cared for using the principle of superposition. Figure 2 demonstrates the use of superposition in determining the concentration of Xe-135 from its major precursors.

Fission production and initial concentration are not both considered at the same time. A different set of solutions is determined for each, and the principle of superposition is again used to reunite these two solutions.

Consider first the situation where constant production exists and all initial amounts are set to zero. The system of equations to be solved is the following,

$$\frac{dN_1}{dt} + N_1\Omega_1 = Prod_1,$$

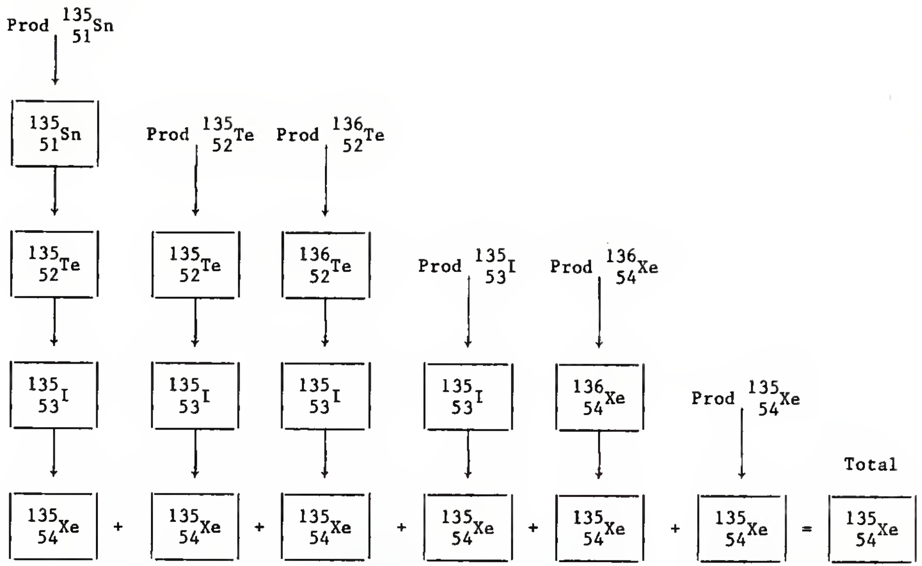

Figure 2. An example of superposition for Xe-135.

$$\frac{dN_2}{dt} + N_2\Omega_2 = N_1\varepsilon_1 \,, \tag{2.17}$$

$$\vdots$$

$$\frac{dN_i}{dt} + N_i\Omega_i = N_{i-1}\,\varepsilon_{i-1} \,,$$

where,

$$N_1(0) = N_2(0) = \ldots = N_i(0) = 0. \tag{2.18}$$

Performing Laplace transforms on this system yields,

$$s\bar{N}_1 + \Omega_1\bar{N}_1 = \frac{\text{Prod}}{s} \,,$$

$$s\bar{N}_2 + \Omega_2\bar{N}_2 = \varepsilon_1\bar{N}_1 \,, \tag{2.19}$$

$$\vdots$$

$$s\bar{N}_i + \Omega_i\bar{N}_i = \varepsilon_{i-1}\bar{N}_{i-1} \,.$$

Successive substitution of each equation into the next yields,

$$\bar{N}_i = \frac{\text{Prod} \prod_{j=1}^{i-1} \varepsilon_j}{s \prod_{j=1}^{i} (s + \Omega_j)} \,. \tag{2.20}$$

Assume that all of the total transition coefficients are independent, that is,

$$\Omega_1 \neq \Omega_2 \neq \Omega_3 \neq \ldots \neq \Omega_i \,. \tag{2.21}$$

Therefore, one can assume a solution of the form,

$$\frac{\bar{N}_i}{\text{Prod} \prod_{j=1}^{i-1} \varepsilon_j} = \frac{1}{s \prod_{j=1}^{i} (s + \Omega_j)} = \sum_{j=1}^{i} B_j \left(\frac{1}{s} - \frac{1}{s + \Omega_j}\right) + \frac{A}{s} \,. \tag{2.22}$$

which, if the B_j are selected properly, form a complete solution set without A.

To determine the B_j, multiply by $(s + \Omega_j)$ and let s approach $-\Omega_j$, to obtain,

$$B_j \Omega_j = \frac{1}{\prod_{\substack{k=1 \\ k \neq j}}^{i} (\Omega_k - \Omega_j)} . \tag{2.24}$$

Thus,

$$B_j = \frac{1}{\Omega_j \prod_{\substack{k=1 \\ k \neq i}}^{i} (\Omega_k - \Omega_j)} . \tag{2.25}$$

Applying the inverse Laplace transform to Eq. (2.22) and rearranging yields the general result

$$N_i = \text{Prod} \prod_{j=1}^{i-1} \varepsilon_j \sum_{j=1}^{i} \frac{1 - e^{-\Omega_j t}}{\Omega_j \prod_{\substack{k=1 \\ k \neq j}}^{i} (\Omega_k - \Omega_j)} . \tag{2.26}$$

One cannot always assume that the Ω_j are independent. For instance, if an isotope appears in its own transition chain then there will be at least two total transition coefficients which are the same. An example of this would be I-131 which could beta-decay to Xe-131, which could then undergo a (n,p) reaction to form I-131 again. Figure 3 demonstrates this.

$${}^{131}_{53}I \xrightarrow[\text{decay}]{\text{Beta-}} {}^{131}_{54}Xe + {}^{0}_{-1}\beta$$

$${}^{131}_{54}Xe + {}^{1}_{0}n \xrightarrow{(n,p)} {}^{131}_{53}I + {}^{1}_{1}H$$

Figure 3. An example of an isotope appearing in its own transition chain.

In this case assume,

$$\Omega_\ell = \Omega_m, \tag{2.27}$$

and seek a solution of the form,

$$\frac{\bar{N}_i}{\text{Prod} \prod_{j=1}^{i-1} \varepsilon_j} = \frac{1}{s \prod_{j=1}^{i} (s+\Omega)} = \sum_{\substack{j=1 \\ j\neq \ell,m}}^{i} B_j \left(\frac{1}{s} - \frac{1}{s + \Omega_j}\right) + C_o \left(\frac{1}{s} - \frac{1}{s+\Omega_\ell}\right)$$

$$+ \frac{C_1}{(s+\Omega_\ell)^2} + \frac{A}{s} . \tag{2.28}$$

Multiplying by S gives,

$$\frac{1}{\prod_{j=1}^{i} (s+\Omega_j)} = \sum_{\substack{j=1 \\ j\neq \ell,m}}^{i} \frac{B_j\Omega_j}{s+\Omega_j} + \frac{C_o\Omega_\ell}{s+\Omega_\ell} + \frac{C_1 s}{(s+\Omega_\ell)^2} + A , \tag{2.29}$$

which, upon rearranging, becomes,

$$\frac{1}{\prod_{j=1}^{i} (s+\Omega_j)} = \sum_{\substack{j=1 \\ j\neq \ell,m}}^{i} \frac{B_j\Omega_j}{s+\Omega_j} + \frac{C_0'}{s+\Omega_\ell} - \frac{\Omega_\ell C_1}{(s+\Omega_\ell)^2} + A . \tag{2.30}$$

If the B_j, C_o, and C_1 are chosen properly, they form a complete set of solutions on their own and A is not needed. The B_j are found as before by multiplying by $(s + \Omega_j)$ and letting s approach $-\Omega_j$, to obtain,

$$B_j = \frac{1}{\Omega_j \prod_{\substack{k=1 \\ k\neq j}}^{i} (\Omega_k-\Omega_j)} . \tag{2.31}$$

Similarly, C_1 is found by multiplying each side of Eq. (2.30) by $(s + \Omega_\ell)^2$ and letting s approach $-\Omega_\ell$, which gives,

$$-\Omega_\ell C_1 = \frac{1}{\prod\limits_{\substack{k=1\\k\neq\ell,m}}^{i} (\Omega_k-\Omega_\ell)} , \tag{2.32}$$

or,

$$C_1 = -\frac{1}{\Omega_\ell \prod\limits_{\substack{k=1\\k\neq\ell,m}}^{i} (\Omega_k-\Omega_\ell)} . \tag{2.33}$$

In order to determine C_o one needs to derive the first few equations, using a direct application of differential equation techniques, and from those deduce the general form of C_o. As Eq. (2.20) indicates, the order in which the equations fall is unimportant to the final solution. Thus, Ω_1, can be set equal to Ω_2 without any loss of generality. Deriving the first four equations yields,

$$N_1 = \frac{\text{Prod}}{\Omega_1}(1 - e^{-\Omega_1 t}) , \tag{2.34}$$

$$N_2 = \text{Prod} \cdot \varepsilon_1 \left(\frac{1}{\Omega_1^2}(1 - e^{-\Omega_1 t}) - \frac{1}{\Omega_1} t e^{-\Omega_1 t}\right) , \tag{2.35}$$

$$N_3 = \text{Prod} \cdot \varepsilon_1\varepsilon_2 \left[\frac{\frac{1}{\Omega_1} - \frac{1}{\Omega_3-\Omega_1}}{\Omega_1(\Omega_3-\Omega_1)}(1 - e^{-\Omega_1 t}) + \frac{1-e^{-\Omega_3 t}}{\Omega_3(\Omega_1-\Omega_3)^2} - \frac{t e^{-\Omega_1 t}}{\Omega_1(\Omega_3-\Omega_1)}\right] \tag{2.36}$$

and,

$$N_4 = \text{Prod} \cdot \varepsilon_1\varepsilon_2\varepsilon_3 \left[\frac{\frac{1}{\Omega_1} - \frac{1}{\Omega_3-\Omega_1} - \frac{1}{\Omega_4-\Omega_1}}{\Omega_1(\Omega_3-\Omega_1)(\Omega_4-\Omega_1)}(1 - e^{-\Omega_1 t}) + \frac{1 - e^{-\Omega_3 t}}{\Omega_3(\Omega_1-\Omega_3)^2(\Omega_4-\Omega_3)}\right.$$

$$\left. + \frac{1 - e^{-\Omega_4 t}}{\Omega_4(\Omega_1-\Omega_4)^2(\Omega_3-\Omega_4)} - \frac{t e^{-\Omega_1 t}}{\Omega_1(\Omega_3-\Omega_1)(\Omega_4-\Omega_1)}\right] . \tag{2.37}$$

From this one can deduce the general form of C_o to be,

$$C_o = \frac{\dfrac{1}{\Omega_\ell} - \displaystyle\sum_{\substack{j=1\\ j\neq \ell,m}}^{i} \frac{1}{\Omega_j-\Omega_\ell}}{\Omega_\ell \displaystyle\prod_{\substack{j=1\\ j\neq \ell,m}}^{i} (\Omega_j-\Omega_\ell)} . \tag{2.38}$$

Applying an inverse Laplace transform to Eq. (2.28) gives,

$$N_i = \text{Prod} \prod_{j=1}^{i-1} \varepsilon_j \left(\sum_{\substack{j=1\\ j\neq \ell,m}}^{i} \frac{1 - e^{-\Omega_j t}}{\Omega_j \displaystyle\prod_{\substack{k=1\\ k\neq j}}^{i} (\Omega_k-\Omega_j)} + \frac{\dfrac{1}{\Omega_\ell} - \displaystyle\sum_{\substack{j=1\\ j\neq \ell,m}}^{i} \frac{1}{\Omega_j-\Omega_\ell}}{\Omega_\ell \displaystyle\prod_{\substack{j=1\\ j\neq \ell,m}}^{i} (\Omega_j-\Omega_\ell)} - \frac{t\, e^{-\Omega_\ell t}}{\Omega_\ell \displaystyle\prod_{\substack{j=1\\ j\neq \ell,m}}^{i} (\Omega_j-\Omega_\ell)} \right) , \tag{2.39}$$

the general solution of Eq. (2.17) for Ω_ℓ equal to Ω_m.

A third special case is the case where one isotope is both radioactively stable and has a negligible neutron absorption cross section. This can only occur at the end of the transition chain. Thus, Eq. (2.20) becomes,

$$\bar{N}_i = \frac{\text{Prod} \displaystyle\prod_{j=1}^{i-1} \varepsilon_j}{s^2 \displaystyle\prod_{j=1}^{i-1} (s+\Omega\ )} , \tag{2.40}$$

and one seeks a solution of the form,

$$\frac{\bar{N}_i}{\text{Prod} \displaystyle\prod_{j=1}^{i-1} \varepsilon_j} = \frac{1}{s^2 \displaystyle\prod_{j=1}^{i-1} (s+\Omega_j)} = \sum_{j=1}^{i-1} B_j \left(\frac{1}{s} - \frac{1}{s+\Omega_j}\right) + \frac{C_o}{s^2} + \frac{C_1}{s} . \tag{2.41}$$

Multiplying by s gives,

$$\frac{1}{s \prod_{j=1}^{i-1} (s+\Omega_j)} = \sum_{j=1}^{i-1} \frac{B_j \Omega_j}{s+\Omega_j} + \frac{C_o}{s} + C_1 . \tag{2.42}$$

The B_j and C_o, if chosen properly, form a complete solution without C_1. The B_j are found by multiplying by $(s+\Omega_j)$ snd letting s approach $-\Omega_j$. This results in,

$$B_j = \frac{-1}{\Omega_j^2 \prod_{\substack{k=1 \\ k\neq j}}^{i-1} (\Omega_k \cdot \Omega_j)} . \tag{2.43}$$

Similarly, to find C_o, multiply Eq. (2.42) by s and let s approach zero. Thus,

$$C_o = \frac{1}{\prod_{j=1}^{i-1} \Omega_j} . \tag{2.44}$$

Applying an inverse Laplace transform to Eq. (2.41) gives,

$$N_i = \text{Prod} \prod_{j=1}^{i-1} \varepsilon_j \left[\frac{t}{\prod_{j=1}^{i-1} \Omega_j} - \sum_{j=1}^{i-1} \frac{1 - e^{-\Omega_j t}}{\Omega_j^2 \prod_{\substack{k=1 \\ k\neq j}}^{i-1} (\Omega_k - \Omega_j)} \right] . \tag{2.45}$$

Now consider the second branch of Bateman equations, those in which no production is considered, snd only the first isotope in each chain is considered to have any initial amount. The system of equations for this case is,

$$\frac{dN_1}{dt} + N_1 \Omega_1 = 0 ,$$

$$\frac{dN_2}{dt} + N_2\Omega_2 = N_1\varepsilon_1 \ , \tag{2.46}$$

$$\vdots$$

$$\frac{dN_i}{dt} + N_i\Omega_i = N_{i-1}\,\varepsilon_{i-1} \ ,$$

where,

$$N_1(0) = X \ , \tag{2.47}$$

and,

$$N_2(0) = N_3(0) = \ldots = N_i(0) = 0 \ . \tag{2.48}$$

Performing a Laplace transform on this system yields,

$$s\bar{N}_1 + \Omega_1\bar{N}_1 = X \ ,$$

$$s\bar{N}_2 + \Omega_2\bar{N}_2 = \varepsilon_1\bar{N}_1 \ , \tag{2.49}$$

$$\vdots$$

$$s\bar{N}_i + \Omega_i\bar{N}_i = \varepsilon_{i-1}\bar{N}_{i-1} \ .$$

Successive substitution of each equation into the next gives,

$$\bar{N}_i = \frac{X \prod_{j=1}^{i-1} \varepsilon_j}{\prod_{j=1}^{i} (s+\Omega_j)} \ . \tag{2.50}$$

Now, assuming that all of the total transition coefficients are independent, as in Eq. (2.21), a solution of the form,

$$\frac{\bar{N}_i}{X \prod_{j=1}^{i-1} \varepsilon_j} = \frac{1}{\prod_{j=1}^{i} (s+\Omega_j)} = \sum_{j=1}^{i} \frac{B_j}{s+\Omega_j} \ , \tag{2.51}$$

should be sought. To find the B_j, multiply each side by $(s+\Omega_j)$ and let s approach $-\Omega_j$. This yields,

$$B_j = \frac{1}{\prod_{\substack{k=1\\k\neq j}}^{i} (\Omega_k - \Omega_j)} . \tag{2.52}$$

Applying the inverse Laplace transform to Eq. (2.51) and rearranging yields the general result,

$$N_i = X \prod_{j=1}^{i-1} \varepsilon_j \sum_{j=1}^{i} \frac{e^{-\Omega_j t}}{\prod_{\substack{k=1\\k\neq j}}^{i} (\Omega_k - \Omega_j)} . \tag{2.53}$$

Once again, one cannot always assume independence for all the transition coefficients. The situation found in Eq. (2.27) could arise. In this case, a solution of the form,

$$\frac{\bar{N}_i}{X \prod_{j=1}^{i-1} \varepsilon_j} = \frac{1}{\prod_{j=1}^{i} (s+\Omega_j)} = \sum_{\substack{j=1\\j\neq \ell,m}}^{i} \frac{B_j}{s+\Omega_j} + \frac{C_o}{s+\Omega_\ell} + \frac{C_1}{(s+\Omega_\ell)^2} , \tag{2.54}$$

is sought. The B_j are found, as before, by multiplying each side of Eq. (2.54) by $(s+\Omega_j)$ and letting s approach $-\Omega_j$. This yields,

$$B_j = \frac{1}{\prod_{\substack{k=1\\k\neq j}}^{i} (\Omega_k - \Omega_j)} . \tag{2.55}$$

Similarly, to find C_1, multiply by $(s+\Omega_\ell)^2$ and let s approach $-\Omega_\ell$, to give,

$$C_1 = \frac{1}{\prod\limits_{\substack{j=1 \\ j\neq \ell,m}}^{i} (\Omega_j - \Omega_\ell)} . \tag{2.56}$$

Again, no smooth formulae are provided to determine C_o. One needs to derive the first few equations using direct substitution and differential equation techniques, and from these deduce the correct general form of C_o. Once again, the order of substitution is unimportant, so for simplicity assume Ω_1 is equal to Ω_2. Deriving the first few equations yields,

$$N_1 = Xe^{-\Omega_1 t} , \tag{2.57}$$

$$N_2 = X\varepsilon_1 \, [te^{-\Omega_1 t} - e^{-\Omega_1 t}] , \tag{2.58}$$

$$N_3 = X\varepsilon_1\varepsilon_2 \left(\frac{e^{-\Omega_3 t}}{(\Omega_1-\Omega_3)^2} + \frac{te^{-\Omega_1 t}}{(\Omega_3-\Omega_1)} - \frac{e^{-\Omega_1 t}}{(\Omega_3-\Omega_1)^2} \right) , \tag{2.59}$$

and,

$$N_4 = X\varepsilon_1\varepsilon_2\varepsilon_3 \left(\frac{e^{-\Omega_3 t}}{(\Omega_1-\Omega_3)^2 \, (\Omega_4-\Omega_3)} + \frac{e^{-\Omega_4 t}}{(\Omega_1-\Omega_4)^2 \, (\Omega_3-\Omega_4)} \right.$$

$$\left. + \frac{te^{-\Omega_1 t}}{(\Omega_3-\Omega_1) \, (\Omega_4-\Omega_1)} - e^{-\Omega_1 t} \left(\frac{\frac{1}{\Omega_3-\Omega_1} + \frac{1}{\Omega_4-\Omega_1}}{(\Omega_3-\Omega_1) \, (\Omega_3-\Omega_1)} \right) \right) . \tag{2.60}$$

From this one can deduce the general form of C_o to be,

$$C_o = \frac{-\sum\limits_{\substack{j=1\\ j\neq \ell,m}}^{i} \frac{1}{\Omega_j-\Omega_\ell}}{\prod\limits_{\substack{j=1\\ j\neq \ell,m}}^{i} (\Omega_j-\Omega_\ell)} \quad . \tag{2.61}$$

Applying the inverse Laplace transform to Eq. (2.54) gives,

$$N_i = X \prod_{j=1}^{i-1} \varepsilon_j \left(\sum_{\substack{j=1\\ j\neq \ell,m}}^{i} \frac{e^{-\Omega_j t}}{\prod\limits_{k=1}^{i} (\Omega_k-\Omega_j)} + \frac{te^{-\Omega_\ell t}}{\prod\limits_{\substack{j=1\\ j\neq \ell,m}}^{i} (\Omega_j-\Omega_\ell)} - \frac{e^{-\Omega_\ell t} \sum\limits_{\substack{j=1\\ j\neq \ell,m}}^{i} \frac{1}{\Omega_j-\Omega_\ell}}{\prod\limits_{\substack{j=1\\ j\neq \ell,m}}^{i} (\Omega_j-\Omega_\ell)} \right) . \tag{2.62}$$

The major equations used in isotope inventory calculations are now derived. Neutron flux is calculated by Eq. (2.7). Fission product production rate is determined by Eq. (2.12). The Bateman equations for constant production rate are Eqs. (2.26), (2.39), and (2.45). Finally, the Bateman equations for initial concentration are Eqs. (2.53) and (2.62). No special equation is needed for $\Omega_\ell = 0$ in the case where no production is considered, since the introduction of $\Omega_\ell = 0$ does not generate any repeat roots as it does for the case where constant production is not set to zero.

III. Algorithm Development

A. Reduction of ORIGEN2 Size Requirements

The primary objective of the Kansas State Isotope Generation Code (KSIG) was to reduce the cost of isotope inventory calculations. This was to be accomplished by transferring the problem to a microcomputer, reducing the problem size and reducing the time required to perform the calculations.

In moving to the microcomputer, the computer memory size became a limiting factor. This factor was overcome by removing all but the most necessary options and by using a technique called memory management.

One option eliminated by KSIG was the choice of a wide variety of output tables provided by ORIGEN2. The only table provided by KSIG is the one for isotopic abundance in grams. All other tables provided by ORIGEN2 can be generated using the abundances calculated by KSIG. This reduced the problem to one of calculating isotope inventories, and eliminated the need for some data libraries and an excessive amount of computer programming.

Memory management is a technique which releases memory space, for other uses, when the code or data previously stored in that space is no longer needed. Code and data not needed by the executing step are retained on an external storage device. The release of memory space is facilitated by the fact that the main memory area can be divided into two regions, volatile and non-volatile.

Volatile memory consists of all variables originally accessed by a subroutine. When the subroutine returns control to the calling routine, all memory used by the variables created is released automatically for other uses. Hence, the name volatile.

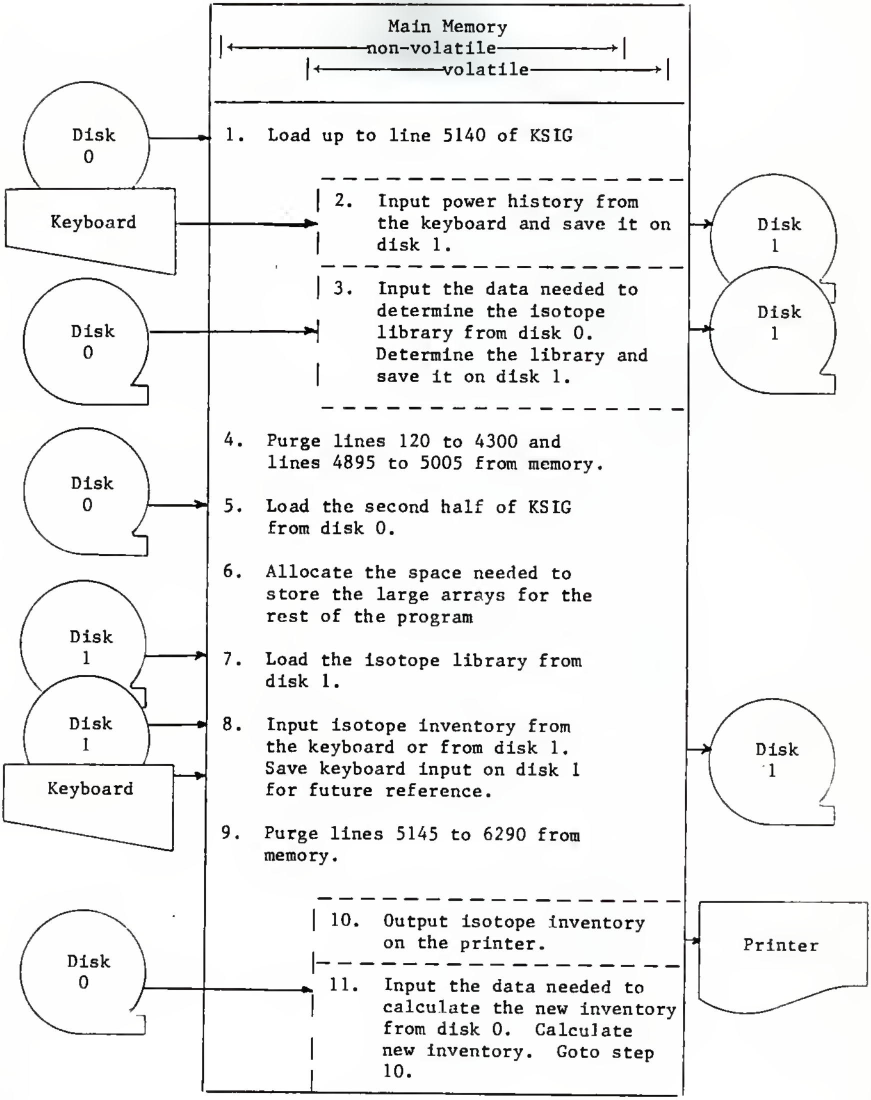

Figure 4. Allocation of Memory During the Execution of KSIG.

Non-volatile memory consists of the computer code and all of the variables and vectors accessed by the main program. Unlike volatile memory, no memory space is released automatically. The only way to release non-volatile memory is by purging unwanted subroutines with a DELSUB command or by deallocating unwanted vectors with a DEALLOCATE command.

Modulizing the steps in KSIG (input, library construction, calculation, and output), that is, isolating each function in its own subroutine, allows for deallocation when that subroutine is completed. Further, it facilitates the definition of large temporary vectors, allowing data stored on external disks residence in main memory for the duration of the step which requires them. Figure 4 demonstrates the allocation of memory during the execution of KSIG.

The hardware used in the development of KSIG are a HP9816 microcomputer with graphic capabilities, a HP9121 dual disk drive and a HP82905B dot-matrix printer. The physical layout of this equipment is found in Fig. 5.

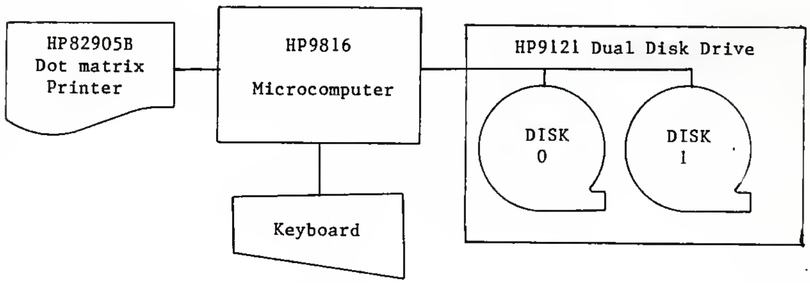

Fig. 5. Physical Layout of the Computer System.

The size of the problem is reduced by considering only small subsets of isotopes. ORIGEN2 considers 1306 different isotopes at one time. KSIG uses an algorithm which determines the few isotopes which contribute significantly to any one isotope of major interest, and uses these in its calculations. Since any isotope can be designated as the major isotope of interest, no generality is lost on this point.

Some calculational effort is reduced by making approximations to the Bateman equations. Since these equations are performed thousands of times during the course of a program run, the reduction in effort can be quite substantial.

The first of these approximations is for isotopes whose transition coefficients are very large. These isotopes establish equilibrium early, therefore, one assumes that,

$$\frac{dN_n}{dt} = 0 \ , \tag{3.1}$$

for these isotopes. Thus,

$$sN_n = 0 \ . \tag{3.2}$$

Substituting this into Eq. (2.19) and Eq. (2.49) gives,

$$\bar{N}_i = \frac{\mathrm{Prod} \prod_{j=1}^{i-1} \varepsilon_j}{s\Omega_n \prod_{\substack{j=1 \\ j \neq n}}^{i} (s+\Omega_j)} \ , \tag{3.3}$$

and,

$$\bar{N}_i = \frac{X \prod_{j=1}^{i-1} \varepsilon_j}{\Omega_n \prod_{\substack{j=1 \\ j \neq n}}^{i} (s+\Omega_j)} \ . \tag{3.4}$$

Notice that these equations are similar to Eq. (2.2) and Eq. (2.50). Therefore, the solutions are similar. The difference is that isotope n is not considered in the regular Bateman calculations, and the result without isotope n is divided by Ω_n to give the correct approximation. The only exception to this occurs when the first isotopes in the chain have very large transition coefficients. In this case the solution of Eq. (3.4) for N_n is found to be equal to zero.

The second approximation to the Bateman equations is for the case of constant production, with isotopes of very small transition coefficients.

Expanding $(1-e^{-\Omega_n t})$ in a Taylor series about $\Omega_n t = 0$ gives,

$$1 - e^{-\Omega_n t} = \Omega_n t - \frac{(\Omega_n t)^2}{2!} + \frac{(\Omega_n t)^3}{3!} - \frac{(\Omega_n t)^4}{4!} + \ldots , \qquad (3.5)$$

for $\Omega_n t$ very small. Dividing Eq. (3.5) by $\Omega_n t$ gives,

$$\frac{1-e^{-\Omega_n t}}{\Omega_n t} = 1 - \frac{\Omega_n t}{2} + \frac{(\Omega_n t)^2}{6} - \frac{(\Omega_n t)^3}{24} + \ldots . \qquad (3.6)$$

Comparing Eq. (3.6) to Eq. (2.26) suggests the approximation:

$$\frac{(1-e^{-\Omega_n t})}{\Omega_n \prod_{\substack{j=1 \\ j\neq n}}^{i} (\Omega_j - \Omega_n)} = \frac{t}{\prod_{\substack{j=1 \\ j\neq n}}^{i} (\Omega_j - \Omega_n)} \sum_{j=0}^{11} \frac{(-\Omega_n t)^j}{(j+1)!} . \qquad (3.7)$$

This approximation will yield better numerical results than the left-hand side of Eq. (3.7).

The final approximation concerns isotopes appearing in their own transition chain as in Fig. 3. When this happens the problem of Ω_ℓ

equalling Ω_m occurs. This, in itself, isn't a problem because formulas exist to account for this. The problem arises by continuing this chain until the isotope appears a third, fourth and fifth time. Obviously, it would become very difficult to develop new equations for every situation. To overcome this problem, one can use a method used to determine subcritical neutron multiplication [10].

The sum of the first two appearances of the repeating isotope can be represented as,

$$S_1 = N_\ell^{(0)} (1+r), \qquad (3.8)$$

where r is the ratio between the concentration of the first two generations, or

$$r = N_\ell^{(1)} / N_\ell^{(0)} . \qquad (3.9)$$

Now, since the same decay process lies between the first and second generations as lies between the second and third and third and fourth generations, one might assume that the ratio between each of these generations, and in fact all generations, is the same. The sum of the first N generations would then be,

$$S_N = N_\ell^{(0)} \sum_{i=0}^{N} r^i . \qquad (3.10)$$

In reality, the loop would repeat an infinite number of times, so,

$$S_\infty = N_\ell^{(0)} \sum_{i=0}^{\infty} r^i . \qquad (3.11)$$

Since the ratio will always be less than one, a geometric series solution can be employed to transform Eq. (3.11) to,

$$S_\infty = \frac{N_\ell^{(0)}}{1-r} . \tag{3.12}$$

Therefore, the contribution of isotopes appearing in their own decay chain can be approximated by merely calculating the first two generations.

B. Data Libraries Associated with KSIG.

B.1. The Decay Library

The decay library used by KSIG is divided into ten segments. Each contains the data for all of the isotopes whose identification number begins with the number of the segment (0 through 9). This library is found in Appendix B.1.

The data contained in the decay library include, the isotope identification number of each isotope, the decay mode(s), the decay heat, the radioactive half-life, the units of the radioactive half-life, and the percentage yields for each possible decay mode. Figure 6 demonstrates the structure of this library.

Characters 2 through 7 of each entry contain the isotope identification number. The first two characters of this number contain the atomic number of the isotope. The next three characters are the atomic weight of the isotope, and the last character is the atomic state. One indicates the excited state and zero indicates the ground state.

The half-life of each isotope is found in characters 24 through 32. The units for this half-life are coded into character ten. These units are translated in Table 1.

```
12345678901234567890123456789012345678901234567890123456789012

 982540   453 1.994E+02 6.050E+01 3.100E-02
 982550   310 1.000E-01 1.500E+00
 992530   430 9.782E-02 2.047E+01
 992540   430 6.623E+00 2.757E+02
 992541   394 8.173E+00 3.930E+01 1.547E-02 7.800E-04 1.030E-03

|--II--| U|M| |--DH---| |--T½---| |---f1--| |--f2---| |--f3---|

12345678901234567890123456789012345678901234567890123456789012
```

II - Isotope Identification Number
U - Units of the Radioactive Half-Life
M - Decay mode
DH - Decay heat
$T_{1/2}$ - Radioactive Half-life
f_1 - fraction of decays for the first alternate decay mode
f_2 - fraction of decays for the second alternate decay mode
f_3 - fraction of decays for the third alternate decay mode

Fig. 6 The Identification of Each Datum in the Decay Library.

Table 1. The Definition of Units for the Radioactive Half-life.

Unit	Definition
1	Half-life is given in seconds
2	Half-life is given in minutes
3	Half-life is given in hours
4	Half-life is given in days
5	Half-life is given in years
6	Isotope is stable
7	Half-life is given in 10^3 years
8	Half-life is given in 10^6 years
9	Half-life is given in 10^9 years

The decay mode of each isotope is given in characteristics 11 and 12. The first character indicates the primary decay mode. The second character, if not zero, indicates the secondary decay mode. If the first character is nine, then more than two decay modes exist for this isotope. Table 2 provides the definition of the decay modes indicated by each character.

Table 2. Definition of Decay Modes.

Code	Decay Mode
1	Beta-decay
2	Electron capture
3	Alpha-decay
4	Internal transfer
5	Spontaneous fission
6	Beta-decay to an excited state
7	Electron capture to an excited state
8	Beta + neutron decay
91	Primary decay mode: Internal transfer Secondary decay modes: 1) Alpha-decay 2) Spontaneous fission
92	Primary decay mode: Beta-decay Secondary decay modes: 1) Beta-decay to an excited state 2) Beta + neutron decay
93	Primary decay mode: Beta-decay Secondary decay modes: 1) Alpha-decay 2) Spontaneous fission
94	Primary decay mode: Alpha-decay Secondary decay modes: 1) Internal transfer 2) Electron capture 3) Spontaneous fission

The possibility of more than one decay mode suggests the use of variable length entries. If only one decay mode exists, the entry is only 32 characters in length. If two decay modes exist, characters 34 through 42 contain the fraction of decays resulting in the alternate decay type. If three or more decay modes exist, then the fractions of the third and fourth decay mode are stored in characteristics 44 through 52 and 54 through 62, respectively. The fraction of times the primary decay mode occurs is not stored, since this would simply duplicate data already in existence.

Finally, the decay heat is stored in characters 14 through 22.

B.2. Neutron Cross Section Library

The neutron cross section library, like the decay library, is divided into ten segments. Each segment contains the cross section data for each isotope whose identifier begins with the number of the segment (0 through 9). This library is found in Appendix B.2. It contains the isotope identifier, the number of neutron reactions possible, the identification code for each type of reaction and the microscopic cross section for each type of reaction. The location of each datum in each entry can be found in Fig. 7 and the definition of each transition type can be found in Table 3.

```
1234567890123456789012345678901234567890123456789012345

 942430  3128    1.360E+01 1.661E-02 2.798E+01
 942440  11      1.195E+00
 942450  11      1.755E+01
 952410  512785  1.058E+02 3.208E-04 1.532E-06 1.123E+00 1.307E+01

|--II--| N|-M-| |--X1--| |--X2--| |--X3--| |--X4--| |--X5--|

1234567890123456789012345678901234567890123456789012345
```

II - Isotope identification number
N - Number of different neutron reactions
M - Code for each transition mode
X_N - Neutron cross section for the N^{th} type of neutron reaction

Fig. 7. The Identification of Each Datum in the Cross Section Library.

Table 3. Definitions of Each Coded Neutron Transition Mode.

Code	Neutron Transition Code
1	(n,γ)
2	(n,2n)
3	(n,α)
4	(n,p)
5	(n,γ) to an excited state
6	(n,2n) to an excited state
7	(n,3n)
8	(n, fission)

B.3. Fission Product Library

The fission product library is divided into six segments (0,2 through 6). Segments one, seven, eight, and nine are excluded because there are no fission fragments whose isotope identifier begins with these numbers. The data contained in this library include the isotope identification number and the fission yields for the neutron induced fission of U-233, U-235, U-238 Pu-239, and Pu-241. Each yield is given as a percentage of fissions resulting in a fragment which has the same mass, atomic number and atomic state of the isotope in question. Figure 8 contains the structure for this library. This library can be found in Appendix B.3.

```
12345678901234567890123456789012345678901234567890123

 270720  2.26E-06 8.87E-07 6.04E-05 1.43E-07 1.79E-06
 270730  2.04E-08 9.07E-08 2.06E-05 9.74E-10 5.24E-07
 270740  5.54E-08 7.32E-08 3.83E-06 1.79E-09 5.79E-08

|—II—| |—Y1—| |—Y2—| |—Y3—| |—Y4—| |—Y5—|

12345678901234567890123456789012345678901234567890123
```

II - Isotope identification number
Y_1 - Fission yield from U-233
Y_2 - Fission yield from U-235
Y_3 - Fission yield from U-238
Y_4 - Fission yield from Pu-239
Y_5 - Fission yield from Pu-241

Fig. 8. The Structure of the Fission Yield Library.

B.4. Natural Abundance Library

The natural abundance library contains all isotopes which occur in nature and the percentage of each element which is composed of a given isotope. Each entry is nineteen characters in length. The first seven characters contain the isotope identification number. The last nine characters contain that isotope's percentage found in nature. This library can be found in Appendix B.4.

B.5. Vectors Created by KSIG

There are basically three types of vectors created by KSIG and stored externally. These vectors are isotope vectors, concentration vectors, and power/time history vectors.

The first type of vector, the isotope vector, contains the isotope identification numbers for all isotopes on which any calculations will be performed. The first entry in this vector contains the number of isotopes included in the vector. Each isotope to be used follows. A star preceding the isotope identification number indicates that this is an isotope of primary interest and whose concentration will be output.

Several vectors included as libraries are All, Poison, Dose, and Act. Each of these has some interest to certain people. All includes all 1306 isotopes, Poison contains the major neutron poisons generated during the operation of a nuclear facility, dose includes several of the intermediate-lived (three to four weeks) isotopes with high energy gamma rays, and Act includes the five actinides whose fission yields are being considered.

The second type of vector, a concentration vector, is created at two different points in KSIG. The first point is when the initial concentration vector is input and the second when the final concentration vector is output. Each entry is eighteen characters in length and contains two bits of information, the isotope identification number and the concentration of the isotope in grams.

The final type of vector is the power/time history vector. The first entry in this vector is either POWER or FLUX, indicating whether the reactor power is given or the neutron flux is given. The following entries contain the power or flux followed by the length of the time step and its units. The final entry is 'END' to indicate the end of the decay process.

C. The KSIG Computer Code

A complete listing of KSIG can be found in Appendix A. The following discussion will refer frequently to this listing.

C.1. The Main Routine

The first 23 lines of KSIG (lines 5 to 115) constitute the main routine of KSIG. They direct the flow of the program, define the large vectors required throughout the program, and control the uses of main memory. Memory control is facilitied by the DELSUB command in lines 25 and 60 which eliminates unneeded code and the LOADSUB command (line 30) which loads new code off disk. A flowchart of this routine is found in Fig. 9.

C.2. Subroutine Powin

The first subroutine called from the main routine is Powin (lines 120 to 685). Its purpose is to set up a file with a power/time history to be used throughout the run. Lines 130 to 160 warn the operator to line up the printer and to insert his data disk in drive 1. Lines 165 to 185 give the option to choose from a previously stored power history or to input his own. The stored option is covered in lines 190 to 275 and the new option is covered by lines 280 to 605.

If the stored option is selected, the program asks for the name of the power input data file. If that file can't be found on disk 1, or if the first entry is neither 'FLUX' or 'POWER' then an error message is printed and the question as to whether one chooses to use a stored power history or a new one is posed again. If 'FLUX' is the first entry, then Ptype is set to zero, and if 'POWER' is the first entry, then Ptype is set to one.

Now if the option to input a power history is selected, the name of the new output file is requested (lines 285 to 305). Next, the type of file is asked for - Flux or Power - and Ptype is set appropriately (lines 310 to 365). The first entry in the file will be 'FLUX' or 'POWER'.

Lines 370 to 475 govern data format. First, general directions on leaving this loop are given (lines 370 to 395). Then initial conditions for the loop are set (line 400). Next the power or flux is input (lines 405 to 425). If nothing is entered then the program branches out of the

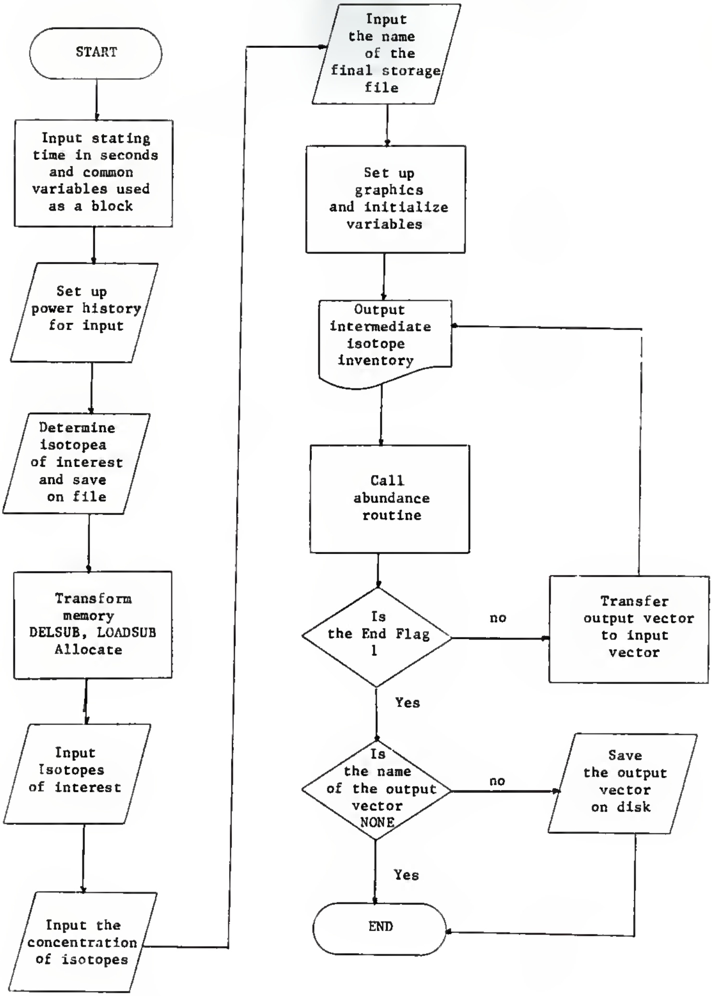

Fig. 9. Flowchart of Main Routine for KSIC.

loop. Line 435 converts the input power or flux into a string which looks like a number in exponential format. The entry is completed by inputting the time length for the step and adding it to the string (lines 440 to 465). Program control then loops back for another entry.

When all new entries have been input an attempt is made to create the new data file. If an error occurs while creating the data file an attempt is made to rectify this error by changing the name of the file or warning the programmer to try a different data disk (lines 550 to 605). If no error occurs the data are transferred to disk and an 'END' is written to the end to indicate the end of the power data (lines 510 to 530). Finally, the file is re-opened and the first entry (POWER or FLUX) is read, so that the file is ready to output power data.

Once the power file has been designated a few more initialization questions are asked. First, it is determined whether fission products are to be considered (lines 620 to 660). If they aren't, then two is added to Ptype to indicate such. Finally, the output threshold is requested (line 680).

C.3. Subroutine Isotope

The second subroutine called by the main routine is isotope (lines 690 to 4300). Its purpose is to access a file containing the isotope identification numbers of all the isotopes needed to calculate, accurately, the abundances of the isotopes of interest. Variables are dimensioned and initial conditions are set in lines 695 to 705. In lines 710 to 725, the programmer is asked whether he is interested in only certain isotopes or all isotopes. If he is interested in all isotopes, then @Iso is assigned to the file containing all 1306 isotopes (lines 730 to 740). If certain isotopes are of interest, then the program asks whether the programmer is interested in poisons, dose, or other isotopes (lines 745 to 765). If poison or dose are choosen the @Iso is assigned to the appropriate file (lines 770 to 795). Once any of these three are selected -- All, Dose, or Poison - the first entry to these files is read (lines 4280 to 4285), which tells the number of isotopes in the file. Control is then returned to the main routine.

If the option 'Other' is selected, then the next question is, "Is this a new file or a previously stored one?" (lines 800 to 820). If this file was previously stored then the program asks for the name of the file (line 835). If that file is not found on the disk then an error message is printed and the file name is asked for again (lines 895 to 910). If the file is found, then the first entry is read (lines 850 to 865). If this entry is not a number or if it is greater than 1306, then an error message is again printed and again the file name is requested (lines 875 to 890). Upon successfully reading the first entry the program returns control to the calling routine.

The final option, New, is the option for which all of the variables are dimensioned (lines 695 to 700). These vectors are of three types.

The first type of vector includes those dimensioned to 1306, the maximum number of different isotopes. They are I$ and Weight. I$ contains all of the isotopes which will be considered in the following calculations. Weight contains the weighting factor associated with these isotopes. These retain their values throughout the duration of the subroutine.

The second type contain segments of the libraries stored on disk. These vectors are Xsec$, Dec$, and Fiss$. These will grow every time a new segment is called from disk. They retain their value only during the execution of the big loop associated with each isotope of interest.

The final type of vector includes those which define characteristics of the particular decay chain being observed. D$ contains the decay characteristics of each isotope in the chain, X$ contains the cross section information for each element, E contains the coupling coefficients associated with each element, and O contains the total transition coefficients. F1$ and F2$ contain information related to the linking of these isotopes together. Each of these vectors change as the decay chain considered changes.

When this option 'new' is selected, the first thing done is the initialization of variables (lines 915 to 925). General instructions on leaving the loop are then printed (lines 930 to 975). Next the atomic number is entered (lines 980 to 1010). If nothing is input before pressing enter then the input loop is exited. Upon completion of inputting the atomic number, the isotope index, I, is increased by one and the dimension definitions of the data libraries are set to zero (lines 1015 to 1030). Now the atomic weight is entered in lines 1035 to 1060 and the atomic state, excited or ground, is input in lines 1065 to 1080. The isotope identification number ia constructed in lines 1085 to 1105 if the isotope is excited and in lines 1110 to 1125, if ground. If the space before the identifier is a '*' this indicates that this isotope is an isotope of interest.

After entering the isotope of interest, the big loop begins. The first thing done is printing the isotope of interest and initializing variables (lines 1130 to 1165). Line 1170 then inputs the applicable data library segmenta and updates the dimenaion definitions of the data libraries. The decay library is then aearched for the entry for the isotope of interest (lines 1175 to 1200). If this entry is not found, or the isotope is found to be stable, then Ω_1 is set to zero and the first entry to D$ is constructed to reflect this (lines 1225 and 1230). If the isotope is radioactively unstable, the Ω_1 is set equal to the decay coefficient which is calculated in lines 1205 and 1210, and the first entry in D$ is set equal to the entry corresponding to this isotope in the decay library (line 1215).

Next, the cross section vector is searched for the isotope of interest (lines 1235 to 1255). If it isn't found in this library then the first entry in X$ is set to zero (line 1285). If it is found then all of its cross sections are normalized, multiplied by the flux and added to Ω_1, and the string containing this cross section data is stored in the first entry in X$ (lines 1260 to 1280).

Line 1290 is the beginning point for a new isotope added to the chain. The length of the chain is increased by one and the chain data are moved so that the isotope of interest occupies the last entry in the chain (lines 1290 to 1320). The isotope index is increased by one and the inner loop counter is set to test for Beta-decay (lines 1325 and 1330). The inner loop officially begins in line 1335, which controls branching to test for the transition modes.

The first transition mode to be tested is Beta-decay (lines 1340 to 1550). If the isotope, whose parents are being sought, is either hydrogen or in the excited state, this test is not performed (lines 1340 and 1345). The index indicating the state being tested is then inverted (lines 1350 to 1370). Line 1375 then constructs the isotope identification number for the potential parent. Next, a search is made for this isotope in the decay library (lines 1380 to 1415). If it isn't found the test is ended. A special condition is set if none of the entries has the same first digit in the isotope identification number. In this case the libraries needed are added to the existing libraries and the test is re-stated (lines 1495 to 1540).

When the isotope is found it is checked for beta-decay. If it doesn't beta-decay, the test is ended. If it does, the coupling coefficient is calculated, based on the radioactive half-life and the fraction of decays which are beta-decays (lines 1420 to 1475). Next, the isotope is tested for inclusion in the library (I$) (line 1480). Upon successful completion of the test the search begins for this new isotope's parents (line 1490). Failure results in the continued search for the previous isotope's parents (line 1485). Rejection at any point, except for the special case due to non-inclusion of the appropriate library segment, results in a test of the state of the isotope being tested (line 1545). If it is the excited state then the inner loop counter is increased by one and control is returned to line 1335 to select a new transition mode (line 1550).

The other thirteen transition modes follow a similar pattern. Therefore, a detailed description is not needed for each transition mode. These modes are of two types, the radioactive decay and the neutron absorption. The radioactive decay modes are beta-decay (lines 1345 to 1555), electron capture (lines 1555 to 1725), alpha-decay (lines 1730 to 1915), internal transfer (lines 1920 to 2065), beta + neutron decay (lines 2070 to 2240), beta-decay to an excited state (lines 2245 to 2405), and electron capture to an excited state (lines 2410 to 2560). The neutron transformations are (n, gamma) (lines 2565 to 2700), (n,2n) (lines 2705 to 2835), (n,3n) (lines 2840 to 2970), (n, alpha) (lines

2975 to 3110), (n,p) (lines 3115 to 3250), a (n, gamma) resulting in an excited daughter (line 3255 to 3390), and a (n,2n) resulting in an excited daughter (lines 3395 to 3660).

The failure of an excited isotope to undergo a (n,2n) reaction resulting in an excited daughter signals the end of the search for the parents of the second isotope in the decay chain. At this point the search for the parents of the third isotope in the chain continues (lines 3550 to 3660). The first step in this transition is decreasing the index for the transition chain by one (line 3550). If this index is now one, then the search for the parents of this isotope of interest is over and control is returned to the point requesting a new isotope of interest (lines 3595 to 3575). Otherwise the atomic weight and atomic number of the third isotope in the chain are recovered (lines 3580 to 3585).

F1$ and F2$ are used as storage vectors. They contain the point in the search where a successful test occurred, for all isotopes in the transition chain. F1$ indicates the type of transition, while F2$ indicates whether it decayed from an excited state or a ground one. Therefore, these strings need adjusted when in transition from one length of chain to another. F2$ is shortened by one and the last inner loop index is recovered from F1$ (lines 3590 and 3595). If the last parent tested was in the excited state then the inner loop index is increased by one (line 3600).

The next step is to move the data in the chain vectors so that the isotope of interest again occupies the last position (lines 3605 to 3630). Finally, before returning to line 1340, F2$ is shortened by one (lines 3635 to 3660).

The tests performed for inclusion begin with a test to determine if the isotope already appears in the decay chain (lines 3665 to 3675). If it does, there is no need to search this branch any further. All isotopes which it could contribute will have already been accounted for elsewhere.

The second test for inclusion is to determine if the given chain generates enough of the isotope of interest to be included. The total transition coefficient for this isotope is calculated in lines 3680 to 3785. This is exactly as in lines 1175 to 1285. Next the amount of the isotope of interest is calculated based on the exposure of one gram of the new isotope to a neutron flux of 10^{13} neutrons per cm^2 S for one year (lines 3790 to 3795). A concentration of more than 10^{16} moles of the isotope of interest is considered sufficient for inclusion in the library. These criteria are totally arbitrary but prove to be sufficient for the accuracy required. If this test fails, there is an alternate test which can be performed.

The alternate second test calculates the abundance of the isotope of interest based on fission yield. Thus, if Ptype if greater than two, indicating that fission products aren't considered, or if the first digit of the isotope identification number for this isotope is one, seven, eight, or nine, indicating that no fission yield exists, this test is not performed and a negative response to the test is given (lines 3805 to 3810). Next, a search is conducted to find the isotope being considered in the fission product library (lines 3815 to 3830). If it isn't found then the test ends and a negative response is returned. If it is found then the production rate is calculated based on 235 grams of U-235 (line 3840). Using this production rate, the concentration of the isotope of interest is calculated (line 3845). If this concentration is greater than 10^{-16} mol, the second test is passed. If not, a negative response is returned (lines 3855 to 3860).

The final test for inclusion is to search all previously accepted isotopes for the one being considered for acceptance (lines 3865 to 3905). If it is found, a comparison is made between the corresponding element of Weight and the amount calculated. If the element of Weight is greater than the amount calculated, the isotope is rejected. If not, then the element of Weight assumes the value of amount. This criteria allows continuation of the search for parents if the new chain proves to be more closely linked than any previous chain.

Once the isotope is accepted, the element of Weight corresponding to the isotope accepted is set equal to the amount calculated in the second test (line 3910). A positive response is then given to the test, and the string F1$ is updated to reflect the lengthening of the decay chain (lines 3915 to 3925). Next, the accepted isotope is printed on the screen (lines 3930 to 3985), and its atomic weight and atomic number are recovered (lines 3990 to 3995). Finally, the vector of isotopes is searched for the newly accepted isotope (lines 4000 to 4025). If it is found before the last entry, the last entry is eliminated.

After all the isotopes have been entered and the null line has been entered instead of an atomic number, the output stage begins. The first step in the output stage is to eliminate all of the repeats of isotopes (lines 4040 to 4110). This would only occur if a second or later isotope of interest were to be one of the contributing isotopes to an earlier isotope of interest. Therefore, a search is made for the second or later isotopes of interest (line 4050). Once they have been found a comparison for each is made to all isotopes appearing before it in the vector (lines 4055 to 4100). If a duplicate is found then all isotopes previous to the duplicate one are moved up one, thus eliminating the duplicate (lines 4070 to 4080).

The second output step is the creation of the output file. First, the file name is entered (line 4115 to 4140). Second, the dimension of the file is calculated (lines 4145 to 4150). Finally, an attempt is made to create the new file (lines 4160 to 4170). If this attempt should fail, there is provision for overcoming some errors (lines 4210 to 4265).

The data are now ready to be output. The number of entries in the isotope vector is saved first, followed by each of the elements in the isotope vector (lines 4175 to 4195).

Finally, the isotope file complete, the code is ready to complete this step. The new isotope file is reopened to provide input (line 4200), and the first element is read from the file, giving the length of the vector, to be used later in the program (line 4280 and 4285). Control is then returned to the main routine of KSIG (lines 4290 to 4300).

The heart of KSIG, the area in which the Bateman calculations are performed, is located in the subroutines Const_n and Const_p. These subroutines embody the Bateman equations (Eqs. (2.26), (2.39), (2.45), (2.53), and (2.62)). They also perform the approximations implied by Eq. (3.4) and given by Eq. (3.7). Without these two subroutines KSIG would do nothing more than shuffle data files.

C.4. Subroutine Const_n

Const_n is the subroutine used to calculate the concentration of an isotope when the concentration of one of its parents is given. It begins by calculating the product of all the coupling coefficients in a given chain (lines 4320 to 4335). It then calculates the contributions due to each of the total transition coefficients (lines 4340 to 4480).

If $\Omega_i t$ is very large, the approximation implied by Eq. (3.4) is used. Instead of calculating a term for the summation in Eq. (2.45) and Eq. (2.53), the product of the coupling coefficients, ε_i, is divided by Ω_i (lines 4350 to 4365). Since Ω_i is not used in any term under the summation, it is bypassed when calculating the product of the differences between Ω_i (line 4390).

If $\Omega_i t$ is not very large, its term in the summation must be calculated. The first step is to calculate the product of the differences between the total transition coefficients. This is performed in lines 4380 to 4430. If a repeating isotope is discovered, the difference is skipped and a note is made for future reference (lines 4395 to 4420).

If a repeating isotope is discovered, then the inner sum of Eq. (2.53) is needed. This sum is calculated in lines 4435 to 4460. The two terms needed for this step are combined into one, by dividing the product of the differences just calculated by the difference between the time, in seconds, and the inner sum (line 4465). The second reference to the repeating isotope is eliminated by line 4400.

The sum is completed by adding the new term in line 4475. The final concentration is the product of the coupling coefficients and the sum (line 4485).

C.5. Subroutine Const_p

Const_p is the subroutine used to calculate the concentration of an isotope, when a constant production rate is assumed for one of its parents. It, like Const_n, begins by calculating the product of coupling coefficients for a given chain (lines 4510 to 4525). It then calculates the contributions due to each of the total transition coefficients (lines 4530 to 4775).

Again, if $\Omega_i t$ is very large, the approximation implied by Eq. (3.4) is used. The product of the coupling coefficients is again divided by Ω_i (lines 4540 to 4555), and again, the term for Ω_i is bypassed when calculating the product of the differences between the Ω_i (line 4580).

If $\Omega_i t$ is not very large, the product of the differences between Ω_i is needed (lines 4560 to 4620). If a repeating isotope is tagged while calculating this product, its difference is skipped and a note is made for future reference (lines 4585 to 4610).

If a repeating isotope is involved, the inner sum of Eq. (2.39) must be calculated (lines 4625 to 4655)). Each time a repeating isotope appears, the solution functions the same. The outer summation is reduced by the term linear in time given in Eq. (2.39) (lines 4670 and 4755), and the product of the differences of Ω_i is divided by the inner sum (lines 4675 and 4760). No time appears in these equations, but is saved for the final step in line 4785.

Three different cases now remain, $\Omega_i t$ in the intermediate range, $\Omega_i t$ very small, and $\Omega_i t$ equal to zero. Each of these cases is governed by its own equation and therefore its own section of code. All cases can occur for the same chain, the only difference in calculation is for the exponential term of each. For $\Omega_i t$ intermediate, less than 100 but greater than two, Eq. (2.26) is used and the exponential term is calculated in lines 4660 to 4695. For $\Omega_i t$ very small, the approximation of Eq. (3.7) is used (lines 4720 to 4770). Finally, for $\Omega_i t$ equal to zero, Eq. (2.45) is used (lines 4700 to 4715).

The final step is to multiply the sum of exponentials by the product of coupling coefficients and time. This results in the correct value for all cases except when all $\Omega_i t$ are very large. In that case, the sum of exponentials is zero, which makes the product zero. In reality, using the approximation of Eq. (3.4), the solution should be the product of the coupling coefficients, divided by the total transition coefficients and multiplied by the production rate. Thus, when the sum of exponentials is zero, the code sets it to 1/T (line 4780).

C.6. Miscellaneous Functions and Subroutines

Several short functions and subroutines are frequently called throughout the execution of KSIG. These are the functions FNC1 and FNSt$, and the subroutine Astring. FNC1 serves to transform a given radioactive decay constant from its given units to the units of sec^{-1} (lines 4795 to 4835). FNSt$ creates the isotope identification number from its component parts, the atomic number, atomic weight and atomic state (lines 4840 to 4890). And, Astring creates an alpha-numeric string which represents a given number in exponential format, e.g., 1.7532E+11 (lines 5010 to 5140).

C.7. Subroutine Libin

One subroutine called by Isotope, but not elsewhere in KSIG is Libin (lines 4895 to 5005). This subroutine directs the input from the data libraries stored on disk. It adds each new segment needed to the end of the segments already read. The first library accessed is the decay library (lines 4900 to 4930) followed by the cross section library (lines 4935 to 4960) and the fission yield library (lines 4965 to 5000). The subroutine allows the access of data from disk as it is needed.

C.8. Subroutine Isin

Once the file containing the isotopes of interest has been accessed, the next step is to read these isotopes into non-volatile memory. This is done in Isin (lines 5145 to 5195). This routine reads not only the isotopes of interest to the operator, but also the isotopes required to determine flux or power. These isotopes are the fissioning isotopes known as the actinides.

C.9. Subroutine Inin

Next, initial concentrations are needed. These are input in the subroutine Inin (lines 5200 to 6055). Two options are given for input, either previously stored or newly input (lines 5210 to 5225). If the previously stored option is selected, input occurs from disk (lines 5230 to 5435), otherwise they are input by hand (lines 5540 to 6040).

When the stored option is selected, the first thing the program does is ask for the name of the inventory file (lines 5240 to 5250). An attempt is then made to access that file (lines 5255 to 5265). If this file can not be found, an error message is printed and the file name is asked for again (lines 5385 to 5420). After the successful access of a file, an entry is read from that file (lines 5265 to 5280). If an error occurs while reading an entry (line 5265), or the entry is not 18 characters long, the length of a properly saved entry (line 5285), an error message is printed and a file name is asked for again (lines 5405 to 5420).

After inputting an entry, the next step is to store this entry into its appropriate non-volatile vector. The vector of isotopes is searched to find the isotope in the entry (lines 5290 to 5325). If it is found, the concentration in the entry is stored in the appropriate element of the isotope concentration vector (line 5305). Next, the vector of actinides is searched for the isotope in the entry (lines 5330 to 5375). If found, the concentration is stored in the appropriate element of the actinide concentration vector (line 5350). Any error occurring during this process results in an error message and a return to the request for a new file name.

With the concentration stored, the program loops back to read a new entry (line 5380). This process continues until all entries have been read from the file. The file is then closed and control is returned to the main routine (lines 5425 to 5435).

The first step in the option 'new' is to print general instructions on leaving the input loop and on indicating naturally occurring elements (lines 5440 to 5495). Next, the atomic number of the isotope whose concentration is being entered is asked for (lines 5515 to 5545). A null entry indicates the end of input and the program branches out of the input loop (line 5525). The atomic weight is input in lines 5555 to 5575. A non-zero value indicates an isotope, therefore to define this isotope completely, the atomic state is requested (lines 5585 to 5620). An atomic weight of zero, on the other hand, indicates a naturally occurring element, therefore the question of atomic state would be skipped (line 5580). Once the isotope or element is defined, the concentration is requested (lines 5625 to 5645).

The next step is to create data entries for the given isotope or element. If the atomic weight is not zero, the isotope is well-defined and the entry easily constructed. The concentration is converted to string form by Astring and the isotope identification number is created by FNST$ (lines 5660 to 5665). These two strings are combined to form an inventory entry. This entry is then stored in a temporary vector and printed on the computer screen (line 5670). Finally, the program loops back and a new entry is started (line 5675).

If the atomic weight is zero, more than one entry may be needed for some naturally occurring isotopes. A file of naturally occurring isotopes is searched to find the element specified (lines 5685 to 5740). When an isotope of this element is found a new entry is created. The concentration used in constructing this entry is calculated by multiplying the total elemental concentration by the percentage of this isotope occurring in nature and dividing by 100 (line 5710). The actual construction of the entry is similar to that performed when the isotope is defined (lines 5715 to 5725). When the entry is complete it is stored in the temporary vector and printed on the screen.

Since only rarely is one isotope of an element the only naturally occurring isotope of that element, the program loops back and attempts to find a second or third isotope (line 5740). This process continues until either the isotope read is found to be of higher Z value than the element in question, or else the last entry in the file has been read (lines 5695 to 5700). When this occurs before any new entries have been created, an error message is printed (lines 5745 to 5765). Otherwise, control is returned back to input a new entry unabated (line 5765).

After all data entries have been constructed, the operator is given the option to save this newly constructed vector to disk (lines 5770 to 5790). If the operator chooses to save this vector, the computer asks for the new file's name (lines 5795 to 5820). It then attempts to create the new file (lines 5825 to 5850). If an error occurs during this attempt the computer gives the operator an opportunity to recover from his mistake (lines 5975 to 6030). Finally, the data entries are written to disk and the file closed (lines 5855 to 5875).

The final step in this routine is the transfer of concentrations from this temporary vector to a more permanent one. This step is accomplished exactly as in lines 5265 to 5380 except that the data are now read from a vector instead of from disk. The opportunity for error has been removed (lines 5890 to 5970). After this step is completed, control is returned to the main routine.

C.10. Subroutine Typout

The next subroutine called by the main routine and the last in which any operator interaction is required is Typout (lines 6060 to 6135). This subroutine performs two functions. It designates the name of the output file, and identifies the print control parameter for the main routine to be one.

The print control character, Typout, controls whether or not an output table is printed when the subroutine Out is called. A value of one indicates yes while a value of zero indicates no. If Typout is zero, the only function which Out performs is the initiation of updating the graphic display.

When determining the name of the output file, the operator is asked if he wants to save the final concentration vector (lines 6070 to 6085).

The advantage to saving this vector is that it can be used as the initial concentration vector for later runs. If the operator answers 'No', the name of the output file is set to 'NONE' (lines 6090 to 6100). If the operator answers 'Yes', he is asked to input the name he wishes the output file to have (lines 6200 to 6225).

C.11. Subroutine Frm

The next subroutine, Frm, builds the framework for the graphics display. It turns on and clears the graphics and draws and labels the axes. The graphics display, when complete, consists of a histogram of atomic number vs. elemental abundance. The atomic number scale is a linear scale ranging from 0 to 100, and the abundance scale is logrithmic ranging from 10^{-3} to 10^{5} grams.

C.12. Subroutine Out

Out is the output subroutine. Its primary function is to control all visual output. It begins its execution by dimensioning variables and inputting the two-character name for each element from disk (lines 6300 to 6340). Next, it calculates the concentration of each element represented in either the isotope vector or the actinide vector (lines 6345 to 6425). This is accomplished by adding the contribution of each isotope to its appropriate element. To avoid counting an isotope twice, the isotopes which appear in both vectors are skipped when going through the isotope vector (lines 6345 to 6405) and are counted in the actinide vector (lines 6410 to 6425). The running time is then calculated (line 6430) and the graph is updated (line 6435). Now, if the print control character is zero, the rest of the routine is skipped (line 6440).

The second half of the output subroutine controls the printing of the output table (lines 6445 to 6565). The table printed consists of every isotope previously designated as an isotope of interest, which has a concentration of at least that of the threshold (line 6465). Each page of output has its own heading and can contain, as many as, 56 lines of entries with three entries per line. Each entry consists of the element's name, atomic weight and its concentration in grams. A star printed beside the atomic weight designates the isotope is in an excited state. A new page is generated each time this sequence is executed.

C.13. Subroutine Graph

The subroutine Graph, called from the subroutine Out, draws the histogram of element vs. abundance (lines 6570 to 6610). It also prints on the graph the elapsed computation time, in seconds, the simulated run time at the end of the time step, in seconds, the thermal power in MW/unit, and the neutron flux, in neutrons/cm^2 s (lines 6615 to 6655). It then completes the picture by drawing a frame around the graph (lines 6660 to 6680).

C.14. Subroutine Head

The subroutine Head, also called from Out, prints the heading of each new page (lines 6685 to 6805). Before it prints any heading, it calculates the simulated run time in its most appropriate units (lines 6695 to 6760). It then prints the page header. This header consists of the simulated time, page number, neutron flux, and thermal power density. These information headers are followed by the column headings of Isotope and Mass, three times each.

C.15. Subroutine Abund

Subroutine Abund is the routine which directs and controls the calculation step in the program. Its major function is to prevent the introduction of a time step so large that the fission yield spectrum shifts significantly. The first step in this routine is data input and interpretation of those data. Lines 6815 to 6835 dimension variables and initialize certain parameters. Next, the power/time step is entered from the power file and converted to usable data (lines 6840 to 6900). If the power time step is 'END,' indicating the end of the file, the end flag is set to one and control is returned to the main routine (lines 7270 to 7280). The power type is then interpreted, setting a flag if fission products are not to be considered in this run (lines 6905 to 6965).

The second and final step is to direct control of the irradiation. If constant flux is indicated as the power type, calculations are controlled by lines 6970 to 7085. The general flow of logic for this routine is as follows. Power is calculated at the beginning of the time step. The actinides are then irradiated for the full length of the time step, and the power is again calculated, but at the end of the time step. If the power changes by more than two percent, it is assumed that the fission yields are not sufficiently constant. So, the time step is reduced and the actinides are irradiated again. This procedure continues until a time step sufficiently small to prevent a change in power of two percent is achieved.

With a small change in power, fission yields are assumed constant. Therefore, the fission rate of each contributing actinide is calculated, at both the beginning and end of the time step. The average of these two values is taken to reduce possible error (lines 7090 to 7155). The isotopes of interest are then irradiated.

Since the time step may have been shortened, a check is made to determine if the total time step has been completed (lines 7035 to 7055). If the step has been completed, control is returned to the main routine. If not, at least one more irradiation is needed. The concentrations of the isotopes at the end of the time step are transferred to the initial concentration vectors, A and Aact, (line 7060). Then, the output routine is called to update the graph (line 7070). Finally, a new time step is calculated that will bring the irradiation to the end of the original time step and control is returned to the beginning of the constant flux routine (lines 7075 to 7085).

Two exceptions to this procedure may occur. First, the flux may be zero, therefore, no fissioning or fission products, or second fission products may not be considered, Pflag may be one. In each case, a change in power is not important, therefore the test for a power change is skipped.

Now, if constant power is being considered, the calculations are directed by lines 7160 to 7265. Nearly the same procedure is followed as for the case of constant flux. The only difference is that, instead of power changes being controlled, the change in Flux is of interest.

C.16. Functions FNPower, FNFlux, and FNEpf

Three functions called, either directly or indirectly, by Abund are FNPower (lines 7290 to 7330), FNFlux (lines 7335 to 7375), and FNEpf (lines 7380 to 7395). These functions are the three equations derived earlier. FNPower is Eq. (2.8), FNFlux is Eq. (2.7) and FNEpf is Eq. (2.3).

C.17. Subroutine Decay

Subroutine Decay (lines 7400 to 8005) is the subroutine which calculates the isotopic abundances for a given vector. It uses a large number of vectors, most of which are similar to those used in the subroutine Isotope. Several new vectors added are Am, Fract, Lo, and Ap. Each of these four vectors are used in the transition chain calculations. Am is the amount of the isotope generated in the first generation by this transition chain, Fract is the ratio between the first and second generations of an isotope appearing in its own transition chain, Lo is the location of the given isotope in the isotope vector, and Ap is the mass of unaccounted for isotopes which will appear down a given branch of a decay chain. The first three of these vectors are essential for calculating the concentration of isotopes appearing in their own transition chain. The final vector, Ap, is used as a criterion to determine the value of continuing a given branch of a decay chain.

The major portion of this subroutine is, a large FOR-NEXT loop, which cycles through each isotope in the given isotope vector. Each loop begins by placing an 'X' on the appropriate atomic number of the graphics display and updating the running time (lines 7435 to 7460). This is done to provide some motion to indicate that the program is still executing. Then, the subroutine Omega is called to calculate the total transition coefficient for this isotope, and to place its decay and cross section data into the appropriate vector (line 7465). Next, a number of variables are initialized (lines 7470 to 7490).

Now the calculations begin. First, the initial number of moles of the isotope is determined (lines 7495 to 7520). If the initial amount of this isotope is not zero, the number of moles at the end of this step are calculated (line 7525). Otherwise, control goes directly to the production step.

If flux is zero or if fission products are not to be considered the production step is skipped (lines 7535 to 7540). If not, the production rate of this is calculated using Eq. (2.9) (lines 7545 to 7580). The concentration of this isotope which is due to fission production is then calculated (line 7585). These two amounts are summed and stored in Am (lines 7590 to 7605). Fract is set to zero and Ap for this chain is calculated by adding the initial concentration, of this isotope, to the total amount produced by fission, subtracting the amount remaining at the end of the time step, and multiplying the entire thing by the isotopes atomic weight (lines 7610 to 7615).

Next, the subroutine which finds the daughters is called, which returns the location of the next daughter of this isotope and the coupling coefficient between the two (line 7625). If daughter can not find a new daughter for this isotope, it shortens the transition chain and searches for new daughters at a higher level. If it has searched through all possible daughters of the original isotope, it sets Eflag to one.

If Daughter returns with a transition chain which is shorter than the last time Daughter was called, the concentration of the isotopes removed from the chain are added to the output vector, B, (lines 7630 to 7665). This procedure uses Eq. (3.12). If no isotopes are repeated, this equation degenerates to adding a concentration to a vector. If Eflag is set to one, the program loops back for a new isotope (line 7670).

If Eflag is not one, Ap for this link is calculated by dividing the coupling coefficient by the total transition coefficient of the previous link and then multiplying by the amount passed to the previous link (line 7675).

Several different conditions can cause the termination of a given branch (lines 7680 to 7820). The first of these conditions is if the amount passed to this branch is more than four orders of magnitude smaller than the output threshold. This is the range of desired accuracy. The second condition is if the amount passed to a step divided by the total amount produced (X+prod*t) falls below 10^{-10}. If this occurs the concentrations being calculated are mostly round off error. The third condition is if the amount passed to a branch is less than the level of significance for any of the isotopes of interest. The final condition which may cause the termination of a chain is if an isotope appears more than twice in a decay chain.

If this branch isn't terminated, Omega is called to determine the total transition coefficient of this isotope (line 7825). The concentration for this isotope is then calculated from both sources and summed (lines 7830 to 7880). Now, if this is the first appearance of the isotope in the chain, the amount calculated is stored in Am and Fract is set to zero (lines 7885 to 7900). If it is the second appearance, Am is set to zero and the ratio between the amounts calculated between the first and second appearance is added to the Fract of the first appearance (lines 7905 to 7935). If for some reason the amount of the first appearance is zero, Am for the first appearance is set equal to the sum of all the second appearances (lines 7915 to 7935).

The amount passed from this step is calculated by subtracting the mass of this isotope remaining at the end of the time step, from that passed to this link (line 7950). The program then loops back to find a new daughter (line 7960). Finally, when the program has looped through all of the isotopes, the program returns to Abund.

C.18. Subroutine Omega

Subroutine Omega calculates the total transition coefficient for an isotope and stores its decay and cross section data in their appropriate string (lines 8010 to 8165). If K1$ is 'N', this is the first time Omega has been called, and its libraries are empty. Therefore, the first library segments are loaded (lines 8015 to 8035). This segment is loaded and kept permanently in the library vectors, because many different isotopes may undergo an (n,p) reaction or alpha-decay. When this happens the data for hydrogen and helium are needed.

Next, K1$ and K2$ are checked to see if the library contains the segment needed for this step (lines 8040 to 8055). If it doesn't have the isotope needed, the appropriate library segment is loaded. The decay library is then searched for the isotope whose transition coefficient is to be calculated (line 8060 to 8075). If or when this entry is found, the first half of the total transition coefficient is calculated and the decay string is stored in the appropriate place (lines 8080 to 8110). The search for the cross section string follows with similar results (lines 8115 to 8160). Finally, control is returned to the subroutine Decay.

C.19. Subroutine Lib

Subroutine Lib is the subroutine which loads the decay, cross section, and fission yield libraries from disk (lines 8170 to 8390).

This routine differs from subroutine Libin by the fact that the first library segment is loaded and left in the library memory, and that, at most, only two other segments are kept in memory. It controls the segments by setting the library counters to the appropriate values. If the library is empty the counters are set to zero. If the first new segment is being read, the counter is set to the end of the constant data. If the second new segment is being read, the counters are left as is. If the third new segment is being read, the counters are reset as if it were the first new segment (lines 8185 to 8280).

Once the counters are set the data are read from the disk and stored in the appropriate vector (lines 8285 to 8385). Control is then returned to subroutine Omega.

C.20. Subroutine Daughter

Subroutine Daughter determines the next daughter of a transition chain and calculates the coupling coefficient for this isotope (lines 8395 to 9205). This process is complicated if an isotope decays by alpha emission or by a (n,p) reaction. When this happens two isotopes are formed by the transition process, one of which is hydrogen or helium. A separate transition chain exists for each. A special vector is used in Daughter to keep track of these transitions. The vector, Frac, stores the location of the isotope formed in the alternate branch of the transition chain. Its value is recovered after the original branch has been followed to its end (lines 8400 to 8425).

If no alternative branch is to be recovered, a new daughter must be found. The length of F1$ is tested to see if this daughter is on a new level in the transition chain (line 8430). If it isn't, the index which indicates the type of transition last tested at this level is recovered (line 8435). If the index is less than seven, the transition was by radioactive decay.

If the index is less than seven, the eleventh character of the decay string is tested to determine if it is a nine (line 8445). If this character is a nine, more than two decay modes exist for this isotope. If it isn't, and since this is at least the second time through this step for this isotope, the secondary decay mode is of interest for this isotope. Therefore, the codes for the old decay mode and the secondary decay mode are recovered (lines 8450 to 8460). A test is made to see if the secondary decay mode is zero, indicating no secondary decay, a'5', indicating that the secondary decay is spontaneous fission, or equal to the old decay mode, indicating that the secondary mode has already been tested. If it is any of these three values, the cross section data are searched for a transition mode (line 8465). If not, the coupling coefficient is calculated, the transition index is updated and the next stage of testing begins (lines 8470 to 8490).

When a '9' is encountered in character eleven of the decay string, a special technique is needed to determine the new daughter. Each of the four possible multiple chains is controlled by its own section of code. Therefore, a branch is immediately made to that section (line 8605). Next, a search is made for the old decay mode. If it is found, the transition index is updated, the location of the appropriate fraction is stored in F2, the coupling coefficient is calculated and the next stage of testing begins (lines 8610 to 8735). If the old decay mode proves to be the last, for this isotope, the cross section string is searched for transition modes.

If this is a new level, the primary decay mode for this isotope is choosen automatically and the coupling coefficient is calculated appropriately (lines 8495 to 8600). But, if this isotope is radioactively stable, the cross section string is searched for a transition mode.

Once all of the decay data have been exhausted, the search of the cross section string begins. If this is the first time the cross section string is accessed for this isotope, the first transition mode is chosen as the current one and the coupling coefficient is calculated (lines 8740 to 8760). If this is not the first time, the cross section string is searched for the old code. When it is found, the next transition mode is assumed to be the current one and the coupling coefficient is calculated appropriately (lines 8765 to 8815). If the old transition mode is the last one in this string, the decay chain is shortened by one and the test starts over again (lines 9135 to 9160). If the length of the transition chain is now zero, the end flag is set to one and control is returned to Decay.

The next stage of testing begins by recovering the atomic number and atomic weight of this isotope (lines 8820 to 8825) and determining the atomic weight, atomic number and atomic state of the daughter isotope, based on the transition mode (lines 8830 to 9015). During this process, a note is made if the isotope emits an alpha particle or a proton during the process of transition. Once this is constructed (line 9020), the isotope vector is searched to determine if this isotope is to be considered in calculations (lines 9110 to 9130). If it isn't, the program loops back to find another daughter (line 9030). If it is found, the location of this isotope is stored in I (line 9035).

If an alpha-particle or proton is emitted during the transition, the isotope vector is searched for the appropriate particle (lines 9040 to 9100). If it is found, the location of this isotope is stored in the appropriate element of Frac, otherwise a zero is placed there.

Finally, when a new daughter is located, the string Fl$ is updated and the length of the transition chain is increased by one. Control then returns to Decay (lines 9165 to 9205).

C.21. Subroutine Vectout

The final subroutine of KSIG, is Vectout (lines 9250 to 9655). Its purpose is to construct a concentration vector and store it on disk 1. The first step of this subroutine is to search the isotope vector for all isotopes whose concentration is greater than 10^{-99} grams (lines 9270 to 9345). Once such an isotope has been found, an entry for the concentration vector is constructed. The process used to construct this entry is identical to that used in Inin (lines 9385 to 9510).

Next, the actinide vector is searched for isotopes with concentrations greater than 10^{-99} grams (lines 9350 to 9375). A similar procedure is followed to construct the entry for the concentration vector. To avoid duplication of isotopes which appear in both the isotope vector and the actinide vector, the isotopes appearing in both are skipped during the search of the isotope vector (lines 9280 to 9325).

Finally, when all entries have been constructed, output beings. First, the new file is created (lines 9515 to 9545). If an error occurs while creating this file, provision is made for recovering from the error (lines 9595 to 9650). If no error occurs, the data are written sequentially to the file (lines 9550 to 9580), the file is closed (line 9585), and control is returned to the main routine.

IV. Results and Conclusions

A. General Operation of KSIG

KSIG is an interactive program. It has been constructed to be highly "user friendly". The only stage of the program which requires the presence of the operator is the first, input, stage. This stage requires little time provided the data files used have been previously stored on a data disk. A sample dialogue where this is the case is presented below. Sample input which deviates from the general case is included in parentheses (). All computer responses are included in quotations "".

1. Place the Basic System disk into drive 0.
2. Turn on the computer and the disk drive unit. The computer responds by loading the Basic System.
3. Remove the Basic System disk and place the KSIG Master disk into drive 0.
4. Type in LOAD "KSIG" and press the |ENTER| key. The computer responds by loading the first half of KSIG into the computer memory.
5. Press the |RUN| key.

   "Make certain your Data Disk is in Drive 1
   and that the paper on your printer is lined up with the top
   press CONT when ready"

6. Place the disk with the data files in drive 1, roll the computer paper up so that the perforations line up with the metal bar above the print head, and then press the |CONT| key.

   "Do you wish to input a new power/time history or use a stored one"

   |NEW| |STORED|

7. If the power history file is stored already, press |K6|. If you need to input a new power history press |K5|.

   (Press |K6|)

   "Enter the name of the ASCII file in which the data are stored"

8. Enter the name of the file on the data disk which contains the power/time history. Only files previously saved by KSIG will be used.

   (Type: FULL |ENTER|)

   "Do you wish to consider fission product production or just neutron activation and decay"

   |FISS PROD| |NO FISS PROD|

9. If the concentrations of fission products are to be calculated press |K5|. If not, then press |K6|.

   (Press |K5|)

   "What is the threshold for output in grams (Default is IE-5)"

10. The computer needs to know the minimum mass which must be obtained in order for an isotope to be output in the output table. If this mass is 10^{-5} grams simply press |ENTER|. If not, type in the mass required in grams and press |ENTER|.

    (Type: IE-4 |ENTER|)

    "Are you interested in only certain isotopes or all isotopes"

    |CERTAIN| |ALL|

11. If the concentration of all 1306 isotopes is wanted, press |K6|. If the concentration of a select group of isotopes, press |K5|.

    (Press |K5|)

    "Those Isotopes you are interested in are:"

    |POISON| |DOSE| |OTHER|

12. Pressing |K5| indicates that the concentrations of the strong neutron absorbers will be calculated. Pressing |K6| means that the concentration for isotopes with large gamma yields will be calculated. Pressing |K7| indicates that a different group of isotopes will be considered.

(Press |K7|)

"Do you wish to input new isotopes or use previously stored ones"

|STORED| |NEW|

13. Pressing |K5| indicates that a file containing the isotopes of interest exists on the data disk. Pressing |K6| indicates that a new file must be constructed. Only isotope files constructed by KSIG will work.

(Press |K5|)

"What is the name of the file where the isotopes are stored"

14. The computer needs to know the name of the file where the list of isotopes is stored. Key in the name then press |ENTER|.

(Type: TEST |ENTER|)

"Do you wish to input a new isotope inventory or use a stored one"

|NEW| |STORED|

15. Pressing |K6| indicates that a file containing the initial concentration of the isotopes already exists on the data disk. Pressing |K5| indicates that a new file must be constructed. Again, only a file constructed by KSIG will work.

(Press |K6|)

"Enter the name of the file these data are stored in"

16. The computer needs to know the name of the file where the concentrations of isotopes are stored. Key in the name then press

|ENTER|.

(Type: INVTYP |ENTER|)

"Do you wish to save the final output vector"

|YES| |NO|

17. The computer wants to know whether or not the concentrations calculated by this run are to be saved in a concentration file. If they are, press |K5|. If not, press |K6|.

(Press |K5|)

"Input the name of the output file
Default is OUT1"

18. The computer needs to know what the output file should be called. If it is to be called OUT1, simply press |ENTER|. If not, then enter the name the file is to have.

(Type: TEST_OUT |ENTER|)

The first alternative to be explored is the new power history alternative. This alternative requires only as much time as it takes to key in the data. If the operator chooses to input a new power/time history, steps 7 and 8 of the above would be replaced by the following.

"Do you wish to input a new power/time history or use a stored one"

|NEW| |STORED|

7a. (Press |K5|)

"Input the name of the file. Default will be POW1"

7b. The computer needs to know what the new power/time history should be named. If it's to be named POW1, simply press |ENTER|. If not, then enter the name that the power/time history file will be called.

(Type: SHORT |ENTER|)

"What will the power be stored as {FLUX/POWER}"

|POWER| |FLUX|

7c. Pressing |K6| indicates that the neutron flux will be entered as a function of time. Pressing |K5| means that the thermal power produced by the actinides whose concentrations have been input will be entered as a function of time.

(Press |K5|)

"Input the power/time steps

To leave this input mode just hit (ENTER) when asked for the flux or power"

"Enter the power {MW/CELL} or FLUX {N/CM^2S}"

7d. If |K6| was pressed in response to 7c, then the computer needs the neutron flux. If |K5| was pressed, then the computer needs the thermal power. Enter the appropriate number, or if there are no more entries then press |ENTER|.

(Type: 14 |ENTER|)

"Enter the length of the time step"

7e. The computer needs to know the length of the decay step.

(Type: 1 |ENTER|)

"Enter the time units {S/M/H/D/Y}"

7f. Now the computer wants the units used for the time step. Enter S for seconds, M for minutes, H for hours, D for days, and Y for years. Upon completion of this step, the computer prints the data file entry created.

(Type: D |ENTER|)

"1.4000 E+01 1.0000E+00 D"

"Enter the power {MW/CELL} or flux {N/CM^2S}"

7d'. The computer is ready for the second power/time step.

(Type: 12 |ENTER|)

"Enter the length of the time step"

7e'. (Type: 1 |ENTER|)

"Enter the time units {S/M/H/D/Y}"

7f'. (Type: Y |ENTER|)

"1.2000E+01 1.0000 E+00 Y"

"Enter the power {MW/CELL} or flux {N/CM^2S}"

.

.

.

"Enter the power {MW/CELL} or flux {N/CM^2S}"

$7d^n$. (Press |ENTER|)

"Do you wish to consider fission product production or just neutron activation and decay"

|FISS PROD| |NO FISS PROD|

The second alternative to be explored is the creation of a new isotope list. This procedure may require a great deal of time. Typical run times vary from about 5 minutes to about two or three hours, depending on the number of isotopes of interest and how tightly isotopes are coupled. If the operator chooses to develop a new list of isotopes, steps 13 and 14 of the main procedure would be replaced by the following.

"Do you wish to input new isotopes or use previously stored ones"

|STORED| |NEW|

13a. (Press |K6|)

"Enter the isotopes you are interested in
When finished entering new isotopes of interest press enter
when asked for the atomic number"

"Enter the atomic number"

13b. The computer wants to know the atomic number of an isotope of interest. This is the Z number of an isotope. To continue, enter the appropriate number. When there are no more isotopes of interest simply press |ENTER|.

(Type: 27 |ENTER|)

"Enter the atomic weight"

13c. The computer needs to know the atomic weight of the isotope of interest. To continue enter the appropriate number.

(Type: 60 |ENTER|)

"Are you interested in the excited or ground state"

|EXCITED| |GROUND|

13d. If this isotope of interest is in the excited state, press |K5|. If it is in the ground state, press |K6|. Upon completion of this step, the computer procedes to print all isotopes which pass the test for inclusion into the library, including the isotope just entered.

(Press |K6|)

"*270600
270601
270590
.
.
.
280600"

"Enter the atomic number"

13b'. The computer is ready for another isotope of interest.

(Type: 28 |ENTER|)

"Enter the atomic weight"

13d'. (Press |K6|)

"280600
280590
280580"

"Enter the atomic number"

.
.
.

"Enter the atomic number"

13b^{n}. (Press |ENTER|)

"Input the name of the new isotope file. The default will be file: ISO1."

13e. The computer needs to know what the new isotope file should be called. If it is to be called ISO1, simply press |ENTER|. If not then enter the name the file is to have.

(Type: CO60 |ENTER|)

"Do you wish to input a new isotope inventory or use a stored one"

|NEW| |STORED|

The final alternative to be explored is the creation of a new isotope inventory file. This step uses very little time, only as much time as it takes to key in the data. IF the operator chooses to create a new isotope inventory file, steps 15 and 16 of the main procedure would be replaced by the following.

"Do you wish to input a new isotope inventory or use a stored one"

|NEW| |STORED|

15a. (Press |K5|)

"Input the isotope inventories

To leave this input mode press (ENTER) when asked for atomic number

To indicate that the naturally occurring element is being input rather than a specific isotope, press (ENTER) when asked for atomic weight"

"Enter the atomic number"

15b. The computer wants to know the atomic number of an isotope which has an initial concentration. To continue enter the Z number of such an isotope, or if all isotopes whose initial concentration is known to have already been input, press |ENTER|.

(Type: 27 |ENTER|)

"Enter the atomic weight"

15c. The computer needs to know the atomic weight of this isotope. If this is an element, say naturally occurring oxygen, rather than a specific isotope, say O-16, then simply press |ENTER|. Otherwise, enter the appropriate atomic weight.

(Type: 60 |ENTER|)

"Is this isotope in the excited or ground state"

|GROUND| |EXCITED|

15d. If this isotope is in the excited state, press |K6|. If it is in the ground state press |K5|.

(Press |K5|)

"Enter the isotope/element inventory in grams"

15e. If an atomic weight was entered in step 15c, the total mass of this isotope is needed. If nothing was entered at step 15c, the total initial mass of the naturally occurring element needs to be entered. Upon completion of this step, the computer proceeds to print the data file entry or entries just created.

(Type: 1000 |ENTER|)

"270600 1.000E+03"

"Enter the atomic number"

15b'. The computer is ready for another isotope or element.

(Type: 26 |ENTER|)

"Enter the atomic weight"

15c'. (Press |ENTER|)

"Enter the isotope/element inventory in grams"

15e'. (Type: 100 |ENTER|)

"260540 5.8100E+00
260560 9.1750E+01
260570 2.1500E+00
260580 2.9000E-01"

"Enter the atomic number"

.
.
.

"Enter the atomic number"

15b^{n}. (Press |ENTER|)

"do you wish to save this vector"

|YES| |NO|

15f. If this vector is to be saved for later runs, press |K5|. If not, press |K6|.

(Press |K5|)

"Input the name of the new isotope inventory file.
The default will be INV1"

15g. The computer needs to know what the new concentration file should be called. If it is to be called INV1, press |ENTER|. If not, then enter the name of the new file.

(Press |ENTER|)

"Do you wish to save the final output vector"

|YES| |NO|

The second stage of KSIG, the calculation and output stage, does not require the presence of an operator. This stage requires a great deal of time. An average time step, with a non-zero neutron flux, and which calculates fission products, requires anywhere from 15 minutes to a couple of hours, depending on the number of isotopes being calculated. If no transmutation takes place, a time step can take as little as three minutes or as many as 20 minutes. The run detailed in Appendix C.1 required five minutes, while the run detailed in Appendix C.2 required 6½ hours.

An attempt was made to reduce the calculation time, by reducing required accuracy. This was done by taking the first two time steps of the problem in Appendix C.2 and varying the output threshold while holding everything else constant. Table 4 contains a summary of the results. This test demonstrated a substantial decrease in calculation time, with a minimal change in accuracy. In fact, these changes could be considered insignificant.

Table 4. The reduction of calculation time, due to lost accuracy.

Output Threshold	Mass of CS-134	% Change	Time (min)
10^{-5}	2.2915160E-1		52.6
10^{-4}	2.2915142E-1	7.86×10^{-5}	45.4
10^{-3}	2.2914824E-1	1.47×10^{-3}	39.8
10^{-2}	2.2911639E-1	1.54×10^{-2}	34.6

B. Comparison of Sample Runs

To test the accuracy of KSIG, two sample runs where made. The first run was a very simple 'hand-type' calculation. Its purpose was to demonstrate that KSIG can perform a simple calculation accurately. The second was a complex run made for comparison with ORIGEN2.

B.1. The Simple Run

The simple test performed involved the Beta-decay of Cobalt-60 to Nickel-60. An initial sample size of 1000 grams of Cobalt-60 was assumed, and the concentrations of both Cobalt-60 and Nickel-60 were calculated for a 1 year decay time.

Since the object of this test was to determine the operation of the code, and not the authenticity of the data used, the radioactive half-lives of these two isotopes were found in Appendix B.1. The half-life of Cobalt-60 was found to be 1.663×10^{8} seconds, while Nickel-60 was found to be radioactively stable.

The equation used in the hand-calculation of the concentration of Cobalt-60 was,

$$N_{27} = N_{27}^{0}\, e^{-\lambda_{27} t}, \tag{4.1}$$

where, N_{27}^{0} is the initial concentration of CO-60, and

λ_{27} is the radioactive decay constant for CO-60.

The equation used to calculate the concentration of Nickle-60 was,

$$N_{28} = N_{27}^{0}(1-e^{-\lambda_{27} t}). \tag{4.2}$$

The radioactive decay constant is found by using Eq. (2.16), when flux is zero.

Substituting into these equations gives a final concentration of 876.74969 grams of Co-60 and 123.25031 grams of Ni-60. Comparison to the KSIG results demonstrates that KSIG predicted these results exactly. A copy of this KSIG run can be found in Appendix C.1.

B.2. Comparison of ORIGEN2

The second comparison run is a complex run involving ten irradiation steps and twelve decay steps for six different isotopes. The KSIG version of this run is found in Appendix C.2. ORIGEN2 uses the same data used by KSIG.

The concentrations of Xe-135, Xe-133, X3-131, Cs-135, Cs-134, and Cs-133, were calculated during and after a constant irradiation of 14 MW/fuel element. The initial concentrations used were those of a hypothetical fuel element. Both ORIGEN2 and KSIG were used to perform these calculations. The results from KSIG are summarized in Table 5 and those from ORIGEN2 in Table 6. These two tables were then compared to each other by using the equation,

$$\% \text{ diff} = \frac{|\text{OR} - \text{KSIG}|}{\text{OR}} \times 100\%, \tag{4.3}$$

where, % diff is the percentage difference between the two,
OR is the concentration determined by ORIGEN2, and
KSIG is the result determined by KSIG.

The results of this comparison are found in Table 7.

Upon examination of Table 7, one observes that the maximum difference found is six percent, while the typical range of differences lies between .5 and three percent. These results are very good as a first approximation.

Table 5. The concentrations of six test isotopes during and after an irradiation of 14 MW/fuel element, calculated by KSIG. The units are grams per fuel element.

Time	Xe-135	Xe-133	Xe-131	Cs-135	Cs-134	Cs-133
During Irradiation						
35 D	8.461E-2	4.137	5.622	5.362	4.556E-2	14.45
70 D	8.502E-2	4.184	13.74	10.83	0.2292	33.59
105 D	8.539E-2	4.183	21.90	16.31	0.5508	52.61
140 D	8.560E-2	4.182	29.97	21.81	1.003	71.49
175 D	8.567E-2	4.180	37.93	27.31	1.581	90.21
210 D	8.564E-2	4.178	45.79	32.81	2.278	108.8
245 D	8.552E-2	4.177	53.54	38.30	3.091	127.2
280 D	8.532E-2	4.175	61.17	43.79	4.014	145.4
315 D	8.505E-2	4.174	68.68	49.26	5.044	163.5
365 D	8.464E-2	4.172	79.18	57.11	6.694	189.0
After Irradiation						
30 M	9.213E-2	4.172	79.19	57.12	6.694	189.1
1 H	9.863E-2	4.171	79.19	57.12	6.694	189.1
2 H	1.093E-1	4.171	79.21	57.12	6.693	189.1
3 H	1.175E-1	4.169	79.22	57.14	6.693	189.1
4 H	1.234E-1	4.168	79.23	57.15	6.693	189.1
5 H	1.274E-1	4.165	79.24	57.15	6.693	189.2
10 H	1.282E-1	4.143	79.29	57.20	6.692	189.3
15 H	1.182E-1	4.109	79.34	57.25	6.690	189.4
20 H	9.077E-2	4.063	79.39	57.29	6.689	189.5
1 D	7.437E-2	4.021	79.43	57.31	6.688	189.6
2 D	1.683E-2	3.694	79.66	57.39	6.682	190.1
3 D	3.095E-2	3.318	79.87	57.40	6.676	190.6

Table 6. The concentrations of six test isotopes during and after an irradiation of 14 MW/fuel element, calculated by ORIGEN2. The units are grams per fuel element.

Time	Xe-135	Xe-133	Xe-131	Cs-135	Cs-134	Cs-133
During Irradiation						
35 D	8.391E-2	3.982	5.612	5.273	.04849	14.56
70 D	8.464E-2	4.041	13.75	10.68	0.2381	33.90
105 D	8.491E-2	4.037	21.95	16.11	0.5690	53.16
140 D	8.501E-2	4.033	30.05	21.54	1.034	72.25
175 D	8.515E-2	4.029	38.05	27.00	1.625	91.18
210 D	8.499E-2	4.026	45.94	32.45	2.340	109.9
245 D	8.493E-2	4.023	53.72	37.90	3.170	128.6
280 D	8.478E-2	4.020	61.38	43.35	4.111	147.0
315 D	8.454E-2	4.017	68.92	48.79	5.159	165.3
365 D	8.417E-2	4.048	79.46	56.57	6.833	191.0
After Irradiation						
30 M		4.048	79.47	56.57	6.833	191.0
1 H		4.049	79.47	56.57	6.833	191.0
2 H		4.049	79.48	56.58	6.833	191.0
3 H		4.048	79.50	56.59	6.833	191.1
4 H		4.046	79.51	56.60	6.832	191.1
5 H		4.044	79.52	56.61	6.832	191.1
10 H		4.025	79.57	56.66	6.831	191.2
15 H		3.993	79.62	56.70	6.830	191.3
20 H		3.951	79.67	56.74	6.829	191.4
1 D		3.911	79.71	56.77	6.827	191.5
2 D		3.596	79.94	56.84	6.821	192.0
3 D		3.232	80.14	56.85	6.815	192.5

Table 7. The percentage difference between the concentrations found by KSIG (Table 5) and ORIGEN2 (Table 6).

Time	Xe-135	Xe-133	Xe-131	Cs-135	CS-134	Cs-133
During Irradiation						
35 D	0.83	3.89	0.18	1.69	6.04	0.76
70 D	0.45	3.54	0.07	1.38	3.74	0.91
105 D	0.57	3.62	0.23	1.24	3.20	1.03
140 D	0.69	3.69	0.27	1.25	3.00	1.05
175 D	0.61	3.75	0.32	1.15	2.71	1.06
210 D	0.76	3.78	0.33	1.11	2.65	1.00
245 D	0.69	3.83	0.34	1.06	2.49	1.09
280 D	0.64	3.86	0.34	1.01	2.36	1.09
315 D	0.60	3.91	0.35	0.96	2.23	1.09
365 D	0.56	3.06	0.35	0.95	2.03	1.05
After Irradiation						
30 M		3.06	0.35	0.97	2.03	0.99
1 H		3.01	0.35	0.97	2.03	0.99
2 H		3.01	0.34	0.95	2.05	0.99
3 H		2.99	0.35	0.97	2.05	1.05
4 H		3.02	0.35	0.97	2.03	1.05
5 H		2.93	0.35	0.95	2.03	0.99
10 H		2.98	0.35	0.95	2.03	0.99
15 H		2.91	0.35	0.97	2.05	0.99
20 H		2.83	0.35	0.97	2.05	0.99
1 D		2.81	0.35	0.95	2.04	0.99
2 D		2.73	0.35	0.97	2.04	0.99
3 D		2.66	0.34	0.97	2.04	0.99

Further examination of the output data show that the neutron flux calculated by KISG is consistently less than that calculated by ORIGEN2 (see Table 8). This could be a contributing factor in the difference between the results.

C. Summary

The main objective of this research, as stated in Chapter I, was to down-size an isotope inventory code and transfer it to a microcomputer. This was accomplished by forfeiting a little accuracy. By giving up a little more accuracy, calculation times were substantially reduced also.

A second objective was to reduce the volume of output. The ORIGEN2 run of problem IVB.2 required 190 pages of output. the comparable KSIG run required only 27 pages of output. Therefore, this objective was accomplished.

The final objective was to reduce the cost of isotope inventory calculations. This objective was accomplished, also. To see this, consider that, after the initial cash outlay of five to six thousand dollars for the computer system, an average KSIG run will only cost one or two dollars per run for paper, disks and upkeep. An average ORIGEN2 run costs approximately 90 dollars. Therefore, the computer system is totally paid for after approximately 100 computer runs.

One other advantage to operating a microcomputer is the ease with which program changes are made. The operator has total flexibility in correcting a code, tailoring a code for a specific job, or programming the code to output to disk at select points in time. This can not be easily accomplished using a packaged code on someone else's computer system.

Table 8. The neutron flux calculated by both KSIG and ORIGEN2 and the percentage difference between the two.

Time	ORIGEN2	KSIG	% Diff
35 D	2.23E14	2.20E14	1.35
70 D	2.22E14	2.19E14	1.35
105 D	2.22E14	2.19E14	1.35
140 D	2.22E14	2.19E14	1.35
175 D	2.22E14	2.20E14	0.901
210 D	2.23E14	2.21E14	0.897
245 D	2.23E14	2.22E14	0.448
280 D	2.24E14	2.23E14	0.446
315 D	2.26E14	2.25E14	0.443
365 D	2.27E14	2.28E14	0.441

One disadvantage to owning your own system is that all maintenance becomes the owner's responsibility. This, however, is not always a disadvantage. At least the operator understands the condition of the equipment at all times.

V. Suggestions for Further Study

Several possibilities for further study do exist. The first possibility lies in the generation of some of the output tables generated by ORIGEN2. These tables could include a neutron poison table, photon tables, and radioactive ingestion/inhalation hazard tables. These could be created using the data generated by KSIG.

A second possibility might be to expand KSIG to handle spatial dependence. This could then be coupled to a neutronics code. This would lead to a determination of spatial effects of nuclear poisons.

Third, with advances in computer technology, new, faster, personal systems are constantly being developed. A possibility for further study might stem from transferring KSIG to one of these systems.

Finally, KSIG has only been developed and tested with data for a Uranium fueled light water reactor. Data for other reactor types exist and with a little work they could be formed into the same structure as the files used by KSIG. With a few minor modifications, KSIG could be made to calculate concentrations for different reactor types.

VI. Acknowledgements

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APPENDIX A: Program KSIG

APPENOIX A FILE:K3I6 PAGE I

```
5     Rtime=TINEOATE MOO 86400
10    COM T,Flux,Power,Rtime,Thresh
15    CALL Powin(@Power,Ptype,P$,Thresh)
20    CALL Isotope(@Iso,N,Ptype)
25    DELSUB Powin,Isotope,Libin
30    LOAOSUB ALL FRON "PRO62"
35    ALLOCATE A(N),B(N),I$(N)[7],Aact(82),Bact(82),Act$(82)[7]
40    CALL Isin(@Iso,N,I$(*),Act$(*))
45    CALL Inin(I$(*),A(*),Act$(*),Aact(*),N)
50    CALL Typout(Typout,Fout$)
55    CALL Frm
60    OELSUB Isin,Inin,Typout,Frm
65    T=0
70    Flux=0
75    Power=0
80    Page=I
85    CALL Out(I$(*),A(*),Act$(*),Aact(*),Typout,N,Page)
90    CALL Abund(I$(*),A(*),B(*),Act$(*),Aact(*),Bact(*),@Power,Ptype,Eflag,N,P$)
95    IF Eflag=I THEN Endfl
100   CALL Tran(A(*),B(*),N,Aact(*),Bact(*))
105   GOTO 85
110 EndfI:IF Fout$<>"NONE" THEN CALL Vectout(I$(*),A(*),Act$(*),Aact(*),N,Fout$)
115        ENO
120   SUB Powin(@Power,Ptype,FI$,Thresh)
125   OIN A$[I00],B$(I000)[23]
130   GOSUB Clscreen
135   NASS STORAGE IS ":HP82901,700,1"
140   CONIROL I,1;5
145   PRINT "NAKE CERTAIN THAT YOUR OATA OISK IS IN ORIVE I"
150   PRINT "ANO THAT THE PAPER ON YOUR PRINTER IS LINEO UP NITH THE TOP"
155   PRINT "PRESS CONT NHEN REAOY"
160   PAUSE
165   GOSUB Clscreen
170   OISP " OO YOU NISH TO INPUT A NEW PONER/TINE HISTORY OR USE A STOREO ONE"
175   ON KEY 5 LABEL "NEN" GOTO New
180   ON KEY 6 LABEL "STOREO" GOTO Stored
185   GOTO 185
190 Stored:    OFF KEY
195   INPUT "ENTER THE NANE OF THE ASCII FILE IN NHICH THE OATA ARE STOREO",FI$
200   ON ERROR GOTO Err
205   ASSIGN @Power TO FI$
210   OFF ERROR
215   ENTER @Power;A$
220   OFF ERROR
225   IF A$<>"FLUX" THEN 240
230     Ptype=0
235     GOTO EndfI
240   IF A$<>"PONER" THEN 255
245     Ptype=1
250     GOTO EndfI
255   CONTROL I,1;5
260 Err:  PRINT " FILE:";FI$;" EITHER OOES NOT EXIST OR IS NOT FORNATEO PROPERLY"
265   PRINT "   NAKE A NEN SELECTION"
270   OFF ERROR
275   GOTO I70
280 New:     OFF KEY
285   FI$="PONI"
290   GOSUB Clscreen
295   CONTROL 1,1;5
300   PRINT "INPUT THE NAME OF THE NEN FILE.  THE OEFAULT NILL BE ";FI$
305   INPUT FI$
310   GOSUB Clscreen
315   OISP "NHAT WILL THE POWER BE STOREO AS. (FLUX/PONER)"
320   ON KEY 5 LABEL "POWER" GOTO Power
325   ON KEY 6 LABEL "FLUX" GOTO Flux
330   GOTO 330
335 Power:    OFF KEY
340   Ptype=1
345   B$(1)="PONER"
350   GOTO 370
```

APPENDIX A FILE:KSIG PAGE 2

```
355 Flux:    OFF KEY
360   Ptype=0
365   B$(I)="FLUX"
370   CONTROL 1,1;5
375   PRINT "INPUT THE ";B$(I);"/TIME STEPS"
380   PRINT
385   PRINT "TO LEAVE THIS INPUT MODE JUST HIT (ENTER) WHEN ASKED FOR"
390   PRINT "THE FLUX OR POWER"
395   PRINT
400   I=1
405   A1=-1
410   A=-1
415   INPUT "ENTER THE POWER (MW/CELL) OR FLUX (N/CM^2S)",A
420   IF A=A1 THEN Out
425   I=I+1
430   A1=A
435   CALL Astring(A,B$(I))
440   INPUT "ENTER THE LENGTH OF THE TIME STEP",A
445   CALL Astring(A,A$)
450   B$(I)=B$(I)&" "&A$
455   INPUT "ENTER THE TIME UNITS (S/M/H/D/Y)",T$
460   IF T$<>"S" AND T$<>"M" AND T$<>"H" AND T$<>"D" AND T$<>"Y" THEN 455
465   B$(I)=B$(I)&" "&T$
470   PRINT B$(I)
475   GOTO 405
480 Out: F1=((I-1)*26+13)/256
485  F1=INT(F1)+1
490  GOSUB Clscreen
495  ON ERROR GOTO Flg
500  CREATE ASCII F1$,F1
505  OFF ERROR
510  ASSIGN @Power TO F1$
515  FOR J=1 TO I
520    OUTPUT @Power;B$(J)
525  NEXT J
530  OUTPUT @Power;"END"
535  ASSIGN @Power TO F1$
540  ENTER @Power;A$
545  GOTO Endfl
550 Flg:  X=ERRN
555  IF X<>54 THEN 570
560    F1$[LEN(F1$);1]=CHR$(NUM(F1$[LEN(F1$);1])+1)
565    GOTO 495
570  IF X<>55 AND X<>64 THEN 595
575    DISP "THIS DISK IS FULL. TRY A DIFFEREN ONE AND PRESS (CONT)"
580    BEEP
585    PAUSE
590    GOTO 495
595  DISP "ERROR ENCOUNTERED WHILE TRYING TO CREATE FILE:";F1$
600  BEEP
605  STOP
610 Clscreen:   OUTPUT 2 USING "#,B";255,75
615   RETURN
620 Endfl:   GOSUB Clscreen
625    CONTROL 1,1;5
630    PRINT "DO YOU WISH TO CONSIDER FISSION PROUCT PRODUCTION OR"
635    PRINT "JUST NEUTRON ACTIVATION AND DECAY ?"
640    ON KEY 5 LABEL "FISS PROD" GOTO 660
645    ON KEY 6 LABEL "NO FISS PROD" GOTO 655
650    GOTO 650
655    Ptype=Ptype+2
660    OFF KEY
665    GOSUB Clscreen
670    CONTROL 1,1;5
675    Thresh=1.E-5
680    INPUT "WHAT IS THE THRESHOLD FOR OUTPUT IN GRAMS (DEFAULT IS 1E-5)",Thresh
685    SUBEND
690   SUB Isotope(@Iso,N,Ptype)
695   DIM I$(1306)[7],A$[75],E(50),D(50),D$(50)[62],X$(50)[65],F2$[50],F1$[50]
700   DIM Xsec$(900)[75],Dec$(900)[62],Weight(1306),Fiss$(600)[53]
```

APPENDIX A FILE:KSIG PAGE 3

```
705   MASS STORAGE IS ":HP82901,700,0"
710   DISP "ARE YOU INTERESTED IN ONLY CERTAIN ISOTOPES OR ALL ISOTOPES"
715   ON KEY 5 LABEL "CERTAIN" GOTO Certain
720   ON KEY 6 LABEL "ALL" GOTO Al
725   GOTO 725
730 Al:     OFF KEY
735         ASSIGN @Iso TO "ALL"
740         GOTO Endfl
745 Certain:  DISP "THOSE ISOTPOPES YOU ARE INTERSTED IN ARE:"
750             ON KEY 5 LABEL "POISON" GOTO Poison
755             ON KEY 6 LABEL "DOSE" GOTO Dose
760             ON KEY 7 LABEL "OTHER" GOTO Other
765             GOTO 765
770 Poison:  OFF KEY
775            ASSIGN @Iso TO "POISON"
780            GOTO Endfl
785 Dose:  OFF KEY
790         ASSIGN @Iso TO "DOSE"
795         GOTO Endfl
800 Other:DISP "DO YOU WISH TO INPUT NEW ISOTOPES OR USE PREVIOUSLY STORED ONES"
805        ON KEY 5 LABEL "STORED" GOTO Stored
810        ON KEY 6 LABEL "NEW" GOTO New
815        OFF KEY 7
820        GOTO 820
825 Stored:OFF KEY
830       MASS STORAGE IS ":HP82901,700,1"
835       INPUT "WHAT IS THE NAME OF THE FILE WHERE THE ISOTOPES ARE STORED?",Fl$
840       ON ERROR GOTO Err1
845       ASSIGN @Iso TO Fl$
850       ON ERROR GOTO Err2
855       ENTER @Iso;A$
860       N=VAL(A$)
865       OFF ERROR
870       IF N<1307 THEN Endfl2
875 Err2:     OFF ERROR
880            DISP "FILE:";Fl$;" IS INCORRECTLY FORMATED"
885            BEEP
890            GOTO Stored
895 Err1:    OFF ERROR
900           DISP "FILE:";Fl$;" IS NOT A PROPER FILE ON THIS DISK"
905           BEEP
910           GOTO Stored
915 New:    OFF KEY
920         Flux=1.E+14
925         Tim=86400*365
930         GOSUB Clscreen
935         CONTROL 1,1;5
940         C1=1
945         C2=10
950         PRINT "ENTER THE ISOTOPES YOU ARE INTERESTED IN"
955         PRINT
960         PRINT "WHEN FINISHED ENTERING NEW ISOTOPES OF INTEREST PRESS ENTER"
965         PRINT " WHEN ASKED FOR THE ATOMIC NUMBER"
970         PRINT
975         I=0
980         Z=-1
985         INPUT "ENTER THE ATOMIC NUMBER",Z
990         IF Z=-1 THEN Out
995         IF Z<1 OR Z>99 THEN
1000           BEEP
1005           GOTO 985
1010           END IF
1015        I=I+1
1020        Xsec=0
1025        Dec=0
1030        Fiss=0
1035        A=0
1040        INPUT "ENTER THE ATOMIC WEIGHT",A
1045        IF A<1 THEN
1050           BEEP
```

APPENDIX A FILE:KSIG   PAGE 4

```
1055            GOTO 1040
1060            END IF
1065        DISP "ARE YOU INTERESTED IN THE EXCITED STATE OR THE GROUND STATE"
1070        ON KEY 5 LABEL "EXCITED" GOTO Excited
1075        ON KEY 6 LABEL "GROUND" GOTO Ground
1080        GOTO 1080
1085 Excited: OFF KEY
1090            DISP
1095            I$(I)=FNSt$(Z,A,"1")
1100            I$(I)[1;1]="*"
1105            GOTO Find_parent
1110 Ground:  OFF KEY
1115            DISP
1120            I$(I)=FNSt$(Z,A,"0")
1125            I$(I)[1;1]="*"
1130 Find_parent:J=1
1135        CONTROL 1,0;C1
1140        PRINT I$(I)
1145        Weight(1)=1
1150        F1$=""
1155        F2$="1"
1160        K$=I$(I)[2;1]
1165        IF K$=" " THEN K$="0"
1170        CALL Libin(Xsec$(*),Dec$(*),Fiss$(*),K$,Xsec,Dec,Fiss)
1175        K=0
1180        K=K+1
1185        IF K=Dec+1 THEN No_dec
1190        IF Dec$(K)[2,7]<>I$(I)[2,7] THEN 1180
1195        A$=Dec$(K)
1200        IF A$[10;1]="6" THEN No_dec
1205        D(1)=LOG(2)/VAL(A$[24;9])
1210        D(1)=FNC1(D(1),A$)
1215        D$(1)=A$
1220        GOTO Xsec
1225 No_dec: D(1)=0
1230            D$(1)=" "&I$(I)[2;6]&"  6"
1235 Xsec: K=0
1240        K=K+1
1245        IF K=Xsec THEN No_xsec
1250        IF Xsec$(K)[2,7]<>I$(I)[2,7] THEN 1240
1255        A$=Xsec$(K)
1260        X$(1)=A$[10,LEN(A$)]
1265        FOR K=1 TO VAL(A$[10;1])
1270            D(1)=D(1)+VAL(A$[7+K*10;9])*Flux*1.E-24
1275        NEXT K
1280        GOTO Parent
1285 No_xsec:  X$(1)="0"
1290 Parent:J=J+1
1295         FOR K=J-1 TO 1 STEP -1
1300            D(K+1)=D(K)
1305            E(K+1)=E(K)
1310            D$(K+1)=D$(K)
1315            X$(K+1)=X$(K)
1320         NEXT K
1325         I=I+1
1330         As=65
1335 Loop:ON (As-64) GOTO Beta,Ec,Alpha,It,Bn,Bx,Ecx,N_gamma,N_2n,N_3n,N_alpha,N_p,N_gx,N_2nx
1340 Beta:IF D$(2)[7;1]="1" THEN Not_1
1345       IF Z-1=0 THEN Not_1
1350       IF F2$[J-1;1]="0" THEN
1355          F2$[J-1;1]="1"
1360          GOTO 1375
1365          END IF
1370       F2$[J-1;1]="0"
1375       I$(I)=FNSt$(Z-1,A,F2$[J-1;1])
1380       K$=I$(I)[2;1]
1385       K=0
1390       Flag=0
1395       K=K+1
1400       IF K=Dec+1 THEN Not_1
```

APPENDIX A FILE:KS16 PAGE 5

```
1405        IF Dec$(K)[2;1]=K$ THEN Flag=1
1410        IF I$(1)[2,7]<>Dec$(K)[2,7] THEN 1395
1415        A$=Dec$(K)
1420        IF A$[10;1]="6" THEN Not_1
1425        E(1)=LOG(2)/VAL(A$[24;9])
1430        IF A$[11;1]="1" THEN 1445
1435        IF A$[11;1]="9" THEN 1460
1440        GOTO Not_1
1445        IF A$[12;1]="0" THEN 1475
1450        E(1)=E(1)*(1-VAL(A$[34;9]))
1455        GOTO 1475
1460        IF A$[12;1]="1" OR A$[12;1]="4" THEN Not_1
1465        E(1)=E(1)*(1-VAL(A$[34;9])-VAL(A$[44;9]))
1470        IF E(1)<0 THEN Not_1
1475        E(1)=FNC1(E(1),A$)
1480        GOSUB Test
1485        IF Test=0 THEN Not_1
1490        GOTO Parent
1495 Not_1:   IF Flag=0 THEN
1500              IF K$=" " THEN K$="0"
1505              CALL Libin(Xsec$(*),Dec$(*),Fiss$(*),K$,Xsec,Dec,Fiss)
1510              IF F2$[J-1;1]="1" THEN
1515                 F2$[J-1;1]="0"
1520              ELSE
1525                 F2$[J-1;1]="1"
1530              END IF
1535              GOTO Loop
1540              END IF
1545           IF F2$[J-1;1]="1" THEN As=As+1
1550           GOTO Loop
1555 Ec: IF D$(2)[7;1]="1" THEN Not_2
1560       IF Z+1>99 THEN Not_2
1565       IF F2$[J-1;1]="0" THEN
1570          F2$[J-1;1]="1"
1575          GOTO 1590
1580          END IF
1585       F2$[J-1;1]="0"
1590       I$(1)=FNSt$(Z+1,A,F2$[J-1;1])
1595       K$=I$(1)[2;1]
1600       K=0
1605       Flag=0
1610       K=K+1
1615       IF K=Dec+1 THEN Not_1
1620       IF Dec$(K)[2;1]=K$ THEN Flag=1
1625       IF I$(1)[2,7]<>Dec$(K)[2,7] THEN 1610
1630       A$=Dec$(K)
1635       IF A$[10;1]="6" THEN Not_2
1640       E(1)=LOG(2)/VAL(A$[24;9])
1645       IF A$[11;1]="2" THEN 1665
1650       IF A$[11;1]="9" THEN 1680
1655       IF A$[12;1]="2" THEN 1695
1660       GOTO Not_2
1665       IF A$[12;1]="0" THEN 1700
1670       E(1)=E(1)*(1-VAL(A$[34;9]))
1675       GOTO 1700
1680       IF A$[12;1]<>"4" THEN Not_2
1685       E(1)=E(1)*VAL(A$[44;9])
1690       GOTO 1700
1695       E(1)=E(1)*VAL(A$[34;9])
1700       E(1)=FNC1(E(1),A$)
1705       GOSUB Test
1710       IF Test=0 THEN Not_2
1715       GOTO Parent
1720 Not_2: IF F2$[J-1;1]="1" THEN As=As+1
1725          GOTO Loop
1730 Alpha: IF D$(2)[7;1]="1" THEN Not_3
1735           IF Z+2>99 THEN Not_3
1740           IF F2$[J-1;1]="0" THEN
1745              F2$[J-1;1]="1"
1750              GOTO 1765
```

```
1755           END IF
1760          F2$[J-1;1]="0"
1765          I$(1)=FNSt$(Z+2,A+4,F2$[J-1;1])
1770          K$=I$(1)[2;1]
1775          K=0
1780          Flag=0
1785          K=K+1
1790          IF K=Dec+1 THEN Not_1
1795          IF Dec$(K)[2;1]=K$ THEN Flag=1
1800          IF I$(1)[2,7]<>Dec$(K)[2,7] THEN 1785
1805          A$=Dec$(K)
1810          IF A$[10;1]="6" THEN Not_3
1815          E(1)=LOG(2)/VAL(A$[24;9])
1820          IF A$[11;1]="3" THEN 1840
1825          IF A$[11;1]="9" THEN 1855
1830          IF A$[12;1]="3" THEN 1885
1835          GOTO Not_3
1840          IF A$[12;1]="0" THEN 1890
1845          E(1)=E(1)*(1-VAL(A$[34;9]))
1850          GOTO 1890
1855          IF A$[12;1]="2" THEN Not_3
1860          IF A$[12;1]="4" THEN
1865             E(1)=E(1)*(1-VAL(A$[34;9])-VAL(A$[44;9])-VAL(A$[54;9]))
1870             IF E(1)<0 THEN Not_3
1875             GOTO 1890
1880             END IF
1885          E(1)=E(1)*VAL(A$[34;9])
1890          E(1)=FNC1(E(1),A$)
1895          GOSUB Test
1900          IF Test=0 THEN Not_3
1905          GOTO Parent
1910 Not_3:      IF F2$[J-1;1]="1" THEN As=As+1
1915             GOTO Loop
1920 It:   IF D$(2)[7;1]="1" THEN Not_4
1925        I$(1)=FNSt$(Z,A,"1")
1930        K$=I$(1)[2;1]
1935        K=0
1940        K=K+1
1945        IF K=Dec+1 THEN Not_4
1950        IF I$(1)[2,7]<>Dec$(K)[2,7] THEN 1940
1955        A$=Dec$(K)
1960        IF A$[10;1]="6" THEN Not_4
1965        E(1)=LOG(2)/VAL(A$[24;9])
1970        IF A$[11;1]="4" THEN 1990
1975        IF A$[11;1]="9" THEN 2005
1980        IF A$[12;1]="4" THEN 2035
1985        GOTO Not_4
1990        IF A$[12;1]="0" THEN 2040
1995        E(1)=E(1)*(1-VAL(A$[34;9]))
2000        GOTO 2040
2005        IF A$[12;1]="2" OR A$[12;1]="3" THEN Not_4
2010        IF A$[12;1]="1" THEN
2015           E(1)=E(1)*(1-VAL(A$[34;9])-VAL(A$[44;9]))
2020           IF E(1)<0 THEN Not_4
2025           GOTO 2040
2030           END IF
2035        E(1)=E(1)*VAL(A$[34;9])
2040        E(1)=FNC1(E(1),A$)
2045        GOSUB Test
2050        IF Test=0 THEN Not_4
2055        GOTO Parent
2060 Not_4:  As=As+1
2065         GOTO Loop
2070 Bn:   IF D$(2)[7;1]="1" THEN Not_5
2075        IF Z-1=0 THEN Not_5
2080        IF F2$[J-1;1]="0" THEN
2085           F2$[J-1;1]="1"
2090           GOTO 2105
2095           END IF
2100        F2$[J-1;1]="0"
```

APPENDIX A FILE:KSIG   PAGE 7

```
2105        I$(I)=FNSt$(Z-1,A+1,F2$[J-1;1])
2110        K$=I$(1)[2;1]
2115        K=0
2120        Flag=0
2125        K=K+1
2130        IF K=Dec+1 THEN Not_1
2135        IF Dec$(K)[2;1]=K$ THEN Flag=1
2140        IF I$(I)[2,7]<>Dec$(K)[2,7] THEN 2125
2145        A$=Dec$(K)
2150        IF A$[10;1]="6" THEN Not_5
2155        E(1)=LOG(2)/VAL(A$[24;9])
2160        IF A$[11;1]="8" THEN 2180
2165        IF A$[11;1]="9" THEN 2195
2170        IF A$[12;1]="8" THEN 2210
2175        GOTO Not_5
2180        IF A$[12;1]="0" THEN 2215
2185        E(1)=E(1)*(1-VAL(A$[34;9]))
2190        GOTO 2215
2195        IF A$[12;1]<>"2" THEN Not_5
2200        E(1)=E(1)*VAL(A$[44;9])
2205        GOTO 2215
2210        E(1)=E(1)*VAL(A$[34;9])
2215        E(1)=FNC1(E(1),A$)
2220        GOSUB Test
2225        IF Test=0 THEN Not_5
2230        GOTO Parent
2235 Not_5: IF F2$[J-1;1]="1" THEN As=As+1
2240          GOTO Loop
2245 Bx:    IF D$(2)[7;1]="0" THEN Not_6
2250        IF Z-1=0 THEN Not_6
2255        IF F2$[J-1;1]="0" THEN
2260           F2$[J-1;1]="1"
2265           GOTO 2280
2270           END IF
2275        F2$[J-1;1]="0"
2280        I$(1)=FNSt$(Z-1,A,F2$[J-1;1])
2285        K$=I$(1)[2;1]
2290        K=0
2295        Flag=0
2300        K=K+1
2305        IF K=Dec+1 THEN Not_1
2310        IF Dec$(K)[2;1]=K$ THEN Flag=1
2315        IF I$(1)[2,7]<>Dec$(K)[2,7] THEN 2300
2320        A$=Dec$(K)
2325        IF A$[10;1]="6" THEN Not_6
2330        E(1)=LOG(2)/VAL(A$[24;9])
2335        IF A$[11;1]="6" THEN 2355
2340        IF A$[11;1]="9" THEN 2370
2345        IF A$[12;1]="6" THEN 2375
2350        GOTO Not_6
2355        IF A$[12;1]="0" THEN 2380
2360        E(1)=E(1)*(1-VAL(A$[34;9]))
2365        GOTO 2380
2370        IF A$[12;1]<>"2" THEN Not_6
2375        E(1)=E(1)*VAL(A$[34;9])
2380        E(1)=FNC1(E(1),A$)
2385        GOSUB Test
2390        IF Test=0 THEN Not_6
2395        GOTO Parent
2400 Not_6:  IF F2$[J-1;1]="1" THEN As=As+1
2405           GOTO Loop
2410 Ecx:     IF D$(2)[7;1]="0" THEN Not_7
2415          IF Z+1>99 THEN Not_7
2420          IF F2$[J-1;1]="0" THEN
2425             F2$[J-1;1]="1"
2430             GOTO 2445
2435             END IF
2440          F2$[J-1;1]="0"
2445          I$(1)=FNSt$(Z+1,A,F2$[J-1;1])
2450          K$=I$(1)[2;1]
```

```
2455          K=0
2460          Flag=0
2465          K=K+1
2470          IF K=Dec+1 THEN Not_1
2475          IF Dec$(K)[2;1]=K$ THEN Flag=1
2480          IF I$(I)[2,7]<>Dec$(K)[2,7] THEN 2465
2485          A$=Dec$(K)
2490          IF A$[10;1]="6" THEN Not_7
2495          E(1)=LOG(2)/VAL(A$[24;9])
2500          IF A$[11;1]="7" THEN 2515
2505          IF A$[12;1]="7" THEN 2530
2510          GOTO Not_7
2515          IF A$[12;1]="0" THEN 2535
2520          E(1)=E(1)*(1-VAL(A$[34;9]))
2525          GOTO 2535
2530          E(1)=E(1)*VAL(A$[34;9])
2535          E(1)=FNC1(E(1),A$)
2540          GOSUB Test
2545          IF Test=0 THEN Not_7
2550          GOTO Parent
2555 Not_7:     IF F2$[J-1;1]="1" THEN As=As+1
2560            GOTO Loop
2565 N_gamma:IF O$(2)[7;1]="1" THEN Not_8
2570           IF A-1=0 THEN Not_8
2575           IF F2$[J-1;1]="0" THEN
2580              F2$[J-1;1]="1"
2585              GOTO 2600
2590              END IF
2595           F2$[J-1;1]="0"
2600           I$(I)=FNSt$(Z,A-1,F2$[J-1;1])
2605           K$=I$(I)[2;1]
2610           K=0
2615           Flag=0
2620           K=K+1
2625           IF K=Xsec+1 THEN Not_1
2630           IF Xsec$(K)[2;1]=K$ THEN Flag=1
2635           IF I$(I)[2,7]<>Xsec$(K)[2,7] THEN 2620
2640           A$=Xsec$(K)
2645           FOR K=1 TO VAL(A$[10;1])
2650               IF A$[K+10;1]="1" THEN
2655                  E(1)=VAL(A$[K*10+7;9])*Flux*1.E-24
2660                  GOTO 2680
2665                  END IF
2670           NEXT K
2675           GOTO Not_8
2680           GOSUB Test
2685           IF Test=0 THEN Not_8
2690           GOTO Parent
2695 Not_8:    IF F2$[J-1;1]="1" THEN As=As+1
2700           GOTO Loop
2705 N_2n:    IF O$(2)[7;1]="1" THEN Not_9
2710          IF F2$[J-1;1]="0" THEN
2715             F2$[J-1;1]="1"
2720             GOTO 2735
2725             END IF
2730          F2$[J-1;1]="0"
2735          I$(I)=FNSt$(Z,A+1,F2$[J-1;1])
2740          K$=I$(I)[2;1]
2745          K=0
2750          Flag=0
2755          K=K+1
2760          IF K=Xsec+1 THEN Not_1
2765          IF Xsec$(K)[2;1]=K$ THEN Flag=1
2770          IF I$(I)[2,7]<>Xsec$(K)[2,7] THEN 2755
2775          A$=Xsec$(K)
2780          FOR K=1 TO VAL(A$[10;1])
2785              IF A$[K+10;1]="2" THEN
2790                 E(1)=VAL(A$[K*10+7;9])*Flux*1.E-24
2795                 GOTO 2815
2800                 END IF
```

```
2805         NEXT K
2810         GOTO Not_9
2815         GOSUB Test
2820         IF Test=0 THEN Not_9
2825         GOTO Parent
2830 Not_9:   IF F2$[J-1;1]="1" THEN As=As+1
2835          GOTO Loop
2840 N_3n:   IF O$(2)[7;1]="1" THEN Not_10
2845         IF F2$[J-1;1]="0" THEN
2850            F2$[J-1;1]="1"
2855            GOTO 2870
2860            END IF
2865         F2$[J-1;1]="0"
2870         I$(1)=FNSt$(Z,A+2,F2$[J-1;1])
2875         K$=I$(1)[2;1]
2880         K=0
2885         Flag=0
2890         K=K+1
2895         IF K=Xsec+1 THEN Not_1
2900         IF Xsec$(K)[2;1]=K$ THEN Flag=1
2905         IF I$(1)[2,7]<>Xsec$(K)[2,7] THEN 2890
2910         A$=Xsec$(K)
2915         FOR K=1 TO VAL(A$[10;1])
2920              IF A$[10+K;1]="7" THEN
2925                 E(1)=VAL(A$[10*K+7;9])*Flux*1.E-24
2930                 GOTO 2950
2935                 END IF
2940         NEXT K
2945         GOTO Not_10
2950         GOSUB Test
2955         IF Test=0 THEN Not_10
2960         GOTO Parent
2965 Not_10:  IF F2$[J-1;1]="1" THEN As=As+1
2970           GOTO Loop
2975 N_alpha:IF O$(2)[7;1]="1" THEN Not_11
2980          IF Z+2>99 THEN Not_11
2985          IF F2$[J-1;1]="0" THEN
2990             F2$[J-1;1]="1"
2995             GOTO 3010
3000             END IF
3005         F2$[J-1;1]="0"
3010         I$(1)=FNSt$(Z+2,A+3,F2$[J-1;1])
3015         K$=I$(1)[2;1]
3020         K=0
3025         Flag=0
3030         K=K+I
3035         IF K=Xsec+1 THEN Not_1
3040         IF Xsec$(K)[2;1]=K$ THEN Flag=1
3045         IF I$(1)[2,7]<>Xsec$(K)[2,7] THEN 3030
3050         A$=Xsec$(K)
3055         FOR K=1 TO VAL(A$[10;1])
3060              IF A$[10+K;1]="3" THEN
3065                 E(1)=VAL(A$[10*K+7;9])*Flux*1.E-24
3070                 GOTO 3090
3075                 END IF
3080         NEXT K
3085         GOTO Not_11
3090         GOSUB Test
3095         IF Test=0 THEN Not_11
3100         GOTO Parent
3105 Not_11:   IF F2$[J-1;1]="1" THEN As=As+1
3110           GOTO Loop
3115 N_p: IF O$(2)[7;1]="1" THEN Not_12
3120      IF Z+1>99 THEN Not_12
3125      IF F2$[J-1;1]="0" THEN
3130         F2$[J-1;1]="1"
3135         GOTO 3150
3140         END IF
3145      F2$[J-1;1]="0"
3150      I$(1)=FNSt$(Z+1,A,F2$[J-1;1])
```

```
3155        K$=I$(1)[2;1]
3160        K=0
3165        Flag=0
3170        K=K+1
3175        IF K=Xsec+1 THEN Not_1
3180        IF Xsec$(K)[2;1]=K$ THEN Flag=1
3185        IF I$(1)[2,7]<>Xsec$(K)[2,7] THEN 3170
3190        A$=Xsec$(K)
3195        FOR K=1 TO VAL(A$[10;1])
3200            IF A$[10+K;1]="4" THEN
3205               E(1)=VAL(A$[10*K+7;9])*Flux*1.E-24
3210               GOTO 3230
3215               END IF
3220       NEXT K
3225       GOTO Not_12
3230       GOSUB Test
3235       IF Test=0 THEN Not_12
3240       GOTO Parent
3245 Not_12:  IF F2$[J-1;1]="1" THEN As=As+1
3250           GOTO Loop
3255 N_gx: IF O$(2)[7;1]="0" THEN Not_13
3260         IF A-1=0 THEN Not_13
3265         IF F2$[J-1;1]="0" THEN
3270            F2$[J-1;1]="1"
3275            GOTO 3290
3280            END IF
3285         F2$[J-1;1]="0"
3290         I$(1)=FNSt$(Z,A-1,F2$[J-1;1])
3295         K$=I$(1)[2;1]
3300         K=0
3305         Flag=0
3310         K=K+1
3315         IF K=Xsec+1 THEN Not_1
3320         IF Xsec$(K)[2;1]=K$ THEN Flag=1
3325         IF I$(1)[2,7]<>Xsec$(K)[2,7] THEN 3310
3330         A$=Xsec$(K)
3335         FOR K=1 TO VAL(A$[10;1])
3340             IF A$[10+K;1]="5" THEN
3345                E(1)=VAL(A$[K*10+7;9])*Flux*1.E-24
3350                GOTO 3370
3355                END IF
3360         NEXT K
3365         GOTO Not_13
3370         GOSUB Test
3375         IF Test=0 THEN Not_13
3380         GOTO Parent
3385 Not_13: IF F2$[J-1;1]="1" THEN As=As+1
3390           GOTO Loop
3395 N_2nx: IF O$(2)[7;1]="0" THEN Not_14
3400          IF F2$[J-1;1]="0" THEN
3405             F2$[J-1;1]="1"
3410             GOTO 3430
3415             END IF
3420          F2$[J-1;1]="0"
3425          I$(1)=FNSt$(Z,A+1,F2$[J-1;1])
3430          K$=I$(1)[2;1]
3435          K=0
3440          Flag=0
3445          K=K+1
3450          IF K=Xsec+1 THEN Not_14
3455          IF Xsec$(K)[2;1]=K$ THEN Flag=1
3460          IF I$(1)[2,7]<>Xsec$(K)[2,7] TNEN 3445
3465          A$=Xsec$(K)
3470          FOR K=1 TO VAL(A$[10;1])
3475              IF A$[10+K;1]="6" THEN
3480                 E(1)=VAL(A$[K*10+7;9])*Flux*1.E-24
3485                 GOTO 3505
3490                 END IF
3495         NEXT K
3500         GOTO Not_14
```

```
3505        GOSUB Test
3510        IF Test=0 THEN Not_14
3515        GOTO Parent
3520 Not_14:  IF Flag=0 THEN
3525              IF K$=" " THEN K$="0"
3530              CALL Libin(Xsec$(*),Dec$(*),K$,Xsec,Dec)
3535              GOTO 3435
3540              END IF
3545           IF F2$[J-1;1]="0" THEN Loop
3550           J=J-1
3555           IF J=1 THEN
3560              I=I-1
3565              BEEP
3570              GOTO 980
3575              END IF
3580          Z=VAL(O$(3)[2,3])
3585          A=VAL(O$(3)[4,6])
3590          F2$=F2$[1,J-1]
3595          As=NUM(F1$[J-1;1])
3600          IF F2$[J-1;1]="1" THEN As=As+1
3605          FOR K=2 TO J
3610              E(K)=E(K+1)
3615              O(K)=O(K+1)
3620              O$(K)=O$(K+1)
3625              X$(K)=X$(K+1)
3630          NEXT K
3635          IF J=2 THEN
3640             F1$=""
3645             GOTO Loop
3650             END IF
3655          F1$=F1$[1,J-2]
3660          GOTO Loop
3665 Test: FOR K=2 TO J
3670             IF I$(1)[2,7]=O$(K)[2,7] THEN No
3675        NEXT K
3680        K=0
3685        K=K+1
3690        IF K=Dec+1 THEN Not_dec
3695        IF I$(1)[2,7]<>Dec$(K)[2,7] THEN 3685
3700        A$=Dec$(K)
3705        IF A$[10;1]="6" THEN Not_dec
3710        O(1)=LOG(2)/VAL(A$[24;9])
3715        O(1)=FNC1(O(1),A$)
3720        O$(1)=A$
3725        GOTO Xsec2
3730 Not_dec:O(1)=0
3735          O$(1)=" "&I$(1)[2,7]&"  6"
3740 Xsec2: K=0
3745         K=K+1
3750         IF K=Xsec+1 THEN Not_xsec
3755         IF Xsec$(K)[2,7]<>I$(1)[2,7] THEN 3745
3760         A$=Xsec$(K)
3765         FOR K=1 TO VAL(A$[10;1])
3770             O(1)=O(1)+VAL(A$[10*K+7;9])*Flux*1.E-24
3775         NEXT K
3780         GOTO Calculate
3785 Not_xsec:  X$(1)="0"
3790 Calculate: X=1/VAL(I$(1)[4,6])
3795               CALL Const_n(J,E(*),O(*),Tim,X,Amt)
3800               IF Amt>1.E-16 THEN Yes
3805               IF Ptype>2 THEN No
3810               IF K$="1" OR K$="7" OR K$="8" OR K$="9" THEN No
3815               K=0
3820               K=K+1
3825               IF K=Fiss+1 THEN No
3830               IF Fiss$(K)[2,7]<>I$(1)[2,7] THEN 3820
3835               A$=Fiss$(K)
3840               Prod=Flux*VAL(A$[19;8])*4.671E-25
3845               CALL Const_p(J,E(*),O(*),Tim,Prod,Amt)
3850               IF Amt>1.E-16 THEN Yes
```

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```
3855 No:   Test=0
3860       RETURN
3865 Yes:   Flagg=1
3870        FOR K=1 TO I-1
3875            IF I$(I)[2,7]=I$(K)[2,7] THEN
3880               IF Weight(K)>=Amt THEN Flagg=0
3885               IF Flagg=1 THEN Weight(K)=Amt
3890               K=I-1
3895               END IF
3900        NEXT K
3905        IF Flagg=0 THEN No
3910        Weight(I)=Amt
3915        Test=1
3920        F1$=F1$&CHR$(As)
3925        F2$=F2$&"1"
3930        STATUS 1,1;X
3935        IF X=19 THEN
3940           C1=C1+9
3945           CONTROL 1,1;C2
3950           IF C1>70 THEN
3955              GOSUB Clscreen
3960              C1=1
3965              C2=1
3970              END IF
3975           END IF
3980        CONTROL 1,0;C1
3985        PRINT I$(I)
3990        Z=VAL(I$(I)[2,3])
3995        A=VAL(I$(I)[4,6])
4000        FOR K=1 TO I-1
4005            IF I$(K)[2,7]=I$(I)[2,7] THEN
4010               I=I-1
4015               K=I
4020               END IF
4025        NEXT K
4030        RETURN
4035 Out:    MASS STORAGE IS ":HP82901,700,1"
4040         L=1
4045         FOR J=2 TO I
4050              IF I$(J)[1;1]="$" THEN
4055                 FOR K=L TO J-1
4060                      IF I$(K)[2,7]=I$(J)[2,7] THEN
4065                         IF K=L THEN 4085
4070                         FOR M=K-1 TO L STEP -1
4075`                            I$(M+1)=I$(M)
4080                         NEXT M
4085                         L=L+1
4090                         K=J-1
4095                         END IF
4100                 NEXT K
4105                 END IF
4110         NEXT J
4115         FI$="ISO1"
4120         GOSUB Clscreen
4125         CONTROL 1,1;5
4130         PRINT "INPUT THE NAME OF THE NEW ISOTOPE FILE.  THE DEFAULT"
4135         PRINT "WILL BE FILE:";FI$
4140         INPUT FI$
4145         FI=((I-L+1)*10+LEN(VAL$(I-L+1))+3)/256
4150         FI=INT(FI)+1
4155         GOSUB Clscreen
4160         ON ERROR GOTO Err3
4165         CREATE ASCII FI$,FI
4170         OFF ERROR
4175         ASSIGN @Iso TO FI$
4180         OUTPUT @Iso;VAL$(I-L+1)
4185         FOR J=L TO I
4190             OUTPUT @Iso;I$(J)
4195         NEXT J
4200         ASSIGN @Iso TO FI$
```

```
4205           GOTO Endfl
4210 Err3: X=ERRN
4215        IF X<>54 THEN 4230
4220        FI$[LEN(FI$);1]=CHR$(NUM(FI$[LEN(FI$);1])+1)
4225        GOTO 4165
4230        IF X<>55 AND X<>64 THEN 4255
4235        DISP "THIS DISK IS FULL.  TRY A DIFFERENT ON AND PRESS (CONT)"
4240        BEEP
4245        PAUSE
4250        GOTO 4165
4255        DISP "AN ERROR HAS BEEN ENCOUNTERED WHILE TRYING TO CREATE FILE:";FI$
4260        BEEP
4265        STOP
4270 Clscreen:  OUTPUT 2 USING "#,B";255,75
4275           RETURN
4280 Endfl: ENTER @Iso;A$
4285        N=VAL(A$)
4290 Endfl2:GOSUB Clscreen
4295        MASS STORAGE IS ":HP82901,700,0"
4300        SUBEND
4305  SUB Const_n(N,E(*),D(*),T,X,A)
4310  S=0
4315  X1=X
4320  IF N=1 THEN 4340
4325  FOR I=1 TO N-1
4330      X1=X1*E(I)
4335  NEXT I
4340  FOR I=1 TO N
4345      Dt=D(I)*T
4350      IF Dt>100 THEN
4355         X1=X1/D(I)
4360         GOTO 4480
4365         END IF
4370      P=1
4375      Np=0
4380      FOR J=1 TO N
4385          IF J=I THEN 4430
4390          IF D(J)*T>100 THEN 4430
4395          IF D(J)=D(I) THEN
4400             IF J<I THEN 4480
4405             Np=Np+1
4410             IF Np=1 THEN I1=J
4415             GOTO 4430
4420             END IF
4425          P=P*(D(J)-D(I))
4430      NEXT J
4435      IF Np=1 THEN
4440         S1=0
4445         FOR J=1 TO N
4450             IF J=I OR J=I1 THEN 4460
4455             S1=S1+1/(D(J)-D(I))
4460         NEXT J
4465         IF Np=1 THEN P=P/(T-S1)
4470         END IF
4475      S=S+EXP(-Dt)/P
4480  NEXT I
4485  A=S*X1
4490  SUBEND
4495  SUB Const_p(N,E(*),D(*),T,P,A)
4500  R=0
4505  P1=1
4510  IF N=1 THEN 4530
4515  FOR I=1 TO N-1
4520      P1=P1*E(I)
4525  NEXT I
4530  FOR I=1 TO N
4535      Dt=D(I)*T
4540      IF Dt>100 THEN
4545         P1=P1/D(I)
4550         GOTO 4775
```

```
4555          END IF
4560       Pr=I
4565       Mp=0
4570       FOR J=I TO N
4575            IF J=I THEN 4620
4580            IF D(J)*T>I00 THEN 4620
4585            IF D(J)=D(I) THEN
4590               IF J<I THEN 4775
4595               Mp=Mp+I
4600               I1=J
4605               GOTO 4620
4610               END IF
4615            Pr=Pr*(D(J)-D(I))
4620       NEXT J
4625       IF Mp=I THEN
4630          SI=I/D(I)
4635          FOR J=I TO N
4640               IF J=I OR J=II THEN 4650
4645               SI=SI-I/(D(J)-D(I))
4650          NEXT J
4655          ENO IF
4660       IF Dt>=.2 THEN
4665          IF Mp=I THEN
4670             R=R-EXP(-Dt)/(D(I)*Pr)
4675             Pr=Pr/SI
4680             ENO IF
4685          R=R+(I-EXP(-Dt))/(Dt*Pr)
4690          GOTO 4775
4695          ENO IF
4700       IF Dt=0 THEN
4705          R=R+T/Pr
4710          GOTO 4775
4715          ENO IF
4720       M=I
4725       S=0
4730       FOR J=0 TO II
4735            M=M*(J+1)
4740            S=S+(-Dt)^J/M
4745       NEXT J
4750       IF Mp=I THEN
4755          R=R-EXP(-Dt)/(D(I)*Pr)
4760          Pr=Pr/SI
4765          ENO IF
4770       R=S/Pr+R
4775  NEXT I
4780  IF R=0 THEN R=I/T
4785  A=R*PI*T*P
4790  SUBEND
4795  OEF FNCI(A,A$)
4800    CI=VAL(A$[I0;I])
4805    IF CI>I THEN A=A/60
4810    IF CI>2 THEN A=A/60
4815    IF CI>3 THEN A=A/24
4820    IF CI>4 THEN A=A/365.25
4825    IF CI>6 THEN A=A/I.E+3^(CI-6)
4830    RETURN A
4835 FNENO
4840 DEF FNSt$(Z,A,F$)
4845        Z$=VAL$(Z)
4850   IF LEN(Z$)=I THEN Z$=" "&Z$
4855   A$=VAL$(A)
4860   IF LEN(A$)<3 THEN
4865      A$="0"&A$
4870      GOTO 4860
4875      ENO IF
4880   I$=" "&Z$&A$&F$
4885   RETURN I$
4890 FNENO
4895 SUB Libin(Xsec$(*),Dec$(*),Fiss$(*),K$,Xs,Oec,Fiss)
4900   ASSIGN @Path TO "OECAY_LIB"&K$
```

```
4905   DIM A$[75]
4910   ENTER @Path;A$
4915   ON END @Path GOTO End_dec
4920   Dec=Dec+1
4925   Dec$(Dec)=A$
4930   GOTO 4910
4935 End_dec:   ASSIGN @Path TO "XSEC_LIB"&K$
4940            ENTER @Path;A$
4945            ON END @Path GOTO End_xsec
4950            Xs=Xs+1
4955            Xsec$(Xs)=A$
4960            GOTO 4940
4965 End_xsec: IF K$="1" OR K$="7" OR K$="8" OR K$="9" THEN 5000
4970           ASSIGN @Path TO "FISS_LIB"&K$
4975           ENTER @Path;A$
4980           ON END @Path GOTO End_fiss
4985           Fiss=Fiss+1
4990           Fiss$(Fiss)=A$
4995           GOTO 4975
5000 End_fiss: ASSIGN @Path TO *
5005           SUBEND
5010  SUB Astring(A,A$)
5015  E=0
5020  C$="000000"
5025  IF ABS(A)<.00001 THEN 5080
5030  IF A<10 THEN 5050
5035  A=A/10
5040  E=E+1
5045  GOTO 5030
5050  IF A>=1 THEN 5070
5055  A=A*10
5060  E=E-1
5065  GOTO 5050
5070  A=A+.00005
5075  IF A>=10 THEN 5030
5080  A$=VAL$(A)
5085  IF LEN(A$)>6 THEN A$=A$[1,6]
5090  IF LEN(A$)<6 THEN A$=A$&C$[1,6-LEN(A$)]
5095  A$[2;1]="."
5100  IF E>=0 THEN A$=A$&"E+"
5105  IF E<0 THEN
5110    A$=A$&"E-"
5115    E=-E
5120    END IF
5125 T$=VAL$(E)
5130 IF LEN(T$)=1 THEN A$=A$&"0"&T$
5135 IF LEN(T$)=2 THEN A$=A$&T$
5140 SUBEND
5145  SUB Isin(@Iso,N,I$(*),Act$(*))
5150  FOR I=1 TO N
5155      ENTER @Iso;I$(I)
5160  NEXT I
5165  MASS STORAGE IS ":HP82901,700,0"
5170  ASSIGN @Iso TO "ACT"
5175  FOR I=1 TO 82
5180      ENTER @Iso;Act$(I)
5185  NEXT I
5190  ASSIGN @Iso TO *
5195  SUBEND
5200  SUB Inin(I$(*),A1(*),Act$(*),Aact(*),N)
5205  DIM A$[100],T$(1306)[19]
5210  DISP "DO YOU WISH TO INPUT A NEW ISOTOPE INVENTORY OR USE A STORED ONE"
5215  ON KEY 5 LABEL "NEW" GOTO New
5220  ON KEY 6 LABEL "STORED" GOTO Stored
5225  GOTO 5225
5230 Stored:OFF KEY
5235        MASS STORAGE IS ":HP82901,700,1"
5240        INPUT "ENTER THE NANE OF THE FILE THESE DATA ARE STORED IN",FI$
5245        DISP
5250        CONTROL 1,1;5
```

```
5255        ON ERROR GOTO Err
5260        ASSIGN @Inin TO FI$
5265        ON ERROR GOTO Err1
5270        ENTER @Inin;A$
5275        OFF ERROR
5280        ON END @Inin GOTO End_in
5285        IF LEN(A$)<>18 THEN Err1
5290        FOR I=1 TO N
5295            IF A$[2,7]=I$(I)[2,7] THEN
5300               ON ERROR GOTO Err1
5305               AI(I)=VAL(A$[9;10])
5310               OFF ERROR
5315               I=N
5320               END IF
5325        NEXT I
5330        IF A$[2;1]="8" OR A$[2;1]="9" THEN
5335           FOR I=1 TO 82
5340               IF A$[2,7]=Act$(I)[2,7] THEN
5345                  ON ERROR GOTO Err1
5350                  Aact(I)=VAL(A$[9;10])
5355                  OFF ERROR
5360                  I=82
5365                  END IF
5370           NEXT I
5375           END IF
5380       GOTO 5265
5385 Err:DISP "FILE:";FI$;" DOSEN'T EXIST.  PLEASE CHOOSE ANOTHER FILE. PRESS (CONT)"
5390       BEEP
5395       PAUSE
5400       GOTO Stored
5405 Err1: DISP "FILE:";FI$;" IS NOT FORMATTED CORRECTLY.  CHOOSE ANOTHER. PRESS (CONT)"
5410        BEEP
5415        PAUSE
5420        GOTO Stored
5425 End_in: GOSUB Clscreen
5430           ASSIGN @Inin TO *
5435           GOTO Finis
5440 New: OFF KEY
5445       GOSUB Clscreen
5450       CONTROL 1,1;5
5455       PRINT "INPUT THE ISOTOPE INVENTORIES"
5460       PRINT
5465       PRINT "TO LEAVE THIS INPUT MODE PRESS (ENTER) WHEN ASKED FOR"
5470       PRINT "ATOMIC NUMBER"
5475       PRINT
5480       PRINT "TO INIDICATE THAT THE NATUARLLY OCCURING ELEMENT IS"
5485       PRINT "BEING INPUT RATHER THAN A SPECIFIC ISOTOPE, PRESS"
5490       PRINT "(ENTER) WHEN ASKED FOR ATOMIC WEIGHT"
5495       PRINT
5500       I=0
5505       C$="000000"
5510       MASS STORAGE IS ":HP82901,700,0"
5515       Z=0
5520       INPUT "ENTER THE ATOMIC NUMBER",Z
5525       IF Z=0 THEN Out
5530       IF Z<1 OR Z>99 THEN
5535          BEEP
5540          GOTO 5515
5545          END IF
5550       A=0
5555       INPUT "ENTER THE ATOMIC WEIGHT",A
5560       IF A<0 OR A>300 THEN
5565          BEEP
5570          GOTO 5555
5575          END IF
5580       IF A=0 THEN Excited
5585       DISP "IS THIS ISOTOPE IN THE GROUND OR EXCITED STATE"
5590       ON KEY 5 LABEL "GROUND" GOTO Ground
5595       ON KEY 6 LABEL "EXCITED" GOTO Excited
5600       GOTO 5600
```

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```
5605 Ground:K$="0"
5610        GOTO 5620
5615 Excited:K$="1"
5620         OFF KEY
5625         INPUT "ENTER THE ISOTOPE/ELEMENT INVENTORY IN GRAMS",Inv
5630         IF Inv<0 THEN
5635            BEEP
5640            GOTO 5625
5645            END IF
5650         IF A=0 THEN Nat
5655         I=I+1
5660         CALL Astring(Inv,B$)
5665         T$(I)=FNSt$(Z,A,K$)&" "&B$
5670         PRINT T$(I)
5675         GOTO 5515
5680 Nat: Inv1=Inv
5685       ASSIGN @Inin TO "NAT_ABUND"
5690       ENTER @Inin;A$
5695       ON END @Inin GOTO End_nat
5700       IF VAL(A$[2,3])>Z THEN End_nat
5705       IF VAL(A$[2,3])=Z THEN
5710          Inv=VAL(A$[10;9])*Inv1/100
5715          I=I+1
5720          CALL Astring(Inv,B$)
5725          T$(I)=A$[1,8]&B$
5730          PRINT T$(I)
5735          END IF
5740     GOTO 5690
5745 End_nat: IF II=I THEN
5750              PRINT Z;" NOT NATUARALLY OCCURING"
5755              BEEP
5760              END IF
5765           GOTO 5515
5770 Out:  GOSUB Clscreen
5775        DISP "DO YOU WISH TO SAVE THIS INVENTORY VECTOR"
5780        ON KEY 5 LABEL "YES" GOTO Yes
5785        ON KEY 6 LABEL "NO" GOTO No
5790        GOTO 5790
5795 Yes:  OFF KEY
5800        F1$="INV1"
5805        CONTROL 1,1;5
5810        PRINT "INPUT THE NAME OF THE NEW ISOTOPE INVENTORY FILE."
5815        PRINT "THE DEFAULT WILL BE ";F1$
5820        INPUT F1$
5825        MASS STORAGE IS ":HP82901,700,1"
5830        F1=INT(I*22/256)+1
5835        ON ERROR GOTO Err3
5840        CREATE ASCII F1$,F1
5845        OFF ERROR
5850        DISP
5855        ASSIGN @Inin TO F1$
5860        FOR J=1 TO I
5865           OUTPUT @Inin;T$(J)
5870        NEXT J
5875        ASSIGN @Inin TO *
5880 No: OFF KEY
5885      DISP
5890      FOR J=1 TO I
5895         FOR K=1 TO N
5900              IF T$(J)[2,7]=I$(K)[2,7] THEN
5905                 AI(K)=VAL(T$(J)[9;10])
5910                 K=N
5915                 END IF
5920         NEXT K
5925         IF T$(J)[2;1]="8" OR T$(J)[2;1]="9" THEN
5930            FOR K=1 TO 82
5935                 IF T$(J)[2,7]=Act$(K)[2,7] THEN
5940                    Aact(K)=VAL(T$(J)[9;10])
5945                    K=82
5950                    END IF
```

```
5955             NEXT K
5960             ENO IF
5965    NEXT J
5970    GOTO Finis
5975 Err3: X=ERRN
5980       IF X<>54 THEN 5995
5985         FI$[LEN(FI$);1]=CHR$(NUN(FI$[LEN(FI$);1])+1)
5990         GOTO 5840
5995       IF X<>55 AND X<>64 THEN 6020
6000         DISP "THIS DISK IS FULL.  TRY A DIFFERENT ONE AND PRESS (CONT)"
6005         BEEP
6010         PAUSE
6015         GOTO 5840
6020       DISP "AN ERROR HAS OCCURED WHILE TRYING TO CREATE FILE:";FI$
6025       BEEP
6030       STOP
6035 Clscreen:OUTPUT 2 USING "#,B";255,75
6040          RETURN
6045 Finis:DISP
6050       GOSUB Clscreen
6055       SUBEND
6060  SUB Typout(Typout,Fout$)
6065    Typout=1
6070    DISP "DO YOU WISH TO SAVE THE FINAL OUTPUT VECTOR"
6075    ON KEY 5 LABEL "YES" GOTO Yes
6080    ON KEY 6 LABEL "NO" GOTO No
6085    GOTO 6085
6090 No:OFF KEY
6095    Fout$="NONE"
6100    GOTO Endfl
6105 Yes:OFF KEY
6110     Fout$="OUT1"
6115     CONTROL 1,1;5
6120     PRINT "INPUT THE NANE OF THE OUTPUT FILE"
6125     PRINT "DEFAULT IS ";Fout$
6130     INPUT Fout$
6135 Endfl:SUBEND
6140  SUB Frm
6145  GOSUB Clscreen
6150  GINIT
6155  GRAPHICS ON
6160  CLIP 20,120,10,110
6165  FRANE
6170  AXES 10,10,20,10
6175  CLIP 0,140,0,120
6180  LORG 4
6185  CSIZE 4
6190  FOR I=0 TO 100 STEP 10
6195      NOVE I+20,5
6200      LABEL I
6205  NEXT I
6210  MOVE 70,0
6215  LABEL " ATONIC NUNBER"
6220  LORG 8
6225  FOR I=-3 TO 5
6230      MOVE 20,I*10+40
6235      LABEL "1E";I
6240  NEXT I
6245  MOVE 0,50
6250  DEG
6255  LORG 6
6260  LDIR 90
6265  LABEL "ABUNDANCE (GRANS)"
6270  LDIR 0
6275  GOTO 6290
6280 Clscreen: OUTPUT 2 USING "#,B";255,75
6285           RETURN
6290  SUBEND
6295  SUB Out(I$(*),A(*),Act$(*),Aact(*),Typ,N,Page)
6300  COM T,Flux,Pow,Rt,Thresh
```

APPENDIX A FILE:KSIG PAGE 19

```
6305  DIM Bb(99),Name$(99)[2]
6310  MASS STORAGE IS ":HP82901,700,0"
6315  ASSIGN @Path TO "NAMES"
6320  FOR I=1 TO 99
6325       Bb(I)=0
6330       ENTER @Path;Name$(I)
6335  NEXT I
6340  ASSIGN @Path TO *
6345  FOR I=1 TO N
6350       Flag=1
6355       IF I$(I)[2;1]<>"8" AND I$(I)[2;1]<>"9" THEN 6395
6360       FOR J=1 TO 82
6365           IF I$(I)[2,7]=Act$(J)[2,7] THEN
6370               Flag=0
6375               J=82
6380               END IF
6385       NEXT J
6390       IF Flag=0 THEN EndI
6395       K=VAL(I$(I)[2,3])
6400       Bb(K)=Bb(K)+A(I)
6405 EndI:NEXT I
6410      FOR I=1 TO 82
6415          K=VAL(Act$(I)[2,3])
6420          Bb(K)=Bb(K)+Aact(I)
6425      NEXT I
6430      Et=(TIMEDATE MOD 86400)-Rt
6435      CALL Graph(Bb(*),T,Flux,Pow,Et)
6440      IF Typ=0 THEN 6565
6445      CALL Head(T,Flux,Pow,Page)
6450      No=0
6455      L=10
6460      FOR I=1 TO N
6465          IF I$(I)[1;1]="*" AND A(I)>=Thresh THEN
6470              El$=Name$(VAL(I$(I)[2,3]))&"-"&I$(I)[4,6]
6475              IF I$(I)[7;1]="1" THEN El$=El$&"*"
6480              No=No+1
6485              IF No=4 THEN
6490                  L=L+1
6495                  OUTPUT 701
6500                  IF L=66 THEN
6505                      Page=Page+1
6510                      CALL Head(T,Flux,Pow,Page)
6515                      L=10
6520                      END IF
6525                  No=1
6530                  END IF
6535              OUTPUT 701 USING 6540;El$,A(I)
6540              IMAGE #,9A,Z.DDDDDDE,4X
6545              END IF
6550        NEXT I
6555        Page=Page+1
6560        OUTPUT 701
6565        SUBEND
6570 SUB Graph(Bb(*),T,Flux,Pow,Et)
6575      FOR I=1 TO 99
6580          MOVE I+20,110
6585          PEN -1
6590          DRAW I+20,10
6595          PEN 1
6600          IF Bb(I)<=1.E-3 THEN 6610
6605          DRAW I+20,LGT(Bb(I))*10+40
6610      NEXT I
6615      CONTROL 1,1;2
6620      PRINT USING 6640;Et
6625      PRINT USING 6645;T
6630      PRINT USING 6650;Pow
6635      PRINT USING 6655;Flux
6640      IMAGE 25X,"ELAPSED TIME   ",D.DDDE," S"
6645      IMAGE 25X,"SIMULATED TIME ",D.DDDE," S"
6650      IMAGE 25X,"POWER          ",D.DDDE," MW/UNIT"
```

APPENDIX A FILE:KSIG PAGE 20

```
6655      IMAGE 25X,"NEUTRON FLUX   ",D.DDDE," #/CM*CM*S"
6660      CLIP 20,120,10,110
6665      FRAME
6670      AXES 10,10,20,10
6675      CLIP 0,140,0,120
6680      SUBEND
6685   SUB Head(T,Flux,Pow,Page)
6690   OUTPUT 701;CHR$(12)
6695   U$="S"
6700   Tim=T
6705   IF Tim<60 THEN 6765
6710   U$="M"
6715   Tim=Tim/60
6720   IF Tim<60 THEN 6765
6725   U$="H"
6730   Tim=Tim/60
6735   IF Tim<24 THEN 6765
6740   U$="D"
6745   Tim=Tim/24
6750   IF Tim<366 THEN 6765
6755   U$="Y"
6760   Tim=Tim/365.25
6765   OUTPUT 701 USING 6770;Tim,U$,Page
6770   IMAGE "SIMULATED TIME = ",D.DDDE,X,A,42X,"PAGE ",DDDD
6775   OUTPUT 701 USING 6780;Flux,Pow
6780   IMAGE "NEUTRON FLUX   = ",D.DDDE," (#/CM^2*S)",14X,"POWER = ",D.DDDDE," (MW/UNIT)"
6785   OUTPUT 701
6790   OUTPUT 701 USING 6795
6795   IMAGE "ISOTOPE   MASS(GRAMS)      ISOTOPE   MASS(GRAMS)      ISOTOPE   MASS(GRAMS)"
6800   OUTPUT 701
6805   SUBEND
6810   SUB Abund(I$(*),A(*),B(*),Act$(*),Aact(*),Bact(*),@Power,Ptype,Eflag,N,P$)
6815   COM Ttemp,Flux,Power,Rt,Thresh
6820   T=Ttemp
6825   DIM Xsec$(161)[75],Dec$(575)[62],Fiss$(488)[53],Nact(5),A$[50],Mact(5)
6830   K2$="X"
6835   K1$="N"
6840   ENTER @Power;A$
6845   IF A$="END" THEN Set_eflag
6850   Flux=VAL(A$[1,10])
6855   Tstep=VAL(A$[11;11])
6860   T$=A$[23;1]
6865   IF T$="S" THEN 6905
6870   Tstep=Tstep*60
6875   IF T$="M" THEN 6905
6880   Tstep=Tstep*60
6885   IF T$="H" THEN 6905
6890   Tstep=Tstep*24
6895   IF T$="D" THEN 6905
6900   Tstep=Tstep*365.25
6905   IF Flux=0 THEN
6910      Power=0
6915      GOTO Flux
6920      END IF
6925   Pflag=0
6930   IF Ptype>=2 THEN
6935      Pflag=1
6940      IF Ptype-2=1 THEN 6955
6945      END IF
6950   IF Ptype=1 THEN
6955      Power=Flux
6960      GOTO Power
6965      END IF
6970 Flux: Stemp=Tstep
6975         Pow1=FNPower(Aact(*),Flux)
6980         CALL Decay(Act$(*),Aact(*),Bact(*),82,Xsec$(*),Dec$(*),Fiss$(*),Xsec,Dec,Fiss,K1$,K2$,Ste
     mp,Flux,Nact(*),Rt,Thresh,Pflag)
6985         IF Flux=0 THEN 7020
6990         Pow2=FNPower(Bact(*),Flux)
6995         IF Pflag=1 THEN 7030
```

APPENDIX A FILE:KS16 PAGE 21

```
7000       Test=ABS((Pow1-Pow2)*50/Pow1)
7005       IF Test<=1 THEN 7020
7010       Stemp=.8*Stemp/Test
7015       GOTO 6980
7020       Flux2=Flux
7025       GOSUB Nact
7030       CALL Decay(I$(*),A(*),B(*),N,Xsec$(*),Dec$(*),Fiss$(*),Xsec,Dec,Fiss,K1$,K2$,Stemp,Flux,N
      act(*),Rt,Thresh,Pflag)
7035       Ttemp=Ttemp+Stemp
7040       IF Ttemp=T+Tstep THEN
7045          Power=Pow2
7050          GOTO Endfl
7055          END IF
7060       CALL Tran(A(*),B(*),N,Aact(*),Bact(*))
7065       Power=Pow2
7070       CALL Out(I$(*),A(*),Act$(*),Aact(*),0,N,0)
7075       Stemp=T+Tstep-Ttemp
7080       Pow1=Pow2
7085       GOTO 6980
7090 Nact: Nact(1)=Flux*Aact(82)*6.231E-23/233
7095       Mact(1)=Flux2*Bact(82)*6.231E-23/233
7100       Nact(2)=Flux*Aact(81)*4.671E-23/235
7105       Mact(2)=Flux2*Bact(81)*4.671E-23/235
7110       Nact(3)=Flux*Aact(80)*1.004E-25/238
7115       Mact(3)=Flux2*Bact(80)*1.004E-25/238
7120       Nact(4)=Flux*Aact(1)*1.062E-22/239
7125       Mact(4)=Flux2*Bact(1)*1.062E-22/239
7130       Nact(5)=Flux*Aact(79)*1.181E-22/241
7135       Mact(5)=Flux2*Bact(79)*1.181E-22/241
7140       FOR K=1 TO 5
7145          Nact(K)=(Nact(K)+Mact(K))/2
7150       NEXT K
7155       RETURN
7160 Power: Stemp=Tstep
7165        Flux1=FNFlux(Aact(*),Power)
7170        CALL Decay(Act$(*),Aact(*),Bact(*),82,Xsec$(*),Dec$(*),Fiss$(*),Xsec,Dec,Fiss,K1$,K2$,St
      emp,Flux1,Nact(*),Rt,Thresh,Pflag)
7175        Flux2=FNFlux(Bact(*),Power)
7180        Flux=Flux1
7185        Test=ABS((Flux1-Flux2)*50/Flux1)
7190        IF Test<=1 THEN 7205
7195        Stemp=.8*Stemp/Test
7200        GOTO 7170
7205        GOSUB Nact
7210        Flux=(Flux1+Flux2)/2
7215        CALL Decay(I$(*),A(*),B(*),N,Xsec$(*),Dec$(*),Fiss$(*),Xsec,Dec,Fiss,K1$,K2$,Stemp,Flux,
      Nact(*),Rt,Thresh,Pflag)
7220        Ttemp=Ttemp+Stemp
7225        IF Ttemp=T+Tstep THEN
7230           Flux=Flux2
7235           GOTO Endfl
7240           END IF
7245        Stemp=T+Tstep-Ttemp
7250       CALL Tran(A(*),B(*),N,Aact(*),Bact(*))
7255       Flux=Flux2
7260       CALL Out(I$(*),A(*),Act$(*),Aact(*),0,N,0)
7265       GOTO 7165
7270 Set_eflag:ASSIGN @Power TO *
7275           Eflag=1
7280           GOTO Endfl
7285 Endfl:SUBEND
7290 DEF FNPower(A(*),Flux)
7295  Power=A(82)*62.31*FNEpf(92,233)/233
7300  Power=Power+A(81)*46.71*FNEpf(92,235)/235
7305  Power=Power+A(80)*.1004*FNEpf(92,238)/238
7310  Power=Power+A(1)*106.2*FNEpf(94,239)/239
7315  Power=Power+A(79)*118.1*FNEpf(94,241)/241
7320  Power=Power*Flux/1.0364927E+19
7325  RETURN Power
7330  FNEND
```

```
7335 DEF FNFlux(A(*),Power)
7340  Flux=A(82)*62.31*FNEpf(92,233)/233
7345  Flux=Flux+A(81)*46.71*FNEpf(92,235)/235
7350  Flux=Flux+A(80)*.1004*FNEpf(92,238)/238
7355  Flux=Flux+A(1)*106.2*FNEpf(94,239)/239
7360  Flux=Flux+A(79)*118.1*FNEpf(94,241)/241
7365  Flux=Power*1.0364927E+19/Flux
7370  RETURN Flux
7375  FNEND
7380 DEF FNEpf(Z,A)
7385  Epf=1.29927E-3*Z*Z*SQR(A)+33.12
7390  RETURN Epf
7395  FNEND
7400  SUB Decay(I$(*),A(*),B(*),N,Xsec$(*),Dec$(*),Fiss$(*),Xsec,Dec,Fiss,K1$,K2$,T,Flux,Nact(*),Rt,
     Thresh,Pflag)
7405  DIM O(50),E(50),X$(50)[65],D$(50)[62],F1$[50],Am(50),Fract(50),Lo(50),Fracl(50),Ap(50)
7410  CALL Zero(B(*),N)
7415  PEN 0
7420  LORG 5
7425  CSIZE 5
7430  FOR I=1 TO N
7435      MOVE VAL(I$(I)[2,3])+20,10
7440      LABEL "X"
7445      Et=(TIMEDATE MOD 86400)-Rt
7450      CONTROL 1,1;2
7455      PRINT USING 7460;Et
7460      IMAGE 25X,"ELAPSED TIME   ",D.DDDE," S"
7465      CALL Omega(O(1),Xsec$(*),Dec$(*),Fiss$(*),Xsec,Dec,Fiss,K1$,K2$,I$(I),X$(1),D$(1),Flux)
7470      J=1
7475      F1$=""
7480      Fracl(1)=0
7485      Lo(1)=I
7490      Eflag=-1
7495      IF A(I)=0 THEN
7500         X=0
7505         Amt=0
7510         GOTO 7530
7515         END IF
7520      X=A(I)/VAL(I$(I)[4,6])
7525      CALL Const_n(J,E(*),O(*),T,X,Amt)
7530      Prod=0
7535      IF Flux=0 THEN 7600
7540      IF Pflag=1 THEN 7600
7545      IF K$="1" OR K$="7" OR K$="8" OR K$="9" THEN 7600
7550      K=0
7555      K=K+1
7560      IF K=Fiss+1 THEN 7600
7565      IF I$(I)[2,7]<>Fiss$(K)[2,7] THEN 7555
7570      FOR L=1 TO 5
7575          Prod=Prod+Nact(L)*VAL(Fiss$(K)[L*9+1;8])/100
7580      NEXT L
7585      CALL Const_p(J,E(*),D(*),T,Prod,Amt1)
7590      Amt=Amt+Amt1
7595      GOTO Test
7600 Test:IF Amt<0 THEN Amt=0
7605      Am(1)=Amt
7610      Ap(1)=(X+Prod*T-Amt)*VAL(I$(I)[4,6])
7615      Fract(1)=0
7620      J1=J
7625 Daughter: CALL Daughter(E(*),X$(*),D$(*),F1$,Flux,I$(*),N,I1,Fracl(*),J,Eflag)
7630           IF J<=J1 THEN
7635              FOR K=J TO J1
7640                  IF Am(K)=0 THEN 7655
7645                  IF Fract(K)<0 THEN Fract(K)=0
7650                  B(Lo(K))=B(Lo(K))+Am(K)*VAL(I$(Lo(K))[4,6])/(1-Fract(K))
7655              NEXT K
7660              END IF
7665            J1=J
7670          IF Eflag=1 THEN End1
7675          Ap(J)=Ap(J-1)*E(J-1)/O(J-1)
```

```
7680          IF Ap(J)<Thresh*1.E-4 THEN 7805
7685          IF Ap(J)/(X+Prod)<1.E-10 THEN 7805
7690          Flag=1
7695          FOR Lc=1 TO N
7700              IF I$(Lc)[1;1]="*" THEN
7705                 IF Ap(J)<B(Lc)*1.E-4 THEN 7750
7710                 FOR Lc2=1 TO J-1
7715                     IF Lo(Lc2)=Lc THEN
7720                        IF Ap(J)<Am(Lc2)*1.E-4 THEN 7750
7725                        GOTO 7760
7730                        END IF
7735                 NEXT Lc2
7740                 GOTO 7760
7745                 END IF
7750          NEXT Lc
7755          GOTO 7805
7760          Lo(J)=I1
7765          C1=0
7770          FOR K=1 TO J-1
7775              IF Lo(K)=I1 THEN
7780                 C1=C1+1
7785                 Par=K
7790                 END IF
7795          NEXT K
7800          IF C1=2 THEN
7805             J=J-1
7810             J1=J1-1
7815             GOTO Daughter
7820             END IF
7825          CALL Omega(D(J),Xsec$(*),Dec$(*),Fiss$(*),Xsec,Dec,Fiss,K1$,K2$,I$(I1),X$(J),D$(J),Flux
   )
7830          IF X=0 THEN
7835             Amt=0
7840             GOTO 7860
7845             END IF
7850          CALL Const_n(J,E(*),D(*),T,X,Amt)
7855          IF Amt<0 THEN Amt=0
7860          IF Prod=0 THEN 7880
7865          CALL Const_p(J,E(*),D(*),T,Prod,Amt1)
7870          IF Amt1<0 THEN Amt1=0
7875          Amt=Amt+Amt1
7880          IF Amt<0 THEN Amt=0
7885          IF C1=0 THEN
7890             Am(J)=Amt
7895             Fract(J)=0
7900             END IF
7905          IF C1=1 THEN
7910             Am(J)=0
7915             IF Am(Par)=0 OR Fract(Par)<0 THEN
7920                Am(Par)=Amt+Am(Par)
7925                Fract(Par)=-1
7930                GOTO 7955
7935                END IF
7940             Fract(Par)=Fract(Par)+Amt/Am(Par)
7945             END IF
7950          IF Amt=0 THEN 7805
7955          Ap(J)=Ap(J)-Amt*VAL(I$(I1)[4,6])
7960          GOTO Daughter
7965 End1:MOVE VAL(I$(I)[2,3])+20,10
7970       LABEL "X"
7975       NEXT I
7980       SUBEND
7985       SUB Zero(B(*),N)
7990           FOR I=1 TO N
7995               B(I)=0
8000           NEXT I
8005       SUBEND
8010 SUB Omega(D,Xsec$(*),Dec$(*),Fiss$(*),Xsec,Dec,Fiss,K1$,K2$,I$,X$,D$,Flux)
8015     IF K1$="N" THEN
8020        K$=" "
```

```
8025        CALL Lib(Xsec$(*),Dec$(*),Fiss$(*),Xsec,Dec,Fiss,K$,K1$,K2$)
8030        END IF
8035     IF I$[2;1]=" " THEN 8060
8040     IF I$[2;1]<>K1$ AND I$[2;1]<>K2$ THEN
8045        K$=I$[2;1]
8050        CALL Lib(Xsec$(*),Dec$(*),Fiss$(*),Xsec,Dec,Fiss,K$,K1$,K2$)
8055        END IF
8060     I=0
8065     I=I+1
8070     IF I=Dec+1 THEN Not_dec
8075     IF Dec$(I)[2,7]<>I$[2,7] THEN 8065
8080     D$=Dec$(I)
8085     IF D$[10;1]="6" THEN Not_dec
8090     D=LOG(2)/VAL(D$[24;9])
8095     D=FNC1(D,D$)
8100     GOTO Xsec
8105 Not_dec: D$=I$&"  6"
8110          D=0
8115 Xsec:I=0
8120       I=I+1
8125       IF I=Xsec+1 THEN Not_xsec
8130       IF Xsec$(I)[2,7]<>I$[2,7] THEN 8120
8135       X$=Xsec$(I)[10;LEN(Xsec$(I))]
8140      FOR I=1 TO VAL(X$[1;1])
8145          D=D+VAL(X$[I*10-2;9])*Flux*1.E-24
8150       NEXT I
8155       GOTO 8165
8160 Not_xsec:X$="0"
8165            SUBEND
8170 SUB Lib(X$(*),D$(*),F$(*),X,D,F,K$,K1$,K2$)
8175       DIM A$[75]
8180       B$=K$
8185       IF B$=" " THEN
8190          B$="0"
8195          X=0
8200          D=0
8205          F=0
8210          END IF
8215       ASSIGN @Path TO "DECAY_L18"&B$
8220       IF K$=" " THEN 8285
8225       Flag=-1
8230       IF K2$="N" THEN
8235          K2$=K$
8240          Flag=1
8245          END IF
8250       IF Flag=-1 THEN
8255          K1$=K$
8260          K2$="N"
8265          D=31
8270          X=19
8275          F=6
8280          END IF
8285       ENTER @Path;A$
8290       ON END @Path GOTO 8310
8295       D=D+1
8300       D$(D)=A$
8305       GOTO 8285
8310       ASSIGN @Path TO "XSEC_L18"&B$
8315       ENTER @Path;A$
8320       ON END @Path GOTO 8340
8325       X=X+1
8330       X$(X)=A$
8335       GOTO 8315
8340       IF K$="1" OR K$="7" OR K$="8" OR K$="9" THEN
8345          GOTO Endfl
8350          END IF
8355       ASSIGN @Path TO "FISS_L18"&B$
8360       ENTER @Path;A$
8365       ON END @Path GOTO Endfl
8370       F=F+1
```

```
8375      F$(F)=A$
8380      GOTO 8360
8385 Endfl: ASSIGN @Path TO *
8390         SUBEND
8395  SUB Daughter(E(*),X$(*),D$(*),F1$,Flux,I$(*),N,I,Frac(*),J,Eflag)
8400  IF Frac(J)<>0 THEN
8405      I=Frac(J)
8410      Frac(J)=0
8415      F1$=FI$[1,J]
8420      GOTO 9200
8425      END IF
8430  IF LEN(F1$)<J THEN Find_first
8435  F1=NUM(F1$[J;1])-64
8440  IF F1>7 THEN Xsec
8445  IF D$(J)[11;1]="9" THEN Nine
8450  A1$=VAL$(F1)
8455  IF F1=5 THEN A1$="8"
8460  T$=D$(J)[12;1]
8465  IF T$=A1$ OR T$="0" OR T$="5" THEN New_xsec
8470  E(J)=VAL(D$(J)[34;9])*LOG(2)/VAL(D$(J)[24;9])
8475  E(J)=FNC1(E(J),D$(J))
8480  F1=VAL(T$)
8485  IF F1=8 THEN F1=5
8490  GOTO Test_daughter
8495 Find_first:IF D$(J)[10;1]="6" THEN New_xsec
8500            IF D$(J)[11;1]="9" THEN
8505               F1=0
8510               GOTO Nine
8515               END IF
8520            E(J)=LOG(2)/VAL(D$(J)[24;9])
8525            IF D$(J)[12;1]<>"0" THEN E(J)=E(J)*(1-VAL(D$(J)[34;9]))
8530            E(J)=FNC1(E(J),D$(J))
8535            F1=VAL(D$(J)[11;1])
8540            GOTO 8485
8545 Nine:IF F1=0 THEN
8550         Sc1=1-VAL(D$(J)[34;9])-VAL(D$(J)[44;9])
8555         IF D$(J)[12;1]="4" THEN
8560            F1=3
8565            Sc1=Sc1-VAL(D$(J)[54;9])
8570            END IF
8575         IF D$(J)[12;1]="1" THEN F1=4
8580         IF D$(J)[12;1]="2" OR D$(J)[12;1]="3" THEN F1=1
8585         E(J)=LOG(2)*Sc1/VAL(D$(J)[24;9])
8590         E(J)=FNC1(E(J),D$(J))
8595         GOTO Test_daughter
8600         END IF
8605      ON VAL(D$(J)[12;1]) GOTO 8610,8630,8610,8680
8610         IF F1=3 THEN New_xsec
8615         F1=3
8620         F2=1
8625         GOTO 8725
8630         IF F1=5 THEN New_xsec
8635         IF F1=6 THEN
8640            F1=5
8645            F2=2
8650            END IF
8655         IF F1=1 THEN
8660            F1=6
8665            F2=1
8670            END IF
8675         GOTO 8725
8680         IF F1=2 THEN New_xsec
8685         IF F1=4 THEN
8690            F1=2
8695            F2=2
8700            END IF
8705         IF F1=3 THEN
8710            F1=4
8715            F2=1
8720            END IF
```

```
8725      E(J)=LOG(2)*VAL(D$(J)[F2*10+24;9])/VAL(D$(J)[24;9])
8730      E(J)=FNC1(E(J),D$(J))
8735      GOTO Test_daughter
8740 New_xsec:IF X$(J)[1;1]="0" THEN New_daughter
8745           IF Flux=0 THEN New_daughter
8750           F1=VAL(X$(J)[2;1])+7
8755           E(J)=VAL(X$(J)[8;9])*Flux*1.E-24
8760           GOTO Test_daughter
8765 Xsec:T$=VAL$(F1-7)
8770     Ii=0
8775     Ii=Ii+1
8780     IF Ii=VAL(X$(J)[1;1]) THEN New_daughter
8785     IF X$(J)[Ii+1;1]<>T$ THEN 8775
8790     IF X$(J)[Ii+2;1]="8" THEN
8795        T$="8"
8800        GOTO 8775
8805        END IF
8810     F1=VAL(X$(J)[Ii+2;1])+7
8815     E(J)=VAL(X$(J)[Ii*10+8;9])*Flux*1.E-24
8820 Test_daughter:Z=VAL(D$(J)[2,3])
8825    A=VAL(D$(J)[4,6])
8830    A$="0"
8835    Alph=0
8840    ON (F1) GOTO 8845,8855,8865,9020,8885,8900,8915,8930,8940,8950,8970,8985,9000,9015,Xsec
8845    Z=Z+1
8850    GOTO 9020
8855    Z=Z-1
8860    GOTO 9020
8865    Z=Z-2
8870    A=A-4
8875    Alph=1
8880    GOTO 9020
8885    Z=Z+1
8890    A=A-1
8895    GOTO 9020
8900    Z=Z+1
8905    A$="1"
8910    GOTO 9020
8915    Z=Z-1
8920    A$="1"
8925    GOTO 9020
8930    A=A+1
8935    GOTO 9020
8940    A=A-1
8945    GOTO 9020
8950    A=A-3
8955    Z=Z-2
8960    Alph=1
8965    GOTO 9020
8970    Z=Z-1
8975    Alph=2
8980    GOTO 9020
8985    A=A+1
8990    A$="1"
8995    GOTO 9020
9000    A=A-1
9005    A$="1"
9010    GOTO 9020
9015    A=A-2
9020    A$=FNSt$(Z,A,A$)
9025    GOSUB Find
9030    IF Ii=N+1 THEN 8440
9035    I=Ii
9040    IF Alph=1 THEN
9045       A$="  20040"
9050       GOSUB Find
9055       IF Ii=N+1 THEN Alph=0
9060       Frac(J)=Ii
9065       END IF
9070    IF Alph=2 THEN
```

```
9075        A$="  10010"
9080        GOSUB Find
9085        IF Ii=N+1 THEN Alph=0
9090        Frac(J)=Ii
9095        END IF
9100     IF Alph=0 THEN Frac(J)=0
9105     GOTO Endf1
9110 Find:Ii=0
9115       Ii=Ii+1
9120       IF Ii=N+1 THEN RETURN
9125       IF I$(Ii)[2,7]<>A$[2,7] THEN 9115
9130       RETURN
9135 New_daughter: J=J-1
9140                 IF J=0 THEN
9145                    Eflag=1
9150                    GOTO Endf1
9155                    END IF
9160                 GOTO 8400
9165 Endf1: IF J<=1 THEN
9170            F1$=""
9175            IF J=1 THEN GOTO 9195
9180            IF J=0 THEN GOTO 9200
9185            END IF
9190         F1$=F1$[1,J-1]
9195         F1$=F1$&CHR$(F1+64)
9200         J=J+1
9205         SUBEND
9210  SUB Tran(A(*),B(*),N,C(*),D(*))
9215     FOR I=1 TO N
9220         A(I)=B(I)
9225     NEXT I
9230     FOR I=1 TO 82
9235         C(I)=D(I)
9240     NEXT I
9245  SUBEND
9250  SUB Vectout(I$(*),A(*),Act$(*),Act(*),N,Fout$)
9255     DIM Out$(1306)[19]
9260     K=0
9265     C$="000000"
9270     FOR I=1 TO N
9275         IF A(I)<1.E-99 THEN End1
9280         IF I$(I)[2;1]="8" OR I$(I)[2;1]="9" THEN
9285            Flag=-1
9290            FOR J=1 TO 82
9295                IF I$(I)[2,7]=Act$(J)[2,7] THEN
9300                   Flag=1
9305                   J=82
9310                   END IF
9315            NEXT J
9320            IF Flag=1 THEN End1
9325            END IF
9330         B$=I$(I)
9335         B=A(I)
9340         GOSUB Vect
9345 End1:NEXT I
9350     FOR I=1 TO 82
9355     IF Act(I)<1.E-99 THEN End2
9360     B$=Act$(I)
9365     B=Act(I)
9370     GOSUB Vect
9375 End2:NEXT I
9380     GOTO Out
9385 Vect: E=0
9390       IF B<10 THEN 9410
9395       B=B/10
9400       E=E+1
9405       GOTO 9390
9410       IF B>=1 THEN 9430
9415       B=B*10
9420       E=E-1
```

APPENDIX A FILE:KSIG PAGE 28

```
9425        GOTO 9410
9430        B=B+.00005
9435        IF B>10 THEN 9395
9440        K=K+1
9445        O$=VAL$(B)
9450        IF LEN(O$)>6 THEN O$=O$[1,6]
9455        IF LEN(O$)<6 THEN O$=O$&C$[1,6-LEN(O$)]
9460        O$[2;1]="."
9465        IF E>=0 THEN O$=O$&"E+"
9470        IF E<0 THEN
9475          O$=O$&"E-"
9480          E=-E
9485          END IF
9490        E$=VAL$(E)
9495        IF LEN(E$)=1 THEN O$=O$&"0"&E$
9500        IF LEN(E$)=2 THEN O$=O$&E$
9505        Out$(K)=" "&B$[2,7]&" "&O$
9510        RETURN
9515 Out:MASS STORAGE IS ":HP82901,700,1"
9520     FI=INT(K*22/256)+1
9525     GRAPHICS OFF
9530     ON ERROR GOTO Err
9535     CREATE ASCII Fout$,FI
9540     OFF ERROR
9545     DISP
9550     ASSIGN @Inin TO Fout$
9555     OUTPUT 2 USING "#,B";255,75
9560     CONTROL 1,1;5
9565     FOR I=1 TO K
9570         PRINT Out$(I)
9575         OUTPUT @Inin;Out$(I)
9580     NEXT I
9585     ASSIGN @Inin TO *
9590     GOTO Endfl
9595 Err:X=ERRN
9600      IF X<>54 THEN 9615
9605        Fout$[LEN(Fout$);1]=CHR$(NUM(Fout$[LEN(Fout$);1])+1)
9610        GOTO 9535
9615      IF X<>55 AND X<>64 THEN 9640
9620        DISP "THIS DISK IS FULL. TRY A DIFFERENT ONE AND PRESS (CONT)"
9625        BEEP
9630        PAUSE
9635        GOTO 9535
9640     DISP "AN ERROR HAS OCCURED WHILE TRYING TO CREATE FILE:";Fout$
9645     BEEP
9650     STOP
9655 Endfl:SUBEND
```

APPENDIX B: Data Files Borrowed from ORIGEN2 and Used by KSIG

APPENDIX B.1 FILE:DECAY_L18 PAGE: 1

SEGMENT 0

```
10010  6
10020  6
10030  110 5.680E-03 3.897E+08
10040  110 0.0   +   1.000E-03
20030  6
20040  6
20060  110 1.568E+00 8.081E-01
30060  6
30070  6
30080  110 6.290E+00 8.420E-01
40080  130 9.500E-02 2.000E-16
40090  6
40100  110 2.025E-01 5.049E+13
40110  110 1.151E+01 1.360E+01
50100  6
50110  6
50120  110 1.337E+01 2.030E-02
60120  6
60130  6
60140  110 4.947E-02 1.808E+11
60150  110 2.871E+00 2.449E+00
70130  120 1.511E+00 5.982E+02
70140  6
70150  6
70160  110 7.311E+00 7.120E+00
80160  6
80170  6
80180  6
80190  110 4.819E+00 2.900E+01
90190  6
90200  110 7.030E+00 1.140E+01
```

SEGMENT 1

```
100200  6
100210  6
100220  6
100230  110 2.068E+00 3.724E+01
110220  120 2.387E+00 8.211E+07
110230  6
110240  110 4.675E+00 5.400E+04
110241  140 4.720E-01 1.990E-02
110250  110 1.936E+00 5.960E+01
120240  6
120250  6
120260  6
120270  110 1.593E+00 5.677E+02
120280  110 1.533E+00 7.528E+04
130270  6
130280  110 3.026E+00 1.344E+02
130290  110 2.351E+00 3.912E+02
130300  110 5.723E+00 3.685E+00
140280  6
140290  6
140300  6
140310  110 5.965E-01 9.438E+03
140320  510 2.100E-01 6.500E+02
150310  6
150320  410 1.710E+00 1.430E+01
150330  410 2.480E-01 2.500E+01
150340  110 5.100E+00 1.240E+01
160320  6
160330  6
160340  6
160350  410 1.674E-01 8.800E+01
160360  6
160370  210 4.800E+00 5.060E+00
170350  6
170360  112 2.488E-01 9.499E+12 1.900E-02
170370  6
170380  110 3.016E+00 2.233E+03
170381  140 6.713E-01 7.160E-01
180360  6
180370  120 2.100E-03 3.026E+06
180380  6
180390  510 5.650E-01 2.690E+02
180400  6
180410  110 1.748E+00 6.577E+03
180420  510 6.000E-01 3.300E+01
190390  6
190400  112 6.104E-01 4.039E+16 1.070E-01
190410  6
190420  110 1.706E+00 4.450E+04
190430  110 1.279E+00 8.136E+04
190440  210 5.200E+00 2.200E+01
```

SEGMENT 2

```
200400  6
200410  720 2.700E-03 8.100E+01
200420  6
200430  6
200440  6
200450  110 7.720E-02 1.408E+07
200460  6
200470  110 1.408E+00 3.919E+05
200480  6
200490  210 5.260E+00 8.800E+00
210450  6
210460  110 2.122E+00 7.240E+06
210461  140 1.372E-01 1.867E+01
210470  110 2.708E-01 2.895E+05
210480  110 3.568E+00 1.577E+05
210490  210 2.008E+00 5.750E+01
210500  110 4.827E+00 1.025E+02
220460  6
220470  6
220480  6
220490  6
220500  6
220510  110 1.235E+00 3.456E+02
230490  120 4.300E-03 2.851E+07
230500  512 1.860E+00 4.000E+16 7.000E-01
230510  6
230520  110 2.514E+00 2.250E+02
230530  110 2.037E+00 9.660E+01
230540  110 7.300E+00 5.500E+01
240500  6
240510  120 3.620E-02 2.394E+06
240520  6
240530  6
240540  6
240550  110 1.101E+00 2.130E+02
250540  120 8.398E-01 2.700E+07
250550  6
250560  110 2.521E+00 9.283E+03
250570  110 1.171E+00 9.660E+01
250580  110 3.995E+00 6.530E+01
260540  6
260550  520 5.700E-03 2.600E+00
```

APPENDIX 8.1 FILE:DECAY_L18 PAGE: 2

```
260560  6
260570  6
260580  6
260590  410 1.573E+00 4.500E+01
270580  120 1.009E+00 6.115E+06
270581  140 2.466E-02 3.294E+04
270590  6
270600  110 2.601E+00 1.663E+08
270601  114 6.303E-02 6.282E+02 9.975E-01
270610  110 5.460E-01 5.940E+03
270620  110 3.200E+00 9.000E+01
270720  110 8.579E+00 1.227E-01
270730  110 7.624E+00 1.155E-01
270740  110 9.537E+00 1.075E-01
270750  110 8.568E+00 8.016E-02
280580  6
280590  720 6.700E-03 8.000E+01
280600  6
280610  6
280620  6
280630  510 6.700E-02 9.200E+01
280640  6
280650  110 1.181E+00 9.072E+03
280660  110 6.700E-02 1.966E+05
280720  110 3.207E+00 2.419E+00
280730  110 5.375E+00 3.935E-01
280740  110 4.250E+00 6.483E-01
280750  110 6.419E+00 1.796E-01
280760  110 5.272E+00 2.684E-01
280770  110 7.390E+00 1.028E-01
280780  110 6.303E+00 1.376E-01
290620  120 2.293E+00 5.844E+02
290630  6
290640  112 3.130E-01 4.572E+04 6.280E-01
290650  6
290660  110 1.155E+00 3.060E+02
290670  110 2.709E-01 2.227E+05
290720  110 4.691E+00 6.002E+00
290730  110 3.458E+00 3.948E+00
290740  110 5.606E+00 5.731E-01
290750  110 4.506E+00 7.666E-01
290760  110 6.629E+00 2.211E-01
290770  110 5.522E+00 2.946E-01
290780  110 7.591E+00 1.206E-01
290790  110 6.538E+00 1.474E-01
290800  110 9.538E+00 9.110E-02
290810  110 9.112E+00 7.447E-02
```

SEGMENT 3

```
300630  220 2.018E+00 3.850E+01
300640  6
300650  120 5.904E-01 2.107E+07
300660  6
300670  6
300680  6
300690  110 3.209E-01 3.420E+03
300691  114 4.388E-01 4.954E+04 9.997E-01
300700  6
300710  210 2.806E+00 2.400E+00
300711  314 2.963E+00 3.920E+00 5.000E-04
300720  110 2.553E-01 1.674E+05
300730  110 2.455E+00 2.350E+01
300740  110 1.084E+00 9.500E+01
300750  110 3.278E+00 9.000E+00
300760  110 2.199E+00 5.400E+00
300770  110 4.227E+00 1.400E+00
300780  110 3.094E+00 2.429E+00
300790  110 5.261E+00 3.821E-01
300800  110 4.065E+00 7.113E-01
300810  110 7.266E+00 1.294E-01
300820  110 6.729E+00 1.353E-01
300830  110 8.226E+00 8.386E-02
310690  6
310700  110 6.531E-01 1.266E+03
310710  6
310720  110 3.207E+00 5.076E+04
310721  140 1.200E-01 3.968E-02
310730  160 7.630E-01 1.757E+04
310740  110 4.341E+00 4.860E+02
310750  116 1.381E+00 1.140E+02 4.000E-02
310760  110 4.869E+00 2.710E+01
310770  116 2.559E+00 1.300E+01 8.800E-01
310780  110 4.584E+00 4.900E+00
310790  118 3.502E+00 2.860E+00 1.400E-03
310800  118 5.623E+00 1.700E+00 8.600E-03
310810  110 4.480E+00 7.053E-01
310820  110 7.590E+00 1.538E-01
310830  110 7.139E+00 1.477E-01
310840  110 8.545E+00 9.887E-02
310850  110 8.079E+00 9.197E-02
320700  6
320710  420 9.000E-03 1.180E+01
320711  140 1.960E-01 2.190E-02
320720  6
320730  6
320731  140 6.700E-02 5.300E-01
320740  6
320750  110 4.660E-01 4.968E+03
320751  140 1.390E-01 4.890E+01
320760  6
320770  110 1.733E+00 4.068E+04
320771  114 1.034E+00 5.430E+01 2.100E-01
320780  110 5.150E-01 5.220E+03
320790  110 2.144E+00 4.300E+01
320800  110 1.029E+00 2.400E+01
320810  110 3.247E+00 1.010E+01
320820  110 2.064E+00 4.600E+00
320830  118 5.041E+00 1.900E+00 1.600E-03
320840  118 4.335E+00 1.200E+00 9.600E-02
320850  110 6.069E+00 2.342E-01
320860  110 5.557E+00 2.589E-01
320870  110 7.125E+00 1.255E-01
320880  110 6.499E+00 1.427E-01
330750  6
330760  110 1.494E+00 9.475E+04
330770  116 2.376E-01 1.397E+05 2.480E-03
330780  110 2.637E+00 5.442E+03
330790  160 8.790E-01 5.400E+02
330800  110 3.129E+00 1.650E+01
330810  110 1.669E+00 3.200E+01
330820  110 3.489E+00 2.100E+01
330821  110 5.704E+00 1.300E+01
330830  116 2.661E+00 1.350E+01 6.400E-01
330840  118 5.865E+00 5.800E+00 1.300E-03
330850  118 5.037E+00 2.030E+00 2.000E-01
330860  118 6.806E+00 9.000E-01 3.800E-02
330870  118 5.897E+00 3.000E-01 3.100E-01
330880  110 7.906E+00 1.299E-01
330890  110 7.334E+00 1.294E-01
330900  110 9.027E+00 9.009E-02
340740  6
340750  120 4.058E-01 1.035E+07
340760  6
340770  6
340771  140 2.500E-01 1.750E+01
340780  6
340790  110 4.200E-02 2.050E+12
340791  140 9.500E-02 2.334E+02
340800  6
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APPENDIX 8.1   FILE:DECAY_L18   PAGE: 3

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340811  140 1.030E-01 3.438E+03
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340830  110 3.001E+00 1.350E+03
340831  110 2.211E+00 7.000E+01
340840  110 9.390E-01 1.980E+02
340850  110 3.354E+00 3.900E+01
340851  110 3.494E+00 1.900E+01
340860  116 2.439E+00 1.660E+01 5.000E-01
340870  118 4.238E+00 5.600E+00 1.800E-03
340880  118 3.727E+00 1.500E+00 5.000E-03
340890  118 5.095E+00 4.100E-01 5.000E-02
340900  110 4.590E+00 5.545E-01
340910  110 6.545E+00 1.845E-01
340920  110 5.570E+00 2.478E-01
340930  110 7.514E+00 1.068E-01
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350801  140 8.453E-02 1.591E+04
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350850  160 1.041E+00 1.720E+02
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350861  110 4.752E+00 4.500E+00
350870  118 3.862E+00 5.580E+01 2.300E-02
350880  118 2.529E+00 1.630E+01 4.600E-02
350890  118 4.797E+00 4.500E+00 8.600E-02
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350930  110 6.564E+00 2.012E-01
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360940  118 3.868E+00 2.100E-01 4.400E-02
360950  110 5.889E+00 5.000E-01
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360970  110 6.996E+00 1.485E-01
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370870  110 1.410E-01 1.482E+18
370880  110 2.684E+00 1.068E+03
370890  110 3.099E+00 9.120E+02
370900  110 4.021E+00 1.530E+02
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380870  6
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380940  110 2.112E+00 7.560E+01
380950  110 3.301E+00 2.600E+01
380960  110 2.472E+00 4.000E+00
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390990  118 3.738E+00 8.000E-01 3.800E-02
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391010  110 4.613E+00 9.762E-01
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391030  110 5.539E+00 3.660E-01
391040  110 7.626E+00 1.442E-01
391050  110 6.646E+00 1.736E-01
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391070  110 7.476E+00 1.046E-01
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SEGMENT 4

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400920  6
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400940  6
400950  116 8.545E-01 5.528E+06 7.000E-03
400960  6
400970  116 8.791E-01 6.084E+04 9.463E-01
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401010	110	3.123E+00	3.300E+00	
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401030	110	4.137E+00	1.770E+00	
401040	110	2.977E+00	3.783E+00	
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401060	110	3.960E+00	9.801E-01	
401070	110	5.999E+00	2.485E-01	
401080	110	4.856E+00	4.076E-01	
401090	110	6.861E+00	1.387E-01	
410910	520	1.720E-02	1.000E+04	
410920	420	1.510E+00	1.016E+01	
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410931	140	2.989E-02	4.292E+08	
410940	110	1.719E+00	6.406E+11	
410941	114	4.710E-02	3.756E+02	9.952E-01
410950	110	8.092E-01	3.037E+06	
410951	140	2.344E-01	3.118E+05	
410960	110	2.805E+00	8.406E+04	
410970	110	1.123E+00	4.326E+03	
410971	140	7.427E-01	6.000E+01	
410980	110	2.082E+00	2.800E+00	
410981	110	3.245E+00	3.090E+03	
410990	110	1.557E+00	1.430E+01	
410991	110	2.169E+00	1.560E+02	
411000	110	3.980E+00	2.400E+00	
411001	110	3.484E+00	2.410E+00	
411010	110	2.231E+00	7.000E+00	
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411070	110	4.968E+00	6.694E-01	
411080	110	7.013E+00	2.220E-01	
411090	110	5.896E+00	2.861E-01	
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411110	110	6.773E+00	1.561E-01	
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420950	6			
420960	6			
420970	6			
420980	6			
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421070	110	3.693E+00	6.391E+00	
421080	110	2.691E+00	1.500E+00	
421090	110	4.592E+00	1.033E+00	
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430971	440	9.650E-02	9.000E+01	
430980	110	1.532E+00	1.325E+14	
430990	110	8.460E-02	6.722E+12	
430991	140	1.422E-01	2.167E+04	
431000	110	1.485E+00	1.580E+01	
431010	110	8.097E-01	8.520E+02	
431020	110	1.740E+00	5.280E+00	
431021	114	3.202E+00	2.610E+02	5.000E-02
431030	110	1.227E+00	5.000E+01	
431040	110	3.668E+00	1.092E+03	
431050	110	1.861E+00	4.800E+02	
431060	110	3.888E+00	3.700E+01	
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431080	110	4.621E+00	5.200E+00	
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431100	110	5.638E+00	8.300E-01	
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431170	110	7.023E+00	1.352E-01	
431180	110	8.927E+00	7.722E-02	
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440970	127	2.526E-01	2.506E+05	7.540E-04
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441000	6			
441010	6			
441020	6			
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441060	110	1.003E-02	3.181E+07	
441070	110	1.452E+00	2.520E+02	
441080	110	5.160E-01	2.700E+02	
441090	116	2.382E+00	3.500E+01	5.000E-01
441100	110	1.539E+00	1.600E+01	
441110	110	3.242E+00	1.542E+01	
441120	110	2.206E+00	7.000E-01	
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441150	110	4.890E+00	7.294E-01	
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441170	110	5.820E+00	3.089E-01	
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441190	110	6.565E+00	1.771E-01	
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451041	114	1.400E-01	2.604E+02	9.987E-01
451050	110	2.309E-01	1.273E+05	
451051	140	1.289E-01	4.500E+01	
451060	110	1.618E+00	2.990E+01	
451061	110	3.215E+00	7.920E+03	
451070	110	8.069E-01	1.302E+03	
451080	110	2.332E+00	1.680E+01	
451081	110	3.179E+00	3.540E+02	
451090	116	1.275E+00	9.000E+01	5.000E-01
451091	140	2.500E-01	5.000E+01	
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451160	110	5.737E+00	8.333E-01	
451170	110	4.588E+00	1.076E+00	
451180	110	6.688E+00	2.953E-01	
451190	110	5.316E+00	4.477E-01	
451200	110	7.383E+00	1.624E-01	
451210	110	6.233E+00	2.210E-01	
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461071  140 2.100E-01 2.130E+01
461080  6
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491240  110 4.455E+00 3.200E+00
491250  116 3.231E+00 2.330E+00 7.000E-01
491251  116 3.351E+00 1.200E+01 9.200E-01
491260  110 5.132E+00 1.530E+00
491270  118 4.066E+00 2.000E+00 6.700E-03
491271  110 4.248E+00 3.640E+00
491280  118 5.869E+00 3.700E+00 1.200E-02
491290  192 4.619E+00 8.000E-01 5.180E-01 3.500E-02
491300  118 5.373E+00 5.300E-01 4.500E-02
491310  118 5.419E+00 3.000E-01 9.500E-02
491320  110 8.485E+00 1.200E-01
491330  110 7.803E+00 1.139E-01
491340  110 9.148E+00 7.754E-02
```

SEGMENT 5

```
501120  6
501130  170 2.810E-02 9.945E+06
501131  220 7.930E-02 2.000E+01
501140  6
501150  6
501160  6
501170  6
501171  140 3.129E-01 1.210E+06
501180  6
501190  6
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501191	140	8.720E-02	2.117E+07	
501200	6			
501210	110	2.040E-01	9.648E+04	
501211	110	3.380E-01	1.577E+09	
501220	6			
501230	110	5.269E-01	1.116E+07	
501231	110	6.148E-01	2.405E+03	
501240	6			
501250	110	1.118E+00	8.329E+05	
501251	110	1.135E+00	5.712E+02	
501260	160	2.104E-01	3.156E+12	
501270	110	2.442E+00	7.560E+03	
501271	110	1.628E+00	2.480E+02	
501280	160	8.140E-01	3.540E+03	
501290	110	2.530E+00	4.500E+02	
501291	110	2.687E+00	1.500E+02	
501300	160	1.315E+00	2.232E+02	
501310	110	3.012E+00	6.300E+01	
501320	110	2.062E+00	4.000E+01	
501330	118	4.887E+00	1.470E+00	2.100E-04
501340	110	4.135E+00	8.447E-01	
501350	110	5.641E+00	2.911E-01	
501360	110	4.898E+00	4.130E-01	
511210	6			
511220	112	1.006E+00	2.333E+05	2.400E-02
511221	140	1.620E-01	2.520E+02	
511230	6			
511240	110	2.240E+00	5.201E+06	
511241	114	4.337E-01	9.300E+01	8.000E-01
511250	116	5.274E-01	8.741E+07	2.300E-01
511260	110	3.117E+00	1.071E+06	
511261	114	2.148E+00	1.140E+03	1.400E-01
511270	116	1.001E+00	3.326E+05	1.390E-01
511280	110	3.482E+00	3.244E+04	
511281	110	2.960E+00	6.240E+02	
511290	116	1.885E+00	1.555E+04	1.307E-01
511300	110	3.949E+00	2.400E+03	
511301	110	3.716E+00	3.780E+02	
511310	116	2.442E+00	1.380E+03	6.800E-02
511320	110	3.936E+00	1.680E+02	
511321	110	3.931E+00	2.520E+02	
511330	116	3.700E+00	1.440E+02	2.200E-02
511340	110	4.930E+00	1.100E+01	
511341	118	5.048E+00	1.070E+01	8.000E-04
511350	118	4.872E+00	1.700E+00	8.000E-02
511360	110	6.576E+00	2.313E-01	
511370	110	5.846E+00	2.837E-01	
511380	110	7.449E+00	1.304E-01	
511390	110	6.496E+00	1.719E-01	
521200	6			
521210	120	5.853E-01	1.469E+06	
521211	142	2.955E-01	1.331E+07	1.140E-01
521220	6			
521230	120	1.710E-02	3.156E+20	
521231	140	2.457E-01	1.034E+07	
521240	6			
521250	6			
521251	140	1.418E-01	5.011E+06	
521260	6			
521270	110	2.278E-01	3.366E+04	
521271	114	9.074E-02	9.418E+06	9.760E-01
521280	6			
521290	110	6.027E-01	4.176E+03	
521291	114	2.958E-01	2.903E+06	6.500E-01
521300	6			
521310	110	1.139E+00	1.500E+03	
521311	114	1.622E+00	1.080E+05	2.220E-01
521320	110	3.342E-01	2.815E+05	
521330	110	1.746E+00	7.470E+02	
521331	114	2.982E+00	3.324E+03	1.300E-01
521340	110	1.182E+00	2.508E+03	
521350	110	3.106E+00	1.920E+01	
521360	118	2.841E+00	2.100E+01	5.000E-03
521370	118	4.292E+00	3.500E+00	5.000E-03
521380	110	3.588E+00	1.640E+00	
521390	110	5.250E+00	4.237E-01	
521400	110	4.242E+00	7.519E-01	
521410	110	6.010E+00	2.358E-01	
521420	110	4.631E+00	4.913E-01	
531250	420	5.870E-02	5.970E+01	
531260	112	5.994E-01	1.125E+06	5.600E-01
531270	6			
531280	112	8.368E-01	1.499E+03	6.000E-02
531290	110	7.804E-02	4.954E+14	
531300	110	2.429E+00	4.450E+04	
531301	114	3.076E-01	5.400E+02	8.300E-01
531310	116	5.730E-01	6.947E+05	1.110E-02
531320	110	2.773E+00	8.280E+03	
531330	116	1.013E+00	7.488E+04	2.882E-02
531331	140	1.631E+00	9.000E+00	
531340	110	3.248E+00	3.156E+03	
531341	114	3.468E-01	2.220E+02	9.800E-01
531350	116	1.936E+00	2.380E+04	1.540E-01
531360	110	4.256E+00	8.300E+01	
531361	110	3.824E+00	4.600E+01	
531370	118	3.543E+00	2.460E+01	5.400E-02
531380	118	4.000E+00	6.400E+00	2.500E-02
531390	118	4.224E+00	2.400E+00	1.000E-01
531400	118	5.020E+00	8.600E-01	3.200E-01
531410	118	4.834E+00	4.000E-01	1.200E-01
531420	110	6.836E+00	1.960E-01	
531430	110	5.511E+00	3.281E-01	
531440	110	7.217E+00	1.327E-01	
531450	110	6.227E+00	1.867E-01	
541240	6			
541250	320	3.011E-01	1.700E+01	
541251	140	2.501E-01	5.700E+01	
541260	6			
541270	120	3.091E-01	3.146E+06	
541271	140	2.278E-01	7.000E+01	
541280	6			
541290	6			
541291	140	2.360E-01	6.912E+05	
541300	6			
541310	6			
541311	140	1.623E-01	1.028E+06	
541320	6			
541330	110	1.807E-01	4.532E+05	
541331	140	2.317E-01	1.892E+05	
541340	6			
541341	140	1.904E+00	2.900E-01	
541350	110	5.645E-01	3.272E+04	
541351	140	5.267E-01	9.174E+02	
541360	6			
541370	110	1.963E+00	2.298E+02	
541380	110	1.801E+00	8.502E+02	
541390	110	2.672E+00	3.950E+01	
541400	110	2.243E+00	1.360E+01	
541410	118	3.841E+00	1.720E+00	5.400E-04
541420	118	2.863E+00	1.220E+00	5.100E-03
541430	118	4.488E+00	3.000E-01	1.100E-02
541440	110	3.204E+00	1.000E+00	
541450	110	5.036E+00	9.000E-01	
541460	110	3.953E+00	9.372E-01	
541470	110	5.716E+00	2.638E-01	
551310	420	2.790E-02	9.700E+00	
551320	112	7.283E-01	5.594E+05	9.800E-01
551330	6			
551340	110	1.717E+00	6.507E+07	
551341	140	1.352E-01	1.044E+04	
551350	110	5.630E-02	7.258E+13	
551351	240	1.619E+00	5.300E+01	
551360	116	2.300E+00	1.132E+06	1.648E-01
551370	116	1.866E-01	9.467E+08	9.460E-01

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551380	110	3.558E+00	1.932E+03	
551381	114	9.339E-01	1.740E+02	7.500E-01
551390	110	1.997E+00	5.640E+02	
551400	110	4.062E+00	6.380E+01	
551410	118	3.202E+00	2.500E+01	7.300E-04
551420	118	4.589E+00	1.700E+00	2.100E-03
551430	118	3.733E+00	1.700E+00	1.130E-02
551440	118	5.391E+00	1.020E+00	1.100E-02
551450	118	4.022E+00	5.600E-01	4.400E-02
551460	118	5.802E+00	1.900E-01	3.900E-02
551470	110	4.906E+00	5.578E-01	
551480	110	6.566E+00	2.016E-01	
551490	110	5.721E+00	2.782E-01	
551500	110	7.261E+00	1.244E-01	
561300	6			
561310	120	5.153E-01	1.020E+06	
561311	240	1.800E-01	1.500E+01	
561320	6			
561330	120	4.424E-01	3.389E+08	
561331	142	2.850E-01	1.400E+05	1.100E-04
561340	6			
561350	6			
561351	140	2.666E-01	1.033E+05	
561360	6			
561361	140	2.040E+00	3.080E-01	
561370	6			
561371	140	6.624E-01	1.531E+02	
561380	6			
561390	110	9.394E-01	4.962E+03	
561400	110	4.707E-01	1.105E+06	
561410	110	1.729E+00	1.096E+03	
561420	110	1.469E+00	6.420E+02	
561430	110	2.659E+00	1.360E+01	
561440	110	1.694E+00	1.100E+01	
561450	110	3.208E+00	6.200E+00	
561460	110	1.940E+00	2.200E+00	
561470	110	3.658E+00	2.227E+00	
561480	110	2.620E+00	5.901E+00	
561490	110	4.308E+00	9.175E-01	
561500	110	3.411E+00	1.797E+00	
561510	110	5.077E+00	4.368E-01	
561520	110	4.192E+00	7.548E-01	
571370	120	3.098E-02	1.893E+12	
571380	112	1.237E+00	4.260E+18	6.710E-01
571390	6			
571400	110	2.828E+00	1.448E+05	
571410	110	9.907E-01	1.415E+04	
571420	110	3.572E+00	5.562E+03	
571430	110	1.972E+00	8.400E+02	
571440	110	3.447E+00	4.000E+01	
571450	110	2.578E+00	2.900E+01	
571460	110	4.125E+00	8.300E+00	
571470	110	2.875E+00	1.000E+01	
571480	110	4.601E+00	1.300E+00	
571490	110	3.582E+00	2.864E+00	
571500	110	5.270E+00	6.485E-01	
571510	110	4.400E+00	9.536E-01	
571520	110	6.072E+00	3.094E-01	
571530	110	5.208E+00	4.371E-01	
571540	110	6.834E+00	1.753E-01	
571550	110	6.120E+00	2.215E-01	
581360	6			
581370	120	5.223E-02	3.240E+04	
581371	142	2.561E-01	1.238E+05	1.000E-02
581380	6			
581390	120	1.924E-01	1.189E+07	
581391	140	7.519E-01	5.620E+01	
581400	6			
581410	110	2.470E-01	2.809E+06	
581420	130	0.0 +	3.311E+18	
581430	110	7.105E-01	1.188E+05	
581440	116	1.119E-01	2.456E+07	1.200E-02
581450	110	1.485E+00	1.800E+02	
581460	110	4.391E-01	8.520E+02	
581470	110	2.123E+00	7.000E+01	
581480	110	9.860E-01	4.300E+01	
581490	110	2.514E+00	1.000E+00	
581500	110	1.520E+00	1.000E+00	
581510	110	3.098E+00	1.000E+00	
581520	110	2.236E+00	1.403E+01	
581530	110	3.811E+00	1.725E+00	
581540	110	2.951E+00	3.591E+00	
581550	110	4.571E+00	7.125E-01	
581560	110	3.831E+00	1.162E+00	
581570	110	5.353E+00	3.617E-01	
591390	320	1.679E-01	4.400E+00	
591400	220	7.000E-01	3.390E+00	
591410	6			
591420	110	8.671E-01	6.887E+04	
591421	140	2.500E-01	8.760E+02	
591430	110	3.143E-01	1.172E+06	
591440	110	1.240E+00	1.037E+03	
591441	114	5.772E-02	4.320E+02	9.994E-01
591450	110	6.915E-01	2.153E+04	
591460	110	2.563E+00	1.452E+03	
591470	110	1.568E+00	7.200E+02	
591480	110	2.821E+00	1.380E+02	
591490	110	1.409E+00	1.380E+02	
591500	110	3.212E+00	1.240E+01	
591510	110	2.377E+00	4.000E+00	
591520	110	3.986E+00	8.318E+00	
591530	110	3.144E+00	7.743E+00	
591540	110	4.723E+00	1.307E+00	
591550	110	3.884E+00	1.891E+00	
591560	110	5.509E+00	5.104E-01	
591570	110	4.788E+00	6.779E-01	
591580	110	6.318E+00	2.629E-01	
591590	110	5.728E+00	3.141E-01	

SEGMENT 6

601410	320	9.166E-02	2.500E+00	
601420	6			
601430	6			
601440	130	0.0 +	6.623E+22	
601450	6			
601460	6			
601470	110	4.070E-01	9.556E+05	
601480	6			
601490	110	8.900E-01	6.228E+03	
601500	6			
601510	110	1.483E+00	7.440E+02	
601520	110	5.620E-01	6.900E+02	
601530	110	2.088E+00	6.754E+01	
601540	110	1.079E+00	4.000E+01	
601550	110	2.553E+00	2.606E+01	
601560	110	1.725E+00	5.849E+01	
601570	110	3.245E+00	4.149E+00	
601580	110	2.536E+00	7.889E+00	
601590	110	3.959E+00	1.408E+00	
601600	110	3.372E+00	2.121E+00	
601610	110	4.868E+00	5.558E-01	
611450	120	4.430E-02	5.586E+08	
611460	512	8.508E-01	5.500E+00	6.300E-01
611470	110	6.051E-02	8.279E+07	
611480	110	1.299E+00	4.640E+05	
611481	114	2.139E+00	3.568E+06	4.900E-02
611490	110	3.769E-01	1.911E+05	
611500	110	2.283E+00	9.648E+03	
611510	110	6.210E-01	1.022E+05	
611520	110	1.727E+00	2.460E+02	

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611521  110 1.707E+00 4.500E+02
611530  110 7.500E-01 3.240E+02
611540  110 2.645E+00 1.680E+02
611541  114 2.556E+00 1.080E+02 1.000E-01
611550  110 1.961E+00 3.656E+01
611560  110 3.215E+00 1.310E+01
611570  110 2.626E+00 6.802E+01
611580  110 4.145E+00 3.801E+00
611590  110 3.455E+00 4.230E+00
611600  110 4.893E+00 9.963E-01
611610  110 4.322E+00 1.188E+00
611620  110 5.818E+00 3.999E-01
621440  6
621450  120 9.717E-02 2.938E+07
621460  830 2.540E+00 7.000E+01
621470  130 2.310E+00 3.377E+18
621480  130 2.014E+00 2.525E+23
621490  130 0.0    +  3.154E+23
621500  6
621510  110 1.978E-02 2.840E+09
621520  6
621530  110 3.310E-01 1.681E+05
621540  6
621550  110 9.840E-01 1.332E+03
621560  110 4.270E-01 3.384E+04
621570  110 1.521E+00 4.800E+02
621580  110 7.070E-01 2.639E+03
621590  110 1.977E+00 1.622E+02
621600  110 1.791E+00 3.491E+02
621610  110 2.746E+00 1.288E+01
621620  110 2.179E+00 1.959E+01
621630  110 3.579E+00 2.563E+00
621640  110 2.937E+00 4.247E+00
621650  110 4.389E+00 9.274E-01
631490  420 7.467E-02 9.310E+01
631500  520 1.540E+00 3.600E+01
631510  6
631520  112 1.276E+00 4.292E+08 7.214E-01
631521  112 8.104E-01 3.355E+04 2.800E-01
631530  6
631540  110 1.509E+00 2.714E+08
631550  110 1.227E-01 1.565E+08
631560  110 1.741E+00 1.312E+06
631570  110 7.520E-01 5.472E+04
631580  110 2.130E+00 2.754E+03
631590  110 1.582E+00 1.086E+03
631600  110 2.269E+00 5.100E+01
631610  110 2.077E+00 4.206E+01
631620  110 3.349E+00 2.698E+02
631630  110 3.008E+00 1.484E+01
631640  110 4.410E+00 2.170E+00
631650  110 3.780E+00 2.548E+00
641520  130 2.198E+00 3.408E+21
641530  120 1.524E-01 2.091E+07
641540  6
641550  6
641551  140 1.215E-01 3.100E-02
641560  6
641570  6
641580  6
641590  110 5.500E-01 6.696E+04
641600  6
641610  110 1.224E+00 2.220E+02
641620  116 6.130E-01 6.000E+02 2.000E-02
641630  110 1.667E+00 9.277E+01
641640  110 1.075E+00 1.301E+03
641650  110 2.327E+00 1.002E+02
651570  120 8.100E-03 4.734E+09
651590  6
651600  110 1.374E+00 6.247E+06
651610  110 3.380E-01 5.979E+05
651620  110 1.682E+00 4.482E+02
651621  110 1.832E+00 8.028E+03
651630  110 1.018E+00 1.170E+03
651631  210 7.490E-01 7.000E+00
651640  110 2.363E+00 1.800E+02
651650  116 1.703E+00 3.275E+01 5.000E-01
661560  6
661570  120 3.621E-01 2.916E+04
661580  6
661590  420 5.790E-02 1.440E+02
661600  6
661610  6
661620  6
661630  6
661640  6
661650  110 7.810E-01 8.460E+03
661651  114 1.260E-01 7.536E+01 9.750E-01
661660  110 1.970E-01 2.934E+05
671630  520 9.000E-03 3.300E+01
671650  6
671660  110 7.231E-01 9.648E+04
671661  110 1.869E+00 3.787E+10
681620  6
681630  220 1.000E-02 7.500E+01
681640  6
681650  320 4.569E-02 1.030E+01
681660  6
681670  6
681671  140 2.080E-01 2.300E+00
681680  6
681690  410 3.400E-01 9.400E+00
681700  6
681710  110 8.066E-01 2.707E+04
681720  310 9.100E-01 4.900E+01
691690  6
691700  112 3.347E-01 1.111E+07 1.460E-03
691701  140 0.0    +  4.100E-06
691710  110 2.616E-02 6.059E+07
691720  310 1.880E+00 6.360E+01
691730  310 1.320E+00 8.240E+00
```

SEGMENT 7

```
701680  6
701690  120 4.234E-01 2.766E+06
701700  6
701710  6
701720  6
701730  6
701740  6
701750  110 1.693E-01 3.620E+05
701751  140 5.130E-01 6.700E-02
701760  6
701770  310 1.400E+00 1.900E+00
711750  6
711760  910 1.020E+00 3.000E+01
711761  310 1.310E+00 3.690E+00
711770  110 1.820E-01 5.797E+05
711771  414 1.358E+00 1.550E+02 2.200E-01
721740  6
721750  420 4.149E-01 7.000E+01
721760  6
721770  6
721780  6
721781  140 1.147E+00 4.000E+00
721790  6
721791  140 3.780E-01 1.860E+01
721800  6
721801  340 1.142E+00 5.500E+00
```

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```
721810  110 7.540E-01 3.663E+06
721820  810 5.000E-01 9.000E+00
731800  510 3.000E-01 1.600E+13
731810  6
731820  110 1.502E+00 9.936E+06
731821  240 5.030E-01 1.650E+01
731830  410 1.070E+00 5.100E+00
741800  6
741810  120 4.830E-02 1.047E+07
741820  6
741830  6
741831  140 2.600E-01 5.200E+00
741840  6
741850  410 4.325E-01 7.510E+01
741851  240 1.970E-01 1.670E+00
741860  6
741870  110 7.651E-01 8.604E+04
741880  110 1.009E-01 5.996E+06
741890  210 2.000E+00 1.150E+01
751850  6
751860  312 3.607E-01 9.064E+01 6.500E-02
751870  910 2.590E+00 5.000E+01
751880  110 8.371E-01 6.113E+04
751881  240 1.720E-01 1.870E+01
751890  310 1.010E+00 2.430E+01
761840  6
761850  420 7.192E-01 9.400E+01
761860  6
761870  6
761880  6
761890  6
761900  6
761901  240 1.706E+00 9.900E+00
761910  110 2.450E-01 1.331E+06
761911  340 7.400E-02 1.300E+01
761920  6
761930  310 1.132E+00 3.100E+01
761940  510 9.700E-02 6.000E+00
771910  6
771920  112 1.033E+00 6.395E+06 4.780E-02
771921  540 1.610E-01 2.410E+02
771930  6
771940  110 9.002E-01 6.894E+04
771941  110 1.000E-01 3.200E-02
781900  930 3.250E+00 6.000E+02
781910  420 3.533E-01 3.000E+00
781920  6
781930  520 5.300E-03 5.000E+02
781931  440 1.480E-01 4.300E+00
781940  6
781950  6
781951  140 2.457E-01 2.713E+05
781960  6
781970  310 7.500E-01 1.800E+01
781971  214 4.220E-01 8.000E+01 9.700E-01
781980  6
781990  210 1.680E+00 3.000E+01
781991  140 4.250E-01 1.410E+01
791970  6
791980  410 1.374E+00 2.698E+00
791990  110 2.307E-01 2.713E+05
792000  210 2.200E+00 4.840E+01
```

SEGMENT 8

```
801960  6
801970  320 1.306E-01 6.500E+01
801971  342 3.017E-01 2.400E+01 6.000E-02
801980  6
801990  6
801991  240 5.330E-01 4.300E+01
802000  6
802010  6
802020  6
802030  110 3.360E-01 4.025E+06
802040  6
802050  210 1.600E+00 5.500E+00
812030  6
812040  512 2.389E-01 3.800E+00 2.100E-02
812050  6
812060  210 1.524E+00 4.190E+00
812070  110 4.954E-01 2.862E+02
812080  110 3.970E+00 1.842E+02
812090  110 2.803E+00 1.320E+02
822040  530 2.600E+00 1.400E+17
822050  820 4.900E-03 3.000E+01
822060  6
822070  6
822080  6
822090  310 1.940E-01 3.300E+00
822100  110 3.908E-02 7.037E+08
822110  110 5.055E-01 2.166E+03
822120  110 3.212E-01 3.830E+04
822140  110 5.380E-01 1.608E+03
832080  720 2.654E+00 3.680E+02
832090  6
832100  110 3.890E-01 4.330E+05
832101  813 5.296E+00 3.000E+00 9.960E-01
832110  113 6.729E+00 1.278E+02 9.972E-01
832120  113 2.896E+00 3.633E+03 3.593E-01
832130  113 7.092E-01 2.739E+03 2.160E-02
832140  113 2.162E+00 1.194E+03 2.100E-04
842100  130 5.408E+00 1.196E+07
842110  130 7.592E+00 5.600E-01
842111  130 7.600E+00 2.500E+01
842120  130 8.940E+00 3.000E-07
842130  130 8.537E+00 4.200E-06
842140  130 7.833E+00 1.643E-04
842150  130 7.531E+00 1.780E-03
842160  130 6.906E+00 1.500E-01
842180  113 6.113E+00 1.830E+02 9.998E-01
852170  130 7.199E+00 3.230E-02
862180  130 7.260E+00 3.500E-02
862190  130 7.000E+00 3.960E+00
862200  130 6.405E+00 5.560E+01
862220  130 5.590E+00 3.304E+05
872210  130 6.511E+00 2.880E+02
872230  113 4.381E-01 1.308E+03 6.000E-05
882220  130 6.680E+00 3.800E+01
882230  130 6.007E+00 9.879E+05
882240  130 5.790E+00 3.162E+05
882250  110 1.183E-01 1.279E+06
882260  130 4.871E+00 5.049E+10
882280  510 1.300E-02 6.700E+00
892250  130 5.893E+00 8.640E+05
892270  113 8.169E-02 6.871E+08 1.380E-02
892280  110 1.458E+00 2.207E+04
```

SEGMENT 9

```
902260  230 6.450E+00 3.100E+01
902270  130 6.157E+00 1.617E+06
902280  130 5.517E+00 6.037E+07
902290  130 5.161E+00 2.316E+11
902300  130 4.774E+00 2.430E+12
902310  110 9.466E-02 9.187E+04
902320  130 4.084E+00 4.434E+17
902330  210 4.270E-01 2.210E+01
```

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902340	160	6.840E-02	2.082E+06			
912310	130	5.083E+00	1.034E+12			
912320	110	1.103E+00	1.132E+05			
912330	110	3.829E-01	2.333E+06			
912340	110	2.423E+00	2.412E+04			
912341	114	8.337E-01	7.020E+01	1.300E-03		
912350	210	4.710E-01	2.410E+01			
922300	430	5.991E+00	2.080E+01			
922310	120	1.395E-01	3.629E+05			
922320	130	5.416E+00	2.272E+09			
922330	130	4.904E+00	5.002E+12			
922340	130	4.859E+00	7.716E+12			
922350	130	4.418E+00	2.221E+16			
922360	130	4.570E+00	7.389E+14			
922370	110	3.192E-01	5.832E+05			
922380	130	4.279E+00	1.410E+17			
922390	110	4.541E-01	1.412E+03			
922400	160	1.384E-01	5.076E+04			
922410	110	4.040E-01	1.000E+00			
932350	123	9.800E-03	3.422E+07	1.400E-05		
932360	112	3.403E-01	3.629E+12	9.100E-01		
932361	112	1.333E-01	8.100E+04	5.200E-01		
932370	130	5.156E+00	6.753E+13			
932380	110	8.080E-01	1.829E+05			
932390	110	4.078E-01	2.035E+05			
932400	110	1.788E+00	3.900E+03			
932401	110	9.776E-01	4.440E+02			
932410	210	4.710E-01	1.600E+01			
942360	130	5.871E+00	8.997E+07			
942370	420	6.220E-02	4.560E+01			
942380	130	5.591E+00	2.769E+09			
942390	130	5.199E+00	7.594E+11			
942400	130	5.253E+00	2.063E+11			
942410	113	5.230E-03	4.544E+08	2.450E-05		
942420	130	4.982E+00	1.221E+13			
942430	110	1.947E-01	1.784E+04			
942440	135	4.892E+00	2.607E+15	1.200E-03		
942450	310	4.000E-01	1.060E+01			
942460	410	1.420E-01	1.085E+01			
952390	123	4.077E-01	4.284E+04	1.000E-04		
952400	120	1.104E+00	1.829E+05			
952410	130	5.604E+00	1.364E+10			
952420	112	1.915E-01	5.767E+04	1.730E-01		
952421	191	6.664E-02	4.797E+09	5.000E-03	1.600E-10	
952430	130	5.423E+00	2.329E+11			
952440	310	8.840E-01	1.010E+01			
952441	212	5.103E-01	2.600E+01	4.100E-04		
952450	310	3.130E-01	2.070E+00			
952460	210	1.362E+00	2.500E+01			
962410	423	6.934E-01	3.600E+01	1.000E-02		
962420	130	6.216E+00	1.410E+07			
962430	113	6.189E+00	8.994E+08	9.976E-01		
962440	130	5.901E+00	5.715E+08			
962450	130	5.598E+00	2.682E+11			
962460	135	5.523E+00	1.493E+11	2.610E-04		
962470	130	5.390E+00	4.923E+14			
962480	135	2.100E+01	1.070E+13	8.330E-02		
962490	110	2.936E-01	3.849E+03			
962500	793	1.233E+02	1.740E+01	2.500E-01	6.100E-01	
962510	110	3.000E-01	1.000E+00			
972490	193	1.250E-01	2.765E+07	1.450E-05	4.600E-10	
972500	110	1.172E+00	1.160E+04			
972510	210	1.100E+00	5.700E+01			
982490	130	7.806E+00	1.106E+10			
982500	135	6.267E+00	4.128E+08	7.700E-04		
982510	130	6.027E+00	2.834E+10			
982520	135	1.204E+01	8.325E+07	3.100E-02		
982530	113	9.782E-02	1.539E+06	3.100E-03		
982540	453	1.994E+02	6.050E+01	3.100E-03		
982550	310	1.000E-01	1.500E+00			
992530	430	9.782E-02	2.047E+01			
992540	430	6.623E+00	2.757E+02			
992541	394	8.173E+00	3.930E+01	1.547E-02	7.800E-04	1.030E-03
992550	430	7.370E+00	3.900E+01			

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SEGMENT 0

10010	11	3.474E-02				
10020	212	4.874E-05	1.192E-03			
10030	11	5.518E-07				
20030	214	5.879E+01	4.902E+02			
30060	3134	2.575E-03	8.297E+01	1.268E-03		
30070	213	3.165E-03	7.908E-03			
40090	3123	8.427E-04	6.596E-02	3.825E-02		
40100	11	9.197E-05				
50100	3134	4.598E-02	4.015E+02	2.480E-03		
50110	3123	5.351E-04	7.779E-07	2.755E-06		
60120	213	3.106E-04	3.890E-04			
60130	213	1.048E-04	7.969E-04			
60140	11	9.197E-08				
70140	3134	6.896E-03	2.628E-02	1.812E-01		
70150	3134	2.207E-06	4.000E-06	5.977E-07		
80160	3134	1.669E-05	2.725E-03	5.535E-06		
80170	13	2.159E-02				
80180	213	3.287E-05	4.597E-04			
90190	3134	1.202E-03	5.250E-03	4.815E-04		

SEGMENT 1

100200	213	3.403E-03	6.130E-03			
100210	213	6.364E-02	1.380E-01			
100220	11	4.415E-03				
110220	11	6.282E+03				
110230	41345	5.283E-02	1.722E-04	4.733E-04	3.814E-02	
120240	3134	4.945E-03	4.601E-04	4.012E-04		
120250	3134	1.729E-02	5.210E-03	6.115E-04		
120260	213	3.705E-03	9.195E-04			
120270	11	3.679E-03				
130270	3134	2.279E-02	1.988E-04	9.505E-04		
140280	3134	1.567E-02	2.266E-04	1.226E-03		
140290	3134	2.575E-02	1.961E-03	8.285E-04		
140300	3134	1.126E-02	3.065E-05	1.211E-06		
140310	11	4.415E-02				
150310	3134	1.653E-02	3.960E-04	9.505E-03		
160320	3134	4.874E-02	4.656E-03	1.839E-02		
160330	3234	2.393E-06	1.288E-02	1.839E-04		
160340	3134	2.207E-02	7.666E-04	1.928E-04		
160360	11	1.380E-02				
170350	3134	3.897E+00	1.877E-03	5.372E-02		
170360	11	9.197E-01				
170370	41345	4.175E-02	3.678E-04	7.371E-05	5.029E-04	
180360	3134	4.660E-01	1.237E-02	2.185E-02		
180380	11	7.456E-02				
180390	11	5.518E+01				
180400	213	6.348E-02	5.794E-02			
180410	11	4.598E-02				
190390	3134	1.807E-01	5.635E-03	2.204E-02		
190400	3134	2.759E+00	3.583E-02	4.048E-01		
190410	11	1.530E-01				

SEGMENT 2

200400	3134	3.679E-02	2.287E-03	1.440E-02		
200420	3134	5.972E-02	7.350E-03	6.440E-03		
200430	3134	6.369E-01	2.575E-03	1.041E-03		
200440	41234	9.468E-02	3.525E-08	1.072E-05	2.450E-05	
200460	11	6.450E-02				
200480	11	1.012E-01				
210450	41345	1.544E+00	1.140E-05	2.538E-05	8.774E-01	
210460	11	7.358E-01				
220460	3134	5.838E-02	2.027E-04	3.935E-03		
220470	3134	1.818E-01	1.686E-03	6.743E-03		
220480	3134	7.220E-01	3.387E-06	6.433E-05		
220490	3134	2.149E-01	2.478E-04	7.053E-04		
220500	3134	1.738E-02	1.236E-07	1.532E-05		
230500	11	7.311E+00				
230510	3134	4.612E-01	1.084E-06	3.080E-05		
240500	3134	1.473E+00	1.992E-04	7.770E-03		
240510	11	7.358E-02				
240520	41234	3.348E-01	2.994E-05	2.684E-05	4.711E-04	
240530	3134	1.690E+00	9.198E-04	3.040E-05		
240540	3134	3.355E-02	1.410E-05	1.226E-06		
250540	11	9.197E-01				
250550	3134	1.523E+00	3.210E-05	3.698E-04		
260540	3134	2.115E-01	7.347E-04	2.026E-02		
260560	3134	2.683E-01	8.831E-05	1.670E-03		
260570	3134	2.326E-01	1.072E-03	1.231E-04		
260580	3134	1.223E-01	3.065E-06	3.065E-06		
270580	11	3.216E+02				
270581	11	1.251E+04				
270590	41345	2.229E+00	7.387E-02	9.195E-05	2.622E+00	
270600	11	2.676E-01				
270601	11	1.035E+01				
280580	41234	4.866E-01	2.491E-06	1.371E-03	2.097E-02	
280590	213	1.084E+01	1.104E+00			
280600	3134	2.634E-01	2.454E-04	6.127E-04		
280610	3134	2.416E-01	5.467E-03	5.214E-04		
280620	3134	1.316E+00	1.993E-05	3.065E-05		
280630	11	2.115E+00				
280640	11	1.476E-01				
280650	11	2.236E+00				
290630	3134	4.846E-01	2.205E-04	2.759E-03		
290650	41234	2.346E-01	2.172E-04	4.601E-05	1.107E-04	
290660	11	1.242E+01				

SEGMENT 3

300640	213	9.754E-02	1.363E-06			
300660	213	8.844E-02	1.876E-06			
300670	213	1.050E+00	5.521E-07			
300680	3135	1.566E-01	1.873E-06	1.128E-02		
300700	215	7.633E-03	8.003E-04			
310690	11	5.197E-01				
310710	215	1.125E+00	3.587E-02			
320700	215	3.091E-01	2.746E-02			
320720	11	1.230E-01				
320730	11	3.274E+00				
320740	215	5.509E-02	1.552E-02			
320750	11	4.139E-01				
320760	215	5.651E-02	3.929E-02			
330750	11	2.150E+00				
340740	11	1.809E+01				
340760	215	7.879E+00	1.967E+00			
340770	11	4.385E+00				
340780	215	1.855E-01	1.226E-01			
340790	11	3.630E-01				
340800	215	8.990E-02	1.188E-02			
340820	215	8.616E-03	5.336E-04			
350790	215	4.805E+00	1.059E+00			
350810	215	1.789E+00	1.330E+00			
360780	215	4.886E-01	2.281E-02			
360800	512345	2.817E+00	6.130E-05	8.754E-06	1.132E-04	8.166E-01
360820	512345	7.249E+00	1.195E-04	2.737E-06	2.330E-05	3.804E+00
360830	41234	2.130E+01	2.054E-03	3.110E-06	7.961E-05	
360840	512345	1.251E-01	1.900E-04	1.686E-05	2.439E-06	5.257E-02

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360850	11	1.840E-01				
360860	41234	1.010E-02	2.605E-04	1.055E-05	5.181E-08	
360870	11	5.518E+01				
370850	215	2.517E-01	2.410E-02			
370860	11	1.141E+00				
370870	11	7.690E-02				
370880	11	9.197E-02				
380840	215	1.047E-01	2.215E-01			
380860	215	3.914E-01	1.664E-01			
380870	11	4.302E+00				
380880	11	1.243E-03				
380890	11	5.264E-02				
380900	11	8.739E-02				
390890	215	1.331E-01	1.001E-04			
390900	215	4.332E-01	1.588E-01			
390910	11	1.651E-01				

SEGMENT 4

400900	3134	2.507E-02	1.108E-06	2.760E-04		
400910	3134	2.755E-01	4.601E-04	8.567E-05		
400920	3134	5.433E-02	2.266E-05	4.907E-05		
400930	213	1.029E+00	1.532E-05			
400940	3134	1.943E-02	4.288E-06	3.068E-06		
400950	11	2.325E-01				
400960	3134	1.768E-01	9.204E-08	1.225E-07		
410930	512345	4.099E-01	4.597E-04	1.856E-05	1.746E-04	1.012E-01
410940	11	4.285E+00				
410950	11	8.508E-01				
420920	41345	1.643E-02	9.547E-06	1.900E-03	5.518E-04	
420940	3134	3.951E-02	2.023E-04	2.544E-04		
420950	3134	4.219E+00	1.134E-03	3.991E-05		
420960	3134	6.870E-01	9.192E-05	5.827E-05		
420970	3134	6.934E-01	3.984E-04	3.988E-05		
420980	3134	2.371E-01	2.023E-05	2.450E-06		
420990	11	1.013E+00				
421000	3134	1.483E-01	1.165E-06	3.060E-07		
430990	212	9.136E+00	6.130E-04			
440960	11	1.826E-01				
440980	11	7.358E-01				
440990	11	4.313E+00				
441000	11	7.797E-01				
441010	11	2.950E+00				
441020	11	2.621E-01				
441030	11	2.666E+00				
441040	11	2.620E-01				
441050	11	2.908E-01				
441060	11	8.898E-02				
451030	3125	3.681E+01	2.237E-04	2.873E+00		
451040	11	3.679E+00				
451041	11	7.358E+01				
451050	215	1.018E+03	4.945E+02			
461020	11	4.415E-01				
461040	11	6.463E-01				
461050	11	3.830E+00				
461060	215	2.748E-01	7.056E-03			
461070	11	2.816E+00				
461080	215	7.090E+00	1.170E-01			
461100	215	2.595E-01	3.999E-02			
471070	512345	6.252E+00	4.597E-04	2.306E-05	2.141E-05	4.289E-01
471090	512345	3.888E+01	4.904E-04	2.088E-05	2.373E-05	2.081E+00
471100	215	7.542E+00	9.197E-22			
471101	215	7.542E+00	7.542E+00			
471110	11	3.461E+00				
481060	11	9.197E-02				
481080	11	2.644E-01				
481090	11	5.978E+01				
481100	215	2.238E+00	1.705E-02			
481110	11	3.555E+00				
481120	215	6.333E-01	3.222E-01			
481130	3124	4.044E+03	1.471E-03	2.065E-06		
481140	215	6.448E-01	5.560E-02			
481151	11	8.225E+00				
481160	215	1.048E-01	3.996E-03			
481180	215	4.598E-02	4.598E-02			
491130	215	7.031E+00	5.170E+00			
491150	215	9.615E+01	7.580E+01			
491170	215	4.598E-01	4.598E-01			
491171	215	4.598E-01	4.598E-01			
491190	215	3.679E-02	5.518E-02			
491191	215	3.679E-02	5.518E-02			
491200	11	1.476E-03				
491201	11	1.476E-03				

SEGMENT 5

501120	215	5.267E-01	2.304E-01			
501140	3134	3.761E-02	5.866E-06	9.192E-05		
501150	3134	4.553E+00	8.898E-05	9.186E-05		
501160	41345	3.452E-01	6.387E-07	1.533E-05	2.711E-01	
501170	3134	7.621E-01	1.655E-05	2.758E-05		
501180	41345	2.269E-01	6.253E-08	3.064E-06	1.735E-01	
501190	3134	3.021E-01	2.665E-06	6.130E-06		
501200	3135	5.873E-02	6.130E-07	3.430E-04		
501220	3135	4.222E-02	1.226E-07	1.617E-04		
501230	11	1.085E-01				
501240	3135	2.217E-01	3.065E-08	1.752E-01		
501250	11	5.443E-01				
501260	215	3.083E-02	1.359E-02			
511210	215	5.439E+00	4.775E-02			
511230	215	3.337E+00	9.485E-03			
511240	11	1.373E+00				
511250	215	6.914E-01	7.073E-02			
511260	11	1.871E+00				
521200	215	1.839E-01	3.127E-02			
521220	215	2.422E+00	8.622E-01			
521230	11	1.732E+02				
521240	215	8.361E-01	4.245E-03			
521250	11	8.996E-01				
521260	215	4.268E-01	4.300E-02			
521271	11	2.053E+00				
521280	215	1.151E-01	3.792E-03			
521291	11	2.900E-01				
521300	215	3.579E-02	2.654E-03			
521320	11	4.890E-04				
521340	11	9.197E-03				
531250	11	4.101E+02				
531260	11	1.481E+03				
531270	11	4.846E+00				
531290	215	3.225E+00	2.047E+00			
531300	11	6.665E+00				
531310	11	3.229E-01				
531350	11	2.119E-03				
541240	215	8.191E+01	1.700E+01			
541250	11	5.150E+02				
541260	215	1.177E+00	8.180E-02			
541280	512345	6.541E-01	4.904E-04	6.469E-07	8.466E-07	4.898E-02
541290	41234	8.447E+00	4.291E-03	4.676E-06	2.522E-06	
541300	512345	6.260E-01	6.743E-04	2.388E-07	2.024E-06	5.661E-02
541310	41234	3.046E+01	6.436E-03	1.639E-06	2.946E-06	
541320	512345	1.025E-01	1.011E-03	6.914E-08	4.546E-07	3.299E-03
541330	11	2.440E+01				
541340	512345	4.416E-02	1.410E-03	3.010E-08	5.221E-07	3.364E-04
541350	11	2.445E+05				
541360	41234	1.664E-02	1.747E-03	1.294E-08	2.343E-08	
551330	512345	1.072E+01	6.130E-03	1.103E-06	8.514E-05	1.082E+00
551340	215	1.675E+01	6.232E+00			
551341	215	1.196E-01	1.196E-01			

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551350	11	2.391E+00				
551360	11	1.336E+00				
551370	11	2.559E-02				
551410	11	1.518E-03				
561300	215	3.896E+00	8.856E-01			
561320	215	7.817E-01	6.256E-02			
561340	215	8.530E-01	5.748E-02			
561350	215	3.485E+00	7.030E-03			
561360	215	1.020E-01	1.608E-03			
561370	11	5.509E-01				
561380	11	3.560E-02				
561390	11	5.518E-01				
561400	11	5.285E-01				

571380	11	2.407E+01				
571390	11	1.043E+00				
571400	11	2.210E+00				
581360	215	2.006E+00	3.024E-01			
581380	215	1.012E-01	1.384E-03			
581400	11	6.309E-02				
581410	11	2.971E+00				
581420	11	1.061E-01				
581430	11	1.755E+00				
581440	11	1.491E-01				
591410	512345	1.506E+00	5.823E-04	3.773E-06	3.506E-06	4.088E-01
591420	11	5.590E+00				
591430	11	1.214E+01				

SEGMENT 6

601420	11	1.710E+00				
601430	41234	2.866E+01	8.888E-03	5.293E-05	2.651E-06	
601440	11	4.715E-01				
601450	41234	9.347E+00	1.165E-02	1.897E-05	8.002E-07	
601460	41234	2.391E-01	3.371E-03	2.401E-06	6.326E-08	
601470	11	2.006E+01				
601480	41234	8.674E-01	3.678E-04	7.255E-07	1.472E-08	
601500	41234	6.430E-01	3.678E-03	1.773E-07	9.598E-09	
611470	512345	6.192E+01	3.065E-03	6.188E-06	1.661E-06	3.212E+01
611480	11	1.170E+03				
611481	11	2.918E+03				
611490	11	1.324E+02				
611510	11	1.031E+02				
621440	11	6.438E-02				
621450	11	1.012E+01				
621470	41234	2.391E+01	7.049E-03	6.513E-05	4.509E-06	
621480	11	1.137E+00				
621490	41234	7.276E+03	4.597E-03	4.505E-05	4.505E-05	
621500	11	1.529E+01				
621510	41234	7.260E+02	1.563E-02	9.878E-06	8.855E-07	
621520	41234	7.563E+01	1.870E-03	5.569E-07	7.858E-08	
621530	11	8.977E+01				
621540	11	1.518E+00				
631510	512345	7.406E+02	1.165E-03	3.891E-05	1.983E-05	2.964E+02
631520	41234	1.914E+02	4.291E-03	5.077E-05	6.653E-05	
631530	212	7.177E+01	1.808E-03			
631540	41234	1.286E+02	2.881E-03	6.798E-05	1.008E-04	
631550	41234	3.655E+02	2.360E-03	4.021E-07	3.302E-07	
631560	11	7.378E+01				
631570	11	4.609E+01				

641520	213	1.628E+02	6.475E-04			
641540	215	1.348E+01	7.056E-03			
641550	213	2.757E+03	8.185E-06			
641560	11	3.770E+00				
641570	213	1.172E+04	5.058E-05			
641580	11	1.795E+00				
641600	11	3.705E-01				
641610	11	2.851E+03				
651590	214	1.485E+01	1.839E+00			
651600	11	6.862E+01				
661560	213	2.629E+01	8.196E-04			
661580	213	6.431E+00	5.538E-04			
661600	213	4.938E+01	2.749E-05			
661610	213	7.619E+01	2.743E-06			
661620	11	7.454E+01				
661630	213	4.820E+01	1.793E-06			
661640	512345	1.940E+02	2.360E-03	6.038E-05	7.650E-06	1.434E+02
661650	11	8.567E+02				
671650	41345	2.550E+01	1.839E-06	1.597E+00	1.188E+00	
681620	213	1.335E+01	1.014E-03			
681640	213	3.635E+00	1.100E-04			
681660	3135	6.743E+00	6.438E-06	2.268E+00		
681670	213	2.134E+02	6.162E-06			
681680	213	1.043E+00	8.250E-06			
681700	11	9.531E-01				
681710	11	2.575E+01				
691690	3135	4.718E+01	9.197E-07	3.465E+00		
691700	11	1.876E+01				
691710	11	3.267E+00				

SEGMENT 7

701680	213	1.043E+03	3.510E-04			
701700	213	8.189E+00	3.679E-06			
701710	213	1.221E+01	3.679E-06			
701720	213	7.202E-01	2.750E-06			
701730	11	1.113E+01				
701740	3135	1.774E+00	1.853E-06	4.296E+00		
701760	11	3.418E-01				
711750	3135	7.115E+00	5.595E-06	1.667E+01		
711760	3135	1.978E+02	1.835E-04	6.548E-01		
721740	11	4.299E+01				
721760	11	2.029E+01				
721770	215	2.075E+02	6.244E-01			
721780	215	2.108E+01	3.386E+01			
721790	215	1.826E+01	1.398E-01			
721800	11	2.077E+00				
721810	11	3.679E+00				
731800	11	7.139E+01				
731810	215	1.916E+01	9.392E-03			
731820	11	6.880E+02				
741800	11	5.203E+00				
741820	215	1.619E+01	4.569E-02			
741830	11	9.312E+00				
741840	215	4.895E-01	5.392E-04			

741860	11	1.536E+01				
741870	11	7.307E+01				
751850	11	5.162E+01				
751870	215	2.861E-01	1.308E+01			
751880	11	1.839E-01				
761840	213	2.759E+02	9.105E-04			
761860	13	9.197E-06				
761870	213	4.908E+01	9.271E-06			
761880	213	3.669E+00	2.768E-06			
761890	3135	2.029E+01	9.096E-07	2.234E-04		
761900	3135	5.295E-01	1.793E-06	1.236E+00		
761920	3135	2.937E-01	9.261E-07	2.117E-03		
761930	11	1.416E+02				
771910	215	1.669E+02	6.846E-02			
771920	11	1.012E+02				
771930	215	4.044E+01	2.132E+00			
781900	213	1.380E+01	7.312E-04			
781920	3135	2.676E+00	1.803E-05	4.987E-01		
781940	3135	1.808E-01	4.635E-07	1.466E-02		
781950	213	1.092E+01	4.718E-07			
781960	215	2.393E-01	1.735E-02			
781980	215	1.665E+00	1.224E-02			
791970	11	4.637E+01				

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791980	11	2.373E+03				
791990	11	2.759E+00				

SEGMENT 8

801960	215	2.593E+02	1.116E+01			
801980	215	1.858E+00	1.782E-02			
801990	11	1.656E+02				
802000	11	5.518E+00				
802010	11	5.518E+00				
802020	11	5.169E-01				
802040	11	3.955E-02				
812030	11	1.862E+00				
812040	11	3.863E+00				
812050	11	2.531E-02				
822040	11	9.529E-02				
822060	11	2.472E+00				
822070	11	6.720E-02				
822080	11	4.479E-05				
822100	11	4.598E-02				
832090	512458	4.228E-03	5.805E-04	1.747E-06	3.115E-03	1.747E-06
832100	11	4.966E-03				
842100	215	2.759E-03	4.600E-05			
862200	11	1.839E-02				
862220	11	6.622E-02				
882230	218	1.196E+01	6.438E-02			
882240	11	1.104E+00				
882260	218	6.392E+00	9.197E-06			
882280	218	3.311E+00	1.839E-01			
892270	218	4.736E+01	1.839E-04			

SEGMENT 9

902270	18	1.839E+01				
902280	218	3.487E+01	2.759E-02			
902290	218	2.897E+01	1.388E+01			
902300	3128	2.351E+01	4.968E-03	5.784E-02		
902320	41278	3.051E+00	5.089E-03	2.660E-05	2.217E-02	
902330	218	1.312E+02	1.380E+00			
902340	218	1.655E-01	9.197E-04			
912310	3128	6.737E+01	3.283E-03	3.681E-01		
912320	218	6.990E+01	6.438E+01			
912330	512785	1.234E+01	1.364E-03	6.743E-05	1.456E-01	1.234E+01
912340	18	4.598E+02				
912341	218	2.202E+01	4.598E+01			
922300	18	2.299E+00				
922310	18	3.679E+01				
922320	41278	1.128E+01	2.062E-03	9.195E-06	1.675E+01	
922330	41278	7.581E+00	2.863E-03	1.931E-06	6.231E+01	
922340	41278	1.923E+01	4.266E-04	1.349E-05	4.504E-01	
922350	41278	1.046E+01	2.696E-03	1.160E-06	4.671E+01	
922360	41278	7.541E+00	2.644E-03	2.207E-05	1.975E-01	
922370	218	4.424E+01	2.317E-01			
922380	41278	9.021E-01	5.525E-03	4.597E-05	1.004E-01	
922390	3128	3.723E+00	2.191E-02	1.538E+00		
922400	3128	5.447E-01	1.131E-02	7.290E-02		
932350	215	1.692E+01	1.472E+02			
932360	18	2.305E+02				
932370	512786	3.212E+01	2.746E-04	2.912E-06	5.244E-01	7.877E-04
932380	218	1.793E+01	1.778E+02			
932390	3185	1.134E+01	4.261E-01	2.851E+00		
942360	218	2.040E+01	2.063E+01			
942370	218	2.207E+02	2.207E+02			
942380	41278	3.467E+01	1.673E-04	9.195E-06	2.465E+00	
942390	41278	5.861E+01	1.120E-03	8.560E-07	1.062E+02	
942400	41278	1.040E+02	4.478E-04	1.073E-05	5.840E-01	
942410	41278	3.868E+01	7.518E-03	2.421E-05	1.181E+02	
942420	41278	3.172E+01	2.307E-03	2.268E-05	4.146E-01	
942430	3128	1.360E+01	1.661E-02	2.798E+01		
942440	11	1.195E+00				
942450	11	1.755E+01				
952410	512785	1.058E+02	3.280E-04	1.532E-06	1.123E+00	1.307E+01
952420	41278	2.064E+01	5.670E-03	5.823E-05	1.851E+02	
952421	41278	9.804E+01	5.670E-03	5.823E-05	4.662E+02	
952430	41285	2.487E+00	2.074E-04	3.959E-01	4.726E+01	
952440	18	2.115E+02				
952441	18	1.472E+02				
962420	3128	5.801E+00	5.295E-05	5.591E-01		
962430	41278	8.392E+00	3.685E-03	1.532E-05	7.170E+01	
962440	3128	1.382E+01	1.048E-03	8.746E-01		
962450	3128	2.909E+01	6.458E-03	1.710E+02		
962460	3128	2.905E+00	1.213E-03	5.756E-01		
962470	3128	1.650E+01	1.002E-02	2.546E+01		
962480	3128	6.318E+00	1.824E-03	7.558E-01		
962490	218	1.472E-01	4.598E+00			
962500	11	1.839E-01				
972490	41278	2.308E+02	6.379E-03	3.050E+01	2.863E-01	
972500	218	8.829E+01	2.759E+02			
982490	3128	4.963E+01	6.852E-03	1.528E+02		
982500	41278	4.576E+02	3.282E-03	2.854E+02	8.905E-01	
982510	3128	2.623E+02	1.172E-02	5.513E+02		
982520	3128	2.922E+00	2.657E-03	6.262E+00		
982530	218	3.925E+01	1.302E+02			
982540	11	9.204E+00				
992530	215	1.322E+02	9.185E+01			
992540	218	3.679E+00	2.885E+02			
992541	218	1.196E-01	1.692E+02			

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SEGMENT 0

10030	1.35E-02	1.10E-02	2.30E-02	1.75E-02	1.75E-02
30060	5.00E-05	5.00E-05	5.00E-05	5.00E-05	5.00E-05
30070	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06
40090	1.50E-06	1.50E-06	1.50E-06	1.50E-06	1.50E-06
40100	9.00E-06	9.00E-06	9.00E-06	9.00E-06	9.00E-06
60140	1.30E-06	1.30E-06	1.30E-06	1.30E-06	1.30E-06

SEGMENT 2

270720	2.26E-06	8.87E-07	6.04E-05	1.43E-07	1.79E-06
270730	2.04E-08	9.07E-08	2.06E-05	9.74E-10	5.24E-07
270740	5.54E-08	7.32E-08	3.83E-06	1.79E-09	5.79E-08
270750	7.39E-09	9.62E-09	5.06E-07	1.19E-10	8.07E-09
280720	1.87E-04	2.85E-05	9.22E-04	1.97E-05	5.11E-05
280730	1.60E-05	1.49E-05	9.17E-04	1.23E-06	4.43E-05
280740	4.07E-05	2.42E-05	5.08E-04	2.54E-06	1.50E-05
280750	1.65E-05	9.94E-06	2.07E-04	5.50E-07	6.66E-06
280760	2.56E-06	3.26E-06	5.02E-05	8.28E-08	2.09E-06
280770	1.78E-07	4.51E-07	9.19E-06	7.18E-09	2.36E-07
280780	1.24E-08	5.06E-08	1.07E-06	2.37E-10	3.24E-08
290660	2.25E-09	5.09E-10	4.40E-10	1.03E-10	1.06E-10
290720	5.12E-04	3.36E-05	5.50E-04	8.51E-05	5.43E-05
290730	3.34E-04	9.86E-05	1.43E-03	4.25E-05	1.24E-04
290740	8.08E-04	2.31E-04	2.13E-03	9.34E-05	1.15E-04
290750	9.30E-04	2.71E-04	2.41E-03	6.14E-05	1.47E-04
290760	4.46E-04	2.70E-04	1.70E-03	2.87E-05	1.39E-04
290770	9.89E-05	1.17E-04	8.80E-04	8.29E-06	5.04E-05
290780	2.37E-05	4.45E-05	3.08E-04	1.08E-06	2.35E-05
290790	2.44E-06	5.18E-06	1.30E-04	7.17E-08	3.64E-06
290800	1.60E-07	7.03E-07	1.30E-05	4.31E-09	4.06E-07
290810	5.18E-09	3.67E-08	1.04E-06	1.15E-10	1.99E-08

SEGMENT 3

300660	0.0	3.38E-11	0.0	0.0	0.0
300670	1.92E-10	2.36E-11	4.91E-12	4.69E-12	0.0
300720	2.44E-04	6.76E-06	5.43E-05	6.26E-05	9.70E-06
300730	1.07E-03	1.28E-04	3.93E-04	2.18E-04	6.02E-05
300740	2.44E-03	3.62E-04	1.54E-03	4.91E-04	1.46E-04
300750	7.16E-03	1.09E-03	4.53E-03	8.81E-04	4.90E-04
300760	9.56E-03	2.95E-03	8.33E-03	1.15E-03	1.24E-03
300770	6.18E-03	3.62E-03	1.10E-02	1.03E-03	1.30E-03
300780	4.79E-03	4.25E-03	1.04E-02	5.01E-04	1.88E-03
300790	1.74E-03	1.65E-03	1.33E-02	1.21E-04	1.00E-03
300800	3.72E-04	7.55E-04	4.22E-03	2.46E-05	3.57E-04
300810	3.93E-05	1.32E-04	1.20E-03	2.15E-06	6.01E-05
300820	3.55E-06	1.33E-05	1.75E-04	1.05E-07	7.62E-06
300830	1.48E-07	1.02E-06	1.76E-05	3.92E-09	5.25E-07
310710	3.87E-07	5.71E-09	5.50E-09	1.66E-08	1.11E-09
310720	3.98E-06	4.22E-08	1.51E-07	1.71E-06	5.34E-08
310730	1.37E-04	6.88E-06	3.53E-06	4.71E-05	1.00E-06
310740	2.99E-04	2.19E-05	3.98E-05	1.06E-04	7.13E-06
310750	2.22E-03	1.79E-04	3.34E-04	4.90E-04	6.57E-05
310760	7.67E-03	1.28E-03	1.66E-03	1.63E-03	4.42E-04
310770	1.52E-02	5.32E-03	5.51E-03	4.05E-03	1.24E-03
310780	2.91E-02	1.42E-02	1.38E-02	6.54E-03	5.03E-03
310790	3.37E-02	1.52E-02	4.38E-02	5.28E-03	8.12E-03
310800	2.15E-02	2.13E-02	3.99E-02	3.42E-03	8.30E-03
310810	7.06E-03	1.16E-02	3.64E-02	9.52E-04	4.47E-03
310820	2.09E-03	3.84E-03	1.69E-02	1.39E-04	1.83E-03
310830	3.13E-04	9.54E-04	5.41E-03	1.63E-05	4.30E-04
310840	2.05E-05	5.49E-05	1.00E-03	9.42E-07	5.62E-05
320720	7.27E-09	2.79E-11	4.28E-11	5.45E-09	3.07E-11
320730	1.21E-06	2.42E-08	1.60E-09	7.74E-07	9.40E-10
320731	1.21E-06	2.42E-08	1.60E-09	7.68E-07	9.40E-10
320740	4.98E-06	1.68E-07	1.20E-07	3.38E-06	4.27E-08
320750	5.25E-05	2.06E-06	1.58E-06	2.24E-05	6.10E-07
320751	5.25E-05	2.06E-06	1.58E-06	2.24E-05	6.10E-07
320760	1.05E-03	8.75E-05	4.83E-05	4.10E-04	2.46E-05
320770	3.14E-03	6.89E-04	2.18E-04	1.38E-03	1.01E-04
320771	2.47E-03	4.78E-04	2.18E-04	1.38E-03	1.01E-04
320780	2.98E-02	2.00E-03	2.68E-03	1.38E-02	2.34E-03
320790	9.97E-02	2.66E-02	2.40E-02	3.28E-02	1.09E-02
320800	1.70E-01	8.88E-02	6.18E-02	6.03E-02	2.89E-02
320810	1.55E-01	1.33E-01	1.61E-01	4.93E-02	4.43E-02
320820	1.38E-01	1.31E-01	2.13E-01	2.09E-02	5.24E-02
320830	6.87E-02	9.74E-02	1.95E-01	7.14E-03	3.85E-02
320840	1.66E-02	1.91E-02	1.16E-01	1.48E-03	1.64E-02
320850	1.81E-03	6.44E-03	2.47E-02	1.74E-04	2.74E-03
320860	1.44E-04	1.14E-03	5.28E-03	1.49E-05	4.07E-04
320870	7.94E-06	1.83E-04	6.62E-04	1.54E-06	2.91E-05
320880	4.22E-08	2.08E-06	4.88E-05	2.07E-08	1.11E-06
330750	1.32E-07	2.42E-09	7.31E-10	1.16E-07	5.68E-10
330760	4.20E-06	1.66E-07	3.62E-08	3.23E-06	3.71E-08
330770	9.95E-05	1.27E-05	9.82E-07	6.70E-05	9.82E-07
330780	1.15E-03	2.18E-04	1.83E-05	1.13E-03	3.64E-05
330790	1.19E-02	9.41E-03	7.11E-04	8.31E-03	5.57E-04
330800	5.36E-02	1.49E-02	3.79E-03	4.07E-02	4.12E-03
330810	1.26E-01	5.98E-02	3.03E-02	9.51E-02	1.74E-02
330820	1.55E-01	8.18E-02	5.31E-02	4.99E-02	2.75E-02
330821	1.55E-01	8.15E-02	5.34E-02	4.99E-02	2.77E-02
330830	4.52E-01	3.22E-01	2.52E-01	9.08E-02	1.13E-01
330840	3.57E-01	3.00E-01	4.31E-01	5.97E-02	1.40E-01
330850	1.39E-01	2.01E-01	2.87E-01	2.14E-02	7.13E-02
330860	3.80E-02	1.13E-01	1.79E-01	5.75E-03	3.50E-02
330870	7.38E-03	6.44E-02	6.95E-02	1.99E-03	8.58E-03
330880	1.93E-04	2.63E-03	1.72E-02	9.42E-05	1.20E-03
330890	8.40E-06	2.07E-04	2.21E-03	3.65E-06	9.95E-05
340760	1.73E-09	3.15E-11	2.63E-12	2.72E-09	5.52E-12
340770	4.56E-06	5.25E-09	9.15E-10	1.93E-07	2.50E-10
340771	6.68E-08	2.02E-09	1.30E-10	9.44E-08	2.50E-10
340780	5.28E-06	2.76E-07	1.37E-05	1.23E-05	7.02E-08
340790	9.58E-05	8.03E-06	4.29E-07	1.58E-04	1.77E-06
340791	9.58E-05	8.05E-06	4.29E-07	1.58E-04	1.77E-06
340800	2.62E-03	3.56E-04	2.93E-05	4.67E-03	8.09E-05
340810	8.98E-03	2.19E-03	4.25E-04	1.46E-02	5.41E-04
340811	1.30E-02	6.85E-03	3.59E-04	4.94E-03	5.39E-04
340820	1.19E-01	3.45E-02	8.62E-03	8.18E-02	9.93E-03
340830	2.05E-01	4.83E-02	2.88E-02	9.43E-02	2.89E-02
340831	2.71E-01	6.40E-02	2.87E-02	9.43E-02	2.88E-02
340840	1.17E+00	6.36E-01	2.75E-01	3.43E-01	1.90E-01
340850	7.11E-01	4.60E-01	2.69E-01	1.68E-01	1.38E-01
340851	7.11E-01	4.60E-01	2.69E-01	1.68E-01	1.38E-01
340860	1.19E+00	1.19E+00	8.78E-01	2.55E-01	3.95E-01
340870	7.45E-01	9.34E-01	9.40E-01	2.75E-01	2.98E-01
340880	1.09E-01	3.55E-01	7.04E-01	4.32E-02	1.39E-01
340890	1.58E-02	9.27E-02	2.93E-01	5.55E-03	3.79E-02
340900	7.04E-03	3.22E-02	8.35E-02	5.62E-04	7.04E-03
340910	1.97E-04	3.22E-03	2.00E-02	3.68E-05	7.76E-04
340920	6.88E-06	4.77E-05	1.63E-03	1.69E-06	6.40E-05
350790	3.86E-08	1.34E-09	2.25E-11	1.58E-07	2.65E-10
350791	3.53E-08	1.41E-09	2.13E-11	1.44E-07	2.49E-10
350800	9.44E-06	3.79E-07	2.61E-09	1.77E-06	1.91E-08
350801	3.09E-06	2.86E-07	2.73E-09	4.10E-06	1.99E-08
350810	7.40E-05	8.83E-06	5.42E-07	3.01E-04	1.83E-06
350820	7.73E-04	5.92E-05	9.85E-06	2.88E-03	2.73E-05
350821	6.35E-04	7.30E-05	9.85E-06	6.90E-04	2.73E-05
350830	2.05E-02	3.71E-03	4.10E-04	1.65E-02	1.02E-03
350840	7.70E-02	1.80E-02	3.15E-03	3.94E-02	5.31E-03
350841	7.70E-02	1.90E-02	3.15E-03	4.05E-02	5.32E-03
350850	5.78E-01	1.69E-01	3.94E-02	1.99E-01	4.31E-02
350860	6.80E-01	2.92E-01	8.75E-02	2.00E-01	8.83E-02

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350861	6.80E-01	3.02E-01	8.76E-02	2.00E-01	8.83E-02
350870	1.54E+00	1.19E+00	4.99E-01	4.75E-01	3.72E-01
350880	2.38E+00	2.14E+00	1.03E+00	5.54E-01	5.12E-01
350890	1.14E+00	1.80E+00	1.24E+00	2.16E-01	4.11E-01
350900	6.64E-01	1.24E+00	9.56E-01	7.36E-02	2.29E-01
350910	6.02E-02	3.91E-01	6.18E-01	1.58E-02	7.94E-02
350920	7.22E-03	1.89E-02	1.63E-01	2.28E-03	2.13E-02
350930	4.27E-04	4.71E-03	2.51E-02	1.77E-04	3.26E-03
350940	1.74E-05	3.27E-04	2.47E-03	1.10E-05	2.58E-04
350950	8.06E-08	7.33E-06	3.01E-04	2.85E-07	1.41E-05
350960	8.81E-09	3.34E-07	1.66E-05	9.38E-09	4.26E-07
360800	8.01E-10	7.08E-09	0.0	2.77E-09	1.89E-12
360810	1.50E-08	8.54E-10	1.79E-11	1.64E-07	1.49E-10
360811	1.57E-08	8.92E-10	1.86E-11	1.73E-07	1.54E-10
360820	1.83E-06	1.02E-07	4.59E-09	5.01E-06	3.14E-08
360830	5.12E-05	3.65E-06	1.40E-07	9.47E-05	1.01E-06
360831	5.12E-05	3.99E-06	1.40E-07	1.10E-04	1.00E-06
360840	2.79E-03	3.11E-04	1.65E-05	3.28E-03	2.09E-03
360850	2.14E-02	2.28E-03	8.55E-03	7.01E-03	5.76E-04
360851	1.85E-02	1.37E-02	1.86E-04	1.03E-02	4.77E-04
360860	2.66E-01	4.87E-02	5.04E-03	1.09E-01	1.25E-02
360870	1.66E+00	3.42E-01	6.25E-02	1.70E-01	8.07E-02
360880	2.79E+00	1.09E+00	4.63E-01	7.25E-01	3.25E-01
360890	4.20E+00	2.74E+00	1.29E+00	1.20E+00	7.20E-01
360900	3.88E+00	3.45E+00	2.01E+00	1.22E+00	1.09E+00
360910	2.16E+00	3.02E+00	2.38E+00	7.73E-01	1.05E+00
360920	8.17E-01	1.47E+00	2.22E+00	3.29E-01	8.23E-01
360930	1.64E-01	5.00E-01	1.14E+00	7.95E-02	4.00E-01
360940	2.48E-02	2.27E-01	3.04E-01	1.59E-02	1.01E-01
360950	3.21E-04	1.02E-02	1.36E-01	1.21E-03	1.65E-02
360960	1.36E-04	1.67E-03	2.18E-02	1.37E-04	1.86E-03
360970	4.26E-06	4.06E-05	1.56E-03	6.50E-06	1.25E-04
360980	7.15E-08	4.24E-06	1.96E-04	1.81E-07	5.35E-06
370850	6.49E-05	7.22E-05	2.47E-04	2.60E-03	5.28E-07
370860	2.04E-04	2.40E-05	1.87E-06	1.58E-04	1.23E-05
370861	5.87E-03	5.52E-05	1.87E-06	4.71E-04	1.23E-05
370870	2.37E-02	2.68E-03	9.92E-05	4.77E-02	5.39E-04
370880	1.80E-01	3.20E-02	2.18E-03	4.73E-02	7.36E-03
370890	8.34E-01	1.70E-01	4.80E-02	2.88E-01	4.94E-02
370900	1.02E+00	6.76E-01	8.63E-02	3.70E-01	1.04E-01
370901	1.02E+00	4.28E-01	7.65E-02	3.78E-01	1.04E-01
370910	3.38E+00	2.23E+00	7.16E-01	1.31E+00	6.45E-01
370920	3.47E+00	3.26E+00	1.21E+00	1.49E+00	1.14E+00
370930	2.08E+00	3.03E+00	2.38E+00	1.14E+00	1.56E+00
370940	9.11E-01	1.55E+00	1.95E+00	5.87E-01	1.12E+00
370950	1.19E-01	8.96E-01	1.55E+00	1.75E-01	5.70E-01

370960	4.83E-02	2.00E-01	7.39E-01	4.64E-02	1.96E-01
370970	5.21E-03	3.64E-02	1.60E-01	6.87E-03	4.29E-02
370980	3.06E-04	5.26E-03	5.86E-02	6.08E-04	5.93E-03
370990	1.72E-05	4.06E-04	6.51E-03	3.29E-05	6.13E-04
371000	3.86E-07	1.70E-05	6.87E-04	1.09E-06	3.41E-05
380860	3.54E-05	2.59E-08	2.70E-10	9.17E-07	4.84E-09
380870	2.67E-05	2.55E-06	9.18E-07	1.49E-05	1.92E-07
380871	2.73E-05	9.81E-07	7.76E-09	1.53E-05	1.75E-07
380880	1.49E-03	9.94E-05	1.88E-06	5.74E-04	1.92E-05
380890	1.99E-02	2.58E-03	1.46E-03	8.99E-03	4.33E-04
380900	1.66E-01	2.82E-02	1.90E-02	7.98E-02	5.75E-03
380910	8.72E-01	2.29E-01	1.61E-02	3.81E-01	5.17E-02
380920	2.22E+00	1.18E+00	4.53E-01	1.16E+00	2.73E-01
380930	4.47E+00	2.70E+00	1.05E+00	2.47E+00	9.56E-01
380940	4.79E+00	4.25E+00	1.95E+00	3.12E+00	2.02E+00
380950	3.48E+00	4.57E+00	3.35E+00	2.91E+00	2.84E+00
380960	1.99E+00	3.58E+00	3.63E+00	1.82E+00	2.66E+00
380970	6.80E-01	1.90E+00	3.17E+00	7.83E-01	1.71E+00
380980	1.32E-01	6.98E-01	2.07E+00	2.09E-01	7.07E-01
380990	1.92E-02	1.54E-01	8.90E-01	3.26E-02	1.99E-01
381000	1.75E-03	2.38E-02	2.20E-01	4.06E-03	3.69E-02
381010	9.80E-05	2.96E-03	3.57E-02	2.62E-04	4.51E-03
381020	2.49E-06	1.97E-04	3.66E-03	1.77E-05	4.11E-04
381030	2.14E-06	4.80E-06	1.24E-04	4.59E-07	1.88E-05
381040	2.73E-08	8.23E-08	5.35E-06	7.04E-09	1.01E-06
390890	8.76E-06	3.60E-07	3.01E-09	5.38E-06	4.54E-08
390891	6.56E-06	2.84E-07	3.01E-09	3.85E-06	4.54E-08
390900	2.34E-04	2.30E-04	1.69E-07	1.18E-04	2.04E-06
390901	1.49E-04	1.24E-05	1.54E-07	1.04E-04	2.10E-06
390910	3.20E-03	6.24E-04	1.50E-05	5.13E-03	6.21E-05
390911	2.71E-03	2.72E-04	6.56E-06	3.82E-03	1.93E-04
390920	4.74E-02	9.81E-03	3.99E-03	3.24E-02	2.06E-03
390930	2.79E-01	9.81E-02	9.93E-03	1.93E-01	2.51E-02
390940	1.02E+00	3.52E-01	5.33E-02	6.68E-01	1.42E-01
390950	2.43E+00	9.48E-01	2.29E-01	1.67E+00	5.73E-01
390960	2.91E+00	2.24E+00	7.25E-01	2.57E+00	1.41E+00
390970	2.80E+00	3.12E+00	1.92E+00	2.86E+00	2.43E+00
390980	1.60E+00	2.92E+00	2.66E+00	2.06E+00	2.68E+00
390990	6.84E-01	1.86E+00	3.12E+00	9.80E-01	2.11E+00
391000	1.91E-01	8.57E-01	2.08E+00	3.68E-01	1.04E+00
391010	3.18E-02	2.69E-01	1.01E+00	7.25E-02	3.66E-01
391020	2.78E-03	5.37E-02	3.27E-01	1.37E-02	9.86E-02
391030	2.52E-03	5.34E-03	5.83E-02	1.48E-03	1.67E-02
391040	9.71E-05	2.54E-04	5.79E-03	6.14E-05	2.12E-03
391050	4.12E-06	2.25E-05	2.58E-04	1.98E-06	1.09E-04
391070	1.17E-09	3.74E-08	1.00E-07	1.31E-10	3.39E-08

SEGMENT 4

400900	3.68E-08	8.19E-03	3.96E-12	3.64E-08	1.41E-10
400901	3.68E-08	1.00E-09	3.96E-12	3.63E-08	1.42E-10
400910	3.83E-06	9.70E-07	1.65E-09	1.23E-03	1.67E-05
400920	1.20E-04	7.98E-06	2.30E-05	1.07E-04	1.65E-06
400930	2.57E-03	2.33E-04	5.04E-06	1.99E-03	5.62E-05
400940	3.18E-02	3.38E-03	2.89E-04	2.13E-02	1.28E-03
400950	2.25E-01	2.95E-02	2.07E-03	1.47E-01	1.67E-02
400960	7.36E-01	2.12E-01	2.10E-02	6.26E-01	1.21E-01
400970	1.84E+00	8.74E-01	1.41E-01	1.81E+00	5.96E-01
400980	3.04E+00	2.10E+00	5.95E-01	3.26E+00	1.76E+00
400990	3.51E+00	3.77E+00	1.91E+00	4.31E+00	3.61E+00
401000	2.67E+00	4.45E+00	3.30E+00	4.36E+00	4.36E+00
401010	1.21E+00	3.20E+00	4.29E+00	2.37E+00	3.92E+00
401020	3.33E-01	1.73E+00	3.88E+00	1.17E+00	2.83E+00
401030	2.70E-01	5.26E-01	2.07E+00	3.78E-01	1.30E+00
401040	3.51E-02	8.01E-02	6.79E-01	5.29E-02	4.64E-01
401050	3.45E-03	1.03E-02	9.60E-02	5.23E-03	6.99E-02
401060	3.22E-04	2.48E-03	7.46E-03	2.56E-04	7.88E-03
401070	1.09E-05	1.19E-04	3.84E-04	4.68E-06	3.35E-04
401080	3.52E-07	2.64E-06	3.89E-04	1.89E-07	2.41E-06
401090	7.11E-09	1.33E-08	2.94E-05	4.31E-08	2.16E-08
410930	2.72E-07	8.82E-09	1.33E-09	2.51E-07	1.79E-09
410931	2.72E-07	9.37E-09	3.63E-11	2.51E-07	1.80E-09

410940	1.28E-05	4.35E-07	3.41E-09	8.76E-06	1.40E-07
410941	1.27E-05	4.38E-07	3.36E-09	8.73E-06	1.40E-07
410950	2.73E-04	1.72E-05	4.95E-07	6.83E-04	6.44E-06
410951	9.59E-04	1.29E-04	2.30E-07	6.83E-04	6.38E-06
410960	6.81E-03	5.90E-04	6.28E-05	4.05E-03	1.28E-02
410970	5.59E-02	1.68E-02	5.90E-03	7.49E-02	2.31E-03
410971	2.40E-02	6.86E-03	1.83E-04	2.01E-02	2.31E-03
410980	2.14E-01	4.48E-02	1.83E-03	1.85E-01	2.04E-02
410981	1.19E-01	2.72E-02	2.10E-03	1.04E-01	2.04E-02
410990	4.32E-01	1.37E-01	2.09E-02	3.84E-01	1.21E-01
410991	2.79E-01	1.49E-01	2.09E-02	3.84E-01	1.21E-01
411000	7.30E-01	4.69E-01	1.04E-01	1.02E+00	3.69E-01
411001	7.30E-01	4.69E-01	1.04E-01	1.02E+00	3.69E-01
411010	1.64E+00	1.50E+00	7.63E-01	2.87E+00	1.67E+00
411020	1.27E+00	2.04E+00	1.84E+00	3.28E+00	2.99E+00
411030	9.28E-01	1.68E+00	2.66E+00	2.84E+00	3.37E+00
411040	3.62E-01	7.32E-01	2.55E+00	1.21E+00	3.03E+00
411050	9.05E-02	2.03E-01	1.17E+00	3.73E-01	1.38E+00
411060	2.21E-02	7.00E-02	3.07E-01	6.04E-02	4.93E-01
411070	2.85E-03	1.14E-02	4.90E-02	4.62E-03	9.28E-02
411080	2.34E-04	8.49E-04	4.25E-02	4.69E-04	3.21E-03
411090	1.80E-05	2.47E-05	9.27E-03	1.55E-04	1.13E-04
411100	2.78E-07	1.06E-06	1.16E-03	1.49E-06	3.81E-06

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411110	4.40E-09	1.41E-08	9.98E-05	1.67E-08	8.27E-08
420950	1.46E-07	2.87E-09	1.17E-11	1.09E-07	1.07E-09
420960	5.08E-06	1.68E-07	1.14E-09	3.98E-06	7.12E-08
420970	1.38E-04	2.45E-05	6.91E-04	2.01E-04	3.83E-06
420980	2.36E-03	1.64E-04	3.21E-06	1.65E-03	1.09E-04
420990	2.25E-02	2.87E-03	1.07E-04	1.95E-02	2.05E-03
421000	1.29E-01	2.88E-02	1.70E-03	1.52E-01	1.77E-02
421010	3.84E-01	1.12E-01	1.99E-02	6.71E-01	1.12E-01
421020	8.38E-01	4.14E-01	1.41E-01	1.60E+00	5.37E-01
421030	5.53E-01	9.23E-01	5.95E-01	3.56E+00	1.55E+00
421040	6.09E-01	1.02E+00	1.67E+00	4.16E+00	3.34E+00
421050	3.53E-01	7.21E-01	2.40E+00	3.55E+00	4.17E+00
421060	2.04E-01	2.94E-01	1.81E+00	1.71E+00	4.19E+00
421070	7.01E-02	1.24E-01	8.49E-01	4.06E-01	2.46E+00
421080	1.73E-02	3.27E-02	5.97E-01	1.20E-01	4.54E-01
421090	3.93E-03	4.05E-03	2.99E-01	4.80E-02	4.93E-02
421100	2.68E-04	5.80E-04	1.08E-01	2.19E-03	5.07E-03
421110	1.36E-05	3.42E-05	2.56E-02	8.58E-05	3.07E-04
421120	4.53E-07	3.48E-06	4.81E-03	4.13E-06	2.48E-05
421130	4.27E-08	2.22E-07	3.43E-04	1.21E-07	1.71E-06
421140	2.94E-10	1.23E-08	3.53E-05	1.84E-09	6.39E-08
421150	4.01E-12	2.71E-10	2.37E-06	3.86E-11	1.53E-09
430990	8.61E-06	4.16E-05	3.24E-09	6.23E-06	2.04E-07
430991	8.61E-06	3.34E-07	3.24E-09	6.23E-06	2.04E-07
431000	3.23E-04	2.29E-05	3.45E-07	3.16E-04	1.07E-05
431010	2.82E-03	2.34E-04	1.43E-05	3.74E-03	2.07E-04
431020	9.80E-03	1.29E-03	1.35E-04	1.34E-02	1.28E-03
431021	9.80E-03	1.29E-03	1.54E-04	1.34E-02	1.47E-03
431030	1.16E-02	1.80E-02	4.18E-03	1.70E-01	2.36E-02
431040	3.98E-02	5.75E-02	3.91E-02	5.85E-01	1.38E-01
431050	5.55E-02	9.69E-02	1.85E-01	1.36E+00	5.22E-01
431060	7.52E-02	4.98E-02	4.40E-01	1.78E+00	1.43E+00
431070	6.42E-02	5.38E-02	5.62E-01	1.17E+00	2.42E+00
431080	4.29E-02	4.64E-02	3.27E-01	9.09E-01	2.01E+00
431090	2.72E-02	2.10E-02	3.79E-01	4.97E-01	6.82E-01
431100	6.83E-03	8.78E-03	3.27E-01	8.25E-02	1.75E-01
431110	1.23E-03	2.49E-03	2.30E-01	1.27E-02	3.33E-02
431120	1.70E-04	5.20E-04	1.07E-01	1.26E-03	5.13E-03
431130	3.23E-05	1.13E-04	3.10E-02	1.30E-04	9.42E-04
431140	1.22E-06	1.53E-05	7.34E-03	5.94E-06	8.23E-05
431150	5.45E-08	1.23E-06	1.58E-03	3.92E-07	6.07E-06
431160	1.33E-06	6.94E-08	9.83E-05	1.64E-08	2.64E-07
431170	1.37E-10	1.09E-08	4.15E-06	3.79E-10	8.51E-09
440990	1.31E-09	1.13E-10	0.0	7.85E-10	7.86E-12
441000	8.18E-08	1.78E-09	6.77E-12	6.58E-08	6.36E-10
441010	2.21E-06	4.91E-08	1.13E-09	2.55E-06	3.84E-08
441020	5.29E-05	1.71E-06	6.86E-08	5.07E-05	1.69E-06
441030	2.78E-05	4.00E-05	3.17E-06	9.97E-04	3.99E-05
441040	3.30E-04	4.28E-04	1.06E-04	1.11E-02	6.91E-04
441050	1.23E-03	2.34E-03	2.24E-03	8.06E-02	8.51E-03
441060	4.30E-03	1.20E-03	1.58E-02	7.60E-01	7.48E-02
441070	9.92E-03	3.71E-03	6.13E-02	1.61E+00	4.02E-01
441080	1.84E-02	1.15E-02	2.90E-02	1.15E+00	1.53E+00
441090	3.19E-02	1.89E-02	8.24E-02	8.39E-01	1.50E+00
441100	2.58E-02	2.12E-02	1.73E-01	4.42E-01	8.70E-01
441110	1.64E-02	1.80E-02	2.97E-01	1.73E-01	3.75E-01
441120	7.42E-03	9.88E-03	3.60E-01	4.50E-02	1.28E-01
441130	2.24E-03	5.50E-03	3.13E-01	1.29E-02	4.87E-02
441140	5.11E-04	2.04E-03	1.85E-01	1.97E-03	1.13E-02
441150	6.02E-05	4.72E-04	9.83E-02	3.29E-04	2.03E-03
441160	5.42E-04	8.26E-05	2.27E-02	4.34E-05	2.75E-04
441170	1.02E-06	4.75E-05	3.27E-03	3.30E-06	2.63E-05
441180	5.65E-08	8.43E-07	2.33E-02	2.50E-07	3.64E-06
441200	1.83E-10	2.39E-09	4.83E-06	3.17E-10	2.58E-08
451030	7.35E-10	3.70E-07	3.66E-11	6.90E-08	5.60E-05
451031	7.35E-10	1.05E-09	2.66E-11	6.90E-08	2.52E-09
451040	3.38E-08	3.68E-08	3.20E-09	2.74E-06	3.86E-08
451041	3.30E-08	3.81E-08	3.34E-09	2.70E-06	4.06E-08
451050	3.45E-07	5.20E-03	4.41E-06	6.55E-05	1.75E-06
451051	3.45E-07	7.30E-07	2.52E-07	6.55E-05	1.75E-06
451060	3.15E-06	3.96E-07	1.39E-05	9.84E-04	5.25E-05
451061	2.51E-05	3.78E-07	8.06E-06	5.67E-04	5.25E-05
451070	4.60E-05	7.24E-06	1.93E-04	2.51E-02	2.02E-03
451080	1.35E-04	4.58E-05	3.65E-05	2.75E-02	2.10E-02
451081	1.35E-04	4.58E-05	3.64E-05	2.75E-02	2.10E-02
451090	6.93E-04	3.17E-04	2.80E-04	2.76E-02	6.48E-02
451091	6.93E-04	3.17E-04	2.80E-04	2.76E-02	6.48E-02
451100	1.99E-03	1.00E-03	1.59E-03	4.86E-02	8.79E-02
451101	1.99E-03	1.00E-03	1.59E-03	4.87E-02	8.78E-02
451110	8.59E-03	5.56E-03	1.48E-02	9.18E-02	1.90E-01
451120	1.11E-02	7.53E-03	4.98E-02	5.78E-02	1.20E-01
451130	9.80E-03	9.75E-03	1.37E-01	4.37E-02	9.89E-02
451140	6.04E-03	8.64E-03	1.73E-01	1.90E-02	4.88E-02
451150	2.44E-03	5.22E-03	2.56E-01	7.94E-03	2.21E-02
451160	6.22E-03	2.58E-03	1.57E-01	2.85E-03	7.59E-03
451170	2.14E-04	6.01E-03	8.26E-02	8.10E-04	2.40E-03
451180	4.25E-05	2.11E-04	1.56E-01	1.44E-04	7.33E-04
451190	6.45E-06	4.17E-05	9.44E-03	8.74E-04	1.89E-04
451200	8.84E-07	5.10E-06	2.14E-03	1.58E-06	3.22E-05
451210	8.64E-08	4.87E-07	3.42E-04	9.90E-08	4.31E-06
451220	8.03E-09	4.82E-08	4.16E-05	6.28E-09	4.37E-07
451230	4.91E-10	4.62E-09	3.57E-06	5.28E-10	2.09E-08
461040	1.24E-12	1.31E-12	0.0	2.53E-10	0.0
461050	3.73E-11	4.49E-07	2.76E-04	2.13E-08	1.67E-06
461060	9.76E-10	1.29E-08	5.29E-07	1.10E-06	1.48E-08
461070	1.11E-08	7.25E-10	3.41E-08	3.08E-05	5.30E-07
461071	1.02E-08	7.64E-10	2.88E-08	1.77E-05	4.80E-07
461080	4.37E-07	8.01E-08	1.85E-08	3.26E-04	1.35E-04
461090	3.94E-06	1.30E-06	2.02E-07	2.31E-04	7.37E-04
461091	3.70E-06	1.30E-06	2.02E-07	2.31E-04	7.37E-04
461100	8.58E-05	2.55E-05	6.61E-06	3.11E-03	5.13E-03
461110	3.62E-04	1.26E-04	4.62E-05	3.94E-03	6.02E-03
461111	4.59E-04	1.25E-04	4.64E-05	3.93E-03	5.90E-03
461120	3.11E-03	8.99E-04	1.04E-03	1.38E-02	1.89E-02
461130	7.28E-03	3.02E-03	6.63E-03	2.71E-02	3.46E-02
461140	1.14E-02	6.39E-03	2.76E-02	2.98E-02	3.60E-02
461150	1.20E-02	9.43E-03	1.19E-01	2.94E-02	4.10E-02
461160	1.15E-02	1.19E-02	1.81E-01	2.52E-02	3.06E-02
461170	6.87E-03	9.72E-03	2.62E-01	1.85E-02	2.31E-02
461180	3.51E-03	6.38E-03	1.76E-01	9.22E-03	1.79E-02
461190	1.30E-03	3.39E-03	1.88E-01	1.92E-02	1.05E-02
461200	4.29E-04	1.14E-03	1.09E-01	7.93E-04	4.30E-03
461210	1.03E-04	2.92E-04	4.51E-02	1.40E-04	1.38E-03
461220	2.51E-05	6.88E-05	1.42E-02	2.37E-05	3.40E-04
461230	4.22E-06	1.54E-05	3.26E-03	4.58E-06	4.95E-05
461240	5.32E-07	3.03E-06	5.92E-04	8.58E-07	2.14E-05
461260	1.66E-09	3.78E-08	8.15E-06	1.11E-08	8.23E-07
471070	0.0	0.0	0.0	2.20E-09	6.13E-12
471080	7.70E-12	5.60E-12	0.0	2.16E-08	4.65E-09
471081	7.68E-12	5.60E-12	0.0	2.15E-08	4.64E-09
471090	5.30E-09	1.35E-10	2.86E-12	4.64E-08	1.46E-06
471091	1.34E-08	1.33E-10	2.86E-12	4.64E-08	2.95E-07
471100	2.16E-08	3.70E-09	1.48E-10	1.19E-06	1.74E-06
471101	2.33E-08	4.00E-09	1.57E-10	1.30E-06	1.93E-06
471110	1.22E-06	1.58E-07	7.61E-09	9.54E-06	1.23E-05
471111	1.07E-06	1.62E-07	7.04E-09	9.53E-06	1.18E-05
471120	6.27E-06	1.70E-04	3.84E-05	9.04E-05	8.98E-05
471130	9.81E-05	1.52E-05	5.57E-06	2.65E-04	2.01E-04
471131	9.81E-05	1.52E-05	5.16E-06	2.63E-04	1.99E-04
471140	8.55E-04	1.67E-04	1.32E-04	1.84E-03	9.68E-04
471150	1.39E-03	4.67E-04	8.87E-04	2.12E-03	1.33E-03
471151	1.39E-03	3.54E-04	8.36E-04	2.10E-03	1.33E-03
471160	4.18E-04	1.11E-03	3.97E-03	4.48E-03	2.55E-03
471161	4.18E-04	1.11E-03	3.97E-03	4.48E-03	2.55E-03
471170	4.03E-03	3.33E-04	1.58E-02	7.96E-03	4.45E-03
471171	4.03E-03	3.33E-04	1.57E-02	7.96E-03	4.45E-03
471180	4.81E-03	6.57E-03	3.72E-03	1.01E-02	8.14E-03
471181	4.81E-03	3.58E-03	3.72E-03	1.01E-02	8.14E-03
471190	7.89E-03	9.26E-03	1.44E-01	1.58E-02	1.99E-02
471200	5.81E-03	7.65E-03	1.92E-01	1.10E-02	1.81E-02
471210	3.18E-03	4.80E-03	1.88E-01	5.06E-03	1.27E-02
471220	1.94E-03	2.56E-03	1.40E-01	2.18E-03	7.08E-03
471230	8.52E-04	1.28E-03	8.00E-02	9.36E-04	2.93E-03
471240	2.87E-04	5.85E-04	3.67E-02	3.76E-04	2.01E-03

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471250	5.65E-05	1.39E-04	1.12E-02	1.40E-04	9.59E-04
471260	9.11E-06	5.32E-05	3.30E-03	3.19E-05	4.28E-04
471280	5.03E-08	1.38E-06	1.25E-04	5.01E-07	3.32E-05
481090	0.0	0.0	0.0	1.87E-12	1.25E-11
481100	2.45E-12	1.13E-12	0.0	2.10E-10	2.84E-10
481110	2.01E-10	2.07E-11	0.0	2.38E-09	2.29E-09
481111	1.89E-10	1.93E-11	0.0	2.21E-09	2.13E-09
481120	2.17E-08	1.25E-04	1.91E-11	6.48E-08	4.43E-08
481130	3.08E-07	1.67E-08	8.08E-10	1.51E-06	2.52E-07
481131	3.08E-07	6.46E-05	8.08E-10	6.19E-07	2.52E-07
481140	8.22E-06	5.16E-07	6.59E-08	1.44E-05	3.01E-06
481150	9.38E-05	8.06E-05	1.41E-06	7.26E-05	1.89E-05
481151	3.86E-05	3.64E-06	1.40E-06	4.29E-05	1.16E-05
481160	7.81E-06	5.97E-05	4.22E-05	4.92E-04	1.19E-04
481170	8.08E-04	2.94E-06	3.89E-04	1.15E-03	2.68E-04
481171	8.08E-04	2.94E-06	2.66E-04	1.15E-03	2.68E-04
481180	4.57E-03	1.38E-03	3.83E-05	7.61E-03	2.50E-03
481190	4.06E-03	2.23E-03	9.16E-03	1.11E-03	3.34E-03
481191	4.06E-03	2.23E-03	9.16E-03	1.11E-03	3.34E-03
481200	1.25E-02	8.71E-03	5.89E-02	2.41E-02	1.30E-02
481210	1.44E-02	1.21E-02	1.35E-01	2.89E-02	1.91E-02
481220	1.98E-02	1.39E-02	2.24E-01	2.61E-02	2.24E-02
481230	2.09E-02	1.39E-02	2.96E-01	2.32E-02	2.36E-02
481240	1.74E-02	1.41E-02	3.17E-01	1.88E-02	2.45E-02
481250	1.07E-02	7.78E-03	2.32E-01	1.62E-02	2.46E-02
481260	4.98E-03	8.16E-03	1.72E-01	9.41E-03	2.51E-02
481270	1.84E-03	4.10E-03	8.20E-02	4.86E-03	2.97E-02
481280	2.73E-04	1.82E-03	3.15E-02	1.19E-03	1.27E-02
481290	2.42E-05	3.06E-04	1.81E-02	2.62E-04	3.82E-03
481300	6.24E-05	8.10E-04	1.63E-02	2.52E-04	1.21E-03
481310	2.51E-06	7.70E-05	3.05E-03	1.53E-05	1.42E-04
481320	4.83E-08	6.14E-06	2.94E-04	3.66E-07	7.51E-06
491130	2.23E-11	3.90E-13	0.0	3.34E-11	7.18E-12
491131	2.13E-11	3.53E-12	0.0	3.17E-11	6.87E-12
491140	9.23E-10	1.80E-11	0.0	1.32E-09	1.05E-10
491141	8.94E-10	1.76E-11	0.0	1.28E-09	1.03E-10
491150	3.02E-08	7.03E-10	5.03E-11	5.36E-08	2.45E-09
491151	2.99E-08	7.03E-10	1.62E-03	2.21E-08	2.45E-09
491160	8.81E-10	2.09E-08	2.65E-09	3.67E-07	3.51E-08
491161	8.81E-10	2.09E-08	2.65E-09	3.67E-07	3.51E-08
491170	4.99E-06	6.33E-10	1.12E-07	4.96E-06	4.40E-07
491171	4.99E-06	6.33E-10	1.12E-07	4.96E-06	4.40E-07
491180	3.73E-05	4.15E-06	2.32E-09	4.87E-05	5.76E-06
491181	3.73E-05	4.15E-06	2.15E-09	4.87E-05	5.76E-06
491190	1.55E-04	3.71E-05	3.42E-05	4.58E-06	3.64E-05
491191	1.55E-04	3.71E-05	3.42E-05	4.58E-06	3.64E-05
491200	5.30E-04	1.85E-04	2.94E-04	1.06E-03	1.70E-04
491201	5.30E-04	1.85E-04	2.94E-04	1.06E-03	1.70E-04
491210	1.32E-03	6.28E-04	1.74E-03	2.91E-03	5.64E-04
491211	1.32E-03	9.58E-04	1.74E-03	2.76E-03	5.64E-04
491220	4.03E-03	1.55E-03	7.06E-03	6.20E-03	1.44E-03
491221	4.04E-03	1.55E-03	7.06E-03	6.23E-03	1.44E-03
491230	9.56E-03	3.21E-03	2.24E-02	1.07E-02	3.84E-03
491231	9.56E-03	3.13E-03	2.24E-02	1.07E-02	3.84E-03
491240	3.60E-02	1.35E-02	1.10E-01	3.24E-02	1.17E-02
491250	3.09E-02	7.96E-03	9.48E-02	2.99E-02	1.18E-02
491251	3.09E-02	7.96E-03	9.69E-02	3.00E-02	1.18E-02
491260	7.51E-02	3.99E-02	3.30E-01	8.07E-02	5.06E-02
491270	4.10E-02	2.49E-02	2.05E-01	5.24E-02	6.53E-02
491271	4.10E-02	2.50E-02	2.05E-01	5.24E-02	6.53E-02
491280	3.55E-02	6.20E-02	3.44E-01	7.10E-02	1.37E-01
491290	1.19E-02	3.94E-02	3.94E-01	4.84E-02	1.40E-01
491300	2.15E-02	7.34E-02	3.62E-01	4.97E-02	1.01E-01
491310	3.06E-03	2.44E-02	1.83E-01	1.05E-02	3.95E-02
491320	3.16E-04	6.62E-03	5.79E-02	9.64E-04	7.15E-03
491330	5.47E-06	3.95E-04	8.93E-03	3.42E-05	5.88E-04
491340	1.06E-07	6.96E-06	6.09E-04	7.21E-07	1.79E-05

SEGMENT 5

501150	8.99E-10	0.0	0.0	5.51E-10	0.0
501160	0.0	2.85E-12	0.0	1.09E-10	4.02E-12
501170	3.27E-09	0.0	4.41E-12	2.22E-09	7.20E-11
501171	3.04E-09	0.0	4.22E-12	2.07E-09	6.82E-11
501180	1.37E-07	5.30E-09	0.0	1.37E-07	5.52E-09
501190	7.15E-07	7.01E-08	1.32E-08	1.96E-09	4.34E-08
501191	7.15E-07	7.01E-08	1.32E-08	1.96E-09	4.34E-08
501200	1.18E-05	1.94E-06	6.37E-07	2.44E-05	1.03E-06
501210	3.47E-05	8.75E-06	5.24E-06	8.57E-05	4.14E-06
501211	4.43E-05	8.78E-06	5.24E-06	4.79E-05	4.14E-06
501220	5.15E-04	1.04E-04	1.12E-04	9.46E-04	5.04E-05
501230	1.48E-03	1.62E-03	4.74E-04	1.68E-03	1.90E-04
501231	1.48E-03	2.94E-04	4.74E-04	1.68E-03	1.90E-04
501240	1.30E-02	2.29E-03	6.09E-03	9.97E-03	9.07E-04
501250	3.03E-02	1.06E-02	1.14E-01	3.72E-02	1.90E-03
501251	3.03E-02	5.15E-03	1.32E-02	1.92E-02	1.90E-03
501260	1.77E-01	2.40E-02	1.13E-01	1.13E-01	1.77E-02
501270	2.58E-01	4.72E-02	1.94E-01	1.71E-01	4.93E-02
501271	2.58E-01	5.04E-02	1.90E-01	1.71E-01	4.97E-02
501280	5.82E-01	3.06E-01	8.22E-01	5.75E-01	2.38E-01
501290	2.73E-01	2.03E-01	5.59E-01	4.16E-01	2.97E-01
501291	2.73E-01	3.30E-01	5.44E-01	4.16E-01	2.97E-01
501300	8.61E-01	8.72E-01	1.73E+00	1.19E+00	1.11E+00
501310	4.00E-01	9.59E-01	1.98E+00	8.01E-01	1.30E+00
501320	1.19E-01	5.86E-01	1.63E+00	2.62E-01	7.38E-01
501330	9.62E-03	1.69E-01	7.69E-01	3.75E-02	2.17E-01
501340	7.81E-04	1.19E-02	1.79E-01	3.06E-03	2.69E-02
501350	2.21E-05	1.24E-03	2.36E-02	1.22E-04	1.70E-03
501360	5.96E-07	5.43E-05	2.45E-03	4.35E-06	8.10E-05
511210	4.06E-08	1.92E-05	7.29E-10	2.56E-05	1.45E-09
511220	4.29E-07	4.48E-08	1.03E-08	9.59E-07	1.05E-08
511221	4.52E-07	4.72E-08	1.07E-08	1.00E-06	1.10E-08
511230	1.36E-05	1.16E-06	5.09E-07	1.58E-05	5.08E-07
511240	7.81E-05	6.96E-06	4.55E-06	4.89E-05	9.70E-07
511241	7.81E-05	6.70E-06	4.54E-06	4.89E-05	9.74E-07
511250	2.20E-03	1.20E-04	1.10E-04	8.34E-04	1.86E-05
511260	8.41E-03	9.52E-04	5.30E-03	3.11E-03	1.03E-04
511261	8.40E-03	5.02E-04	6.44E-04	3.10E-03	1.03E-04
511270	1.31E-01	7.46E-03	1.34E-02	4.51E-02	2.73E-03
511280	1.84E-01	1.60E-02	4.65E-02	9.37E-02	8.25E-03
511281	1.84E-01	1.21E-02	4.65E-02	9.35E-02	8.26E-03
511290	8.81E-01	1.14E-01	1.20E-01	5.52E-01	1.03E-01
511300	6.15E-01	2.18E-01	2.28E-01	5.37E-01	2.43E-01
511301	6.15E-01	3.02E-01	2.28E-01	5.37E-01	2.43E-01
511310	1.65E+00	1.59E+00	1.25E+00	2.04E+00	1.54E+00
511320	6.42E-01	1.08E+00	1.16E+00	1.05E+00	1.23E+00
511321	6.42E-01	1.07E+00	1.16E+00	1.05E+00	1.23E+00
511330	4.28E-01	2.08E+00	2.81E+00	1.08E+00	2.30E+00
511340	6.80E-02	2.58E-01	9.08E-01	1.58E-01	5.19E-01
511341	6.81E-02	2.58E-01	9.08E-01	1.58E-01	5.19E-01
511350	1.47E-02	1.96E-01	6.82E-01	4.45E-02	2.33E-01
511360	1.47E-03	2.99E-02	2.04E-01	5.60E-03	3.86E-02
511370	8.23E-05	2.13E-03	4.70E-02	3.99E-04	3.42E-03
511380	2.59E-06	1.32E-04	6.96E-03	1.57E-05	2.00E-04
511390	1.51E-07	5.87E-06	5.43E-04	8.02E-07	7.53E-06
521220	1.58E-10	8.79E-12	0.0	4.26E-10	0.0
521230	3.16E-09	1.42E-10	1.27E-11	3.75E-09	3.23E-11
521231	3.31E-09	1.48E-10	1.31E-11	3.86E-09	3.34E-11
521240	2.05E-07	1.05E-08	1.35E-09	1.04E-07	4.21E-10
521250	4.77E-06	1.25E-06	2.40E-08	9.50E-07	4.73E-09
521251	4.77E-06	1.38E-07	2.40E-08	8.51E-07	4.73E-09
521260	2.09E-04	5.39E-06	1.62E-06	4.23E-05	2.60E-07
521270	2.28E-03	5.45E-05	6.29E-05	4.09E-04	3.79E-06
521271	2.28E-03	8.93E-05	3.04E-05	4.09E-04	3.79E-06
521280	3.82E-02	5.15E-04	1.54E-03	9.35E-03	1.44E-04
521290	1.24E-01	1.48E-02	4.89E-03	3.02E-02	1.27E-03
521291	1.24E-01	1.20E-02	3.12E-03	3.02E-02	1.27E-03
521300	2.98E-01	4.59E-02	2.18E-02	1.62E-01	3.34E-02
521310	4.27E-01	1.19E-01	8.46E-02	4.51E-01	1.56E-01
521311	1.03E+00	1.90E-01	1.80E-01	4.53E-01	1.59E-01

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521320	3.09E+00	1.54E+00	9.01E-01	2.77E+00	1.44E+00
521330	1.15E+00	1.32E+00	1.30E+00	2.28E+00	1.97E+00
521331	3.02E+00	2.88E+00	1.29E+00	2.28E+00	1.97E+00
521340	2.92E+00	6.18E+00	4.24E+00	3.63E+00	5.71E+00
521350	1.09E+00	3.11E+00	3.84E+00	1.88E+00	4.02E+00
521360	3.73E-01	1.85E+00	2.80E+00	7.72E-01	2.08E+00
521370	7.47E-02	4.20E-01	1.57E+00	1.67E-01	5.92E-01
521380	7.64E-03	8.72E-02	6.33E-01	2.09E-02	1.12E-01
521390	1.47E-03	1.30E-02	1.57E-01	3.25E-03	1.40E-02
521400	2.29E-05	1.21E-03	2.32E-02	1.69E-04	1.11E-03
521410	4.07E-07	4.19E-05	1.15E-03	3.55E-06	3.82E-05
521420	8.38E-09	8.03E-07	1.45E-04	8.44E-08	1.48E-06
531270	4.55E-06	8.04E-08	1.84E-04	3.75E-07	5.63E-10
531280	6.98E-05	1.18E-05	5.83E-07	9.99E-05	3.19E-08
531290	2.22E-03	1.80E-04	5.46E-03	1.90E-04	1.60E-06
531300	2.71E-03	1.64E-04	1.50E-05	4.38E-03	3.18E-05
531301	1.46E-03	7.87E-05	1.50E-05	1.29E-03	3.18E-05
531310	4.43E-02	4.15E-03	8.34E-04	1.19E-02	2.01E-03
531320	2.75E-01	2.06E-02	8.36E-02	1.38E-01	4.60E-02
531330	8.77E-01	1.65E-01	6.30E-02	8.88E-01	1.31E-01
531331	4.71E-01	1.29E-01	6.22E-02	3.37E-01	1.12E-01
531340	1.68E+00	4.57E-01	3.11E-01	2.13E+00	6.37E-01
531341	1.08E+00	4.52E-01	3.00E-01	1.11E+00	6.37E-01
531350	3.75E+00	2.98E+00	1.37E+00	4.40E+00	2.65E+00
531360	1.75E+00	1.19E+00	1.15E+00	1.68E+00	1.94E+00
531361	1.40E+00	1.95E+00	1.15E+00	1.68E+00	1.94E+00
531370	1.80E+00	2.84E+00	2.66E+00	1.97E+00	3.14E+00
531380	5.55E-01	1.57E+00	2.43E+00	8.21E-01	1.72E+00
531390	3.32E-01	7.23E-01	1.65E+00	3.20E-01	6.59E-01
531400	1.67E-02	2.15E-01	6.74E-01	5.10E-02	1.67E-01
531410	1.25E-03	3.08E-02	1.63E-01	4.62E-03	2.37E-02
531420	7.28E-05	2.23E-03	3.74E-02	2.81E-04	2.44E-03
531430	1.71E-06	9.08E-05	2.75E-03	1.39E-05	1.66E-04
531440	5.05E-08	3.42E-06	2.56E-04	3.84E-07	6.23E-06
541280	4.73E-05	9.79E-07	2.62E-11	8.71E-06	0.0
541290	1.08E-06	2.52E-07	7.18E-06	3.07E-08	4.86E-11
541291	9.72E-07	5.82E-09	1.49E-11	2.81E-08	4.61E-11
541300	2.43E-06	4.91E-08	4.19E-09	1.28E-06	1.22E-08
541310	4.29E-05	1.04E-06	3.12E-04	8.21E-06	6.65E-07
541311	4.29E-05	1.04E-06	2.32E-07	8.21E-06	6.65E-07
541320	2.35E-03	9.65E-05	4.78E-05	8.67E-04	1.40E-04
541330	1.53E-02	8.79E-04	3.32E-03	1.02E-02	1.06E-03
541331	4.09E-02	2.67E-03	8.05E-03	3.52E-02	1.06E-03
541340	1.49E-01	2.55E-02	7.91E-03	9.31E-02	2.08E-02
541341	1.27E-01	2.38E-02	7.23E-03	9.31E-02	2.08E-02
541350	5.38E-01	9.78E-02	7.85E-02	4.61E-01	9.46E-02
541351	7.97E-01	1.70E-01	1.06E-01	6.54E-01	1.33E-01
541360	3.25E+00	1.24E+00	4.89E-01	2.51E+00	1.26E+00
541370	4.19E+00	2.87E+00	1.13E+00	3.76E+00	2.84E+00
541380	3.81E+00	4.56E+00	1.99E+00	3.98E+00	4.15E+00
541390	2.82E+00	4.35E+00	2.71E+00	3.09E+00	4.33E+00
541400	1.34E+00	3.40E+00	3.22E+00	1.81E+00	3.10E+00
541410	3.28E-01	1.15E+00	1.97E+00	4.92E-01	1.32E+00
541420	6.23E-02	3.80E-01	1.25E+00	9.53E-02	4.22E-01
541430	4.20E-03	5.20E-02	2.71E-01	1.40E-02	7.94E-02
541440	4.39E-04	6.57E-03	7.14E-02	1.28E-03	9.87E-03
541450	8.18E-06	1.48E-04	1.10E-02	1.39E-04	6.45E-04
541460	1.09E-07	1.38E-05	7.38E-04	3.75E-06	2.58E-05
541470	9.36E-10	2.33E-07	7.38E-05	5.52E-08	3.99E-07
551330	3.69E-05	4.46E-05	1.68E-05	1.52E-05	4.27E-07
551340	5.95E-04	1.38E-05	5.96E-06	2.22E-04	1.77E-05
551341	5.94E-04	2.72E-05	5.96E-06	2.23E-04	1.77E-05
551350	1.05E-02	9.01E-04	1.89E-04	4.07E-03	4.49E-04
551351	1.05E-02	6.25E-04	1.68E-04	3.52E-03	3.92E-04
551360	1.12E-01	7.26E-03	1.30E-02	1.11E-01	1.74E-02
551370	6.78E-01	1.25E-01	2.08E-01	7.56E-01	9.45E-02
551380	6.39E-01	3.01E-01	2.53E-01	5.42E-01	1.98E-01
551381	7.39E-01	2.48E-01	6.60E-02	4.04E-01	2.01E-01
551390	2.69E+00	1.31E+00	8.68E-01	1.90E+00	1.15E+00
551400	3.37E+00	2.23E+00	1.22E+00	2.88E+00	2.32E+00
551410	2.72E+00	3.24E+00	2.17E+00	2.83E+00	2.52E+00
551420	1.35E+00	2.46E+00	2.18E+00	1.51E+00	2.24E+00
551430	3.62E-01	1.47E+00	1.66E+00	6.11E-01	1.19E+00
551440	7.56E-02	3.11E-01	1.01E+00	1.64E-01	4.52E-01
551450	6.74E-03	7.18E-02	3.41E-01	3.88E-02	9.37E-02
551460	3.34E-04	8.10E-03	7.37E-02	3.68E-03	1.30E-02
551470	1.08E-05	5.90E-04	1.95E-02	2.13E-04	8.56E-04
551480	2.15E-07	1.81E-05	1.43E-03	6.76E-06	3.01E-05
551500	2.99E-11	4.29E-09	1.45E-06	1.65E-09	1.24E-08
561340	4.93E-07	3.37E-08	8.97E-10	1.08E-07	2.94E-09
561350	1.71E-05	3.47E-07	5.61E-08	3.61E-06	1.51E-07
561351	1.52E-05	3.01E-07	5.00E-08	3.24E-06	1.51E-07
561360	5.28E-04	1.10E-05	9.15E-06	2.32E-04	1.79E-05
561370	6.84E-03	2.58E-04	1.37E-04	1.57E-03	1.83E-04
561371	6.84E-03	2.58E-04	4.64E-05	1.47E-03	1.83E-04
561380	8.88E-02	7.66E-03	1.50E-03	2.34E-02	5.79E-03
561390	5.12E-01	6.71E-02	1.36E-01	3.41E-01	4.57E-02
561400	1.64E+00	4.29E-01	8.33E-02	7.86E-01	2.56E-01
561410	3.41E+00	1.46E+00	4.52E-01	2.02E+00	9.81E-01
561420	4.51E+00	2.93E+00	1.16E+00	3.20E+00	2.03E+00
561430	3.87E+00	3.78E+00	2.25E+00	3.32E+00	2.92E+00
561440	2.17E+00	3.93E+00	2.63E+00	2.39E+00	2.89E+00
561450	6.07E-01	1.92E+00	2.39E+00	1.28E+00	1.70E+00
561460	1.04E-01	6.68E-01	1.61E+00	3.90E-01	7.44E-01
561470	1.02E-02	1.30E-01	6.19E-01	6.96E-02	1.60E-01
561480	7.84E-04	1.52E-02	1.78E-01	8.21E-03	2.20E-02
561490	3.68E-05	9.27E-04	2.70E-02	5.41E-04	1.88E-03
561500	1.13E-06	4.32E-05	2.27E-03	2.49E-05	1.09E-04
561520	9.17E-11	1.89E-08	7.06E-06	8.19E-09	8.58E-08
571380	1.30E-04	5.78E-05	3.00E-07	1.77E-05	1.69E-06
571390	3.70E-03	8.11E-05	1.66E-05	3.32E-04	4.80E-05
571400	2.27E-02	6.04E-03	2.56E-03	2.30E-02	5.86E-03
571410	1.76E-01	1.94E-02	3.30E-03	3.88E-02	9.19E-03
571420	6.22E-01	1.00E-01	2.93E-02	1.81E-01	6.74E-02
571430	1.51E+00	6.01E-01	1.17E-01	5.84E-01	2.75E-01
571440	1.96E+00	1.11E+00	3.42E-01	1.18E+00	7.46E-01
571450	1.79E+00	1.69E+00	7.64E-01	1.45E+00	1.25E+00
571460	9.41E-01	1.62E+00	1.26E+00	1.33E+00	1.46E+00
571470	2.98E-01	9.37E-01	1.20E+00	7.19E-01	1.02E+00
571480	6.98E-02	3.42E-01	8.50E-01	2.60E-01	4.35E-01
571490	9.98E-03	7.02E-02	3.63E-01	5.53E-02	1.18E-01
571500	9.60E-04	1.01E-02	1.00E-01	8.69E-03	2.25E-02
571510	3.75E-05	8.95E-04	1.72E-02	7.29E-04	2.64E-03
571520	1.05E-06	4.98E-05	2.56E-03	3.39E-05	1.92E-04
571530	1.50E-08	1.46E-06	3.12E-04	1.02E-06	8.29E-06
571540	1.11E-10	2.93E-08	1.49E-05	3.15E-08	2.30E-07
581400	1.44E-03	2.35E-06	5.33E-06	1.08E-03	1.18E-05
581410	1.00E-03	2.43E-05	3.05E-06	9.09E-05	2.41E-05
581420	1.24E-02	5.13E-04	9.08E-05	1.39E-03	2.66E-04
581430	9.14E-02	2.85E-02	1.59E-03	1.31E-02	3.27E-03
581440	4.16E-01	6.09E-02	9.22E-03	8.18E-02	2.91E-02
581450	9.21E-01	2.30E-01	5.02E-02	3.04E-01	1.40E-01
581460	1.40E+00	6.73E-01	2.04E-01	7.91E-01	5.00E-01
581470	1.26E+00	1.16E+00	5.34E-01	1.20E+00	1.04E+00
581480	8.13E-01	1.17E+00	9.53E-01	1.20E+00	1.31E+00
581490	3.21E-01	7.10E-01	1.01E+00	7.29E-01	1.00E+00
581500	8.90E-02	2.87E-01	7.73E-01	3.52E-01	5.63E-01
581510	1.24E-02	7.58E-02	3.44E-01	9.43E-02	1.94E-01
581520	1.18E-03	1.36E-02	1.23E-01	1.47E-02	4.44E-02
581530	5.84E-05	1.31E-03	3.56E-02	1.37E-03	6.07E-03
581540	1.51E-06	8.09E-05	4.94E-03	1.10E-04	5.45E-04
581550	3.09E-08	3.31E-06	6.58E-04	8.05E-06	3.48E-05
581560	5.16E-10	8.20E-08	6.54E-05	5.99E-07	2.24E-06
581570	6.89E-12	1.70E-09	5.37E-06	1.84E-08	8.83E-08
591410	1.40E-07	8.46E-10	7.83E-09	4.77E-09	2.74E-09
591420	2.98E-06	3.05E-08	3.64E-09	1.31E-07	1.23E-08
591421	2.99E-06	3.05E-08	3.67E-09	1.30E-07	1.23E-08
591430	1.51E-04	2.95E-06	2.80E-07	9.17E-06	2.69E-06
591440	8.31E-04	8.25E-05	6.06E-06	2.08E-04	1.47E-05
591441	6.81E-04	3.42E-05	3.67E-06	8.38E-05	1.47E-05
591450	1.63E-02	9.32E-04	1.13E-04	2.01E-03	4.54E-04
591460	8.01E-02	8.54E-03	1.30E-03	1.65E-02	5.62E-03
591470	2.11E-01	5.38E-02	1.09E-02	7.84E-02	4.40E-02
591480	3.74E-01	1.61E-01	5.74E-02	2.24E-01	1.60E-01

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591490	3.63E-01	2.89E-01	1.62E-01	4.53E-01	3.22E-01
591500	2.70E-01	3.00E-01	3.26E-01	5.09E-01	5.26E-01
591510	1.18E-01	2.24E-01	3.80E-01	3.87E-01	4.89E-01
591520	3.45E-02	1.08E-01	2.75E-01	1.84E-01	3.06E-01
591530	5.50E-03	3.13E-02	1.66E-01	4.97E-02	1.20E-01
591540	4.77E-04	5.53E-03	5.64E-02	1.11E-02	3.22E-02
591550	3.15E-05	6.84E-04	1.70E-02	1.75E-03	5.85E-03
591560	1.62E-06	5.08E-05	3.93E-03	2.87E-04	1.01E-03
591570	6.56E-08	3.10E-06	7.72E-04	2.61E-05	1.14E-04
591580	1.60E-08	1.19E-07	6.46E-05	1.17E-06	5.86E-06
591590	3.82E-12	1.71E-09	2.71E-06	2.87E-08	1.59E-07

SEGMENT 6

601420	2.77E-10	2.46E-11	0.0	4.58E-12	0.0
601430	2.46E-08	2.83E-10	6.91E-12	4.84E-10	1.20E-10
601440	4.38E-06	8.75E-04	1.05E-05	1.09E-07	2.94E-09
601450	3.27E-05	4.04E-07	2.95E-08	1.20E-06	1.92E-07
601460	5.74E-04	1.27E-05	9.67E-07	3.91E-05	6.90E-06
601470	6.62E-03	2.96E-04	3.11E-05	6.51E-04	2.45E-04
601480	2.74E-02	3.07E-03	5.53E-04	6.00E-03	2.64E-03
601490	7.50E-02	1.81E-02	4.93E-03	3.13E-02	1.80E-02
601500	1.42E-01	5.34E-02	2.98E-02	1.27E-01	8.31E-02
601510	1.82E-01	1.19E-01	1.08E-01	2.94E-01	2.19E-01
601520	1.48E-01	1.45E-01	1.54E-01	3.75E-01	3.53E-01
601530	6.77E-02	1.17E-01	1.90E-01	2.65E-01	3.61E-01
601540	1.76E-02	5.10E-02	1.49E-01	1.62E-01	2.60E-01
601550	3.46E-03	1.72E-02	9.24E-02	6.04E-02	1.21E-01
601560	5.22E-04	3.50E-03	4.64E-02	2.09E-02	5.15E-02
601570	6.13E-05	5.94E-04	1.96E-02	4.85E-03	1.57E-02
601580	1.69E-05	6.66E-05	3.58E-03	6.45E-04	2.44E-03
601590	4.75E-08	3.08E-06	4.83E-04	4.93E-05	2.11E-04
601600	6.79E-10	9.67E-07	4.50E-05	3.16E-06	9.24E-06
601610	1.21E-11	1.86E-09	4.57E-06	1.03E-07	2.80E-07
611470	3.33E-06	2.73E-07	9.06E-05	2.10E-07	2.35E-08
611480	9.47E-07	5.10E-06	7.02E-08	2.07E-06	5.43E-07
611481	2.79E-05	7.42E-07	7.02E-08	2.07E-06	5.43E-07
611490	4.79E-04	3.12E-05	4.51E-06	1.06E-04	2.49E-05
611500	2.59E-03	5.04E-04	9.40E-05	1.60E-03	3.94E-04
611510	1.12E-02	1.77E-03	8.93E-04	7.00E-03	2.97E-03
611520	1.29E-02	3.67E-03	2.04E-03	1.53E-02	7.71E-03
611521	1.29E-02	3.67E-03	2.04E-03	1.53E-02	7.71E-03
611530	3.36E-02	1.65E-02	1.34E-02	5.99E-02	4.39E-02
611540	1.16E-02	9.40E-03	1.22E-02	4.94E-02	4.21E-02
611541	1.16E-02	9.40E-03	1.22E-02	4.94E-02	4.22E-02
611550	1.22E-02	1.57E-02	3.11E-02	8.88E-02	9.47E-02
611560	4.84E-03	8.04E-03	3.49E-02	6.27E-02	9.35E-02
611570	1.52E-03	3.47E-03	2.96E-02	3.25E-02	6.75E-02
611580	4.69E-04	1.04E-03	1.22E-02	1.08E-02	2.87E-02
611590	1.38E-05	1.43E-04	4.25E-03	2.33E-03	7.29E-03
611600	6.32E-07	4.94E-05	8.96E-04	3.99E-04	9.73E-04
611610	3.37E-08	8.02E-07	1.92E-04	3.98E-05	9.29E-05
611620	1.52E-09	4.67E-08	1.54E-05	5.04E-07	3.73E-06
621470	2.02E-10	1.01E-06	0.0	2.42E-12	0.0
621480	1.80E-08	7.01E-11	3.44E-12	2.76E-10	4.29E-11
621490	2.98E-07	6.53E-09	4.18E-10	1.91E-08	3.48E-09
621500	5.35E-06	2.82E-07	3.24E-08	8.56E-07	1.95E-07
621510	8.39E-05	3.80E-06	3.22E-04	2.47E-05	6.19E-06
621520	6.41E-04	4.65E-05	1.45E-05	3.29E-04	8.19E-05
621530	2.52E-03	3.34E-04	1.55E-04	2.00E-03	7.27E-04
621540	5.32E-03	1.08E-03	7.48E-04	1.03E-02	4.18E-03
621550	7.43E-03	2.59E-03	2.22E-03	2.51E-02	1.25E-02
621560	7.40E-03	3.34E-03	6.06E-03	3.80E-02	2.80E-02
621570	5.66E-03	3.53E-03	1.09E-02	4.06E-02	4.99E-02
621580	1.92E-03	2.58E-03	1.27E-02	2.93E-02	5.35E-02
621590	4.65E-04	9.04E-04	1.09E-02	1.61E-02	3.62E-02
621600	6.37E-05	3.55E-04	5.58E-03	6.55E-03	1.32E-02
621610	9.62E-06	4.03E-05	2.48E-03	1.79E-03	3.59E-03
621620	7.57E-07	6.92E-06	8.68E-04	1.40E-04	4.32E-04
621630	4.54E-08	4.28E-07	1.43E-04	9.89E-06	3.93E-05
621640	2.10E-09	2.19E-08	1.59E-05	5.08E-07	2.21E-06
621650	3.97E-11	9.36E-10	1.13E-06	1.71E-08	8.68E-08
631510	1.53E-08	4.99E-05	9.06E-08	1.50E-09	1.83E-10
631520	2.04E-07	3.33E-09	5.78E-10	4.55E-08	5.44E-09
631521	2.04E-07	3.33E-09	5.78E-10	4.55E-08	5.44E-09
631530	6.26E-04	6.02E-05	3.85E-08	1.76E-06	3.01E-07
631540	3.81E-05	1.73E-06	6.59E-07	3.17E-05	5.58E-06
631550	1.61E-04	1.25E-05	5.01E-06	2.38E-04	4.85E-05
631560	4.33E-04	4.54E-05	3.69E-05	8.49E-04	5.07E-04
631570	8.37E-04	1.31E-04	1.55E-04	2.06E-03	1.34E-03
631580	3.17E-04	2.58E-04	6.59E-04	3.43E-03	4.01E-03
631590	5.76E-04	2.62E-04	1.58E-03	4.72E-03	7.31E-03
631600	2.08E-04	1.12E-04	2.07E-03	4.16E-03	6.91E-03
631610	8.02E-05	7.50E-05	2.13E-03	2.99E-03	4.98E-03
631620	1.05E-05	3.30E-05	1.84E-03	1.14E-03	1.60E-03
631630	1.86E-06	5.89E-06	8.39E-04	2.32E-04	4.02E-04
631640	2.65E-07	9.17E-07	2.69E-04	3.65E-05	6.58E-05
631650	1.59E-08	1.20E-07	5.71E-05	3.86E-06	7.90E-06
641520	2.49E-11	6.68E-13	0.0	2.15E-12	0.0
641530	1.42E-09	9.70E-12	1.00E-12	1.45E-10	1.13E-11
641540	2.90E-08	2.95E-10	5.76E-11	1.01E-08	7.36E-10
641550	3.97E-07	6.31E-09	1.18E-09	2.50E-07	1.93E-08
641560	3.21E-06	2.28E-04	4.53E-08	2.76E-04	3.16E-07
641570	1.76E-05	4.12E-06	2.55E-07	1.38E-05	4.17E-06
641580	7.45E-06	3.88E-06	4.51E-06	5.59E-05	3.84E-05
641590	1.21E-04	1.22E-05	3.55E-05	2.15E-04	2.14E-04
641600	1.16E-04	8.60E-06	1.36E-04	4.57E-04	5.99E-04
641610	1.11E-04	2.78E-05	3.63E-04	7.99E-04	1.19E-03
641620	2.32E-05	2.81E-05	7.09E-04	1.52E-03	1.01E-03
641630	1.08E-05	1.38E-05	8.61E-04	8.22E-04	6.66E-04
641640	4.23E-06	5.97E-06	7.24E-04	3.51E-04	2.88E-04
641650	7.30E-07	2.15E-06	4.10E-04	1.06E-04	9.40E-05
651590	7.94E-07	2.02E-08	1.93E-08	2.69E-07	1.61E-07
651600	2.34E-06	9.47E-08	1.11E-05	1.45E-06	1.45E-06
651610	5.85E-06	4.79E-07	1.93E-06	7.07E-06	8.98E-06
651620	1.01E-06	4.78E-07	4.65E-06	3.98E-05	1.16E-05
651621	1.01E-06	4.77E-07	4.65E-06	3.99E-05	1.16E-05
651630	2.54E-06	1.41E-06	3.34E-05	1.18E-04	4.38E-05
651640	2.59E-06	1.74E-06	7.84E-05	1.33E-04	5.12E-05
651650	1.18E-06	1.65E-06	1.19E-04	1.07E-04	4.42E-05
661600	5.29E-09	6.97E-11	4.65E-11	4.77E-10	3.54E-10
661610	3.85E-08	1.45E-09	9.27E-10	8.60E-05	7.55E-09
661620	2.31E-08	4.49E-09	1.36E-08	5.20E-07	6.02E-08
661630	8.87E-08	2.27E-08	1.57E-07	2.36E-06	3.62E-07
661640	2.64E-07	8.99E-08	1.15E-06	8.17E-06	1.31E-06
661650	1.65E-07	1.20E-07	2.64E-06	9.29E-06	1.66E-06
661651	1.66E-07	1.21E-07	2.64E-06	9.29E-06	1.66E-06
661660	1.57E-06	2.11E-06	3.37E-04	1.37E-04	1.47E-04
671650	2.98E-09	1.21E-09	6.24E-09	9.81E-08	6.89E-09
671660	7.91E-09	3.20E-09	3.22E-08	2.86E-07	4.89E-08
671661	7.91E-09	2.97E-09	3.22E-08	2.86E-07	4.89E-08
681660	4.96E-11	1.78E-11	2.49E-11	1.05E-09	6.77E-11
681670	2.31E-07	1.25E-06	1.97E-04	5.14E-05	5.97E-05
681671	5.35E-11	6.57E-11	2.71E-10	3.76E-09	3.97E-10

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10010	9.998E+01	240540	2.360E+00	420970	9.600E+00	541360	8.900E+00	701720	2.190E+01
10020	1.500E-02	250550	1.000E+02	420980	2.410E+01	551330	1.000E+02	701730	1.620E+01
20030	1.300E-04	260540	5.810E+00	421000	9.600E+00	561300	1.100E-01	701740	3.160E+01
20040	1.000E+02	260560	9.175E+01	440960	5.500E+00	561320	1.000E-01	701760	1.260E+01
30060	7.500E+00	260570	2.150E+00	440980	1.900E+00	561340	2.400E+00	711750	9.740E+01
30070	9.250E+01	260580	2.900E-01	440990	1.270E+01	561350	6.590E+00	711760	2.600E+00
40090	1.000E+02	270590	1.000E+02	441000	1.260E+01	561360	7.900E+00	721740	1.600E-01
50100	2.000E+01	280580	6.827E+01	441010	1.700E+01	561370	1.120E+01	721760	5.200E+00
50110	8.000E+01	280600	2.610E+01	441020	3.160E+01	561380	7.170E+01	721770	1.860E+01
60120	9.889E+01	280610	1.130E+00	441040	1.870E+01	571380	8.900E-02	721780	2.710E+01
60130	1.110E+00	280620	3.590E+00	451030	1.000E+02	571390	9.991E+01	721790	1.374E+01
70140	9.963E+01	280640	9.100E-01	461020	1.000E+00	581360	1.900E-01	721800	3.520E+01
70150	3.660E-01	290630	6.920E+01	461040	1.100E+01	581380	2.500E-01	731800	1.200E-02
80160	9.976E+01	290650	3.080E+01	461050	2.220E+01	581400	8.848E+01	731810	9.999E+01
80170	3.800E-02	300640	4.860E+01	461060	2.730E+01	581420	1.108E+01	741800	1.300E-01
80180	2.040E-01	300660	2.790E+01	461080	2.670E+01	591410	1.000E+02	741820	2.630E+01
90190	1.000E+02	300670	4.100E+00	461100	1.180E+01	601420	2.720E+01	741830	1.430E+01
100200	9.051E+01	300680	1.878E+01	471070	5.183E+01	601430	1.220E+01	741840	3.067E+01
100210	2.700E-01	300700	6.200E-01	471090	4.817E+01	601440	2.380E+01	741860	2.860E+01
100220	9.220E+00	310690	6.010E+01	481060	1.300E+00	601450	8.300E+00	751850	3.740E+01
110230	1.000E+02	310710	3.990E+01	481080	8.900E-01	601460	1.720E+01	751870	6.260E+01
120240	7.899E+01	320700	2.050E+01	481100	1.250E+01	601480	5.700E+00	761840	1.800E-02
120250	1.000E+01	320720	2.740E+01	481110	1.280E+01	601500	5.600E+00	761860	1.582E+00
120260	1.101E+01	320730	7.800E+00	481120	2.411E+01	621440	3.100E+00	761870	1.600E+00
130270	1.000E+02	320740	3.650E+01	481130	1.220E+01	621470	1.510E+01	761880	1.330E+01
140280	9.223E+01	320760	7.800E+00	481140	2.870E+01	621480	1.130E+01	761890	1.610E+01
140290	4.670E+00	330750	1.000E+02	481160	7.500E+00	621490	1.390E+01	761900	2.640E+01
140300	3.100E+00	340740	8.700E-01	491130	4.300E+00	621500	7.400E+00	761920	4.100E+01
150310	1.000E+02	340760	9.030E+00	491150	9.570E+01	621520	2.660E+01	771910	3.730E+01
160320	9.502E+01	340770	7.600E+00	501120	1.000E+00	621540	2.260E+01	771930	6.270E+01
160330	7.500E-01	340780	2.350E+01	501140	6.700E-01	631510	4.790E+01	781900	1.300E-02
160340	4.213E+00	340800	4.980E+01	501150	3.800E-01	631530	5.210E+01	781920	7.870E-01
160360	1.700E-02	340820	9.200E+00	501160	1.470E+01	641520	2.000E-01	781940	3.290E+01
170350	7.577E+01	350790	5.069E+01	501170	7.750E+00	641540	2.100E+00	781950	3.380E+01
170370	2.423E+01	350810	4.931E+01	501180	2.430E+01	641550	1.480E+01	781960	2.530E+01
180360	3.370E-01	360780	3.500E-01	501190	8.600E+00	641560	2.060E+01	781980	7.200E+00
180380	6.300E-02	360800	2.250E+00	501200	3.240E+01	641570	1.570E+01	791970	1.000E+02
180400	9.960E+01	360820	1.160E+01	501220	4.600E+00	641580	2.480E+01	801960	1.500E-01
190390	9.326E+01	360830	1.150E+01	501240	5.600E+00	641600	2.180E+01	801980	1.000E+01
190400	1.200E-02	360840	5.700E+01	511210	5.730E+01	651590	1.000E+02	801990	1.685E+01
190410	6.730E+00	360860	1.730E+01	511230	4.270E+01	661560	5.700E-02	802000	2.310E+01
200400	9.694E+01	370850	7.217E+01	521200	9.100E-02	661580	1.030E-01	802010	1.320E+01
200420	6.465E-01	370870	2.783E+01	521220	2.500E+00	661600	2.340E+00	802020	2.980E+01
200430	1.300E-01	380840	5.600E-01	521230	8.890E-01	661610	1.900E+01	802040	6.900E+00
200440	2.090E+00	380860	9.840E+00	521240	4.620E+00	661620	2.550E+01	812030	2.950E+01
200460	3.500E-03	380870	7.000E+00	521250	7.000E+00	661630	2.490E+01	812050	7.050E+01
200480	1.900E-01	380880	8.260E+01	521260	1.870E+01	661640	2.810E+01	822040	1.400E+00
210450	1.000E+02	390890	1.000E+02	521280	3.170E+01	671650	1.000E+02	822060	2.410E+01
220460	8.250E+00	400900	5.150E+01	521300	3.450E+01	681620	1.400E-01	822070	2.210E+01
220470	7.450E+00	400910	1.120E+01	531270	1.000E+02	681640	1.560E+00	822080	5.240E+01
220480	7.370E+01	400920	1.710E+01	541240	1.000E-01	681660	3.340E+01	832090	1.000E+02
220490	5.400E+00	400940	1.740E+01	541260	9.000E-02	681670	2.290E+01	902320	1.000E+02
220500	5.200E+00	400960	2.800E+00	541280	1.910E+00	681680	2.710E+01	922340	5.400E-03
230500	2.500E-01	410930	1.000E+02	541290	2.640E+01	681700	1.490E+01	922350	7.200E-01
230510	9.975E+01	420920	1.480E+01	541300	4.100E+00	691690	1.000E+02	922380	9.927E+01
240500	4.350E+00	420940	9.300E+00	541310	2.120E+01	701680	1.400E-01		
240520	8.379E+01	420950	1.590E+01	541320	2.690E+01	701700	3.140E+00		
240530	9.500E+00	420960	1.670E+01	541340	1.040E+01	701710	1.440E+01		

APPENDIX C.1: Simple KSIG Run

Table 9. Miscellaneous Input data for the simple KSIG run.

Variable	Value
Output Threshold	10^{-5} grams
Considering Fission Product Production?	No
Power/Time History File	ZERO
Isotope Name File	CO60
Isotope Concentration File	CO_INV

APPENDIX C.1 FILE: ZERO

```
FLUX
0.0000E+00 1.0000E+00 Y
END
```

APPENDIX C.1 FILE: CO60

```
23          270590     250580     280580     260560     270610     290620     280630
*270600     260590     270580     260570     250560     280620     280590     300630
 270601     260580     270581     250570     280610     270620     290630    *280600
```

APPENDIX C.1 FILE: CO_INV

```
 270600 1.0000E+03
```

SIMULATED TIME = 0.0000E+00 S | PAGE 1
NEUTRON FLUX = 0.0000E+00 (#/CM^2*S) | POWER = 0.0000E+00 (MW/UNIT)

ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)
CO-060	1.0000000E+03				

SIMULATED TIME = 3.6525E+02 D | PAGE 2
NEUTRON FLUX = 0.0000E+00 (#/CM^2*S) | POWER = 0.0000E+00 (MW/UNIT)

ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)
CO-060	8.7674969E+02	NI-060	1.2325031E+02		

APPENDIX C.2: Complex KSIG Run

Table 10. Miscellaneous Input data for the complex KSIG run.

Variable	Value
Output Threshold	10^{-5} grams
Considering Fission Product Production?	Yes
Power/Time History File	FULL
Isotope Name File	TEST
Isotope Concentration File	INVTYP

APPENDIX C.2 FILE: FULL

```
POWER                          1.4000E+01 3.5000E+01 D    0.0000E+00 1.0000E+00 H
1.4000E+01 3.5000E+01 D        1.4000E+01 3.5000E+01 D    0.0000E+00 5.0000E+00 H
1.4000E+01 3.5000E+01 D        1.4000E+01 5.0000E+01 D    0.0000E+00 5.0000E+00 H
1.4000E+01 3.5000E+01 D        0.0000E+00 3.0000E+01 M    0.0000E+00 5.0000E+00 H
1.4000E+01 3.5000E+01 D        0.0000E+00 3.0000E+01 M    0.0000E+00 4.0000E+00 H
1.4000E+01 3.5000E+01 D        0.0000E+00 1.0000E+00 H    0.0000E+00 1.0000E+00 D
1.4000E+01 3.5000E+01 D        0.0000E+00 1.0000E+00 H    0.0000E+00 1.0000E+00 D
1.4000E+01 3.5000E+01 D        0.0000E+00 1.0000E+00 H    END
```

APPENDIX C.2 FILE: TEST

```
112      541351   521331   541360   481310   511290   541290  #541310   501270   521260
#541350  541340   531331   531360   521311   501290   541291   521280   491270   511260
 531350  531340   541331   521370   521300   501291   541280   511280   491271   511261
 521350  501340   541320   511370   511300   491290   531280   511281   501271   541260
 511350  491340   531320   531361   511301   481290   561330   501280   541270   541240
 501350  531341   521320   531370   501300   521291   561331   491280   541271
 521340  541341   511320  #551330   491300   551310   561320   481280   481270
 511340  531330   501320   531310   481300   561310  #551340   471280   471270
 511341  521330   491320   521310   531300   561311   551341   521271   531260
 521360  511330   481320   511310   531301   561300  #551350   531270   531250
 511360  501330   511321   501310   531290   541311   551351   521270   541250
 501360  491330   551320   491310   521290   541300  #541330   511270   541251
```

APPENDIX C.2 FILE: INVTYP

```
 922350 1.5398E+04
 922380 4.9785E+05
  80160 3.4471E+04
  80170 1.3131E+01
  80180 7.0490E+01
```

```
SIMULATED TIME = 0.0000E+00 S                                   PAGE    1
NEUTRON FLUX   = 0.0000E+00 (#/CM^2*S)          POWER = 0.0000E+00 (MW/UNIT)

ISOTOPE   MASS(GRAMS)       ISOTOPE   MASS(GRAMS)       ISOTOPE   MASS(GRAMS)



SIMULATED TIME = 3.5000E+01 D                                   PAGE    2
NEUTRON FLUX   = 2.1955E+14 (#/CM^2*S)          POWER = 1.4000E+01 (MW/UNIT)

ISOTOPE   MASS(GRAMS)       ISOTOPE   MASS(GRAMS)       ISOTOPE   MASS(GRAMS)

XE-135    8.4609615E-02     CS-133    1.4452198E+01     CS-134    4.5560360E-02
CS-135    5.3616074E+00     XE-133    4.1371241E+00     XE-131    5.6217105E+00



SIMULATED TIME = 7.0000E+01 D                                   PAGE    3
NEUTRON FLUX   = 2.1891E+14 (#/CM^2*S)          POWER = 1.4000E+01 (MW/UNIT)

ISOTOPE   MASS(GRAMS)       ISOTOPE   MASS(GRAMS)       ISOTOPE   MASS(GRAMS)

XE-135    8.5021287E-02     CS-133    3.3589184E+01     CS-134    2.2915160E-01
CS-135    1.0826697E+01     XE-133    4.1844413E+00     XE-131    1.3738570E+01



SIMULATED TIME = 1.0500E+02 D                                   PAGE    4
NEUTRON FLUX   = 2.1879E+14 (#/CM^2*S)          POWER = 1.4000E+01 (MW/UNIT)

ISOTOPE   MASS(GRAMS)       ISOTOPE   MASS(GRAMS)       ISOTOPE   MASS(GRAMS)

XE-135    8.5387981E-02     CS-133    5.2617437E+01     CS-134    5.5079306E-01
CS-135    1.6311241E+01     XE-133    4.1831621E+00     XE-131    2.1897864E+01



SIMULATED TIME = 1.4000E+02 D                                   PAGE    5
NEUTRON FLUX   = 2.1910E+14 (#/CM^2*S)          POWER = 1.4000E+01 (MW/UNIT)

ISOTOPE   MASS(GRAMS)       ISOTOPE   MASS(GRAMS)       ISOTOPE   MASS(GRAMS)

XE-135    8.5596914E-02     CS-133    7.1489936E+01     CS-134    1.0034750E+00
CS-135    2.1807030E+01     XE-133    4.1815018E+00     XE-131    2.9967039E+01



SIMULATED TIME = 1.7500E+02 D                                   PAGE    6
NEUTRON FLUX   = 2.1976E+14 (#/CM^2*S)          POWER = 1.4000E+01 (MW/UNIT)

ISOTOPE   MASS(GRAMS)       ISOTOPE   MASS(GRAMS)       ISOTOPE   MASS(GRAMS)

XE-135    8.5674355E-02     CS-133    9.0206496E+01     CS-134    1.5811199E+00
CS-135    2.7307427E+01     XE-133    4.1798948E+00     XE-131    3.7933514E+01



SIMULATED TIME = 2.1000E+02 D                                   PAGE    7
NEUTRON FLUX   = 2.2072E+14 (#/CM^2*S)          POWER = 1.4000E+01 (MW/UNIT)

ISOTOPE   MASS(GRAMS)       ISOTOPE   MASS(GRAMS)       ISOTOPE   MASS(GRAMS)

XE-135    8.5641936E-02     CS-133    1.0876672E+02     CS-134    2.2784310E+00
CS-135    3.2807139E+01     XE-133    4.1783219E+00     XE-131    4.5791923E+01
```

PAGE 8

SIMULATED TIME = 2.4500E+02 D
NEUTRON FLUX = 2.2194E+14 (#/CM^2*S)
POWER = 1.4000E+01 (MW/UNIT)

ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)
XE-135	8.5517343E-02	CS-133	1.2716969E+02	CS-134	3.0907227E+00
CS-135	3.8301980E+01	XE-133	4.1767656E+00	XE-131	5.3537752E+01

PAGE 9

SIMULATED TIME = 2.8000E+02 D
NEUTRON FLUX = 2.2338E+14 (#/CM^2*S)
POWER = 1.4000E+01 (MW/UNIT)

ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)
XE-135	8.5315224E-02	CS-133	1.4541411E+02	CS-134	4.0138393E+00
CS-135	4.3788693E+01	XE-133	4.1752126E+00	XE-131	6.1166872E+01

PAGE 10

SIMULATED TIME = 3.1500E+02 D
NEUTRON FLUX = 2.2500E+14 (#/CM^2*S)
POWER = 1.4000E+01 (MW/UNIT)

ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)
XE-135	8.5047850E-02	CS-133	1.6349837E+02	CS-134	5.0439038E+00
CS-135	4.9264810E+01	XE-133	4.1736531E+00	XE-131	6.8675477E+01

PAGE 11

SIMULATED TIME = 3.6500E+02 D
NEUTRON FLUX = 2.2761E+14 (#/CM^2*S)
POWER = 1.4000E+01 (MW/UNIT)

ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)
XE-135	8.4642997E-02	CS-133	1.8904409E+02	CS-134	6.6936095E+00
CS-135	5.7111967E+01	XE-133	4.1715069E+00	XE-131	7.9184018E+01

PAGE 12

SIMULATED TIME = 3.6502E+02 D
NEUTRON FLUX = 0.0000E+00 (#/CM^2*S)
POWER = 0.0000E+00 (MW/UNIT)

ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)
XE-135	9.2127222E-02	CS-133	1.8905557E+02	CS-134	6.6935604E+00
CS-135	5.7115356E+01	XE-133	4.1715103E+00	XE-131	7.9189317E+01

PAGE 13

SIMULATED TIME = 3.6504E+02 D
NEUTRON FLUX = 0.0000E+00 (#/CM^2*S)
POWER = 0.0000E+00 (MW/UNIT)

ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)
XE-135	9.8629226E-02	CS-133	1.8906705E+02	CS-134	6.6935024E+00
CS-135	5.7119007E+01	XE-133	4.1714074E+00	XE-131	7.9194613E+01

SIMULATED TIME = 3.6508E+02 D PAGE 14
NEUTRON FLUX = 0.0000E+00 (#/CM^2*S) POWER = 0.0000E+00 (MW/UNIT)

ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)
XE-135	1.0934509E-01	CS-133	1.8909002E+02	CS-134	6.6933635E+00
CS-135	5.7126967E+01	XE-133	4.1707656E+00	XE-131	7.9205192E+01

SIMULATED TIME = 3.6513E+02 D PAGE 15
NEUTRON FLUX = 0.0000E+00 (#/CM^2*S) POWER = 0.0000E+00 (MW/UNIT)

ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)
XE-135	1.1747130E-01	CS-133	1.8911298E+02	CS-134	6.6931995E+00
CS-135	5.7135637E+01	XE-133	4.1694905E+00	XE-131	7.9215743E+01

SIMULATED TIME = 3.6517E+02 D PAGE 16
NEUTRON FLUX = 0.0000E+00 (#/CM^2*S) POWER = 0.0000E+00 (MW/UNIT)

ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)
XE-135	1.2339179E-01	CS-133	1.8913593E+02	CS-134	6.6930159E+00
CS-135	5.7144836E+01	XE-133	4.1675682E+00	XE-131	7.9226262E+01

SIMULATED TIME = 3.6521E+02 D PAGE 17
NEUTRON FLUX = 0.0000E+00 (#/CM^2*S) POWER = 0.0000E+00 (MW/UNIT)

ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)
XE-135	1.2742961E-01	CS-133	1.8915887E+02	CS-134	6.6928167E+00
CS-135	5.7154413E+01	XE-133	4.1650061E+00	XE-131	7.9236750E+01

SIMULATED TIME = 3.6542E+02 D PAGE 18
NEUTRON FLUX = 0.0000E+00 (#/CM^2*S) POWER = 0.0000E+00 (MW/UNIT)

ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)
XE-135	1.2811550E-01	CS-133	1.8927327E+02	CS-134	6.6916820E+00
CS-135	5.7203971E+01	XE-133	4.1432611E+00	XE-131	7.9288700E+01

SIMULATED TIME = 3.6563E+02 D PAGE 19
NEUTRON FLUX = 0.0000E+00 (#/CM^2*S) POWER = 0.0000E+00 (MW/UNIT)

ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)
XE-135	1.1182138E-01	CS-133	1.8938608E+02	CS-134	6.6904440E+00
CS-135	5.7250010E+01	XE-133	4.1085548E+00	XE-131	7.9339839E+01

SIMULATED TIME = 3.6583E+02 D | PAGE 20

NEUTRON FLUX = 0.0000E+00 (#/CM^2*S) | POWER = 0.0000E+00 (MW/UNIT)

ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)
XE-135	9.0769470E-02	CS-133	1.8949939E+02	CS-134	6.6891748E+00
CS-135	5.7288672E+01	XE-133	4.0632796E+00	XE-131	7.9390171E+01

SIMULATED TIME = 1.0021E+00 Y | PAGE 21

NEUTRON FLUX = 0.0000E+00 (#/CM^2*S) | POWER = 0.0000E+00 (MW/UNIT)

ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)
XE-135	7.4368715E-02	CS-133	1.8958842E+02	CS-134	6.6881525E+00
CS-135	5.7313826E+01	XE-133	4.0208226E+00	XE-131	7.9429858E+01

SIMULATED TIME = 1.0048E+00 Y | PAGE 22

NEUTRON FLUX = 0.0000E+00 (#/CM^2*S) | POWER = 0.0000E+00 (MW/UNIT)

ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)
XE-135	1.6831484E-02	CS-133	1.9009918E+02	CS-134	6.6820021E+00
CS-135	5.7386805E+01	XE-133	3.6938346E+00	XE-131	7.9657350E+01

SIMULATED TIME = 1.0075E+00 Y | PAGE 23

NEUTRON FLUX = 0.0000E+00 (#/CM^2*S) | POWER = 0.0000E+00 (MW/UNIT)

ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)	ISOTOPE	MASS(GRAMS)
XE-135	3.0953048E-03	CS-133	1.9056260E+02	CS-134	6.6758550E+00
CS-135	5.7401789E+01	XE-133	3.3177984E+00	XE-131	7.9867242E+01

KSIG - KANSAS STATE UNIVERSITY ISOTOPE GENERATION MICROCOMPUTER PROGRAM

by

FRED A. MONGER

B.S., Kansas State University, 1983

An Abstract of

A MASTER'S THESIS

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requirements for the degree

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ABSTRACT

During the operation of a nuclear reactor, a large variety of radioactive isotopes are produced. With this production comes the need to predict the concentrations of these isotopes. This task has traditionally been performed by the computer code ORIGEN2.

ORIGEN2 is a large computer code which, not only predicts isotope inventories, but also gives tables ranging from the gamma-ray emissions from these isotopes to their ingestion hazard. Some of the drawbacks of this code are: 1) it requires a large computer; 2) it uses a large amount of computer time; and 3) it provides a large amount of output.

The objective of this research was to overcome the drawbacks of ORIGEN2 and to reduce the cost of isotope inventory calculations. This was accomplished by the Kansas State Isotope Generation code (KSIG). KSIG is an isotope inventory code written for a microcomputer (HP9816). Several features of KSIG are: 1) its exclusive use of the Bateman equations and their appropriate approximations for the inventory calculations; 2) the large size of the problem being performed on a microcomputer; and 3) its extended use of temporary storage vectors as a means of reducing the volume of memory required to perform these calculations.

KSIG produced exactly the same results as a simple hand calculation and varied by no more than six percent when compared to ORIGEN2. The typical range of variation was from .5 to 3 percent. Output for this run was reduced from 190 to 27 pages.

The calculation time of KSIG was its one drawback, with an average calculation requiring hours of computational effort. However, when comparing the cost of computer time on a large computer to the purchase

and maintenance cost of a microcomputer, the microcomputer more than pays for itself with approximately 100 KSIG runs. Therefore KSIG meets its final objective and demonstrates itself as a useful tool for predicting isotope inventories.