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USER'S MANUAL FOR NOISY1 -
A PROGRAM FOR CALCULATION
OF SPACE DEPENDENT SPECTRAL DENSITIES
IN CUBICAL REACTORS

J. R. Sheff

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A PROGRAM FOR CALCULATION OF SPACE DEPENDENT
SPECTRAL DENSITIES IN CUBICAL REACTORS

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(a) Now employed by WADCO Corp., a Subsidiary of Westinghouse
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I. INTRODUCTION

A program for calculating space-dependent auto and cross spectral densities in bare cubical reactors has been under development for several years. For several reasons it seems at this time particularly appropriate to describe its capabilities and make it generally available. First, new measurement techniques have successfully revealed pure space-dependent effects. These effects are useful in themselves and dictate correction of the experimental data via space-dependent calculations. Second, these pure space-dependent effects occur in even relatively small systems and, hence, will be rather widely observable. Finally, some of the recent measurements are not explained well by either calculations with this system or with other known systems. By making this system generally available it can provide a basis for the extensions necessary to resolve the experimental and theoretical inconsistencies.

The calculated auto and cross spectral densities are evaluated from analytical expressions for nonperturbing point or cubical neutron detectors located arbitrarily in a cubical reactor. These analytical expressions, which are described in Section III, are based on one-energy-group diffusion theory including an arbitrary number of delayed-neutron groups. The solutions are expansions in Helmholtz modes resulting in a six-dimensional series. Because of its size, this series presents a sizable summation problem, the solution of which is discussed in Section V.

The program currently operates on a UNIVAC 1108 and is essentially written in FORTRAN IV but includes several unique features of UNIVAC FORTRAN V. There is a routine available⁽¹⁾ which can be used to generate a FORTRAN IV compatible version. Extension amounts of the output results are capable of being graphed by the printer using printer-constructed-graphs as part of the regular output. Key parts of the output are also stored on tape as individually named, unique absolute-data elements which can be directly reprocessed to obtain CALCOMP graphs of widely varied combinations of the results. These features are described in Sections IV and VI.

Feedback effects at a level of either one- and two-temperature coefficients are included as an available option, but only in a fundamental mode or space independent sense. The programming was done such that extension to more coefficients or to space-dependent temperature effects can be done easily.

The program input format is presented in Section VIII. The input and output for a small sample case are discussed in Section X. The auxiliary programs, SNOOPY and SEARCH/DESTRY, are discussed in Section IX. A program listing is not given, but the program is available from the author and will be available through the Argonne Code Center. The program tape contains a more extensive sample case.

II. SUMMARY AND CONCLUSIONS

The features of the NOISY1 program for calculation of space-dependent auto and cross spectral density functions of the noise in a nuclear reactor are described. Because of the long period over which this system has evolved, the extensive program which has resulted has many features advantageous to potential users of such calculations. The program is expected to be error free with respect to the basic formulation because of the extensive testing done during its evolution. Comparisons

have been made with a fundamentally different formulation of the same problem. Thus, NOISY1 can be assumed to be functioning correctly providing error free answers. NOISY1, therefore, provides a logical basis for doing planning and result analysis calculations for experimental tests.

Furthermore, for those many situations in which NOISY1 is still inadequate, it should provide an advanced basis from which to work toward a better, more complete solution of the space and energy dependent noise problem.

The program's basic modular structure provides a beneficial basis for any desired calculation, especially those which are not expected to be repeated many times.

Several unique uses of some of the features available on UNIVAC machines are described as applied to NOISY1, because they are of general benefit to the goal of convenient trouble-free programs.

The format for input data is described and input and output are given for a sample case.

III. THEORETICAL MODEL

The calculations performed by NOISY1 are the auto and cross spectral density functions of the neutron density and detector count rates in bare cubical reactors. The neutron density of the reactor is described by one-energy group diffusion theory, and the reactor has a source distribution which is a fundamental space mode. The spectral densities may be calculated at either localized points or for finite nonperturbing regions. The latter approximate detectors. These detectors fully overlap for the auto spectra case and do not overlap for the cross spectra case.

The theoretical development is published elsewhere^(2,5) and thus, will only be sketched briefly here. The auto and cross spectral density can be written as follows:

$$\begin{aligned}
 \Phi_{z_1 z_2}(\bar{r}_1, \bar{r}_2, \omega) = & C_0 \frac{(2/\Pi)^3}{abd} \Delta V \left\{ \left(\sum_{\bar{g}} G_{\bar{g}} R_{\bar{g}}^2(\bar{r}_1) \frac{(\delta k_{\bar{1}} + k_{\bar{1}}\beta)/\ell_{\bar{1}}}{(\delta k_{\bar{g}} + k_{\bar{g}}\beta)/\ell_{\bar{g}}} \right. \right. \\
 & + 2 \sum_{\substack{\bar{g}\bar{h} \\ \bar{g} \neq \bar{h}}} G_{\bar{g}\bar{h}} R_{\bar{g}}(\bar{r}_1) R_{\bar{h}}(\bar{r}_1) \frac{(\delta k_{\bar{1}} + k_{\bar{1}}\beta)/\ell_{\bar{1}}}{(\delta k_{\bar{g}\bar{h}} + k_{\bar{g}\bar{h}}\beta)/\ell_{\bar{g}\bar{h}}} \Bigg) \delta_{\bar{r}_1, \bar{r}_2} \\
 & + \epsilon' \left(\frac{k_{\bar{1}}}{\ell_{\bar{1}}} \right)^2 \left| 1 - i\omega \sum_{j=1}^N \frac{\beta_j}{i\omega + \lambda_j} \right|^2 \left(\frac{\bar{v}^2 - \bar{v}}{\bar{v}^2} \right) \\
 & \left(\sum_{\bar{g}} \frac{G_{\bar{g}} R_{\bar{g}}(\bar{r}_1) R_{\bar{g}}(\bar{r}_2)}{[\alpha_{\bar{g}}^2 + (\gamma_{\bar{g}}\omega)^2]} \right. \\
 & + \sum_{\substack{\bar{g}\bar{h} \\ \bar{g} \neq \bar{h}}} \frac{G_{\bar{g}\bar{h}} R_{\bar{g}}(\bar{r}_1) R_{\bar{h}}(\bar{r}_2)}{[\alpha_{\bar{g}\bar{h}} + (\gamma_{\bar{g}}\omega)^2 + i\omega \frac{L^2}{\ell} (B_{\bar{g}}^2 - B_{\bar{h}}^2)]} \Bigg) \Bigg\} \quad (1)
 \end{aligned}$$

The result has been arranged to emphasize which terms are real and which terms are complex, and the effect of delayed neutrons has been included. The detailed definitions of the quantities in Equation (1) have been given.⁽²⁻⁵⁾

Briefly, the G 's are constants, $R_{\bar{g}}(\bar{r}_1)$ and $R_{\bar{h}}(\bar{r}_2)$ are three-dimensional space eigenfunctions, $\bar{g}$ and $\bar{h}$ are triple summation indexes, and ϵ' is the detector efficiency. The quantity $\alpha_{\bar{g}}$ is approximately $(\delta k_{\bar{g}} + k_{\bar{g}}\beta)/\lambda_{\bar{g}}$ for large ω , and $\gamma_{\bar{g}}$ is approximately unity for large ω . The quantities $\alpha_{\bar{g}}(\omega)$ and $\gamma_{\bar{g}}(\omega)$, aside from their dependence upon higher order bucklings, are the usual quantities found in the spectral density, including delayed-neutron effects. That is, they are the real and the imaginary part of the in-hour equation where the roots have been taken as $i\omega$. The assumption of an extraneous neutron source distribution is necessary for the subcritical case, along with the previously noted assumption of one-energy-group diffusion theory. The source distribution shaped like a critical fundamental mode was chosen because it is the most interesting and realistic form. The generalization to the point source distribution can be easily made if desired.

The detector efficiency is given by

$$\epsilon' = \frac{\Sigma_d}{\Sigma_f} = \frac{v\Sigma_d n}{v\Sigma_f n}$$

and is the ratio of detector counts per unit volume to fissions per unit volume. The definition most frequently used in the space-independent theory is the ratio of total counts in the detector to total fissions in the reactor.

One interesting fact about Equation (1) obtained by numerical calculations is that, when the space-independent form, or the leading term of the series, dominates, it is not primarily because of rapid convergence. Instead, it usually is

because of a high degree of cancellation among the higher order terms. As a result, in a bare cube the individual breaks, in general, for higher order terms will not be observed as such since the deviation from the fundamental term is a complex sum of many terms.

The definition of the eigenfunctions, $R_g(\bar{r}_1)$, generalized to include the case of a finite detector of edge a' will be given as it has not appeared previously.

$$R_g(\bar{r}) = \sin \left[\frac{g\pi}{a} \left(x - \frac{a}{2} \right) \right] \sin \left[\frac{n\pi}{b} \left(y - \frac{b}{2} \right) \right] \sin \left[\frac{p\pi}{d} \left(z - \frac{d}{2} \right) \right] \\ \times \left[\frac{\sin \left(\frac{g\pi}{a} \frac{a'}{2} \right) \sin \left(\frac{n\pi}{b} \frac{a'}{2} \right) \sin \left(\frac{p\pi}{d} \frac{a'}{2} \right)}{\frac{1}{8} \left(\frac{g\pi}{a} \right) \left(\frac{n\pi}{b} \right) \left(\frac{p\pi}{d} \right) \Delta V} \right]$$

The quantity within the brackets represents the finite detector contribution and is identically equal to one for the case of $a' = 0$.

IV. PROGRAM FEATURES INDEPENDENT OF NOISY1 ITSELF

The basic modular system into which NOISY1 is installed is essentially a mathematical function calculating, tabling, and graphing program. The system is built up of modules as shown in Figure 1. The reason for proceeding in this manner was to develop a ready-to-go system having convenient features into which desired function evaluations could be inserted. To the writer of large extensive production systems, this is probably not too important a feature. But it is of the greatest benefit to the scientist or engineer user who has many varied and frequently short lifetime calculations. Everyone is well acquainted with the "quickie" program which prints out several

FIGURE 1. Basic Program Layout

pages of completely unidentified output which is totally useless to all except perhaps the writer. It is even difficult for the writer to wade through such results a week after such a program was last used.

The first subroutine or the "main" program has control over reading the general input quantities, control of the calling sequence of most other subroutines, and does the basic housekeeping chores of the program. This includes decisions about repeating calculation sequences for more data sets with or without mode changes and shutdown. Included are routines which recover from and generate shutdown procedures after "end of file" or "error" status is encountered by the system. These chores include production of an in-house accounting card showing operator name, run number, time spent, pages output, cards output, and to what account number it was charged. The error status routine currently recovers, providing this summary in all cases except when maximum time and page expectations are exceeded.

In keeping with the concept of general usage function evaluation, a five-dimensional matrix of input data is generated via specification of initial values, increments, and the number of points to be calculated. One dimension, the one associated with the frequency in the spectral density calculations, has a much more extensive system for specification of the input array. Least often used options are direct reading of an input data set and various linear incrementing schemes. The most used alternative is a logarithmic data generating scheme. As input, one specifies a starting point and up to three pairs of integers for the points per decade and the number of decades desired. The spacing of the points in a given decade is specified as either uniform or "almost" uniform. The first is ideal for plotting log information on linear paper and the second allows simple almost uniform plotting on typical log graph papers

because nearby integer values are picked. The uniform system is the one most generally used and is best for mechanized graph drawing machines.

The basic output routine is rather conventional and is tailored to the calculation being done. In the way of special features, however, it does check the specified neutron detector location to see if it either is or is near to a reasonable fraction of the reactor's size. If such a reasonable fraction is found, it is given as output along with its decimal equivalent to eight places. This is a useful check upon the input which is frequently specified as a fraction and has been occasionally entered incorrectly.

The tabular output routine is built around use of 15 three-dimensional arrays. Various quantities that are desired as output from the program are stored in these arrays. The logarithm of the array and/or a printer-constructed plot of the array or its logarithm may be included in the output by internally setting an integer associated with each array.

The problems created by stacks and stacks of computer paper are attacked in several ways by the NOISY1 system. The formats are automatically adjusted internally to reduce the number of output pages. For example, if only a few frequency points are desired, two tables are put on a page for a page savings of 25 to 50%. If only a few columns are desired on a page, the formats are adjusted to print more significant figures. If a plot constructed by the line printer is found to have zero range, it is skipped. The latter also saves much computer time.

The fifteen arrays and sizable amounts of the other output are stored on tape. The particular procedure for tape storage is also significant. The data is stored as named binary elements which can be moved from place to place using

the UNIVAC routines for subroutine and program manipulation. The ability to call these data elements by name and move them with the extensive routines for subroutine handling makes the procedure simple, convenient, and practical. The problems of keeping track of unidentified data sets stacked sequentially in tape or drum files is completely eliminated.

V. FEATURES OF THE NOISY1 CALCULATIONS

The actual subroutines for the calculations are split into four similar and essentially parallel paths (see Figure 2) for the four basic calculations done by the program. These are the auto and cross spectra calculations each for both point and finite detectors. These four paths are assigned to mutual core locations or "overlaid" via the UNIVAC Memory Allocator Processor (MAP).

The principle task performed by each of these paths is to simply evaluate and sum terms in the series solution. The task is not trivial even though each individual term is actually rather simple in form. The series is six-dimensional corresponding to the two detector points $\bar{r}_1$ and $\bar{r}_2$ (this is still true when $\bar{r}_1 = \bar{r}_2$). Six dimensions lead to a sizable term summation problem even when convergence would normally be considered good. For example, for the relatively nominal single-dimensional series requiring ten terms for adequate convergence, the equivalent six-dimensional series might require on the order of 10^6 terms.

It is possible, of course, to set up a single giant six-dimensional do-loop and proceed to evaluate all terms, large and small, within a cubical volume in the six space. This is very wasteful in terms of machine utilization and actually makes such calculations out of reach in terms of the funds available. Such an approach can be supplemented via checks of convergence, but because the region of maximum term size lies along and near

FIGURE 2. Program Flow in the Calculation Section Showing the Basic Paths.

to the six-dimensional diagonal, the checks become quite complex and time consuming. It is also desirable to have an alternate calculational scheme in view of the absence of information about the relative effects of various types of terms and their convergence in various situations.

The final basis for a workable system was to structure the program so that sums were first taken along and close to the diagonal in the six space. This was accomplished by first summing over the three-dimensional set of terms obtained by making equal the three pairs of indexes for the two points. Thus, for $\bar{r}_1$ and $\bar{r}_2$, the vector indexes $\bar{g}$ (g,m,p) and $\bar{h}$ (h,n,q) for which $g = h$, $m = n$, and $p = q$ are considered first and are called the diagonal terms. It should also be noted that all terms involving an even and an odd eigenfunction go to zero, so for convenience, the series is split along even and odd terms (sines and cosines). Out of the 64 combinations of a given set of even and adjacent odd indexes, only 8 are nonzero. Thus, when a specific term is mentioned, one is really talking about 8. When 10^6 terms are referred to, one means the 8×10^6 nonzero terms out of $20^6 = 64 \times 10^6$ terms possible.

It turns out that summations over this single set of diagonal terms usually yields an answer which very closely approximates the full summation. Thus, for all detector positions near the core center, the summation of 10^3 terms yields approximately the same result as would be obtained by blind summation of 10^6 terms or a 10^3 reduction in effort results without need of any convergence checks.

The convergence becomes slower as the outer edge of the cube is approached. This comparison between the "exact" answer and the approximation using only the terms diagonal in three dimensions or the "fully diagonal terms" (DDD) is shown in Figure 3 for the case of a detector at $3S/8$ on the diagonal of the cube. The approximation is seen to break down at large ω .

FIGURE 3. Comparison of the Auto Spectral Density Function and the "Fully Diagonal" Term Approximation

Inspection of the low frequency end of Figure 3 shows that the curves do differ in shape even in the plateau regions, but the difference does not become significant until about $\omega = 100$. For $\omega > 100$, the "exact" curve falls below the approximation, and approaches the infinite medium point detector shape, $\propto \omega^{-1/2}$, at $\omega \approx 10^4$. Note also that the slope of the "exact" result in the normal space-independent region, however, is $\propto \omega^{-2}$. The dashed curves will be discussed below.

The observation that in many cases the DDD terms are an adequate approximation has been freely utilized in the calculationally much more difficult problem of the spectrum in three region problems.⁽⁵⁾ In that case, the fully diagonal terms are the only ones which have been programmed at this time.

To improve upon the results obtainable via summation of the fully diagonal terms, one must then search for the next larger set of terms and sum these. The obvious next step then is to gradually move away from the six-space diagonal in other directions. It is beneficial to draw a comparison to the cube in three spaces. The summation of the fully diagonal terms has included all terms on the principle diagonal or by analogy along the diagonal running between opposite corners of a cube. These are the terms for which all of the 6 (3 pairs) indexes are equal. Also included have been terms along the minor diagonals such as the terms along the diagonal between opposite corners on the face of a cube. These correspond to the case where say 2 or 4 (1 or 2 pairs) indexes are equal to each other but not to the other 2 (1 pair) indexes.

At this point, one must move to even lower order diagonals which would correspond in the cube to terms along an edge. The analogy has, of course, started to break down at this point as these terms really correspond best to the fully nondiagonal terms. In any case, the next set of terms should be diagonal by pairs in four dimensions and nondiagonal in the other two.

The requirement upon the vector indexes $\bar{g}$ (g,m,p) and $\bar{h}$ (h,n,q) thus becomes $g = h$, $m = n$, and $p \neq q$ and the other two possible rotations of this. In the special case of auto spectra, further simplification results because of symmetry between the case when $p > q$ and $q > p$. Whether symmetry exists or not, however, one now must in some manner sum over these three four-dimensional series in which one index is restricted to values less than another. The programming is most simple if one sacrifices memory by neither attempting to utilize in tandem the already set up, fully diagonal term logic or the tandem usage of a single new four-fold do-loop. Thus one is led to three essentially identical loops which differ only in the manner in which the indexes are arranged. This fact is relevant in that there are in usage in many places machines of capacity quite inadequate compared to a UNIVAC 1108. Via expenditure or some programming effort, the storage requirements of the program could be reduced to a significant degree.

These additional terms, the "diagonal, diagonal, non-diagonal terms" (DDND), are less significant contributors to the result, and thus, the program makes provision for the user to sum these terms to a different level than that picked for the diagonal terms. It has been found through experience that the level should be picked at about two-thirds that of the fully diagonal terms. The actual value is, in general, not critical as the do-loops incorporate (also at the option of the user) a fairly high level of convergence checking and, hence, compensate quite well for a poor choice in this index.

The curves labeled 1 and 2 in Figure 4 are the DDD and DDND terms for the example given above in Figure 3. The sign of the DDND terms is negative and, hence, inclusion of only this additional set of terms would make the result negative for $\omega > 200$. The level of summation for the DDND terms is 4

FIGURE 4. Contributions to the Auto Spectral Density

for low frequencies and 6 for high frequencies. The change can be noted by the discontinuity in the curve near the break frequency.

The general attack upon the problem has been sufficiently well described now as to make a quantitative formulation of it useful to show clearly where one must next proceed to provide the capability of complete summation for at least check purposes. For a six-dimensional series, summed to a level of N , there are N^6 terms. Out of the N^2 in one pair of components, there are N terms which have equal indexes. This leaves $N(N - 1) = N^2 - N$ remaining and provides the clue to how one should express the N^6 terms. One has

$$\begin{aligned} N^6 &= \left\{ N [1 + (N - 1)] \right\}^3 \\ &= N^3 + 3N^3(N - 1) + 3N^3(N - 1)^2 + N^3(N - 1)^3 \end{aligned}$$

where the first term, N^3 , is the number of fully diagonal terms and the second term, $3N^3(N - 1)$, is the three sets of DDND terms. The third term is three sets of what will be referred to as "diagonal-nondiagonal-nondiagonal terms", DNDND, and the final term, $N^3(N - 1)^3$, is the set of "full nondiagonal terms", ND.

These last two sets of terms are also programed with control of the level of the number of terms left to the user in the sense that the DNDND is set at the same level as the DDND and the ND is adjustable directly through input.

The relative magnitudes of these four contributions are shown for the example case in Figure 4. The level of summation was 10 for the DDD terms, 6 for the DDND and DNDND terms, and 5 for the ND terms. For $\omega < \beta/\ell$, the level is reduced by 2 for all terms other than the DDD ones. The program was running with the convergence checking mode operating for these calculations, but because of the optimum choice of the

level of summation, the results differ significantly enough to be shown only when combined into the final results. The dashed curve above the solid line shown in Figure 3 is the same case without the convergence mode operating. For comparison, if the DDND, the DNDND, and the ND terms are summed to a level of 10 terms with convergence checking, the lower dashed curve is obtained.

The fully nondiagonal terms are almost never of significant consequences for the cases observed, so that by this choice of attack, one is able to eliminate from the calculation a very large fraction of the terms without necessity of any convergence checks. In quantitative terms, the fraction eliminated is

$$\frac{N^3(N-1)^3}{N^6} = \frac{(N-1)^3}{N^3} = 1 - \frac{3}{N} + \frac{3}{N^2} - \frac{1}{N^3}$$

or for the case of $N = 10$, seven-tenths of the terms can be easily eliminated.

As stated above, in the process of programming for the UNIVAC 1108, it was expediate to sacrifice machine capacity through almost redundancy in these latter summations rather than expend programming time.

The relative calculational effort required can be bracketed between $\frac{1}{N^3}$ for the fully diagonal terms only and $\approx 3/N$ for exclusion of only the fully nondiagonal terms where $N > 3$.

VI. OPERATION MODE AND DELETE CONTROL

The desire for displays of debugging information and benchmarks in a program usually poses the problem of how this can be accomplished without overloading the machines capacity and greatly slowing down operating speed with checks to see if printing is desired. Similarly, one frequently encounters a need for being able to calculate using more than one operational mode or

strategy. This is the case with NOISY1, and an ideal solution seems to exist with the combination of two operations available in UNIVAC FORTRAN-V.

In the UNIVAC system, the FORTRAN language programs (symbolics), the machine language programs (relocatables) and the coupled groups of machine language subroutines forming a full program (absolutes) are all named and stored on tape. The symbolics can be altered via a system allowing cards to be removed and/or inserted. Cards common to many symbolics may be named, stored separately once and then called automatically into a particular symbolic when compilation is taking place. This is the INCLUDE option.

Also available is a so-called DELETE option which provides a system for telling the compiler to either ignore or not ignore groups of cards at compile time. DELETE is a poor title, however, because although the chosen cards are deleted from the compilation, they are not deleted from the symbolic deck. Thus a better word is "Ignored". The key that allows the compiler to decide whether the referenced group of cards should be ignored or not is the value of an integer as specified by a PARAMETER definition card within the symbolic deck. This PARAMETER card can be most simply changed and easily routed to all desired places via the INCLUDE option.

Consider, as an example of this usage, the problem of convergence checking in the many series involved in this program. As will be noted below, the convergence in the presence of the trigonometric terms is not uniform, but oscillates about zero where the absolute maximum value is converging. Thus, the convergence checking is not always desirable and certainly should be checked in certain cases. One is also concerned about the time spent in checking versus the time required for excessive calculations without checking.

Hence, one would like to have two versions of the program, one with checking and one without. Normally such a situation results in at least frustration, if nothing more serious, in the attempt to keep the two versions identical with respect to improvements and revisions.

Implementing this system, to this case of a need for several operating versions, then proceeds as follows. At the end of each do-loop in which checks are desired, they are installed bounded before and after by two cards as specified by the DELETE option. One of these cards has present upon it a control integer whose value tells the compiler whether or not to ignore these cards when compiling. This control integer is set within the symbolic deck by compiler request from a group of similar symbolic cards stored together in a named element called a Procedures Definition Table.

The production of the two desired versions proceeds directly then by naming one set of "relocatables" and its "absolute" one name and the other set another. Both, however, are produced from the same set of "symbolic" decks. At compile time, in one case the single relevant card in the Procedures Definition Table is used as it is, and in the other case it is changed immediately before compilation to the alternate value. That is, the integer parameter is changed in value from zero to one or the reverse.

The system is also used in the program to include options for calculating fewer terms at frequencies below the break than above and to allow one to print out basic information for each term in the series.

The debugging of the program has been under this type of control for some time now in an "install what is necessary at the time" manner. Hence, many debugging problems are now being answered by merely rerunning the problem containing the difficulties after recompiling the relevant subroutines with

the debugging parameter card set so as to include in the compilation such debugging cards as are available.

VII. SERIES CONVERGENCE AND THE EXISTENCE OF HIGHER ORDER BREAKS

The series convergence can be easily determined by inspection of Equation (1). Consider first the diagonal terms which appear as the first summation of the last line of Equation (1). $G_{\bar{g}}$ starts at $(4/3)^3$ and asymptotically approaches one, and the eigenfunctions in general oscillate between minus and plus one. Thus one must depend upon the denominator for convergence. Clearly for all terms with $\gamma_{\bar{g}}^{-\omega} > \alpha_{\bar{g}}^{-}$, the series will not converge; thus one must always sum up to terms where $\alpha_{\bar{g}}^{-}$ is sufficiently large that the series will converge.

Inspection of the various nondiagonal terms, the second summation in the last line of Equation (1), reveals exactly the same situation except that convergence is also aided by the coefficient $G_{\bar{g}\bar{h}}$ which goes to zero as the disparity between $\bar{g}$ and $\bar{h}$ increases.

The lowest order terms are shown in Figure 5. The top curve is the fundamental mode or space independent term and has three pairs of cosines in the eigenfunctions. The second curve is the next high mode, and because of symmetry, there are three such terms each containing two pairs of cosines and a pair of sines. The bottom curve has two pairs of sines and one pair of cosines and again represents three terms. The center curve has three pairs of sines. The discontinuity at the left edge of the lines indicates the asymptotic level neglecting delayed neutrons.

Note how closely all the higher order break frequencies are bunched together as compared to the separation of the fundamental and the first higher order break. The breaks become progressively more compressed at a rapid rate which

FIGURE 5. The Lowest Order Terms in the Auto Spectral Density. See text for Explanation of the Labels.

essentially rules out the possibility of discrete separate breaks appearing in the final sum. In fact, there are about 512 terms having break frequencies less than 10^4 for the case considered.

VIII. USER'S INFORMATION

As noted in Section VI, the program can exist in a number of operating modes (two principle ones at this time), but this does not alter the input format or structure. The basic input element consists of eight cards for a single case. Multiple cases can be run with various modes of repetition of the basic eight data cards. Indeed because the program is built about a general calculating system plus a particular calculation, the flexibility of the system in this case outstrips the needs of the calculation. This is because the calculation is complex and long. In other words, the system will allow one to quickly set up a complete solution of interest in only eight cards, but it might well out run the allotted budget. Hence, it is usually desirable to use more cards so that the results for single cases can be checked as an aid toward planning additional desired calculations. For more modest goals, say for example, the space independent case (i.e. fundamental mode), all cases of logical interest can be run with eight cards at only a modest expenditure of time. The new user should start slowly away from the sample case in the search for his own compromise between the number of data sets versus a single complex data set.

The first five input cards enter the main subroutine, KILD5C. With reference to Figure 1, these cards are the "basic input." Their format and function are given in Table 1. Cards 6 and 7 enter routines which generate a tabular array of parameters. There are two such routines, and each has its own input format. Both generate a five-dimensional array of input

TABLE 1. Basic Input for NOISY1

FIRST CARD *****

COLUMNS	FORMAT	CONTENTS
1-10	1PE10.3	ARBITRARY NORMALIZATION CONSTANT. USUALLY BASED UPON MEAN NEUTRON DENSITY OR COUNT RATE. NEGATIVE GIVES NEUTRON DENSITY SPECTRA. IF FEEDBACK, THE COUNT RATE MODE NOW GIVES DENSITIES. POSITIVE GIVES COUNT RATE SPECTRA.
GOOFED UP		BLANK GIVES STANDARD NORM. FOR NO POWER OR MATERIAL CHANGES IN SYSTEM.
11-20	1PE10.3	INFINITE MEDIUM PROMPT NEUTRON LIFETIME - SMALL $L = 1.0 / V \text{ SIGMA-A}$.
21-30	1PE10.3	DIFFUSION LENGTH ----- ($D/\text{SIGMA A}$)**1/2 (MIGRATION LENGTH)
31-35	I5	LINLG = -1 READ IN X(I) (USES LOG ROUTINE) 0 FOR LOG TABLE 1 FOR GENERAL TABLE
36-40	I5	NGRID, FOR OMEGA = $2 \cdot \text{PI} \cdot F$ ONE HAS- INPUT OUTPUT =0 OMEGA OMEGA =1 F F =2 F OMEGA =3 OMEGA F
AT THIS MOMENT ONLY NGRID = 0 OR 3 OPERATIVE.		
ENTER NEXT 1 AS ZERO FOR CUBE SPECTRA.		
41-45	I5	NMCK, RANGE, IN DECADES, OF INTEGRATION.
46-50	I5	NSTOP, ENTER ZERO TO TEN FOR VARYING NUMBER OF TERMS RETURNED FOR AUTO, EQUALS NINE FOR CROSS.
51-52	I2	IP = 0, NO EFFECT. = POSITIVE IS UPPER SUM LIMIT FOR Y DIRECTION RATHER THAN NT1, NT2, AND NT3 = NEG. IS Y SUM LIMIT - NON Y, DIAG. ONLY
53-54	I2	JP, -1 GIVES FUNDAMENTAL MODE SPECTRUM, 0 GIVES REGULAR CUBE SPECTRA, AND ABOVE OPTION APPEARS REMOVED, REASON UNKNOWN NOW.
55-56	I2	KP, EQUALS ZERO, REGULAR SPECTRUM EQUALS ONE, ONE QUADRANT OF CUBE
57-58	I2	LP, GREATER ZERO, IS CROSS SPECTRUM = 0 IS AUTO SPECTRUM
59-60	I2	NO, LOGICAL NO. OF OUTPUT. IF ZERO, WILL BE SET TO 6.
61-62	I2	NT1 NUMBER OF DIAGONAL TERMS PER DIMENSION.
63-64	I2	NT2 NUMBER OF ALMOST DIAGONAL TERMS.
65-66	I2	NT3 NUMBER OF TOTAL NON-DIAGONAL TERMS. MAXIMUM IS 15.
67-68	I2	NCONTR, - CONTROL INTEGER. =0, BARE CUBE - POINT DETECTOR. =1, FINITE DETECTOR =2, FEED BACK - POINT DETECTOR. CARD 3A IS REQUIRED.
69-70	I2	NFDBK, NUMBER OF FEED BACK COEFFICIENTS.

TABLE 1. (contd)

SECOND CARD *****

COLUMNS	FORMAT	CONTENTS
1-10	1PE10.3	SS, DETECTOR POSITION X2 (BLANK FOR AUTO)
11-20	1PE10.3	TT, DETECTOR POSITION Y2 (BLANK FOR AUTO)
21-30	1PE10.3	UU, DETECTOR POSITION Z2 (BLANK FOR AUTO)
31-40	1PE10.3	AAA, X - DETECTOR EDGE
41-50	1PE10.3	BBB, Y - DETECTOR EDGE
51-60	1PE10.3	DDD, Z - DETECTOR EDGE

THIRD CARD *****

COLUMNS	FORMAT	CONTENTS
1-10	1PE10.3	B1, CUBE SIZE
11-20	1PE10.3	B2, DETECTOR EFFICIENCY IN COUNT SPECTRUM.
21-30	1PE10.3	B3=VOL OR THE DETECTOR VOLUME
31-40	1PE10.3	FISENG, FISSION ENERGY RELEASED, MEV
41-50	1PE10.3	VELFLD, FLUID VELOCITY IN CHANNELS (CM/SEC)

3A CARD *****

REQUIRED IF (COL 67-68 OF CARD ONE) NCONTR = 2.

COLUMNS	FORMAT	CONTENTS
1-10	1PE10.3	GAIN, A FEED BACK GAIN CONSTANT
11-20	1PE10.3	TCOEF, TEMPERATURE COEFFICIENT, DEL-K/DEG C. FROM CRITICAL YES, ITS ENTERED NEGATIVE FOR A NEG. TEMP. COEF.
21-30	1PE10.3	HTCP, SPECIFIC HEAT OF REACTOR J/CC DEG C.
31-40	1PE10.3	UHEAT, HEAT TRANSFER COEFFICIENT
41-50	1PE10.3	TGOOP, OPERATING TEMPERATURE, DEG. C.
51-60	1PE10.3	TSINK, SINK TEMPERATURE, DEG. C,
61-70	1PE10.3	TBASE, BASE TEMP. COEF. (CRIT.) DEG. C

FOURTH CARD *****

COLUMNS	FORMAT	CONTENTS
1- 6	I6	NUMBER OF DELAY GROUPS.
	6F11.8	DELAYED NEUTRON FRACTIONS - BETA(I). (UP TO NEXT SIX FIELDS)

FIFTH CARD *****

COLUMNS	FORMAT	CONTENTS
	6F12.8	DELAYED NEUTRON DECAY CONST. - LAMBDA(I).

parameters over which the spectra is to be evaluated. In NOISY1, the input to this array frequently is made degenerate in several of the five dimensions. The principle dimension is that of frequency, and the two subroutines available, TABLOG and TABLIN, treat the frequencies in a logarithmic or linear fashion, respectively. If the desired frequencies are spaced equally or semiequally on log scales, then TABLOG is used and Cards 6 and 7 are as described in Table 2. They enter TABLOG under the direction of a control integer in Column 35 of Card 1.

TABLOG allows two choices as to how the points will be spaced within a single decade of the log scale. Equal spacing allows more convenient machine or hand plotting of the logarithmic data on linear paper. The semiequal option automatically picks near equally spaced round numbers such as those which appear on standard log graph paper scales. Along with a starting value, the user can pick up to three sets of points-per-decade and number-of-decades.

TABLIN can be used to generate straight linear arrays as well as quite complex arrays of basically linear-oriented data. Indeed TABLIN can generate almost the equivalent of log arrays, but it is much more difficult to operate at such levels of complexity. The TABLIN format for Cards 6 and 7 is given in Table 3.

The last card, Card 8 for TABLOG and Card 9 for TABLIN, is picked up in the tabular output section of the program by the subroutine PRIN. It is a title card and consists of 80 hollarith characters.

Cards 6 to 8 or 9, may be repeated (in the initial format) any number of times, and the system is shutdown by a blank card. By control characters in otherwise blank pairs of Cards 6 and 7,

TABLE 2. Input for Frequencies Spaced Uniformly
on a Logarithmic Scale

SIXTH CARD *****

COLUMNS	FORMAT	CONTENTS
1-10	1PE10.3	FIRST ANGULAR FREQUENCY OR TIME. THIS, IN GENERAL, SHOULD BE 10.**N, IF NOT, BEST PICK AS ONE OF OTHER VALUES FOR THAT NO. OF STEPS SO THAT WILL REPEAT ITSELF, I.E. PICK 1/4 POINT TO START AND THEN 1/2 AS STEPS.
11-12	I2	BLANK FOR CONVENIENT GRAPH SPACING, ALLOWED VALUES - 2,3,4,5,8, AND 10. ONE FOR UNIFORM SPACING ON LOG SCALE, MAXIMUM NO./DECADE 50
13-14	I2	NUMBER OF PAIRS OF INPUT, MAXIMUM NO. =THREE
15-16	19-20	23-24 I2
17-18	21-22	25-26 I2
		NUMBER OF DECADES.
		IF X(I) IS READ BY LIST, FIRST OMEGA NUMBER IS THE LENGTH
		IF COLS17-18 IS NEGATIVE, PROGRAM WILL CALL FOR ANOTHER PAIR OF CARDS BEFORE STARTING CALCULATIONS. AFTER COL 26, ONLY A 1 IN 49 IS REQUIRED IN FIRST PAIR OF CARDS.
27-36	1PE10.3	FIRST DELTA MULTIPLICATION CONST. - 1.-K IN DOLLARS.
37-46	1PE10.3	DELTA MULTIPLICATION CONSTANT INCREMENT.
47-49	I3	NUMBER OF DELTA K VALUES -- NOT OVER FOUR.
50-59	1PE10.3	FIRST PARALLEL SEP. DIST. OR X1,X2,Z1,Z2 VALU
60-69	1PE10.3	FIRST PAR. SEP. DIST. OR X1,X2,Z1,Z2 VAL. INC
70-72	I3	NUMBER OF SEPARATION VALUES -- NOT OVER FOUR

SEVENTH CARD *****

COLUMNS	FORMAT	CONTENTS
1-10	1PE10.3	FIRST INITIAL PERPENDICULAR POINT.
11-20	1PE10.3	DELTA INITIAL PERPENDICULAR POINT INCREMENT.
21-23	I3	NUMBER OF INT. PER. POINT VALUES--NOT OVER 4
24-33	1PE10.3	FIRST FINAL PERPENDICULAR POINT.
34-43	1PE10.3	DELTA FINAL PERPENDICULAR POINT INCREMENT.
44-46	I3	NUMBER OF FIN. PER. POINT VALUES--NOT OVER 4

7A CARD *****

REQUIRED IF (COL 31-35 OF CARD ONE) LINLG = -1.

COLUMNS	FORMAT	CONTENTS
1-80	1P8E10.3	LIST - IN X(I)-S. 8 PER CARD

IF COLUMNS 11-12 ARE 1, MINIMUM NUMBER OF POINTS IS 2, ONE DECADE APART. USE 11-12 = 0, THEN NUMBER OF POINTS IS 1 (15-16 AND 17-18 ARE 1)

TABLE 3. Input for Frequencies Spaced
Uniformly on a Linear Scale

SIXTH CARD *****

COLUMNS	FORMAT	CONTENTS
1-10	1PE10.3	FIRST ANGULAR FREQUENCY.
11-20	1PE10.3	OMEGA INCREMENT.
21-23	I3	NUMBER OMEGA VALUES OR NUMBER OF OMEGA VALUE PER SET OF INCREMENTS AND STARTING VALUES. SET LIMIT 50 , TOTAL LIMIT 50 .
24-26	I3	NO. MULTIPLIER SETS FOR OMEGA VALUES, MAX 3.
27-36	1PE10.3	FIRST DELTA MULTIPLICATION CONSTANT - 1.0-K. IN UNITS OF DOLLARS FOR BARE CUBE PROBLEM.
37-46	1PE10.3	DELTA MULTIPLICATION CONSTANT INCREMENT.
47-49	I3	NUMBER OF DELTA K VALUES -- NOT OVER FOUR.
50-59	1PE10.3	FIRST PARALLEL SEP. DIST. OR X1,X2,Z1,Z2 VALU
60-69	1PE10.3	FIRST PAR. SEP. DIST. OR X1,X2,Z1,Z2 VAL. INC
70-72	I3	NUMBER OF SEPARATION VALUES -- NOT OVER FOUR

SEVENTH CARD *****

COLUMNS	FORMAT	CONTENTS
1-10	1PE10.3	FIRST INITIAL PERPENDICULAR POINT.
11-20	1PE10.3	DELTA INITIAL PERPENDICULAR POINT INCREMENT.
21-23	I3	NUMBER OF INT. PER. POINT VALUES--NOT OVER 4
24-33	1PE10.3	FIRST FINAL PERPENDICULAR POINT.
34-43	1PE10.3	DELTA FINAL PERPENDICULAR POINT INCREMENT.
44-46	I3	NUMBER OF FIN. PER. POINT VALUES--NOT OVER 4

EIGHTH CARD *****

COLUMNS	FORMAT	CONTENTS
1- 7 25-31 49-55	1PE7.3	FIRST OMEGA BASE MULTIPLIER.
8-14 32-38 56-62	1PE7.3	FIRST OMEGA MULTIPLIER.
15-21 39-45 63-69	1PE7.3	FIRST OMEGA INCREMENT MULTIPLIER. RELATIV TO BASE DECADE SIZE. THE OMEGA MULTIPLIE IS USED FOR THE LARGE ORDER PART OF SHIFT
22-24 46-48 70-72	I3	NUMBER OF TIMES MULTIPLIER OPERATES.

one can switch from TABLIN to TABLOG or cause either a whole or partial new set of cards to be read. The input signals for these options are given in Table 4.

IX. THE AUXILIARY PROGRAMS SNOOPY AND SEARCH/DESTROY

To construct graphs such as those included in this report, two auxiliary programs are utilized. This approach has been adopted because it allows much greater flexibility. In NOISY1, merely graphing the results is not desired as this is done adequately by the printer-constructed plots which appear with the tabular output. The printer constructed plots are preferred for this purpose because they remain an integral part of output and they are not subject to plotter turn-around delays. Therefore, the CALCOMP graph drawing program was designed to serve for report graph preparation and data comparisons between runs. In keeping with the spirit of the latter use, it is called SNOOPY.

To obtain such flexibility, the output of each NOISY1 run includes a binary data file which is assigned a name and stored along with the program in the Program Complex File (PCF). These data files can be moved about, called, deleted or handled in other ways just as a program element by use of the UNIVAC control routines.

Before SNOOPY can produce plots, one or more of these data absolutes must be processed by a code dubbed SEARCH/DESTROY. Via a very flexible, but unfortunately quite cumbersome, set of data cards, a series of arrays is generated and stored in another binary data file. This final data file is then used as input into SNOOPY. Actually, SNOOPY is also built about a scaled-down version of the general system that NOISY1 is made of. The input data format for SEARCH/DESTROY and SNOOPY are give in Tables 5 and 6.

In conclusion, the graphs in this report were generated using these graph routines and the CALCOMP plotter.

TABLE 4. Summary of Options Causing a Repeat of Various Case Types

FOLLOW -1-5- CARDS WITH ANY NUMBER OF 6 TO 9 LINEAR CARDS OR 6 TO 8 LOG CARDS OF THE SAME TYPE.

OTHER OPTIONS	---	PRECEED WITH CARD AS BELOW PLUS ONE OR TWO BLANK ONES.			
		LINEAR	LOG		
NEW 1-5 CARDS.	-1	21-23	15-16		
NEW 4-5 CARDS, SAME FORM.	-2	21-23	15-16		
LOG TO LIN AND					
LIN TO LOG, SAME 1-5 CARDS.	+1	21-23	15-16	-1	47-4
NEW 4-5 CARDS.	-2	21-23	15-16	-1	47-4
NEW 1-5 CARDS		USE OPTION ABOVE FOR NEW 1-5 CARDS			

FOLLOW DATA WITH TWO BLANK CARDS
THIS MUST BE DONE FOR A CONTROLLED SHUTDOWN.

FOR BARE CUBE, THE FIVE DIMENSIONS ARE X1,Y1,Z1,DELTA K IN DOLLARS SUBCRITICAL , AND FREQUENCY.

TABLE 5. Input for SEARCH/DESTROY

FIRST CARD *****

COLUMNS	FORMAT	CONTENTS
1-5	I5	NDAT = NUMBER OF DATA FILES. MAX = 5.
6-10	I5	NLPG = NUMBER OF LINES PER GRAPH IF NDAT = 1

SECOND CARD *****

COLUMNS	FORMAT	CONTENTS
1-5	I5	NTPE = THE NUMBER OF RUNS ON DATA FILE NN MAX = NDAT
6-10	I5	NVARRY = 0 JUST CHECK DATA = POSITIVE. GENERATE GRAPH = NEGATIVE. FIX DATA FILE
15-20	A6	NAME = GENERATED DATA FILE NAME
25-30	A6	VERSION = GENERATED DATA FILE VERSION.
31-35	I5	NDUM NOW. CHANGE DECK VIA CARD 3
36-40	I5	NGRAPH = NO. OF GRAPHS
41-45	I5	NMODFX = MODIFICATION NUMBER IF MAKING NEW.
46-50	I5	NSAVTM = NUMBER OF CHANGE CARDS FOR SAV(I).
51-55	I5	NATMS = NUMBER OF CHANGE CARDS FOR A(I).

THIRD CARD *****

COLUMNS	FORMAT	CONTENTS
1-80	16I5	ILPG = LINES PER GRAPH FOR EACH GRAPH. IF ANY BLANK, LAST NON ZERO USED ENTER NGRAPH OF THEM

TYPE FOUR CARDS *****
THERE SHOULD BE NGRLNS/3.0 OF THESE.

COLUMNS	FORMAT	CONTENTS
1-5 26-30	51-55 I5	NTPEN(I) = DATA SET NUMBER FOR LINE I.
6-10 31-35	56-60 I5	NAUT(I) = THE AUT NUMBER OF LINE I.
11-15 36-40	61-65 I5	J(I) = THE J INDEX FOR LINE I.
16-20 41-45	66-70 I5	K(I) = THE K INDEX FOR LINE I.
21-25 46-50	71-75 I5	THEKEY(I) = SCALE FACTOR FOR DATA IF NON ZERO.

TYPE FIVE CARD *****

COLUMNS	FORMAT	CONTENTS
1-48	8A6	SUDS(I) = GRAPH ORDINATE AND ABSCISSA TITLES.

TYPE 5A CARD *****
REQUIRED IF(COL 6-10 ON CARD 2) NVARRY = -1
AND IF(COL 41-45 ON CARD 2) NMODFX = 0

COLUMNS	FORMAT	CONTENTS
1-4	I4	LSDS = LENGTH OF CHANGE PER A6.
5-8	I4	NSDS = STARTING ADDRESS OF CHANGE.
9-80		
OR 1-72	12A6	SUDS(I) = THE CHANGE.

TABLE 6. Input for SNOOPY

INPUT IS ON SEVEN CARD TYPES AS FOLLOWS

FIRST CARD *****

COL 1 TO 40 ARE BLANK IF (COL 6-10 OF CARD 4) NDAT = 0.

COLUMNS	FORMAT	CONTENTS
1-10	1PE10.3	FIRST A
11-20	1PE10.3	A INCREMENT
21-30	1PE10.3	FIRST X
31-40	1PE10.3	X INCREMENT
41-45	15	NA - NUMBER OF A VALUES NOT OVER 10
46-50	15	NX - NUMBER OF X VALUES NOT OVER 1000
51-55	15	PAGE CONTROL. IF GREATER THAN ZERO, THIS WILL BE FIRST PAGE NUMBER. IF ZERO, PAGE NUMBERING WILL CONTINUE WITH PREVIOUS CASE.
56-60	15	NLOGX = 0 REGULAR AXIS 1 LOG AXIS
61-65	15	NLOGY = 0 REGULAR AXIS 1 LOG AXIS
66-70	15	NEWTIT = 0 READS A TITLE CARD 1 USES OVER LAST TITLE (IF NOT FROM TAPE)
71-75	15	NLABL = 2 I, J LOCATE LABELS 1 READ IN LABEL CARD 0 NO LABEL ON LINES
76-80	15	NFILE = FILE NUMBER OF PLOTS ON TAPE (BLANK YIELDS FILE 1)

SECOND CARD *****

IF LEFT BLANK IN ANY FIELD, THE PROGRAM WILL
CALCULATE A VALUE.

COLUMNS	FORMAT	CONTENTS
1-10	1PE10.3	ABSORG - STARTING VALUE OF X
11-20	1PE10.3	ABSINC - INCREMENT VALUE OF X
21-30	1PE10.3	ORDORG - STARTING VALUE OF Y
31-40	1PE10.3	ORDINC - INCREMENT VALUE OF Y
41-50	1PE10.3	FACT - MULTIPLIER CONTROLLING PLOT SIZE
51-60	1PE10.3	ROTE - ANGLE OF ROTATION OF PLOT
61-70	1PE10.3	XTIT - IN INCHES FROM SCALE ORIGIN (BASE 1 IN)
71-80	1PE10.3	YTIT - IN INCHES FROM SCALE ORIGIN (BASE 3 IN)

THIRD CARD *****

COLUMNS	FORMAT	CONTENTS
1-10	1PE10.3	DEL = LENGTH IN INCHES OF DASHES IN LINES 0 - ZERO, LINE IS SOLID.
11-20	1PE10.3	GAP - LENGTH OF GAP BETWEEN DASHES. BLANK IF LINE IS SOLID.

TABLE 6. (contd)

EVENTUALLY THIS CARD SHOULD CONTROL LINES 1 TO NA
(COL 41-45 CARD ONE)

FOURTH CARD *****

COLUMNS	FORMAT	CONTENTS
1- 5	I5	NTIT = 0 TITLE AS IS 1 TITLE FROM TAPE
6-10	I5	NDAT = 0 AS IS 1 READ X, A, V FROM CARDS 2 READ X, A, V FROM TAPE
11-15	I5	NAXS = 0 AS IS 1 NAX(J) FOR EACH J
16-20	I5	NABLBL = 0 ABSISSA LABEL FROM TAPE 1 ABSISSA LABEL FROM CARD 4B
21-25	I5	NORDLB = 0 ORDINATE LABEL FROM TAPE 1 ORDINATE LABEL FROM CARD 4B
26-30	F5.3	ASIZ = MINIMUM LETTER SIZE IF NON ZERO
31-80	10I5	NAX(J) FOR J = 1 TO 10

C

TYPE 4A CARD *****

REQUIRED IF (COL 71-75 ON CARD 1) NLABL = 1
OR NLABL = 2

THERE SHOULD BE NA/3.0 OF THESE. IF THE FIRST OF THESE CARDS
IS BLANK, THIS OPTION IS SKIPPED.

COLUMNS	FORMAT	CONTENTS
1-3	F3.1 OR I3	XSTAR(1) VALUE OF X ORIGIN IN INCHES OR NLIN(1)
4-6	F3.1 OR I3	YSTAR(1) VALUE OF Y ORIGIN IN INCHES OR NPNT(1)
7-9	F3.1	XINC(1) INCREMENT OF X IN INCHES
10-12	F3.1	YINC(1) INCREMENT OF Y IN INCHES
13-15	I3	ICHAR(1) = - TO THE LEFT OF ORIGIN START + TO THE RIGHT OF ORIGIN START
16-25	10H	LNLBL(1) - LABEL FOR LINE ONE.
26-28	F3.1 OR I3	XSTAR(2) VALUE OF X ORIGIN IN INCHES OR NLIN(2)
29-31	F3.1 OR I3	YSTAR(2) VALUE OF Y ORIGIN IN INCHES OR NPNT(2)
32-34	F3.1	XINC(2) INCREMENT OF X IN INCHES
35-37	F3.1	YINC(2) INCREMENT OF Y IN INCHES
38-40	I3	ICHAR(2) = - TO THE LEFT OF ORIGIN START + TO THE RIGHT OF ORIGIN START
41-50	10H	LNLBL(2) - LABEL FOR LINE TWO.
51-53	F3.1 OR I3	XSTAR(3) VALUE OF X ORIGIN IN INCHES OR NLIN(3)
54-56	F3.1 OR I3	YSTAR(3) VALUE OF Y ORIGIN IN INCHES OR NPNT(3)
57-59	F3.1	XINC(3) INCREMENT OF X IN INCHES
60-62	F3.1	YINC(3) INCREMENT OF Y IN INCHES
63-65	I3	ICHAR(3) = - TO THE LEFT OF ORIGIN START + TO THE RIGHT OF ORIGIN START
66-75	10H	LNLBL(3) - LABEL FOR LINE THREE.

TABLE 6. (contd)

TYPE 4B CARD *****

NEW - OPTIONAL

REQUIRED IF(COL 16-25 ON CARD 4) EITHER NABLBL = 1
OR NORDLB = 1

COLUMNS	FORMAT	CONTENTS
1-24	4A6	E(I) ABSISSA LABEL
24-48	4A6	F(I) ORDINATE LABEL

FIFTH CARD TYPE *****

TITLE OR NAME OF FUNCTION - HOLLERITH

COLUMNS	FORMAT	CONTENTS
1-40	40H	C = FIRST 1/2 OR LINE ONE OF TITLE
41-80	40H	D = SECOND 1/2 OR LINE TWO OF TITLE

5A CARD *****

REQUIRED IF(COL 6-10 OF CARD FOUR) NDAT = 1

COLUMNS	FORMAT	CONTENTS
1-80	1P8E10.3	LIST ALL X, ALL A, ALL V-S. 8 PER CARD.

FOLLOW DATA WITH ONE BLANK CARD

X. SAMPLE CASE

On the pages which follow is the input card list and the output for a sample case of all three programs. This is followed by the CALCOP plots generated.

The input deck for the UNIVAC 1108 is shown in Table 7. The execution of the three programs, NOISY1, SEARCH/DESTROY, and SNOOPY starts on lines 8, 22, and 30.

The blank appearing in Column 35 (5 spaces after the third piece of data) of the ninth card indicates that TABLOG is being used. Therefore the data in the sixteenth and seventeenth card is described in Table 2. The two blank cards, 19 and 20 cause TABLOG to shutdown the calculations in an orderly fashion. The need for these cards is indicated in Table 4 along with the other control options.

Card 21, the DAT card, instructs the machine that the binary data set CUBSPC/542053 is to be read by the next program. CUBSPC/542053 is stored on a fast drum file along with other similar files, the three programs, and all of the subroutines used to create the program. The execution of NOISY1 produces an element with the same name, CUBSPC, but with a version set equal to the log number of the run.

The execution of SEARCH/DESTROY will produce a data element named BASICS/AUTEST containing data for two graphs. Line 29 is the DAT card telling the machine that SNOOPY will read such an element.

SNOOPY then cycles twice; Cards 31 to 36 and 37 to 43. Card 44 shuts down the execution of SNOOPY in an orderly fashion.

The output from the sample run is given in Table 8. The execution of NOISY1 occurs on Page 38. It is followed by a statement of the time since the job was started. The first five input cards are then displayed. General output

appears on pages 39 and 40 and is all self-explanatory. The comment "ERROR=" on the left side of page 40 under "The Calculation Term Status" is currently irrelevant.

Page 41 starts the tabular output. Two data sets are put on a page because only 9 points were requested. These are followed by plots of the logarithm of the first data set. The second data set is not plotted. This configuration is controlled by the internal setting of integers in the subroutines calling the print routine. Two plots appear after the two arrays of data on page 43. The overrun of data in a plot is signaled by the appearance of an L or H instead of a * on the left or right edge of the graph. On page 48, the table of the logarithm has been suppressed. The program wrap-up information appears on page 52.

The printed output from SEARCH/DESTRY is not identified and will not be described here. The program's purpose is not to produce printed output, but to produce the desired data set. It is anticipated the present output will eventually be shut off except for debug.

The execution of SNOOPY starts on page 58. The lines being plotted are also tabulated in tables. Also shown is information on the scales for the plots to aid in adjusting to potentially more desirable ones.

TABLE 7. UNIVAC 1108 DATA DECK for the Test Case

```

1 @O RUN 5,CUB017, 300.5000 SHEFF
2 @RX ASG A=U0761
3 @RX ASG W B=U9380
4 @RX ASG W H=U1905
5 @N XGT CUR
6 IN A
7 TRI A
8 @N XGT NOISY1/NOPT1
9 116.3686 6.00747-05 2.880E 00 10 1 0 6 9 6 5 8 5 4
10
11 5.000E+01 0.0012 2.5 E+01
12 6 0.0027 0.00074 0.00253 0.00125 0.0014 0.00021
13 3.01 1.14 0.301 0.111 0.0305 0.0124
14 3.162277-2 1 2-1 1
15
16 1.0 E-00 1 3 1 1 2 1 1 2 0.0 E 00 6.0 E 00 2 2.000E+01 1
17 0.000E+00 1 0.000E+00 1
18 0 BASIC SAMPLE CASE FOR CUBE AUTO SPECTRAL DENSITY.
19
20 @ DAT CUBSPC/542053*2
21 @N XGT SEARCH/DESTROY
22
23 1 1 BASICS AUTEST 2
24 2 4
25 1 10 1 1 1 10 2 1 1 10 1 1
26 1 14 1 1 1 13 1 1 1 1 1
27 FREQUENCY, R/SEC AMPLITUDE
28 @N DAT BASICS/AUTEST*3
29 @N XGT SNOOPY
30
31 2 9 -90.0 1 1 0 2 3
32 0.56
33
34 2 1 1
35 1 71.00.5 CRITICAL 2 6--51.0-106$ SUB CRT
36 AUTO SPECTRA FOR ZERO AND SIX DOLLARS SUB. (AUT10)
37 -2.0 0.8 -2.0 0.25 0.56 -90.0 1 1 0 2
38
39 2 1 1
40 3 30.51.5 +4 X WHITE 4 51.01.0 NON W + WH 2 8-2.1.0-101/4X WHITE
41 1 7-1.-1.- 9NON WHITE
42 VARIOUS WHITE LEVEL
43
44 @N XGT CUR
45 OUT B 2.7.4.3.1
46 TEF B
47 TRI B
48 TOC
49 @ FIN
50

```

TABLE 8. Output for Sample Case

```

ALTERNATE PRINT FILE

@S RUN JRS014, WDC030, 360, 5000          LOG NUMBER = JRS014
@TA   APR, W  U2373 (, H)                L  0
@    COM 1100000

@RX ASG A=U9380                          SHEFF 703 RLOG
*TAPE ASSIGNMENTS*      A= 4/06 U9380

@RX ASG, W B=U9312                      25 MAY 78 22:12:44 1 01142714 2160 1 (DELETED)
*TAPE ASSIGNMENTS*      B= 4/04 U9312

@RX ASG, W HEU1905                      1
*TAPE ASSIGNMENTS*      HE 4/03 U1905

@N XQT CUR
1. IN A
END FILE --- UNIT A
2. DEL CUBSPC/JRS017
CUBSPC JRS017 ABSOLUTE
3. TRI A
END CUR

@N XQT NOISY1/NOPT1

ELAPSED TIME FROM START OF JOB IS 0 MIN 53 SEC

INPUT DATA CARDS ONE THROUGH FIVE ARE
1.164+02 6.007-05 2.880+00 -0 -0 10-0-0 1 0 6 9 6 5-0-0
-0.000 -0.000 -0.000 -0.000 -0.000 -0.000
5.000+01 1.200-03 2.500+01 -0.000 -0.000 -0.000
6 .00027000 .00074000 .00253000 .00125000 .00140000 .00021000
3.01000000 1.13999999 .30100000 .11100000 .03050000 .01240000

```

TABLE 8 (contd)

NEUTRON DENSITY FLUCUATION AUTO SPECTRAL DENSITY FUNCTIONS IN A BARE CUBE
POINT -FINITE BARE CUBE WITH DELAY GROUPS.

BASIC SAMPLE CASE FOR CUBE AUTO SPECTRAL DENSITY.

DATE IS 26 AUG 70 TIME IS 12:57:46

FRACTIONAL DETECTOR LOCATION = 25/ 5 WHICH IS EXACTLY 2.0000000+01

DETECTOR LOCATIONS----	INITIAL CM	UNIT DIFF LENGTH	FRACTIONAL CORE EDGE	FINAL CM	UNIT DIFF LENGTH	FRACTIONAL CORE EDGE
X COORDINATE VALUE --	20.0000	6.9444	.4000	20.0000	6.9444	.4000
Y COORDINATE VALUE --	-.0000	.0000	.0000	-.0000	.0000	.0000
Z COORDINATE VALUE --	-.0000	.0000	.0000	-.0000	.0000	.0000

PROMPT INFINITE LIFETIME = 6.007-05 DIFFUSION LENGTH = 2.880

MEAN DENSITY OR COUNTS = 1.393727+02 FOR INPUT CONST = 1.163686+02 NORMALIZE CONSTS. ARE
FR. DEP.= 5.9370+04 5.4898+04
FR. IND.= 2.1784+01 1.5165+02

BETA(I) OR DELAYED NEUTRON FRACTIONS FOR BETA = .00640000
.00027000 .00074000 .00253000 .00125000 .00140000 .00021000

DECAY CONSTANTS = LAMDA(I).
3.01000000 1.13999999 .30100000 .11100000 .03050000 .01240000

CUBE WIDTH = 5.000000+01 INPUT NORM.= 1.163686+02
EFFICIENCY= 1.200000-03 CONST. STUFX= 1.169994+00
L**2B**2= 9.823493-02 DET. VOLUME= 2.500000+01

BREAK FREQUENCY FOR BASIC TERMS

IBREAK = 7

116.9994	814.5030
1752.2124	2449.7160
1752.2124	2449.7160
1752.2124	2449.7160
3387.4255	4084.9290
3387.4255	4084.9290
3387.4255	4084.9290
5022.6385	5720.1421

TABLE 8. (contd)

SUMMATION LIMITS - DIAGONAL= 9 ALMST DIAG= 6 NON DIAG= 5

WHERE IP = -0 AND IF NEGATIVE, GIVES DIAGONAL NON Y LIMIT (OTHERS = 1)
 ZERO, TERMS ARE UNIFORMLY AS LISTED ABOVE IN ALL DIMEN.
 POSITIVE, THEN GIVES UNIFORM NON Y LIMIT.

THE CALCULATION TERM STATUS	DIAG	DDND	DNND	NGN D	ERROR
UPPER LIMIT	729	1620	8100	4000	
MAX USED	599	1073	2043	492	2.2824-06
NEAR BREAK	262	281	615	62	2.2776-06
MIN USED	262	281	615	60	7.7385-07
FLAT TERM	635	842	0	1000	2.0899-06

FIRST THREE SINES AND COSINES FOR X₁, Y₁, AND Z₁.

.58779	.30902	.00000	1.00000	.00000	1.00000
-.95106	-.80902	.00000	1.00000	.00000	1.00000
.95106	1.00000	.00000	1.00000	.00000	1.00000

FREQUENCY INDEPENDENT TERM FOR COUNT RATE AUTO SPECTRUM

3.175623-01 1.902834+00

LOW FREQUENCY LEVEL WITHOUT DELAYED NEUTRONS.

9.969565-01 3.638792-02

LOG .0013238 -1.4390427

TABLE 8. (contd)

NEUTRON DENSITY FLUCUATION AUTO SPECTRAL DENSITY FUNCTIONS IN A BARE CUBE
FREQUENCY DEPENDENT RESULT AUT NUMBER 10

FREQUENCY	DELTA K	-0.000000	6.000000	COMMON LOGARITHM
				DELTA K -0.00000 6.00000
3.1623-02	1.3462+01	4.2080-02		1.1291081 -1.3759269
9.4868-02	4.7733+00	4.0602-02		9.4868170 -1.3914482
3.1623-01	1.9380+00	3.8567-02		3.1623-01 .2873578 -1.4137807
1.0000+00	1.2594+00	3.7189-02		1.0000+00 .1001475 -1.4295818
1.0000+01	9.9234-01	3.6413-02		1.0000+01 -.0033413 -1.4387415
3.1623+01	9.2609-01	3.6362-02		3.1623+01 -.0333481 -1.4393563
1.0000+02	5.8612-01	3.6119-02		1.0000+02 -.2320114 -1.4422600
1.0000+03	3.9515-02	2.5672-02		1.0000+03 -1.4032404 -1.5905446
1.0000+04	1.0549-02	9.3460-03		1.0000+04 -1.9767681 -2.0293758

NEUTRON DENSITY FLUCUATION AUTO SPECTRAL DENSITY FUNCTIONS IN A BARE CUBE
FREQ. DEP. NORM. DOWN BY (FUNDAMENTAL MODE)**2 AUT NUMBER 12

FREQUENCY	DELTA K	-0.000000	6.000000	COMMON LOGARITHM
				DELTA K -0.00000 6.00000
3.1623-02	1.4098+02	4.4066-01		2.1491435 -.3558915
9.4868-02	4.9986+01	4.2519-01		1.6988524 -.3714128
3.1623-01	2.0295+01	4.0388-01		3.1623-01 1.3073932 -.3937453
1.0000+00	1.3188+01	3.8945-01		1.1201829 -.4095464
1.0000+01	1.0392+01	3.8132-01		1.0166942 -.4187060
3.1623+01	9.6981+00	3.8075-01		3.1623+01 .9866873 -.4193208
1.0000+02	6.1380+00	3.7825-01		1.0000+02 .7880240 -.4222246
1.0000+03	4.1380-01	2.6884-01		1.0000+03 -.3832050 -.5705091
1.0000+04	1.1048-01	9.7872-02		1.0000+04 -.9567327 -1.0093403

FREQUENCY	FREQUENCY DEPENDENT RESULT					AUT NUMBER						
	-3.00	-2.60	-2.20	-1.80	-1.40	-1.00	-.60	-.20	.20	.60	1.00	1.40
*	*	*	*	*	*	*	*	*	*	*	*	*
.032	*	*	*	*	X	*	*	*	*	*	W	*
*	*	*	*	*	*	*	*	*	*	*	*	*
.095	*	*	*	*	X	*	*	*	*	W	*	*
*	*	*	*	*	*	*	*	*	*	*	*	*
.316	*	*	*	*	X	*	*	*	W	*	*	*
*	*	*	*	*	*	*	*	*	*	*	*	*
1.000	*	*	*	X	*	*	*	W	*	*	*	*
*	*	*	*	*	*	*	*	*	*	*	*	*
10.000	*	*	*	X	*	*	W	*	*	*	*	*
*	*	*	*	*	*	*	*	*	*	*	*	*
31.623	*	*	*	X	*	*	W	*	*	*	*	*
*	*	*	*	*	*	*	*	*	*	*	*	*
100.000	*	*	*	X	*	*	W	*	*	*	*	*
*	*	*	*	*	*	*	*	*	*	*	*	*
1000.000	*	*	X	*	W	*	*	*	*	*	*	*
*	*	*	*	*	*	*	*	*	*	*	*	*
9999.999	*	X	W	*	*	*	*	*	*	*	*	*
FREQUENCY	-3.00	-2.60	-2.20	-1.80	-1.40	-1.00	-.60	-.20	.20	.60	1.00	1.40

TABLE 8. (contd)

NEUTRON DENSITY FLUCTUATION AUTO SPECTRAL DENSITY FUNCTIONS IN A BARE CUBE
FREQ. DEPENDENT PLUS 1/4 OF FREQ. INDEP. RESULT

AUT NUMBER 14

DELTA K	-.000000	6.000000
FREQUENCY		
3.1623-02	1.3541+01	5.1779-01
9.4868-02	4.8527+00	5.1631-01
3.1623-01	2.0174+00	5.1428-01
1.0000+00	1.3387+00	5.1290-01
1.0000+01	1.0717+00	5.1212-01
3.1623+01	1.0055+00	5.1207-01
1.0000+02	6.6551-01	5.1183-01
1.0000+03	1.1891-01	5.0138-01
1.0000+04	8.9940-02	4.8505-01

COMMON LOGARITHM		
DELTA K	-.000000	6.000000
FREQUENCY		
3.1623-02	1.1316618	-.2858478
9.4868-02	.6859809	-.2870886
3.1623-01	.3047938	-.2888039
1.0000+00	.1266974	-.2899691
1.0000+01	.0300840	-.2906268
3.1623+01	.0023725	-.2906705
1.0000+02	-.1768433	-.2908760
1.0000+03	-.9247985	-.2998327
1.0000+04	-1.0460467	-.3142094

NEUTRON DENSITY FLUCTUATION AUTO SPECTRAL DENSITY FUNCTIONS IN A BARE CUBE
FREQ. DEPENDENT PLUS 4 TIMES FREQ. INDEP. RESULT

AUT NUMBER 13

DELTA K	-.000000	6.000000
FREQUENCY		
3.1623-02	1.4732+01	7.6534+00
9.4868-02	6.0435+00	7.6519+00
3.1623-01	3.2083+00	7.6499+00
1.0000+00	2.5296+00	7.6485+00
1.0000+01	2.2626+00	7.6478+00
3.1623+01	2.1963+00	7.6477+00
1.0000+02	1.8564+00	7.6475+00
1.0000+03	1.3098+00	7.6370+00
1.0000+04	1.2808+00	7.6207+00

COMMON LOGARITHM		
DELTA K	-.000000	6.000000
FREQUENCY		
3.1623-02	1.1682677	.8838553
9.4868-02	.7812907	.8837715
3.1623-01	.5062705	.8836560
1.0000+00	.4030523	.8835778
1.0000+01	.3546050	.8835337
3.1623+01	.3416989	.8835307
1.0000+02	.2686650	.8835170
1.0000+03	.1171931	.8829233
1.0000+04	.1074809	.8819939

TABLE 8. (contd)

FREQ. DEPENDENT PLUS 1/4 OF FREQ. INDEP. RESULT	AUT NUMBER	14	1.00	1.33
-2.33	-1.67	-1.33	-1.00	.67
-2.00	-1.67	-1.33	-1.00	.67
-1.67	-1.33	-1.00	.67	.33
-1.33	-1.00	.67	.33	.00
-1.00	.67	.33	.00	.33
-.67	.33	.00	.33	.67
-.33	.00	.33	.67	1.00
0.00	.33	.67	1.00	1.33
.33	.67	1.00	1.33	
.67	1.00	1.33		
1.00	1.33			
1.33				
1.67				
2.00				
2.33				
2.67				
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99.67				
100.00				

TABLE 8. (contd)

FREQ. DEPENDENT PLUS 4 TIMES FREQ. INDEP. RESULT		AUI NUMBER 13	
FREQUENCY	FREQ. DEPENDENT PLUS 4 TIMES FREQ. INDEP. RESULT	AUI NUMBER 13	FREQUENCY
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9
10	10	10	10
11	11	11	11
12	12	12	12
13	13	13	13
14	14	14	14
15	15	15	15
16	16	16	16
17	17	17	17
18	18	18	18
19	19	19	19
20	20	20	20
21	21	21	21
22	22	22	22
23	23	23	23
24	24	24	24
25	25	25	25
26	26	26	26
27	27	27	27
28	28	28	28
29	29	29	29
30	30	30	30
31	31	31	31
32	32	32	32
33	33	33	33
34	34	34	34
35	35	35	35
36	36	36	36
37	37	37	37
38	38	38	38
39	39	39	39
40	40	40	40
41	41	41	41
42	42	42	42
43	43	43	43
44	44	44	44
45	45	45	45
46	46	46	46
47	47	47	47
48	48	48	48
49	49	49	49
50	50	50	50
51	51	51	51
52	52	52	52
53	53	53	53
54	54	54	54
55	55	55	55
56	56	56	56
57	57	57	57
58	58	58	58
59	59	59	59
60	60	60	60
61	61	61	61
62	62	62	62
63	63	63	63
64	64	64	64
65	65	65	65
66	66	66	66
67	67	67	67
68	68	68	68
69	69	69	69
70	70	70	70
71	71	71	71
72	72	72	72
73	73	73	73
74	74	74	74
75	75	75	75
76	76	76	76
77	77	77	77
78	78	78	78
79	79	79	79
80	80	80	80
81	81	81	81
82	82	82	82
83	83	83	83
84	84	84	84
85	85	85	85
86	86	86	86
87	87	87	87
88	88	88	88
89	89	89	89
90	90	90	90
91	91	91	91
92	92	92	92
93	93	93	93
94	94	94	94
95	95	95	95
96	96	96	96
97	97	97	97
98	98	98	98
99	99	99	99
100	100	100	100

TABLE 8. (contd)

NEUTRON DENSITY FLUCTUATION AUTO SPECTRAL DENSITY FUNCTIONS IN A BARE CUBE FREQUENCY DEPENDENT PLUS FREQUENCY INDEP. RESULT				AUT NUMBER
DELTA K	-.000000	6.000000	COMMON LOGARITHM	1
FREQUENCY			DELTA K	
3.1623-02	1.3780+01	1.9449+00	3.1623-02	1.1392339
9.4868-02	5.0908+00	1.9434+00	9.4868-02	.7067898
3.1623-01	2.2556+00	1.9414+00	3.1623-01	.3532583
1.0000+00	1.5769+00	1.9400+00	1.0000+00	.1978084
1.0000+01	1.3099+00	1.9392+00	1.0000+01	.1172376
3.1623+01	1.2436+00	1.9392+00	3.1623+01	.0946980
1.0000+02	9.0369-01	1.9390+00	1.0000+02	-.0439829
1.0000+03	3.5708-01	1.9285+00	1.0000+03	-.4472380
1.0000+04	3.2811-01	1.9122+00	1.0000+04	-.4839781
				.2889004
				.2885704
				.2881154
				.2878070
				.2876332
				.2876217
				.2875674
				.2852210
				.2815288

NEUTRON DENSITY FLUCTUATION AUTO SPECTRAL DENSITY FUNCTIONS IN A BARE CUBE SUM OF THE DIAGONAL TERMS				AUT NUMBER
DELTA K	-.000000	6.000000		15
FREQUENCY				
3.1623-02	2.2731-04	8.2590-07		
9.4868-02	8.0835-05	7.9775-07		
3.1623-01	3.2971-05	7.5895-07		
1.0000+00	2.1499-05	7.3264-07		
1.0000+01	1.6976-05	7.1781-07		
3.1623+01	1.5846-05	7.1681-07		
1.0000+02	1.0038-05	7.1200-07		
1.0000+03	6.9831-07	5.0483-07		
1.0000+04	1.8784-07	1.7970-07		

TABLE 8. (contd)

NEUTRON DENSITY FLUCTUATION AUTO SPECTRAL DENSITY FUNCTIONS IN A BARE CUBE
SUM OF DIAGONAL, DIAGONAL, NON-DIAGONAL TERMS

AUT NUMBER 11

DELTA K -.000000 6.000000

FREQUENCY

3.1623-02	-3.0299-07	1.1677-08
9.4868-02	-2.2291-07	1.2269-08
3.1623-01	-1.5334-07	1.3085-08
1.0000+00	-1.2761-07	1.3631-08
1.0000+01	-1.1161-07	1.3941-08
3.1623+01	-1.0215-07	1.3975-08
1.0000+02	-5.0091-08	1.4208-08
1.0000+03	4.4378-08	3.4946-08
1.0000+04	3.5713-08	3.3974-08

NEUTRON DENSITY FLUCTUATION AUTO SPECTRAL DENSITY FUNCTIONS IN A BARE CUBE
SUM OF DIAGONAL, NON-DIAGONAL, NON-DIAG. TERMS

AUT NUMBER 9

DELTA K -.000000 6.000000

FREQUENCY

3.1623-02	-2.3832-07	-6.4155-08
9.4868-02	-1.9659-07	-6.3564-08
3.1623-01	-1.6006-07	-6.2710-08
1.0000+00	-1.4637-07	-6.2105-08
1.0000+01	-1.3782-07	-6.1752-08
3.1623+01	-1.3281-07	-6.1725-08
1.0000+02	-1.0529-07	-6.1581-08
1.0000+03	-6.5585-08	-6.1429-08
1.0000+04	-3.8351-08	-3.6860-08

TABLE 8. (contd)

NEUTRON DENSITY FLUCTUATION AUTO SPECTRAL DENSITY FUNCTIONS IN A BARE CUBE
SUM OF THE COMPLETE NON-DIAGONAL TERMS

AUT NUMBER 8

DELTA K -.000000 6.000000

FREQUENCY

3.1623-02	-1.9774-08	-6.9081-09
9.4868-02	-1.6768-08	-6.8555-09
3.1623-01	-1.4127-08	-6.7941-09
1.0000+00	-1.3132-08	-6.7391-09
1.0000+01	-1.2508-08	-6.7068-09
3.1623+01	-1.2146-08	-6.7045-09
1.0000+02	-1.0149-08	-6.6933-09
1.0000+03	-1.1534-08	-1.0718-08
1.0000+04	-7.5148-09	-6.5665-09

NEUTRON DENSITY FLUCTUATION AUTO SPECTRAL DENSITY FUNCTIONS IN A BARE CUBE
SLA1*2 - 'BREAK' FREQUENCY TERM - F(OMEGA L)

AUT NUMBER 7

DELTA K -.000000 6.000000			COMMON LOGARITHM DELTA K -.000000 6.000000		
FREQUENCY			FREQUENCY		
3.1623-02	1.3689+04	6.6342+05	3.1623-02	4.1363672	5.8217853
9.4868-02	1.6723+03	5.4956+05	9.4868-02	3.2233165	5.7400112
3.1623-01	5.5984+03	5.9899+05	3.1623-01	3.7480602	5.7774204
1.0000+00	1.0153+04	6.3823+05	1.0000+00	4.0066112	5.8049750
1.0000+01	1.3542+04	6.6243+05	1.0000+01	4.1316885	5.8211405
3.1623+01	1.3673+04	6.6331+05	3.1623+01	4.1358743	5.8217172
1.0000+02	1.3687+04	6.6340+05	1.0000+02	4.1363177	5.8217784
1.0000+03	1.3689+04	6.6341+05	1.0000+03	4.1363667	5.8217852
1.0000+04	1.3689+04	6.6342+05	1.0000+04	4.1363672	5.8217853

100

100

TABLE 8. (contd)

NEUTRON DENSITY FLUCTUATION AUTO SPECTRAL DENSITY FUNCTIONS IN A BARE CUBE
ABS(A_{BK}) - THE BREAK FREQUENCY SHIFT FACTOR

AUT NUMBER 6

DELTA K -.000000 6.000000		
FREQUENCY		
3.1623-02	8.0256+02	7.7178+02
9.4868-02	3.5697+02	3.4331+02
3.1623-01	1.1747+02	1.1300+02
1.0000+00	2.5281+01	2.4349+01
1.0000+01	1.4612+00	1.4435+00
3.1623+01	1.0474+00	1.0456+00
1.0000+02	1.0048+00	1.0046+00
1.0000+03	1.0000+00	1.0000+00
1.0000+04	1.0000+00	1.0000+00

COMMON LOGARITHM DELTA K -.000000 6.000000		
FREQUENCY		
3.1623-02	2.9044772	2.8874932
9.4868-02	2.5526372	2.5356803
3.1623-01	2.0699406	2.0530827
1.0000+00	1.4028018	1.3864817
1.0000+01	.1647109	.1594150
3.1623+01	.0201170	.0193615
1.0000+02	.0020602	.0019812
1.0000+03	.0000207	.0000199
1.0000+04	.0000002	.0000002

NEUTRON DENSITY FLUCTUATION AUTO SPECTRAL DENSITY FUNCTIONS IN A BARE CUBE
FUNDAMENTAL TERM ---- SIN X,COS Y,COS Z

AUT NUMBER 3

DELTA K -.000000 6.000000		
FREQUENCY		
3.1623-02	1.2669-02	5.9933-03
9.4868-02	1.3840-02	6.3669-03
3.1623-01	1.3295-02	6.1954-03
1.0000+00	1.2904-02	6.0698-03
1.0000+01	1.2677-02	5.9961-03
3.1623+01	1.2665-02	5.9925-03
1.0000+02	1.2627-02	5.9833-03
1.0000+03	9.5560-03	5.1372-03
1.0000+04	3.7738-04	3.3930-04

COMMON LOGARITHM DELTA K -.000000 6.000000		
FREQUENCY		
3.1623-02	-1.8972640	-2.2223331
9.4868-02	-1.8588712	-2.1960708
3.1623-01	-1.8763055	-2.2079279
1.0000+00	-1.8892706	-2.2168234
1.0000+01	-1.8969826	-2.2221339
3.1623+01	-1.8973863	-2.2223896
1.0000+02	-1.8986864	-2.2230605
1.0000+03	-2.0197216	-2.2892741
1.0000+04	-3.4232242	-3.4694123

TABLE 8. (Contd)

ABS(ABK) - THE BREAK FREQUENCY SHIFT FACTOR													
FREQUENCY	-.33	-.00	.33	.67	1.00	1.33	1.67	AUT NUMBER	2.00	2.33	2.67	3.00	3.33
	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****
	*	*	*	*	*	*	*	*	*	*	*	*	*
.032	*	*	*	*	*	*	*	*	*	*	*	*	*
	*	*	*	*	*	*	*	*	*	*	*	*	*
.095	*	*	*	*	*	*	*	*	*	*	*	*	*
	*	*	*	*	*	*	*	*	*	*	*	*	*
	*	*	*	*	*	*	*	*	*	*	*	*	*
.316	*	*	*	*	*	*	*	*	*	*	*	*	*
	*	*	*	*	*	*	*	*	*	*	*	*	*
	*	*	*	*	*	*	*	*	*	*	*	*	*
1.000	*	*	*	*	*	*	*	*	*	*	*	*	*
	*	*	*	*	*	*	*	*	*	*	*	*	*
	*	*	*	*	*	*	*	*	*	*	*	*	*
10.000	*	*	*	*	*	*	*	*	*	*	*	*	*
	*	*	*	*	*	*	*	*	*	*	*	*	*
	*	*	*	*	*	*	*	*	*	*	*	*	*
31.623	*	*	*	*	*	*	*	*	*	*	*	*	*
	*	*	*	*	*	*	*	*	*	*	*	*	*
	*	*	*	*	*	*	*	*	*	*	*	*	*
100.000	*	*	*	*	*	*	*	*	*	*	*	*	*
	*	*	*	*	*	*	*	*	*	*	*	*	*
	*	*	*	*	*	*	*	*	*	*	*	*	*
1000.000	*	*	*	*	*	*	*	*	*	*	*	*	*
	*	*	*	*	*	*	*	*	*	*	*	*	*
	*	*	*	*	*	*	*	*	*	*	*	*	*
9999.999	*	*	*	*	*	*	*	*	*	*	*	*	*
	*	*	*	*	*	*	*	*	*	*	*	*	*
	*	*	*	*	*	*	*	*	*	*	*	*	*
FREQUENCY	-.33	-.00	.33	.67	1.00	1.33	1.67	2.00	2.33	2.67	3.00	3.33	

TABLE 8. (Contd)

NEUTRON DENSITY FLUCTUATION AUTO SPECTRAL DENSITY FUNCTIONS IN A BARE CUBE
FUNDAMENTAL TERM ---- COS X, COS Y, COS Z

AUT NUMBER 2

DELTA K -.000000 6.000000		
FREQUENCY		
3.1623-02	9.8170-01	1.8731-02
9.4868-02	4.7668+00	2.2568-02
3.1623-01	1.9257+00	2.0701-02
1.0000+00	1.2452+00	1.9452-02
1.0000+01	9.7693-01	1.8752-02
3.1623+01	9.0982-01	1.8703-02
1.0000+02	5.6505-01	1.8450-02
1.0000+03	1.3256-02	7.4698-03
1.0000+04	1.3437-04	1.2344-04

COMMON LOGARITHM		
DELTA K -.00000 6.00000		
FREQUENCY		
3.1623-02	-.0080205	-1.7274496
9.4868-02	.6782231	-1.6465130
3.1623-01	.2845934	-1.6840097
1.0000+00	.0952229	-1.7110426
1.0000+01	-.0101356	-1.7269414
3.1623+01	-.0410455	-1.7280968
1.0000+02	-.2479129	-1.7339995
1.0000+03	-1.8775985	-2.1266887
1.0000+04	-3.8717129	-3.9085362

TIME OF WRITE = .0000 BUFFER PAUSE = 0

** END **

NAME	JOB N.	CUS N.	CARDS-IN	-OUT	PAGES	IN-TIME	TOT. TIME
JAMES SHEFF	JRS014	WDC036	24	3	522	04 53S	1M 28S

BNWL-1260

TABLE 8. (contd)

Q DAT CUBSPC/JRS024,2

QN XQT SEARCH/DESTRY

DRUM =	313860	314940	313860	314940	0	0	0
--------	--------	--------	--------	--------	---	---	---

DATA CARDS ARE AS FOLLOWS

1	1	BASICS	AUTEST	-0	2	-0	-0	
2	4							
1	10	1	1****	1	10	2	1****	1 10 1
1	14	1	1****	1	13	1	1****	1 1 1

FREQUENCY, R/SEC AMPLITUDE

TIME OF WRITE = .0000 BUFFER PAUSE = 0

CHECK DRUM STATUS WORDS FOR NTRAN

-1 0

CAUGHT IN THE NTRAN LOOP

-1

CAUGHT IN THE NTRAN LOOP

-1

TIME OF WRITE = .0234 BUFFER PAUSE = 0

DRUM =	313860	314940	314113	314940	214728712*****	0
--------	--------	--------	--------	--------	----------------	---

IDRM =	0	0	0	0	0	0
--------	---	---	---	---	---	---

TABLE 8. (contd)

[illegible]

BASIC SAMPLE CASE FOR CUBE AUTO SPECTRAL DENSITY.

30 JUL 70

09:11:59

JRS024

CHECK DRUM STATUS WORDS FOR NTRAN

253 819

TIME OF WRITE = .1611 BUFFER PAUSE = 0

TABLE 8. (contd)

TABLE 8. (contd)

CHECK DRUM STATUS WORDS FOR NTRAN

253 819

TIME OF WRITE = .5723 BUFFER PAUSE = 0

3.162277-02	9.486831-02	3.162277-01	1.000000+00	1.000000+01	3.162278+01	1.000000+02	1.000000+03	9.999999+03	-0.000000
-0.000000	-0.000000	-0.000000	1.346195+01	4.773281+00	1.938018+00	1.259353+00	9.923359-01	9.260872-01	5.861227-01
3.951478-02	1.054950-02	1.354134+01	4.852672+00	2.017409+00	1.338744+00	1.071727+00	1.005478+00	6.655133-01	1.189054-01
8.994009-02	1.473220+01	6.043531+00	3.208267+00	2.529603+00	2.262585+00	2.196337+00	1.856372+00	1.309764+00	1.280799+00
1.377952+01	5.090844+00	2.255580+00	1.576915+00	1.309898+00	1.243650+00	9.036851-01	3.570771-01	3.281118-01	-1.825397-01
2.064289-27	3.643282-20	1.331266+02	2.298981-15	1.144828-19	1.588303+24	3.519537-15	9.378335-27	3.284106+22	2.051539-27
2.051539-27	2.051539-27	2.051539-27	2.715723-27	5.564438-15	5.046882+18	2.051539-27	2.539074-27	1.012044+22	2.051539-27

DRUM = 313860 314940 314932 314940 214728712 314113 0

IDRM = 696062 1100000 696190 696190 0 0 0

CHECK DRUM STATUS WORDS FOR NTRAN
BASICS AUTEST ABSOLUTE

253 819 0 71
30 JUL 70 09:12:36 1 01147074 264 1 (DELETED)

TABLE 8. (contd)

JN DAT BASICS/AUTEST,3

QN XGT SNOOPY

ELAPSED TIME FROM START OF JOB IS 1 MIN 28 SEC
 DATE IS 26 AUG 70 TIME IS 12:58:20

FILE NUMBER 3

AUTO SPECTRA FOR ZERO AND
 ARGUMENTS FROM .031623 TO *****

PAGE 1

A-.000000 -.000000

X
 .31623-01 13.4620 .420797-01
 .94868-01 4.77328 .406024-01
 .31623 1.93802 .385673-01
 1.0000 1.25935 .371893-01
 ***** .992336 .364132-01
 31.623 .926087 .363617-01
 ***** .586123 .361194-01
 ***** .395148-01 .256717-01
 ***** .105495-01 .934597-02

FREQUENCY	LOG OF THE REAL PART OF THE F G PRODUCT										AUT NUMBER									
	-6.0	-4.0	-2.0	.0	2.0	4.0	6.0	8.0	10.0	12.0	1	2	3	4	5	6	7	8	9	10
.032				X																
.095				X																
.316				X																
1.000				X																
10.000				X																
31.623				X																
100.000				X																
1000.000				X																
9999.999				X																
FREQUENCY	-6.0	-4.0	-2.0	.0	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0	30.0	32.0

```

ABSISSA ORIGIN = -2.4000000+00  ABSISSA DEC/IN = 8.0000000-01  ORIGINATE ORIGIN = -3.6000000+00  ORIGINATE DEC/IN = 4.0000000-01

```

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TABLE 8. (contd)

VARIOUS WHITE LEVEL			.031623	REDUCE SIZE TO 0.55 TO *****	PAGE 2
ARGUMENTS FROM					
A--	0.00000	--0.00000	--0.00000	--0.00000	
X					
.31623-01	13.4620	13.5413	14.7322	13.7795	
.94868-01	4.77328	4.85267	6.04353	5.09084	
.31623	1.93802	2.01741	3.20827	2.25558	
1.0000	1.25935	1.33874	2.52960	1.57692	
*****	.992336	1.07173	2.26259	1.30990	
31.623	.926087	1.00548	2.19634	1.24365	
*****	.586123	.665513	1.85637	.903685	
*****	.395148-01	.118905	1.30976	.357077	
*****	.105495-01	.899401-01	1.28080	.328112	

ABSISSA ORIGIN = -2.0000000+00 ABSISSA DEC/IN = 8.0000000-01 ORDINATE ORIGIN = -2.0000000+00 ORDINATE DEC/IN = 2.5000000-01

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TABLE 8. (contd)

QW XQT CUR

1. OUT B, 2,7,4,3,1

2. TEF B

3. TRI B

4. TOC

ELEMENT TABLE

UNIVAC	NINETY	ABSOLUTE	29 JUL 70	15:49:02	1	00437654	24216	1
CUBSPC	549556	ABSOLUTE	25 JAN 70	09:50:40	1	00467370	1704	1
CUBSPC	500077	ABSOLUTE	20 JAN 70	01:38:26	1	00471114	1704	1
CUBSPC	500362	ABSOLUTE	30 JAN 70	05:04:29	1	00472640	13056	1
CUBSPC	500903	ABSOLUTE	31 JAN 70	08:26:16	1	00507440	1704	1
CUBSPC	502443	ABSOLUTE	08 FEB 70	11:21:50	1	00511164	33984	1
CUBSPC	503169	ABSOLUTE	14 FEB 70	07:32:21	1	00552324	2928	1
CUBSPC	004532	ABSOLUTE	18 FEB 70	21:31:53	1	00555214	13056	1
SEARCH	DESTROY	ABSOLUTE	24 APR 70	17:09:07	1	00572014	13800	1
AUTCRS	TESRUN	ABSOLUTE	24 APR 70	17:09:08	1	00607400	864	1
NO1SY1	NOPT1	ABSOLUTE	20 MAY 70	14:11:01	1	00610260	99600	1
NO1SY1	NOPT2	ABSOLUTE	20 MAY 70	14:11:09	1	00751470	95664	1
SNOOPY	NO1SY1	ABSOLUTE	23 MAY 70	09:17:21	1	01107020	28536	1
CUBSPC	JRS017	ABSOLUTE	23 MAY 70	22:12:44	1	01142714	2160	1 (DELETED)
CUBSPC	JRS024	ABSOLUTE	30 JUL 70	09:11:59	1	01145004	2160	1
BASICS	AUTEST	ABSOLUTE	30 JUL 70	09:12:36	1	01147074	264	1 (DELETED)
CUBE	PROCEDURE	PROCEDURE	03 JAN 70	17:52:15	0	01147300	28	101
REGON3	PROCEDURE	PROCEDURE	31 JAN 70	08:24:59	1	01152106	72	1
NO1SY1	MAPCODE	PROCESSED MAP	00 JUL 68	08:40:29	1	01152152	28	81
ELAP	CODE	RELOCATABLE	20 OCT 67	16:04:26	62	01154330	48	1
JUNK	CODE	RELOCATABLE	02 NOV 67	18:07:13	1	01154360	336	1
TABLIN	SHRCD	RELOCATABLE	10 NOV 67	08:49:06	1	01154644	24	1
CBLAUT	OPTICD	RELOCATABLE	10 NOV 67	08:49:48	0	01154660	28	1
CALFLT	CODE	RELOCATABLE	10 NOV 67	08:50:10	0	01154712	24	1
CBFDAT	CODE	RELOCATABLE	10 NOV 67	08:50:42	0	01154746	96	1
PRIGAM	SHRCD	RELOCATABLE	10 NOV 67	08:51:37	0	01155026	28	54
CALC1	SHRCD	RELOCATABLE	10 NOV 67	08:51:59	1	01156412	120	333
					0	01156506	28	1
					1	01167574	120	163
					0	01167670	28	1
					0	01174242	120	1
					0	01174336	28	368
					0	01206376	96	1
					0	01206456	28	55
					1	01210060	72	1

TABLE 8. (contd)

CALCA1	SHRCDE	RELOCATABLE	APS	10 NOV 67	08:52:03	0	01210124	28	2
						1	01210160	72	1
TERGAM	SHRCDE	RELOCATABLE		20 NOV 67	09:09:14	0	01210224	28	2
						1	01210260	96	1
FIXEND	CODE	RELOCATABLE		05 DEC 67	02:16:32	1	01210340	28	62
						0	01212104	48	1
ERR1	CODE	RELOCATABLE		06 FEB 68	20:11:52	0	01212134	28	1
						1	01212152	24	1
BLOODY	CODE	RELOCATABLE		11 APR 68	15:16:27	0	01212166	28	1
						1	01212204	96	1
CAAFDC	OPT1CD	RELOCATABLE	AP	01 JUL 68	13:25:18	0	01212264	28	6
						1	01212410	120	1
CLOG10	CODE	RELOCATABLE		03 JUL 68	20:05:14	0	01212504	28	568
						1	01232124	72	1
CAAFDC	OPT2CD	RELOCATABLE	S	05 JUL 68	16:08:33	0	01232170	28	3
						1	01232242	120	1
ALGG10	CODE	RELOCATABLE		17 JUL 68	12:05:06	0	01232336	28	562
						1	01251632	72	1
TABL65	SHRCDE	RELOCATABLE	APS	23 SEP 68	09:04:13	0	01251676	28	8
						1	01252056	120	1
PHASE	CODE	RELOCATABLE	PRS	17 DEC 68	18:18:42	0	01252152	28	60
						1	01253662	72	1
CCLAUT	OPT1CD	RELOCATABLE	AP	17 JAN 69	13:04:59	1	01253726	28	4
						0	01254016	120	1
CBLAUT	OPT2CD	RELOCATABLE	S	17 JAN 69	13:05:37	0	01254112	28	220
						1	01262122	120	1
CCLAUT	OPT2CD	RELOCATABLE	S	17 JAN 69	13:05:51	0	01262216	28	322
						1	01273052	120	1
BOX	CODE	RELOCATABLE		20 JUL 68	20:59:29	0	01273146	28	210
						1	01300742	72	1
DUMMY	CODE	RELOCATABLE		14 JUL 69	10:54:28	0	01301006	28	9
						1	01301204	72	1
DATA	SHRCDE	RELOCATABLE	APS	18 NOV 69	14:36:09	0	01301250	28	2
						1	01301304	48	1
PRNBAS	CODE	RELOCATABLE		10 NOV 69	14:36:18	0	01301334	28	68
						1	01303224	120	1
DAFDAT	CODE	RELOCATABLE		18 NOV 69	14:37:04	0	01303320	28	82
						1	01305514	144	1
CAFDAT	CODE	RELOCATABLE		18 NOV 69	14:37:13	0	01305624	28	180
						1	01312554	168	1
DALAUT	OPT2CD	RELOCATABLE	S	18 NOV 69	14:37:25	0	01312700	28	103
						1	01315542	144	1
CALAUT	OPT2CD	RELOCATABLE	S	18 NOV 69	14:37:33	0	01315652	28	155
						1	01322044	168	1
CAFDOR	OPT2CD	RELOCATABLE	S	18 NOV 69	14:37:49	0	01322170	28	102
						1	01325014	144	1
DALAUT	OPT1CD	RELOCATABLE	AP	18 NOV 69	14:38:02	0	01325124	28	73
						1	01327122	144	1
						0	01327232	28	161

TABLE 8. (contd)

CALAUT	OPT1CD	RELOCATABLE	AP	18 NOV 69	14:38:11	1	01333550	168	1
CAFDCR	OPT1CD	RELOCATABLE	AP	18 NOV 69	14:38:27	0	01333674	120	120
DASHLN	CODE	RELOCATABLE		27 DEC 69	11:36:39	0	01337114	144	1
PRIN	SHRCD	RELOCATABLE	APS	03 JAN 70	17:52:22	1	01341256	72	75
PLOT	CODE	RELOCATABLE		03 JAN 70	17:52:29	0	01341322	28	38
TAKLG	CODE	RELOCATABLE		03 JAN 70	17:52:34	1	01342472	168	1
LOGAXS	CODE	RELOCATABLE		22 JAN 70	17:44:47	0	01346144	28	131
CALC	OPT1CD	RELOCATABLE	AP	28 JAN 70	01:37:44	0	01346224	96	1
CALC	OPT2CD	RELOCATABLE	S	28 JAN 70	01:37:57	0	01350562	28	89
CALCA	CODE	RELOCATABLE	APS	31 JAN 70	08:24:05	1	01350642	28	17
CALCRS	OPT2CD	RELOCATABLE	S	31 JAN 70	08:24:12	0	01351220	28	94
CAACRS	OPT2CD	RELOCATABLE	S	31 JAN 70	08:24:23	0	01351300	28	94
CBLCRS	OPT2CD	RELOCATABLE	S	31 JAN 70	08:24:43	1	01353744	216	1
CCLCRS	OPT2CD	RELOCATABLE	S	31 JAN 70	08:24:57	0	01354120	28	171
CALCRS	OPT1CD	RELOCATABLE	AP	31 JAN 70	08:25:06	1	01361026	28	170
CAACRS	OPT1CD	RELOCATABLE	AP	31 JAN 70	08:25:17	0	01365542	168	1
CBLCRS	OPT1CD	RELOCATABLE	AP	31 JAN 70	08:25:36	0	01365666	28	28
CCLCRS	OPT1CD	RELOCATABLE	AP	31 JAN 70	08:25:51	0	01366476	144	1
CALPLT	CODE	RELOCATABLE		04 FEB 70	09:47:35	0	01366606	28	71
DATLD2	CODE	RELOCATABLE		04 FEB 70	02:57:17	1	01370550	120	1
SNOPSR	CODE	RELOCATABLE		24 APR 70	17:09:05	0	01372522	120	1
GARBGE	CODE	RELOCATABLE		08 MAY 70	21:53:59	0	01375346	28	357
PLTLAB	CODE	RELOCATABLE		17 MAY 70	22:00:47	0	01407154	120	1
KILD5C	SHRCD	RELOCATABLE		28 MAY 70	14:10:51	1	01416340	144	1
KILD5C	SHR	SYMBOLIC		28 MAY 70	14:10:51	0	01416450	28	91
						0	01421042	120	1
						0	01421136	28	192
						0	01426336	120	1
						0	01426432	28	409
						1	01441570	120	1
						0	01441664	28	307
						0	01452176	144	1
						0	01452306	28	87
						1	01454610	96	1
						0	01454670	28	79
						1	01457012	72	1
						0	01457056	28	178
						1	01463752	120	1
						0	01464046	28	24
						1	01464566	96	1
						0	01464646	28	23
						1	01465350	96	1
						0	01465430	28	48
						0	01466670	28	249

TABLE 8. (contd)

DATA	SHR	SYMBOLIC	18	NOV 69	14:36:09	0	01475526	28	135
FIXEND		SYMBOLIC	05	DEC 67	02:16:32	0	01501270	28	23
GARBGE		SYMBOLIC	06	MAY 70	21:53:59	0	01501772	28	65
ERR1		SYMBOLIC	06	FEB 68	20:11:52	0	01503610	28	14
ELAP		SYMBOLIC	20	OCT 67	16:04:26	0	01504114	28	13
JUNK		SYMBOLIC	02	NOV 67	18:07:13	0	01504402	28	17
TABL65	SHR	SYMBOLIC	23	SEP 68	09:04:13	0	01504760	28	211
TABLIN	SHR	SYMBOLIC	10	NOV 67	08:49:06	0	01512572	28	166
CALC	SHR	SYMBOLIC	26	JAN 70	01:37:57	0	01517216	28	488
PRIN	SHR	SYMBOLIC	03	JAN 70	17:52:22	0	01534476	28	250
PRNBAS		SYMBOLIC	10	NOV 69	14:36:18	0	01543352	28	259
PLOT		SYMBOLIC	03	JAN 70	17:52:29	0	01552424	28	192
TAKLG		SYMBOLIC	03	JAN 70	17:52:34	0	01557624	28	36
ALGG10		SYMBOLIC	17	JUL 68	12:05:06	0	01560614	28	18
CLOG10		SYMBOLIC	03	JUL 68	20:05:14	0	01561210	28	16
CALCA		SYMBOLIC	31	JAN 70	08:24:05	0	01561550	28	87
CALCA1	SHR	SYMBOLIC	19	NOV 67	08:52:03	0	01564052	28	9
CALCRS		SYMBOLIC	31	JAN 70	08:25:06	0	01564250	28	251
BLOODY	UNIVAC	SYMBOLIC	11	APR 68	15:16:27	0	01573142	28	7
CAACRS		SYMBOLIC	31	JAN 70	08:25:17	0	01573304	28	336
CBLCRS		SYMBOLIC	31	JAN 70	08:25:36	0	01604444	28	667
CCLCRS		SYMBOLIC	31	JAN 70	08:25:51	0	01626636	28	457
CAFDCR		SYMBOLIC	18	NOV 69	14:38:27	0	01643234	28	164
CAAFDC		SYMBOLIC	05	JUL 68	16:08:53	0	01647624	28	401
CALC1	SHR	SYMBOLIC	10	NOV 67	08:51:59	0	01662602	28	9
CALAUT		SYMBOLIC	18	NOV 69	14:38:11	0	01663000	28	362
DALAUT		SYMBOLIC	18	NOV 69	14:38:02	0	01674714	28	278
CBLAUT		SYMBOLIC	17	JAN 69	13:05:37	0	01704400	28	540
TERGAM	SHR	SYMBOLIC	20	NOV 67	09:09:14	0	01723210	28	127
CCLAUT		SYMBOLIC	17	JAN 69	13:05:51	0	01726572	28	384
CAF0AT		SYMBOLIC	18	NOV 69	14:37:13	0	01741172	28	266
DAFDAT		SYMBOLIC	18	NOV 69	14:37:04	0	01750406	28	319
CBFDAT		SYMBOLIC	18	NOV 67	08:50:42	0	01761170	28	617
CALFLT		SYMBOLIC	19	NOV 67	08:50:10	0	02002066	28	312
PRIGAM	SHR	SYMBOLIC	19	NOV 67	08:51:57	0	02012506	28	156
SNOPSR		SYMBOLIC	24	APR 70	17:09:05	0	02016716	28	491
DALD2		SYMBOLIC	08	FEB 70	02:57:17	0	02034250	28	294
CALPLT		SYMBOLIC	04	FEB 70	09:47:55	0	02044274	28	182
DASHLN		SYMBOLIC	27	DEC 69	11:36:59	0	02051260	28	120
LOGAXS		SYMBOLIC	22	JAN 70	17:44:47	0	02054500	28	163
BOX		SYMBOLIC	29	JUL 68	20:59:29	0	02061052	28	12
DUMMY		SYMBOLIC	14	JUL 69	10:54:28	0	02061322	28	6
PLTLAB		SYMBOLIC	17	MAY 70	22:00:47	0	02061446	28	39
NOISY1	MAP	SYMBOLIC	09	JUL 68	08:40:29	0	02062510	28	1
PHASE		SYMBOLIC	17	DEC 68	18:18:42	0	02062526	28	9
JUNK		SYMBOLIC	30	JUL 70	10:38:13	0	02062724	28	17
FIX	FIXED	SYMBOLIC	30	JUL 70	10:38:24	0	02063302	28	10314
CUBSPC	JRS014	ABSOLUTE	26	AUG 70	12:57:45	1	02515316	2144	1
BASICS	AUTEST	ABSOLUTE	26	AUG 70	12:58:19	1	02517376	256	1

TABLE 8. (contd)

ENTRY POINT TABLE									
1	000054	ALG610 (ALG610/CODE)	BLOODY (BLOODY/CODE)	1	000051	BOX (BOX/CODE)	1	000072	
1	002724	CAACRS (CAACRS/OPT2CD)	CAACRS (CAACRS/OPT1CD)	1	003331	CAAFDC (CAAFDC/OPT1CD)	1	013171	
1	013072	CAAFDC (CAAFDC/OPT2CD)	CAFADT (CAFADT/CODE)	1	001529	CAFDCR (CAFDCR/OPT2CD)	1	001132	
1	001151	CAFDCR (CAFDCR/OPT1CD)	CALAUT (CALAUT/OPT2CD)	1	001502	CALAUT (CALAUT/OPT1CD)	1	001705	
1	002632	CALC (CALC/OPT1CD)	CALC (CALC/OPT2CD)	1	002621	CALCA (CALCA/CODE)	1	000277	
1	000011	CALCA1 (CALCA1/SHRCDE)	CALCRS (CALCRS/OPT2CD)	1	001074	CALCRS (CALCRS/OPT1CD)	1	001341	
1	000011	CALC1 (CALC1/SHRCDE)	CALFLT (CALFLT/CODE)	1	002660	CALPLT (CALPLT/CODE)	1	001332	
1	006410	CBFADT (CBFADT/CODE)	CBLAUT (CBLAUT/OPT1CD)	1	005711	CBLAUT (CBLAUT/OPT2CD)	1	005537	
1	006257	CBLCRS (CBLCRS/OPT2CD)	CBLCRS (CBLCRS/OPT1CD)	1	007263	CCLAUT (CCLAUT/OPT1CD)	1	003710	
1	003534	CCLAUT (CCLAUT/OPT2CD)	CCLCRS (CCLCRS/OPT2CD)	1	004463	CCLCRS (CCLCRS/OPT1CD)	1	005375	
1	000024	CLOG10 (CLOG10/CODE)	DAFADT (DAFADT/CODE)	1	003106	DALAUT (DALAUT/OPT2CD)	1	002544	
1	002640	DALAUT (DALAUT/OPT1CD)	ELAP (ELAP/CODE)	0	000000	ERROR (ERR1/CODE)	0	000006	
0	000000	ERR1 (ERR1/CODE)	GARBGE (GARBGE/CODE)	1	000257	GENRAL (DUMMY/CODE)	1	000014	
1	000000	JUNK (JUNK/CODE)	LINE (DASHLN/CODE)	1	000467	LOGAXS (LOGAXS/CODE)	1	001463	
1	000035	PHASE (PHASE/CODE)	PLOT (PLOT/CODE)	1	001345	PLTLAB (PLTLAB/CODE)	1	000152	
1	001021	PRIGAM (PRIGAM/SHRCDE)	PRIN (PRIN/SHRCDE)	1	001262	PRNBAS (PRNBAS/CODE)	1	001205	
1	000023	RESEOF (FIXEND/CODE)	SAVEOF (FIXEND/CODE)	1	000000	TABLIN (TABLIN/SHRCDE)	1	000725	
1	0000765	TABLOG (TABLG5/SHRCDE)	TAKLG (TAKLG/CODE)	1	000206	TERGAM (TERGAM/SHRCDE)	1	000756	

BLOCK TABLE

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DATA      (DATA/SHRCD)  34  BANK 2  DEPENDENT
COBOL LIBRARY TABLE EMPTY

PROCEDURE NAME  TABLE
ABCA      00513232      ACRS      00511276      ALLC      00507654      AUT      00507746      AUTO      00511224

326 TRACKS REQUIRED FOR BATCH FASTRAND FILE

END CUR
26 AUG 70. 12:56:52  LOG JRS014  USER ID WDC036  CARDS IN  54  CARDS OUT  4  LINES 1141  PROCESSOR TIME 151.47 SECONDS
***** COMPUTER SCIENCES CORP.  RL5EA5  AUG 04, 1970  C O N V E R S A T I O N A L  E X E C U T I V E  * * *
*****1*****5*****2*****5*****3*****5*****4*****5*****5*****5*****6*****5*****5*****5*****8*****5*****5*****5*****0*****5*****1*****5*****2*****5*****3*****

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Graph for Sample Case

Graph for Sample Case

REFERENCES

1. J. R. Sheff. Unpublished Data, Battelle-Northwest, Richland, Washington, 1970.
2. J. R. Sheff and R. W. Albrecht. "Space Dependence of the Reactor-Noise Spectral-Density Function," Neutron Dynamics and Control, CONF-650413, pp.213, 322. AEC Symposium Series, No. 7, Available from Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 1966.
3. J. R. Sheff. The Cross Correlation of the Neutron Density Fluctuation at Two Points in a Nuclear Reactor, University of Washington, 1965 (Ph.D. Thesis)(University Microfilms, Inc., Abstract No. 65-8530).
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6. J. R. Sheff. "Exact Treatment of Neutron Fluctuations in Reflected Systems," ANS Trans., vol II. no. 1, p. 233. 1968.

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