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Calculation of Atomic-Energy-Level Values

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Leon J. Radziemski, Jr.
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CONTENTS

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Leon J. Radziemski, Jr., Kay J. Fisher, and David W. Steinhaus

ABSTRACT

Two methods for solving the least-squares formulation of the atomic-energy-level calculation problem have been coded. The matrix-inversion method is capable of handling a 285 by 1000 level array with up to 19,000 classifications. An important advantage of this method is that the complete variance-covariance matrix is calculated, which leads to the correct computation of calculated wave-number uncertainties. The iterative method is presently capable of accepting a 1000 by 1000 level array with 20,000 transitions. It is inherently capable of computing the least-squares answers to even larger arrays, but has the disadvantage that the variance-covariance matrix cannot be easily calculated. The Gauss-Seidel iterative method as applied to the level calculation problem has been demonstrated to be a convergent iterative process.

I. Introduction

One of the classical tasks of experimental atomic spectroscopy is the calculation of atomic-energy-level values and uncertainties from experimental data on classified lines. An atomic-energy-level array consists of two sets of energy levels of different parity and the transitions between them. We exclude transitions within sets. There are wide variations in the accuracies of the wave-number values corresponding to observed transitions, and usually there are many more observed transitions than energy levels. The problem then is to determine the best values for the levels from this excess of data of nonhomogeneous accuracy. The uncertainties in the level values are also important quantities because these are used to determine the accuracies of calculated wave numbers.

Reference 1 is an abstract of a preliminary report on this work.

II. Historical Background

Historically, some variation of the method of common differences has generally been used to determine level values. In this method, one starts with the lowest two levels of one parity and finds all levels of opposite parity to which common transitions are observed. Wave-number differences for all such pairs are then combined to find the average difference. The process is repeated for successive pairs of levels, and the higher level values are the consecutive sums of the lower differences. The first set of level values and the transitions are then used to calculate the second set and the cycle is repeated a few times. If sufficient iterations are not carried out, cumulative errors may exist within the array. Large amounts of data are difficult to handle, and the relative accuracies and effects of different combinations are difficult to establish.

Bockasten[2] (1955) discusses the calculation of term values (level value = limit − term value) from a network of observed transitions by using the method of weighted least squares. He derives the normal equations and describes in detail how they can be solved by a method of successive approximations. His is essentially the Gauss-Seidel iterative method discussed in Sec. V. He correctly deduced that weak links (levels or blocks of levels connected to the rest of the array through only a few transitions) slow the iterative convergence. Also, he states that the question of convergence has not been investigated theoretically but that rapid convergence is favored if the levels are well connected by observed lines and if the weights are not too different. Both of these assertions have been confirmed by our experience.

Goldman[3] (1962) developed a different method for solving the normal equations. He recognized that these are a system of linear equations that can be expressed in a matrix notation as

$$N_1 \beta = Y_1 \quad .$$

The matrix N_1 contains weight and occupation information, the vector β contains the level parameters to be determined, and the column vector Y_1 contains the linear combinations of the observed transitions. The form of these matrices is shown on p. 10, App. A. The straightforward solution of the above equation is

$$\hat{\beta} = N_1^{-1} Y_1 \quad ;$$

however, because of the large number of parameters to be estimated, which leads to an N_1 with order (Σ levels − 1), it is difficult to invert N_1 with the required accuracy. Goldman[3] divided the problem into two parts: one set of levels is calculated by inverting a matrix whose order is the number of levels in that set, and the other set is computed by means of relations between the two sets. This reduces the size of the matrix to be inverted to the size of the smaller side of the array. In addition, the variance-covariance matrix can be obtained. The elements of the matrix are necessary to properly calculate level and wave-number uncertainties. At the time it was developed, Goldman's method was coded on the IBM 7030 (STRETCH), but was not used extensively.

Brill[4] and Radziemski[5] independently coded an iterative method (similar to Bockasten's[2]) for the Univac SS80 and for the IBM 7094, respectively, and reported their work in theses (1964). Fisher and Steinhaus also coded an iterative method for the IBM 7094 in 1965 and used it to obtain the U I energy-level values reported in Ref. 6.

A method similar to Goldman's was developed independently by Vander Sluis[7] (1966). A good description of the traditional iterative-common difference method was given with a comment that iterative procedures do not give least-squares answers. This is not completely accurate because iterative methods based upon the normal equations can produce least-squares answers.

Our concern with the problem of level calculation arose because of the desire to calculate level values for arrays with many levels and transitions, and because of the question about convergence of iterative methods.

III. Least-Squares Formulation

One procedure for determining the best set of energy-level values when an excess of weighted data is available is the method of least squares. In this method, the residual

$$R = \sum_{i=1}^{M} \sum_{j=1}^{N} n_{ij} w_{ij} (a_i - b_j - y_{ij})^2 \qquad (1)$$

is to be minimized. The symbols are defined as follows:

- a_i is a member of the set of M level values of one parity. $\hat{a}_i$ is its least-squares estimate.
- b_j is a member of the set of N level values of the other parity. $\hat{b}_j$ is its least-squares estimate.
- y_{ij}'s are the experimental wave-number values of classified lines between levels a_i and b_j.
- n_{ij} equals 1 if the transition is observed, but equals 0 if it is not.
- w_{ij} is the weight inversely proportional to the square of the experimental error assigned to y_{ij}.

The quantity R will be a minimum when

$$\frac{\partial R}{\partial a_1} = \frac{\partial R}{\partial a_2} = \cdots = \frac{\partial R}{\partial a_M} = \frac{\partial R}{\partial b_1} = \cdots = \frac{\partial R}{\partial b_N} = 0 \, .$$

This leads to the two sets of equations:

$$\sum_{i=1}^{M} n_{ij} w_{ij} (\hat{a}_i - \hat{b}_j - y_{ij}) = 0 \quad (j = 1, \ldots, N) \, , \qquad (2)$$

$$\sum_{j=1}^{N} n_{ij} w_{ij} (\hat{a}_i - \hat{b}_j - y_{ij}) = 0 \quad (i = 1, \ldots, M) \, . \qquad (3)$$

Between these M + N equations there is one relationship: the sum of Eqs. (2) is equal to the sum of Eqs. (3). This constitutes a singularity, which means that the solutions to Eqs. (2) and (3) are not unique. This situation can be remedied by setting one of the level values equal to a constant and by removing the corresponding equation from the problem. Physically, this is equivalent to setting one level (usually the lowest) equal to a constant (usually zero). The system of linear equations is then nonsingular and can be solved for the unique level values, at least to an additive constant. Two methods of solution of this set of equations are described and evaluated in the following sections.

IV. Solution by the Inversion Method

Goldman's manuscript, presented as App. A, contains the equations for solving the problem by means of matrix inversion, and also gives the definitions of other

symbols. The code resulting from the programming of this method uses the CDC 6600 computer, a 60-bit binary word, and $64{,}000_{10}$ words of core storage. Table I summarizes the amounts of data which the code can handle and the expansion capacity for both this method and the iterative method (Sec. V). Rounded floating-point operations are used throughout the inversion code to minimize the effects of round-off error.

The inversion code consists of three subroutines called by a main program; the order and purpose of these codes is shown in Fig. 1. The first of these subroutines sorts the transitions according to classification and stores them, along with other data associated with the "row" levels (row defined below), upon magnetic tape in separate records. The second routine computes the elements in the matrix to be inverted, and inverts the matrix to obtain the numbers necessary to evaluate the level values and the variances. This information remains in memory to be used by the third subroutine, which also uses the data stored on magnetic tape to complete the computation. These programs are discussed in detail below.

SORTD is the first subprogram and has as input the wave number, uncertainty, and classification for each observed transition. Each wave number is the difference between two energy levels: $y_{ij} = a_i - b_j$, where a_i is a level of one parity, and b_j is a level of the other parity. The set of levels $\{b_j\}$ $j = 1, \ldots, N$ are called column levels and must contain the reference level. The $\{a_i\}$ $i = 1, \ldots, M$ are the row levels. The lowest energy level is commonly used as the reference level, but this is not necessary for the computation. Indeed, the smaller set of levels should be used as the $\{b_j\}$ to minimize the size of the matrix to be inverted. SORTD determines the number of levels and their code names from the classifications, and the weights for the transitions from the uncertainties. The data are ordered according to the row level classification by using the TORDER subroutine. For each row the quantities

TABLE I

AMOUNTS OF DATA THAT THE INVERSION AND ITERATION CODES ARE PRESENTLY CAPABLE OF ACCEPTING, AND EXPANSION CAPABILITIES

Computer: CDC 6600
Core memory: $64{,}000_{10}$ words
Word size: 60 binary bits
Mode: Single precision with rounded floating point operations

Code Name	Present Maximum Amounts of Data		
	Small Side of Array	Large Side of Array	Number of Classifications
INVERSION	285	1000	19000

The inversion method may be reprogrammed to accommodate any number of transitions and large-side levels. Increasing the small side increases the inversion time by the cube of the ratio (N_{new} / N_{old}).

ITERATION	1000	1000	20000

The iteration method may be reprogrammed to accommodate combinations of transitions and levels which satisfy the relationship:

$$2(\text{number transitions}) + 3(\text{small side number of levels}) + 4(\text{large side number of levels}) \leqslant 47{,}000.$$

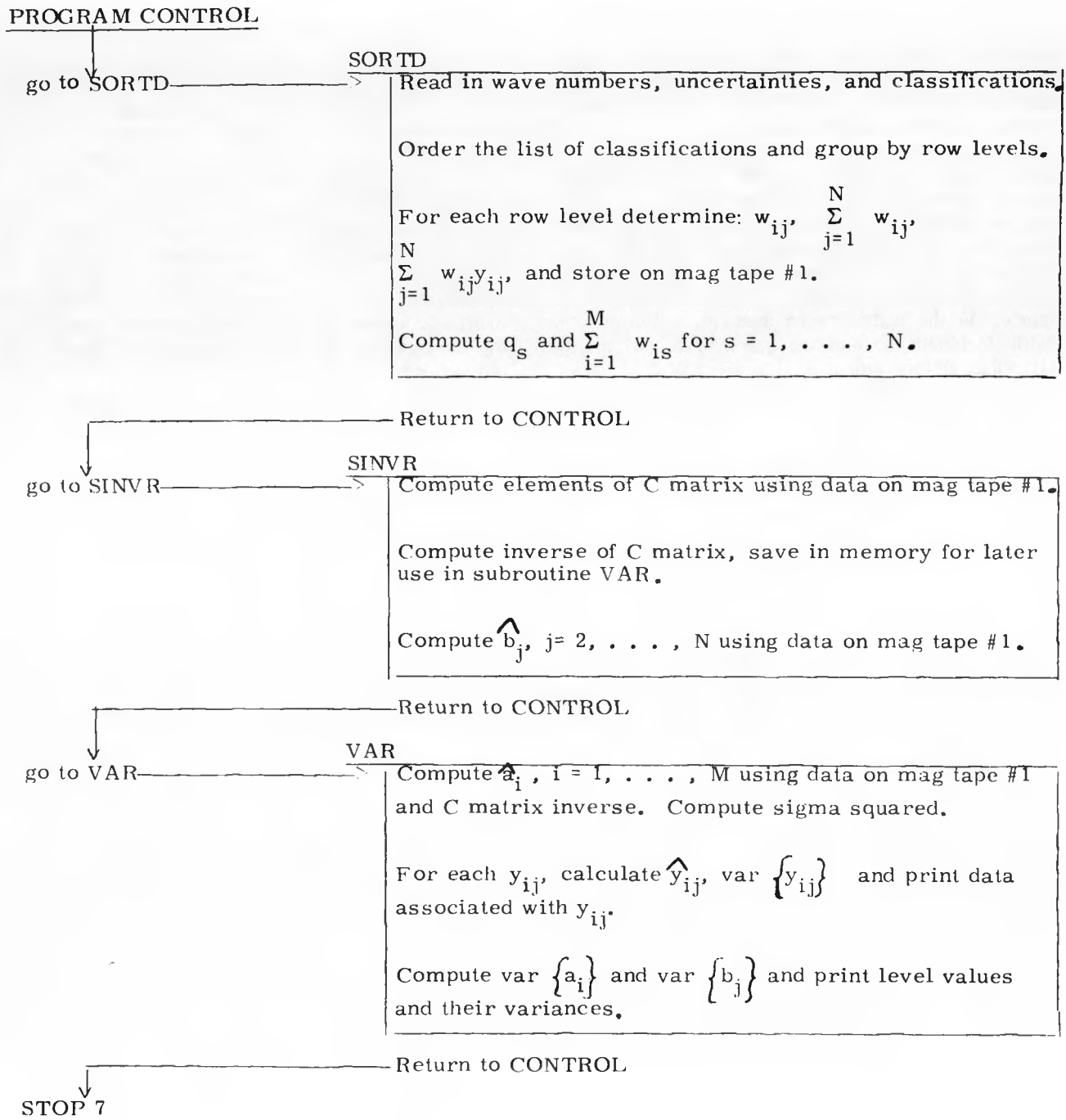

Fig. 1.
Generalized flow diagram for the inversion code.

$\sum_{j=1}^{N} w_{ij}$, $\sum_{j=1}^{N} w_{ij}y_{ij}$, and q_j(p. 14, App. A) are computed. The running time and the storage required by this subprogram increase linearly in proportion to the number of transitions.

SINVR computes the elements of the C matrix (p. 15, App. A) and inverts the matrix. The storage presently allows for a 284 by 284 matrix placed in an array dimensioned 143 by 284. Because C is symmetric, only c_{ij}, where $i \leqslant j$, is stored in memory. The elements c_{ij}, where $i > 143$, are stored in positions $c_{(286-i)(j-i+1)}$. The c_{ij} in the code refers to $c_{(i+1)(j+1)}$ in App. A because all the elements of the first row and first column of the C matrix are 0. Because of the storage manipulations mentioned above, the inversion method uses central memory very efficiently. The algorithms used in the inversion as well as a detailed example are contained in App. B. On the CDC 6600, a 284 by 284 C matrix is inverted in 55 sec and uses 64,000 words of storage. The increase in inversion time is proportional to the cube of the increase of the small side of the array (Fig. 2). The storage requirement increases as the square of the small side. A 400 by 400 matrix could be inverted in 2½ min by present techniques.

The accuracy of the inversion has been tested by comparison with double-precision calculations for arrays up to 172 levels on the small side. The single-precision rounded floating-point calculations matched the double-precision inversion results to 12 out of a possible 14 decimal digits. Inversion accuracy is sensitive to the connection between the reference level and the remainder of the array. This connection appears in the ordering of the magnitude of the diagonal elements of the C matrix. For the greatest accuracy, the matrix should be rearranged so that $c_{ii} > c_{(i+1)(i+1)}$. The code at present does not make provision for automatically ordering the levels so that the above condition is met. The lowest level is used as the reference level. The justification for this is that in all cases so far investigated, the improvement in the inversion accuracy acheived by performing the rearrangement has been in decimal places far beyond the physical significance of the data. There is no indication that the round-off error is increasing with increasing matrix size, and we ascribe this peculiar result to the use of the automatic floating-point, round-off procedure available on the CDC 6600. However, a test of the round-off error can be made if the automatic round-off procedure is not used. A calculation is made by using all available octal digits, and then repeating by masking completely one octal digit throughout the calculation. If the level values change significantly, then the round-off error may also have affected the results of the first calculation. If the level values do not change, it is safe to assume that the effect from round off is negligible.

VAR is the subprogram to determine level values and variances, and uses these to calculate wave numbers and their variances. Although level values and their variances are dependent upon the choice of reference level, the same quantities for the wave numbers are not dependent upon reference level, basically because wave numbers are differences of level values. The differences $(y_{obs} - y_{calc})$ are then computed, grouped into weight classes, and the rms value for each weight class is determined. The ratios of rms values to uncertainties should be similar for all weight classes. A departure from that condition is an indication that the uncertainties should be reexamined.

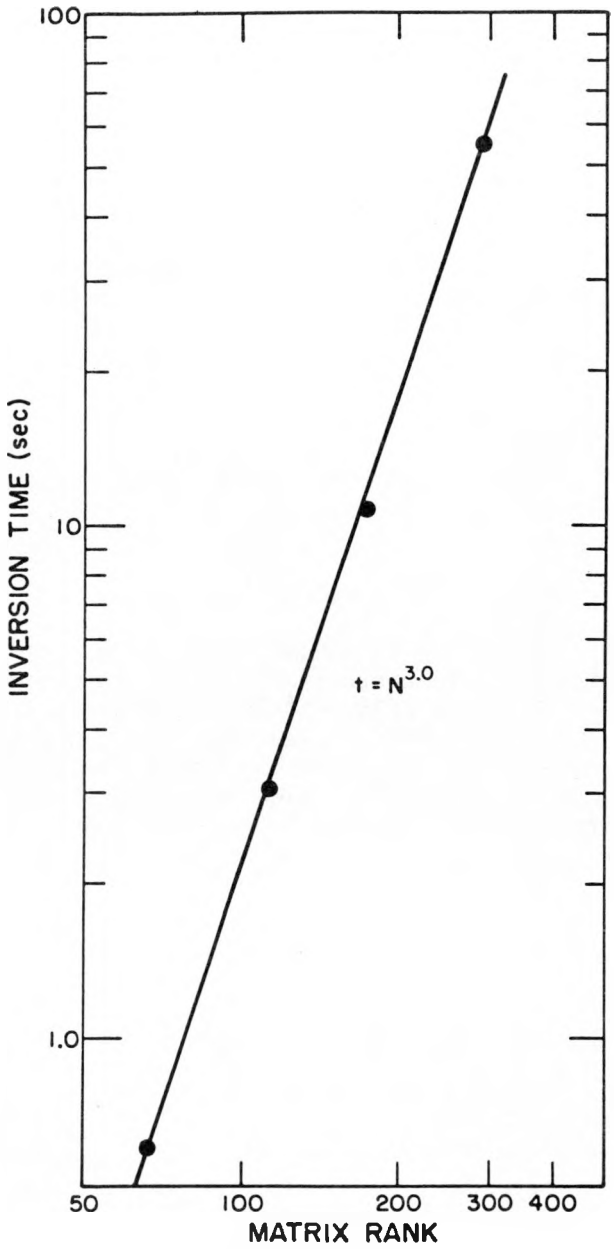

Fig. 2.
Inversion time as a function of matrix size as determined from four calculations.

The inversion method is attractive for many reasons. There is no question of convergence as in the iterative method, all the data are used simultaneously, and the complete variance-covariance matrix can be computed. This latter allows a mathematically correct calculation for the uncertainties of calculated wave numbers, avoiding the question of relative and absolute level uncertainties. The correct expression for the variance of the calculated wave number, which we take to be its uncertainty, is

$$\text{var}\,(y_{ij}^{\text{calc}}) = \text{var}\,a_i + \text{var}\,b_j - 2\,\text{cov}\,(a_i, b_j) \quad .$$

The calculations of variances and covariances are described in App. A.

A copy of the inversion code is contained in App. D.

V. Solution by the Iterative Method

Solution by the iterative method can be succinctly described in matrix notation. The following development is similar to that of Varga's.[8] Once the normal equations are obtained and the singularity is removed, the problem can be written in the form $Ax = k$ as stated in Sec. II.* The iterative method of solution is set up by splitting A into three parts: a diagonal matrix $D = (a_{ii}\,\delta_{ij})$, a lower triangular matrix E, and an upper triangular matrix F so that

$$A = D - E - F \quad . \tag{4}$$

All are of dimension n by n where $n = M + N - 1$. The matrix description of our iterative scheme is

$$(D - E)\,x^{(m+1)} = F\,x^{(m)} + k \quad , \tag{5}$$

where m is the iteration number and x is a vector containing the a_i and b_j level values. Equation (5) is then

$$a_{ii}\,x_i^{(m+1)} = \sum_{j=1}^{i-1} a_{ij}x_j^{(m+1)} - \sum_{j=i+1}^{n} a_{ij}x_j^{(m)} + k_i \tag{6}$$

for $m \geq 0$ and $1 \leq i \leq n$. This is called the Gauss-Seidel (GS) iteration method. We first calculate the x_i corresponding to the $\{b_j\}$ and then, by using these, the x_i corresponding to the $\{a_i\}$. All the $x^{(m+1)}$ corresponding to either set, $\{a_i\}$ or $\{b_j\}$, are used at the same time when we change from calculating levels of one parity to computing levels of the opposite parity. In practice, only the corrections are determined and added to the old values. This reduces the round-off problem because, at any stage, only small numbers ($< 0.1\ \text{cm}^{-1}$) are being computed. The solution described above is the same method developed by Bockasten.[2]

Using the matrix notation introduced above, we now address ourselves to the question of convergence. Equation (5) can be rewritten as

$$x^{(m+1)} = (D - E)^{-1}\,F\,x^{(m)} + (D - E)^{-1}\,k \quad . \tag{7}$$

The matrix $(D - E)$ is nonsingular so that $(D - E)^{-1}$ exists. The matrix

$$M = (D - E)^{-1}\,F$$

is called the Gauss-Seidel iterative matrix associated with A. According to Varga (Ref. 8, p. 59) the iterative method converges if, and only if, M is a convergent matrix. The proof that it is a convergent matrix in the level-calculation problem is found in App. C along with statements of the theorems involved.

Another iterative method we have used is that of successive overrelaxation (SOR) (Ref. 8, p. 59). In this scheme, the correction Δx to the old level value is calculated, but $\omega(\Delta x)$ is added. The object is to speed up the convergence. In the cases we tried, convergence was speeded up, but improvement factors were not calculated. Varga shows that this process is convergent for $1 \leq \omega \leq 2$.

A disadvantage to using either the GS or the SOR method is that it is not easy to obtain an estimate of the speed of convergence. Stated in another way, the solution cannot be easily guaranteed to approximate the least-squares solution to a specified number of digits. However, we have made several comparisons between inversion solutions and iterative solutions for the same problems. Specifically, we have looked at arrays of C1 I, Th I, Cu II, U I. The results indicate that it is generally, but not always, sufficient to iterate until the maximum change in level value from successive iterations is less than 100 times the maximum accuracy desired.

Round-off error is not significant because of the small numbers used by the code. The time for running, based on the speed of convergence, appears to depend upon the number of weak links in the array; that is, segments of the array that are only loosely connected. Table II contains some of the results obtained in our comparisons between iteration and inversion calculations and may serve as a guide for other problems.

The present capability of the iteration program is shown in Table I. A copy of the program is contained in App. E.

A disadvantage of the iteration method is that it is not easy to calculate the variance-covariance matrix, which means that a statistically correct determination of

---

*The notation is changed from that followed in Secs. II through IV to conform to the notation used by Varga.[8] This will help those who want more details as found in Ref. 8. The correspondence between symbols is:

Secs. II - IV	Sec. V
N_1	A
Y_1	k

TABLE II

RESULTS OF SOME ITERATION CALCULATIONS

Spectrum	N	M	Number of Transitions	Total[a] Iteration Time (sec)	Largest Iteration-Inversion Difference	Largest Level Change Last Cycle	Number of Cycles
U I	66	791	8850	21	$0.8 \times 10^{-6} cm^{-1}$	$0.8 \times 10^{-6} cm^{-1}$	23
C1 I	112	124	1091	48	110.	1.	516
Cu II	173	178	1688	8	3.6	0.8	44
Th I	285	409	12542	34	0.7	0.7	27

[a]Each iteration calculation was started from integer level values. The iterations continued until the largest level change from one iteration to the next was less than 10^{-6} cm^{-1}.

level and wave-number uncertainties is difficult. The rms attached to level values derived from many lines is an indication of the uncertainty, but this is based, in many cases, upon the poor statistics of a few combinations.

VI. Conclusions

We have coded two methods for solving the least-squares formulation of the atomic-energy-level calculation problem. The matrix method of solution is capable of handling a 285 by 1000 level array with up to 19,000 classifications. With suitable modifications, it can probably be made to work on arrays up to 1000 by 1000 on computers with speeds equivalent to the CDC 6600. An important advantage of this method is that the variances can be used to calculate correctly the uncertainties for calculated wave numbers, which is the ultimate aim of any level calculation method. The iterative method is inherently capable of computing the least-squares answers to larger arrays, but has the disadvantage that the variance-covariance matrix cannot be easily calculated. The Gauss-Seidel iterative method as applied to the level problem has been demonstrated to be inherently a convergent iterative process.

VII. References

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APPENDIX A

EQUATIONS DESCRIBING THE INVERSION METHOD DERIVED BY A. S. GOLDMAN

This appendix contains the unpublished work of Goldman upon which our matrix inversion code is based. The manuscript was written while Dr. Goldman was an employee of Los Alamos Scientific Laboratory. It is identical to a manuscript given to us by him, except that a few typographical errors have been removed. Our modifications for the introduction of weighting are indicated by the column-wide boxes.

ESTIMATING THE PARAMETERS IN THE MODEL $y_{ijk} = a_i - b_j + e_{ijk}$

Aaron S. Goldman

The problem of estimating parameters in the two-way classification fixed-effects model is usually solved by adding a constraint to the singular system of normal equations to make the equations independent so that a solution is obtained. Because there is a large number of parameters to be estimated, it happens the matrix of coefficients formed by the normal equations cannot be inverted with the desired accuracy; therefore, it is necessary to reduce the size of the matrix. We shall present a procedure to find a matrix whose dimensions are equal to the number of one of the two sets of parameters. We will also derive the technique of obtaining estimates of the other set. The overall variance-covariance matrix will also be obtained. The model to be used differs only slightly from the general two-way design; however, the results are readily seen to be the same.

STATEMENT OF PROBLEM: It is desired to estimate the parameters in the model

$$y_{ijk} = a_i - b_j + e_{ijk},$$

where

$i = 1, 2, 3, \cdots, m,$

$j = 1, 2, 3, \cdots, n,$

$k = 0, 1, \cdots, n_{ij},$

y_{ijk} is an observed random variable,

$a = \{a_1, a_2, \cdots, a_m\}$, $b = \{b_1, b_2, b_3, \ldots, b_n\}$ are the set of parameters to be estimated, and e_{ijk} is an independently distributed random variable with mean 0 and variance σ^2.

NOTATION: In order to simplify the form of the equations, the following notation will be used

$$y_{.j.} = \sum_i \sum_k y_{ijk}$$

$$y_{i..} = \sum_j \sum_k y_{ijk}$$

$$n_{i.} = \sum_j n_{ij}$$

$$n_{.j} = \sum_i n_{ij}$$

w_{ij} = weight associated with y_{ij}

$$y_{.j.} = \sum_{i=1}^{M} w_{ij}\, y_{ij}$$

$$y_{i..} = \sum_{j=1}^{N} w_{ij}\, y_{ij}$$

$$n_{i.} = \sum_{j=1}^{N} w_{ij}$$

$$n_{.j} = \sum_{i=1}^{M} w_{ij}$$

if y_{ij} not given $w_{ij} = 0$

$\hat{a} = \left\{\hat{a}_1, \hat{a}_2, \ldots, \hat{a}_m\right\}$, $\hat{b} = \left\{\hat{b}_1, \hat{b}_2, \ldots, \hat{b}_n\right\}$ are the least-squares estimates of a and b.

NORMAL EQUATIONS: The normal equations are found to be

$$y_{r..} = n_{r.}\,\hat{a}_r - \sum_j n_{rj}\,\hat{b}_j \qquad r = 1, 2, \ldots, m$$

$$y_{.s.} = \sum_i n_{is}\,\hat{a}_i - n_{.s}\,\hat{b}_s \qquad s = 1, 2, \ldots, n$$

$$y_{r..} = n_{r.}\,\hat{a}_r - \sum_{j=1}^{N} w_{rj}\,\hat{b}_j \qquad r = 1, 2, \ldots, m$$

$$y_{.s.} = \sum_{i=1}^{M} w_{is}\,\hat{a}_i - n_{.s}\,\hat{b}_s \qquad s = 1, 2, \ldots, n.$$

In order to solve these m + n linearly dependent equations, it is necessary to use the constraint $\hat{b}_1 = 0$. Thus, we may reduce the system to n + m - 1 linearly independent equations. Since $\hat{b}_1$ is not an estimable function, we are assured of the independence (see Graybill, An Introduction to Linear Statistical Models, Vol. 1, McGraw-Hill, 1961).

SOLUTION: Let

$$\underset{(m+n-1)\times 1}{\hat{\beta}} = \begin{bmatrix} \hat{a}_1 \\ \hat{a}_2 \\ \vdots \\ \hat{a}_m \\ -\hat{b}_2 \\ -\hat{b}_3 \\ \vdots \\ -\hat{b}_n \end{bmatrix} \qquad N_1 = \underset{m+n-1}{\underset{m+n-1}{}} \times \left[\begin{array}{c|c} \underset{m\times m}{N_{11}} & \underset{m\times(n-1)}{N_{12}} \\ \hline \underset{(n-1)\times m}{N_{21}} & \underset{(n-1)\times(n-1)}{N_{22}} \end{array}\right] = \left[\begin{array}{c|c} \begin{matrix} n_{1.} & 0 & 0 & \cdots & 0 \\ 0 & n_{2.} & 0 & \cdots & 0 \\ \vdots & & & & \\ 0 & 0 & 0 & \cdots & n_{m.} \end{matrix} & \begin{matrix} n_{12} & n_{13} & \cdots & n_{1n} \\ n_{22} & n_{23} & \cdots & n_{2n} \\ \vdots & \vdots & & \vdots \\ n_{m2} & n_{m3} & \cdots & n_{mn} \end{matrix} \\ \hline \begin{matrix} n_{12} & n_{22} & \cdots & n_{m2} \\ n_{13} & n_{23} & \cdots & n_{m3} \\ \vdots & & & \\ n_{1n} & m_{2n} & \cdots & n_{mn} \end{matrix} & \begin{matrix} n_{.2} & 0 & \cdots & 0 \\ 0 & n_{.3} & \cdots & 0 \\ \vdots & & & \\ 0 & \cdots & & n_{.n} \end{matrix} \end{array}\right]$$

$$\underset{(m+n-1)\times 1}{Y_1} = \begin{bmatrix} y_{1..} \\ y_{2..} \\ \vdots \\ y_{m..} \\ y_{.2.} \\ y_{.3.} \\ \vdots \\ y_{.n.} \end{bmatrix} \qquad \underset{(m+n-1)\times 1}{\beta} = \begin{bmatrix} a_1 \\ a_2 \\ \vdots \\ a_m \\ -b_2 \\ \vdots \\ -b_n \end{bmatrix} \qquad \underset{(m+n-1)\times 1}{e} = \begin{bmatrix} e_{1..} \\ e_{2..} \\ \vdots \\ e_{m..} \\ e_{.2.} \\ e_{.3.} \\ \vdots \\ e_{.n.} \end{bmatrix}$$

Thus, $Y_1 = N_1\hat{\beta}$

or

$$\hat{\beta} = N_1^{-1} Y_1 .$$

Since $Y_1 = N_1\beta + e$,

then

$$E\left\{\hat{\beta}\right\} = E\left\{N_1^{-1}(N_1\hat{\beta} + e)\right\} = \beta ,$$

and

$$\text{Var}\left\{\hat{\beta}\right\} = \text{Var}\left\{N_1^{-1}Y\right\} = N_1^{-1}N_1^{-1}\,\text{Var}\left\{N_1\beta + e\right\}$$

$$= N_1^{-1} N_1^{-1} N_1\sigma^2$$

$$= N_1^{-1}\sigma^2 .$$

The following demonstrates why $\text{Var}\left\{e\right\} = N_1\sigma^2$.

$$\text{Var}\left\{e\right\} = E\left\{[e][e]'\right\} =$$

$$E\begin{bmatrix} e_{11} & e_{12} \\ m \times m & m \times (n-1) \\ e_{21} & e_{22} \\ (n-1) \times m & (n-1) \times (n-1) \end{bmatrix} =$$

$$E\left[\begin{array}{ccc|ccc} e_{1..}^2 & (e_{1..}e_{2..}) \cdots & (e_{1..}e_{m..}) & (e_{1..}e_{.2.})(e_{1..}e_{.3.}) \cdots & (e_{1..}e_{.n.}) \\ \vdots & & & \vdots & \\ (e_{m..}e_{1..}) & (e_{m..}e_{2..}) \cdots & e_{m..}^2 & (e_{m..}e_{.2.})(e_{m..}e_{.3.}) \cdots & (e_{m..}e_{.n.}) \\ \hline (e_{.2.}e_{1..}) & \cdots & (e_{m..}e_{.2.}) & e_{.2.}^2 \quad (e_{.2.}e_{.3.}) \cdots & (e_{.2.}e_{.n.}) \\ \vdots & & & \vdots & \\ (e_{.n.}e_{1..}) & \cdots & (e_{.n.}e_{m..}) & (e_{.n.}e_{.2.}) \cdots & e_{.n.}^2 \end{array}\right]$$

$$= N_1\sigma^2 .$$

An example of the above is given in the special case when $n_{ij} = 1$ for all i and j.

In this case $n_{i.} = n$, $n_{.j} = m$, and we may obtain

$$N_1 = \left[\begin{array}{c|c} \underset{m \times m}{N_{11}} & \underset{m \times (n-1)}{N_{12}} \\ \hline \underset{(n-1) \times m}{N_{12}'} & \underset{(n-1) \times (n-1)}{N_{22}} \end{array}\right] = \left[\begin{array}{c|c} \underset{m \times m}{nI} & \underset{m \times (n-1)}{J} \\ \hline \underset{(n-1) \times m}{J'} & \underset{(n-1) \times (n-1)}{mI} \end{array}\right]$$

where N_{12}' denotes the transpose of N_{12}.

I is the identity matrix

$$I = \begin{bmatrix} 1 & 0 & 0 & \cdots & 0 \\ 0 & 1 & 0 & \cdots & 0 \\ \cdot & & & & \\ \cdot & & & & \\ \cdot & & & & \\ 0 & \cdots & \cdots & \cdots & 1 \end{bmatrix},$$

and J is a matrix composed of ones everywhere

$$J = \begin{bmatrix} 1 & 1 & \cdots & \cdots & 1 \\ 1 & 1 & \cdots & \cdots & 1 \\ \cdot & & & & \\ \cdot & & & & \\ \cdot & & & & \\ 1 & 1 & \cdots & \cdots & 1 \end{bmatrix}.$$

Thus,

$$N_1^{-1} = \left[\begin{array}{c|c} \underset{m \times m}{N_{11}^*} & \underset{m \times (n-1)}{N_{12}^*} \\ \hline \underset{(n-1) \times m}{N_{12}^{*\prime}} & \underset{(n-1) \times (n-1)}{N_{22}} \end{array}\right] =$$

$$\left[\begin{array}{ccccc|ccc}
\frac{m+n-1}{mn} & \frac{n-1}{mn} & \cdots\cdots & \frac{n-1}{mn} & & -\frac{1}{m} & -\frac{1}{m} & \cdots & -\frac{1}{m} \\
\frac{n-1}{mn} & \frac{m+n-1}{mn} & \cdots\cdots & \frac{n-1}{mn} & & & & & \\
\vdots & & & & & & & & \\
\frac{n-1}{mn} & \frac{n-1}{mn} & \cdots\cdots & \frac{m+n-1}{mn} & & -\frac{1}{m} & \cdots\cdots & & -\frac{1}{m} \\
\hline
-\frac{1}{m} & -\frac{1}{m} & \cdots\cdots & -\frac{1}{m} & & \frac{2}{m} & \frac{1}{m} & \cdots\cdots & \frac{1}{m} \\
\vdots & & & & & & & & \\
-\frac{1}{m} & -\frac{1}{m} & \cdots\cdots & -\frac{1}{m} & & \frac{1}{m} & \frac{1}{m} & \cdots\cdots & \frac{2}{m}
\end{array}\right].$$

Thus,

$$\text{Var}\left\{\hat{a}_i\right\} = \frac{m+n-1}{mn}\sigma^2,$$

$$\text{Cov}\left\{\hat{a}_i, \hat{a}_t\right\} = \frac{n-1}{mn}\sigma^2,$$

$$\text{Cov}\left\{\hat{a}_i, \hat{b}_j\right\} = -\frac{1}{m}\sigma^2,$$

$$\text{Var}\left\{\hat{b}_s\right\} = \frac{2}{m}\sigma^2,$$

$$\text{and Cov}\left\{\hat{b}_s, \hat{b}_q\right\} = \frac{1}{m}\sigma^2.$$

If $m = 2$ and $n = 3$, we obtain

$$\text{Var}\left\{\hat{a}_i\right\} = \frac{2}{3}\sigma^2,$$

$$\text{Cov}\left\{\hat{a}_i, \hat{a}_t\right\} = \frac{1}{3}\sigma^2,$$

$$\text{Cov}\left\{\hat{a}_i, \hat{b}_j\right\} = -\frac{1}{2}\sigma^2,$$

$$\text{Var}\left\{\hat{b}_j\right\} = 1\,\sigma^2,$$

$$\text{and Cov}\left\{\hat{b}_s, \hat{b}_q\right\} = \frac{1}{2}\sigma^2.$$

We have shown that in the two-way classification, the problem of estimating parameters may be solved quite expediently as well as exact. The difficulty lies in round-off errors when computing N_1^{-1}. One way of surmounting this difficulty is to solve the normal equations in a different manner. To do this, we shall first of all solve for $\hat{b}$ only, and then solve for $\hat{a}$ in terms of these results. The errors will also be derived.

From the normal equations, we obtain

$$n_{.s}\hat{b}_s = \sum_i n_{is}\hat{a}_i - y_{.s.},$$

$$\hat{a}_i = \frac{y_{i..}}{n_{i.}} + \frac{\sum_j n_{ij}\hat{b}_j}{n_{i.}},$$

$$n_{.s}\hat{b}_s = \sum_i n_{is}\left(\frac{y_{i..}}{n_{i.}} + \sum_j \frac{n_{ij}\hat{b}_j}{n_{i.}}\right) - y_{.s.},$$

$$n_{.s}\hat{b}_s - \sum_i n_{is}\sum_j\left(\frac{n_{ij}\hat{b}_j}{n_{i.}}\right) = \sum_i\left(\frac{n_{is}y_{i..}}{n_{i.}}\right) - y_{.s.} = q_s,$$

$$n_{.s}\hat{b}_s - \sum_i\sum_j\left(\frac{n_{is}n_{ij}\hat{b}_j}{n_{i.}}\right) = q_s,$$

$$n_{.s}\hat{b}_s - \hat{b}_s\sum_i\left(\frac{n_{is}^2}{n_{i.}}\right) - \sum_i\sum_{j\neq s}\left(\frac{n_{is}n_{ij}\hat{b}_j}{n_{i.}}\right) = q_s,$$

and

$$\left[n_{.s} - \sum_i\left(\frac{n_{is}^2}{n_{i.}}\right)\right]\hat{b}_s - \sum_i\sum_{j\neq s}\left(\frac{n_{is}n_{ij}\hat{b}_j}{n_{i.}}\right) = q_s.$$

$$\left[\sum_{i=1}^{M} w_{is} - \sum_i^M\left(\frac{w_{is}^2}{\sum_{j=1}^{N} w_{ij}}\right)\right]\hat{b}_s - \sum_{i=1}^{M}\sum_{\substack{j=1\\ j\neq s}}^{N}\left(\frac{w_{is}w_{ij}\hat{b}_j}{\sum_{j=1}^{N} w_{ij}}\right) = q_s.$$

Summarizing the above in matrix notation, we obtain

$$C\hat{B} = Q$$

where C is a symmetric matrix, $\hat{B}$ is the estimate of B, and Q is a vector composed of q_s elements where s = 2, 3, $\cdots$, n. They may be written as follows:

$$\underset{(n-1)\times(n-1)}{C} = \begin{bmatrix} c_{22} & c_{23} \cdots & c_{2n} \\ & c_{33} \cdots & c_{3n} \\ & & \vdots \\ & & c_{nn} \end{bmatrix} =$$

$$\begin{bmatrix} \left[n_{.2} - \sum_i \left(\frac{n_{i2}^2}{n_{i.}}\right)\right] - \sum_i \left(\frac{n_{i2}\, n_{i3}}{n_{i.}}\right) - \sum_i \left(\frac{n_{i2}\, n_{i4}}{n_{i.}}\right) \cdots \sum_i \left(\frac{n_{i2}\, n_{in}}{n_{i.}}\right) \\ \left[n_{.3} - \sum_i \left(\frac{n_{i3}^2}{n_{i.}}\right)\right] - \sum_i \frac{n_{i3}\, n_{i4}}{n_{i.}} \cdots \sum_i \left(\frac{n_{i3}\, n_{in}}{n_{i.}}\right) \\ \vdots \\ \left(n_{.n} - \sum_i \frac{n_{in}^2}{n_{i.}}\right) \end{bmatrix},$$

$$n_{.2} - \sum \left(\frac{n_{i2}^2}{n_{i.}}\right) = \sum_{i=1}^{M} w_{i2} - \sum_{i=1}^{M} \left(\frac{w_{i2}^2}{\sum_{n=1}^{N} w_{ij}}\right)$$

$$\sum_i \left(\frac{n_{i2}\, n_{i3}}{n_{i.}}\right) = \sum_{i=1}^{M} \left(\frac{w_{i2}\, w_{i3}}{\sum_{j=1}^{N} w_{ij}}\right),$$

and

$$C^{-1}_{(n-1)\times(n-1)} = \begin{bmatrix} c_{22}^{-1} & c_{23}^{-1} & \cdots & c_{2n}^{-1} \\ & c_{33}^{-1} & \cdots & c_{3n}^{-1} \\ & & \cdots & c_{nn}^{-1} \end{bmatrix}.$$

$$\hat{B} = \begin{bmatrix} \hat{b}_2 \\ \hat{b}_3 \\ \vdots \\ b_n \end{bmatrix} \qquad Q = \begin{bmatrix} q_2 \\ q_3 \\ \vdots \\ q_n \end{bmatrix} = \begin{bmatrix} \sum_i \left(\frac{n_{i2}\, y_{i..}}{n_{i.}} \right) - y_{.2.} \\ \sum_i \left(\frac{n_{i3}\, y_{i..}}{n_{i.}} \right) - y_{.3.} \\ \vdots \\ \sum_i \left(\frac{n_{in}\, y_{i..}}{n_{i.}} \right) - y_{.n.} \end{bmatrix}$$

$$\sum_i \left(\frac{n_{i2}\, y_{i..}}{n_{i.}} \right) - y_{.2.} = \sum_{i=1}^{M} \left[\frac{w_{i2} \left(\sum_{j=1}^{N} w_{ij}\, y_{ij} \right)}{\sum_{j=1}^{N} w_{ij}} \right] - \sum_{i=1}^{M} w_{i2}\, y_{i2}$$

Thus,

$$\hat{B} = C^{-1} Q$$

$$E\{\hat{B}\} = E\{C^{-1}Q\} = C^{-1} E\{Q\} = C^{-1} CB = B$$

where

$$B = \begin{bmatrix} b_2 \\ b_3 \\ \vdots \\ b_n \end{bmatrix}$$

and

$$E\left\{q_t\right\} = \sum_i \frac{n_{it}(n_{i.}\, a_i - \sum_j n_{ij} b_j)}{n_{i.}} - \sum_i n_{it} a_i + n_{.t} b_t$$

$$= n_{.t} b_t - \sum_i n_{it} \sum_j \frac{n_{ij}\, b_j}{n_{i.}} .$$

But these coefficients of the $\hat{B}$ vector are the t^{th} row elements in the C matrix; hence

$$E\left\{Q\right\} = CB .$$

Also,

$$\text{Var}\left\{\hat{B}\right\} = C^{-1} C^{-1} \text{Var}\left\{Q\right\} = C^{-1} C^{-1} C\sigma^2 = C^{-1} \sigma^2 .$$

In order to obtain $\text{Var}\left\{Q\right\}$, we will derive the resulting matrix by examining the variances and covariances of the Q vector.

$$\text{Var}\left\{q_s\right\} = \text{Var}\left\{\sum_i \left(\frac{n_{is}\, y_{i..}}{n_{i.}}\right)\right\} + \text{Var}\left\{y_{.s.}\right\} - 2\,\text{Cov}\left\{\sum_i \left(\frac{n_{is}\, y_{i..}}{n_{i.}}\right),\, y_{.s.}\right\}$$

$$= \sigma^2 \sum_i \left(\frac{n_{is}^2\, n_{i.}}{n_{i.}^2}\right) + \sigma^2 n_{.s} - 2\sigma^2 \sum_i \left(\frac{n_{is}^2}{n_{i.}}\right)$$

$$= \left[n_{.s} - \sum_i \left(\frac{n_{is}^2}{n_{i.}}\right)\right] \sigma^2$$

$$= c_{ss}\, \sigma^2 .$$

$$\text{Cov}\left\{q_s, q_t\right\} = \text{Cov}\left\{\left[\sum_i \left(\frac{n_{is}\, y_{i..}}{n_{i.}}\right) - y_{.s.}\right], \left[\sum_i \left(\frac{n_{it}\, y_{i..}}{n_{i.}}\right) - y_{.t.}\right]\right\}$$

$$= \text{Cov}\left\{\sum_i \left(\frac{n_{is}\, y_{i..}}{n_{i.}}\right), \sum_i \left(\frac{n_{it}\, y_{i..}}{n_{i.}}\right)\right\} - \text{Cov}\left\{y_{.t.}, \sum_i \left(\frac{n_{is}\, y_{i..}}{n_{i.}}\right)\right\}$$

$$- \text{Cov}\left\{y_{.s.}, \sum_i \left(\frac{n_{it}\, y_{i..}}{n_{i.}}\right)\right\} + \text{Cov}\left\{y_{.s.}, y_{.t.}\right\}$$

$$= \sigma^2 \sum_i \left(\frac{n_{is}\, n_{it}}{n_{i.}}\right) - \sigma^2 \sum_i \left(\frac{n_{is}\, n_{it}}{n_{i.}}\right) - \sigma^2 \sum_i \left(\frac{n_{is}\, n_{it}}{n_{i.}}\right) + 0$$

$$= -\sigma^2 \sum_i \left(\frac{n_{is}\, n_{it}}{n_{i.}}\right)$$

$$= c_{st}\, \sigma^2 .$$

Thus,

$$\text{Var}\left\{\hat{B}\right\} = C^{-1}\, \sigma^2 .$$

For example, let $n_{ij} = 1$ for all i and j. Then

$$n_{.s} = m, \quad \sum_i \left(\frac{n_{i2}}{n_{i.}}\right) = \frac{m}{n}, \text{ and } \sum_i \left(\frac{n_{i2}\, n_{i3}}{n_{i.}}\right) = \frac{m}{n} .$$

Also,

$$C = \frac{m}{n}\begin{bmatrix} (n-1) & -1 & -1 \ldots & -1 \\ & (n-1) & -1 \ldots & -1 \\ & & & \vdots \\ & & & (n-1) \end{bmatrix},$$

$$C^{-1} = \frac{n}{m}\begin{bmatrix} \frac{2}{n} & \frac{1}{n} \cdots\cdots\cdots\cdots & \frac{1}{n} \\ & \frac{2}{n} \cdots\cdots\cdots\cdots & \frac{1}{n} \\ & & \vdots \\ & & \frac{2}{n} \end{bmatrix}$$

$$= \begin{bmatrix} \frac{2}{m} & \frac{1}{m} \cdots\cdots\cdots\cdots & \frac{1}{m} \\ & \frac{2}{m} & \frac{1}{m} \\ & & \vdots \\ & & \frac{2}{m} \end{bmatrix}.$$

If $m = 2$ and $n = 3$

$$C^{-1} = \begin{bmatrix} 1 & 1/2 \\ 1/2 & 1 \end{bmatrix},$$

$$\text{Var}\left\{\hat{b}_j\right\} = \sigma^2,$$

and

$$\text{Cov}\left\{\hat{b}_j, \hat{b}_y\right\} = (1/2)\ \sigma^2 .$$

In order to obtain $\hat{a}$, we refer to the normal equations and obtain

$$\hat{a}_r = \frac{y_{r..}}{n_{r.}} + \sum_j \left(\frac{n_{rj} \hat{b}_j}{n_{r.}} \right) ,$$

$$\boxed{\hat{a}_r = \frac{\sum_{j=1}^{N} w_{rj} y_{rj}}{\sum_{j=1}^{N} w_{rj}} + \sum_{j=1}^{N} \left(\frac{w_{rj} \hat{b}_j}{\sum_{j=1}^{N} w_{rj}} \right)}$$

$$E\left\{\hat{a}_r\right\} = \frac{n_{r.} a_r}{n_{r.}} - \sum_j \left(\frac{n_{rj} b_j}{n_{r.}} \right) + \sum_j \left(\frac{n_{rj} b_j}{n_{r.}} \right)$$

$$= a_r .$$

$$\text{Var}\left\{\hat{a}_r\right\} = \text{Var}\left\{\frac{y_{r..}}{n_{r.}}\right\} + \text{Var}\left\{\sum_j \frac{n_{rj} \hat{b}_j}{n_{r.}}\right\} + 2\,\text{Cov}\left\{\frac{y_{r..}}{n_{r.}} , \sum_j \left(\frac{n_{rj} \hat{b}_j}{n_{r.}} \right)\right\}$$

$$= \frac{\sigma^2}{n_{r.}} + \frac{\sigma^2}{n_{r.}^2} \sum_j \sum_p \left(n_{rj} n_{rp} c_{jp}^{-1} \right) + 0$$

$$= \frac{\sigma^2}{n_{r.}} \left[1 + \sum_j \sum_p \left(\frac{n_{rj} n_{rp} c_{jp}^{-1}}{n_{r.}} \right) \right],$$

$$\boxed{\text{Var}\left\{\hat{a}_r\right\} = \frac{\sigma^2}{\sum_{j=1}^{N} w_{rj}} \left[1 + \sum_{j=1}^{N} \sum_{p=1}^{N} \left(\frac{w_{rj} w_{rp} c_{jp}^{-1}}{\sum_{j=1}^{N} w_{rj}} \right) \right] .}$$

Derivation of the separate variances is as follows:

$$\mathrm{Var}\left\{\frac{y_{r..}}{n_{r.}}\right\} = E\left\{\frac{e_{r..}^{2}}{n_{r.}^{2}}\right\} = \frac{\sigma^2 n_{r.}}{n_{r.}^{2}} = \frac{\sigma^2}{n_{r.}} \quad ,$$

$$\mathrm{Var}\left\{\sum_j \left(\frac{n_{rj}\,\hat{b}_j}{n_{r.}}\right)\right\} = \sum_j \frac{n_{rj}^{2}}{n_{r.}^{2}}\,\mathrm{Var}\left\{\hat{b}_j\right\} + 2\sum_{\substack{p\ j \\ p<j}}\left(\frac{n_{rj}\,n_{rp}}{n_{r.}^{2}}\,\mathrm{Cov}\left\{\hat{b}_j,\,\hat{b}_p\right\}\right)$$

$$= \left[\sum_j \left(\frac{n_{rj}^{2}}{n_{r.}^{2}}\,c_{jj}^{-1}\right) + 2\sum_{\substack{p\ j \\ p<j}}\left(\frac{n_{rj}\,n_{rp}}{n_{r.}^{2}}\,c_{jp}^{-1}\right)\right]\sigma^2$$

$$= \frac{\sigma^2}{n_{r.}^{2}}\left[\sum_j \sum_p \left(n_{rj}\,n_{rp}\,c_{jp}^{-1}\right)\right].$$

$$\mathrm{Cov}\left\{\frac{y_{r..}}{n_{r.}},\ \sum_j\left(\frac{n_{rj}\,\hat{b}_j}{n_{r.}}\right)\right\} = E\left\{\left[\frac{y_{r..}}{n_{r.}} - E\left\{\frac{y_{r..}}{n_{r.}}\right\}\right]\left[\sum_j n_{rj}\,b_j - E\left\{\sum_j n_{rj}\,b_j\right\}\right]\right\}$$

$$= E\left\{\left(\frac{e_{r..}}{n_{r.}}\right)\left(\sum_j \frac{n_{rj}}{n_{r.}}\sum_j c_{rj}^{-1}\,q_j\right)\right\}$$

$$= E\left\{\left[\frac{e_{r..}}{n_{r.}}\right]\left[\sum_j\left(\frac{n_{rj}}{n_{r.}}\right)\sum_j c_{rj}^{-1}\left[\sum_i\left(\frac{n_{ij}\,e_{i..}}{n_{i.}}\right) - e_{.j.}\right]\right]\right\}$$

$$= E\left\{\left[\frac{e_{r..}}{n_{r.}}\right]\left[\sum_j c_{rj}^{-1}\sum_i\left(\frac{n_{ij}e_{i..}}{n_{i.}}\right) - \sum_j\left(c_{rj}^{-1}e_{.j.}\right)\right]\right\}$$

$$= \sigma^2\left[\sum_j\left(\frac{c_{rj}^{-1}}{n_{r.}^2}\, n_{rj}\, n_{r.}\right) - \sum_j\left(\frac{c_{rj}^{-1}}{n_{r.}}\, n_{rj}\right)\right]$$

$$= 0 \ .$$

The covariance between $\hat{a}_r$ and $\hat{a}_t$ is derived as follows:

$$\mathrm{Cov}\left\{\hat{a}_r, \hat{a}_t\right\} = \mathrm{Cov}\left\{\left(\frac{y_{r..}}{n_{r.}} - \sum_j \frac{n_{rj}\hat{b}_j}{n_{r.}}\right), \left(\frac{y_{t..}}{n_{t.}} - \sum_j \frac{n_{tj}\hat{b}_j}{n_{t.}}\right)\right\}$$

$$= \mathrm{Cov}\left\{\frac{y_{r..}}{n_{r.}}, \frac{y_{t..}}{n_{t.}}\right\} - \mathrm{Cov}\left\{\sum_j\left(\frac{n_{rj}\hat{b}_j}{n_{r.}}\right), \frac{y_{t..}}{n_{t.}}\right\}$$

$$- \mathrm{Cov}\left\{\frac{y_{r..}}{n_{r.}}, \sum_j \frac{n_{tj}\hat{b}_j}{n_{t.}}\right\} + \mathrm{Cov}\left\{\sum_j\left(\frac{n_{rj}\hat{b}_j}{n_{r.}}\right), \sum_j\left(\frac{n_{tj}\hat{b}_j}{n_{t.}}\right)\right\}$$

$$= 0 - 0 - 0 + \left[\sum_j\left(\frac{n_{rj}\, n_{tj}}{n_{r.}\, n_{t.}}\, c_{jj}^{-1}\right) + \sum_{\substack{p \\ p \neq q}}\sum_q\left(\frac{n_{rp}\, n_{tq}}{n_{r.}\, n_{t.}}\, c_{pq}^{-1}\right)\right]\sigma^2 \ .$$

The first term of the derivation is 0 because $y_{r..}$ and $y_{t..}$ are independent. The next two terms were shown to be 0 in the derivation of $\mathrm{Var}\left\{\hat{a}_i\right\}$. The derivation of the last term is as follows:

$$\mathrm{Cov}\left\{\sum_j \left(\frac{n_{rj}\, b_j}{n_{r.}}\right),\ \sum_j \left(\frac{n_{tj}\, b_j}{n_{t.}}\right)\right\}$$

$$= \sum_j \left(\frac{n_{rj}\, n_{tj}}{n_{r.}\, n_{t.}}\ \mathrm{Var}\left\{\hat{b}_j\right\}\right) + \sum_{\substack{p \\ p \neq q}} \sum_q \left(\frac{n_{rp}\, n_{tq}}{n_{r.}\, n_{t.}}\ \mathrm{Cov}\left\{\hat{b}_p, \hat{b}_q\right\}\right)$$

$$= \left[\sum_j \left(\frac{n_{rj}\, n_{tj}}{n_{r.}\, n_{t.}}\ c_{jj}^{-1}\right) + \sum_{\substack{p \\ p \neq q}} \sum_q \left(\frac{n_{rp}\, n_{tq}}{n_{r.}\, n_{t.}}\ c_{pq}^{-1}\right)\right]\ \sigma^2.$$

Again, using the example $n_{ij} = 1$ for all i and j, m = 2, and n = 3, we obtain

$$c_{jj}^{-1} = 1,\ c_{pq}^{-1} = 1/2,\ n_{rj} = n_{tk} = 1,\ n_{r.} = n_{t.} = n, \text{ and } (n - 1) = 2.$$

Thus,

$$\mathrm{Var}\left\{\hat{a}_i\right\} = \frac{\sigma^2}{n}\left[1 + \frac{(n-1)(n-2)}{n}\, c_{pq}^{-1} + \frac{(n-1)}{n}\, c_{jj}^{-1}\right]$$

$$= \frac{\sigma^2}{3}\left[1 + \frac{2}{6} + \frac{2}{3}\right]$$

$$= \left(\frac{2}{3}\right)\sigma^2.$$

Also,

$$\text{Cov}\left\{\hat{a}_r, \hat{a}_t\right\} = \sigma^2 \left[\frac{(n-1)}{n \times n} c_{jj}^{-1} + \frac{(n-1)(n-2)}{n \times n} c_{pq}^{-1}\right]$$

$$= \sigma^2 \left[\frac{2}{9} + \frac{1}{9}\right]$$

$$= \left(\frac{1}{3}\right) \sigma^2 .$$

The covariance of $\hat{a}_r$ and $\hat{b}_s$ is found to be

$$\text{Cov}\left\{\hat{a}_r, \hat{b}_s\right\} = + \sum_t \left(\frac{n_{rt} c_{st}^{-1}}{n_{r.}}\right) \sigma^2 .$$

The derivation is as follows:

$$\text{Cov}\left\{\hat{a}_r, \hat{b}_s\right\} = \text{Cov}\left\{\left[\frac{y_{r..}}{n_{r.}} + \sum_j \left(\frac{n_{rj} \hat{b}_j}{n_{r.}}\right)\right], \hat{b}_s\right\}$$

$$= \text{Cov}\left\{\frac{y_{r..}}{n_{r.}}, \hat{b}_s\right\} + \text{Cov}\left\{\sum_j \left(\frac{n_{rj} \hat{b}_j}{n_{r.}}\right), \hat{b}_s\right\} .$$

$$\text{Cov}\left\{\frac{y_{r..}}{n_{r.}}, \hat{b}_s\right\} = \text{Cov}\left\{\frac{y_{r..}}{n_{r.}}, \sum_t c_{st}^{-1} q_t\right\}$$

$$= \text{Cov}\left\{\frac{y_{r..}}{n_{r.}}, \sum_t c_{st}^{-1} \left[\sum_i \left(\frac{n_{it} y_{i..}}{n_{i.}}\right) - y_{.t.}\right]\right\}$$

$$= \text{Cov}\left\{\frac{y_{r..}}{n_{r.}}, \sum_t c_{st}^{-1} \sum_i \left(\frac{n_{it} y_{i..}}{n_{i.}}\right)\right\} - \text{Cov}\left\{\frac{y_{r..}}{n_{r.}}, \sum_t c_{st}^{-1} y_{.t.}\right\}$$

$$= E\left\{\left[\frac{e_{r..}}{n_{r.}}\right]\left[\sum_t c_{st}^{-1} \sum_i \frac{n_{it}\, e_{i..}}{n_{i.}}\right]\right\} - E\left\{\left[\frac{e_{r..}}{n_{r.}}\right]\left[\sum_t c_{st}^{-1}\, e_{.t.}\right]\right\}$$

$$= \sigma^2 \sum_t \left(\frac{c_{st}^{-1}\, n_{rt}}{n_{r.}}\right) - \sigma^2 \sum_t \left(\frac{c_{st}^{-1}\, n_{rt}}{n_{r.}}\right)$$

$$= 0.$$

From earlier work, we obtain

$$\mathrm{Cov}\left\{\sum_j \left(\frac{n_{rj}\,\hat{b}_j}{n_{r.}}\right),\ \hat{b}_s\right\} = \sum_t \left(\frac{n_{rt}\, c_{st}^{-1}}{n_{r.}}\right)\sigma^2 .$$

Thus,

$$\mathrm{Cov}\left\{\hat{a}_r,\ \hat{b}_s\right\} = +\sigma^2 \sum_t \left(\frac{n_{rt}\, c_{st}^{-1}}{n_{r.}}\right),$$

$$\mathrm{Cov}\left\{\hat{a}_r,\ \hat{b}_s\right\} = \sigma^2 \sum_{t=1}^{N}\left(\frac{w_{rt}\, c_{st}^{-1}}{\sum_{t=1}^{N} w_{rt}}\right)$$

Referring to our example when $n_{ij} \equiv 1$, $m = 2$, and $n = 3$, we obtain

$$\mathrm{Cov}\left\{\hat{a}_r,\ \hat{b}_s\right\} = +\left(\frac{1 + \frac{1}{2}}{3}\right) = +\frac{1}{2}$$

It is seen that throughout the special example when $n_{ij} = 1$ that the results are compatible with the entire matrix solution. For example, in this special case

$$\text{Cov}\left\{\hat{a}_r, \hat{b}_s\right\} = +\sigma^2 \sum_t \left(\frac{n_{rt}\, c_{st}^{-1}}{n_{r.}}\right) = +\frac{\sigma^2}{n} \sum_t c_{st}^{-1}$$

$$= +\frac{\sigma^2}{n} \quad \frac{n}{m} = +\frac{\sigma^2}{m} .$$

This result agrees when $n_{ij} \equiv 1$ in the entire matrix solution.

ESTIMATING σ^2: The estimate of σ^2 will be obtained by using

$$\hat{\sigma}^2 = \sum_k \sum_j \sum_i \frac{(y_{ijk} - \hat{y}_{ijk})^2}{n_{..} - m - n}$$

where

$$\hat{y}_{ijk} = \hat{a}_i - \hat{b}_j .$$

and y_{ijk} is the observed value.

$$\sigma^2 = \sum_{i=1}^{M} \sum_{j=1}^{N} \frac{w_{ij} (y_{ij} - \hat{y}_{ij})^2}{\sum_{i=1}^{M} \sum_{j=1}^{N} n_{ij} - (M + N - 1)}$$

Note: Denominator is the number of transitions less the number of levels.

$$\text{Var}\left\{\hat{y}_{ij}\right\} = \text{Var}\left\{\hat{a}_i\right\} + \text{Var}\left\{\hat{b}_j\right\} - 2\,\text{Cov}\left\{\hat{a}_i, \hat{b}_j\right\}$$

APPENDIX B

METHOD OF INVERSION AND SIMPLE EXAMPLE OF THE INVERSION PROCESS

The following steps are executed for each row i in the matrix. Capitalized names refer to names used in the code (App. D).

1. DMULT = $(c_{ii})^{-1}$, c_{ii} set to 1.

2. RMULT (k) = c_{ki} $\quad k = 1, \ldots, i - 1$

   RMULT (k) = 1 = c_{ii} $\quad k = i$

   RMULT (k) = c_{ik} $\quad k = i + 1, \ldots, N1$

3. ROW (k) = - DMULT * RMULT (k) $\quad k = 1, \ldots, i - 1$

   ROW (k) = DMULT * RMULT (k) $\quad k = i, \ldots, N1$

4. c_{ki} = 0 $\quad k = 1, \ldots, i - 1$

   c_{ik} = ROW (k) $\quad k = i, \ldots, N1$

5. For rows IX, where IX $\neq$ i

   $c_{IX,J} = c_{IX,J}$ - RMULT (IX) * ROW(J) $\quad J = IX, \ldots, N1$.

In the example which follows, the quantities in boxes are the quantities stored in the array in the computer. After each series of operations, the numerical arrays look like the arrays shown.

A (N1 x N1)			I (N1 x N1)			Computer Array C (N1 x N1)		
[4]	[-2]	[0]	1	0	0	4	-2	0
-2	[2]	[-1]	0	1	0		2	-1
0	-1	[3]	0	0	1			3

1. DMULT = $\frac{1}{4}$, c_{11} = 1
2. RMULT (k) = 1, -2, 0 $\quad k = 1, 2, N1$
3. ROW (k) = $\frac{1}{4} * 1, \frac{1}{4} * -2, \frac{1}{4} * 0$

   = $\frac{1}{4}, -\frac{1}{2}, 0$ $\quad k = 1, 2, N1$
4. c(1, k) = ROW (k) $\quad k \geq i$
5. $c_{IX,J} = c_{IX,J}$ - RMULT (IX) * ROW (J)

   where IX = 1, ..., n and IX $\neq$ i

   where J = IX, ..., N1

i = 1

1	$\boxed{-\frac{1}{2}}$	$\boxed{0}$	$\boxed{\frac{1}{4}}$	0	0	$\frac{1}{4}$	$-\frac{1}{2}$	0
0	$\boxed{1}$	$\boxed{-1}$	$\frac{1}{2}$	1	0		1	-1
0	-1	$\boxed{3}$	0	0	1			3

1. DMULT = 1/1, $c_{22} = 1$
2. RMULT (k) = $-\frac{1}{2}$, 1, -1
3. ROW (k) = (-1) $(-\frac{1}{2})$, (1) (1), (1) (-1)
   = $\frac{1}{2}$, 1, -1
4. c(k, 2) = 0 $\quad k < i$
   c(2, k) = ROW (k) $\quad k \geq i$
5. $c_{IX,J} = c_{IX,J}$ - RMULT (IX) * ROW (J)
   IX ≠ i

i = 2

1	0	$\boxed{-\frac{1}{2}}$	$\boxed{\frac{1}{2}}$	$\boxed{\frac{1}{2}}$	0	$\frac{1}{2}$	$\frac{1}{2}$	$-\frac{1}{2}$
0	1	$\boxed{-1}$	$\frac{1}{2}$	$\boxed{1}$	0		1	-1
0	0	$\boxed{2}$	$\frac{1}{2}$	1	1			2

1. DMULT = $\frac{1}{2}$ $\quad c_{33} = 1$
2. RMULT (k) = $-\frac{1}{2}$, -1, 1
3. ROW (k) = $-(\frac{1}{2})$ $(-\frac{1}{2})$, $-(\frac{1}{2})$ (-1), $(\frac{1}{2})$ (1)
   = $\frac{1}{4}$, $\frac{1}{2}$, $\frac{1}{2}$
4. c(k, 3) = 0 $\quad k < 3$
   c(3, k) = ROW (k) $\quad k \geq 3$
5. $c_{IX,J} = c_{IX,J}$ - RMULT (IX) * ROW (J)

i = 3

1	0	0	$\boxed{5/8}$	$\boxed{3/4}$	$\boxed{1/4}$	5/8	3/4	1/4
0	1	0	3/4	$\boxed{3/2}$	$\boxed{1/2}$		3/2	1/2
0	0	1	1/4	1/2	$\boxed{1/2}$			1/2

APPENDIX C

DEMONSTRATION THAT THE ITERATIVE SOLUTION TO THE PROBLEM IS CONVERGENT IN PRINCIPLE

In Sec. V, the Gauss-Seidel iteration matrix corresponding to matrix A is defined as

$$M = (D - E)^{-1} F ,$$

where D is a diagonal matrix, $D = (a_{ii}\, \delta_{ij})$, and E and F are the lower and upper strictly triangular parts of A, respectively. The iterative method converges if, and only if, M is a convergent matrix (Ref. 8, p. 59). The fact that M is a convergent matrix follows from some properties of the A matrix. Theorem 3.4 (Ref. 8, p. 73) states in essence:

If $A = (a_{ij})$ is a strictly or irreducibly diagonally dominant n x n complex matrix, then both the point Jacobi and point Gauss-Seidel matrices are convergent and the corresponding iterative methods of (3.5) and (3.8) for the matrix problem Ax = k are convergent for any initial vector approximation $x^{(o)}$.

But the A we described above in App. A (called N_1 there) is an irreducibly diagonally dominant real matrix. QED.

Demonstration:

1. Definition 1.5 (Ref. 8, p. 18) defines irreducibility. By the graphical method indicated, our A satisfies this criterion because we exclude unconnected "floating" arrays.
2. Definition 1.7 (Ref. 8, p. 25) defines irreducibly diagonally dominant. After we strike out one row and column to remove the singularity from the normal equations, A has at least one row for which

$$|a_{ii}| = \sum_{\substack{j=1 \\ i \neq j}}^{n} |a_{ij}|$$

so A satisfies Definition 1.7.

3. A real matrix is a degenerate case of a complex matrix.

APPENDIX D

THE INVERSION CODE: INSTRUCTIONS AND LISTING

```
      PROGRAMCONTROL(INPUT,OUTPUT,TAPE3=INPUT,TAPE1,TAPE9,TAPE5,
     1TAPE7)
C
C
C TAPE 1 IS USED AS A STORAGE MEDIUM TO PASS INFORMATION FROM SORTD
C TO SINVR AND VAR
C TAPE 5 IS USED TO STORE THE INVERTED MATRIX AND LEVEL VALUES AFTER
C COMPLETION OF COMPUTATION.
C TAPE 7 IS USED AS A SCRATCH TAPE IN VAR AND NEEDED ONLY IF IF THERE
C ARE MORE THAN 170 ROW LEVELS.
C TAPE 9 IS A BCD TAPE CONTAINING CARD IMAGES OF THE INPUT DATA
C COMMON STORAGE CONTAINS DATA NECESSARY FOR ALL THREE SUBROUTINES.
C
C
000002        DIMENSIONLIST(2)
000002        COMMONSTOR(41185)
000002        LIST(2)=0
000003        LFILE=3LLGO
000004        LIST(1)=5LPRCG1
000006        CALLSEGMENT(LFILE,1,LIST,0,1)
000012        CALLSORTD
000013        LIST(1)=5LPRCG2
000015        CALLSEGMENT(LFILE,1,LIST,0,1)
000020        CALL SINVR
000021        LIST(1)=5LPRCG3
000023        CALLSEGMENT(LFILE,1,LIST,0,1)
000026        CALL VAR
000027        STOP7
000031        END


PROGRAM LENGTH INCLUDING I/O BUFFERS
014251

FUNCTION ASSIGNMENTS

STATEMENT ASSIGNMENTS

BLOCK NAMES AND LENGTHS
       -   120341

VARIABLE ASSIGNMENTS
LFILE  -  000074    LIST   -  000072    STOR   -  000000C01

START OF CONSTANTS
000034

START OF TEMPORARIES
00007C

START OF INDIRECTS
000072

UNUSED COMPILER SPACE
005400


      SUBROUTINESORTD
000001        DOUBLEYI,SNI,DTEMP,QTAB
000001        COMMONN,M,WTUNC,WV(285),LEVC(285),YV(285),WTJ(285),QTAB(285),
     1LA(19000),IWX(19000)
000001        LOGICAL ISOTOP
000001        DATAIXHAF/95C1/
```

```
000001     1    FORMAT(A7,3X,F5.4)
000001     2    FORMAT(F15.4,I7,I7,F5.4,F7.3,A1)
000001     8    FORMAT(1HO,I3* COLUMN LEVELS*/1HO,I4* ROW LEVELS*/*0*I5
               1* TRANSITIONS*)
000001        9 FORMAT(1X,I10,F15.2)
000001       13 FORMAT(*0DUPLICATE CLASSIFICATION, 2ND ENTRY*
              1* IGNORED*2I10,2F14.4)
           C
           C
           C
           C INPUT DECK
           C
           C CONTROL CARD
           C  COL 1-7 (A7) ISOTOPE   FOR ISOTOPE SHIFT RUN
           C  COL 1-7 (A7) .NE. ISOTOPE   FOR WAVE NUMBER RUN
           C  COL 11-15 (F5.4) UNCERTAINTY ASSOCIATED WITH WEIGHT OF ONE
           C
           C DATA CARDS
           C  COL 1-15 (F15.4) WAVE NUMBER
           C  COL 16-22 (I7) ROW LEVEL CLASSIFICATION NAME
           C COL 23-29 (I7) COLUMN LEVEL CLASSIFICATION NAME
           C COL 30-34 (F5.4) UNCERTAINTY OF WAVE NUMBER
           C ISOTOPE SHIFT UNCERTAINTY IS ASSUMED TO BE 1.
           C COL 35-41 (F7.3) SIGNED ISOTOPE SHIFT
           C COL 42 (A1) S   IF ISOTOPE SHIFT VALUE GIVEN
           C
           C
           C FOR EXAMPLE, WAVE NUMBER 25637.2066 IS THE TRANSITION BETWEEN
           C 4663.8815 (J-VALUE=3) AND 30301.0873 (J-VALUE=4) WITH THE
           C UNCERTAINTY=.003 AND THE ISOTOPE SHIFT=-0.13.  THE LEVEL NAME SHOULD
           C BE UNIQUE.  4663.8815 MAY BE REPRESENTED AS 466303 AND 30301.0873
           C AS 3030104.  THE LEVEL NAME IS USED ONLY TO CLASSIFY THE TRANSITON
           C AND HAS NO EFFECT ON THE LEVEL ESTIMATE COMPUTED BY THE PROGRAM.
           C RESULTS ARE ORDERED BY THE LEVEL NAME.
           C
           C
           C
           C CARD SPECIFIES LEVEL OR ISOTOPE SHIFT DATA AND MAY SPECIFY THE
           C UNCERTAINTY TO BE ASSOCIATED WITH WEIGHT ONE.
000001           READ1,ITYPE,WTUNC
000011           ISOTOP=ITYPE.EQ.7HISOTOPE
000015           IF(WTUNC.EQ.0.)WTUNC=1.
000017           IX=0
           C READ IN DATA CARDS
000020     170   READ(9,2)WN,LR,LC,UNC,SFT,SFTX
000040           IF(EOF,9)220,180
000043     180   IF(ISOTOP)GOTO185
           C TRANSITIONS AND THEIR UNCERTAINTIES ARE CONVERTED TO INTEGERS
           C AND PACKED TOGETHER IN ONE WORD TO CONSERVE STORAGE.
000045           IWN=WN*10000.
000047           IUNC=UNC*10000.
000051           GOTO190
000052     185   IF(SFTX.NE.1HS)GOTO170
000054           IWN=SFT*1000.+20000.
000057           IUNC=10000
000061     190   CONTINUE
000061           IX=MINO(IX+1,19000)
000065           CALL SHIFT(IWN,IWX(IX),-17)
000070           IWX(IX)=IWX(IX).OR.IUNC
000073           CALL SHIFT(LR,LR,-27)
           C THE ROW AND COLUMN LEVEL CLASSIFICATIONS ARE PACKED IN ONE WORD
000075           LA(IX)=LR.OR.LC
000100           GOTO170
000100     220   CONTINUE
           C
           C THE ORDERING SUBROUTINE REQUIRES ADDITIONAL STORAGE FOR SORTING.
           C IF MORE THAN 9500 TRANSITIONS ARE PRESENT, THE DATA IS STORED
           C UNTIL NEEDED AGAIN.
           C EXTENDED CORE STORAGE IS USED, BUT DATA MAY BE STORED ON ANY MEDIUM.
           C
000100           IF(IX.LT.IXHAF)GOTO230
```

```
000103          CALLECWR(IWX,0,IX,IERR)
000106          IF(IERR.NE.0)STOP1
000111          CALLECWR(LA,IX,IX,IERR)
000114          IF(IERR.NE.0)STOP1
000117          GOTO250
000120      230 JX=IX
000122          DO240I=1,IX
000130          JX=JX+1
000131      240 IWX(JX)=LA(I)
            C EXTRACT THE COLUMN LEVELS AND ORDER THEM.
000133      250 DO260I=1,IX
000141      260 LA(I)=LA(I).AND.777777777B
000143          CALLTORDER(LA,IX)
000145          KX=0
000146          N=0
            C ELIMINATE DUPLICATIONS AND STORE IN LEVC LIST.
000147          DO360I=1,IX
000150          IF(LA(I).EQ.KX)GOTO360
000152          KX=LA(I)
000153          N=MINO(N+1,285)
000157          LEVC(N)=KX
000161      360 CONTINUE
000164          IF(IX.LT.IXHAF)GOTO370
            C IF NECESSARY, RETURN CLASSIFICATION LIST TO CORE MEMORY.
000166          CALLECRD(LA,IX,IX,IERR)
000171          IF(IERR.NE.0)STOP2
000174          GOTO390
000175      370 JX=IX
000177          DO380I=1,IX
000205          JX=JX+1
000206      380 LA(I)=IWX(JX)
000210      390 IXN=512
000211          IXXN=10
000212      395 IF(N+2.GT.IXN)GOTO400
000216          CALLSHIFT(IXN,IXN,1)
000220          IXXN=IXXN-1
000222          GOTO395
000222      400 CALLSHIFN(N,JCN,-1)
            C
            C FOR EACH CLASSIFICATION REPLACE THE COLUMN LEVEL WITH JC (ITS
            C INDEX IN THE LEVC ARRAY) AND ALSO STORE I (THE INDEX OF THE
            C ASSOCIATED TRANSITION IN THE IWX ARRAY)
            C
000225          DO450I=1,IX
000230          LC=LA(I).AND.777777777B
000231          LA(I)=LA(I).AND.777777777000000000B
000233          KX=IXN
000234          JC=JCN
000236          DO430J=1,IXXN
000240          CALLSHIFN(KX,KX,-1)
000242          IF(LC-LEVC(JC))410,440,420
000245      410 JC=MAXO(1,JC-KX)
000251          GOTO430
000251      420 JC=MINO(N,JC+KX)
000255      430 CONTINUE
000260          JC=0
000261      440 CALLSHIFT(JC,JC,-17)
000264          LA(I)=LA(I).OR.JC.OR.I
000267      450 CONTINUE
            C ORDER THE LIST WHICH RESULTS IN GROUPING BY ROW LEVEL.
000271          CALLTORDER(LA,IX)
000273          IF(IX.LT.IXHAF)GOTO500
            C IF NECESSARY, RETURN LIST OF TRANSITONS TO CORE MEMORY.
000276          CALLECRD(IWX,0,IX,IERR)
000301          IF(IERR.NE.0)STOP2
000304          CALLECFL(0)
000306      500 REWIND1
000310          NTRAN=0
000311          DO505I=1,N
000320          WTJ(I)=0.
000321      505 QTAB(I)=0.D
```

```
000324      506 M=0
          C KX CONTAINS THE ROW LEVEL
000325          KX=LA(1).AND.777777770000000C0B
000327          NX1=1
000330          I=1
000331      510 I=I+1
000333          IF(I.GT.IX)GOTO511
000336          LEVT=LA(I).AND.7777777770000000B
000337          IF(LEVT.EQ.KX)GOTO510
000341      511 CALLSHIFT(KX,KX,27)
000344          NX2=I-1
000346          SNI=0.D
000351          YI=0.D
000353          K=0
000354          DO540J=NX1,NX2
000356          JX=LA(J).AND.777400000B
000360          CALLSHIFT(JX,JX,17)
000363          IF(JX.EQ.0)GOTO540
000364          K=K+1
000366          LX=LA(J).AND.377777B
000370          CALLSHIFT(IWX(LX),IY,17)
          C YV CONTAINS THE WAVE NUMBER OR ISOTOPE SHIFT
000373          IF(.NOT.ISOTOP)YV(K)=(ISIGN(IY,KX-LEVC(JX)))/10000.
000404          IF(ISOTOP)YV(K)=(IY-20000)/1000.
000413          YV(K)=YV(K).AND.(.NOT.777B)
000416          IF(K.EQ.1.OR.JX.NE.JCX)GOTO539
          C REMOVE DUPLICATE CLASSIFICATIONS
000425          PRINT13,KX,LEVC(JX),YV(K-1),YV(K)
000440          K=K-1
000442          GOTO540
000443       539  JCX=JX
000444          IUNC=IWX(LX).AND.377777B
000447          UNC=IUNC/10000.
          C WV CONTAINS THE WEIGHT OF THE TRANSITION
000451          WV(K)=(WTUNC/UNC)**2
          C SNI CONTAINS THE SUM OF THE WIGHTS IN THE ROW
000453          SNI=SNI+WV(K)
          C
          C YI CONTAINS THE SUM OF THE WEIGHTED TRANSITIONS IN THE ROW
000461          YI=YI+DBLE(WV(K))*DBLE(YV(K))
          C
          C THE COLUMN LEVEL INDEX IS PACKED WITH THE WAVE NUMBER IN YV
000501          YV(K)=YV(K).CR.JX
000504      540 CONTINUE
000507          IF(K.EQ.0)GOTO585
000510          DTEMP=YI/SNI
000523          DO580J=1,K
000534          JX=YV(J).AND.777B
000535          YV(J)=YV(J).AND.(.NOT.777B)
          C
          C QTAB CONTAINS THE Q(I),I=1,...,N
000537          QTAB(JX)=QTAB(JX)+WV(J)*(DTEMP-YV(J))
000557          YV(J)=YV(J).CR.JX
          C
          C WTJ CONTAINS THE SUM OF WEIGHTS IN THE COLUMN
000560      580 WTJ(JX)=WTJ(JX)+WV(J)
000565          M=M+1
          C
          C STORE ROW LEVEL DATA ON TAPE WITH A SEPARATE RECORD FOR EACH ROW
000567          WRITE(1)K,M,YI,SNI,KX,(YV(J),WV(J),J=1,K)
          C
          C NTRAN CONTAINS NUMBER OF TRANSITIONS
000615          NTRAN=NTRAN+K
000617      585 IF(I.GT.IX)GOTO590
000623          NX1=I
000623          KX=LEVT
000625          GOTO510
000625      590 ENDFILE1
000627          WRITE(1)(QTAB(I),I=1,N)
000635          ENDFILE1
000637          REWIND1
```

```
000641          PRINT8,N,M,NTRAN
000653          PRINT9,(LEVC(I),WTJ(I),I=1,N)
000670          RETURN
000671          END


SUBPROGRAM LENGTH
001062

FUNCTION ASSIGNMENTS

STATEMENT ASSIGNMENTS

1       -  000675    2       -  000700    8       -  000704    9       -  000715
13      -  000720    170     -  000021    180     -  000044    185     -  000053
190     -  000062    220     -  000101    230     -  000121    250     -  000134
360     -  000162    370     -  000176    390     -  000211    395     -  000213
400     -  000223    410     -  000246    420     -  000252    430     -  000256
440     -  000262    500     -  000307    506     -  000325    510     -  000332
511     -  000342    539     -  000443    540     -  000505    585     -  000620
590     -  000626

BLOCK NAMES AND LENGTHS
        -  115441

VARIABLE ASSIGNMENTS
DTEMP   -  001023    I       -  001043    IERR    -  001041    ISOTOP  -  001025
ITYPE   -  001027    IUNC    -  001040    IWN     -  001037    IWX     -  05C351C01
IX      -  001030    IXHAF   -  001026    IXN     -  001045    IXXN    -  001046
IY      -  001060    J       -  001051    JC      -  001050    JCN     -  001047
JCX     -  001061    JX      -  001042    K       -  001056    KX      -  001044
LA      -  003261C01 LC      -  001033    LEVC    -  000440C01 LEVT    -  001054
LR      -  001032    LX      -  001057    M       -  000001C01 N       -  000000C01
NTRAN   -  001052    NX1     -  001053    NX2     -  001055    QTAB    -  002167C01
SFT     -  001035    SFTX    -  001036    SNI     -  001021    UNC     -  001034
WN      -  001031    WTJ     -  001532C01 WTUNC   -  000002C01 WV      -  00C003C01
YI      -  001017    YV      -  001075C01

START OF CONSTANTS
000674

START OF TEMPORARIES
000776

START OF INDIRECTS
001010

UNUSED COMPILER SPACE
002600

              SUBROUTINETORDER(LA,L)
            C THIS SUBROUTINE ORDERS THE ARRAY LA IN ASCENDING VALUES.
            C THE PROGRAM REQUIRES LA TO BE DIMENSIONED GREATER THAN OR EQUAL 2*L
000004          DIMENSIONLA(5)
000004          IF(L.EQ.1)RETURN
000006          LL=2*L
000007          IPOS=0
000010          JX=L
000011          LX2=1
000012     400  IX=JX
000013          I1=IPOS+1
000015          IPOS=MOD(IPOS+L,LL)
000021          JX=IPOS
000022          LX=LX2
000023          LX2=LX*2
000024          I2=I1+LX
000025          I1TOT=I1+LX-1
000027          I2TOT=MINO(I2+LX-1,IX)
000033     410  JX=JX+1
000035          IF(LA(I1).LT.LA(I2))GOTO430
```

```
000041          LA(JX)=LA(I2)
000043          I2=I2+1
000044          IF(I2.LE.I2TOT)GOTO410
000047     420  JX=JX+1
000051          LA(JX)=LA(I1)
000053          I1=I1+1
000054          IF(I1.LE.I1TOT)GOTO420
000056          GOTO450
000057     430  LA(JX)=LA(I1)
000062          I1=I1+1
000063          IF(I1.LE.I1TOT)GOTO410
000066     440  JX=JX+1
000070          LA(JX)=LA(I2)
000072          I2=I2+1
000073          IF(I2.LE.I2TOT)GOTO440
000075     450  I1=I1+LX
000077          IF(I1.GT.IX)GOTO460
000102          I1TOT=MINO(I1TOT+LX2,IX)
000105          I2=I2+LX
000106          IF(I2.GT.IX)GOTO420
000111          I2TOT=MINO(I2TOT+LX2,IX)
000114          GOTO410
000114     460  IF(LX2.LT.L)GOTO400
000116          IF(IPOS.EQ.0)GOTO480
000117          DO470I=1,IPOS
000125          IL=I+L
000126     470  LA(I)=LA(IL)
000131     480  RETURN
000132          END


SUBPROGRAM LENGTH
000170

FUNCTION ASSIGNMENTS

STATEMENT ASSIGNMENTS
400    -  000013    410    -  000034    420    -  000050    430    -  000060
440    -  000067    450    -  000076    460    -  000115    480    -  000132

BLOCK NAMES AND LENGTHS

VARIABLE ASSIGNMENTS
I      -  000166    IL     -  000167    IPOS   -  000155    IX     -  000160
I1     -  000161    I1TOT  -  000164    I2     -  000163    I2TOT  -  000165
JX     -  000156    LL     -  000154    LX     -  000162    LX2    -  000157

START OF CONSTANTS
000135

START OF TEMPORARIES
000136

START OF INDIRECTS
000146

UNUSED COMPILER SPACE
005100

               SUBROUTINESINVR
000001         DIMENSIONC(143,284),RMULT(284),ROW(284)
000001         DIMENSIONJV(285),WV(285)
000001         DOUBLEB(285),QTAB(285),SNI,CFB(285)
000001         COMMONSTOR(41185)
000001         DOUBLEDIV
000001         EQUIVALENCE(STOR,N),(STOR(574),C)
000001         EQUIVALENCE(QTAB,JV,RMULT),(QTAB(144),WV,ROW),(B(2),CFB)
       C NCX1 AND NCX2 ARE THE DIMENSIONS OF THE C ARRAY NCX1=NCX2/2+1
000001         DATANCX1,NCX2/143,284/
000001         N1=N-1
```

```
000003          IF(N1.GT.NCX2)STOP1
000007          CFB(1)=0.
000011          DO4010J=1,NCX2
000012          CFB(J+1)=0.0
000015          DO4010I=1,NCX1
000024   4010 C(I,J)=0.
         C COMPUTE ELEMENTS OF THE C MATRIX
         C C-MATRIX IS SYMMETRIC SO ONLY C(I,J) WHERE I.LE.J, IS KEPT IN STORAGE
         C C(I,J) CONTAINED IN C(I,J) FOR I.LE.NCX1
         C C(I,J) CONTAINED IN C(LX,MX) FOR I.GT.NCX1
         C     WHERE LX=NCX2-I+2 AND MX=I-J+1
000030   4012 READ(1)L,ITEMP,SNI,SNI,ITEMP,(JV(I),WV(I),I=1,L)
000056          IF(EOF,1)4100,4015
000061   4015 DO4016I=1,L
000067   4016 JV(I)=JV(I).AND.777B
000071          L1=1
000072          IF(JV(1).EQ.1)L1=2
000075          IF(L1.GT.L)GOTO4090
000101          DO4030I=L1,L
000102          J=JV(I)-1
000104          IF(J.GT.NCX1)GOTO4040
000107          C(J,J)=C(J,J)+WV(I)*(1.-WV(I)/SNI)
000137          IF(I.EQ.L)GOTO4030
000141          L2=I+1
000142          DO4020K=L2,L
000151          JJ=JV(K)-1
000153   4020 C(J,JJ)=C(J,JJ)-WV(I)*WV(K)/SNI
000176   4030 CONTINUE
000201          GOTO4070
000201   4040 DO4060M=1,L
000203          LX=NCX2-JV(M)+3
000205          C(LX,1)=C(LX,1)+WV(M)*(1.-WV(M)/SNI)
000234          IF(M.EQ.L)GOTO4060
000236          L2=M+1
000240          DO4050K=L2,L
000247          MX=JV(K)-JV(M)+1
000251   4050 C(LX,MX)=C(LX,MX)-WV(M)*WV(K)/SNI
000275   4060 CONTINUE
000300   4070 IF(L1.EQ.1)GOTO4012
000302          DO4080I=2,L
000311          J=JV(I)
000312   4080 CFB(J)=CFB(J)+WV(1)*WV(I)/SNI
000336   4090 CFB(1)=CFB(1)+WV(1)*(1.D0-WV(1)/SNI)
000366          GOTO4012
000367   4100 CONTINUE
000367          ASSIGN4110 TO LEXIT
000370          CALLSECOND(TIME)
         C
         C INVERT C-MATRIX
         C
         C STEPS EXECUTED FOR EACH ROW I IN MATRIX
         C 1. DMULT=1./C(I,I)   C(I,I) SET TO 1.
         C 2. RMULT(IX)=C(IX,I) FOR IX=1,...,I-1
         C     RMULT(IX)=C(I,I)=1. FOR IX=I
         C     RMULT(IX)=C(I,IX) FOR IX=I+1,...,N1
         C 3. ROW(IX)=-DMULT*RMULT(IX) FOR IX=1,...,I-1
         C     ROW(IX)=DMULT*RMULT(IX)FORIX=I,...,N1
         C 4. C(IX,I) SET TO 0. FOR IX=1,...,I-1
         C     C(I,IX)=ROW(IX) FOR IX=I,...,N1
         C 5. FOR ALL ROWS IX WHERE IX.NE.I
         C     C(IX,J)=C(IX,J)-RMULT(IX)*ROW(J) FOR J=IX,...,N1
         C
000372          I=0
000373   4110 I=I+1
000375          IF(I.GT.NCX1)GOTO4210
         C WHEN C(I,I)=0., THE I+1 COLUMN LEVEL IS NOT CONNECTED TO THE REFERENCE
         C     LEVEL.
000400          IF(C(I,I).EQ.0.)DMULT=0.
000403          IF(C(I,I).NE.0.)DMULT=1./C(I,I)
000413          C(I,I)=1.
000414          IXN=I-1
```

```
000415          IF(IXN.EQ.0)GOTO4125
000416          DO4120IX=1,IXN
000426          RMULT(IX)=C(IX,I)
000427          C(IX,I)=0.
000430     4120 ROW(IX)=-DMULT*RMULT(IX)
000432     4125 DO4130IX=I,N1
000444          RMULT(IX)=C(I,IX)
000445          ROW(IX)=DMULT*RMULT(IX)
000446     4130 C(I,IX)=ROW(IX)
000447     4140 DO4160IX=1,N1
000451          IF(IX.GT.NCX1)GOTO4170
000454          IF(IX.EQ.I)GOTO4160
000455          IF(RMULT(IX).EQ.0.)GOTO4160
000456          DO4150J=IX,N1
000466     4150 C(IX,J)=C(IX,J)-RMULT(IX)*ROW(J)
000471     4160 CONTINUE
000474          GOTO4200
000474     4170 IX1=NCX1+1
000476          DO4190IX=IX1,N1
000477          IF(IX.EQ.I)GOTO4190
000500          IF(RMULT(IX).EQ.0.)GOTO4190
000501          LX=NCX2-IX+2
000503          DO4180J=IX,N1
000513          MX=J-IX+1
000515     4180 C(LX,MX)=C(LX,MX)-RMULT(IX)*ROW(J)
000523     4190 CONTINUE
000526     4200 IF(I.GE.N1)GOTO4300
000531          GOTOLEXIT,(4110,4220)
000534     4210 ASSIGN4220TOLEXIT
000535          GOTO4230
000536     4220 I=I+1
000540     4230 LX=NCX2-I+2
000542          IF(C(LX,1).EQ.0.)DMULT=0.
000545          IF(C(LX,1).NE.0.)DMULT=1./C(LX,1)
000551          C(LX,1)=1.
000553          DO4240IX=1,NCX1
000561     4240 ROW(IX)=-DMULT*RMULT(IX)
000566          RMULT(IX)=C(IX,I)
000570          C(IX,I)=0.
000570          IXN=I-1
000572          IF(IXN.EQ.NCX1)GOTO4255
000574          IX1=NCX1+1
000575          DO4250IX=IX1,IXN
000603          LX=NCX2-IX+2
000605          MX=I-IX+1
000606          RMULT(IX)=C(LX,MX)
000612          C(LX,MX)=0.
000615     4250 ROW(IX)=-DMULT*RMULT(IX)
000620     4255 DO4260IX=I,N1
000632          LX=NCX2-I+2
000633          MX=IX-I+1
000635          RMULT(IX)=C(LX,MX)
000641          ROW(IX)=DMULT*RMULT(IX)
000642     4260 C(LX,MX)=ROW(IX)
000646          GOTO4140
000647     4300 BDIV=CFB(1)
000652          CALLSECOND(TIMET)
000653          TIME=TIMET-TIME
000655          PRINT3,TIME
000663     3    FORMAT(*0INVERSION TIME=*F7.3)
000663          READ(1)(QTAB(I),I=1,N)
000671          REWIND1
              C COMPUTE COLUMN LEVEL VALUES.
000673          B(1)=0.0
000676          DO4330I=1,N1
000677          B(I+1)=0.0
000702          IF(I.GT.NCX1)GOTO4340
000705          IF(C(I,I).EQ.0.)GOTO4330
000707          DO4310IX=1,I
000720     4310 B(I+1)=B(I+1)+C(IX,I)*QTAB(IX+1)
000732          IF(I.EQ.N1)GOTO4330
```

```
000734          K=I+1
000736          DO4320IX=K,N1
000746     4320 B(I+1)=B(I+1)+C(I,IX)*QTAB(IX+1)
000760     4330 B(1)=B(1)+B(I+1)*CFB(I+1)
000776          GOTO4390
000777     4340 IX1=NCX1+1
001001          DO4380I=IX1,N1
001002          B(I+1)=0.D
001005          LX=NCX2-I+2
001007          IF(C(LX,1).EQ.0.)GOTO4380
001011          DO4350IX=1,NCX1
001022     4350 B(I+1)=B(I+1)+C(IX,I)*QTAB(IX+1)
001034          IX1=NCX1+1
001036          DO4360IX=IX1,I
001045          LX=NCX2-IX+2
001047          MX=I-IX+1
001051     4360 B(I+1)=B(I+1)+C(LX,MX)*QTAB(IX+1)
001066          IF(I.EQ.N1)GOTO4380
001067          K=I+1
001070          LX=NCX2-I+2
001073          DO4370IX=K,N1
001101          MX=IX-I+1
001103     4370 B(I+1)=B(I+1)+C(LX,MX)*QTAB(IX+1)
001117     4380 B(1)=B(1)+B(I+1)*CFB(I+1)
001135     4390 B(1)=(B(1)+QTAB(1))/BDIV
001157          PRINT1,B(1)
001165        1 FORMAT(*0B(1)=*D14.8)
001165          B(1)=0.D
001170          DO4400I=1,N
001176     4400 STOR(I+3)=B(I)
001201          RETURN
001201          END


SUBPROGRAM LENGTH
003510

FUNCTION ASSIGNMENTS

STATEMENT ASSIGNMENTS
1       -  001242    3       -  001222    4012    -  000031    4015    -  000062
4030    -  000177    4040    -  000202    4060    -  000276    4070    -  000301
4090    -  000337    4100    -  000370    4110    -  000374    4125    -  000433
4140    -  000450    4160    -  000472    4170    -  000475    4190    -  000524
4200    -  000527    4210    -  000535    4220    -  000537    4230    -  000541
4255    -  000621    4300    -  000650    4330    -  000761    4340    -  001000
4380    -  001120    4390    -  001136

BLOCK NAMES AND LENGTHS
        -  120341

VARIABLE ASSIGNMENTS
B       -  002362    BDIV    -  003461    C       -  001075C01 CFB     -  002364
DMULT   -  003503    I       -  003467    ITEMP   -  003471    IX      -  003505
IXN     -  003504    IX1     -  003506    J       -  003466    JJ      -  003475
JV      -  001267    K       -  003474    L       -  003470    LEXIT   -  003501
LX      -  003477    L1      -  003472    L2      -  003473    M       -  003476
MX      -  003500    N       -  000000C01 NCX1    -  003463    NCX2    -  003464
N1      -  003465    QTAB    -  001267    RMULT   -  001267    ROW     -  001725
SUI     -  003457    STOR    -  000000C01 TIME    -  003502    TIMET   -  003507
WV      -  001725

START OF CONSTANTS
001204

START OF TEMPORARIES
001251

START OF INDIRECTS
001257
```

```
UNUSED COMPILER SPACE
001400
                SUBROUTINEVAR
000001          DIMENSIONB(285),A(170),AVAR(170),C(143,284),LEVC(285),
               1YV(285),WV(285),LEVR(170)
000001          DIMENSIONWU(38),WTCLAS(38),WRMS(38),WS(38),NRMS(38)
000001          DOUBLEYI,SNI
000001          LOGICALSTAPE
000001          COMMONSTOR(41185)
000001          EQUIVALENCE(STOR,N),(STOR,M),(STOR(4),B),(STOR(289),LEVC),
               1(STOR(574),C),(STOR(3),WTUNC)
000001          DATAWU/.0001,.0002,.0003,.0004,.0005,.0006,.0007,
               1.0008,.0009,.001,.002,.003,.004,.005,.006,.007,
               2.008,.009,.01,.02,.03,.04,.05,.06,.07,.08,.09,.1,
               3.2,.3,.4,.5,.6,.7,.8,.9,1.,100./
000001     1    FORMAT(1H1,3X,5HLEVEL,7X,5HLEVEL,7X,6HWEIGHT,5X,
               113HOBSERVED LINE,2X,15HCALCULATED LINE,3X,
               29HDEVIATION,5X,9HSQRT(VAR),7X,12HVAR/SIGMA**2//)
000001       2 FORMAT(1X,I9,3X,I9,3X,F11.2,3X,F13.5,3X,F14.6,3X,
               1F9.6,A2,3X,F9.6,3X,E19.14)
000001     3    FORMAT(1H1,3X,5HLEVEL,3X,16HCALCULATED LEVEL,3X,
               19HSQRT(VAR),8X,12HVAR/SIGMA**2//)
000001       4 FORMAT(1X,I9,4X,F13.6,4X,F9.6,4X,E20.14)
000001       5 FORMAT(1X,I7,4X,*NO DATA FOR THIS LEVEL*)
000001       6 FORMAT(*0B(1)=*F12.9/*0SIGMA=*F10.6,4X,
               1*SIGMA SQUARED=*F10.6/*0*I4* LEVELS*4X,I5,
               2* TRANSITIONS*)
000001       7 FORMAT(1X)
000001       8 FORMAT(1H0/1H0,1X,5HCLASS,7X,6HWEIGHT,9X,3HRMS,7X,
               18HQUANTITY)
000001       9 FORMAT(1X,F6.4,4X,F11.2,4X,F9.6,4X,I5)
000001      10 FORMAT(1X,*GREATER THAN 1.*10X,F9.6,4X,I5)
          C STAPE =.TRUE. WHEN TAPE 7 HAS BEEN USED FOR INTERMEDIATE STORAGE.
000001          STAPE=.FALSE.
000002          IX=0
000002          NX=170
000003          N1=N-1
000005          NCNT=0
          C CLEAR WEIGHT STATISTICS STORAGE
000006          DO1010I=1,38
000015          WTCLAS(I)=(WTUNC/WU(I))**2
000017          WRMS(I)=0.
000017          WS(I)=0.
000020     1010 NRMS(I)=0
000022          SIGMA=0.
000022          NTRAN=0
000023          NLEV=0
          C
          C FOR EACH ROW, DTERERMINE THE ROW LEVEL VALUE IN AX AND THE
          C VARIANCE TERM IN AVX
          C
000024     1035 READ(1)L,IRCW,YI,SNI,NAME,(YV(I),WV(I),I=1,L)
000052          IF(EOF,1)1100,1040
000055     1040 CONTINUE
000055          AX=YI
000057          AVX=0.
000060          NCNT=NCNT+1
000062          DO1080I=1,L
000063          J=YV(I).AND.777B
000066          AX=AX+WV(I)*B(J)
000071          J=J-1
000072          IF(J.EQ.0)GOTO1080
000073          IF(J.LT.144)GOTO1060
000077          LX=286-J
000100          AVX=AVX+WV(I)**2*C(LX,1)
000104          IF(I.EQ.L)GOTO1080
000105          I1=I+1
000107          DO1050II=I1,L
000121          JJ=(YV(II).AND.777B)-1
000123          MX=JJ-J+1
```

```
000125    1050 AVX=AVX+2.*WV(I)*WV(II)*C(LX,MX)
000133         GOTO1080
000133    1060 AVX=AVX+WV(I)**2*C(J,J)
000140         IF(I.EQ.L)GOTO1080
000143         II=I+1
000144         DO1070II=II,L
000156         JJ=(YV(II).AND.777B)-1
000160    1070 AVX=AVX+2.*WV(I)*WV(II)*C(J,JJ)
000166    1080 CONTINUE
000171         AX=AX/SNI
000203         AVX=(AVX/SNI+1.)/SNI
000234         DO1090I=1,L
000236         J=YV(I).AND.777B
               C
               C SUM THE SQUARES OF THE DIFFERENCES BETWEEN THE OBSERVED AND CALCULATED
               C TRANSITIONS
000237         TEMP=(AX-B(J)-YV(I))**2*WV(I)
000243         SIGMA=SIGMA+TEMP
000245         DO1085IWX=1,37
000247    1085 IF(WV(I).GE.WTCLAS(IWX))GOTO1088
000254         IWX=38
               C
               C WRMS CONTAINS THE SUM OF THE WEIGHTED SQUARES OF THE DIFFERENCES
               C BETWEEN CALCULATED AND OBSERVED TRANSITIONS FOR A GIVEN WEIGHT CLASS
               C NRMS CONTAINS THE NUMBER OF TRANSITIONS IN A GIVEN WEIGHT CLASS
000256    1088 WRMS(IWX)=WRMS(IWX)+TEMP
000260         WS(IWX)=WS(IWX)+WV(I)
000262         NRMS(IWX)=NRMS(IWX)+1
000264    1090 CONTINUE
               C
               C NTRAN CONTAINS THE NUMBER OF TRANSITIONS
000267         NTRAN=NTRAN+L
000270         IX=IX+1
000271         IF(IX.LT.171)GOTO1095
               C
               C USE TAPE 7 FOR INTERMEDIATE STORAGE
000273         WRITE(7)NX,(A(I),AVAR(I),LEVR(I),I=1,NX)
000313         STAPE=.TRUE.
000314         IX=1
000316    1095 A(IX)=AX
000317         AVAR(IX)=AVX
000321         LEVR(IX)=NAME
000323         GOTO1035
000323    1100 CONTINUE
000323         NLEV=NCNT
000324         IF(.NOT.STAPE)GOTO1105
000326         WRITE(7)IX,(A(I),AVAR(I),LEVR(I),I=1,IX)
000346         ENDFILE7
000350         REWIND7
000352         READ(7)NX,(A(I),AVAR(I),LEVR(I),I=1,NX)
000372    1105 IX=0
000373         NLEV=NLEV+N1
               C
               C COMPUTE SIGMA SQUARED
000375         SIGMA=SIGMA/(NTRAN-NLEV)
000400         REWIND1
000402         PRINT1
000406    1112 READ(1)L,IROW,YI,SNI,NAME,(YV(I),WV(I),I=1,L)
000434         IF(EOF,1)1240,1115
000437    1115 CONTINUE
               C
               C FOR EACH TRANSITION COMPUTE THE CALCULATED TRANSITON AND ITS
               C VARIANCE AND PRINT ALL THE DATA ASSOCIATED WITH THE TRANSITION
               C
000437         IX=IX+1
000441         IF(IX.LT.171)GOTO1120
000443         READ(7)NX,(A(I),AVAR(I),LEVR(I),I=1,NX)
000463         IX=1
000464    1120 CONTINUE
000464         L1=1
000465         DO1230I=1,L
```

```
000467          VAR=AVAR(IX)
000472          COM=2L
000473          J=YV(I).AND.777B
000475          TEMP1=A(IX)-B(J)
000477          TEMP2=TEMP1-YV(I)
000501          IF(TEMP2.EQ.0)GOTO1125
000502          TEMP=(WTUNC/TEMP2)**2
                C
                C IF THE DIFFERENCE IS TWICE THE UNCERTAINTY STAR THE PRINTOUT
                C IF THE DIFFERENCE IS THREE TIMES THE UNCERTAINTY DOUBLE STAR THE
                C PRINTOUT
000503          IF(4.*TEMP.GE.WV(I))GOTO1125
000507          IF(9.*TEMP.LT.WV(I))GOTO1123
000512          COM=1L*
000514          GOTO1125
000514    1123  COM=2L**
000516    1125  CONTINUE
000516          IF(J.GT.1)GOTO1130
000522          L1=2
000523          GOTO1220
000523    1130  TVAR=0.
000524          J=J-1
000526          IF(J.GT.143)GOTO1140
000531          VAR=VAR+C(J,J)
000534          GOTO1150
000537    1140  LX=286-J
000541          VAR=VAR+C(LX,1)
000544    1150  DO1200II=L1,L
000546          IF(II.GT.I)GOTO1160
000551          JJ=(YV(I).AND.777B)-1
000553          J=(YV(II).AND.777B)-1
000555          GOTO1170
000556    1160  JJ=(YV(II).AND.777B)-1
000561          J=(YV(I).AND.777B)-1
000563    1170  IF(J.LT.144)GOTO1180
000566          LX=286-J
000567          MX=JJ-J+1
000571          TEMP=C(LX,MX)
000575          GOTO1190
000575    1180  TEMP=C(J,JJ)
000601    1190  TVAR=TVAR+WV(II)*TEMP
000604    1200  CONTINUE
000607          VAR=VAR-2.*TVAR/SNI
000627    1220  VARRT=SQRT(VAR*SIGMA)
000633          J=YV(I).AND.777B
000636    1230  PRINT2,NAME,LEVC(J),WV(I),YV(I),TEMP1,TEMP2,COM,
                1VARRT,VAR
000667          PRINT7
000672          DO1235I=1,L
000702          WV(I)=WV(I).AND.(.NOT.777B)
000703    1235  WV(I)=WV(I).OR.(YV(I).AND.777B)
000706          SPSNI=SNI
                C
                C STORE THE RESULTS ON TAPE 5
000710          WRITE(5)L,IROW,SPSNI,NAME,A(IX),AVAR(IX),
                1(WV(I),I=1,L)
000732          GOTO1112
000733    1240  CONTINUE
000733          ENDFILE5
000735          WRITE(5)N,M,SIGMA,B,LEVC,C
000754          ENDFILE5
000756          PRINT3
000762          IF(.NOT.STAPE)GOTO1250
000764          REWIND7
000766    1248  READ(7)IX,(A(I),AVAR(I),LEVR(I),I=1,IX)
001006          IF(EOF,7)1261,1250
001011    1250  DO1255I=1,IX
001013          A(I)=A(I)-B(1)
001015          VARRT=SQRT(SIGMA*AVAR(I))
                C
                C PRINT ROW LEVEL VALUES AND THE VARIANCES
```

```
      C
001022        PRINT4,LEVR(I),A(I),VARRT,AVAR(I)
001035   1255 CONTINUE
001040        IF(STAPE)GOTO1248
001041   1261 CONTINUE
001041        PRINT3
001045        DO1300I=2,N
001050   1270 B(I)=B(I)-B(1)
001052        J=I-1
001054        IF(J.LT.144)GOTO1280
001060        LX=286-J
001061        VAR=C(LX,1)
001063        IF(VAR.NE.0.)GOTO1290
      C
      C COLUMN LEVELS THAT HAVE ZERO VARIANCES ARE NOT CONNECTED TO THE
      C REFERENCE LEVEL   SIGMA IS INCORRECT SO THE UNCONNECTED LEVELS
      C SHOULD BE REMOVED
      C
001064   1275 PRINT11,LEVC(I)
001072   11   FORMAT(1X,I9,4X,*THIS LEVEL NOT CONNECTED TO THE REFERENCE LEVEL.*
             1/14X*REMOVE THIS LEVEL AND ALL ITS CONNECTED LEVELS AND RUN *
             2*PROBLEM AGAIN.*)
001072        GOTO1300
001073   1280 VAR=C(J,J)
001076        IF(VAR.EQ.0.)GOTO1275
001100   1290 VARRT=SQRT(SIGMA*VAR)
      C
      C PRINT COLUMN LEVEL VALUES AND THE VARIANCES
      C
001105        PRINT4,LEVC(I),B(I),VARRT,VAR
001120   1300 CONTINUE
001123        TEMP=SQRT(SIGMA)
001125        PRINT6,B(1),TEMP,SIGMA,NLEV,NTRAN
001142        PRINT8
      C
      C PRINT WEIGHT STATISTICS
      C
001146        DO1350I=1,37
001150        IF(NRMS(I).EQ.0)GOTO1350
001151        WRMS(I)=SQRT(WRMS(I)/WS(I))
001156        PRINT9,WU(I),WTCLAS(I),WRMS(I),NRMS(I)
001172   1350 CONTINUE
001174        IF(NRMS(38).EQ.0)GOTO1360
001175        WRMS(38)=SQRT(WRMS(38)/WS(38))
001202        PRINT10,WRMS(38),NRMS(38)
001211   1360 CONTINUE
001211        RETURN
001213        END


SUBPROGRAM LENGTH
004064

FUNCTION ASSIGNMENTS

STATEMENT ASSIGNMENTS
1       -  001217    2       -  001242    3       -  001254    4       -  001267
5       -  001274    6       -  001301    7       -  001321    8       -  001323
9       -  001334    10      -  001341    11      -  001375    1035    -  000025
1040    -  000056    1060    -  000134    1080    -  000167    1088    -  000256
1095    -  000316    1100    -  000324    1105    -  000373    1112    -  000407
1115    -  000440    1120    -  000465    1123    -  000515    1125    -  000517
1130    -  000524    1140    -  000536    1150    -  000545    1160    -  000557
1170    -  000564    1180    -  000576    1190    -  000602    1220    -  000630
1240    -  000734    1248    -  000767    1250    -  001012    1261    -  001042
1270    -  001050    1275    -  001065    1280    -  001074    1290    -  001101
1300    -  001121    1350    -  001173    1360    -  001212

BLOCK NAMES AND LENGTHS
        -  120341
```

```
VARIABLE ASSIGNMENTS
A       -  001434    AVAR    -  001706     AVX     -  004043    AX      -  004042
B       -  000003C01 C       -  001075C01  CUM     -  004056    I       -  004033
II      -  004047    IROW    -  004040     IWX     -  004053    IX      -  004027
J1      -  004046    J       -  004044     JJ      -  004050    L       -  004037
LEVC    -  000440C01 LEVR    -  003252     LX      -  004045    L1      -  004054
M       -  000000C01 MX      -  004051     N       -  000000C01 NAME    -  004041
NCNT    -  004032    NLEV    -  004036     NRMS    -  003754    NTRAN   -  004035
NX      -  004030    N1      -  004031     SIGMA   -  004034    SNI     -  004024
SPSNI   -  004063    STAPE   -  004026     STOR    -  000000C01 TEMP    -  004052
TEMP1   -  004057    TEMP2   -  004060     TVAR    -  004061    VAR     -  004055
VARRT   -  004062    WRMS    -  003640     WS      -  003706    WTCLAS  -  003572
WTUNC   -  000002C01 WU      -  003524     WV      -  002615    YI      -  004022
YV      -  002160

START OF CONSTANTS
001216

START OF TEMPORARIES
001415

START OF INDIRECTS
001424

UNUSED COMPILER SPACE
001300
```

```
CORE MAP  15.39.26. SEGMENT     00.      CONTROL                                                  000100    137012    016451    120341
         ---TIME---LOAD MODE --L1--L2-----TYPE---------------USER---++---CALL-------------FWA LOAD--LWA LOAD--BLNK COMN--LENGTH--
         FWA LOADER  152562  FWA TABLES  152416
         -PROGRAM----ADDRESS-                        --LABELED---COMMON--
         CONTROL     000112
         SYSTEM      014363                                  SCOPE2      014363
         SEGMENT     015467
         SIO$        015620
         --ENTRY-----ADDRESS-                                          REFERENCES
         CONTROL     000113
         Q8NTRY      014364              CCNTRCL     000114

         SYSTEM      014661              SEGMENT     015563    015571

         SYSTEMC     014621
         SYSTEMP     014647
         END         014543              CCNTRCL     000145

         STOP        014574              CCNTRCL     000143

         EXIT        014566
         ABNORML     014604              SEGMENT     015572

         SYSTBAC     014654
         LINE.       015235
         FETA.       015236
         KEY.        015240
         FNMA.       015241
         NUMB.       015243
         SEGMENT     015470              CCNTRCL     000124    000132    CC0140

         BKSPRU.     016121
         FIZBAK.     016132
         POSFIL.     016167
         RDPRU.      016177
         DAT.        016221
         CIDL.       016066
         OPEN.       015622              SYSTEM      015150

         SIG.        015734
         ----UNSATISFIED EXTERNALS-----                                REFERENCES
         SORTD                                       000125
         SINVR                                                     CC0133
         VAR                                                       CC0141

CORE MAP  15.39.29. SEGMENT     01.      015556  1407170000000000020401OC0007000000000000  137071    144002    016451    120341
         ---TIME---LOAD MODE --L1--L2-----TYPE---------------USER---++---CALL-------------FWA LOAD--LWA LOAD--BLNK COMN--LENGTH--
         FWA LOADER  152562  FWA TABLES  152057
         -PROGRAM----ADDRESS-                        --LABELED---COMMON--
         SORTD       137071
         TORDER      140153
         INPUTC      140343
         IFETRF      141477
         SHIFT       141524
         ECSRW       141541
         ECFL        141570
         REWINM      141632
         OUTPTC      141714
         DBLE        143261
         OUTPTR      143265
         ENDFIL      143362
         GETBA       143432
         C4020       143451
         BS4020      143560
         XRCL        143775
```

--ENTRY-----	ADDRESS-		REFERENCES						
SORTD	137072								
TORDER	140154	SORTD	137236	137364					
INPUTC	140345	SORTD	137075	137077	137101	137102	137114	137116	137120
			137122	137124	137126	137130	137131		
KRAKER	140447								
IFENDF	141500	SORTD	137133						
SHIFT	141525	SORTD	137161	137166	137311	137355	137435	137454	137464
SHIFN	141536	SORTD	137316	137333					
ECWR	141541	SORTD	137177	137205					
ECRD	141550	SORTD	137262	137372					
ECFL	141571	SORTD	137377						
REWINM	141633	SORTD	137401	137732					
OUTPTC	141716	SORTD	137520	137522	137524	137526	137530	137531	137735
			137737	137741	137743	137744	137747	137753	137755
			137761						
KODER	142063								
DBLE	143262	SORTD	137554	137557					
OUTPTB	143267	SORTD	137662	137664	137666	137670	137672	137674	137700
			137702	137706	137722	137725	137726		
ENDFIL	143363	SORTD	137720	137730					
GETBA	143432	INPUTC	140353						
		IFENDF	141503						
		REWINM	141640						
		OUTPTC	141724						
		OUTPTB	143320						
		ENDFIL	143370						
		BS4020	143707						
C4020	143451	OUTPTC	143256						
BS4020	143561	C4020	143457	143472	143502	143512	143516		
XRCL	143775	BS4020	143736						

----UNSATISFIED EXTERNALS-----	REFERENCES

66 COLUMN LEVELS

792 ROW LEVELS

8889 TRANSITIONS

6	9769725.00
62005	13062395.67
380007	11691361.11
386803	9523400.00
427506	14128294.11
445304	12762590.11
576205	10788273.11
599104	9722934.22

624906	10275724.67
700506	11106825.89
710303	5255091.00
719102	2247328.67
732607	9737340.11
764508	7165475.00
786405	7759068.78
811807	12027751.22
813304	5900873.33
885602	1337077.11
887803	3068593.11
1006907	6106394.67
1008005	4603952.89
1010301	123540.11
1020804	4203236.89
1025405	3254768.00
1028806	3758109.44
1034708	6849084.78
1045707	606978.33
1054003	1055692.44
1055704	2893215.89
1068508	5679589.44
1081903	2641236.00
1084208	91262.00
1098706	3855852.33
1129005	2019751.89
1130807	2839480.22
1140304	1594037.67
1144403	389928.22
1145706	3849336.56
1155804	2167275.11
1163305	2335560.00
1167707	3088962.89
1194304	747597.22
1196805	1652693.89
1236204	426776.22
1282607	4268830.11
1288405	499001.00
1291006	1682026.00
1312709	2854277.44
1334607	2080069.00
1336106	208443.00
1340206	1152936.56
1353509	1197387.89
1356707	189642.11
1363205	384386.11
1441104	179646.11
1450108	1174535.67
1454306	1289221.56
1479007	944682.44
1484510	508885.44
1497005	325671.22
1535307	114134.00
1545808	465507.22
1571207	776249.33
1604010	478358.33
1624408	833532.56
1788209	26965.00

```
CORE MAP  15.41.43. SEGMENT     01.      015556  14071700000000002040100000700000000000  137071    145031    016451    120341
         ---TIME---LOAD MODE --L1--L2-----TYPE--------------USER---++---CALL-------------FWA LOAD--LWA LOAD--BLNK COMN--LENGTH--
         FWA LOADER  152562  FWA TABLES  152242
         -PROGRAM----ADDRESS-                    --LABELED---COMMON--
         SINVR       137071
         INPUTB      142601
         IFENDF      142735
         SECOND      142762
         ACCGER      143006
         OUTPTC      143032
         REWINM      144377
         GETBA       144461
         C4020       144500
         BS4020      144607
         XRCL        145024
         --ENTRY-----ADDRESS-                                    REFERENCES
         SINVR       137072
         INPUTB      142603              SINVR       137123    137125    137127    137131    137133    137135    137141
                                                     137143    137147    137756    137761    137762

         IFENDF      142736              SINVR       137151

         SECOND      142763              SINVR       137463    137744

         ACCGER      143007              SINVR       137624

         OUTPTC      143034              SINVR       137751    137753    137754    140253    140255    140256

         KODER       143201
         REWINM      144400              SINVR       137764

         GETBA       144461              INPUTB      142673
                                         IFENDF      142741
                                         OUTPTC      143042
                                         REWINM      144405
                                         BS4020      144736

         C4020       144500              OUTPTC      144374

         BS4020      144610              C4020       144506    144521    144531    144541    144545

         XRCL        145024              BS4020      144765

         ----UNSATISFIED EXTERNALS-----                          REFERENCES

INVERSION TIME=   .660

B(1)= .227626920-07


CORE MAP  15.42.29. SEGMENT     01.      015556  14071700000000002040100000700000000000  137071    145774    016451    120341
         ---TIME---LOAD MODE --L1--L2-----TYPE--------------USER---++---CALL-------------FWA LOAD--LWA LOAD--BLNK COMN--LENGTH--
         FWA LOADER  152562  FWA TABLES  152040
         -PROGRAM----ADDRESS-                    --LABELED---COMMON--
         VAR         137071
         INPUTB      143155
         IFENDF      143311
         OUTPTB      143336
         ENDFIL      143433
         REWINM      143503
         OUTPTC      143565
         SORT        145132
```

```
GETBA       145212
C4020       145231
OUTPTS      145340
LABRT       145417
BS4020      145526
ACCDER      145743
XRCL        145767
--ENTRY-----ADDRESS-                                    REFERENCES
VAR         137072
INPUTB      143157          VAR         137117  137121  137123  137125  137127  137131  137135
                                        137137  137143  137445  137447  137453  137455  137457
                                        137463  137501  137503  137505  137507  137511  137513
                                        137517  137521  137525  137536  137540  137544  137546
                                        137550  137554  140061  140063  140067  140071  140073
                                        140077

IFENDF      143312          VAR         137145  137527  140101

OUTPTB      143340          VAR         137366  137370  137374  137376  137400  137404  137421
                                        137423  137427  137431  137433  137437  140003  140005
                                        140007  140011  140013  140015  140017  140022  140023
                                        140030  140032  140034  140036  140040  140042  140044
                                        140045

ENDFIL      143434          VAR         137441  140026  140047

REWINM      143504          VAR         137443  137473  140057

OUTPTC      143567          VAR         137476  137477  137732  137734  137736  137740  137742
                                        137744  137746  137750  137752  137754  137755  137762
                                        137763  140052  140053  140115  140117  140121  140123
                                        140125  140126  140135  140136  140160  140162  140163
                                        140200  140202  140204  140206  140210  140211  140220
                                        140222  140224  140226  140230  140232  140233  140236
                                        140237  140252  140254  140256  140260  140262  140263
                                        140275  140277  140301  140302
                                LABRT   145453  145456  145460  145461

KODER       143734          OUTPTS      145345  145362

SQRT        145133          VAR         137724  140112  140175  140215  140246  140272

GETBA       145212          INPUTB      143247
                            IFENDF      143315
                            OUTPTB      143371
                            ENDFIL      143441
                            REWINM      143511
                            OUTPTC      143575
                            BS4020      145655

C4020       145231          OUTPTC      145127
OUTPTS      145342          SQRT        145153  145155  145157  145160

LABRT       145420          SQRT        145162

BS4020      145527          C4020       145237  145252  145262  145272  145276

ACCDER      145744          LABRT       145436

XRCL        145767          BS4020      145704

----UNSATISFIED EXTERNALS-----                          REFERENCES
```

Typical output pages follow:

LEVEL	LEVEL	WEIGHT	OBSERVED LINE	CALCULATED LINE	DEVIATION	SQRT(VAR)	VAR/SIGMA**2
1150206	6	25.00	11502.57000	11502.588718	.018718	.061432	.38761171982857E-02
1150206	62005	4.00	10882.14000	10882.267523	.127523	.061431	.38761065668877E-02
1150206	427506	25.00	7226.93000	7226.895308	-.034692	.061431	.38760717856480E-02
1150206	576205	100.00	5740.52000	5740.528631	.008631	.061431	.38760350965607E-02
1150206	624906	100.00	5253.62000	5253.579128	-.040872	.061431	.38760343411261E-02
1150206	700506	4.00	4496.30000	4497.078344	.778344	.061431	.38761073689357E-02
1161305	6	100.00	11613.92000	11613.943182	.023182	.049092	.24753449078416E-02
1161305	62005	25.00	10993.58000	10993.621987	.041987	.049092	.24753584280681E-02
1161305	427506	4.00	7339.04000	7338.249771	-.790229	.049092	.24753564339080E-02
1161305	445304	25.00	7160.51000	7160.538315	.028315	.049092	.24753683956320E-02
1161305	576205	25.00	5851.84000	5851.883095	.043095	.049092	.24753709212583E-02
1161305	599104	100.00	5622.64000	5622.648873	.008873	.049092	.24753512466801E-02
1161305	624906	25.00	5364.94000	5364.933591	-.006409	.049092	.24753815439107E-02
1161305	700506	100.00	4608.46000	4608.432808	-.027192	.049092	.24753325727686E-02
1203504	62005	100.00	11415.23000	11415.244929	.014929	.047640	.23311003144564E-02
1203504	386803	100.00	8167.03000	8167.093016	.063016	.047640	.23311198039975E-02
1203504	445304	25.00	7582.17000	7582.161258	-.008742	.047640	.23311214396872E-02
1203504	576205	100.00	6273.53000	6273.506038	-.023962	.047640	.23311038961631E-02
1203504	599104	4.00	6044.26000	6044.271816	.011816	.047641	.23311622264687E-02
1203504	710303	100.00	4931.72000	4931.667729	-.052271	.047641	.23311901164577E-02
1264306	6	400.00	12643.40990	12643.408039	-.001861	.048850	.24509804681472E-02
1264306	624906	4.00	6394.39000	6394.398448	.098448	.048852	.24512282129966E-02
1264306	700506	4.00	5637.81000	5637.897665	.087665	.048852	.24512211131923E-02
1346305	6	400.00	13463.39800	13463.397154	-.000846	.029644	.90259884239621E-03
1346305	62005	400.00	12843.11700	12843.075958	-.041042	.029644	.90258421238695E-03
1346305	427506	4.00	9187.61000	9187.703743	.093743	.029645	.90265045327692E-03
1346305	445304	100.00	9009.90990	9009.992287	.082387	.029645	.90265347334240E-03
1346305	576205	100.00	7701.30000	7701.337067	.037067	.029645	.90265609053691E-03
1346305	599104	100.00	7472.06000	7472.102845	.042845	.029646	.90268241570883E-03
1346305	624906	4.00	7214.35000	7214.387563	.037563	.029646	.90269194777736E-03
1371004	386803	100.00	9841.69000	9841.768705	.078705	.052151	.27934086843991E-02
1371004	445304	100.00	9256.83000	9256.836947	.006947	.052151	.27933935002225E-02
1371004	599104	25.00	7719.04000	7718.947504	-.092496	.052151	.27934598083732E-02
1371004	710303	25.00	6606.37000	6606.343418	-.026582	.052152	.27935816665295E-02
1371004	786405	4.00	5846.15000	5846.063199	-.086801	.052152	.27935285841006E-02
1371004	813304	4.00	5577.14000	5576.976984	-.163016	.052152	.27935545171594E-02
1371004	887803	100.00	4831.77000	4831.724111	-.045889	.052152	.27935298029691E-02
1382504	62005	400.00	13205.10000	13205.085271	-.014729	.038467	.15197873537618E-02
1382504	386803	100.00	9956.85000	9956.933357	.083357	.038468	.15199171796550E-02
1382504	576205	25.00	8063.27000	8063.346379	.076379	.038468	.15199097439194E-02
1382504	710303	100.00	6721.51000	6721.508070	-.001930	.038469	.15200091965039E-02
1382504	786405	4.00	5962.16000	5961.227851	-.932149	.038469	.15199626334918E-02
1382504	813304	4.00	5692.43000	5692.141637	-.288363	.038470	.15200122785321E-02
1382504	887803	25.00	4946.85990	4946.888764	.028864	.038472	.15201978030596E-02
1464306	6	400.00	14643.83100	14643.835728	.004728	.027326	.76694848406544E-03
1464306	62005	400.00	14023.52390	14023.514532	-.009368	.027326	.76693831036859E-03
1464306	380007	25.00	10843.00300	10843.018432	.018432	.027327	.76700499859756E-03
1464306	427506	25.00	10368.21990	10368.142317	-.077583	.027327	.76697775731271E-03

1464306	624906	100.00	8394.73000	8394.826137	.096137	.027327	.766999455472 89E-03
1464306	700506	100.00	7638.31000	7638.325353	.015353	.027327	.76699153093769E-03
1464306	732607	25.00	7317.71000	7317.740933	.030933	.027328	.76703863987258E-03
1464306	811807	25.00	6525.27000	6525.230324	-.039676	.027327	.76701376769062E-03
1464306	1006907	100.00	4574.73000	4574.690752	-.039248	.027329	.76709492658025E-03
1464306	1008005	100.00	4562.89000	4562.837235	-.052765	.027330	.76715104448462E-03
1464306	1028806	4.00	4354.85000	4355.251406	.401406	.027331	.76721667387556E-03
1483905	6	400.00	14839.74600	14839.733330	-.012670	.029984	.92342970629660E-03
1483905	62005	400.00	14219.43400	14219.412135	-.021865	.029984	.92341799472379E-03
1483905	445304	100.00	10386.21000	10386.328464	.118464	.029985	.92349117819118E-03
1483905	529104	25.00	8848.39000	8848.439022	.049022	.029986	.92353724695964E-03
1483905	700506	100.00	7834.22000	7834.222956	.002956	.029985	.92349336412156E-03
1483905	813304	4.00	6706.43000	6706.468502	.038502	.029987	.92361990893600E-03
1483905	1008005	25.00	4758.74000	4758.734838	-.005162	.029989	.92368345815840E-03
1483905	1020804	25.00	4631.26000	4631.278329	.018329	.029989	.92370566035577E-03
1483905	1055704	4.00	4282.74000	4282.730750	-.009250	.029991	.92386649670885E-03
1500703	386803	100.00	11139.08000	11138.941131	-.138869	.079512	.64935673999468E-02
1500703	445304	4.00	10554.19000	10554.009373	-.180627	.079513	.64937020420309E-02
1500703	885602	25.00	6149.94000	6150.452716	.512716*	.079518	.64944242160323E-02
1500703	1055704	25.00	4450.34000	4450.411659	.071659	.079515	.64939285274278E-02
1563107	6	400.00	15631.79500	15631.806693	.011693	.035263	.12771856137474E-02
1563107	380007	25.00	11830.99600	11830.989397	-.000603	.035264	.12772797688515E-02
1563107	624906	100.00	9382.78000	9382.797102	.017102	.035264	.12772676943146E-02
1563107	700506	25.00	8626.26000	8626.296319	.036319	.035264	.12772833056462E-02
1563107	732607	100.00	8305.68000	8305.711898	.031898	.035265	.12772892676987E-02
1563107	811807	25.00	7513.19000	7513.201290	.011290	.035264	.12772880698403E-02
1563107	1034708	4.00	5284.51000	5284.494147	-.015853	.035266	.12774044121745E-02
1563107	1098706	4.00	4643.45000	4644.254969	.804970	.035267	.12774930290015E-02
1563107	1145706	100.00	4174.67000	4174.530911	-.139089	.035267	.12774408314422E-02
1563806	6	400.00	15638.32400	15638.334865	.010865	.026031	.69597532480393E-03
1563806	62005	400.00	15018.06400	15018.013670	-.050330	.026031	.69596495465885E-03
1563806	380007	100.00	11837.46990	11837.517570	.047670	.026032	.69601059452045E-03
1563806	576205	4.00	9877.09000	9876.274778	-.815222	.026032	.69603546760760E-03
1563806	624906	100.00	9389.27000	9389.325275	.055275	.026032	.69601810194436E-03
1563806	700506	100.00	8632.77000	8632.824491	.054491	.026032	.69601052731222E-03
1563806	732607	100.00	8312.20000	8312.240070	.040070	.026032	.69604065209563E-03
1563806	786405	25.00	7774.10000	7774.156251	.056251	.026033	.69607227377773E-03
1563806	811807	25.00	7519.73000	7519.729462	-.000538	.026032	.69602809819003E-03
1563806	1006907	100.00	5569.17000	5569.189890	.019890	.026033	.69611097163058E-03
1563806	1008005	4.00	5557.31000	5557.336372	.026372	.026035	.69621097531117E-03
1563806	1028806	25.00	5349.71000	5349.750544	.040544	.026036	.69622481948281E-03
1563806	1098706	4.00	4651.49000	4650.783142	-.706858	.026036	.69623003305103E-03
1563806	1129005	25.00	4348.15000	4348.105731	-.044269	.026041	.69649705065408E-03
1563806	1145706	25.00	4181.10990	4181.059084	-.050816	.026036	.69624754440522E-03
1572005	6	10000.00	15720.68550	15720.684513	-.000987	.009449	.91710671354433E-04
1572005	62005	400.00	15100.38400	15100.363318	-.020682	.009459	.91904727424970E-04
1572005	427506	25.00	11444.93000	11444.991103	.061103	.009459	.91904969972472E-04
1572005	445304	100.00	11267.21000	11267.279647	.069647	.009462	.91948685225879E-04
1572005	576205	100.00	9958.55000	9958.624426	.074426	.009461	.91943738925428E-04
1572005	700506	25.00	8715.24000	8715.174139	-.065861	.009461	.91936267960194E-04
1572005	1008005	100.00	5639.64000	5639.686020	.046020	.009471	.92125688357063E-04
1572005	1020804	25.00	5512.20000	5512.229512	.029512	.009473	.92160839052516E-04
1572005	1055704	4.00	5163.59000	5163.681933	.091933	.009480	.92312029859868E-04
1572005	1140304	100.00	4317.27000	4317.256680	-.013320	.009496	.92613826356542E-04
1572005	1163305	25.00	4087.58000	4087.558995	-.021005	.009485	.92396772743917E-04
1573202	386803	100.00	11863.71000	11863.686118	-.023882	.067770	.47172953434217E-02
1573202	885602	100.00	6875.17000	6875.197703	.027703	.067771	.47173436377984E-02
1573202	887803	4.00	6853.64000	6853.641525	.001525	.067773	.47176690373965E-02

1573202	1081903	4.00	4912.27000	4912.259378	-.010622	.067774	.47178352932891E-02
1573202	1144403	4.00	4287.66000	4287.573561	-.086439	.067801	.47215497091586E-02
1583103	386803	100.00	11962.57000	11962.590625	.020625	.054819	.30865330168925E-02
1583103	445304	100.00	11377.65000	11377.658867	.008867	.054819	.30865217831760E-02
1583103	599104	4.00	9839.65990	9839.769424	.109524	.054819	.30866075018926E-02
1583103	710303	4.00	8727.24000	8727.165338	-.074662	.054821	.30867458798377E-02
1583103.	719102	4.00	8639.42000	8639.404931	-.015069	.054824	.30871378291706E-02
1583103	885602	4.00	6974.10000	6974.102209	.002209	.054829	.30876560202615E-02
1583103	887803	100.00	6952.54000	6952.546031	.006031	.054820	.30866394905479E-02
1583103	1140304	4.00	4427.71000	4427.635900	-.074100	.054825	.30872253821762E-02
1583103	1155804	4.00	4273.24000	4272.404031	-.835969	.054824	.30870822382464E-02
1612104	62005	400.00	15501.58700	15501.565112	-.021888	.030642	.96437964998832E-03
1612104	445304	100.00	11668.45000	11668.481441	.031441	.030643	.96442973337666E-03
1612104	576205	25.00	10359.88000	10359.826220	-.053780	.030643	.96445741157241E-03
1612104	599104	25.00	10130.57000	10130.591998	.021998	.030644	.96447394301557E-03
1612104	710303	100.00	9017.96000	9017.987912	.027912	.030645	.96458953725034E-03
1612104	786405	25.00	8257.71990	8257.707695	-.012207	.030644	.96449896697564E-03
1612104	813304	4.00	7988.68000	7988.621478	-.058522	.030645	.96455790699526E-03
1612104	1008005	100.00	6040.87000	6040.887814	.017814	.030645	.96459180187177E-03
1612104	1020804	100.00	5913.42000	5913.431306	.011306	.030645	.96458888055177E-03
1612104	1054003	25.00	5581.69000	5581.654518	-.035482	.030659	.96545093340073E-03
1612104	1055704	100.00	5564.88000	5564.883727	.003727	.030647	.96471169780285E-03
1612104	1081903	25.00	5301.99000	5301.986458	-.003542	.030650	.96490146117289E-03
1612104	1144403	4.00	4676.79000	4677.300642	.510642	.030717	.96910454265605E-03
1612104	1194304	4.00	4178.03000	4177.980551	-.049449	.030668	.96602501554458E-03
1619506	6	10000.00	16195.36670	16195.364248	-.002452	.009597	.94607893266599E-04
1619506	380007	100.00	12394.55000	12394.546952	-.003048	.009609	.94836149061471E-04
1619506	427506	100.00	11919.63000	11919.670838	.040838	.009608	.94807779243852E-04
1619506	576205	4.00	10433.21990	10433.304161	.084261	.009610	.94851703745599E-04
1619506	700506	4.00	9190.64000	9189.853874	-.786126	.009609	.94840545095150E-04
1619506	732607	25.00	8869.21000	8869.269453	.059453	.009611	.94879911280510E-04
1619506	786405	100.00	8331.08000	8331.185633	.105633	.009612	.94891349640906E-04
1619506	811807	25.00	8076.68000	8076.758845	.078845	.009610	.94856748809565E-04
1619506	1006907	100.00	6126.14000	6126.219273	.079273	.009615	.94963388961796E-04
1619506	1008005	4.00	6114.24000	6114.365755	.125755	.009619	.95035630045233E-04
1619506	1025405	4.00	5940.59000	5940.399078	-.190922	.009623	.95110872291233E-04
1619506	1145706	100.00	4738.07000	4738.088466	.018466	.009621	.95078260381098E-04
1619506	1167707	4.00	4518.35990	4518.363619	.003719	.009626	.95176873520935E-04
1629405	6	111111.11	16294.02580	16294.025466	-.000334	.002823	.81843356645887E-05
1629405	62005	10000.00	15673.70620	15673.704270	-.001930	.002854	.83683214276436E-05
1629405	427506	100.00	12018.21990	12018.332055	.112155	.002856	.83781781136065E-05
1629405	445304	400.00	11840.63000	11840.620599	-.009401	.002864	.84226599274120E-05
1629405	576205	4.00	10531.86000	10531.965379	.105379	.002863	.84185211229570E-05
1629405	599104	100.00	10302.64000	10302.731157	.091157	.002869	.84571719029222E-05
1629405	624906	25.00	10044.92000	10045.015875	.095875	.002863	.84175882465560E-05
1629405	700506	100.00	9288.40000	9288.515091	.115091	.002861	.84096233856325E-05
1629405	786405	100.00	8429.83000	8429.846851	.016851	.002870	.84612455953213E-05
1629405	813304	100.00	8160.65000	8160.760637	.110637	.002883	.85354263445981E-05
1629405	1008005	4.00	6213.05000	6213.026973	-.023027	.002894	.86043511693832E-05
1629405	1020804	25.00	6085.49000	6085.570464	.080464	.002900	.86356973738242E-05
1629405	1025405	4.00	6038.94000	6039.060295	.120295	.002907	.86789967177669E-05
1629405	1028806	4.00	6005.37000	6005.441144	.071144	.002899	.86307747175186E-05
1629405	1055704	100.00	5736.96000	5737.022885	.062885	.002925	.87856525256063E-05
1629405	1140304	4.00	4890.57000	4890.597633	.027633	.002977	.91014836413623E-05
1629405	1155804	25.00	4735.32000	4735.365763	.045763	.002952	.89495713156785E-05
1629405	1163305	4.00	4660.26000	4660.899947	.639947	.002939	.88732921289302E-05
1650506	6	10000.00	16505.78280	16505.788127	.005327	.004023	.16619143617429E-04
1650506	62005	10000.00	15885.46350	15885.466931	.003431	.004021	.16610153925268E-04
1650506	380007	40000.00	12704.97390	12704.970831	-.003069	.004008	.16498759712670E-04

1650506	427506	100.00	12230.08000	12230.094716	.014716	.004021	.166098480429 89E-04
1650506	576205	25.00	10744.12000	10743.728039	-.391961	.004027	.166587460510 48E-04
1650506	624906	100.00	10256.65000	10256.778536	.128536	.004025	.166427468035 85E-04
3748904	445304	400.00	33035.66900	33035.726000	.057000	.009348	.897495179750 67E-04
3748904	710303	400.00	30385.35000	30385.232471	-.117529*	.009357	.899270055343 62E-04
3748904	1055704	10000.00	26932.12810	26932.128286	.000186	.009324	.892968090397 08E-04
3748904	1497005	400.00	22518.50000	22518.555876	.055876	.009561	.938821597751 97E-04
3759606	6	400.00	37596.65400	37596.606083	-.047917	.003016	.934213409437 59E-05
3759606	1006907	400.00	27527.51000	27527.461108	-.048892	.003015	.933884268750 28E-05
3759606	1129005	400.00	26306.42000	26306.376949	-.043051	.003085	.977812083295 76E-05
3759606	1163305	400.00	25963.47000	25963.480564	.010564	.003078	.972921884365 61E-05
3759606	1282607	111111.11	24770.32900	24770.329465	.000465	.002939	.887232075766 06E-05
3762410	1130809	10000.00	26316.40780	26316.412081	.009281	.002221	.506620480408 96E-05
3762410	1312709	111111.11	24496.64500	24496.646434	.001434	.002121	.462039563715 79E-05
3762410	1353509	111111.11	24089.38900	24089.386782	-.002218	.002127	.464882832184 41E-05
3762410	1484510	400.00	22779.23000	22779.246026	.016026	.002588	.688127044711 78E-05
3762410	1604010	400.00	21584.11000	21584.079722	-.030278	.002653	.722842889202 04E-05
3763109	1130809	10000.00	26323.76060	26323.766248	.005648	.002752	.777615890087 24E-05
3763109	1312709	111111.11	24504.00120	24504.000601	-.000599	.002634	.712811786423 92E-05
3763109	1545808	10000.00	22173.43910	22173.441041	.001942	.003095	.983833580218 75E-05
3763109	1624408	10000.00	21387.44810	21387.447163	-.000937	.002905	.866957287361 44E-05
3777909	764508	400.00	30133.58000	30133.533321	-.046679	.002029	.423023849720 83E-05
3777909	1068508	40000.00	27093.39800	27093.400842	.002842	.002015	.417226031073 09E-05
3777909	1130809	10000.00	26471.03670	26471.037591	.000891	.002072	.441130360476 76E-05
3777909	1312709	111111.11	24651.27450	24651.271945	-.002555	.001986	.405062927272 40E-05
3777909	1484510	400.00	22933.92000	22933.871537	-.048463	.002484	.633930169945 61E-05
3777909	1545808	400.00	22320.64000	22320.712385	.072385	.002590	.689247274062 52E-05
3777909	1604010	400.00	21738.67000	21738.705233	.035233	.002512	.647989713379 66E-05
3777909	1624408	111111.11	21534.71710	21534.718507	.001407	.002037	.426049218742 98E-05
3833807	811807	400.00	30219.70000	30219.706274	.006274	.009383	.904268450283 33E-04
3833807	1034708	400.00	27990.97700	27990.999131	.022131	.009388	.905213720130 58E-04
3833807	1282607	400.00	25511.93990	25512.035059	.095159	.009393	.906138966651 84E-04
3833807	1479007	10000.00	23547.37460	23547.369657	-.004943	.009324	.893016505296 39E-04
3871209	1068508	400.00	28027.09000	28027.091200	.001200	.002670	.732229465326 38E-05
3871209	1130809	400.00	27404.76000	27404.727950	-.032050	.002710	.754201968129 50E-05
3871209	1312709	40000.00	25584.95630	25584.962304	.006004	.002656	.724728924556 14E-05
3871209	1484510	10000.00	23867.56040	23867.561895	.001495	.002975	.909309752551 84E-05
3871209	1545808	111111.11	23254.40490	23254.402744	-.002156	.002459	.620822802455 04E-05
3871209	1604010	10000.00	22672.39830	22672.395591	-.002709	.003028	.941556993987 97E-05
3871209	1748709	400.00	20829.90000	20829.959734	.059734	.006592	.446328749213 56E-04

LEVEL	CALCULATED LEVEL	SQRT(VAR)	VAR/SIGMA**2
1150206	11502.588718	.061432	.387611719828 57E-02
1161305	11613.943182	.049092	.247534490784 16E-02
1203504	12035.566125	.047641	.233120071380 32E-02
1264306	12643.408039	.048850	.245098046817 72E-02
1346305	13463.397154	.029644	.902598842396 21E-03
1371004	13710.241813	.052152	.279354150427 94E-02
1382504	13825.406466	.038469	.151994955784 46E-02
1464106	14643.835728	.027326	.766948486065 44E-03
1483905	14839.733330	.029984	.923429706296 60E-03
1500703	15007.414240	.079514	.649381485320 04E-02
1563107	15631.806693	.035263	.127718561374 74E-02
1563806	15638.334865	.026031	.695975324803 93E-03
1572005	15720.684513	.009449	.917106713544 33E-04
1573202	15732.159227	.067772	.471751346859 28E-02
1583103	15831.063733	.054820	.308667725340 98E-02
1612104	16121.886307	.030644	.964499694211 08E-03
1619506	16195.364248	.009597	.946078936665 99E-04
1629405	16294.025466	.002023	.818433564658 87E-05
1650506	16505.788127	.004023	.166191436174 29E-04
1688802	16888.290897	.134292	.185229861572 61E-01
1690007	16900.386934	.004061	.242664216576 57E-04
1692905	16929.766716	.002530	.657679977421 62E-05
1707006	17070.475776	.002529	.656394852639 79E-05
1715403	17154.821038	.026909	.743721067556 79E-03
1736106	17361.901343	.002532	.658287122581 82E-05
1736905	17369.555759	.002100	.452868026027 85E-05
1746804	17468.224032	.004895	.246120966676 41E-04
1789304	17893.882967	.002901	.918664152881 22E-05
1790805	17908.175960	.002098	.451991667490 46E-05
1796803	17968.719982	.023210	.553315642559 69E-03
1818504	18185.999376	.004908	.247397868532 37E-04
1825306	18253.872911	.002100	.452848986133 81E-05
1826002	18260.644332	.036549	.137204155753 29E-02
1829507	18295.777796	.002946	.891552367836 61E-05
1829904	18299.502338	.002982	.913315232153 74E-05
1838304	18383.243423	.002989	.917616845483 08E-05
1840605	18406.523982	.002532	.658595771783 30E-05
1853003	18530.749217	.028950	.860817017046 06E-03
1860704	18607.802283	.062978	.910862945257 24E-05
1874903	18749.849185	.030169	.934820299940 33E-03
1875906	18759.180102	.002047	.451772152620 19E-05
1879404	18794.842846	.002976	.909928869672 03E-05
1883907	18839.263353	.002942	.888938179246 17E-05
1893205	18932.767689	.002959	.899282440299 80E-05
1911503	19115.499404	.032103	.105851951349 42E-02
1911902	19119.755714	.041010	.172740877029 76E-02
1912704	19127.211527	.002972	.907038185342 05E-05
1919204	19192.401297	.002971	.906557632100 11E-05
1930702	19307.749994	.033850	.117688126507 02E-02
1947105	19471.859700	.002814	.813263729862 19E-05
1948908	19489.037531	.009647	.955594347425 19E-04
1955204	19552.519510	.002847	.832474378215 46E-05
1964003	19640.147433	.009666	.959589643554 78E-04
1964707	19647.568040	.004886	.245119629240 33E-04
1966803	19668.423943	.009240	.876886473741 87E-04
1978306	19783.333932	.001726	.305984142201 51E-05
1982606	19826.669488	.002053	.432742770258 30E-05
1982802	19828.464700	.004918	.248396758487 84E-04
1986403	19864.520551	.003006	.927868139167 74E-05
1988507	19885.512543	.002522	.653073572466 69E-05
2011405	20114.296918	.002051	.431815692215 15E-05
2014905	20148.026295	.002647	.719752746598 90E-05
2021806	20218.027021	.001900	.370928551141 55E-05
2025803	20258.142780	.002890	.857731959967 4F-05
2030604	20306.855422	.002860	.840317235123 79E-05
2031105	20311.548955	.002855	.837313973777 10E-05
2039103	20391.508958	.004409	.199630499862 75E-04
2042006	20420.512934	.001635	.274575309077 62E-05
2045202	20452.797504	.004962	.252843784495 22F-04
2046407	20464.520473	.002456	.619400400874 82E-05
2052505	20525.390449	.002082	.445394667562 53E-05
2052808	20528.891031	.004879	.244542291731 03E-04
2056904	20569.222327	.001841	.348286443584 10E-05
2062105	20621.242023	.002563	.674826597706 99F-05
2065102	20651.205277	.003017	.934925084753 64E-05
2066106	20661.507083	.001965	.396404811890 01E-05
2071208	20712.175809	.002993	.919979126452 47E-05
2071904	20719.030672	.002294	.540325280242 14E-05
2076607	20766.499304	.001935	.384736140368 52E-05
2080503	20805.792980	.002148	.473861533273 61E-05
2085105	20851.574227	.002039	.426839476691 13E-05
2094306	20943.421544	.001934	.384178704424 27E-05
2101102	21011.055371	.003011	.931423955961 59E-05
2106203	21062.337688	.002580	.683599295671 53E-05
2107805	21078.724499	.002040	.427522362459 28E-05
2118504	21185.846449	.002986	.915770484838 76E-05
2123202	21232.874806	.003017	.934750094012 76E-05
2126506	21265.087132	.001506	.232427979900 29E-05
2132705	21329.065565	.001727	.306414971510 73E-05
2140703	21407.854339	.002145	.472669061050 44E-05
2140908	21409.967637	.002993	.920268489877 42E-05
2142607	21426.477068	.002098	.452291062510 31E-05
2144804	21448.952800	.002088	.447716765929 40E-05
2153603	21536.840110	.002148	.473691778756 36E-05
2153605	21536.071126	.002230	.510635297430 91E-05
2154504	21545.139536	.001761	.314502893521 71E-05
2158406	21584.686327	.001903	.371959561832 16E-05
2163605	21636.947702	.001507	.233134454416 77E-05
2175304	21753.037748	.001713	.301218814875 81E-05
2176606	21766.521907	.001490	.228140147227 35E-05
2176707	21767.962484	.001935	.384757353241 62E-05
2183003	21830.357274	.002581	.684147076178 39E-05
2194003	21940.630494	.002300	.543223660440 22E-05
2195805	21958.182107	.001452	.216483326182 38E-05
2197604	21976.020628	.001538	.243097102244 72E-05
2198005	21980.104483	.001452	.216412784463 37E-05

LEVEL	CALCULATED LEVEL	SQRT(VAR)	VAR/SIGMA**2
2199306	21993.138642	.001617	.268396457397 26E-05
2203804	22038.026690	.001821	.340627400381 60E-05
2205606	22056.291232	.001434	.211133799141 53E-05
2228304	22283.413539	.001758	.317466101414 64E-05
2236807	22368.457102	.001728	.306762234690 51E-05
2237705	22377.753096	.001325	.180407756566 94E-05
2238304	22383.452402	.001540	.243681557738 51E-05
2240903	22409.637175	.002871	.846643207801 91E-05
2242105	22421.750167	.001618	.268928901823 80E-05
2246406	22464.282780	.001406	.202706301786 65E-05
2257402	22574.808804	.004919	.248544825278 01E-04
2258206	22582.642935	.001385	.196905052165 99E-05
2258404	22584.580301	.001519	.236965162098 59E-05
2259901	22599.947265	.034949	.125450972405 42E-02
2262403	22624.325962	.002574	.680343347481 04E-05
2263107	22631.145844	.001726	.305873564488 79F-05
2263404	22634.130794	.001810	.336344503664 03E-05
2269103	22691.490039	.002578	.682513433151 25E-05
2270004	22700.424095	.002127	.466408121653 37E-05
2275202	22752.416556	.002996	.921874123006 26E-05
2275406	22754.047646	.001276	.167127267802 73E-05
2278605	22786.594730	.001396	.200043628045 44E-05
2278908	22789.776224	.002972	.907422251965 10E-05
2286206	22862.438113	.001241	.158263460488 44E-05
2289103	22891.694542	.002098	.452046467376 95E-05
2290802	22908.791458	.002782	.796649566510 02E-05
2291807	22918.543224	.002036	.446797163570 74E-05
2296409	22964.541277	.027529	.778389173326 29E-03
2305104	23051.151759	.001586	.258375039800 54E-05
2305707	23057.661699	.001616	.268268237127 89E-05
2306906	23069.709907	.001478	.224281148386 17E-05
2316503	23165.633163	.001777	.324454422703 05E-05
2318604	23186.925997	.001644	.277718960054 6F-05
2319607	23196.946096	.001449	.215662417889 67E-05
2321202	23212.062783	.005723	.336449410995 18E-04
2321205	23212.462182	.001254	.161425695207 88E-05
2327203	23272.511425	.001605	.264525518080 48E-05
2332905	23325.176684	.001340	.184457416200 85E-05
2337504	23375.447038	.001543	.244474313855 74E-05
2337802	23378.726334	.002596	.692269062500 54E-05
2343004	23430.161935	.001644	.277528387644 98E-05
2343205	23432.780446	.001166	.139671209120 62E-05
2346403	23464.155396	.001412	.204777269684 49E-05
2348605	23486.680589	.001308	.175748149034 83E-05
2353405	23534.401968	.001436	.211707931180 26E-05
2354307	23543.492554	.001279	.167933100159 56E-05
2356004	23560.618682	.001411	.204532051964 73E-05
2357206	23572.070121	.001179	.142729432360 3E-05
2370802	23708.642202	.003022	.938014565134 99E-05
2371506	23715.276565	.001209	.150223190011 73E-05
2373404	23734.718011	.001940	.386687314719 8E-05
2375303	23753.491054	.001986	.405160153761 72E-05
2375502	23755.579988	.002324	.554499775455 76E-05
2377707	23779.241024	.001281	.168630531027 80E-05
2382404	23825.347651	.001333	.182559265235 24E-05
2384409	23843.725094	.004485	.924113343876 64E-04
2384807	23848.609696	.001300	.173547473210 98E-05
2387303	23873.243699	.001676	.288558935513 2E-05
2392608	23926.768291	.001672	.287132504092 62E-05
2393205	23932.835485	.001096	.123357196340 63E-05
2397204	23972.564498	.002047	.430541057774 80E-05
2400208	24002.425814	.002100	.453157851694 63E-05
2402203	24022.046275	.001619	.269337023109 82E-05
2402606	24026.188095	.001461	.219090105610 96E-05
2406607	24066.549077	.001247	.152660769408 44E-05
2406902	24069.399325	.034893	.125052389705 98E-02
2408205	24082.385230	.001161	.138482968013 85E-05
2411803	24118.245190	.001675	.288272086153 31E-05
2415402	24154.350321	.002345	.565907129733 93E-05
2417206	24172.350957	.001359	.189750251047 35E-05
2418507	24185.786653	.001170	.140511749007 31E-05
2419504	24195.703698	.001462	.219435393884 25E-05
2420703	24207.036446	.001736	.309437266331 50E-05
2422005	24220.632148	.001311	.176424996992 23E-05
2426304	24263.100957	.001417	.206368020197 51E-05
2432206	24322.920585	.001566	.251968410951 97E-05
2433102	24331.751499	.002896	.861178921778 10E-05
2433307	24333.775818	.001353	.188115576713 11E-05
2440003	24400.643642	.001697	.295926335682 97E-05
2443306	24433.241995	.001136	.132476159298 48E-05
2444805	24448.015026	.001245	.159184226563 23E-05
2444904	24449.372322	.001654	.280919953845 96E-05
2445108	24451.746642	.002484	.633962173273 96E-05
2451709	24517.295504	.003013	.932259100606 03E-05
2453505	24535.263540	.001184	.143114691335 9E-05
2455503	24555.717844	.002107	.455868227939 92E-05
2456007	24560.395310	.001103	.125056639797 36E-05
2458108	24581.184729	.001541	.243439624600 84E-05
2459102	24591.194654	.009560	.938646968855 05E-04
2460906	24609.517211	.001329	.181457380116 44E-05
2461304	24613.738891	.001210	.150262153842 13E-05
2465005	24650.400752	.001280	.168385439331 9E-05
2467106	24671.369466	.001177	.142326710665 89E-05
2474105	24741.228190	.001212	.150916299690 29E-05
2475704	24757.252191	.001431	.210321948907 03F-05
2476006	24760.012921	.001600	.262874177912 05F-05
2488407	24884.157913	.001447	.215131001786 50E-05
2489203	24892.666006	.001797	.331721018305 31E-05
2490606	24906.861130	.001095	.123111084882 89E-05
2493807	24938.849196	.001601	.263235898650 26E-05
2496004	24960.520027	.001236	.156930033113 29E-05
2496603	24966.566888	.001668	.295750637420 36E-05
2497304	24973.986228	.001255	.161743550338 20E-05
2500706	25009.710677	.001417	.206164269856 91E-05
2501704	25017.091599	.001383	.196530345324 31E-05
2506402	25068.706137	.003033	.944783452063 09E-05

3279608	32796.383030	.001863	.356420390224586-05
3280206	32802.388869	.001607	.265328959460966-05
3280906	32809.184637	.002639	.715431134226866-05
3284206	32842.330455	.004370	.196152992299746-04
3285203	32852.136887	.005610	.323232647023156-04
3288002	32880.222449	.034893	.125053642745776-02
3289105	32891.124588	.002486	.634728922485846-05
3290207	32902.917988	.002025	.421007830505666-05
3292504	32925.978846	.003316	.112921184256246-04
3292806	32928.653797	.001511	.234570729841656-05
3293209	32932.865915	.001393	.199344484132016-05
3294405	32944.917771	.004406	.199376018628856-04
3295506	32955.055280	.001705	.298654708362406-05
3297707	32977.452034	.001702	.297538476636806-05
3299102	32991.822696	.006873	.485219830021806-04
3299706	32997.577240	.002630	.710437006781176-05
3300804	33008.424105	.002326	.555516708122106-05
3304105	33041.846153	.003703	.140474510309566-04
3307705	33077.841653	.003728	.142780640258006-04
3309003	33090.673794	.006937	.494303812620696-04
3309907	33099.175698	.001887	.365782917856286-05
3311706	33117.972837	.001684	.291242149623796-05
3312404	33124.932622	.002029	.422983792786146-05
3313607	33136.209580	.002507	.645623733487126-05
3315005	33150.685904	.002458	.626030311903226-05
3315406	33154.746641	.002321	.553117675247586-05
3317504	33175.105185	.003709	.141270017976166-04
3317602	33176.734272	.006955	.496767268324136-04
3321403	33213.201143	.004686	.225510221304236-04
3322904	33229.060449	.004010	.166822497584256-04
3326702	33267.690410	.009719	.970150139977746-04
3328206	33282.462947	.002482	.632915534665016-05
3330506	33305.023654	.002894	.860400231114116-05
3332009	33320.601172	.001486	.226934634933316-05
3334106	33341.791527	.002593	.690622547316676-05
3334404	33346.418342	.002715	.757162356642916-05
3335305	33353.795705	.002594	.643813189209106-05
3335702	33357.580596	.009699	.966156071571446-04
3337307	33373.914166	.001782	.326294032703876-05
3341206	33412.204015	.002183	.489348125647646-05
3345704	33457.916035	.005548	.316179424443616-04
3347404	33474.765961	.005565	.318108862244416-04
3351206	33512.596044	.002604	.696300610035026-05
3357007	33570.619835	.001510	.234085034286786-05
3358005	33580.688849	.004862	.242789833595566-04
3359509	33595.009234	.001498	.230607497853816-05
3363906	33639.517370	.001791	.329302519994336-05
3370306	33703.429752	.002039	.426967785902756-05
3370705	33707.636024	.004382	.197248342041986-04
3371907	33719.081786	.002110	.457386722302406-05
3372304	33723.444610	.004214	.184130639776576-04
3373006	33730.735080	.002769	.787403251933376-05
3373304	33733.430290	.003976	.162396594666976-04
3373803	33738.736831	.009183	.866135778545926-04
3376907	33769.973073	.003207	.105637485354446-04
3377806	33778.777713	.002612	.700857830713616-05
3379705	33797.471985	.001754	.391959579185536-05
3382903	33829.162201	.002623	.706455179589996-05
3382908	33829.827455	.001804	.334152130895736-05
3387403	33874.493988	.034889	.125024857853746-02
3389908	33899.398707	.001981	.403034748010336-05
3391606	33916.775892	.002340	.562179661722546-05
3391803	33918.368302	.005546	.320477919871096-04
3392104	33921.663835	.009027	.837007500259096-04
3396209	33962.794376	.001511	.255130999407616-05
3398108	33981.683589	.002507	.645450073434546-05
3398703	33987.443915	.006883	.486595751401646-04
3400006	34000.463069	.004371	.196214617155466-04
3401604	34016.211560	.005616	.323894511963046-04
3404108	34041.968319	.002027	.422010331116356-05
3404603	34046.403307	.003767	.145773559940836-04
3405907	34059.866018	.001539	.243178658865156-05
3407003	34070.689951	.009183	.866151737972036-04
3407505	34075.688830	.005665	.329608093169546-04
3408009	34080.919704	.001677	.288911511746486-05
3410508	34105.363353	.002168	.482983058662516-05
3410903	34109.652659	.006872	.485053392162256-04
3411805	34118.147627	.006822	.478014665245006-04
3414302	34143.628310	.003079	.973934051267726-05
3415504	34155.014571	.009034	.838273554245316-04
3416406	34164.723714	.002321	.553251033083536-05
3420103	34201.427461	.006888	.487311321156826-04
3420505	34205.952841	.002668	.730890880239776-05
3421504	34215.262205	.005655	.328426345922126-04
3423804	34238.897915	.005652	.328089166220476-04
3429304	34293.453212	.004041	.166922201190296-04
3430603	34306.773841	.006944	.495310646224066-04
3431508	34315.613759	.001544	.244936386714796-05
3433804	34338.529037	.005638	.326539678065216-04
3434406	34344.807532	.004793	.235953166761386-04
3440702	34407.110127	.005313	.289940973902796-04
3440705	34407.791869	.006707	.462001965811866-04
3442905	34429.579276	.022076	.500537686466666-03
3443004	34430.307530	.006743	.467069724970816-04
3443409	34434.952158	.002119	.461315836746056-05
3448603	34486.427714	.002632	.711565968993206-05
3450709	34507.278214	.002319	.552417346881876-05
3453504	34535.699689	.004417	.200389262762316-04
3455004	34550.541978	.006860	.483769094301236-04
3464408	34644.086700	.001790	.329151489306866-05
3466203	34662.903571	.024640	.625633778737956-03
3470609	34706.428023	.001959	.394298510873596-05
3470707	34707.725732	.001564	.251245633566506-05
3471507	34715.859178	.002107	.456040805911996-05
3473904	34739.430992	.009295	.887360153207866-04
3476202	34762.934387	.034906	.125144890122026-02
3481206	34812.122392	.002880	.852002548734046-05
3482707	34827.817285	.002020	.419153598040536-04
3484208	34842.875301	.001870	.359009292466376-05
3484609	34846.858963	.001872	.359818941485156-05
3486902	34869.878549	.034892	.125046522342126-02
3488109	34881.840763	.001930	.382616331900386-05
3494304	34943.607736	.004912	.247841210220916-04
3497607	34976.495304	.001895	.368867091851926-05
3500407	35004.114057	.001446	.214631128386826-05
3502902	35029.944478	.028492	.833799580242526-03
3503210	35032.604572	.001534	.241583951724396-05
3503805	35038.794558	.003034	.945206149549606-05
3504808	35048.191502	.002440	.611687265292506-05
3512807	35128.727554	.005615	.323478493320346-04
3521704	35217.624062	.006625	.450772883555556-04
3553607	35546.913134	.002795	.802319357965676-05
3558509	35585.941407	.001575	.254816599431676-05
3561204	35612.865629	.002787	.797609092861026-05
3580706	35807.608574	.002694	.745685085968146-05
3585001	35850.797265	.034949	.125450972405426-02
3587706	35879.247422	.005592	.321233012255016-04
3588704	35887.240618	.006744	.467203910945366-04
3593009	35930.003059	.002152	.475692254476076-05
3593103	35931.233435	.028490	.833677386234146-03
3598103	35981.187227	.003074	.970328349332086-05
3607006	36370.694046	.001744	.312295540163576-05
3650107	36501.876146	.003241	.110581642279926-04
3651909	36519.962220	.003159	.102478049402246-04
3652808	36528.114858	.002450	.616357897171106-05
3655101	36551.278802	.049345	.250091232182836-02
3668807	36688.963027	.005449	.304921680030166-04
3675807	36758.648656	.004894	.245954612025156-04
3715410	37154.724596	.004479	.206037045020736-04
3729409	37294.641067	.002160	.479287674011206-05
3747501	37475.865163	.034896	.125073254374096-02
3748904	37489.130867	.009352	.898329477500786-04
3759606	37596.606083	.003016	.934213409437596-05
3762410	37624.529380	.002198	.496202929195146-05
3763109	37631.883547	.002737	.769586869620486-05
3777409	37774.154891	.002044	.428984910523306-05
3833807	38338.311677	.009388	.905275184866076-04
3871209	38712.845249	.002675	.734910969049606-05
62005	620.371195	.000466	.222906121581226-06
380007	3800.817295	.000489	.245933127436176-06
386803	3868.473109	.000584	.349917480441866-06
427506	4275.693410	.000459	.216603509104406-06
445304	4453.404867	.000508	.264861134556256-06
576205	5762.060087	.000502	.259045690791676-06
599104	5991.243409	.000539	.298650386577466-06
624906	6249.009591	.000499	.255566865040596-06
700506	7005.510374	.000492	.248325064631756-06
710303	7103.898495	.000685	.482011679205276-06
710102	7101.658802	.000942	.912321828330376-06
732607	7326.074795	.000531	.289234125988256-06
764508	7645.621570	.000600	.369458640260406-06
786405	7864.178614	.000542	.301668446466036-06
811807	8118.605403	.000509	.266231613046606-06
813304	8133.264829	.000606	.377135360535776-06
885602	8856.961524	.001186	.144454709175806-05
887803	8878.517702	.000775	.617162276029226-06
1006907	10069.144975	.000605	.376528375902646-06
1008005	10080.998493	.000658	.444478256727256-06
1010301	10103.406727	.000415	.165543609656826-04
1020404	10208.455002	.000682	.477299830108286-06
1025405	10254.965170	.000711	.519533831936946-06
1028806	10288.584322	.000676	.470040154162056-06
1034708	10347.312546	.000611	.383420932070456-06
1045707	10457.717213	.001403	.202069388562786-05
1054003	10540.231789	.001149	.135533294024626-05
1055704	10557.002581	.000782	.627570892812396-06
1068508	10685.754049	.000646	.428338749838866-06
1081903	10819.839849	.000869	.775653934532826-06
1084208	10842.755990	.003389	.117983307357046-04
1098706	10987.551723	.000673	.465014007865586-06
1129005	11290.269135	.000854	.748372349180776-06
1130809	11308.117299	.000840	.724103390069426-06
1140304	11403.427833	.000958	.942729461223366-06
1144403	11444.586665	.002204	.498797525756036-05
1145706	11457.275782	.000693	.493426978774576-06
1155804	11558.659703	.000877	.790860474931636-06
1163305	11633.125519	.000833	.713532624143736-06
1167707	11677.000629	.000756	.587000874331976-06
1194304	11943.905756	.001353	.188003405966386-05
1196805	11968.612425	.000934	.896649055386866-06
1236304	12362.454954	.001803	.333896000851416-05
1282607	12826.276618	.000684	.479341162189036-06
1288405	12884.756115	.001541	.243764228522616-05
1291006	12910.468890	.000935	.897150761401876-06
1312709	13127.842946	.000854	.749626587687976-06
1334607	13346.868542	.000848	.738605005600716-06
1336106	13361.460434	.002350	.567415125776526-05
1340206	13402.494395	.001096	.123346019975646-05
1353509	13535.142599	.001145	.134676726367916-05
1356707	13567.956680	.002555	.670669536190476-05
1363205	13632.085633	.001981	.402949562009546-05
1441104	14411.380282	.002635	.712078732934306-05
1450108	14501.766123	.001119	.128566523904346-05
1454306	14543.727593	.001042	.111514925810266-05
1479007	14790.962020	.001212	.150977603461046-05
1484510	14845.283354	.001626	.271658027974586-05
1497005	14970.574990	.002176	.486530114551246-05
1535407	15353.788383	.003123	.100143592742046-04
1545808	15458.442505	.001755	.316360284163576-05
1571207	15712.810451	.001328	.181180703717496-05
1604010	16040.449658	.001725	.305619294338136-05
1624408	16244.436384	.001348	.186574860606076-05
1788209	17882.885515	.006088	.380707275542366-04

B(1)= 0.000000000

SIGMA= .986718 SIGMA SQUARED= .973613

857 LEVELS 8889 TRANSITIONS

CLASS	WEIGHT	RMS	QUANTITY
.0030	111111.11	.001974	1759
.0050	40000.00	.003707	1089
.0100	10000.00	.008701	1562
.0500	400.00	.062667	2783
.1000	100.00	.083967	336
.2000	25.00	.141689	626
.5000	4.00	.347499	734

END OF FILE TAPE 2

APPENDIX E

THE ITERATIVE CODE: INSTRUCTIONS AND LISTING

```
                PROGRAM IT(INPUT,OUTPUT,TAPE9)
000002          DIMENSIONTCC(1000),TRC(1000),TC(1000),TR(1000)
000002          DIMENSIONSNJ(1000),SNI(1000),DEL(1000),COMT(8)
000002          DIMENSIONWT(20000),WN(20000),IWN(20000),ICT(20000)
000002          DIMENSIONWU(38),WC(38),WRMS(38),NRMS(38),WS(38)
000002          COMMONN,M,NT,TCO,TRC,WF,WN
000002          EQUIVALENCE(WT,ICT),(WN,IWN)
000002          DATAIXHAF/10000/
000002          DATA(WU(I),I=1,37)/.0001,.0002,.0003,.0004,.0005,.0006,
               1.0007,.0008,.0009,.001,.002,.003,.004,.005,.006,.007,.008,
               2.009,.01,.02,.03,.04,.05,.06,.07,.08,.09,.1,.2,.3,.4,.5,.6,.7,.8,
               3.9,1./
000002          LOGICALISOTOP
000002     1    FORMAT(F15.4,2I7,F5.4,F7.3,A1)
000002     2    FORMAT(8A10)
000002     3    FORMAT(I5,F10.9,F10.2,I5,F5.4,3X,A7)
000002        4 FORMAT(1X,I5* ITERATIONS*5X*DELTA=*F16.9)
000002     5    FORMAT(1X,I5,F19.8,2F15.5,F17.5)
000002        6 FORMAT(1H0,2XA3,13X*LEVEL*3X*INITIAL VALUE*
               15X*DIFFERENCE*4X*WEIGHT SUM*)
000002        7 FORMAT(3(1X,8F16.8/)/)
000002        8 FORMAT(1X,F15.8,F16.5,F12.2,F14.2,2F16.5)
000002        9 FORMAT(1H0,I5* COL LEVELS*I5* ROW LEVELS*
               116* TRANSITIONS*)
000002       10 FORMAT(*1CALCULATED LINE   OBSERVED LINE*
               12X*DIFFERENCE*7X*WEIGHT*7X*ROW LEVEL*
               27X*COL LEVEL*)
000002     11    FORMAT(1X*MAXIMUM NUMBER OF ITERATION CYCLES=*I5/
               11X*CUTOFF VALUE FOR DELTA=*F10.9/
               11X*MULTIPLICATION FACTOR=*F10.2/
               11X*PRINT CYCLE=*I5/
               11X*UNCERTAINTY ASSOCIATED WITH WEIGHT OF ONE=*F10.4)
000002       12 FORMAT(*0SIGMA=*F10.6,4X,* NORMALIZED SIGMA=*F10.6)
000002       13 FORMAT(*0UNCERTAINTY*7X*WEIGHT*11X*RMS*5X*QUAN*)
000002     14    FORMAT(4X,F6.4,6X,F12.2,4X,F8.4,4X,I4)
000002       15 FORMAT(* GREATER THAN 1.0*15X,F8.4,5X,I3)
000002     16    FORMAT(1X*ISOTOPE SHIFT DATA*)
000002     17    FORMAT(1X*WAVELENGTH DATA*)
000002     18    FORMAT(1H1,8A10)
C
C
C INPUT DECK
C
C COMMENT CARD
C COL 1-80 (8A10)  COMMENTS USED AS A HEADING FOR OUTPUT LISTING
C
C CONTROL CARD
C COL 1-5 (I5) MAXIMUM NUMBER OF ITERATION CYCLES
C COL 6-15 (F10.9)  CUTOFF VALUE FOR DELTA
C DELTA IS THE MAXIMUM CORRECTION THAT OCCURED IN THE LEVELS FOR THE
C ITERATION CYCLE
C COL 16-25 (F10.2) MULTIPLICATION FACTOR OF CORRECTION TO A LEVEL
C COL 26-30 (I5)  INTERVAL OF PRINT CYCLE OF LEVELS DURING ITERATION
C COL 31-35 (F5.4)  UNCERTAINTY TO BE ASSOCIATED WITH A WEIGHT OF ONE
C COL 39-45 (A7) ISOTOPE  FOR ISOTOPE SHIFT DATA
C COL 39-45 (A7) .NE. ISOTOPE FOR WAVE NUMBER RUN
C
C DATA CARDS
C COL 1-15 (F15.4) WAVE NUMBER
C COL 16-22 (I7) ROW LEVEL CLASSIFICATION NAME
C COL 23-29 (I7) COLUMN LEVEL CLASSIFICATION NAME
C COL 30-34 (F5.4) UNCERTAINTY OF WAVE NUMBER
C ISOTOPE SHIFT UNCERTAINTY IS ASSUMED TO BE 1.
C COL 35-41 (F7.3)  SIGNED ISOTOPE SHIFT DATA
```

```
C COL 42 (A1) S IF ISOTOPE SHIFT VALUE GIVEN
C
C
C FOR EXAMPLE, WAVE NUMBER 25637.2066 IS THE TRANSITION BETWEEN
C 4663.8815 (J-VALUE=3) AND 30301.0873 (J-VALUE=4) WITH UNCERTAINTY
C =.003 AND ISOTOPE SHIFT=-.13.  THE LEVEL NAME MUST BE UNIQUE.
C 4663.8815 MAY BE REPRESENTED AS 46633 AND 30301.0873 AS 303014.  THE
C LEVEL NAME IS USED TO CLASSIFY THE TRANSITION.  THE FIRST SIX DIGITS
C OF THE LEVEL NAME ARE USED AS AN INTEGER INITIAL ESTIMATE OF THE LEVEL
C OR ITS ISOTOPE SHIFT.
C
C
C
C READ COMMENT CARD
C
000002          READ2,CCMT
000010          PRINT18,CCMT
C
C READ CONTROL CARD
C
000016          READ3,MAXIT,DELTA,FACTOR,MODPRT,WTUNC,ITYPE
000036          IF(WTUNC.EQ.0.)WTUNC=1.
000040          ISOTOP=ITYPE.EQ.7HISOTOPE
000044          PRINT11,MAXIT,DELTA,FACTOR,MODPRT,WTUNC
000062          IF(ISOTOP)PRINT16
000067          IF(.NOT.ISOTOP)PRINT17
000074          NT=0
C
C READ DATA CARDS
C
000075    900   READ(9,1)WNN,LR,LC,UNC,SFT,SFTX
000115          IF(EOF,9)940,910
C
C THE WAVE NUMBERS (OR ISOTOPE SHIFTS) AND THE UNCERTAINTIES ARE
C CONVERTED TO INTEGERS PRIOR TO PACKING IN ONE WORD.
C
000120    910   IF(ISOTOP)GOTO920
000122          NT=NT+1
000123          IWN(NT)=WNN*10000.+.5
000127          IUNC=UNC*10000.+.5
000132          GOTO930
000132    920   IF(SFTX.EQ.1H )GOTO900
000134          NT=NT+1
000136          IWN(NT)=(SFT+20.)*1000.+.5
000143          IUNC=10000
C
C IWN CONTAINS THE WAVE NUMBER IN BITS 58-17 AND THE UNCERTAINTY IN
C IN BITS 16-0
C ICT CONTAINS THE ROW CLASSIFICATION IN BITS 58-37, COLUMN
C CLASSIFICATION IN BITS 36-15 AND INDEX OF WAVE NUMBER STORAGE
C IN BITS 14-0
C
000144    930   CALLSHIFT(IWN(NT),IWN(NT),-17)
000150          IWN(NT)=IWN(NT).OR.IUNC
000153          CALLSHIFT(LR,ICT(NT),-22)
000155          ICT(NT)=ICT(NT).OR.LC
000160          CALLSHIFT(ICT(NT),ICT(NT),-15)
000163          ICT(NT)=ICT(NT).OR.NT
000165          GOTO900
C
C THE ORDERING SUBROUTINE TORDER REQUIRES ADDITIONAL STORAGE FOR
C SORTING.  IF MORE THAN 10000 TRANSITIONS ARE PRESENT, THE DATA IS
C STORED UNTIL NEEDED AGAIN.  EXTENDED CORE STORAGE IS USED, BUT DATA
C MAY BE STORED ON ANY MEDIUM
C
000166    940   IF(NT.LE.IXHAF)GOTO950
000171          CALLECWR(IWN,0,NT,IERR)
000174          IF(IERR.NE.0)STOP1
C
C SORT ACCORDING TO ROW CLASSIFICATIONS
C
```

```
000177    950  CALL TORDER(ICT,NT)
000201         M=0
000202         KX=0
000203         DO970I=1,NT
000204         KXT=ICT(I).AND.(.NOT.177777777777B)
000206         IF(KXT.EQ.KX)GOTO960
000210         KX=KXT
000211         M=M+1
000212         CALLSHIFT(KXT,KXT,37)
          C
          C  STORE ROW LEVEL INITIAL GUESS
          C
000215         TRO(M)=KXT/10
000222    960  ICT(I)=ICT(I).AND.17777777777B
000225         CALLSHIFT(ICT(I),ICT(I),-10)
          C
          C  REPLACE ROW LEVEL CLASSIFICATION NAME WITH INDEX OF ROW LEVEL STORAGE
          C
000230         ICT(I)=ICT(I).OR.M
000233    970  CONTINUE
          C
          C  SORT ACCORDING TO COLUMN LEVEL CLASSIFICATION
          C
000235         CALL TORDER(ICT,NT)
000237         N=0
000240         KX=0
000241         DO990I=1,NT
000242         KXT=ICT(I).AND.(.NOT.177777777B)
000244         IF(KXT.EQ.KX)GOTO980
000246         KX=KXT
000247         N=N+1
000250         CALLSHIFT(KXT,KXT,25)
          C
          C
          C  STORE COLUMN LEVEL INITIAL GUESS
          C
000253         TCO(N)=KXT/10
000260    980  ICT(I)=ICT(I).AND.177777777B
000263         CALLSHIFT(ICT(I),ICT(I),-10)
          C
          C  REPLACE COLUMN LEVEL CLASSIFICATION NAME WITH INDEX OF COLUMN LEVEL
          C  STORAGE
          C
000266         ICT(I)=ICT(I).OR.N
000271    990  CONTINUE
          C
          C  SORT ACCORDING TO WAVE NUMBER STORAGE INDEX
          C
000273         CALL TORDER(ICT,NT)
          C
          C  RETURN DATA FROM EXTENDED CORE STORAGE
          C
000275         IF(NT.LE.IXHAF)GOTO1000
000300         CALLECRD(IWN,0,NT,IERR)
000303         IF(IERR.NE.0)STOP1
          C  CLEAR WEIGHT STATISTICS STORAGE
000306    1000 DO1025I=1,38
000310         WRMS(I)=WC(I)=0.
000313         WS(I)=0.
000313    1025 NRMS(I)=0
          C
          C  SAVE INITIAL GUESSES
          C
000316    1030 DO1040I=1,N
000324         TC(I)=TCO(I)
000325    1040 SNJ(I)=0.
000326         DO1050I=1,M
000334         TR(I)=TRO(I)
000335    1050 SNI(I)=0.
000336         DO1060I=1,NT
000341         IUNC=IWN(I).AND.377777B
000342         UNC=IUNC/10000.
```

```
      C
      C WT CONTAINS THE WEIGHT IN BITS 59-20, THE INDEX TO THE ROW LEVEL IN
      C BITS 19-10, AND THE INDEX TO THE COLUMN LEVEL IN BITS 9-0
      C
000344        TEMP=(WTUNC/UNC)**2
000346        TEMP=TEMP.AND.(.NOT.3777777B)
000350        ICT(I)=ICT(I).AND.3777777B
000352        WT(I)=ICT(I).OR.TEMP
000353        JC=WT(I).AND.1777B
000354        IR=WT(I).AND.3776000B
000356        CALLSHIFT(IR,IR,10)
      C
      C SUM THE WEIGHTS OF THE TRANSITIONS CONNECTED TO EACH LEVEL
      C
000363        SNI(IR)=SNI(IR)+TEMP
000365        SNJ(JC)=SNJ(JC)+TEMP
000366        CALLSHIFT(IWN(I),IWN(I),17)
000372        IF(ISOTOP)GOTO1055
000375        WN(I)=IWN(I)/10000.
000377        TEMP=TRO(IR)-TCO(JC)
000402        IF(TEMP.LT.0)WN(I)=-WN(I)
000406        GOTO1060
000407   1055 WN(I)=IWN(I)/1000.-20.
000413   1060 CONTINUE
000416        IXC=0
000417   1065 DO1070I=1,M
000424   1070 DEL(I)=0.
000426        IX=1
000427        GOTO1100
000427   1080 DO1090I=1,N
000434   1090 DEL(I)=0.
000436        IX=2
000437        GOTO1101
000437   1100 DELMAX=0.
000440   1101 DO1130I=1,NT
000443        JC=WT(I).AND.1777B
000444        IR=WT(I).AND.3776000B
000446        CALLSHIFT(IR,IR,10)
000453        TEMP=WT(I).AND.07777777777774000000
000454        TEMP=(TR(IR)-TC(JC)-WN(I))*TEMP
000462        IF(IX.EQ.1)GOTO1110
000464        DEL(JC)=DEL(JC)+TEMP
000466        GOTO1130
000467   1110 DEL(IR)=DEL(IR)-TEMP
000472   1130 CONTINUE
      C
      C DEL CONTAINS THE CORRECTION TO THE LEVEL FOR THIS ITERATION CYCLE
      C
000475        IF(IX.EQ.1)GOTO1150
000477        DO1140JC=1,N
000500        IF(SNJ(JC).EQ.0.)GOTO1140
000502        DEL(JC)=DEL(JC)/SNJ(JC)
000503        DELMAX=AMAX1(DELMAX,ABS(DEL(JC)))
      C
      C THE CORRECTION IS MULTIPLIED BY A GIVEN FACTOR TO SPEED THE ITERATION
      C
000510   1140 TC(JC)=TC(JC)+DEL(JC)*FACTOR
000516        GOTO1170
000516   1150 DO1160IR=1,M
000520        IF(SNI(IR).EQ.0.)GOTO1160
000522        DEL(IR)=DEL(IR)/SNI(IR)
000523        DELMAX=AMAX1(DELMAX,ABS(DEL(IR)))
000530   1160 TR(IR)=TR(IR)+DEL(IR)*FACTOR
000536   1170 GOTO(1080,2000),IX
000544   2000 IXC=IXC+1
      C
      C ON A PRINT CYCLE, THE INTERMEDIATE LEVEL VALUES ARE PRINTED
      C
000546        IF(MOD(IXC,MCDPRT).EQ.0)GOTO2010
000552        IF(IXC.NE.1)GOTO2020
000553   2010 PRINT4,IXC,DELMAX
```

```
000563          PRINT7,(TC(I),I=1,N)
000572          PRINT7,(TR(I),I=1,M)
                C
                C IF THE MAXIMUM NUMBER OF CYCLES HAS BEEN REACHED, STOP ITERATION
                C
000601           2020 IF(IXC.EQ.MAXIT)GOTO2025
                C
                C IF THE CORRECTION HAS BEEN SUFFICIENTLY REDUCED, STOP ITERATION
                C
000603          IF(DELMAX.LE.DELTA)GOTO2025
000606          GOTO1065
000606           2025 PRINT4,IXC,DELMAX
000616          HEAD=3LCOL
                C
                C PRINT COLUMN LEVEL DATA
                C
000620          PRINT6,HEAD
                C
                C ADJUST LEVEL VALUES SUCH THAT THE FIRST COLUMN LEVEL IS ZERO
                C
000625          TONE=TC(1)
000627          DO2050I=1,N
000630          IF(SNJ(I).NE.0.)TC(I)=TC(I)-TONE
000633          TCD=TC(I)-TCO(I)
000636           2050 PRINT5,I,TC(I),TCO(I),TCD,SNJ(I)
000656          HEAD=3LROW
000657          PRINT6,HEAD
                C
                C PRINT ROW LEVEL DATA
                C
000665          DO2060I=1,M
000667          IF(SNI(I).NE.0.)TR(I)=TR(I)-TONE
000672          TCD=TR(I)-TRO(I)
000675           2060 PRINT5,I,TR(I),TRO(I),TCD,SNI(I)
000715          PRINT10
000720          WTSUM=0
000721          SIGMA=0.
000722          DO2065I=1,37
000731          WC(I)=(WTUNC/WU(I))**2
000732           2065 WC(I)=WC(I).AND.(.NOT.37777778)
                C
                C PRINT TRANSITION DATA
                C DETERMINE WEIGHT STATISTICS
                C
000734          DO2090I=1,NT
000736          JC=WT(I).AND.1777B
000737          IR=WT(I).AND.3776000B
000741          CALLSHIFT(IR,IR,10)
000745          PWT=WT(I).AND.0777777777777400000
000747          CALC=ABS(TR(IR)-TC(JC))
000754          PWN=ABS(WN(I))
000755          DEV=CALC-PWN
000757          DO2070J=1,37
000761           2070 IF(PWT.GE.WC(J))GOTO2075
000766          J=38
000771           2075 TEMP=DEV**2*PWT
000772          SIGMA=SIGMA+TEMP
000774          WRMS(J)=WRMS(J)+TEMP
000775          WS(J)=WS(J)+PWT
000777          NRMS(J)=NRMS(J)+1
001000          WTSUM=WTSUM+PWT
001002           2090 PRINT8,CALC,PWN,DEV,PWT,TR(IR),TC(JC)
001025          PRINT9,N,M,NT
001036          NLEV=N+M-1
001040          SIG1=SQRT(SIGMA/(NT-NLEV))
001046          SIG2=SQRT((SIGMA*NT)/(WTSUM*(NT-NLEV)))
001057          PRINT12,SIG1,SIG2
001066          PRINT 13
001072          DO2100I=1,37
001074          IF(NRMS(I).EQ.0)GO TO 2100
```

```
001075          WRMS(I)=SQRT(WRMS(I)/WS(I))
001102          PRINT14,WU(I),WC(I),WRMS(I),NRMS(I)
001116      2100 CONTINUE
001120          IF(NRMS(38).EQ.0)GOTO2110
001121          WRMS(38)=SQRT(WRMS(38)/WS(38))
001126          PRINT15,WRMS(38),NRMS(38)
001135      2110 CONTINUE
001135          RETURN
001137          END


PROGRAM LENGTH INCLUDING I/O BUFFERS
021733

FUNCTION ASSIGNMENTS

STATEMENT ASSIGNMENTS
1       -  001151     2       -  001155     3       -  001157     4       -  001164
5       -  001171     6       -  001175     7       -  001210     8       -  001213
9       -  001220     10      -  001231     11      -  001251     12      -  001312
13      -  001320     14      -  001326     15      -  001333     16      -  001340
17      -  001344     18      -  001350     900     -  000076     910     -  000121
920     -  000133     930     -  000145     940     -  000167     950     -  000200
960     -  000223     980     -  000261     1000    -  000307     1030    -  000317
1055    -  000410     1060    -  000414     1065    -  000420     1080    -  000430
1100    -  000440     1101    -  000441     1110    -  000470     1130    -  000473
1140    -  000511     1150    -  000517     1160    -  000531     1170    -  000537
2000    -  000545     2010    -  000554     2020    -  000602     2025    -  000607
2075    -  000770     2100    -  001117     2110    -  001136

BLOCK NAMES AND LENGTHS
        -  122023

VARIABLE ASSIGNMENTS
CALC    -  013636     COMT    -  013271     DEL     -  011321     DELMAX  -  013627
DELTA   -  013602     DEV     -  013640     FACTOR  -  013603     HEAD    -  013630
I       -  013620     ICT     -  003723C01  IERR    -  013616     IR      -  013624
ISOTOP  -  013600     ITYPE   -  013606     IUNC    -  013615     IWN     -  052763C01
IX      -  013626     IXC     -  013625     IXHAF   -  013577     J       -  013641
JC      -  013623     KX      -  013617     KXT     -  013621     LC      -  013611
LR      -  013610     M       -  000001C01  MAXIT   -  013601     MODPRT  -  013604
N       -  000000C01  NLEV    -  013642     NRMS    -  013463     NT      -  000002C01
PWN     -  013637     PUT     -  013635     SFT     -  013613     SFTX    -  013614
SIGMA   -  013634     SIG1    -  013643     SIG2    -  013644     SNI     -  007351
SNJ     -  005401     TC      -  001461     TCC     -  013632     TCO     -  000003C01
TEMP    -  013622     TONE    -  013631     TR      -  003431     TRO     -  001753C01
UNC     -  013612     WC      -  013347     WN      -  052763C01  WNN     -  013607
WRMS    -  013415     WS      -  013531     WT      -  003723C01  WTSUM   -  013633
WTUNC   -  013605     WU      -  013301

START OF CONSTANTS
001142

START OF TEMPORARIES
001426

START OF INDIRECTS
001447

UNUSED COMPILER SPACE
111100
                SUBROUTINETORDER(LA,L)
000004          DIMENSIONLA(5)
          C
          C C LA MUST BE DIMENSIONED 2*L OR GREATER
          C LA IS SORTED INTO INCREASING INTEGER VALUES
          C
000004          IF(L.EQ.1)RETURN
000006          LL=2*L
000007          IPOS=0
```

```
000010          JX=L
000011          LX2=1
000012     400  IX=JX
000013          I1=IPOS+1
000015          IPOS=MOD(IPOS+L,LL)
000021          JX=IPOS
000022          LX=LX2
000023          LX2=LX*2
000024          I2=I1+LX
000025          I1TOT=I1+LX-1
000027          I2TOT=MINO(I2+LX-1,IX)
000033     410  JX=JX+1
000035          IF(LA(I1).LT.LA(I2))GOTO430
000041          LA(JX)=LA(I2)
000043          I2=I2+1
000044          IF(I2.LE.I2TOT)GOTO410
000047     420  JX=JX+1
000051          LA(JX)=LA(I1)
000053          I1=I1+1
000054          IF(I1.LE.I1TOT)GOTO420
000056          GOTO450
000057     430  LA(JX)=LA(I1)
000062          I1=I1+1
000063          IF(I1.LE.I1TOT)GOTO410
000066     440  JX=JX+1
000070          LA(JX)=LA(I2)
000072          I2=I2+1
000073          IF(I2.LE.I2TOT)GOTO440
000075     450  I1=I1+LX
000077          IF(I1.GT.IX)GOTO460
000102          I1TOT=MINO(I1TOT+LX2,IX)
000105          I2=I2+LX
000106          IF(I2.GT.IX)GOTO420
000111          I2TOT=MINO(I2TOT+LX2,IX)
000114          GOTO410
000114     460  IF(LX2.LT.L)GOTO400
000116          IF(IPOS.EQ.0)GOTO480
000117          DO470I=1,IPCS
000125          IL=I+L
000126     470  LA(I)=LA(IL)
000131     480  RETURN
000132          END


SUBPROGRAM LENGTH
000170

FUNCTION ASSIGNMENTS
STATEMENT ASSIGNMENTS
400    -  000013    410    -  000034    420    -  000050    430    -  000060
440    -  000067    450    -  000076    460    -  000115    480    -  000132

BLOCK NAMES AND LENGTHS

VARIABLE ASSIGNMENTS
I      -  000166    IL     -  000167    IPCS   -  000155    IX     -  000160
I1     -  000161    I1TOT  -  000164    I2     -  000163    I2TOT  -  000165
JX     -  000156    LL     -  000154    LX     -  000162    LX2    -  000157

START OF CONSTANTS
000135

START OF TEMPORARIES
000136

START OF INDIRECTS
000146

UNUSED COMPILER SPACE
115000
```

```
CORE MAP  09.17.43.  NORMAL              CONTROL                                          000100    151637    027614    122023
          ---TIME---LOAD MODE --L1--L2-----TYPE----------USER---++---CALL-------------FWA LOAD--LWA LOAD--BLNK COMN--LENGTH--
          FWA LOADER  152462  FWA TABLES  151645
          -PROGRAM----ADDRESS-                    --LABELED---COMMON--
          IT          000100
          TORDER      022033
          SYSTEM      022223                                SCOPE2      022223
          INPUTC      023327
          OUTPTC      024463
          IFENDF      026030
          SHIFT       026055
          FCSRW       026072
          ACGDER      026121
          SQRT        026145
          SIDS        026225
          GETBA       027056
          C4020       027075
          OUTPTS      027204
          LABRT       027263
          BS4020      027372
          XRCL        027607
          --ENTRY-----ADDRESS-                                          REFERENCES
          IT          000101
          TORDER      022034            IT          000301    000337    000375

          Q8NTRY      022224            IT          000102

          SYSTEM      022521            INPUTC      023366    024255
                                        OUTPTC      024477    025636
                                        IFENDF      026045
                                        ACGDER      026134
                                        OUTPTS      027251
                                        BS4020      027560

          SYSTEMC     022461
          SYSTEMP     022507
          END         022403            IT          001237    001241
                                        TORDER      022167
                                        LABRT       027351

          STOP        022434            IT          000277    000406

          EXIT        022426            LABRT       027333

          ABNORML     022444            INPUTC      023367    024254    024256
                                        OUTPTC      024500    025637
                                        IFENDF      026046
                                        ACGDER      026135
                                        OUTPTS      027252
                                        BS4020      027561

          SYSTBAC     022514            INPUTC      024253

          LINE.       023075            C4020       027120    027104    027102    027144    027145    027150    027151

          FETA.       023076            BS4020      027406    027523    027527

          KEY.        023100            BS4020      027402    027505

          FNMA.       023101            OUTPTC      024504    024502
                                        BS4020      027520
          NUMB.       023103            BS4020      027414    027435    027457    027417    027420    027543    027466
                                                    027441    027453
```

INPUTC	023331	IT	000105	000107	000110	000121	000123	000125	000127
			000131	000133	000135	000136	000200	000202	000204
			000206	000210	000212	000214	000215		
KRAKER	023433								
OUTPTC	024465	IT	000113	000115	000116	000147	000151	000153	000155
			000157	000161	000162	000166	000167	000173	000174
			000656	000660	000662	000663	000666	000671	000672
			000675	000700	000701	000711	000713	000715	000716
			000722	000724	000725	000740	000742	000744	000746
			000750	000752	000753	000762	000764	000765	000777
			001001	001003	001005	001007	001011	001012	001017
			001020	001105	001107	001111	001113	001115	001117
			001121	001122	001127	001131	001133	001135	001136
			001161	001163	001165	001166	001171	001172	001205
			001207	001211	001213	001215	001216	001230	001232
			001234	001235					
		LABRT	027317	027322	027324	027325			
KODER	024632	OUTPTS	027211	027226					
IFENDF	026031	IT	000217						
SHIFT	026056	IT	000250	000255	000263	000315	000330	000353	000366
			000461	000472	000551	001044			
SHIFT	026067								
ECHR	026072	IT	000274						
ECRD	026101	IT	000403						
ACCDER	026122	IT	000642						
		LABRT	027302						
SQRT	026146	IT	001146	001156	001201	001225			
BKSPRU.	026526								
FIZBAK.	026537								
POSFIL.	026574	OUTPTC	024523						
RDPRU.	026604								
DAT.	026626	INPUTC	023376	023353	023405				
		OUTPTC	024526	024550	024564				
		C4020	027146	027105	027117	027156			
		OUTPTS	027247	027222	027232				
C101.	026473								
OPEN.	026227	SYSTEM	023010						
		INPUTC	023351						
		OUTPTC	024513						
SIO.	026341	INPUTC	023401						
		OUTPTC	024563						
GETRA	027056	INPUTC	023337						
		OUTPTC	024473						
		IFENDF	026034						
		BS4020	027521						
C4020	027075	OUTPTC	026025						
OUTPTS	027206	SQRT	026166	026170	026172	026173			
LABRT	027264	SQRT	026175						
BS4020	027373	C4020	027103	027116	027126	027136	027142		
XRCL	027607	BS4020	027550						

----UNSATISFIED EXTERNALS----- REFERENCES

Typical output follows:

```
TEST
MAXIMUM NUMBER OF ITERATION CYCLES=  300
CUTOFF VALUE FOR DELTA=.00C001000
MULTIPLICATION FACTOR=       1.50
PRINT CYCLE=   10
UNCERTAINTY ASSOCIATED WITH WEIGHT OF ONE=     1.0000
WAVELENGTH DATA
     1 ITERATIONS      DELTA=      2.172483904
       -.27409223    620.07272444   3800.56425358   3868.02232159   4275.44083075   4453.04059090   5761.66769338   5990.87191459
   6248.60976013   7005.24547329   7103.42189354   7191.07018742   7325.62659985   7645.15415301   7863.78972918   8118.25691756
   8132.89459036   8856.45058688   8878.05446118  10068.59188276  10080.63419382  10102.41989119  10207.99357118  10254.70817054

  10288.15215649  10346.89144282  10457.31433992  10539.79362963  10556.59511522  10685.41399330  10819.37703175  10842.51778406
  10987.16819725  11289.75209745  11307.58910251  11403.00397803  11443.80695557  11456.85354917  11558.26970166  11632.75593685
  11676.52203459  11943.44565465  11968.18548625  12362.21272183  12825.92724468  12884.55795274  12910.09268124  13127.53743279

  13346.68092940  13361.12161218  13402.23453006  13534.64229858  13567.31785873  13631.56707403  14410.98148614  14501.48993787
  14543.33224793  14790.47964390  14844.55627672  14970.06919601  15353.42688370  15458.01451421  15712.51453571  16040.05415552
  16244.02553126  17882.99149198
  11502.72244186  11614.03184406  12035.19681818  12643.60455882  13463.31521661  13709.64557263  13824.96719605  14643.84823620
  14839.73328255  15006.91C00000  15632.03800766  15638.14797495  15720.97694103  15731.16707547  15830.37722222  16121.67413211
  16195.51250473  16293.99390128  16505.28912082  16887.46111111  16900.55280234  16930.01736184  17070.57884924  17154.58711896

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23375.08742973 23378.36672593 23429.80232557 23432.42085228 23463.79578906 23486.32099836 23534.04238218 23543.13298371
23560.25909365 23571.71052892 23708.27259900 23714.91698878 23734.35840340 23753.13144456 23755.22038321 23778.88141949
23824.99804331 23843.36549303 23848.24949028 23872.88409093 23926.40868588 23932.47587693 23972.20492067 24002.06620890

24021.68667866 24025.82848943 24066.18947160 24069.03971537 24081.99562143 24117.88558230 24153.99073671 24171.99136965
24185.42704652 24195.34469678 24206.67683817 24220.27254062 24262.74134951 24322.56100236 24331.39189556 24333.41621065
24400.28403471 24432.88238665 24447.65545062 24449.01271437 24451.38703738 24516.93590334 24534.90394605 24555.35825221

24560.05571651 24580.82514914 24590.83505483 24609.15760941 24613.37930242 24650.04116117 24671.00987272 24740.86859740
24756.69258241 24759.65331649 24883.79830903 24892.30644292 24906.50154621 24938.48959037 24940.16041902 24966.20728094
24973.62461944 25009.35108898 25016.73199246 25068.34653405 25095.83514209 25098.25451744 25104.60340202 25160.39528259

25177.67121627 25200.10549565 25235.36666141 25294.07224182 25318.89546393 25348.59860745 25388.49092728 25445.32343578
25458.35568704 25462.28219454 25533.82217706 25577.34569063 25580.37072791 25626.28463221 25654.93642212 25672.08581697
25729.47916105 25744.86969169 25787.71093711 25788.65238080 25791.21988770 25793.50220818 25805.46325119 25817.83917549

25825.19313560 25905.76864310 25909.98552597 25917.75728233 25937.85199238 25961.34837786 25975.36145328 25997.40777119
26066.32096979 26078.06744114 26103.27649726 26125.24165506 26207.61017793 26206.95575123 26208.42100535 26225.18845341
26241.41539475 26274.48116690 26287.24871278 26304.73697760 26312.91219233 26324.36661451 26348.65543672 26348.70444863

26390.88678240 26444.61298720 26453.72109769 26550.04675313 26561.95403376 26566.53843408 26583.08408161 26608.10090882
26631.03010735 26649.99854115 26651.72851149 26705.42288842 26712.66478603 26715.09490518 26758.50253141 26759.47425514
26759.98687670 26791.27474178 26840.44747635 26855.07051527 26859.14745641 26892.11743790 26920.33618641 26963.66282453

26971.40031827 26978.90026501 26983.56178205 26996.98829365 27035.06545360 27060.44885440 27072.00334711 27086.03838364
27147.67053133 27150.15160868 27183.77636391 27219.31393697 27251.98401776 27266.89260377 27284.50833710 27322.95531977

27324.14000154	27349.27193192	27366.25813580	27369.68228909	27394.45274507	27440.27244128	27442.93334895	27475.13543627
27477.16957037	27492.41372557	27499.15329718	27520.75839370	27547.82618227	27600.50802556	27603.43073518	27605.38645811
27609.49935574	27615.41196327	27633.04911742	27650.26044006	27681.83990875	27691.34059525	27728.84425018	27743.55805739
27752.74797241	27777.62099858	27790.75616743	27818.10616882	27829.53819095	27886.60671909	27890.34225550	27937.66404727
27940.86617222	27965.53681821	27969.32463467	27972.46218409	28043.99824707	28052.67292506	28067.26010088	28098.52315352
28114.43325825	28118.45559465	28151.50166116	28152.26688081	28187.96799202	28193.92081522	28227.81012367	28255.89876525
28261.76047390	28267.89334877	28285.39703174	28341.16111625	28342.18403083	28355.05739905	28387.55247115	28435.53313519
28444.12628678	28450.68337719	28453.61457557	28469.79196347	28499.47219150	28503.06190440	28515.98598924	28522.68699166
28542.07865338	28543.00616156	28562.24030035	28565.99482420	28596.22105101	28614.01989898	28619.63204297	28627.03796184
28635.04617435	28649.90717566	28668.92792580	28673.22401209	28739.52337783	28745.25681002	28761.28025445	28784.03079123
28798.49722854	28811.56190845	28816.72037371	28840.54769381	28860.48223576	28874.54122609	28893.74666219	28895.20230076
28927.25831114	28931.25335100	28935.67223015	28942.79878679	28987.01261333	28995.98587574	29012.87887844	29033.25534421
29036.16686509	29072.03580753	29097.71955250	29099.18918045	29105.82766181	29106.70118918	29109.44776432	29119.30306789
29125.75144298	29158.43846490	29173.41918944	29184.61627800	29193.89384686	29232.26682124	29235.68489733	29236.17738928
29250.08689715	29254.61979040	29284.90684335	29313.07770149	29338.92255639	29400.51202574	29412.89668990	29441.80391729
29459.51709518	29473.93469554	29475.60355881	29481.00424705	29483.79100259	29487.17432841	29502.82601527	29530.04634358
29558.45846814	29573.08804304	29603.89784798	29604.75081902	29609.74284937	29612.37397521	29644.25988110	29664.97752913
29672.61632403	29673.61471130	29682.33625620	29748.81205213	29752.88298180	29756.39725679	29790.34032852	29790.36782868
29796.88258065	29801.29619989	29809.75017942	29824.75658134	29837.25280221	29865.15666786	29881.36505796	29884.28364136
29909.14743822	29913.87616460	29957.69198767	29985.92517678	30032.30260974	30034.31481059	30047.00758692	30068.82027208
30076.72840005	30106.70971714	30137.72588883	30142.76523244	30168.59340727	30222.01325705	30226.32515889	30239.79375720
30261.84784690	30266.47472595	30285.90991021	30286.03354354	30334.57153942	30353.17012721	30364.95828533	30395.25353456
30406.93972885	30416.16968664	30431.61447465	30435.51676528	30451.02397775	30489.91060850	30489.77198227	30498.75951928
30499.76329625	30504.50132057	30510.70270565	30539.01417732	30544.60279077	30546.28118458	30586.27979286	30587.89411104
30589.31331515	30589.24799850	30621.83011317	30636.27451182	30642.38496267	30681.22319444	30686.49722405	30687.24520137
30702.45887028	30716.19586444	30747.49905455	30766.68424426	30829.49054006	30831.95977612	30840.76818246	30875.18975422
30877.90741198	30886.08591964	30898.88582289	30918.10151943	30931.29361275	30936.26262995	30937.13004256	30944.93482055
30964.98667941	30979.26688913	30985.90182907	30992.61216031	30994.45096922	31024.40108330	31097.71796369	31099.62746140
31129.07858169	31134.50988114	31165.83915184	31178.36253886	31179.43804423	31180.22523651	31182.19925771	31199.01459924
31204.44402052	31205.60968775	31215.49112620	31220.81962780	31232.11560769	31243.14870908	31269.93880845	31275.58372612
31278.73393839	31283.90212053	31295.81390655	31300.67811550	31321.85935277	31339.36350711	31358.25368345	31360.99872350
31367.43819122	31373.96538642	31400.90469385	31408.05908189	31435.00520485	31441.89209070	31441.68838817	31444.88824737
31467.22700994	31479.84254008	31487.83020073	31517.73138614	31551.14343247	31579.82466640	31602.85095403	31630.34097883
31633.57502566	31649.28654297	31678.05999109	31687.40167813	31690.58455256	31721.70551480	31728.11390483	31743.87786978
31756.89427806	31775.99369549	31798.06566499	31804.09446578	31837.37643336	31853.28796120	31871.17193782	31909.08525685
31920.69399893	31922.80081100	31934.19006454	31945.57909648	31954.65420183	31970.52134046	31973.95360302	31986.78387971
31994.74989086	32016.31417608	32043.73360141	32058.74839226	32096.95751517	32097.76900617	32107.78618783	32108.06791591

32140.79705028	32141.68882350	32158.57034885	32179.85851198	32193.11273491	32255.58046703	32270.69011610	32288.10054919
32309.91349462	32317.43189659	32326.55484135	32331.00667414	32367.28991628	32378.38341561	32381.43655234	32387.27244689
32392.29734192	32412.42938577	32413.11022494	32417.49774677	32461.24778212	32469.25303338	32472.55350803	32490.25268270
32495.33424270	32524.64747352	32537.00688187	32545.97067133	32546.01393198	32574.21113800	32582.26349810	32585.00414491
32590.60612247	32603.67221302	32610.73967481	32614.88460164	32648.41644456	32669.60482630	32709.18099616	32723.03224626
32730.73381380	32742.15856996	32773.88808992	32780.49983020	32796.02346342	32802.02926245	32808.82502815	32841.97085053
32851.77727770	32879.86284173	32890.76498104	32902.55838415	32925.61924985	32928.29420297	32932.50630998	32944.55815969
32954.60567283	32977.09243332	32991.46313332	32997.21763321	33008.06449830	33041.48654587	33077.48204445	33090.31418363
33098.81610371	33117.61322994	33124.57301747	33135.84997621	33150.32629641	33154.38710320	33174.74560331	33176.37466799
33212.84150916	33228.70074098	33267.33080601	33282.10335327	33304.66414309	33320.24156457	33341.43191880	33346.05872788
33353.43611003	33357.14099284	33373.55456402	33411.84440681	33457.55645868	33474.40634240	33512.23644321	33570.26024986
33580.32926656	33594.64965095	33639.15776009	33703.07014664	33707.27641668	33718.72218219	33723.08500713	33730.37548026
33733.07069833	33738.37722479	33769.61345699	33778.41810471	33797.11238051	33828.80259453	33829.46786041	33874.13437751
33899.03909761	33916.39628274	33918.00869725	33921.30422728	33962.43401828	33981.32398040	33987.08435572	34000.10345982
34015.85201530	34041.60871203	34046.04370153	34059.50643362	34070.33034760	34075.33922182	34080.56009714	34105.00374575
34109.29305201	34117.78806838	34143.26869322	34154.65496358	34164.36410980	34201.06790573	34205.59323305	34214.90259545
34238.53834009	34293.09360594	34306.41423561	34315.25415270	34338.16941816	34344.53791943	34406.75048570	34407.43232768
34429.21966671	34429.94790817	34434.59254899	34486.06809918	34506.91862845	34535.34007952	34550.18236880	34643.72709318
34662.54396413	34706.06841615	34707.36613414	34715.49958485	34739.07135907	34762.57475962	34811.76278444	34827.45768843
34842.51569386	34846.49939304	34869.51899521	34881.52115679	34943.24813010	34976.13569740	35003.75445217	35029.58487377
35032.24496570	35038.43504925	35047.83189530	35128.36794842	35217.26445388	35536.55353241	35585.58180193	35612.50602263
35807.24905645	35850.43770467	35878.87781202	35886.88100820	35929.64348831	35930.87383004	35980.82761033	36070.33443962
36501.46653741	36519.56261113	36527.75525304	36550.91919872	36688.60342557	36758.28907510	37154.36498978	37294.27145897
37475.52556181	37488.77126038	37596.24647084	37624.16977826	37631.52393783	37778.79528660	38337.95207930	38712.48562177

23 ITERATIONS DELTA= .000000603

COL	LEVEL	INITIAL VALUE	DIFFERENCE	WEIGHT SUM
1	0.00000000	0.00000	0.00000	9769724.97803
2	620.32118915	620.00000	.32119	13062395.63818
3	3800.81729663	3800.00000	.81730	11691361.08643
4	3868.47310393	3868.00000	.47310	9523399.98047
5	4275.69341014	4275.00000	.69341	14128294.08154
6	4453.40486240	4453.00000	.40486	12762590.08398
7	5762.06008702	5762.00000	.06009	10788273.09131
8	5991.29430446	5991.00000	.29430	9722934.20459
9	6249.00959073	6249.00000	.00959	10275724.64551
10	7005.51037297	7005.00000	.51037	11106825.86719
11	7103.89839841	7103.00000	.89840	5255090.99023
12	7191.65880522	7191.00000	.65881	2247328.66260
13	7326.09479097	7326.00000	.09479	9737340.09131
14	7645.62157502	7645.00000	.62158	7165474.96535
15	7864.17860931	7864.00000	.17861	7759068.76367
16	8118.60539927	8118.00000	.60540	12027751.19727
17	8133.26482565	8133.00000	.26483	5900873.32275
18	8856.96152872	8856.00000	.96153	1337077.10840
19	8878.51770034	8878.00000	.51770	3068593.10596
20	10069.14497959	10069.00000	.14498	6106394.65527
21	10080.99849070	10080.00000	.99849	4603952.88184
22	10103.40582002	10103.00000	.40582	123540.11084
23	10208.45499872	10208.00000	.45500	4203236.88184
24	10254.96516209	10254.00000	.96516	3254767.99512
25	10288.58432154	10288.00000	.58432	3758109.43848
26	10347.31254111	10347.00000	.31254	6849089.76367
27	10457.71721739	10457.00000	.71722	606978.33252
28	10540.23178913	10540.00000	.23179	1055692.44336
29	10557.00257770	10557.00000	.00258	2893215.88428
30	10685.75404589	10685.00000	.75405	5679589.43359
31	10819.89983660	10819.00000	.89984	2641235.99512
32	10842.75600445	10842.00000	.75600	91262.00000
33	10987.55172643	10987.00000	.55173	3855852.32764
34	11290.22912635	11290.00000	.22913	2019751.88672
35	11308.11729725	11308.00000	.11730	2839480.21680
36	11403.42782767	11403.00000	.42783	1594037.66504
37	11444.58562666	11444.00000	.58563	380928.22168
38	11457.27578507	11457.00000	.27579	3849336.54932
39	11558.65970106	11558.00000	.65970	2167275.10840
40	11633.12551690	11633.00000	.12552	2335559.99756
41	11677.00063301	11677.00000	.00063	3088962.88428
42	11943.90575690	11943.00000	.90576	747597.22168
43	11968.61242027	11968.00000	.61242	1652693.88672
44	12362.45492234	12362.00000	.45492	426776.22168
45	12826.27661028	12826.00000	.27661	4268830.10352
46	12884.75611027	12884.00000	.75611	499001.00000
47	12910.46887744	12910.00000	.46888	1682025.99756
48	13127.88294570	13127.00000	.88295	2854277.43848
49	13346.86853939	13346.00000	.86854	2080068.99756
50	13361.46042703	13361.00000	.46043	208443.00000
51	13402.49440018	13402.00000	.49440	1152938.55420
52	13535.14260379	13535.00000	.14260	1197387.88672
53	13567.95567433	13567.00000	.95567	189642.11084
54	13632.08565472	13632.00000	.08565	384386.11084
55	14411.38028866	14411.00000	.38029	179646.11084
56	14501.76413220	14501.00000	.76413	1174535.66504
57	14543.72758123	14543.00000	.72758	1289221.55420
58	14790.94202323	14790.00000	.94202	944682.44336
59	14845.28336216	14846.00000	-.71664	508885.44336
60	14970.57499421	14970.00000	.57499	325671.22168
61	15353.78838216	15353.00000	.78838	114134.00000
62	15458.44247221	15458.00000	.44247	465507.22168
63	15712.81045267	15712.00000	.81045	776249.33252
64	16040.44964100	16041.00000	-.55036	478358.33252
65	16244.43638595	16244.00000	.43639	833532.55420
66	17882.88551864	17882.00000	.88552	26965.00000

ROW	LEVEL	INITIAL VALUE	DIFFERENCE	WEIGHT SUM
1	11502.58871515	11502.00000	.58872	258.00000
2	11613.94317977	11613.00000	.94318	404.00000
3	12035.56612270	12035.00000	.56612	429.00000
4	12643.40813681	12643.00000	.40814	408.00000
5	13463.39715977	13463.00000	.39716	1108.00000
6	13710.24180994	13710.00000	.24181	358.00000
7	13825.40646552	13825.00000	.40647	658.00000
8	14643.83575828	14643.00000	.83576	1304.00000
9	14839.73332746	14839.00000	.73333	1083.00000
10	15007.41423704	15007.00000	.41424	154.00000
11	15631.80669284	15631.00000	.80669	783.00000
12	15638.33487206	15638.00000	.33487	1437.00000
13	15720.68451299	15720.00000	.68451	10904.00000
14	15732.15922605	15732.00000	.15923	212.00000
15	15831.06373118	15831.00000	.06373	324.00000

16	16121.88630565	16121.00000	.88631	1037.00000
17	16195.36424797	16195.00000	.36425	10570.00000
18	16204.02546517	16204.00000	.02547	122210.11084
19	16505.78812764	16505.00000	.78813	60687.00000
20	16888.29094199	16888.00000	.29094	54.00000
21	16900.38693404	16900.00000	.38693	41212.00000
22	16929.76671487	16929.00000	.76671	152419.11084
23	17070.47577450	17070.00000	.47577	152602.11084
24	17154.82103390	17154.00000	.82103	1345.00000
25	17361.90134193	17361.00000	.90134	152277.11084
26	17369.55575599	17369.00000	.55576	223592.22168
27	17468.22402628	17468.00000	.22403	40995.00000
28	17893.88290058	17893.00000	.88290	111552.11084
29	17908.17595670	17908.00000	.17596	224013.22168
30	17968.71997871	17968.00000	.71998	1808.00000
31	18185.99937045	18185.00000	.99937	40783.00000
32	18253.87290847	18253.00000	.87291	223580.22168
33	18260.44434190	18260.00000	.44434	729.00000
34	18295.77779586	18295.00000	.77780	112164.11084
35	18299.50233173	18299.00000	.50233	112210.11084
36	18383.24341735	18383.00000	.24342	111681.11084
37	18406.52398084	18406.00000	.52398	152206.11084
38	18530.79924899	18530.00000	.79925	1162.00000
39	18607.80227689	18607.00000	.80228	112514.11084
40	18749.84917914	18749.00000	.84918	1070.00000
41	18759.18009884	18759.00000	.18010	224121.22168
42	18794.82803976	18794.00000	.82804	112631.11084
43	18839.26345135	18839.00000	.26345	112494.11084
44	18932.76768331	18932.00000	.76768	113956.11084
45	19115.49940072	19115.00000	.49940	945.00000
46	19119.75571068	19119.00000	.75571	579.00000
47	19127.21152058	19127.00000	.21152	112993.11084
48	19192.40129091	19192.00000	.40129	113052.11084
49	19307.74999342	19307.00000	.74999	850.00000
50	19471.85970798	19471.00000	.85971	122989.11084
51	19489.03753620	19489.00000	.03754	10487.00000
52	19552.51950410	19552.00000	.51950	123231.11084
53	19640.14742818	19640.00000	.14743	10458.00000
54	19647.50804351	19647.00000	.50804	41187.00000
55	19668.42393914	19668.00000	.42394	11445.00000
56	19783.33393151	19783.00000	.33393	335415.33252
57	19826.66953260	19826.00000	.66953	234142.22168
58	19828.48469510	19828.00000	.48470	40825.00000
59	19864.52054690	19864.00000	.52055	111969.11084
60	19885.51254374	19885.00000	.51254	153544.11084
61	20114.29691493	20114.00000	.29691	234446.22168
62	20148.02629000	20148.00000	.02629	142310.11084
63	20218.82761696	20218.00000	.82702	274200.22168
64	20258.14277542	20258.00000	.14278	121177.11084
65	20306.85541636	20306.00000	.85542	122048.11084
66	20311.54894962	20311.00000	.54895	122443.11084
67	20391.50895313	20391.00000	.50895	50837.00000
68	20420.51293266	20420.00000	.51293	375136.33252
69	20452.79749978	20452.00000	.79750	40104.00000
70	20464.52047429	20464.00000	.52047	162010.11084
71	20525.39044732	20525.00000	.39045	233542.22168
72	20528.89103522	20528.00000	.89104	41299.00000
73	20569.22232170	20569.00000	.22232	303917.22168
74	20621.29202159	20621.00000	.29202	152426.11084
75	20651.20527271	20651.00000	.20527	111119.11084
76	20661.50709807	20661.00000	.50710	263480.22168
77	20712.17581216	20712.00000	.17581	111673.11084
78	20719.03066756	20719.00000	.03067	192456.11084

CALCULATED LINE	OBSERVED LINE	DIFFERENCE	WEIGHT	ROW LEVEL	COL LEVEL
4087.55899609	4087.58000	-.02	25.00	15720.68451	11633.12552
4135.24915405	4135.31000	-.06	4.00	19489.03754	15353.78838
4156.63652637	4156.72000	-.08	4.00	19127.21152	14970.57499
4160.00689706	4160.04000	-.03	4.00	17070.47577	12910.46888
4172.70209106	4172.71000	-.01	25.00	19885.51254	15712.81045
4174.53090777	4174.67000	-.14	100.00	15631.80669	11457.27579
4177.98054875	4178.03000	-.05	4.00	16121.88631	11943.90576
4181.05908698	4181.11000	-.05	25.00	15638.33487	11457.27579
4220.08408834	4220.07000	.01	4.00	20464.52047	16244.43639
4221.82629670	4221.27000	.56	4.00	19192.40129	14970.57499
4272.40403013	4273.24000	-.84	4.00	15831.06373	11558.65970
4276.09030198	4276.16000	-.07	4.00	17908.17596	13632.08565
4282.73074976	4282.74000	-.01	4.00	14839.73333	10557.00258
4284.45464927	4284.72000	-.27	25.00	20528.89104	16244.43639
4287.57359939	4287.66000	-.09	4.00	15732.15923	11444.58563
4293.71966135	4293.77000	-.05	25.00	19647.50804	15353.78838
4317.25668532	4317.27000	-.01	100.00	15720.68451	11403.42783
4337.49931915	4337.52000	-.02	100.00	18839.26345	14501.76413
4338.46889049	4338.64000	-.17	25.00	18749.84918	14411.38029
4348.10574571	4348.15000	-.04	25.00	15638.33487	11290.22913
4355.25143674	4354.85000	.40	4.00	14643.83576	10288.58432

4383.44775110	4382.75000	.70	4.00	18794.82804	14411.38029
4427.07007153	4427.46000	-.39	4.00	19885.51254	15458.44247
4427.63590451	4427.71000	-.07	4.00	15831.06373	11403.42783
4429.54554936	4429.67000	-.12	4.00	19783.33393	15353.78838
4450.41165933	4450.34000	.07	25.00	15007.41424	10557.00258
4451.43246449	4451.45000	-.02	25.00	17361.90134	12910.46888
4459.08687855	4459.10000	-.01	25.00	17369.55576	12910.46888
4484.79964572	4484.82000	-.02	25.00	17369.55576	12884.75611
4497.07834518	4496.30000	.78	4.00	11502.58872	7005.51037
4505.68155652	4505.82000	-.14	4.00	17908.17596	13402.49440
4506.01656629	4505.99000	.03	4.00	20218.82702	15712.81045
4518.36361497	4518.36000	.00	4.00	16195.36425	11677.00063
4521.38739466	4521.50000	-.11	100.00	18932.76768	14411.38029
4522.06291885	4522.06000	.00	25.00	20766.49930	16244.43639
4531.72416158	4531.78000	-.06	25.00	19885.51254	15353.78838
4553.91471574	4553.60000	.31	4.00	18185.99937	13632.08565
4562.83726808	4562.89000	-.05	100.00	14643.83576	10080.99849
4567.31179253	4567.32000	-.01	25.00	16929.76671	12362.45492
4574.69077869	4574.73000	-.04	100.00	14643.83576	10069.14498
4581.94450989	4582.51000	-.57	4.00	19552.51950	14970.57499
4583.46791601	4583.43000	.04	4.00	17468.22403	12884.75611
4608.43280679	4608.46000	-.03	100.00	11613.94318	7005.51037
4631.27832874	4631.26000	.02	25.00	14839.73333	10208.45500
4644.25496641	4643.45000	.80	4.00	15631.80669	10987.55173
4650.78314563	4651.49000	-.71	4.00	15638.33487	10987.55173
4660.89994827	4660.26000	.64	4.00	16294.02547	11633.12552
4677.30067900	4676.79000	.51	4.00	16121.88631	11444.58563
4704.11911206	4703.16000	.96	4.00	19115.49940	14411.38029
4727.82212154	4727.90000	-.08	25.00	18295.77780	13567.95567
4735.36576411	4735.32000	.05	25.00	16294.02547	11558.65970
4738.08846290	4738.07000	.02	100.00	16195.36425	11457.27579
4758.73483726	4758.74000	-.01	25.00	14839.73333	10080.99849
4812.75493730	4812.83000	-.07	25.00	19783.33393	14970.57499
4828.78749464	4828.74000	.05	25.00	16505.78813	11677.00063
4831.72410959	4831.77000	-.05	100.00	13710.24181	8878.51770
4851.37850829	4851.51000	-.13	4.00	18253.87291	13402.49440
4856.09453839	4856.18000	-.09	25.00	19826.66953	14970.57499
4872.66261074	4872.63000	.03	100.00	16505.78813	11633.12552
4890.59763750	4890.57000	.03	4.00	16294.02547	11403.42783
4892.41248144	4892.56000	-.15	4.00	18253.87291	13361.46043
4906.89070820	4906.84000	.05	25.00	22789.77623	17882.88552
4912.25038944	4912.27000	-.01	4.00	15732.15923	10819.89984
4931.66772430	4931.72000	-.05	100.00	12035.56612	7103.89840
4934.31736884	4934.36000	-.04	4.00	18295.77780	13361.46043
4946.88976518	4946.86000	.03	25.00	13825.40647	8878.51770
4948.90025648	4948.90000	.01	25.00	18295.77780	13346.86854
4992.39190828	4992.76000	-.37	4.00	19783.33393	14790.94202
5007.10083365	5007.68000	-.58	4.00	17369.55576	12362.45492
5048.51234257	5048.47000	.04	25.00	16505.78813	11457.27579
5070.44356301	5070.36000	.09	4.00	20528.89104	15458.44247
5081.65576584	5081.61000	.05	25.00	22964.54128	17882.88552
5101.86335423	5102.78000	-.92	4.00	17070.47577	11968.61242
5105.76910494	5105.72000	.05	4.00	17468.22403	12362.45492
5110.73209214	5110.71000	.02	4.00	20464.52047	15353.78838
5127.09444413	5127.17000	-.08	4.00	18759.18010	13632.08565
5143.72192072	5143.81000	-.09	4.00	20114.29691	14970.57499
5163.66193529	5163.59000	.09	4.00	15720.68451	10557.00258
5175.10265806	5175.10000	.00	4.00	20528.89104	15353.78838
5210.91527700	5211.78000	-.86	4.00	17154.82103	11943.90576
5230.61108859	5231.57000	-.96	4.00	20943.42154	15712.81045
5239.60535028	5240.21000	-.60	4.00	19783.33393	14543.72758
5253.57912742	5253.62000	-.04	100.00	11502.58872	6249.00959
5257.04365048	5257.59000	-.55	4.00	19668.42394	14411.38029
5271.30777702	5272.17000	-.86	4.00	18839.26345	13567.95567
5282.94195136	5282.87000	.07	4.00	19826.66953	14543.72758
5284.49415173	5284.51000	-.02	4.00	15631.80669	10347.31254
5296.64119707	5296.57000	.07	25.00	16929.76671	11633.12552
5301.98646905	5301.99000	-.00	25.00	16121.88631	10819.89984
5308.05683263	5307.95000	.11	4.00	20766.49930	15458.44247
5341.78496250	5341.72000	.06	25.00	19885.51254	14543.72758
5349.75055052	5349.71000	.04	25.00	15638.33487	10288.58432
5364.93358903	5364.94000	-.01	25.00	11613.94318	6249.00959
5371.10701381	5371.05000	.06	25.00	16929.76671	11558.65970
5412.31155946	5412.24000	.07	4.00	18759.18010	13346.86854
5412.71092269	5412.66000	.05	4.00	20766.49930	15353.78838
5425.64999909	5424.74000	.91	4.00	17369.55576	11943.90576
5437.35025760	5437.30000	.05	25.00	17070.47577	11633.12552
5443.11114897	5443.06000	.05	25.00	16900.38693	11457.27579
5469.50118558	5469.00000	.50	4.00	18295.77780	12826.27661
5472.49092979	5473.15000	-.66	4.00	16929.76671	11457.27579
5512.22951428	5512.20000	.03	25.00	15720.68451	10208.45500
5523.52609858	5523.48000	.05	25.00	21767.96248	16244.43639
5526.33488720	5526.29000	.05	25.00	16929.76671	11403.42783
5545.72103436	5545.69000	.03	4.00	17908.17596	12362.45492
5552.27667907	5552.24000	.04	4.00	21265.08713	15712.81045
5557.33638185	5557.31000	.03	4.00	15638.33487	10080.99849
5564.88872795	5564.88000	.00	100.00	16121.88631	10557.00258

5569.18089246	5569.17000	.02	100.00	15638.33487	10069.14498
5576.97698429	5577.14000	-.16	4.00	13710.24181	8133.26483
5581.65451692	5581.69000	-.04	25.00	16121.88631	10540.23179
5589.63315911	5589.35000	.28	4.00	20943.42154	15353.78838
5598.64732749	5598.68000	-.03	4.00	20569.22232	14970.57499
5606.26505637	5606.28000	-.01	4.00	17968.71998	12362.45492
5622.64387531	5622.64000	.01	100.00	11613.94318	5991.29430
5629.57090943	5629.41000	.16	4.00	20420.51293	14790.94202
5637.89776384	5637.81000	.09	4.00	12643.40814	7005.51037
5639.68602279	5639.64000	.05	100.00	15720.68451	10080.99849
5650.71702738	5650.81000	-.09	4.00	20621.29202	14970.57499
5673.57345106	5673.50000	.08	4.00	20464.52047	14790.94202
5675.09043773	5675.06000	.04	4.00	20218.82702	14543.72758
5684.90070893	5684.82000	.08	25.00	17361.90134	11677.00063
5690.93210386	5690.97000	-.04	25.00	20661.50710	14970.57499
5692.14163987	5692.43000	-.29	4.00	13825.40647	8133.26483
5702.91662627	5702.90000	.02	4.00	20114.29691	14411.38029
5710.23540724	5709.40000	.84	4.00	17154.82103	11444.58563
5713.66661565	5713.62000	.05	4.00	21426.47707	15712.81045
5728.77582503	5728.70000	.08	100.00	17361.90134	11633.12552
5736.43023909	5736.36000	.07	100.00	17369.55576	11633.12552
5737.02288746	5736.96000	.06	100.00	16294.02547	10557.00258
5740.52363113	5740.52000	.01	100.00	11502.58872	5762.06009
5767.82136838	5767.15000	.67	4.00	20311.54895	14543.72758
5780.24664815	5780.63000	-.38	4.00	17070.47577	11290.22913
5810.89605493	5810.82000	.08	25.00	17369.55576	11558.65970
5846.06320063	5846.15000	-.09	4.00	13710.24181	7864.17861
5848.71122141	5848.67000	.04	25.00	18759.18010	12910.46888
5851.88309274	5851.84000	.04	25.00	11613.94318	5762.06009
5871.87587542	5871.59000	.29	4.00	21584.68633	15712.81045
5874.42398858	5874.59000	-.17	4.00	18759.18010	12884.75611
5876.78535142	5876.81000	-.02	4.00	20420.51293	14543.72758
5895.47512770	5895.89000	-.41	4.00	20306.85542	14411.38029
5900.16866096	5899.28000	.89	4.00	20311.54895	14411.38029
5904.62555686	5904.56000	.07	100.00	17361.90134	11457.27579
5909.56432522	5909.51000	.05	25.00	17468.22403	11558.65970
5912.27997091	5912.20000	.08	4.00	17369.55576	11457.27579
5912.83520762	5912.77000	.07	25.00	16900.38693	10987.55173
5913.43130694	5913.42000	.01	100.00	16121.88631	10208.45500
5920.79289306	5920.73000	.06	4.00	20464.52047	14543.72758
5921.08186187	5921.06000	.02	4.00	19489.03754	13567.95567
5928.79457391	5927.88000	.91	4.00	18839.26345	12910.46888
5937.04740939	5937.14000	-.09	25.00	18299.50233	12362.45492
5940.39906589	5940.59000	-.19	4.00	16195.36425	10254.96516
5942.21498844	5942.14000	.07	100.00	16929.76671	10987.55173
5949.97714368	5950.23000	-.25	25.00	17893.88290	11943.90576
5960.83058035	5960.84000	-.00	4.00	23843.72510	17882.88552
5961.22785621	5962.16000	-.93	4.00	13825.40647	7864.17861
5962.75434209	5962.68000	.08	25.00	20464.52047	14501.76413
5966.12792832	5966.03000	.10	4.00	17369.55576	11403.42783
5968.03459612	5967.97000	.06	4.00	21426.47707	15458.44247
5972.84654706	5972.85000	-.00	4.00	20943.42154	14970.57499
5975.55728161	5975.41000	.15	100.00	20766.49930	14790.94202
5980.12866447	5980.29000	-.16	4.00	20391.50895	14411.38029
6005.44114363	6005.37000	.07	4.00	16294.02547	10288.58432
6022.29380587	6022.24000	.06	25.00	18932.76768	12910.46888
6024.81422180	6024.72000	.09	4.00	17968.71998	11943.90576
6027.12690402	6027.20000	-.07	4.00	20528.89104	14501.76413
6039.06030308	6038.94000	.12	4.00	16294.02547	10254.96516
6040.88781545	6040.87000	.02	100.00	16121.88631	10080.99849
6044.06005850	6044.04000	.03	4.00	16406.52398	12362.45492
6044.27181825	6044.26000	.01	4.00	12035.56612	5991.29430
6048.01157304	6047.96000	.05	4.00	18932.76768	12884.75611
6048.07091025	6048.95000	-.88	4.00	16505.78813	10457.71722
6053.71145366	6053.68000	.03	4.00	21766.52191	15712.81045
6055.15203186	6055.08000	.07	4.00	21767.96248	15712.81045
6056.17925793	6056.15000	.03	4.00	21409.96764	15353.78838
6057.63092959	6056.67000	.96	4.00	16900.38693	10842.75600
6064.79419861	6064.72000	.08	25.00	17468.22403	11403.42783
6069.36530781	6069.15000	.22	4.00	19471.85971	13402.49440
6071.67221558	6071.52000	.15	4.00	17361.90134	11290.22913
6072.68869617	6072.65000	.04	100.00	21426.47707	15353.78838
6079.32462964	6079.27000	.06	4.00	17369.55576	11290.22913
6079.55236918	6079.48000	.07	25.00	19647.50804	13567.95567
6082.92404808	6082.86000	.06	100.00	17070.47577	10987.55173
6085.57046645	6085.49000	.08	25.00	16294.02547	10208.45500
6108.14050287	6108.12000	.03	4.00	21078.72450	14970.57499
6110.39928096	6110.41000	-.01	4.00	19471.85971	13361.46043
6114.01015866	6113.35000	.66	4.00	20525.39045	14411.38029
6114.36575777	6114.24000	.13	4.00	16195.36425	10080.99849
6119.54029610	6119.39000	.15	100.00	24092.42581	17882.88552
6126.21926838	6126.14000	.08	100.00	16195.36425	10069.14498
6142.16899681	6142.11000	.06	100.00	19489.03754	13346.86854
6150.45270832	6149.94000	.51	25.00	15007.41424	8856.96153
6152.47951804	6152.93000	-.45	25.00	20943.42154	14790.94202
6157.84203304	6157.92000	-.08	4.00	20569.22232	14411.38029

6168.34432665	6168.38000	-.04	4.00	18530.79925	12362.45492
6194.58387788	6194.60000	-.02	4.00	19826.66953	13632.08565
6209.91173293	6210.00000	-.09	4.00	20621.29202	14411.38029
6210.41167996	6210.71000	-.30	4.00	20712.17581	14501.76413
6213.02697496	6213.05000	-.02	4.00	16294.02547	10080.99849
6214.63288815	6214.71000	-.08	4.00	16900.38693	10685.75405
6215.27145046	6215.22000	.05	4.00	21185.84644	14970.57499
6222.77172361	6222.75000	.02	25.00	20766.49930	14543.72758
6230.89794594	6230.79000	.11	4.00	21584.68633	15353.78838
6245.01364333	6244.94000	.07	100.00	19647.50804	13402.49440
6245.34734455	6245.99000	-.64	4.00	18607.80228	12362.45492
6250.82296556	6250.97000	-.15	4.00	16505.78813	10254.96516
6258.71385827	6258.68000	.03	4.00	19826.66953	13567.95567
6260.75738368	6259.97000	.79	4.00	17893.88290	11633.12552
6264.73517264	6263.97000	.77	4.00	20766.49930	14501.76413
6273.50603568	6273.53000	-.02	100.00	12035.56612	5762.06009
6275.05043980	6274.98000	.07	100.00	17908.17596	11633.12552
6280.32818961	6279.76000	.57	4.00	21993.13864	15712.81045
6286.04761648	6286.04000	.01	25.00	19647.50804	13361.46043
6294.51213754	6294.55000	-.04	4.00	21265.08713	14970.57499
6300.63950412	6300.58000	.06	25.00	19647.50804	13346.86854
6307.84664311	6308.20000	-.35	4.00	20851.57422	14543.72758
6309.52001232	6309.47000	.05	4.00	21767.96248	15458.44247
6317.55686941	6317.53000	.03	100.00	19885.51254	13567.95567
6330.88991146	6329.90000	.99	4.00	18299.50233	11968.61242
6334.92119730	6334.84000	.08	100.00	17154.82103	10819.89984
6343.48077831	6343.47000	.01	25.00	22056.29123	15712.81045
6348.05915286	6348.15000	-.09	4.00	16888.29094	10540.23179
6349.51625564	6349.50000	.02	100.00	17908.17596	11558.65970
6359.41056988	6359.45000	-.04	4.00	21329.98556	14970.57499
6361.15459050	6361.09000	.06	25.00	19489.03754	13127.88295
6372.76413716	6372.66000	.10	25.00	16929.76671	10557.00258
6374.34961550	6374.31000	.04	100.00	17361.90134	10987.55173
6380.83953134	6380.92000	-.08	25.00	19783.33393	13402.49440
6382.00602956	6381.94000	.06	25.00	17369.55576	10987.55173
6387.49425680	6387.39000	.00	25.00	18749.84918	12362.45492
6388.70945945	6388.97000	-.26	25.00	22633.14585	16244.43639
6394.39854608	6394.30000	.10	4.00	12643.40814	6249.00959
6399.69396003	6399.61000	.08	25.00	20943.42154	14543.72758
6410.06027765	6410.21000	-.15	100.00	17968.71998	11558.65970
6412.73452418	6412.67000	.06	100.00	21766.52191	15353.78838
6414.17410237	6414.15000	.02	4.00	21767.96248	15353.78838
6414.63099708	6414.69000	-.06	4.00	18383.24342	11968.61242
6421.87150449	6421.89000	-.02	4.00	19783.33393	13361.46043
6436.64314805	6436.58000	.06	4.00	16505.78813	10069.14498
6437.91156057	6437.05000	.86	4.00	18406.52398	11968.61242
6440.19393569	6440.27000	-.08	4.00	20851.57422	14411.38029
6449.29727392	6450.07000	-.77	4.00	17893.88290	11444.58563
6450.90017162	6450.87000	.03	100.00	17908.17596	11457.27579
6462.61422394	6462.23000	.39	25.00	18406.52398	11943.90576
6465.20910557	6465.24000	-.03	25.00	19826.66953	13361.46043
6474.14510852	6474.56000	-.41	4.00	21265.08713	14790.94202
6479.40099321	6479.75000	.05	25.00	19826.66953	13346.86854
6483.01914356	6482.97000	.05	25.00	19885.51254	13402.49440
6490.45507291	6490.43000	.03	25.00	17893.88290	11403.42783
6504.74812903	6504.70000	.05	25.00	17908.17596	11403.42783
6515.94063529	6516.14000	-.20	4.00	20148.02629	13632.08565
30965.34628468	30965.39000	-.04	400.00	30965.34628	0.00000
30982.88936998	30982.74000	.15	400.00	31603.21056	620.32119
30992.97176677	30993.09000	-.12	400.00	30992.97177	0.00000
30994.81057485	30994.92000	-.11	400.00	30994.81057	0.00000
31011.30509030	31011.41000	-.10	400.00	34812.12239	3800.81730
31013.61344257	31013.72000	-.11	400.00	31633.93463	620.32119
31024.76088938	31024.87000	-.11	400.00	31024.76069	0.00000
31042.05400165	31042.14000	-.08	400.00	34842.87530	3800.81730
31058.09840810	31058.15000	-.05	400.00	31678.41960	620.32119
31098.07756930	31098.11900	-.04	400.00	31098.07757	0.00000
31108.15432097	31108.13000	.02	400.00	31728.47351	620.32119
31123.91628607	31124.03000	-.11	400.00	31744.23748	620.32119
31129.43818706	31129.52000	-.08	400.00	31129.43819	0.00000
31134.86946663	31134.96000	-.09	400.00	31134.86949	0.00000
31161.47137546	31161.41000	.06	400.00	35029.94448	3868.47310
31166.19875742	31166.29000	-.09	400.00	31166.19876	0.00000
31175.67300365	31175.81000	-.13	400.00	34976.49530	3800.81730
31251.21035428	31251.31000	-.10	400.00	31871.53154	620.32119
31275.04333225	31275.88000	.06	400.00	31275.94333	0.00000
31300.73241504	31300.78000	-.05	400.00	31921.05360	620.32119
31334.69261929	31334.71000	-.02	400.00	31955.01381	620.32119
31339.72311279	31339.65000	.07	400.00	31339.72311	0.00000
31358.61328894	31358.73000	-.12	400.00	31358.61329	0.00000
31366.82229556	31366.93000	-.11	400.00	31987.14348	620.32119
31374.78030709	31374.83000	-.04	400.00	31995.10950	620.32119
31408.41868713	31408.41000	.01	400.00	31408.41869	0.00000
31423.77201718	31423.91000	-.14	400.00	32044.09321	620.32119
31435.36481012	31435.47100	-.11	400.00	31435.36481	0.00000
31467.58661598	31467.52000	.07	400.00	31467.58662	0.00000
31488.18980631	31488.25000	-.06	400.00	31488.18981	0.00000

31520.82546644	31520.94000	-.11	400.00	32141.14666	620.32119
31603.54400842	31603.67000	-.13	400.00	35879.23742	4275.69341
31744.23747521	31744.22990	.01	400.00	31744.23748	0.00000
31945.93870228	31946.01000	-.07	400.00	31945.93870	0.00000
32016.67378140	32016.76000	-.09	400.00	32016.67378	0.00000
32028.45486124	32028.33900	.12	400.00	32648.77605	620.32119
32062.76033189	32062.78000	-.02	400.00	35931.23344	3868.47310
32098.12861141	32098.16100	-.03	400.00	32098.12861	0.00000
32226.13273267	32226.22000	-.09	400.00	36501.82614	4275.69341
32255.94007367	32255.81000	.13	400.00	32255.94007	0.00000
32317.79150339	32317.85000	-.06	400.00	32317.79150	0.00000
32324.59657669	32324.64000	-.04	400.00	32944.91777	620.32119
32334.73408932	32334.79000	-.06	400.00	32955.05528	620.32119
32377.25604968	32377.40000	-.14	400.00	32997.57724	620.32119
32490.61226865	32490.73000	-.12	400.00	32490.61229	0.00000
32495.69384779	32495.83000	-.14	400.00	32495.69385	0.00000
32530.36471248	32530.24000	.12	400.00	33150.68590	620.32119
32534.42552017	32534.36700	.06	400.00	33154.74671	620.32119
32574.57074304	32574.53000	.04	400.00	32574.57074	0.00000
32648.77605038	32648.83000	-.05	400.00	32648.77605	0.00000
32731.09341890	32731.13000	-.04	400.00	32731.09342	0.00000
32733.47452609	32733.45000	.02	400.00	33353.79572	620.32119
32742.51817489	32742.64000	-.12	400.00	32742.51817	0.00000
32791.98282260	32791.97300	-.09	400.00	33412.20401	620.32119
32809.18463302	32809.20000	-.02	400.00	32809.18463	0.00000
33019.19617637	33019.19400	.00	400.00	33639.51737	620.32119
33035.72600184	33035.66900	.06	400.00	37489.13086	4453.40486
33113.10911427	33113.16000	-.05	400.00	33733.43030	620.32119
33136.20958208	33136.29500	-.09	400.00	33136.20958	0.00000
33296.44469905	33296.55000	-.12	400.00	33916.75589	620.32119
33341.79152434	33341.84500	-.05	400.00	33341.79152	0.00000
33380.14187573	33380.28000	-.14	400.00	34000.46306	620.32119
33412.20401174	33412.29000	-.09	400.00	33412.20401	0.00000
33570.61985566	33570.67000	-.05	400.00	33570.61986	0.00000
33639.51736551	33639.60000	-.08	400.00	33639.51737	0.00000
34059.86603972	34059.87000	-.00	400.00	34059.86604	0.00000
34164.72371568	34164.86000	-.14	400.00	34164.72372	0.00000
34827.81729412	34827.87000	-.05	400.00	34827.81729	0.00000
35004.11405757	35004.21300	-.10	400.00	35004.11406	0.00000
37596.60607588	37596.65400	-.05	400.00	37596.60608	0.00000

66 COL LEVELS 792 ROW LEVELS 8889 TRANSITIONS

SIGMA= .986703 NORMALIZED SIGMA= .005817

UNCERTAINTY	WEIGHT	RMS	QUAN
.0030	111111.11	.0020	1759
.0050	40000.00	.0037	1089
.0100	10000.00	.0087	1562
.0500	400.00	.0627	2783
.1000	100.00	.0840	336
.2000	25.00	.1417	626
.5000	4.00	.3475	734

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