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Calculation of Atomic-Energy-Level Values

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Correction for page 37, LA 4402

Replace statements numbered 553 through 570 with the following:

```
00553           DO4240IX=1,NCX1
00564           RMULT(IX)=C(IX,I)
00565           C(IX,I)=0.
00566      4240 ROW(IX)=-DMULT*RMULT(IX)
00570           IXN=I-1
```

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Calculation of Atomic-Energy-Level Values

by

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

CONTENTS

Abstract 1

I. Introduction 1

II. Historical Background 1

III. Least-Squares Formulation 2

IV. Solution by the Inversion Method 2

V. Solution by the Iterative Method 6

VI. Conclusions 7

VII. References 7

Appendix A. Equations Describing the Inversion Method Derived by A. S. Goldman 8

Appendix B. Method of Inversion and Simple Example of the Inversion Process 27

Appendix C. Demonstration That the Iterative Solution to the Problem
Is Convergent in Principle 29

Appendix D. The Inversion Code: Instructions and Listing 30

Appendix E. The Iterative Code: Instructions and Listing 56

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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:

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

PROGRAM CONTROL

go to SORTD → **SORTD**

- Read in wave numbers, uncertainties, and classifications.
- Order the list of classifications and group by row levels.
- For each row level determine: w_{ij}, $\sum_{j=1}^{N} w_{ij}$, $\sum_{j=1}^{N} w_{ij} y_{ij}$, and store on mag tape #1.
- Compute q_s and $\sum_{i=1}^{M} w_{is}$ for $s = 1, \ldots, N$.

Return to CONTROL

go to SINVR → **SINVR**

- Compute elements of C matrix using data on mag tape #1.
- Compute inverse of C matrix, save in memory for later use in subroutine VAR.
- Compute $\hat{b}_j$, $j = 2, \ldots, N$ using data on mag tape #1.

Return to CONTROL

go to VAR → **VAR**

- Compute $\hat{a}_i$, $i = 1, \ldots, M$ using data on mag tape #1 and C matrix inverse. Compute sigma squared.
- For each y_{ij}, calculate $\hat{y}_{ij}$, var $\{y_{ij}\}$ and print data associated with y_{ij}.
- Compute var $\{a_i\}$ and var $\{b_j\}$ and print level values and their variances.

Return to CONTROL

STOP 7

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.

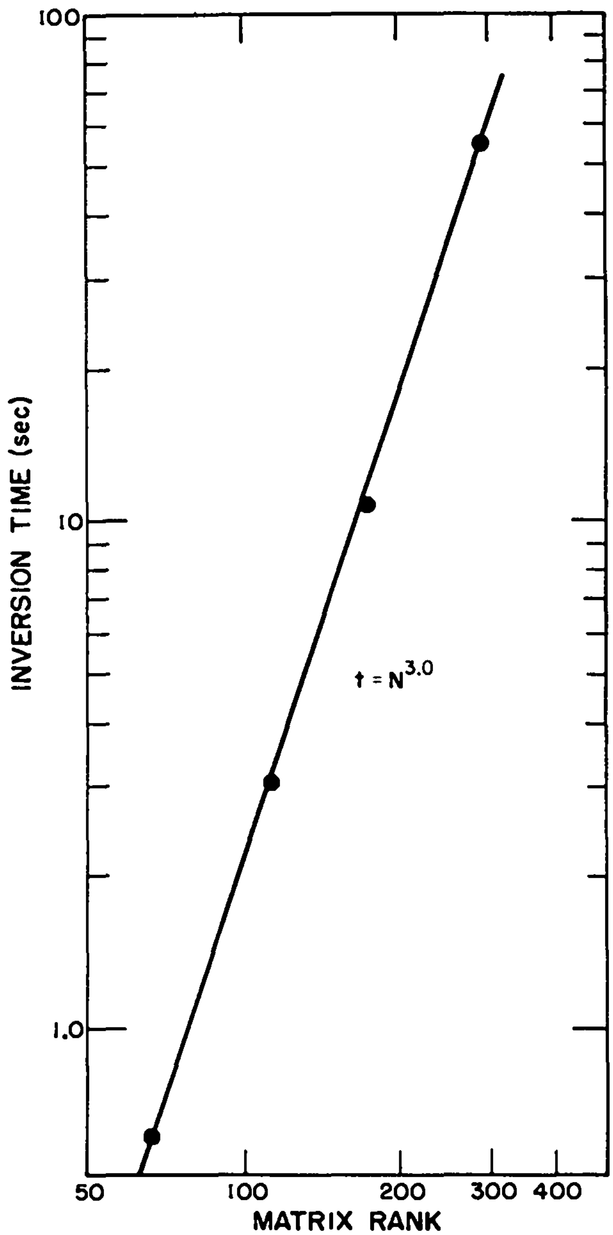

Fig. 2.
Inversion time as a function of matrix size as determined from four calculations.

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.

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

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

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 $m \geqslant 0$ and $1 \leqslant i \leqslant n$. 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 ($< 0.1\ \mathrm{cm}^{-1}$) 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

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

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 $1 \leqslant \omega \leqslant 2$.

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 Cl 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

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*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
Cl 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 $w_{ij} = 0$

$\hat{a} = \{\hat{a}_1, \hat{a}_2, \ldots, \hat{a}_m\}$, $\hat{b} = \{\hat{b}_1, \hat{b}_2, \ldots, \hat{b}_n\}$ 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

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

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

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

$$\begin{aligned} \mathrm{Var}\left\{\hat{\beta}\right\} = \mathrm{Var}\left\{N_1^{-1}Y\right\} &= N_1^{-1}N_1^{-1}\,\mathrm{Var}\left\{N_1\beta + e\right\} \\ &= N_1^{-1}N_1^{-1}N_1\sigma^2 \\ &= N_1^{-1}\sigma^2. \end{aligned}$$

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

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

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

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

$$= N_1\sigma^2 \ .$$

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

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

and J is a matrix composed of ones everywhere

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

Thus,

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

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

Thus,

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

and

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

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

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:

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

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

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

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

and

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

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

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

Thus,

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

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

where

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

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 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,

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

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

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

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

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

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

and

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

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:

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

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

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

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

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

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

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

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

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

$$= 0\ .$$

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

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

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

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

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

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 $\text{Var}\left\{\hat{a}_i\right\}$. The derivation of the last term is as follows:

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

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

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

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,

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

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

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

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

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

Thus,

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

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

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

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

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

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

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

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.

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

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} k = 1, . . . , i - 1

   RMULT (k) = 1 = c_{ii} k = i

   RMULT (k) = c_{ik} k = i + 1, . . . , N1

3. ROW (k) = - DMULT * RMULT (k)   k = 1, . . . , i - 1

   ROW (k) = DMULT * RMULT (k)   k = i, . . . , N1

4. c_{ki} = 0   k = 1, . . . , i - 1

   c_{ik} = ROW (k)   k = i, . . . , N1

5. For rows IX, where IX ≠ i

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

   where IX = 1, ... , n and IX ≠ 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 $k < i$

   c(2, k) = ROW (k) $k \geq i$
5. $c_{IX,J} = c_{IX,J}$ - RMULT (IX) * ROW (J)

   $IX \neq i$

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 = $\frac{1}{2}$ $c_{33} = 1$
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 $k < 3$

   c(3, k) = ROW (k) $k \geq 3$
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

```
              PROGRAMCCNTRCL(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 TC STORE THE INVERTED MATRIX AND LEVEL VALUES AFTER
        C CCMPLETION OF CCMPUTATICN.
        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 CCNTAINS 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/C BUFFERS
014251

FUNCTION ASSIGNMENTS

STATEMENT ASSIGNMENTS

BLOCK NAMES AND LENGTHS
       -   120341

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

START OF CONSTANTS
000034

START OF TEMPORARIES
00007C

START OF INDIRECTS
000072

UNUSED COMPILER SPACE
005400


              SUBROUTINESCRTD
000001        DOUBLEYI,SNI,DTEMP,CTAB
000001        COMMONI,M,WTUNC,WV(285),LEVC(285),YV(285),WTJ(285),QTAB(285),
             1LA(19000),IWX(19000)
000001        LOGICAL ISOTCP
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(1H0,I3* COLUMN LEVELS*/1H0,I4* ROW LEVELS*/*0*I5
               1* TRANSITIONS*)
000001          9 FORMAT(1X,I10,F15.2)
000001         13 FORMAT(*ODUPLICATE 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=2) 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=MIN0(IX+1,19000)
000065          CALLSHIFT(IWN,IWX(IX),-17)
000070          IWX(IX)=IWX(IX).OR.IUNC
000073          CALLSHIFT(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=MAX0(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  REW(ND1
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.77777777700000000B
000327            NX1=1
000330            I=1
000331        510 I=I+1
000333            IF(I.GT.IX)GOTO511
000336            LEVT=LA(I).AND.77777777700000000B
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).OR.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).OR.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    -  050351C01
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    -  000003C01
YI     -  001017   YV     -  001075C01

START OF CONSTANTS
000674

START OF TEMPORARIES
000776

START OF INDIRECTS
001010

UNUSED COMPILER SPACE
002600
```

```
                SUBROUTINETCRDER(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(IPCS+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.(2TCT)GOTO410
000047    420   JX=JX+1
000051          LA(JX)=LA(I1)
000053          I1=I1+1
000054          IF(I1.LE.I1TCT)GOTO420
000056          GOTO450
000057    430   LA(JX)=LA(I1)
000062          (1=I1+1
000063          IF(I1.LE.I1TCT)GOTO410
000066    440   JX=JX+1
000070          LA(JX)=LA(I2)
000072          I2=I2+1
000073          IF(I2.LE.I2TCT)GOTO440
000075    450   I1=I1+LX
000077          IF(I1.GT.IX)GCTC460
000102          I1TOT=MINO(I1TCT+LX2,IX)
000105          I2=I2+LX
000106          IF(I2.GT.(X)GCTC420
000111          I2TOT=MINO(I2TCT+LX2,IX)
000114          GOTO410
000114    460   IF(LX2.LT.L)GCTC400
000116          IF(IPOS.EC.0)GCTO480
000117          DO470I=1,IPCS
000125          IL=I+L
000126    470   LA(()=LA(IL)
000131    480   RETURN
000132          END


SUBPROGRAM LENGTH
000170

FUNCTION ASSIGNMENTS

STATEMENT ASSIGNMENTS
400   -  000013   410    -  000034   420    -  000050   430    -  00C060
440   -  000067   450    -  000076   460    -  000115   480    -  000132

BLOCK NAMES AND LENGTHS

VARIABLE ASSIGNMENTS
I     -  000166   IL     -  000167   IPCS   -  000155   IX     -  000160
(1    -  000161   I1TOT  -  000164   I2     -  000163   I2TOT  -  000165
JX    -  000156   LL     -  000154   LX     -  000162   LX2    -  00C157

START OF CONSTANTS
000135

START OF TEMPURARIES
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),CTAB(285),SNI,CFB(285)
000001          CCMMONSTOR(41185)
000001          DOUBLEDIV
000001          EQUIVALENCE(STOR,N),(STOR(574),C)
000001          EQUIVALENCE(CTAB,JV,RMULT),(QTAB(144),WV,ROW),(B(2),CFB)
          C NCX1 AND NCX2 ARE THE DIMENSICNS CF 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.D
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=I,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,()    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=(
        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         IXM=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.D
000676          DO4330I=1,N1
000677          B(I+1)=0.D
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
SHI    -  003457   STOR   -  000000C01 TIME   -  003502   TIMET  -  003507
WV     -  001725

START OF CONSTANTS
001204

START OF TEMPORARIES
001251

START OF INDIRECTS
001257
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```
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,IROW,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          I1=I+1
000144          DO1070II=I1,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          CCM=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          CCM=1L*
000514          GOTO1125
000514     1123 CCM=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(I)
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
I1     -  004046    J      -  004044    JJ     -  004050    L      -  004037
LEVC   -  000440C01 LLVR   -  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            CONTROL      000114

          SYSTEM        014661            SEGMENT      015563     015571

          SYSTEMC       014621
          SYSTEMP       014647
          END           014543            CONTROL      000145

          STOP          014574            CONTROL      000143

          EXIT          014566
          ABNORML       014604            SEGMENT      015572

          SYSTRAC       014654
          LINE.         015235
          FETA.         015236
          KEY.          015240
          FNMA.         015241
          NUMB.         015243
          SEGMENT       015470            CONTROL      000124     000132     000140

          DKSPRU.       016121
          FIZBAK.       016132
          POSFIL.       016167
          ROPRU.        016177
          DAT.          016221
          CIOI.         016066
          OPEN.         015622            SYSTEM       015150

          SIO.          015734
          ----UNSATISFIED EXTERNALS-----                                       REFERENCES
          SORTO                                        000125
          SINVR                                                                  000133
          VAR                                                                    000141

CORE MAP  15.39.29. SEGMENT     01.      015556  14071700000000000204010C0007000000000000  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--
          SORTO         137071
          TORDER        140153
          INPUTC        140343
          IFENDF        141477
          SHIFT         141524
          ECSRW         141541
          ECFL          141570
          REWINM        141632
          OUTPTC        141714
          HOLE          143261
          OUTPTB        143265
          ENDFIL        143362
          GETBA         143432
          C4020         143451
          US4020        14356C
          XRCL          143775
```

```
--ENTRY-----ADDRESS-                                              REFERENCES
SORTO        137072
TORDER       140154          SCRTO       137236      137364

INPUTC       140345          SCRTO       137075      137077      137101      137102      137114      137116      137120
                                         137122      137124      137126      137130      137131

KRAKER       140447
IFENDF       141500          SCRTO       137133

SHIFT        141525          SORTO       137161      137166      137311      137355      137435      137454      137464


SHIFN        141536          SCRTO       137316      137333

ECWR         141541          SCRTO       137177      137205

ECRD         141550          SCRTO       137262      137372

ECFL         141571          SCRTO       137377

REWINM       141633          SCRTO       137401      137732

OUTPTC       141716          SCRTO       137520      137522      137524      137526      137530      137531      137735
                                         137737      137741      137743      137744      137747      137753      137755
                                         137761

KODER        142063
DBLE         143262          SCRTO       137554      137557

OUTPTB       143267          SCRTO       137662      137664      137666      137670      137672      137674      137700
                                         137702      137706      137722      137725      137726

ENDFIL       143363          SCRTO       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	11106822.89
710303	5255091.00
717102	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
1140104	1594037.67
1144403	380926.22
1145706	3649336.56
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  14071700000000002040100007000000000000  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--
          S1NVR       137071
          INPUTB      142601
          IFENOF      142735
          SECOND      142762
          ACGOER      143006
          OUTPTC      143032
          REWINM      144377
          GETBA       144461
          C4020       144500
          BS4020      144607
          XRCL        145024
          --ENTRY-----ADDRESS-                                                   REFERENCES
          S1NVR       137072
          INPUTB      142603          S1NVR       137123     137125     137127     137131     137133     137135     137141
                                                  137143     137147     137756     137761     137762

          IFENOF      142736          S1NVR       137151

          SECOND      142763          S1NVR       137463     137744

          ACGOER      143007          S1NVR       137624

          OUTPTC      143034          S1NVR       137751     137753     137754     140253     140255     140256

          KDOER       143201
          REWINM      144400          S1NVR       137764

          GETBA       144461          INPUTB      142673
                                      IFENOF      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  14071700000000002040100007000000000000  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
          IFENOF      143311
          OUTPTB      143336
          ENDFIL      143433
          REWINM      143503
          OUTPTC      143565
          SQRT        145132
```

```
GETBA         145212
C4020         145231
OUTPTS        145340
LABRT         145417
BS4020        145526
ACGUER        145743
XRCL          145767
--ENTRY-----ADDRESS-                                   REFERENCES
VAR           137072
INPUT8        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

OUTPT8        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          INPUT8    143247
                              IFENDF    143315
                              OUTPT8    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

ACGUER        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	6394.30000	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	10843.00000	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	.76699945547289E-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	579104	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	11830.99000	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	88780:	100.00	6952.54000	6952.546031	.006031	.054820	.30866394905479E-02
1583103	1140304	4.00	4427.71000	4427.635900	-.07410C	.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	8257.707693	-.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	9280.40000	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	.16609848042989E-04
1650506	576205	25.00	10744.12000	10743.728039	-.391961	.004027	.16658746051048E-04
1650506	624906	100.00	10256.65000	10256.778536	.128536	.004025	.16642746803585E-04
3748904	445304	400.00	33035.66900	33035.726000	.057000	.009348	.89749517975067E-04
3748904	710305	400.00	30385.35000	30385.232471	-.117529*	.009357	.89927005534362E-04
3748904	1055704	10000.00	26932.12810	26932.128286	.000186	.009324	.89296809039708E-04
3748904	1497005	400.00	22518.50000	22518.555876	.055876	.009561	.93882159775197E-04
3759606	6	400.00	37596.65400	37596.606083	-.047917	.003016	.93421340943759E-05
3759606	1006907	400.00	27527.51000	27527.461108	-.048892	.003015	.93388426875028E-05
3759606	1129005	400.00	26306.42000	26306.376949	-.043051	.003085	.97781208329576E-05
3759606	1163305	400.00	25963.47000	25963.410564	.010564	.003078	.97292188436561E-05
3759606	1282607	111111.11	24770.32900	24770.329465	.000465	.002939	.88723207576606E-05
3762410	1130809	10000.00	26316.40780	26316.412081	.009281	.002221	.50662048040896E-05
3762410	1312709	111111.11	24496.64500	24496.646434	.001434	.002121	.46203956371579E-05
3762410	1353509	111111.11	24089.38900	24089.386782	-.002218	.002127	.46488283218441E-05
3762410	1484510	400.00	22779.23000	22779.246026	.016026	.002588	.68812704471178E-05
3762410	1604010	400.00	21584.11000	21584.079722	-.030278	.002653	.72284288920204E-05
3763109	1130809	10000.00	26323.76060	26323.766248	.005648	.002752	.77761589008724E-05
3763109	1312709	111111.11	24504.00120	24504.000601	-.000599	.002634	.71281178642392E-05
3763109	1545808	10000.00	22173.43910	22173.441041	.001942	.003095	.98383358021875E-05
3763109	1624408	10000.00	21387.44810	21387.447163	-.000937	.002905	.86695728736144E-05
3777909	764508	400.00	30133.58000	30133.533321	-.046679	.002029	.42302384972083E-05
3777909	1068508	40000.00	27093.39800	27093.400842	.002842	.002015	.41722603107309E-05
3777909	1130809	10000.00	26471.03670	26471.037591	.000891	.002072	.44113036047676E-05
3777909	1312709	111111.11	24651.27450	24651.271945	-.002555	.001986	.40506292727240E-05
3777909	1484510	400.00	22933.92000	22933.871537	-.048463	.002484	.63393016994561E-05
3777909	1545808	400.00	22320.64000	22320.712385	.072385	.002590	.68924727406252E-05
3777909	1604010	400.00	21738.67000	21738.705233	.035233	.002512	.64798971337966E-05
3777909	1624408	111111.11	21534.71710	21534.718507	.001407	.002037	.42604921874298E-05
3833807	811807	400.00	30219.70000	30219.706274	.006274	.009383	.90426845028333E-04
3833807	1034708	400.00	27990.97700	27990.999131	.022131	.009388	.90521372013058E-04
3833807	1282607	400.00	25511.93990	25512.035059	.095159	.009393	.90613896665184E-04
3833807	1479007	10000.00	23547.37460	23547.369657	-.004943	.009324	.89301650529639E-04
3871209	1068508	400.00	28027.09000	28027.091200	.001200	.002670	.73222946532638E-05
3871209	1130809	400.00	27404.76000	27404.727950	-.032050	.002710	.75420196812950E-05
3871209	1312709	40000.00	25584.95630	25584.962304	.006004	.002656	.72472892455614E-05
3871209	1484510	10000.00	23867.56040	23867.561895	.001495	.002975	.90930975255184E-05
3871209	1545808	111111.11	23254.40490	23254.402744	-.002156	.002459	.62082280245504E-05
3871209	1604010	10000.00	22672.39830	22672.395591	-.002709	.003028	.94155699398797E-05
3871209	1788209	400.00	20829.90000	20829.959734	.059734	.006592	.44632874921356E-04

LEVEL	CALCULATED LEVEL	SQRT(VAR)	VAR/SIGMA**2
1150206	11502.588718	.061432	.38761171982857E-02
1161305	11613.943182	.049092	.24753449078416E-02
1203504	12035.564125	.047641	.23312007138032E-02
1264306	12643.408034	.048850	.24509804668172E-02
1346305	13463.397154	.029644	.90259884239621E-03
1371004	13710.241813	.052152	.27935415042194E-02
1382504	13825.416466	.038469	.15199495578246E-02
1464106	14643.845728	.027326	.76694848406544E-03
1483905	14839.733330	.030984	.92342970629660E-03
1500703	15007.414240	.079514	.64938148532004E-02
1563107	15631.806693	.035363	.12771856137474E-02
1563806	15638.334865	.026031	.69597532480393E-03
1572005	15720.684513	.009449	.91710671354433E-04
1573202	15732.159227	.067772	.47175134685928E-02
1583103	15831.043733	.054820	.30866772534098E-02
1612104	16121.886307	.030644	.96449969321108E-03
1619506	16195.364248	.009597	.94607893266594E-04
1629405	16294.025466	.002823	.81843356645887E-05
1650506	16505.788127	.004023	.16619143617429E-04
1688802	16888.290897	.134292	.18522986157261E-01
1690007	16900.306934	.004861	.24264921457657E-04
1692905	16929.766716	.002530	.65767977742162E-05
1707006	17070.475776	.002529	.65639485263979E-05
1715403	17154.821038	.026909	.74372106755679E-03
1736106	17361.901343	.002532	.65828712258182E-05
1736905	17369.555759	.002100	.45282680262978E-05
1746804	17468.224032	.004895	.24612096567041E-04
1789304	17893.882907	.002981	.91866415288122E-05
1790805	17908.175960	.002098	.45199166749046E-05
1796803	17968.719982	.023210	.55331564255969E-03
1818504	18185.999376	.004968	.24739786853237E-04
1825306	18253.872911	.002100	.45284898613381E-05
1826002	18260.444332	.036549	.13720415575329E-02
1829507	18295.177796	.002946	.89155236783461E-05
1829904	18299.502338	.002982	.91331523213574E-05
1838304	18383.243423	.002989	.91761684548308E-05
1840605	18406.523982	.002532	.65859577178330E-05
1853003	18530.749217	.028950	.86081701704606E-03
1860104	18607.802283	.002978	.91086294525724E-05
1874903	18749.849185	.030169	.93482029994033E-03
1875906	18759.180102	.002097	.45177215262019E-05
1879404	18794.828046	.002976	.90992886967203E-05
1883907	18839.263353	.002942	.88893817924617E-05
1893205	18932.767689	.002959	.89928244029890E-05
1911503	19115.499404	.032103	.10585195154942E-02
1911902	19119.755714	.041010	.17274087702976E-02
1912704	19127.211527	.002972	.90703818534205E-05
1919204	19192.401297	.002971	.90655763210011E-05
1930702	19307.749994	.033850	.11768812850702E-02
1941705	19411.859700	.002814	.81326372984219E-05
1948908	19489.037531	.009647	.95594349425719E-04
1955204	19552.519510	.002847	.83247437482154E-05
1964003	19640.147433	.009666	.95958964355478E-04
1964707	19647.568040	.004886	.24519629240338E-04
1966803	19668.423943	.009240	.87688647374187E-04
1978306	19783.333932	.001726	.30598414220151E-05
1982606	19826.669488	.002053	.43274277025830E-05
1982802	19828.404700	.004918	.24839675848784E-04
1986403	19864.520551	.003006	.92786813916774E-05
1988507	19885.512543	.002522	.65307357246469E-05
2011405	20114.296918	.002051	.43185169221515E-05
2014805	20148.026285	.002647	.71975274659490E-05
2021806	20218.827021	.001900	.37042855114155E-05
2025803	20258.142780	.002890	.85773193399674E-05
2030604	20306.855422	.002860	.84031723512379E-05
2031105	20311.548955	.002855	.83731397377710E-05
2039103	20391.518958	.004409	.19963049986275E-04
2042006	20420.512934	.001635	.27457530907762E-05
2045202	20452.797504	.004962	.25284378549922E-04
2046407	20464.520473	.002456	.61910040081482E-05
2052505	20525.390449	.002082	.44537466156253E-05
2052808	20528.891031	.004879	.24454229173303E-04
2056904	20569.222327	.001841	.34828643584110E-05
2062105	20621.292023	.002563	.67482659706699E-05
2065102	20651.205277	.003017	.93492508475394E-05
2066104	20661.587083	.001965	.39640481189001E-05
2071208	20712.175809	.002993	.91997912645247E-05
2071904	20719.030672	.002294	.54032528024214E-05
2076607	20766.499304	.001935	.38473614036852E-05
2080503	20805.792980	.002148	.47386153527361E-05
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1028806	10288.584322	.000676	.47004015416205E-06
1034708	10347.312546	.000611	.38342093207045E-06
1045707	10457.717213	.001403	.20206938856278E-05
1054003	10540.231789	.001149	.13553329402462E-05
1055704	10557.002581	.000782	.62757089281239E-06
1068508	10685.754049	.000646	.42833814958388E-06
1081903	10819.809849	.000869	.77465393453282E-06
1084208	10842.755990	.003389	.11798330735704E-04
1098706	10987.581723	.000673	.46581400786558E-06
1129005	11290.279135	.000854	.74837234918077E-06
1130809	11308.117299	.000840	.72410331006942E-06
1140304	11403.427833	.000958	.94272946122334E-06
1144403	11444.585665	.002204	.49879752575603E-05
1145706	11457.275782	.000693	.49342697877457E-06
1155804	11558.659703	.000877	.79086047493163E-06
1163305	11633.125519	.000833	.71353262414373E-06
1167707	11677.000629	.000756	.58700087433197E-06
1194304	11943.905756	.001353	.18800340596638E-05
1196805	11968.612425	.000934	.89664905538286E-06
1236204	12362.494954	.001883	.33349600085141E-05
1282607	12826.276618	.000684	.47934116218103E-06
1288405	12884.756115	.001541	.24376422852261E-05
1291006	12910.468890	.000935	.89715076140187E-06
1312709	13121.882946	.000854	.74962658768797E-06
1334607	13346.868542	.000848	.13868900560071E-06
1336106	13361.460434	.002350	.56741512977652E-05
1340206	13402.494395	.001046	.12334601997564E-05
1353509	13535.142599	.001145	.13467672636791E-05
1356797	13567.955680	.002555	.67066953619047E-05
1363205	13632.085633	.001981	.40249956200954E-05
1441104	14411.380282	.002635	.71297873293430E-05
1450108	14501.764123	.001119	.12856652390434E-05
1454306	14543.727593	.001042	.11151492581026E-05
1479907	14790.942020	.001212	.15091160346104E-05
1484510	14845.283354	.001626	.27165802797458E-05
1497005	14970.514990	.002176	.48653011455124E-05
1535307	15353.788383	.003123	.10014359274204E-04
1545808	15458.442505	.001755	.31636028416357E-05
1571207	15712.810451	.001328	.18118070371749E-05
1604010	16040.449658	.001725	.30561929433813E-05
1624408	16244.436384	.001348	.18657486600607E-05
1788209	17882.885515	.006088	.38070727554236E-04

```
BETA= 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),TRO(1000),TC(1000),TR(1000)
000002             DIMENSIONSNJ(1000),SNI(1000),DEL(1000),CONT(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,WT,WN
000002             EQUIVALENCE(WT,ICT),(WN,IWN)
000002             DATA(XHAF/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*
                  1(6* 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  CALLTORDER(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.177777777777B
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         CALLTORDER(ICT,NT)
000237         N=0
000240         KX=0
000241         DO990I=1,NT
000242         KXT=ICT(I).AND.(.NOT.17777777B)
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.17777777B
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         CALLTORDER(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((SOTOP)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(1)=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(().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((R)=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 MULTIIPLIED 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,MODPRT).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.37777777B)
         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.07777777777777774000000
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   PWT     -  013635   SFT     -  013613   SFTX    -  013614
SIGMA   -  013634   SIG1    -  013643   SIG2    -  013644   SNI     -  007351
SNJ     -  005401   TC      -  001461   TCC     -  013632   TCO     -  000003C01
TEMP    -  013622   TUNE    -  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(IPCS+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  04.17.43.  NORMAL                 CONTROL                                                          000100     151637     027614     122023
          ---TIME---LOAD MODE --L1--L2-----TYPE---------------USER---++---CALL-------------FWA LOAD--LWA LOAD--BLNK CCMN--LENGTH--
          FWA LOADER  152462  FWA TABLES  151645
          -PROGRAM----ADDRESS-                          --LABELED---COMMON--
          1T          00010C
          TORDER      022033
          SYSTEM      022223                                       SCOPE2       022223
          INPUTC      023327
          OUTPTC      024463
          IFENDF      026030
          SHIFT       026055
          FCSRW       026072
          ACGOER      026121
          SORT        026145
          SIUS        026225
          GETBA       027056
          C4020       027075
          OUTPTS      027204
          LABRT       027263
          BS4020      027372
          XRCL        027607
          --ENTRY-----ADDRESS-                                               REFERENCES
          1T          000101
          TORDER      022034             1T          000301     000337     000375

          Q8NTRY      022224             1T          000102

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

          SYSTEMC     022461
          SYSTEMP     022507
          END         022403             1T          001237     001241
                                         TORDER      022167
                                         LABRT       027351

          STOP        022434             1T          000277     000406

          EXIT        022426             LABRT       027333

          ABNORML     022444             INPUTC      023367     024254     024256
                                         OUTPTC      024500     025637
                                         IFENDF      026046
                                         ACGOER      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

KQUER      024632          OUTPTS    027211   027226

IFENDF     026031          IT        000217

SHIFT      026056          IT        000250   000255   000263   000315   000330   000353   000366
                                     000461   000472   000551   001044

SHIFN      026067
ECHR       026072          IT        000274

ECHO       026101          IT        000403

ACGOER     026122          IT        000642
                           LABRT     027302

SQRT       026146          IT        001146   001156   001201   001225

OKSPRU.    026526
FIZBAK.    026537
PUSFIL.    026574          OUTPTC    024523

ROPRU.     026604
DAT.       026626          INPUTC    023376   023353   023405
                           OUTPTC    024526   024550   024564
                           C4020     027146   027105   027117   027156
                           OUTPTS    027247   027222   027232

CIOL.      026473
OPEN.      026227          SYSTEM    023010
                           INPUTC    023351
                           OUTPTC    024513

SDI.       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=.000001000
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


  10283.15215649  10346.89144282  10457.31433992  10539.79362963  10556.59511522  10685.41399330  10819.37703175  10842.51778406
  10987.16810725  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


  13346.68042940  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  15006.91000000  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


  17362.22104074  17369.59018497  17467.85056421  17893.84191305  17908.01963355  17968.40329093  18186.01374519  18254.06660677
  18259.73948860  18296.15747135  18299.27087445  18382.88257143  18406.65480214  18530.42707401  18607.72145376  18749.59310280
  18759.02635351  18794.75631634  18839.38264655  18932.67134761  19114.75877778  19119.24196891  19126.83035724  19192.11639361


  19307.24073529  19472.24199838  19487.84317202  19552.27898284  19639.48673264  19646.54505099  19667.91640236  19782.93300764
  19826.71921593  19828.00830374  19864.06911342  19885.43974830  20114.16782812  20147.54543618  20218.82476459  20257.51318949
  20306.79112106  20311.29674061  20391.07392981  20420.18545095  20452.48499102  20464.41108073  20524.79882800  20528.12734037


  20568.77939188  20620.51773531  20650.59823389  20660.72946293  20711.03975372  20718.44566816  20766.07131446  20805.53127342
  20851.14038778  20943.26841554  21010.37097546  21061.82319555  21078.31439718  21185.66201250  21232.60260481  21264.44492758
  21329.42982459  21407.62284362  21409.22709634  21426.19423156  21448.90463883  21536.60184858  21535.31603659  21544.60917198


  21584.37396847  21636.88953280  21752.47512117  21766.10963323  21767.81668900  21829.85235848  21940.34975105  21957.96539371
  21975.56881631  21979.66954349  21992.50132125  22037.48638011  22055.81104463  22283.19300922  22368.26995755  22377.64021465
  22383.11905210  22409.36483943  22421.68862146  22463.82117393  22574.61455882  22582.47171161  22584.39829917  22599.62250000


  22623.97386262  22632.48154244  22633.83272845  22691.24951319  22700.34615900  22751.91000591  22753.52510878  22786.41632550
  22788.94668953  22862.17733896  22891.36813394  22908.40762373  22917.91294599  22963.76245921  23050.73694995  23057.30225472
  23069.62871299  23165.11805092  23186.90065227  23196.90712672  23211.08556146  23212.32378235  23271.95897615  23324.82211334


  23374.88395063  23378.21097500  23429.75311710  23432.68002620  23463.41468121  23486.70758862  23534.14985914  23543.13864106
  23560.34543484  23571.67682019  23707.60500791  23714.95171104  23734.25671116  23753.09705869  23754.73289808  23778.74263149
  23824.97257412  23843.17623550  23848.37233425  23872.67132685  23926.37086469  23932.79213150  23972.40792573  24002.08429776


  24021.19495386  24025.88111219  24066.25920052  24068.43000000  24082.16322383  24117.67319088  24153.52032451  24171.82937372
  24185.59477058  24195.72905824  24206.38257554  24220.55826378  24262.48272322  24322.87686284  24330.83578625  24333.69539776
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```

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31756.03551614	31776.26566532	31798.11187289	31804.02159954	31837.13248768	31853.20735290	31871.52358294	31909.06000000
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31994.56919180	32016.10505495	32043.54241577	32058.66352990	32096.74246880	32097.44747475	32107.46250539	32108.09405702
32141.04251923	32141.70142480	32158.92715517	32179.52913083	32192.67249251	32255.53545649	32270.50136341	32288.40835669
32309.91047248	32317.80302049	32326.35235294	32330.68601499	32367.37018787	32378.43825898	32381.56892045	32387.56932806
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32495.21844081	32523.68548077	32536.68142862	32545.33914668	32545.63657233	32574.06780882	32582.22500000	32585.18704811
32590.45912836	32603.71383824	32610.38759143	32614.93717085	32648.17496429	32669.79238396	32709.11503310	32723.08930317
32730.21120105	32742.51359852	32773.55909401	32780.49369855	32795.78551408	32802.19025363	32808.34752310	32841.63889205
32851.56567308	32879.80500000	32890.49468724	32902.78515808	32925.49306718	32928.05438289	32933.08339394	32944.67251968
32954.28781031	32976.88282172	32991.17228365	32997.22901417	33007.75451392	33042.11031250	33077.85177669	33089.67654412
33098.52160909	33117.68125786	33124.46651699	33135.62975034	33150.24038800	33154.80826312	33174.77718750	33176.43264706
33212.33511628	33228.11595588	33267.05812500	33281.72864168	33303.64883658	33320.39170829	33341.40547368	33345.40153223
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10 ITERATIONS DELTA= .004348414

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10987.19212063	11289.86952043	11307.75769175	11403.06822241	11444.22602214	11456.91617917	11558.30009539	11632.76591153
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16195.00464165	16293.66585925	16505.42852186	16887.93133668	16900.02732769	16929.40710831	17070.11616826	17154.46142816
17361.54173523	17369.19614985	17467.86442093	17893.52329451	17907.81635097	17968.36037289	18185.63976427	18253.51330199
18260.08473676	18295.41818907	18299.14272607	18382.88381197	18406.16437454	18530.43964290	18607.44267091	18749.48957321
18758.82049311	18794.46843375	18838.90384511	18932.40807736	19115.13979509	19119.39610483	19126.85191523	19192.04168535
19307.39038705	19471.50010117	19488.67793153	19552.15989842	19639.78782288	19647.14843832	19668.06433356	19782.97432591
19826.30992638	19828.12508944	19864.16094121	19885.15293758	20113.93730909	20147.66668480	20218.46741269	20257.78317024
20306.49581032	20311.18934391	20391.14934745	20420.15332680	20452.43789380	20464.16086816	20525.03084178	20528.53142961
20568.86271638	20620.93241619	20650.84566736	20661.14749263	20711.81620734	20718.67106243	20766.13969904	20805.43337011
20851.21461859	20943.06193535	21010.69576111	21061.97807796	21078.36489119	21185.48683869	21232.51519547	21264.72752645
21329.62595766	21407.49472879	21409.60803441	21426.11746229	21448.59318865	21536.48049972	21535.71151830	21544.77992549
21584.32672210	21636.58811821	21752.67817189	21766.16230057	21767.60287811	21829.99766451	21940.27088383	21957.82252191
21975.66104432	21979.74488324	21992.77903690	22037.66708045	22055.93162546	22283.05393047	22368.09749712	22377.39348768
22383.09279197	22409.27756523	22421.39055801	22463.92317415	22574.52919387	22582.28332921	22584.22071577	22599.58770452
22623.96635202	22632.78623996	22633.77118560	22691.13042909	22700.06448682	22752.05694624	22753.68804017	22786.23512165
22789.41662138	22862.07852363	22891.33493200	22908.43184838	22918.18363668	22964.18168191	23050.79214907	23057.30209374
23069.35030085	23165.27362134	23186.56639698	23196.63649059	23211.70771141	23212.12157337	23272.15181802	23324.81707702
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
23824.98804331	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	24195.34409678	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
24973.62461044	25009.35108898	25016.73199246	25068.34653405	25095.83514209	25098.25451744	25104.60340202	25160.39528259
25177.61121627	25200.10949565	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
25825.18313560	25905.76863310	25909.98552597	25917.75728233	25937.85199238	25961.34837786	25975.36145328	25997.40777119
26066.32096079	26098.06744114	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
28261.78047390	28267.89334877	28285.39703174	28341.16111625	28342.18403083	28355.05739905	28387.55247115	28435.53313519
28444.12828678	28450.68337719	28453.61457557	28469.79196347	28490.47219150	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	29682.35625620	29748.81205213	29752.88298180	29756.39725679	29790.34032852	29790.36782868
29796.88258865	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	30285.99991021	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
30702.45887928	30716.19586444	30747.49905455	30766.68424426	30829.49054006	30831.95977612	30840.76818246	30875.18975422
30877.96741198	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	31579.82464640	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
31920.68399893	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

32140.78705028	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	32614.38460164	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	33962.43481828	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
34662.54306413	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	3800.81729863	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	6249.00959173	6249.00000	.00959	10275724.64551
10	7005.51037297	7005.00000	.51037	11106825.86719
11	7103.89839641	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	7165474.98535
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	10080.99849620	10080.00000	.99849	4603952.88184
22	10103.40582002	10103.00000	.40582	123540.11084
23	10208.45499072	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	11464.58562666	11464.00000	.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	14411.38028666	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	11502.58871615	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	16294.02546517	16294.00000	.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	18406.52398984	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	234646.22168
62	20148.02629000	20148.00000	.02629	142310.11084
63	20218.82701696	20218.00000	.82702	274200.22168
64	20258.14277552	20258.00000	.14278	121177.11084
65	20306.85541636	20306.00000	.85542	122048.11084
66	20311.54894962	20311.00000	.54895	122443.11084
67	20391.50895113	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
4087.55399609	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
4174.53990777	4174.67000	-.14	100.00	15631.80669	11457.27579
4177.98054875	4178.03000	-.05	4.00	16121.88631	11943.90576
4181.05708698	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
4272.40403813	4273.24000	-.84	4.00	15831.06373	11558.65970
4276.09030198	4276.16000	-.07	4.00	17908.17596	13632.08565
4282.73974976	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
4338.46889069	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	4382.15000	.70	4.00	18794.82804	14411.38029
4427.07007153	4427.46000	-.39	4.00	19885.51254	15458.44247
4427.43790351	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
4522.06291809	4522.06000	.00	25.00	20766.49930	16244.43639
4531.72416158	4531.78000	-.06	25.00	19885.51254	15353.78838
4553.91371574	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
4574.69077069	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
4644.25696641	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
4677.30967900	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
4738.08966290	4738.07000	.02	100.00	16195.36425	11457.27579
4758.73683726	4758.74000	-.01	25.00	14839.73333	10080.99849
4812.75993730	4812.83000	-.07	25.00	19783.33393	14970.57499
4828.78749664	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
4912.25938944	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
4946.88376518	4946.86000	.03	25.00	13825.40647	8878.51770
4948.90125648	4948.90000	.01	25.00	18295.77780	13346.86854
4992.39190828	4992.76000	-.37	4.00	19783.33393	14790.94202
5007.10983365	5007.68000	-.58	4.00	17369.55576	12362.45492
5048.51234257	5048.47000	.04	25.00	16505.78813	11457.27579
5070.44956301	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
5105.76910394	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
5163.68193529	5163.59000	.09	4.00	15720.68451	10557.00258
5175.10265106	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
5239.60635028	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
5284.49615173	5284.51000	-.02	4.00	15631.80669	10347.31254
5296.64119717	5296.57000	.07	25.00	16929.76671	11633.12552
5301.98646905	5301.99000	-.00	25.00	16121.88631	10819.89984
5308.05603263	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
5412.31155966	5412.24000	.07	4.00	18759.18010	13346.86854
5412.71992269	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
5512.22951628	5512.20000	.03	25.00	15720.68451	10208.45500
5523.52609858	5523.48000	.05	25.00	21767.96248	16244.43639
5526.33988720	5526.29000	.05	25.00	16929.76671	11403.42783
5545.72103636	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
5564.88172795	5564.88000	.00	100.00	16121.88631	10557.00258

5569.18984246	5569.17000	.02	100.00	15638.33487	10069.14498
5576.97698629	5577.14000	-.16	4.00	13710.24181	8133.26483
5581.65451452	5581.69000	-.04	25.00	16121.88631	10540.23179
5589.63115911	5589.35000	.28	4.00	20943.42154	15353.78838
5598.64732749	5598.68000	-.03	4.00	20569.22232	14970.57499
5606.26605637	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
5637.89776394	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
5675.09143773	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
5737.02283746	5736.96000	.06	100.00	16294.02547	10557.00258
5740.52363113	5740.52000	.01	100.00	11502.58872	5762.06009
5767.82136638	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
5900.16966016	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
5940.39908589	5940.59000	-.19	4.00	16195.36425	10254.96516
5942.21698844	5942.14000	.07	100.00	16929.76671	10987.55173
5949.97714368	5950.23000	-.25	25.00	17893.88290	11943.90576
5960.83950035	5960.84000	-.00	4.00	23843.72510	17882.88552
5961.22785621	5962.16000	-.93	4.00	13825.40647	7864.17861
5962.75634209	5962.68000	.08	25.00	20464.52047	14501.76413
5966.12792832	5966.03000	.10	4.00	17369.55576	11403.42783
5968.03659612	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
6024.81522180	6024.72000	.09	4.00	17968.71998	11943.90576
6027.12690302	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
6044.06105850	6044.04000	.03	4.00	18406.52398	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
6064.79619861	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
6072.68868617	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
6108.14950287	6108.12000	.03	4.00	21078.72450	14970.57499
6110.39928046	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	24002.42581	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
6210.41167946	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	6264.94000	.07	100.00	19647.50804	13402.49440
6245.34735655	6245.99000	-.64	4.00	18607.80228	12362.45492
6250.82296556	6250.97000	-.15	4.00	16505.78813	10254.96516
6258.71385027	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
6294.51213794	6294.55000	-.04	4.00	21265.08713	14970.57499
6300.63950412	6300.58000	.06	25.00	19647.50804	13346.86854
6307.84464311	6308.20000	-.35	4.00	20851.57422	14543.72758
6309.52801232	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
6359.41056908	6359.45000	-.04	4.00	21329.98556	14970.57499
6361.15459050	6361.09000	.06	25.00	19489.03754	13127.88295
6372.76613716	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
6387.39425680	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
6410.06927765	6410.21000	-.15	100.00	17968.71998	11558.65970
6412.73452418	6412.67000	.06	100.00	21766.52191	15353.78838
6414.17419237	6414.15000	.02	4.00	21767.96248	15353.78838
6414.63099708	6414.69000	-.06	4.00	18383.24342	11968.61242
6421.87350449	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
6462.61922394	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
6479.80099321	6479.75000	.05	25.00	19826.66953	13346.86854
6483.01814356	6482.97000	.05	25.00	19885.51254	13402.49440
6490.45507291	6490.43000	.03	25.00	17893.88290	11403.42783
6504.74912903	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
30982.88936996	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
31011.30509010	31011.41000	-.10	400.00	34812.12239	3800.81730
31013.61344257	31013.72000	-.11	400.00	31633.93463	620.32119
31024.76068908	31024.87000	-.11	400.00	31024.76069	0.00000
31042.05800165	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
31108.15230007	31108.13000	.02	400.00	31728.47351	620.32119
31123.91620607	31124.03000	-.11	400.00	31744.23748	620.32119
31129.43818706	31129.52000	-.08	400.00	31129.43819	0.00000
31134.86948663	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
31175.67800365	31175.81000	-.13	400.00	34976.49530	3800.81730
31251.21035428	31251.31000	-.10	400.00	31871.53154	620.32119
31275.94333225	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
31374.78930709	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
32016.67378160	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	450.00	32255.94007	0.00000
32317.79150319	32317.85000	-.06	400.00	32317.79150	0.00000
32324.59657669	32324.64000	-.04	400.00	32944.91777	620.32119
32334.73406902	32334.79000	-.06	400.00	32955.05528	620.32119
32377.25404968	32377.40000	-.14	400.00	32997.57724	620.32119
32490.61228065	32490.73000	-.12	400.00	32490.61229	0.00000
32495.69304779	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
32574.57074364	32574.53000	.04	400.00	32574.57074	0.00000
32646.77605038	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
32791.88282260	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
33296.43469905	33296.55000	-.12	400.00	33916.75589	620.32119
33341.79152614	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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