

A PROGRAM FOR LEAST SQUARES ANALYSIS, OF
DATA WITH UNEQUAL SUBCLASS NUMBERS

By

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PREFACE

This program was written to mechanize the solution of a practical problem in the field of applied statistics. It demonstrates the flexibility and capacity of a medium-sized computer. Program storage space was held to a minimum by maintaining in memory only that portion of the program which was being utilized at that stage of data processing.

Indebtedness is acknowledged to Dr. Robert D. Morrison, who served as chairman of my advisory committee, for suggesting this problem and for his careful guidance in the development of this program; to Mr. Paul Eugene Pulley, Jr., for his numerous suggestions and tireless efforts in assisting in the programming of this problem; to Dr. David L. Weeks for suggestions concerning matrix notation; to Dr. O. H. Hamilton for serving on my advisory committee; to Dr. L. Wayne Johnson for giving me the opportunity to work at the Oklahoma State University Computing Center; and to my wife, Flodema, for her unselfish sacrifices and contribution to this program.

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CHAPTER I

INTRODUCTION

In many cases the least squares analysis of data with unequal subclass numbers is obtained by solving the normal equations. This set of normal equations in most cases is a less than full rank system. In order to get a unique solution, restrictions are made on the set so that the new system will be of full rank.

One way to arrive at a unique solution is to obtain the normal equations, make a transformation on the set of equations, then invert the coefficient matrix. This thesis describes how to carry out this procedure on the IBM 650 Electronic Digital Computing Machine equipped with floating point device, index register and sixty words of immediate access core storage for models having no more than two way interactions and at least one observation in each cell.

Due to the size of memory storage and the fact that matrix manipulations require a large storage, the program consists of three basic phases:

- (1) Phase I is the program for building the normal equations from the raw data.
- (2) Phase II is the program for making the transformation on the equations so that the new system is reduced to full rank.

- (3) Phase III is the program for inverting the matrix, obtaining estimates of the parameters and obtaining reductions in the sums of squares for each set of attributes after adjusting for all others.

The Programs are given in Appendix A, Tables 1, 2 and 3, respectively.

Due to storage limitation card handling could not be avoided. The overall procedure has been arranged to accomplish the following objectives:

- (1) To operate the Computing Machine with ease.
- (2) To require a minimum amount of card handling.
- (3) To give optional read-in and punch-out features.
- (4) To be able to start at any one of four particular levels of processing.
- (5) To keep a maximum size of matrix.
- (6) To exhibit the results so that they can easily be identified.
- (7) To use a standard (80-80) board in the 533 Machine, i.e., a panel wired such that the data can be in the format of eight ten digit words as indicated on an IBM 5280 General Purpose Eight Field Card.

CHAPTER II

THE PROGRAM: PHASES I AND II

Procedures for Processing

Phase I consists of a program from the library of the Oklahoma State University Computing Center which is used to obtain sums of squares and crossproducts. Operation procedures for this program have already been written and are on file in the Oklahoma State University Computing Center. The write-up for Phase I is in Appendix B. Phase I is the first level of processing.

The basic function of Phase II is to make the transformation on the normal equations. Let $X'XB = X'Y$ be the normal equations where $X'X$ and $X'Y$ are the sums of squares and crossproducts produced by Phase I. The matrix $X'X$ will be assumed to be a $(p \times p)$ matrix of rank n , $n \leq p$; $X'Y$ is a $(p \times r)$ matrix. If $T_L = T \mid \emptyset$ and $T_R = \frac{T'}{\emptyset} \mid \frac{\emptyset}{I}$ where T_R is $(p+r) \times (n+r)$, T_L is $(n) \times (p+r)$, T' is $(p \times n)$, \emptyset is a matrix of zeros, I is an $(r \times r)$ identity matrix and T is constructed so that $T(X'X)T' = R$, where R is $(n \times n)$ of rank n . If $A = \frac{X'X \mid X'Y}{Y'X \mid Y'Y}$, $T_L A T_R = (T \mid \emptyset) \left(\frac{X'X \mid X'Y}{Y'X \mid Y'Y} \right) \left(\frac{T'}{\emptyset} \mid \frac{\emptyset}{I} \right) = T X'X T' \mid T X'Y = R \mid G$ where $G = T X'Y$. This phase of the program calculates $R \mid G$.

The elements of the transformation matrix are determined

by the mathematical model and the restrictions made on the parameters. This phase is applicable for any model to which the T matrix can be constructed. Essentially the T matrix is a set of restrictions on the set of equations $X'XB = X'Y$ so that a particular solution can be found for the normal equations.

In order to explain the details of the operating procedures, a set of data $X | Y$ from a pamphlet by Harvey¹ will be used. The data in punch-card format with proper header card and proper trailer card is given in Appendix A, Table 4. The layout of the header card and trailer card is given in Appendix A, Tables 5 and 6 respectively. The format for $X | Y$ is given in Appendix A, Table 7. The output of Phase I with header card is in Appendix A, Table 8.

Three right hand members have been used in order to show the flexibility of the program. The first of these is the actual data in Harvey's² pamphlet; the other two are fictitious data.

The mathematical model underlying the analysis to be made with these data is

$$y_{ijklm} = u + g_i + s_{ij} + a_k + (ga)_{ik} + bA_{ijklm} + dW_{ijklm} + e_{ijklm}$$

$$i = 1, 2, 3 \qquad k = 1, 2, 3$$

$$j = 1, 2, 3, \dots, \qquad m = 1, 2, \dots,$$

¹Walter R. Harvey, Least Squares Analysis of Data with Unequal Subclass Numbers, Agricultural Research Service Pub. No. ARS-20-8 (Washington, 1960), P. 103.

²Ibid.

where: y_{ijklm} = the average daily gain for the m^{th} steer in the k^{th} age of dam class by the j^{th} sire of the i^{th} line,

u = the theoretical population mean with equal subclass frequencies when weaning age and initial weight both are equal to the absurd value of zero. The population mean with equal frequencies when the weaning age and initial weight both are equal to the average is

$$= u + b\bar{A} + d\bar{W},$$

g_i = effect of the i^{th} breeding group or line,

s_{ij} = effect of the j^{th} sire in the i^{th} line,

a_k = effect of the k^{th} age of dam class,

$(ga)_{ik}$ = interaction effect for line and age of dam,

b = partial regression of average daily gain (ADG) on age at weaning. Since all steers were placed on test at the same time this regression coefficient will measure the effect of time of birth on ADG in the feed lot,

A_{ijklm} = age at weaning for a given steer,

d = partial regression of ADG on initial weight,

W_{ijklm} = initial weight for a given steer,

e_{ijklm} = random error.

Since the example output of the Phase I program is a $(p + r) \times (p + r)$ matrix, the T_R matrix must be a $(p + r) \times (n + r)$ in which n is the rank of the reduced matrix R , r is the number of right hand members in the system and p is the dimension of the $X'X$ matrix. For this sample case n is 17, r is 3 and p is 27, making T_R a 30 x 20 matrix.

A Program for Least Squares Analysis of Data with Unequal Subclass Numbers assumes the T_R matrix is already built.

The T_R matrix may be stored in the machine or it may be read in by this program. It may be in fixed-point or in either of two floating-point modes. The card format is the same as the Phase I output. The two floating-point formats are (1) 50x.xxxxxxx and (2) x.xxxxxxx51; the fixed-point format is 0000000001.

If the T_R matrix is already stored in the machine it must be in row sort with the first element in location 0000 and the elements must be in the floating-point mode x.xxxxxxx51.

If the T_R matrix is to be read into the machine by this program it must be preceded by a proper header card. The T_R matrix header card format is given in Appendix A, Table 9.

The T_R matrix for this example was constructed in the fixed-point mode and is given with the header card in Appendix A, Table 10.

The following is a step by step description of the technique used in constructing the T_R matrix for this example from a 30 x 30 identity matrix:

- (1) Subtract the matrix row associated with (g_3), the last g row, from all the other g rows, i.e., from rows g_1 and g_2 . Delete the g_3 row of the matrix.
- (2) Subtract the row associated with s_{1k} from each row, $s_{11}, s_{12} \dots s_{1, k-1}$ where k is the last group in the s_{1j} group. Delete the s_{1k} row of the matrix from this group.
- (3) Repeat step 2 above for the remaining rows.

- (4) In the same manner as step 1 above, subtract the matrix row associated with the last a row, (a_3), from all the other a rows, i.e., a_1 and a_2 . Delete the last a row from the matrix.

It will be noted that the subsequent steps which are for the rows associated with the interaction part of the model are somewhat more complex. The row associated with the ik subscripts in this part of the T_R matrix is obtained by the formula below in which each term represents a row:

$$g^{a_{ik}} - g^{a_{iq}} - g^{a_{pk}} + g^{a_{pq}}$$

$$\text{where } i = 1, 2, \dots, p$$

$$k = 1, 2, \dots, q$$

For this example $p = 3$, $q = 3$. The rows obtained are indicated below:

$$g^{a_{11}} - g^{a_{13}} - g^{a_{31}} + g^{a_{33}}$$

$$g^{a_{12}} - g^{a_{13}} - g^{a_{32}} + g^{a_{33}}$$

$$* \quad g^{a_{13}} - g^{a_{13}} - g^{a_{33}} + g^{a_{33}}$$

$$g^{a_{21}} - g^{a_{23}} - g^{a_{31}} + g^{a_{33}}$$

$$g^{a_{22}} - g^{a_{23}} - g^{a_{32}} + g^{a_{33}}$$

$$* \quad g^{a_{23}} - g^{a_{23}} - g^{a_{33}} + g^{a_{33}}$$

$$* \quad g^{a_{31}} - g^{a_{33}} - g^{a_{31}} + g^{a_{33}}$$

$$* \quad g^{a_{32}} - g^{a_{33}} - g^{a_{32}} + g^{a_{33}}$$

$$* \quad g^{a_{33}} - g^{a_{33}} - g^{a_{33}} + g^{a_{33}}$$

- (5) Subsequently remove from the matrix the rows corresponding to $g^{a_{iq}}$, $g^{a_{pk}}$ and $g^{a_{pq}}$. These are indicated by an asterisk (*) in the above list.

The remainder of the T_R matrix remains unaltered.

The loading routine for the T_R matrix requires the omission of the rows prescribed in the steps above. It is necessary however that the remaining rows be in proper sort. The row numbers must be in ascending order but it is not necessary that they be consecutive.

The Phase II Program consists of Part 1 and Part 2. The function of Part 1 is to read the T_R matrix into the machine. This is the second level of processing. If the T_R matrix is already on the drum then this part of the program need not be used, i.e., do not place Part 1 in the Read Hopper.

The function of Part 2 is to perform the multiplication $T_L A T_R$. This part assumes the T_R matrix is already on the drum.

It is necessary that the A matrix be preceded by a header card since the A matrix may be in fixed-point or one of the two floating-point formats. The header card format is the same as for the T_R matrix. The header card and the A matrix are given in Appendix A, Table 8.

The order of assembly for Phase II is as follows:

Part 1

- (1) Program: The first and second cards are drum clear cards. The third, fourth and fifth cards constitute the seven-per-card load routine. The next seventeen cards constitute the actual program which is followed by a transfer card (to transfer out of the seven-per-card load routine). The first five cards

and the last card are load cards.

- (2) Blank card
- (3) Header card (non-load): See Appendix A, Table 10.
- (4) T_R matrix (non-load)

Part 2

- (5) Program: The first, second and third cards constitute the seven-per-card load routine. The next thirty cards constitute the actual program. This is followed by a transfer card (to transfer out of the seven-per-card load routine). The first three cards and the last card are load cards.
- (6) Header card (non-load): See Appendix A, Table 8.
- (7) A matrix (non-load)

Three decks of cards constitute the output of Phase II. They are in non-load normal floating-point form. The deck number is punched in card column one. The designation is as follows:

Deck 1 is the intermediate product AT_R .

Deck 2 is the T_L matrix which is obtained by the program from the T_R matrix.

Deck 3 is the product $T_L AT_R = R | G$.

The output format is:

Word 1 wiiiiiyzz where w is the deck number

iiii is the corresponding identification in columns two through six of Word 2 in the A matrix header card

yy is the row number

zz is the card number for the row specified by yy

Words 2 through 8 are the elements of the matrices Decks 1, 2 and 3 for this sample case are given in Appendix A, Tables 11, 12 and 13 respectively.

Operating Instructions

Phase I

The instructions for Phase I are in Appendix B of this thesis.

Phase II

- (1) Assemble the programs and data as described above and place in the Read Feed Hopper of the machine.
- (2) Set the Console: 70 1951 xxxx + Control Run Programmed Stop Half Cycle Run Error Stop Display Program Register Overflow Stop
- (3) Place a standard (80-80) board in the 533 Read Punch Machine.
- (4) Clear the Punch Hopper and load it with blank cards.
- (5) Depress Computer Reset, Program Start and Read Feed Start in that order. This will cause the machine to read in the program and data. The machine will calculate and punch decks 1 and 2 and will halt with 01 1212 1926 in the Program Register.
- (6) Remove decks 1 and 2 from the Punch Hopper; discard the first and last cards which are blank.
- (7) Place decks 1 and 2 from step 6 above (AT_R and T_L

respectively) in the Read Feed Hopper without disturbing the order.

- (8) Depress Program Start. At this point the machine will complete the calculation and punch $T_L A T_R = R | G$, i.e., the reduced normal equations.
- (9) Remove the cards from the Punch Hopper. Discard the first and last cards which are blank.

This completes the operations for Phase II. The $R | G$ matrix is left on the drum in the proper location for Phase III.

CHAPTER III

THE PROGRAM: PHASE III

Procedures for Processing

The Phase III Program consists of Parts 1, 2, 3, 4 and 5.

The function of Part 1 is to read the $R \mid G$ matrix into the machine. This is the third level of processing. It is necessary that this part of the program be followed by a control card. The control card permits the machine to omit the reading of the $R \mid G$ matrix, i.e., if the $R \mid G$ matrix is already stored in the machine with the first element in location 0001 and the elements in the floating-point mode $x.xxxxxxx51$. The format for the $R \mid G$ matrix control card is given in Appendix A, Table 14. The control card for this case is given in Appendix A, Table 15.

The function of Part 2 is to invert the R partition of the $R \mid G$ matrix. This is the fourth level of processing. There is no additional control required for Part 2.

The function of Part 3 is to punch the inverse of the R matrix and the solutions. The inverse and solution $R^{-1} \mid B$ are punched out only if the console is set minus (-). The matrix $R^{-1} \mid B$ for this case is given in Appendix A, Table 16.

The function of Part 4 is to punch segments of the solution vectors (beta vectors) of the $R \mid G$ matrix and the asso-

ciated control cards for Part 5. These vectors and control cards must be removed from the Punch Hopper and be placed in the Read Feed Hopper behind the program for Part 5. The beta vectors and control cards are shown in Appendix A, Table 17, and the formats are shown in Tables 18 and 19 respectively.

The function of Part 5 is to invert the segments on the diagonal of $R^{-1} | B$ and to calculate and punch the scalar value associated with the reduction in the sum of squares to each attribute. The scalars for this case are shown in Appendix A, Table 20, and the format is shown in Table 21.

The order of assembly for Phase III is as follows:

Part 1

- (1) Program: The first card is a program title card. The second and third cards are drum clear cards. The fourth, fifth and sixth cards constitute the seven-per-card load routine. The next twenty-three cards constitute the program. The first six cards and the last card are load cards. These are followed by a blank card which precedes the following specified cards.
- (2) Control card (non-load): See Appendix A, Table 15
- (3) $R | G$ matrix (non-load)

Part 2

- (4) Program: The first thirty-one cards constitute the actual program. These cards are followed by a transfer card (the only load card) to transfer out

of the seven-per-card load routine.

Part 3

- (5) Program: The first thirty-three cards constitute the actual program. These cards are followed by a transfer card (the only load card) to transfer out of the seven-per-card load routine.

Part 4

- (6) Program: The first thirty-five cards constitute the actual program. These cards are followed by a transfer card (the only load card) to transfer out of the seven-per-card load routine.

Part 5

- (7) Program: The first forty cards constitute the actual program. These cards are followed by a transfer card (the only load card) to transfer out of the seven-per-card load routine.
- (8) Beta vectors and control cards (output from Part 4)

Operating Instructions

Phase III

- (1) Assemble the programs and data as described above, except for step 8, and place in the Read Feed Hopper of the machine.
- (2) Set the Console: 70 1951 xxxx ⁺ If the Console is set minus (-) the machine will punch R^{-1} | B. If the Console is set plus (+) the machine will not punch R^{-1} | B. Programmed Stop Address Anything

Half Cycle Run Display Program Register
 Overflow Stop Error Stop Control Run

- (3) Place a standard (80-80) board in the 533 Read Punch Machine.
- (4) Clear the Punch Hopper and load with blank cards.
- (5) Depress Computer Reset, Program Start and Read Feed Start in that order. This will cause the program to read in the reduced normal equations and calculate the inverse of the coefficient matrix and the solution vectors.
- (6) If the Console is set minus (-) the program will punch $R^{-1} | B$ and halt; 01 1999 1999 will appear in the Program Register. Remove the punched cards from the Punch Hopper. These cards cannot be used for any of the subsequent machine calculations.
- (6a) If the Console is set plus (+), $R^{-1} | B$ will not be punched out. The program will operate without interruption and step 7 will be automatic.
- (7) Depress Program Start. At this point the program will punch the segments of the beta vectors and the associated control cards.
- (8) Remove the punched cards from the Punch Hopper. Discard the first and last cards which are blank and place the remaining punched cards behind the last card of the program (Part 5). The program will continue to completion of Phase III.

CHAPTER IV

SUMMARY OF INSTRUCTIONS AND LIMITS OF MAGNITUDE OF MATRICES

Instructions

Phase I

Console Setting: 70 1951 3000 † Programmed Run
Half Cycle Run Control Run Error Stop
Address Selection xxxx Display Program Register
Overflow Stop
Input: Header card (load)
X | Y matrix (non-load)
Trailer card (load)
Output: A matrix

Phase II

Console Setting: 70 1951 xxxx † Programmed Stop
Half Cycle Run Control Run Error Stop
Address Selection xxxx Display Program Register
Overflow Stop
Input: Header card (non-load). Insert behind the
blank card which separates Parts 1 and 2.
Leave the blank card in the program.
 T_R matrix (non-load)
A matrix (non-load)

Output: AT_R matrix (non-load)

T_L matrix (non-load)

Note: At this point the program will halt and 01 1212 1926 will appear in the Program Register. Remove the punched cards from the Punch Hopper and discard the first and last cards which are blank. Place this output (AT_R and T_L respectively) in the Read Feed Hopper, without disturbing the order, and depress Program Start.

Output (continued): R | G matrix (non-load)

Programmed Halts: Reason:

Part 1

01 1243 1946	T_R matrix out of sort
01 1953 1946	Word 3 of the Header card contains some number other than 0, 1 or 2.

Part 2

01 1212 1926	See (Note:) above
01 1243 1946	The matrix being read is out of sort.
01 0003 1946	Word 3 of the Header card contains some number other than 0, 1 or 2.

Phase III

Console Setting: 70 1951 xxxx \pm If the Console is set minus (-) the machine will punch R^{-1} | B. If the Console is set plus (+) the machine will not punch R^{-1} | B.

Half Cycle Run Control Run Error Stop

Address Selection xxxx Display Program Register
 Programmed Stop Overflow Stop

Input: Header card (non-load). Insert behind the blank card which separates Parts 1 and 2. Leave the blank card in the program.

$R \mid G$ matrix

Output: If the Console is set minus (-) the output is $R^{-1} \mid B$ and the program will halt with 01 1999 1999 appearing in the Program Register.

Note: Remove the output from the Punch Hopper; these cards cannot be used for any of the subsequent machine calculations.

Output (continued): Beta vectors and Control cards

Note: Remove the first and last cards which are blank and place this output in the Read Feed Hopper behind Part 5 of the program.

Output (continued): Scalar values, i.e., reductions in the sum of squares.

Programmed Halts:	Reason:
01 1111 1650	The header card specifies the number of rows in the partitions, and the number of rows of the $R \mid G$ matrix; these two numbers do not agree.
01 1650 1650	$R \mid G$ out of sort
01 1999 1999	$R^{-1} \mid B$ was punched out

Limits of Matrices

Matrix	Limits (maximum)
$X Y$	47 variables, i.e., 47 columns
T_R	42 x 43 (or no more than 1806 elements)
A	42 x 42
AT_R	42 x 43 (or no more than 1806 elements)
$R G$	$(NX + 1)(NX + NY) \leq 1630$ NX is the number of rows in $R G$. NY is the number of right hand members.

Note: If NY is 1 then the maximum size of $R | G$ will be 39 x 40. This does not allow T_L , A and AT_R to be maximum size.

APPENDIX A

TABLE I

PROGRAM LISTING OF PHASE I

8000501954	4019531956	5100018003	6119551952	2092101952	7090029900	1519589004	813008000
6090031957	2920009005	2790108003	5119509006	4090079009	5090089004	2000	2790008002
6919521958	7019950000	2419961957	6919541953	2419971954	6919561955	7019510000	2419991956
6919521953	6919521951	2419951958				2419981999	6919581957
2419071996	6919271962	2419221997	7	2419391998	10000	2419681999	2219631971
2419081996	6919281962	2419231997	1080018002	2419401998	6519521911	2419691999	1080011976
2419091996	6919291962	2419241997	1080011934	2419411998	1119151920	2419701999	2219631967
2419101996	6919631968	2419251997	2219778002	2419421998	1619151937	2419711999	2019918001
2419111996	1019141919	2419261997	7119771911	2419431998	1519531941	2419721999	1019911948
2419121996	1019391944	2419271997	6019521963	2419441998	1619531913	2419741999	2219791991
2419131996	1180031921	2419281997	1019521963	2419461998	1019491961	2419751999	2219911965
2419141996	2419781912	2419291997	1119521963	2419481998	6919631970	2419761999	1119791932
2419151996	2419851912	2419301997	1519331989	2419611998	1519641969	2419871999	7019943000
2419161996	1519771917	2419321997	4419351987	2419621998	2419331987	2419881999	6519911946
2419171996	2019771918	2419331997	6019521963	2419631998	2100001988	2419891999	2419491974
2419181996	7119771987	2419341997	1519391943	2419641998	10000	2419911999	6000001949
2419191996	6919221925	2419351997	1080011993	2419651998	3500041930	2419931999	2119491910
2419201996	4419231926	2419361997	6580011942	2419661998	4680011972	2419941999	6519511966
2419211996	4519241936	2419371997	3000041916	2419671987	6980031975	24 1999	
11270007	111273333	2411311134	2419551208	6512191173		1119541309	1512191156
11340007	6519771181	1719541259	111363333	1511401145	6080021147	1012031157	1
11410007	1011361206	6911961299	1119641419	1680021453	3500021151	6911991352	3600001469
11480007	5	2313531356	2411531156	2019771130	2119851338	111533333	111543333
11550007	100001459	2011611164	2112121265	1580011165	1519641369	4512641465	111613333
11620007	1512231269	6980031170	1019641169	2012191172	1112741279	2411311484	1580011173
11690007	2111741177	9812731325	1180021129	6911751128	1619641269	111743333	6512231227
11760007	25420000	2419551158	2412811184	1116161221	9811831265	3000021137	49
11830007	6580021141	2011891136	1912231144	2012741264	2012201189	111883333	111893333
11900007	1612931197	1511941197	2111531456	1712741379	3508901417	1911481451	1417

TABLE I (continued)

11970007	2019541358	1511528002	6913251202	2412031206	3500021457	2412741428	112033333
12040007	4512581281	1916171391	1112091163	2119541257	4612111162	25410000	4613631314
12110007	6912141167	6516171201	6980031270	6011741179	4511681319	6500001300	1511891143
12180007	2000001250	112193333	112203333	4412751153	6519551159	112233333	112243333
12250007	2411318001	2112241477	1611611215	6780031285	4611321233	3000011337	2111361139
12320007	2019781331	1019541309	4511381375	1711881193	2112201374	4611901191	112383333
12390007	1514171471	1513938002	2119841338	6913001603	1613201276	6580031451	2019771280
12460007	6016041291	1012521360	6514781336	1514521410	6012121217	3500021308	6500001301
12530007	112533333	3500021311	1014611354	6913591312	6080021365	6080021317	1712621267
12600007	3000021467	6512741954	50	4611661367	6512881343	6912181271	2012091316
12670007	1812201425	26180000	2012238001	9813731475	2213751178	2112381341	1011761231
12740007	112743333	1080011133	3500041237	2112121315	6080031335	1013531357	7119771378
12810007	112813333	6012861291	2014171131	1112091213	1512381243	6519521310	6480011601
12880007	5000000000	2399900000	6500001417	1519771332	6912461399	3108901417	2012531256
12950007	4511981326	2419561411	6512981255	6013051462	2413751192	3500021207	4512541155
13020007	6516171372	6913061423	1013461354	6516171474	69	6512741229	2012741228
13090007	3000021375	4513641907	2012741278	2411311284	1680021417	1580011421	1112681323
13160007	6913661416	6913201423	113183333	6912221225	59	6412241234	4513761380
13230007	6980031180	1513281283	6014781333	6519771481	6880021135	2019851331	1113531357
13300007	2319778003	6613341239	1519641370	1019641669	2019841331	1912881458	1512898002
13370007	6080021195	1612411295	1080021247	2112741440	2019521478	6512461454	1080011351
13440007	4412971298	4612481325	6516171600	6913251150	6512681448	6912511299	2412531256
13510007	1912741244	2412811600	113533333	6912511449	6919601414	6580031263	3000021281
13580007	9712611313	6011541284	1519641420	25	4110000000	1580011371	3500011272
13650007	3000011321	6913801483	1012741329	113683333	1016161171	1680021330	1580011230
13720007	6914261480	1011761450	2012241274	113753333	1580011339	3600001149	6512321283
13790007	1811821187	6019561291	6014391443	6512901395	6013251142	6013941349	6013251142
13860007	6013251349	6913421296	6513981304	6512901347	6513971347	1112741441	6014451249
13930007	2119781338	6516171472	6913921150	2111881446	6500001251	6519591413	2419561325
14100007	6914631200	6513251442	1516651470	1616161322	2216161447	1180031473	2414781466
14170007	2019781331	114183333	1580011277	2219591412	1019551260	1980011146	2412741377

TABLE I (continued)

14240006	6914441200	2019541307	6914821167	6080021185	3500021236	3000011186	2412741377
14370007	4512401131	1080011345	6516171417	2019541189	1619541600	1013461602	6913251350
14440007	273-6016171212	2012231212	6919531464	1516161455	2413751294	2111548001	
14510007	1012741479	6000001205	3600001226	1014611602	2011761605	6514601156	2112741427
14580007	1013611415	6513621467	6500001300	6516171300	1512161424	4099999872	2419771348
14650007	6512741429	6012521666	114673333	114683333	2112741327	2214671670	4513241326
14720007	6914761352	2419551160	3500021396	6912531167	6912421202	6880021235	6913801483
14790007	1680021287	2411311417	1511401245	6016171422	4480011438	6514171671	2118441497
14860007	1499991898	6919991502	6019511888	6914921495	6519511506	2018241527	2130041820
14930007	2018881543	6017011690	2418461749	4415011738	1515001606	2418901493	1019021510
15000007	3600019684	6919381693	2219998003	6516071773	6080031512	3000011511	3500021514
15070007	3500011516	6518661672	6916751729	6918741728	3500011517	2416161519	3500041523
15140007	2019511504	6915181521	2019511704	1580011525	6916741727	1580011678	1017241529
15210007	2419871972	3500041533	1517371491	6516161522	6915281531	6519511730	6519601515
15280007	16070000	1515321487	6518321842	2319601513	1915521823	1080021691	3500011692
15350007	6914881728	6519991736	2019511754	3500011496	1180031697	4414941694	1980021714
15420003	6918951495	6519511538	115443333	3500011496	1180031697	4414941694	1980021714
15390007	1180031697	4414941694	1980021714	6918951495	6519511538	115443333	115453333
15460007	115463333	115473333	115483333	1915521823	115503333	115513333	115523333
15530007	115533333	115543333	115553333	115563333	115573333	115583333	115593333
15600007	115603333	115613333	115623333	115633333	115643333	115653333	115663333
15670007	115673333	115683333	115693333	115703333	115713333	115723333	115733333
15740007	115743333	115753333	115763333	115773333	115783333	115793333	115803333
15810007	115813333	115823333	115833333	115843333	115853333	115863333	115873333
15880007	115883333	115893333	115903333	115913333	115923333	115933333	115943333
15950007	115953333	115963333	115973333	115983333	115993333	4413031204	1680011210
16020007	6911961449	2412811292	6012381344	1619641266	2018211524	116073333	116083333
16090007	116093333	116103333	116113333	116123333	116133333	2419871940	116153333
16060007	2018211524	116073333	116083333	116093333	116103333	116113333	116123333
16130002	116133333	2419871940	116083333	116093333	116103333	116113333	116123333
16630007	116633333	116643333	2016171398	2212521302	116673333	116683333	2114781282

TABLE I (continued)

16700002	2112528001	1612321437	2016171398	2212521302	116673333	116683333	2114781282
16720007	2419961499	1516761681	7019943000	6518141773	6916178003	2419871940	1019311485
16790007	100011716	2018161526	2419521707	6519851489	1016861541	6516871992	2117771680
16860007	5000	2117421795	1580031695	2117601789	1517061740	2416161520	2019511904
16930007	2417721539	6018971744	1519521713	6917461990	3500021689	2018481998	6015031725
17000007	6516161673	1041031853	6519511507	1517561761	4415081509	2418591712	6516171788
17070007	2019531708	6917111614	2418481788	6516161973	6019531858	6916151718	2019531766
17140007	1980021688	6517701775	7019951995	2417261739	2417501903	1618241881	4617231774
17210007	1580011679	790000	6517261731	2015491702	1515301535	6514311741	2419871490
17280007	2418321685	2419961699	3500011537	1519391796	6514861542	6519511534	6517371892
17350007	1519511815	6917391498	6516071767	6917431693	6917501812	6916151990	1017521761
17420007	117423333	7019961996	1519471696	1517481803	4699991803	3500011540	5000000000
17490007	2016151733	117503333	2017561762	100000		4416821732	2016171900
17560007	117563333	1517601716	6917631717	3500041822	117603333	1119641720	1017658003
17630007	6514291741	4517211996	6017421400	6916741677	4618701880	1517221878	6917761781
17700007	2415431865	1680021882	7019961996	6917761779	1180031783	2418791782	6019521888
17770007	2118851889	2018311787	2418321786	2018851896	3500041790	6517351890	3500011794
17840007	1018371891	1580031793	3500011894	6918401893	1517911755	1180031747	1080011797
17910007	1	1018471851	6980021799	2417981751	6017981703	2017268001	2117531818
17980007	117983333	9618021804	6516071767	1680021759	1018081873	2030041820	1618071811
18050007	1519641719	1118091813	890000	3500001771	6015450000	2218151768	1180021819
18120007	2418231777	4618161817	118143333	3540021771	6518321842	2018231826	6518211876
18190007	1018721877	6518231827	3600019684	2418251828	1530031898	6516071767	118253333
18260007	1018291833	1518301835	1518311785	6015440000	10000	890000	6518851839
18330007	2118388001	2118391818	1018381843	2418391792	10000	6015441549	3540011847
18400007	1519511815	1618441899	1518451850	6918461849	3899269729	10000	2031041820
18470007	1519521815	6017011705	2218031806	1617531857	6918551810	6918071864	2140041820
18540007	2418141769	3500001771	6918591862	4518601861	2219521710	1041031853	1580011867
18610007	6518141869	2218651868	2118251778	2418311734	1040031853	6518251880	2018321818
18680007	1518711875	4517721848	6180021780	299260045	3500001847	2018311834	6518851839
18750007	2018791832	1518791883	1180031836	2218311784	2415441865	4518871886	4518841848

TABLE I (continued)

18820007	2418851888	2018381841	1580011892		6518001805	3500011801	2117421795
18890007	2018471852	2117981758	2118471818	2018008001	2418471772	1680021854	2030041820
18960007	1518071863	1853	4419011803	2018531856	7019971715	100011905	2118851889
19030004	6917061709	4416841536	6080031803	4680011715	7019971715	100011905	2118851889
19310001	3899269729	4416841536	6080031803	4680011715	7019971715	100011905	2118851889
19380001	6519511757	4416841536	6080031803	4680011715	7019971715	100011905	2118851889
19450001	2117981758	4416841536	6080031803	4680011715	7019971715	100011905	2118851889
19470001	6017011705	4416841536	6080031803	4680011715	7019971715	100011905	2118851889
19500001	6619511505	4416841536	6080031803	4680011715	7019971715	100011905	2118851889
19730001	3000041683	4416841536	6080031803	4680011715	7019971715	100011905	2118851889
19900001	2417501698	4416841536	6080031803	4680011715	7019971715	100011905	2118851889
19920001	6919451498	4416841536	6080031803	4680011715	7019971715	100011905	2118851889
19950005	1619511764	6518141773	6519511906	2118591900	2115521879	100011905	2118851889
7019503000-							

TABLE II

PROGRAM LISTING OF PHASE II, PART 1

8000501954	4019531956	5100018003	6119551952	2092101952	7090029900	1519589004	813008000
6090031957	2920009005	2790108003	5119509006	4090079009	5090089004	2000	2790008002
7090109010							
7090029002		6939511988	5220001987	5100011991	3000041986	6519511985	7019981998
2119841999	4680021989	8280021995	5300011994	2440001990	8080021997	5300011996	4019941999
18510007	3500021907		6919251978	2419321886	1619321887		3500061871
18580007	4519121863	5900061965	6080021920			6918661969	
18650007	6519531858	99		5800071886	4518721873	2019251878	6580021879
18720007	1619151919	6918761969		6018901895	98		2119321935
18790007	3500021885	9218831936		8280011888	6580031894	4019378000	2118901893
18860007	6079521908	4619401941	1619151870			8800001897	1119451949
18930007	6580021851	3500021901	1918621882		7019631963		5300011905
19010007	1580031860				4218591909		2118621865
19080007	6919721975	6918621916			1619151869		
19150007	1	8280011891			4519221923	3919731936	
19220007	119531946	6919261969			89		3500021938
19350007	8000001891	2120001853	5080011943	4618921942		112431946	6919511854
19420007	1019451949	5000011899			58	7019611961	
19490002	3280021936				58	7019611961	
19610007	7019621962	6719521857	6519511855		4818681897		
19690007	2419721875				1000000052		9119281880
19780007	5180011884						
1946-TRANSFER OUT OF SEVEN PER CARD READ							

TABLE II (continued)

PROGRAM LISTING OF PHASE II, PART 2

7090109010								
7090029002		6939511988	5220001987	5100011991	3000041986	6519511985	7019981998	
2I19841999	4680021989	8280021995	5300011994	2440001990	8080021997	5300011996	4019941999	
90120007	6020009013	3940009014	3296039015	2196039016	5000019017	5200019018	6580069019	
90190007	1490109020	4490129021	1690019022	4590231835	5900069024	4890251844	5800079026	
90260007	8090119012	3500029028	4690309029	1090429031	1190429031	3280021874	6580039033	
90330007	3500029034	1580039035	6080029036	3990431874	99	98	89	
90400007	1	1000000000	58	1000000052				
18060007	8800001912	2018111814	6990001964	2418121815	8001011966			
18130007	3000011819	4418171868	6918181821	7190021866	1190401825	999	1090411877	
18200007	1690401828	2490441827	2420001963	3000021879	2490001880	4418291830	2490441882	
18270007	6019531807	2018641968	1190401837	6990381824	1590401889	2090451890	8800001839	
18340007	5090451892	6518621967	1180071843	4418411842	2018621890	2096031846	2090111848	
18410007	100031946	6990391824	8201011849	6018621917	3500021851	5900061852	4819001902	
18480007	6090101855	1080061907	112431946	2190101859	4818569012	5000011909	2418111914	
18550007	1918121832	5800071839	3500011813	5190451871	2118641867	5800071891	5000011970	
18630007	2090001921		6080071823	8090111839	1990011840	6990371824	6919511854	
18700007	6918731826	5390101979	5190111931	899	2120001853	1090401883	5190111834	
18770007	8880031836	1618121930	2190011887	6019521857	2018271980	1590411939	2118621816	
18840007	3000021941	6618271881	5200011894	1180031845		3500021895	8090111898	
18910007	2196031949	4019451896	8800001913	5390101972	1580011903	7190021897	6590371863	
18980007	8290101806	3500041810	5800071920	6519511905	7190021908	2018621916	2496031861	
19050007	1618111915	4818601910	2118621865	1590401935	5300011965	2090021920	1590401935	
19120007	7019511901	6996031822	6079521808	4618501869	6518641820	2190021875	5900061924	
19190007	9290321874	6920001904	2118111971	4819761942	8000001929	4819271912	3000021831	
19260007	8200001982	5800071914	5290101982	8200001935	4518901885	4119341886	5290101940	
19330007	6518621870	5090111943	8800001891	3000041947	8001011948		3000041899	
19400007	5900061847	1590401950	7090021893	5900061922	1590411936	5090111858	7019611961	
19470004	3500041937	1580051838	5900061906	3500021911	1590411936	5090111858	7019611961	

TABLE II (continued)

19610007	7019621962	6019541809	5090101872	9190271919	4219181969	1580051923	2090021974
19680007	6990441975	8090111977	5200011876	112121926	4219281978	6518621981	7190021925
19750007	9318781930	5800071913	8200001833	6990011984	4219321983	4619338000	1590411944
19820003	8040001942	7190021884	2418641973	6990011984	4219321983	4619338000	1590411944
1946-TRANSFER		OUT OF	SEVEN	PER CARD	READ		

TABLE III

PROGRAM LISTING OF PHASE III, PART I

8000								
8000501954	4019531956	5100018003	6119551952	2092101952	7090029900	1519589004	813008000	
6090031957	2920009005	2790108003	5119509006	4090079009	5090089004	2000	2790008002	
7090109010								
7090029002		6939511988	5220001987	5100011991	3000041986	6519511985	7019981998	
2119841999	4680021989	8280021995	5300011994	2440001990	8080021997	5300011996	4019941999	
16310007	6518891643	6016671721	4016431637	8000011790	2019251678	116501650	4516901641	
16390007	8800001645	6580021649	6018881693		1639221677	6518891793	8100071751	
16460007	2316991652	5300011753		5800011655	7019511651	7019511701	3000041713	
16530007	1519241679	2418861639	5200011661	5900061662	6539591663	6517291833		
16610007	4216631665	4817151696	3500021669		5000011671			
16690007	2178871640	6916731676	4017511675			101	8100311631	
16760007	2417291632	5000011633	6518871691	6916951949		1	6979521755	
16830007	1117291733	5180011840	2117291682		6017291783		1516801735	
16900007	111111650	4516441695		1018891743		1999	7019511801	
17010007	6919511654	8280011658	6916811684		3500061719		6916991702	
17130007	2316671670		5800071682				3000061683	
17200007	8280011726	1916991720					2016811634	
17270007	1016801635						4516361687	
17340007	5080011741	3500021791					6980031646	
17410007	5000011647		2119241727					
17510007	8300051657		4216561707		2420001703			
17830007	1016801685		2017291790					
17900007	8800001696	1516801785		3500041653				
18010007	6019511705							
18330007	3000021689							
18400007	4018431937			6916811734				
19490002	2419371740			6916811734				
1650-								

TABLE III (continued)

PROGRAM LISTING OF PHASE III, PART 2

16310007	2090301638	1516701775	2090251640	8000011790	2019561759	2017411644	4516901641
16380007	1516911645	8800001645	6916431646	2419531656	2419521655	3217639030	6019531807
16450007	2090241652	2290291702	5300011753		5800011655	6918891642	7019511701
16520007	6519531657	1519241679	2418861639	6918881641	6916591662	1519521707	1680011715
16590007	1	3917639027	8080011667	2419561709	6519561661	1616701725	2419371950
16670007	1616701675	2417639016	2090271676		1	2290329001	1519561761
16740007	1516771631	3500041635	1516791633	8719989989	2090521636	4000009999	1
16820007	2290311688	1117291733	5180011840	2019531706		6017291783	1519531857
16890007	1516801735	111111650	3920010010		1018891743		1999
16960007	7019511801				2120001937	6919511654	6519521757
17030007	6916811684		919611663	1519561711	2090501664		6917121665
17110007	1517141669	1999	2290261720	2120009008	6916681671		2090221674
17190007	2090231726	6916731776	1916991720				2090511632
17260007	6917791682	1016801635		6017651769			1619531658
17330007	4516361687	5080011741	3500021791				
17400007	6980031646	5000011647		2119241727			
17510007	8300051657		4216561707		2420001703		1616701825
17590007	1517621717		1517641719	3400019023		2140009003	1000000051
17690007	3420001700	1000000000					3500041685
17760007	2290281732			6917639032			
17830007	1016801685		2017291790				
17900007	8800001696	1516801785		3500041653			
18010007	6019511705						1919521672
18250007	4516781729						
18330007	3000021689						
18400007	4018431937			6916811734			
18570007	6916601713						
19490002	2419371740	2790011705					
19610007	8290509002	6017659022	5300019004	4290249005	8000009006	8890529025	2417709026

TABLE III (continued)

19680007 8390519009 5000019010 4290119013 6117709028 5200019009 5900019014 4890259015
19750007 8290509031 5300019017 4290319018 6517419019 1616709020 4619379021 2017419001
1650-

TABLE III (continued)

PROGRAM LISTING OF PHASE III, PART 3

16310007	10000	6918591812	2090251640	1	6916381741	2017411644	6519551810
16380007	5118591771	2019271765	6916431646	3000041651	2419521655	3217639030	4017601715
16450007	2090241652	2290291702	5300011753		5800011655	6580001657	2019551658
16520007	6519531657	1519241679	2418861639	2419531656	6918881691	4616601999	6918891642
16590007	6916621665	6518861641	6019531757	119991999	2419561659	1616701725	2419371948
16660007	4216321670	3500041677	2217151718	1516721727	7119271827	5018591777	101
16730007	3917639029	2216711724	4217281779	1516791633	2119521755	1616311635	6519521807
16800007	8300071738	7119271877	2290311688	1117291733	4816371937	6916881791	
16870007	1519521857	5118591644	2019271680	111111650	2419541707	2217381742	1018891743
16950007	1999	7019511801				1000000000	6919511654
17020007	6519521757	6916811684		8880011661	6917591712	6917101663	2019271759
17090007	1080011667		1	3500041721	2217591762	2217601763	2120009008
17170007	2019551758	6916711674	2090231726	6916731776	1517741729		8118591771
17240007	4516781679	2090511632	6917791682	2019551708	2159351739	6916321735	6516321687
17310007	1516341639	1619531658	4516361687	5080011741	2216321785		
17380007	6918591862	5200011675	6980031646	2216381679	6519551809	2119241727	
17510007	8300051657		4216561707		2019531706		1519541709
17580007	2019271730	8018591765	5018591666	1517641719	6917151668	1616311685	2140009003
17650007	8300071632				3420001700	1000000000	4016711675
17740007	20000000	3500041685	2290281732	4217381681	5900011684	7119271778	
17810007	1516341689		1016801685		6917381692		
17880007	5200011688		8800001696	2216881841	2217381759	3500041653	
18010007	6019511705						6917601713
18090007	3500041669	1518131717		2459351788	100		
18250007	4516781729		6519271731				
18330007	3000021689		6917381792			5200011638	
18400007	4018431937	6519561711		6916811734			
18570007	2016321835					2459351838	
18770007	6519271781						

TABLE III (continued)

19480003	6919521705	2419371740	2790011705						
19610007	8290509002	6017659022	5300019004	4290249005	8000009006	8890529025	2417709026		
19680007	8390519009	5000019010	4290119013	6117709028	5200019009	5900019014	4890259015		
19750007	8290509031	5300019017	4290319018	6517419019	1616709020	4619379021	2017419001		

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TABLE III (continued)

PROGRAM LISTING OF PHASE III, PART 4

16310007	1580061689	6918591812	2090251640		1	6980061691	6980071692	5200011743
16380007	5118591771	1519251879	8880021699	2419391642	6019241729	2419411644	6916471700	
16450007	3500041655	6178901745		1	6919821685	6920011666	8000001656	2019251678
16520007	2019411744	6519241779	6618881794	1516581663	8800011662	4616601999	40000000	
16590007	8080021667	1516471651	6019531757	6918901643	6916661669	1616701725	2419371948	
16660007	2440001653	5920001674	2217151718	2216661719	7119271827	5018591777	101	
16730007	3917639029	4916771728	4217281779	1516791633	6618301785	1578901645	6918881641	
16800007	8300061736	7119271877	2290311688	1117291733	4816371937	8080011741	8280011742	
16870007	6519251829	5118591644	2019271730	4218441791	2419831636	2419841687	8380011649	
16940007	1516471851	6916481751	7019511801	6980051703	5800011654	3000041659	2419261679	
17010007	1578901695	5080021644	2419821635		2459341787	5900011736	6917101663	
17080007	2019271759	1080011667		1	3500041721	2217591762	2217601763	2120009008
17150007	8118591771		2019551758	6916711674	6978901693	6916731776	1517741729	
17240007	4516781679	2090511632	6917791682	4817801677	6580051735	1918891660	7119271727	
17310007	1516341639	1619531658	4516361687	5080011741	3500041845	6520001705	8880011793	
17380007	6918591862	5200011675	6980031646	6919831686	6919841737	4216491697	4516981999	
17450007	1919241694		6519411795		7	5000011706	2419371640	
17530007	2019271680		2019531706		1519541709	2019271730	8018591765	
17600007	5018591666	1517641719	6917151668	1616311685	2140009003	8300071632		
17690007	3420001700	1000000000	4016711675			20000000	3500041685	
17760007	2290281732	4217381681	5900011684	5080021637	5000011786	1516341689		
17830007	1016801685		2019271880	5900011728	4816901791	5200011688		
17900007	8800001696	6519271631	4516461747	6519391843	1516471702	1616471652		
18010007	2019391792						6917601713	
18090007	3500041669	1518131717		2459351788	100			
18250007	4516781729		6519271731		3500041639	1947		
18330007	3000021689		6917381792			5200011638		
18400007	4018431937	6519561711		1616471801	5200011750	1517481753		
18510007	5080021719						2016321835	

TABLE III (continued)

18620007	2459351838								
18770007	6519271781		1616471701	7119271937					
19480003	6919521705	2419371740	2790011705	7119271937					
19610007	8290509002	6017659022	5300019004	4290249005	8000009006	8890529025	2417709026		
19680007	8390519009	5000019010	4290119013	6117709028	5200019009	5900019014	4890259015		
19750007	8290509031	5300019017	4290319018	6517419019	1616709020	4619379021	2017419001		

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TABLE III (continued)

PROGRAM LISTING OF PHASE III, PART 5

16310007	6918881641	6519381807	1616961851	6519261731	6519401796	6980051848	6978901699
16380007	2090521870	1516421647	6019371802	2419391692	20000000	2019411644	8800011750
16450007	2119401643	8080021655	6918001703	2419391698	2419841637	6916531656	2019391742
16520007	2019261631	6920011754	5000011660	8200001661	2416591662	6918881752	8000011764
16590007	6920011754	5200011666	6920011850	6916651668	2016591712	2216611714	1856
16660007	6519391743	6519391744	2419471700	6519411813	3940001857	3920010010	2020001999
16730007	2216701723	2140009003		1 6020011670	6518861858	6019531721	3500041639
16800007	2416831636	4516341635	2419281831	6020011670	2419321735	6980061841	6980071649
16870007	8880011707	6018741838	2090301768		10000	6019241779	6978901693
16940007	1616961751	2119261729		1 6918501803	2119261829	2419521855	6518901645
17010007	6018891843	4519991657	2218001753	8280011710	6519401795	6916961799	6519261781
17080007	2119291682	1517621717	6518881793	5200011667	6916611664	6919841687	6518881648
17150007	2419371950	6519381694	6916701673	4216401672	2019531769	3400019023	1919521822
17220007	1616751880	6916761680	6917789032	2090221782	1616751882	6519391859	1619531873
17290007	2019281631	2119291632	1516961652	2419301733	2419311684	1518371869	2419331736
17360007	2419341737	3000041809	3917789029		1516751783	4516591845	4516611747
17430007	1616961651	1616961801	1919261746	5380021705	6980051704	2419381791	2419531706
17500007	6519251679	2019381741	8280011658	1516421697	2440011804	5000011711	2419371640
17570007	2019261730	1518881808	6918121715	5200011716	1000000000	40000000	5800011669
17640007	6900011756	2119291732	919611816	5200011773	1516711775	1519561819	6519521820
17710007	1516741784	2120009008	4216831677	3917789027	2090241832	6918331836	2090271734
17790007	1919261646	1519261881	1516961757	1518351689	3500041719	2090231821	8080011861
17860007	8280011763	1516901811	2417789016			6519251879	5380021701
17930007	2019391792	6078901847	5080021659	1578901846	6519281633	3500041709	2419561759
18000007	6920001854	2019391842	3920011852	2218501853	5000011760	1516591663	5000011862
18070007	8380021683	5080021767	3500021815	2019391860	2016831999	6578901849	1616961863
18140007	6516831787	1580071823	6519561866	2019561867	1519521868	1517721777	1616751883
18210007	6917241827	1519561771	3500021780	2290329001		2120001937	2290311834
18290007	6978901748	7119271727	6578901758	6519531818	3217789030	1519531871	8719989989

TABLE III (continued)

18360007	2290291770	4000009999	3420001826				2419831686	4518001797
18430007	1178901745	3500041805	8000001800	2019401794	1919241844	2419821685	1616961702	
18500007	2440001654	2019281681	2120001806	6578901695	2440011755	6918881749	8000001713	
18570007	3219291708	1517611765	1616961810	4518141865	6919831786	5300011718	2019411864	
18640007	4518538000	6919821785	8080011722	1517201725	2090501726	2090251776	2018251678	
18710007	6917741877	2290281728	1680011885	1000000051	1000000000		2290261884	
18790007	1519381798	3500041817	2019271830	2090511740	4516381688	6917381872	6917881824	
19500001	2790011766	3500041817	2019271830	2090511740	4516381688	6917381872	6917881824	
19610007	8290509002	6018749022	5300019004	4290249005	8000009006	8890529025	2418759026	
19680007	8390519009	5000019010	4290119013	6118759028	5200019009	5900019014	4890259015	
19750007	8290509031	5300019017	4290319018	6518259019	1616759020	4619379021	2018259001	

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TABLE IV

X | Y MATRIX WITH HEADER AND TRAILER CARDS

				Header Card (load card)		
3010000003	1111111111	1111111111	1111133334			
1010000001	1100100000	1001000	19239	224448089	6000000000	
1010000002	1100100000	1001000	15440	3265530106		
1010000003	1100100000	100100	18543	2241482096	4000000000	
1010000004	1100100000	100100	18345	7225450090		
1010000005	1100100000	10010	18648	3258516103	2000000000	
1010000006	1100100000	10010	17746	9267534106	8000000000	
1010000007	1100100000	10010	17742	8271542108	4000000000	
1010000008	1100100000	10010	16343	9247494098	8000000000	
1010000009	1100010000	100100	18843	9229458091	6000000000	
1010000010	1100010000	100100	17840	7226452090	4000000000	
1010000011	1100010000	10010	19849	8197394078	8000000000	
1010000012	1100010000	10010	19345	9214428085	6000000000	
1010000013	1100010000	10010	18645	9244488097	6000000000	
1010000014	1100010000	10010	17537	5252504100	8000000000	
1010000015	1100010000	10010	17138	2172344068	8000000000	
1010000016	1100010000	10010	16841	7275550110		
1010000017	1100001000	1001000	15438	9238476095	2000000000	
1010000018	1100001000	100100	18441	4246492098	4000000000	
1010000019	1100001000	10010	17448	3229458091	6000000000	
1010000020	1100001000	10010	17043	230460092		
1010000021	1100001000	10010	16944	3294588117	6000000000	
1010000022	1010000100	1000001	15838	1250500100		
1010000023	1010000100	1000001	15836	5244488097	6000000000	
1010000024	1010000100	100000	1000016938	6244488097	6000000000	
1010000025	1010000100	100000	1000014433	9215430086		
1010000026	1010000100	10000	100015941	9254508101	6000000000	
1010000027	1010000100	10000	100015246	9274548109	6000000000	
1010000028	1010000100	10000	100014937	6250500100		

TABLE IV (continued)

1010000029	1010000100	10000	100014937	5254508101	6000000000
1010000030	1010000010	1000001	18939	5265530106	
1010000031	1010000010	100000	1000018744	7252504100	8000000000
1010000032	1010000010	100000	1000016543	267534106	8000000000
1010000033	1010000010	10000	100018145	3279558111	6000000000
1010000034	1010000010	10000	100017738	5233466093	2000000000
1010000035	1010000010	10000	100015141	4267534106	8000000000
1010000036	1010000010	10000	100014735	3269538107	6000000000
1010000037	1001000001	100000	1018441	1300600120	
1010000038	1001000001	100000	1018442	249498099	6000000000
1010000039	1001000001	10000	118742	7225450090	
1010000040	1001000001	10000	118440	9249498099	6000000000
1010000041	1001000001	10000	118333	7202404080	8000000000
1010000042	1001000001	10000	117735	2231462092	4000000000
1010000043	1001000000	1001000000	10020547	2257514102	8000000000
1010000044	1001000000	1001000000	10019334	237474094	8000000000
1010000045	1001000000	1000100000	1016237	5264528105	6000000000
1010000046	1001000000	1000010000	120645	1237474094	8000000000
1010000047	1001000000	1000010000	120547	2222444088	8000000000
1010000048	1001000000	1000010000	118740	2190380076	
1010000049	1001000000	1000010000	117846	4261522104	4000000000
1010000050	1001000000	1000010000	117541	4213426085	2000000000
1010000051	1001000000	101000000	10020046	6216432086	4000000000
1010000052	1001000000	101000000	10018435	6233466093	2000000000
1010000053	1001000000	101000000	10017544	9252504100	8000000000
1010000054	1001000000	100100000	1017836	245490098	
1010000055	1001000000	100010000	118938	5144288057	6000000000
1010000056	1001000000	100010000	118443	1172344068	8000000000
1010000057	1001000000	100010000	118340	1217434086	8000000000
1010000058	1001000000	11000000	10016640	4268536107	2000000000
1010000059	1001000000	10100000	1018748	2243486097	2000000000

TABLE IV (continued)

1010000060	1001000000	10100000	1018635	236472094	4000000000
1010000061	1001000000	10100000	1018448	3244488097	6000000000
1010000062	1001000000	10010000	118042	5266532106	4000000000
1010000063	1001000000	10010000	117742	246492098	4000000000
1010000064	1001000000	10010000	117544	9252504100	8000000000
1010000065	1001000000	10010000	116440	5242484096	8000000000
301355-	100020000	2101000000	Trailer card (load card)		

TABLE V
 PHASE I HEADER FORMAT

Header Card (load card)

Word 1	3010000003
	30 variables
	1 indicates a packed card
	3 words beginning in column 11
Words 2, 3 and 4	1111111111, 1111111111, 1111133334

The first twenty-five variables each have one digit. The twenty-sixth through the twenty-ninth variables have three digits each and the thirtieth variable has four digits.

Note: The unused words of the header card may be left blank.

TABLE VI
PHASE I TRAILER FORMAT

Trailer Card (load card)

Word 1	0000301355 -
	30 variables
	1355 - built-in control
Word 2	0100020000
	1 punch $X_i X_j$
	2 with two decimal places
	0 do not punch the associated quantity
Word 3	2101000000
	2101 is the identification to be punched in the output

Note: The unused words of the trailer card may be left blank.

TABLE VII
X | Y MATRIX FORMAT

Word 1 Identification of each individual observation

Words 2 to 8

Columns	Quantity
11	u
12	g_1
13	g_2
14	g_3
15	s_{11}
16	s_{12}
17	s_{13}
18	s_{21}
19	s_{22}
20	s_{31}
21	s_{32}
22	s_{33}
23	s_{34}
24	a_1
25	a_2
26	a_3
27	$(ga)_{11}$
28	$(ga)_{12}$
29	$(ga)_{13}$

TABLE VII (continued)

Columns	Quantity
30	(ga) ₂₁
31	(ga) ₂₂
32	(ga) ₂₃
33	(ga) ₃₁
34	(ga) ₃₂
35	(ga) ₃₃
36 -- 38	b (age)
39 -- 41	d (initial weight)
42 -- 44	first right hand member (ADG)
45 -- 47	second right hand member (fictitious)
48 -- 51	third right hand member (fictitious)
52 -- 60	Zero
61 -- 80	Blank

Note: Columns 11 through 35 contain either the digit zero or one. The digit one (1) was placed in the column if the corresponding quantity was associated with the observation; otherwise the digit zero (0) was placed in the column.

TABLE VIII

NORMAL EQUATIONS A WITH HEADER CARD

		Header card (non-load card)						
6543210000	6543212030	1	3					
2101020101	65	21	15	29	8	8	8	5
2101020102	8	7	6	8	7	8	8	12
2101020103	16	37	3	5	13	3	3	4
2101020104	8	6	7	16	11482	27095	15674	
2101020105	31348	62696						
2101020201	21	21			8	8	8	5
2101020202								3
2101020203	5	13	3	5	13			
2101020204					3725	9096	5044	
2101020205	10088	20176						
2101020301	15		15					
2101020302	8	7						3
2101020303	4	8				3	4	
2101020304	8				2435	5987	3817	
2101020305	7634	15268						
2101020401	29			29				
2101020402			6	8	7	8	8	6
2101020403	7	16						
2101020404		6	7	16	5322	12012	6813	
2101020405	13626	27252						
2101020501	8	8			8			
2101020502								2
2101020503	2	4	2	2	4			
2101020504					1417	3501	1998	
2101020505	3996	7992						
2101020601	8	8				8		
2101020602								
2101020603	2	6		2	6			

TABLE VIII (continued)

2101020604					1457	3436	1809
2101020605	3618	7236					
2101020701	5	5					5
2101020702							1
2101020703	1	3	1	1	3		
2101020704					851	2159	1237
2101020705	2474	4948					
2101020801	8		8				
2101020802	8						2
2101020803	2	4				2	2
2101020804	4				1238	3110	1985
2101020805	3970	7940					
2101020901	7		7				
2101020902		7					1
2101020903	2	4				1	2
2101020904	4				1197	2877	1832
2101020905	3664	7328					
2101021001	6			6			
2101021002			6				
2101021003	2	4					
2101021004			2	4	1099	2356	1456
2101021005	2912	5824					
2101021101	8			8			
2101021102				8			2
2101021103	1	5					
2101021104		2	1	5	1511	3390	1881
2101021105	3762	7524					
2101021201	7			7			
2101021202					7		3
2101021203	1	3					
2101021204		3	1	3	1293	2848	1479

TABLE VIII (continued)

2101021205	2958	5916						
2101021301	8			8				
2101021302						8		1
2101021303	3	4						
2101021304		1	3	4	1419	3418		1997
2101021305	3994	7988						
2101021401	12	3	3	6	2			1
2101021402	2	1		2	3	1		12
2101021403			3			3		
2101021404		6			2128	4810		2949
2101021405	5898	11796						
2101021501	16	5	4	7	2	2		1
2101021502	2	2	2	1	1	3		
2101021503	16			5				4
2101021504			7		2848	6632		3926
2101021505	7852	15704						
2101021601	37	13	8	16	4	6		3
2101021602	4	4	4	5	3	4		
2101021603		37			13			
2101021604	8			16	6506	15653		8799
2101021605	17598	35196						
2101021701	3	3			2			1
2101021702								3
2101021703			3					
2101021704					500	1182		727
2101021705	1454	2908						
2101021801	5	5			2	2		1
2101021802								
2101021803	5			5				
2101021804					918	2149		1167
2101021805	2334	4668						

TABLE VIII (continued)

2101021901	13	13		4	6	3
2101021902						
2101021903		13		13		
2101021904				2307	5765	3150
2101021905	6300	12600				
2101022001	3		3			
2101022002	2	1				3
2101022003					3	
2101022004				505	1141	759
2101022005	1518	3036				
2101022101	4		4			
2101022102	2	2				
2101022103	4					4
2101022104				665	1602	978
2101022105	1956	3912				
2101022201	8		8			
2101022202	4	4				
2101022203		8				
2101022204	8			1265	3244	2080
2101022205	4160	8320				
2101022301	6			6		
2101022302				2	3	1
2101022303						6
2101022304		6				
2101022305	2926	5852		1123	2487	1463
2101022401	7			7		
2101022402			2	1	1	3
2101022403	7					
2101022404			7		1265	2881
2101022405	3562	7124				1781
2101022501	16			16		

TABLE VIII (continued)

			4	5	3	4	
2101022502							
2101022503		16					
2101022504				16	2934	6644	3569
2101022505	7138	14276					
2101022601	11482	3725	2435	5322	1417	1457	851
2101022602	1238	1197	1099	1511	1293	1419	2128
2101022603	2848	6506	500	918	2307	505	665
2101022604	1265	1123	1265	2934	2042090	4801569	2760364
2101022605	5520728	11041456					
2101022701	27095	9096	5987	12012	3501	3436	2159
2101022702	3110	2877	2356	3390	2848	3418	4810
2101022703	6632	15653	1182	2149	5765	1141	1602
2101022704	3244	2487	2881	6644	4801569	11404219	6542844
2101022705	13085688	26171376					
2101022801	15674	5044	3817	6813	1998	1809	1237
2101022802	1985	1832	1456	1881	1479	1997	2949
2101022803	3926	8799	727	1167	3150	759	978
2101022804	2080	1463	1781	3569	2760364	6542844	3828998
2101022805	7657996	15315992					
2101022901	31348	10088	7634	13626	3996	3618	2474
2101022902	3970	3664	2912	3762	2958	3994	5898
2101022903	7852	17598	1454	2334	6300	1518	1956
2101022904	4160	2926	3562	7138	5520728	13085688	7657996
2101022905	15315992	30631984					
2101023001	62696	20176	15268	27252	7992	7236	4948
2101023002	7940	7328	5824	7524	5916	7988	11796
2101023003	15704	35196	2908	4668	12600	3036	3912
2101023004	8320	5852	7124	14276	11041456	26171376	15315992
2101023005	30631984	61263968					

TABLE IX

 T_R MATRIX HEADER CARD FORMAT

Word 1	Irrelevant (load, non-load or blank)
Word 2	iiiiiiyyzz iiiiii is identification yy is the number of rows in T_R zz is the number of columns in T_R
Word 3	000000000t t is 0 if T_R is in normal floating-point form t is 1 if T_R is in fixed-point form t is 2 if T_R is in the form 50x.xxxxxxx
Words 4 to 8	Irrelevant (blank or punched)

TABLE X

T_R MATRIX WITH HEADER CARD

6543210000	6543212030	1	Header card (non-load card)			
6543210101	1					
6543210102						
6543210103						
6543210104						
6543210105						
6543210201		1		1-		
6543210202						
6543210203						
6543210204						
6543210205						
6543210301			1	1-		
6543210302						
6543210303						
6543210304						
6543210305						
6543210501					1	1-
6543210502						
6543210503						
6543210504						
6543210505						
6543210601					1	1-
6543210602						
6543210603						
6543210604						
6543210605						
6543210801						
6543210802	1	1-				
6543210803						

TABLE X (continued)

6543210804								
6543210805								
6543211001								
6543211002		1					1-	
6543211003								
6543211004								
6543211005								
6543211101								
6543211102				1			1-	
6543211103								
6543211104								
6543211105								
6543211201								
6543211202						1	1-	
6543211203								
6543211204								
6543211205								
6543211401								
6543211402								1
6543211403		1-						
6543211404								
6543211405								
6543211501								
6543211502								
6543211503	1		1-					
6543211504								
6543211505								
6543211701								
6543211702								
6543211703				1			1-	
6543211704		1-			1			

TABLE X (continued)

6543211705						
6543211801						
6543211802						
6543211803				1		1-
6543211804			1-	1		
6543211805						
6543212001						
6543212002						
6543212003						1
6543212004	1-		1-		1	
6543212005						
6543212101						
6543212102						
6543212103						1
6543212104	1-		1-		1	
6543212105						
6543212601						
6543212602						
6543212603						
6543212604						1
6543212605						
6543212701						
6543212702						
6543212703						
6543212704						1
6543212705						
6543212801						
6543212802						
6543212803						
6543212804						1
6543212805						

TABLE X (continued)

6543212901	
6543212902	
6543212903	
6543212904	
6543212905	1
6543213001	
6543213002	
6543213003	
6543213004	
6543213005	1

TABLE XI

AT_R MATRIX, DECK 1

1543210101	6500000052	8000000051-1400000052-3000000051	3000000051	1000000051	2000000051-
1543210102		1000000051-2500000052-2100000052-		1000000051	5000000051
1543210103	5000000051	1148200055	2709500055	1567400055	3134800055
1543210201	2100000052	2100000052	3000000051	3000000051	
1543210202		1000000052-8000000051-1000000052-		8000000051-	
1543210203		3725000054	9096000054	5044000054	1008800055
1543210301	1500000052	1500000052		1000000051	
1543210302		5000000051-4000000051-			5000000051-
1543210303	4000000051-2435000054	5987000054	3817000054	7634000054	1526800055
1543210401	2900000052	2900000052-2900000052-			2000000051-
1543210402		1000000051-1000000052-9000000051-		1000000052	9000000051
1543210403	9000000051	5322000054	1201200055	6813000054	1362600055
1543210501	8000000051	8000000051	8000000051		2725200055
1543210502		2000000051-2000000051-2000000051-		2000000051-	
1543210503		1417000054	3501000054	1998000054	3996000054
1543210601	8000000051	8000000051		8000000051	7992000054
1543210602		6000000051-4000000051-6000000051-		4000000051-	
1543210603		1457000054	3436000054	1809000054	3618000054
1543210701	5000000051	5000000051	5000000051-	5000000051-	
1543210702		2000000051-2000000051-2000000051-		2000000051-	
1543210703		8510000053	2159000054	1237000054	2474000054
1543210801	8000000051	8000000051		8000000051	4948000054
1543210802		2000000051-2000000051-			8000000051
1543210803	2000000051-1238000054	3110000054	1985000054	3970000054	7940000054
1543210901	7000000051	7000000051		7000000051-	
1543210902		3000000051-2000000051-			3000000051-
1543210903	2000000051-1197000054	2877000054	1832000054	3664000054	7328000054
1543211001	6000000051	6000000051-6000000051-			6000000051
1543211002		4000000051-2000000051-4000000051	2000000051	4000000051	4000000051

TABLE XI (continued)

1543211003	2000000051	1099000054	2356000054	1456000054	2912000054	5824000054	
1543211101	8000000051	8000000051-8000000051-					
1543211102	8000000051		3000000051-4000000051-	3000000051	4000000051	3000000051	
1543211103	4000000051	1511000054	3390000054	1881000054	3762000054	7524000054	
1543211201	7000000051	7000000051-7000000051-					
1543211202		7000000051		2000000051-		2000000051	
1543211203	2000000051	1293000054	2848000054	1479000054	2958000054	5916000054	
1543211301	8000000051	8000000051-8000000051-					8000000051-
1543211302	8000000051-8000000051-	3000000051-1000000051-	3000000051	1000000051-3000000051	1000000051	3000000051	
1543211303	1000000051	1419000054	3418000054	1997000054	3994000054	7988000054	
1543211401	1200000052	3000000051-3000000051-	1000000051	1000000051-1000000051	1000000051	1000000051	1000000051-
1543211402	1000000051	2000000051	1200000052		3000000051-		3000000051-
1543211403		2128000054	4810000054	2949000054	5898000054	1179600055	
1543211501	1600000052	2000000051-3000000051-	1000000051	1000000051			1000000051-
1543211502	2000000051-2000000051-		1600000052			2000000051-	
1543211503	3000000051-2848000054	6632000054	3926000054	7852000054	1570400055		
1543211601	3700000052	3000000051-8000000051-	1000000051	3000000051			
1543211602	1000000051	1000000051-3700000052-	3700000052-	3000000051	3000000051	8000000051	
1543211603	8000000051	6506000054	1565300055	8799000054	1759800055	3519600055	
1543211701	3000000051	3000000051		1000000051	1000000051-		
1543211702			3000000051		3000000051		
1543211703		5000000053	1182000054	7270000053	1454000054	2908000054	
1543211801	5000000051	5000000051		1000000051	1000000051		
1543211802				5000000051		5000000051	
1543211803		9180000053	2149000054	1167000054	2334000054	4668000054	
1543211901	1300000052	1300000052		1000000051	3000000051		
1543211902			1300000052-	1300000052-	1300000052-	1300000052-	
1543211903		2307000054	5765000054	3150000054	6300000054	1260000055	
1543212001	3000000051		3000000051			1000000051	
1543212002			3000000051				3000000051
1543212003		5050000053	1141000054	7590000053	1518000054	3036000054	

TABLE XI (continued)

1543212101	4000000051		4000000051					
1543212102				4000000051				
1543212103	4000000051	6650000053	1602000054	9780000053	1956000054	3912000054		
1543212201	8000000051		8000000051					
1543212202			8000000051	8000000051-				8000000051-
1543212203	8000000051	1265000054	3244000054	2080000054	4160000054	8320000054		
1543212301	6000000051	6000000051	6000000051-					1000000051-
1543212302	1000000051	2000000051	6000000051		6000000051-			6000000051-
1543212303		1123000054	2487000054	1463000054	2926000054	5852000054		
1543212401	7000000051	7000000051	7000000051-					1000000051-
1543212402	2000000051	2000000051-		7000000051		7000000051-		
1543212403	7000000051	1265000054	2881000054	1781000054	3562000054	7124000054		
1543212501	1600000052	1600000052	1600000052-					
1543212502	1000000051	1000000051	1600000052	1600000052-	1600000052	1600000052	1600000052	1600000052
1543212503	1600000052	2934000054	6644000054	3569000054	7138000054	1427600055		
1543212601	1148200055	1597000054	2887000054	5660000053	6060000053	4100000052	3200000053-	
1543212602	9200000052	1260000053	4378000054	3658000054	4000000051	2800000053	1051000054	
1543212603	1069000054	2042090057	4801569057	2760364057	5520728057	1104145658		
1543212701	2709500055	2916000054	6025000054	1342000054	1277000054	2330000053	1062000054-	
1543212702	2800000052	5700000053	1084300055	9021000054	4260000053	1470000053	2054000054	
1543212703	2121000054	4801569057	1140421958	6542844057	1308568858	2617137658		
1543212801	1567400055	1769000054	2996000054	7610000053	5720000053	1530000053	5410000053-	
1543212802	1160000053	5180000053	5850000054	4873000054	3170000053	1950000053	7850000053	
1543212803	6860000053	2760364057	6542844057	3828998057	7657996057	1531599258		
1543212901	3134800055	3538000054	5992000054	1522000054	1144000054	3060000053	1082000054-	
1543212902	2320000053	1036000054	1170000055	9746000054	6340000053	3900000053	1570000054	
1543212903	1372000054	5520728057	1308568858	7657996057	1531599258	3063198458		
1543213001	6269600055	7076000054	1198400055	3044000054	2288000054	6120000053	2164000054-	
1543213002	4640000053	2072000054	2340000055	1949200055	1268000054	7800000053	3140000054	
1543213003	2744000054	1104145658	2617137658	1531599258	3063198458	6126396858		

TABLE XII
 T_L MATRIX, DECK 2

2543210101	1000000051		
2543210102			
2543210103			
2543210104			
2543210105			
2543210201	1000000051	1000000051-	
2543210202			
2543210203			
2543210204			
2543210205			
2543210301	1000000051	1000000051-	
2543210302			
2543210303			
2543210304			
2543210305			
2543210401		1000000051	1000000051-
2543210402			
2543210403			
2543210404			
2543210405			
2543210501			1000000051 1000000051-
2543210502			
2543210503			
2543210504			
2543210505			
2543210601			
2543210602	1000000051	1000000051-	
2543210603			
2543210604			

TABLE XII (continued)

2543210605			
2543210701			
2543210702	1000000051		1000000051-
2543210703			
2543210704			
2543210705			
2543210801			
2543210802		1000000051	1000000051-
2543210803			
2543210804			
2543210805			
2543210901			
2543210902		1000000051	1000000051-
2543210903			
2543210904			
2543210905			
2543211001			
2543211002			1000000051
2543211003	1000000051-		
2543211004			
2543211005			
2543211101			
2543211102			
2543211103	1000000051	1000000051-	
2543211104			
2543211105			
2543211201			
2543211202			
2543211203		1000000051	1000000051-
2543211204	1000000051-	1000000051	
2543211205			

TABLE XII (continued)

2543211301			
2543211302			
2543211303		1000000051	1000000051-
2543211304		1000000051-	1000000051
2543211305			
2543211401			
2543211402			
2543211403			1000000051
2543211404	1000000051-	1000000051-	
2543211405		1000000051	
2543211501			
2543211502			
2543211503			1000000051
2543211504	1000000051-	1000000051-	1000000051
2543211505			
2543211601			
2543211602			
2543211603			
2543211604			1000000051
2543211605			
2543211701			
2543211702			
2543211703			
2543211704			1000000051
2543211705			

TABLE XIII

REDUCED NORMAL EQUATIONS R | G, DECK 3

6543210000	103170901	202010302	401010000	Control card (non-load card)				
3543210101	6500000052	8000000051-1400000052-3000000051	3000000051	1000000051	2000000051-			
3543210102		1000000051-2500000052-2100000052-		1000000051	5000000051			
3543210103	5000000051	1148200055	2709500055	1567400055	3134800055	6269600055		
3543210201	8000000051-5000000052	2900000052	3000000051	3000000051			2000000051	
3543210202		1000000051		1000000051	2000000052-1700000052-1000000052-			
3543210203	9000000051-1597000054-2916000054-1769000054-3538000054-7076000054-							
3543210301	1400000052-2900000052	4400000052			1000000051	2000000051		
3543210302		1000000051	5000000051	5000000051	1000000052-9000000051-1500000052-			
3543210303	1300000052-2887000054-6025000054-2996000054-5992000054-1198400055-							
3543210401	3000000051	3000000051		1300000052	5000000051			
3543210402								
3543210403		5660000053	1342000054	7610000053	1522000054	3044000054		
3543210501	3000000051	3000000051		5000000051	1300000052			
3543210502			4000000051-2000000051-4000000051-2000000051-					
3543210503		6060000053	1277000054	5720000053	1144000054	2288000054		
3543210601	1000000051		1000000051			1500000052		
3543210602			1000000051				1000000051	
3543210603		4100000052	2330000053	1530000053	3060000053	6120000053		
3543210701	2000000051-2000000051	2000000051					1400000052	
3543210702	8000000051	8000000051	1000000051-1000000051-1000000051	1000000051	1000000051	1000000051	1000000051	
3543210703	1000000051	3200000053-1062000054-5410000053-1082000054-2164000054-						
3543210801							8000000051	
3543210802	1600000052	8000000051		3000000051-		3000000051		
3543210803	3000000051	9200000052	2800000052-1160000053-2320000053-4640000053-					
3543210901	1000000051-1000000051	1000000051					8000000051	
3543210902	8000000051	1500000052	3000000051	1000000051-3000000051-1000000051	3000000051-			
3543210903	1000000051	1260000053-5700000053-5180000053-1036000054-2072000054-						
3543211001	2500000052-		5000000051		4000000051-1000000051	1000000051-		

TABLE XIII (continued)

3543211002		3000000051	4900000052	3700000052	6000000051	3000000051	1100000052
3543211003	8000000051	4378000054	1084300055	5850000054	1170000055	2340000055	
3543211101	2100000052	1000000051	5000000051		2000000051		1000000051
3543211102	3000000051	1000000051	3700000052	5300000052	3000000051	5000000051	8000000051
3543211103	1100000052	3658000054	9021000054	4873000054	9746000054	1949200055	
3543211201		2000000052	1000000052		4000000051		1000000051
3543211202		3000000051	6000000051	3000000051	3800000052	2900000052	2200000052
3543211203	1600000052	4000000051	4260000053	3170000053	6340000053	1268000054	
3543211301	1000000051	1700000052	9000000051		2000000051		1000000051
3543211302	3000000051	1000000051	3000000051	5000000051	2900000052	4100000052	1600000052
3543211303	2300000052	2800000053	1470000053	1950000053	3900000053	7800000053	
3543211401	5000000051	1000000052	1500000052			1000000051	1000000051
3543211402		3000000051	1100000052	8000000051	2200000052	1600000052	3300000052
3543211403	2400000052	1051000054	2054000054	7850000053	1570000054	3140000054	
3543211501	5000000051	9000000051	1300000052				1000000051
3543211502	3000000051	1000000051	8000000051	1100000052	1600000052	2300000052	2400000052
3543211503	3500000052	1069000054	2121000054	6860000053	1372000054	2744000054	
3543211601	1148200055	1597000054	2887000054	5660000053	6060000053	4100000052	3200000053
3543211602	9200000052	1260000053	4378000054	3658000054	4000000051	2800000053	1051000054
3543211603	1069000054	2042090057	4801569057	2760364057	5520728057	1104145658	
3543211701	2709500055	2916000054	6025000054	1342000054	1277000054	2330000053	1062000054
3543211702	2800000052	5700000053	1084300055	9021000054	4260000053	1470000053	2054000054
3543211703	2121000054	4801569057	1140421958	6542844057	1308568858	2617137658	

TABLE XIV

R | G MATRIX CONTROL CARD FORMAT

The control card (non-load) has the following format:

Columns	1 -- 6	Identification desired in $R^{-1} B$
	7 -- 10	Irrelevant
	11 -- 12	00 if R G is on the drum
	11 -- 12	xx (any two digit number other than 00) if R G is not on the drum
	13 -- 14	NY is the number of right hand members
	15 -- 16	NX is the number of rows in the reduced normal equations R G
	17 -- 18	NP is the number of partitions on the main diagonal of R G
	19 -- 20	N1 is the number of rows in the first partition (or segment) of the reduced normal equations
	21 -- 22	N2 is the number of rows in the second segment of the reduced normal equations
	23 -- 24	etc.

TABLE XIV (continued)

•
•
•

79 -- 80 N31 is the number of rows in the
 thirty-first segment of the
 reduced normal equations

Note: Punch zeros in the unused columns of the control card if the matrix is partitioned into less than thirty-one segments. The sum of the number of rows of the segments must agree with the number of rows in the reduced normal equations.

TABLE XV

R | G MATRIX CONTROL CARD

Word 1 6543210000
 654321 is identification
 0000 is irrelevant

Words 2 to 8

Columns	Punched	Indicates
11 -- 12	01	required to read R G
13 -- 14	03	three right hand members
15 -- 16	17	seventeen rows in R G
17 -- 18	09	nine partitions in R G
19 -- 20	01	one row in the first partition
21 -- 22	02	two rows in the second partition
23 -- 24	02	two rows in the third partition
25 -- 26	01	one row in the fourth partition
27 -- 28	03	three rows in the fifth partition
29 -- 30	02	two rows in the sixth partition
31 -- 32	04	four rows in the seventh partition
33 -- 34	01	one row in the eighth partition
35 -- 36	01	one row in the ninth partition
37 -- 80	Zero	(since the complete card must be punched)

TABLE XVI

 $R^{-1} | B$ MATRIX

6543210101	4949899951	3862293249	2484102750	-4859088949	7740185049	2269489650	-2781884449-
6543210102	1405680450	3556999048	-1644374249	-5931567749	2209544050	-1233132150	1444936350
6543210103	2556283049	-2357100349	-1969503648	-3061057153	6122109753	1224419254	
6543210201	3862258749	4683138249	2940094749	-1082053749	-8509200047	2259302848	7138075648-
6543210202	1719524748	9618006047	2432817548	1099928648	-2522377249	1693760547	1657652349-
6543210203	2764541547	1421632647	1493397547	-8035382751	-1607079852	-3214142352-	
6543210301	2484107350	-2940097149	-6232815949	4317450848	8498648548	-7883870148	5275095348-
6543210302	6594486748	-1059421048	4249381047	-2610589948	-4514439048	-7080530948	-1349658049
6543210303	3665623748	1529293548	3411212946	-3730079351	7460157751	1492067152	
6543210401	4859060849	1082053649	-4317470948	9803924949	4173862249	-1392814248	-2595503848-
6543210402	1446589648	7002028247	-1113824149	-2884102748	2062840549	-5481712148	9553178048
6543210403	2365448348	-1169107046	-1285470847	-9051181051	1810233352	3620479352	
6543210501	7740273049	8509340047	8498689948	-4173860949	-1097256650	6673048948	-6085978148
6543210502	2534987748	1971742448	1883286649	4460592948	-2463578149	7722860348	-8588330048-
6543210503	4496578048	1095744448	-2827152647	1074940252	-2149874852	-4299800452-	
6543210601	2269493950	-2259283348	7883873748	1392830948	-6673015948	-7991137349	1629400448-
6543210602	6608073148	-8579248647	-6197338548	-3134911247	-1541458149	9050329348	-1822744949-
6543210603	6626969248	1416977748	5697990146	-1191864552	-2383730152	-4767425552-	
6543210701	2781802749	-7138069448	-5275143148	-2595497648	-6085995648	1629439248	-1349693250
6543210702	4178382349	-5201567449	-1641695049	7047496548	-1005674549	-7936517348	9091108048-
6543210703	6393983148	5487465947	-3120494247	1658513052	3317031652	6634020852	
6543210801	1405681050	1719534748	6594476048	-1446598148	2534963948	6608063048	-4178384449-
6543210802	1045603150	2823527449	-4414560748	-7446531748	2591526048	-2073521548	-8205899648
6543210803	6538683748	-7147622247	-4008057246	-4096936051	8193862951	1638762552	
6543210901	3556709048	-9618027047	1059405348	7001999847	-1971747348	8579383647	-5201567849-
6543210902	2823526549	-1200438450	1136794649	-8034551548	1289111549	7468072448	-1378256849
6543210903	8180597548	-2048453847	-9163268646	2690856452	-5381710752	-1076343553-	
6543211001	1644308449	-2432821448	4249770347	-1113823749	-1883288149	6197371148	-1641695149
6543211002	4414542148	-1136794449	-6011418549	3439438549	-1095975549	4069680748	-9913335048

TABLE XVI (continued)

6543211003 5272523848-4140533747-2436793247 6945896151 1389185552 2778335052
 6543211101 5931574549 1099923648-2610587948-2884107648 4460602448-3134884447-7047506548-
 6543211102 7446533248 8034546848 3439439549-4512374849 7414401348-2961758148 2914304148-
 6543211103 9531171748 3189431547-6941917345-6117838350-1223586751-2447186251-
 6543211201 2209544550-2522375449 4514456248-2062841649-2463581749 1541456349 1005671149-
 6543211202 2591525148-1289113149 1095978349 7414399348-1325020850 7915336649-8091527449-
 6543211203 4507916449 1098601648 8224593746 1100490952-2200979652-4401944552-
 6543211301 1233134150 1693902447 7080531448-5481720048 7722879548-9050325948-7936495948
 6543211302 2073517148-7468082548-4069698748-2961759148 7915337049-9382877349 4838476249
 6543211303 5655457549-7891272647-3245126646 1313935551 2627874651 5255539651
 6543211401 1444941350 1657650849-1349656549 9553187048 8588345048-1822746149-9091130048-
 6543211402 8205912948 1378255749 9913316248 2914298548-8091529949-4838477749 1263875550
 6543211403 7464344049-1045137448-9429588846 2521450951 5042926151 1008553952
 6543211501 2556288849-2764486147 3665623548 2365450348-4496584348 6626968448 6393989148
 6543211502 6538686248-8180591748-5272519248-9531170248 4507917049 5655457949-7464343649-
 6543211503 9893816849 2129849047 2714023546-8066387251-1613278552-3226548052-
 6543211601 2357109749-1421607047 1529296448 1169334046-1095741648-1416979848 5487422147-
 6543211602 7147646347-2048439047-4140495947-3189440247-1098605448 7891288647-1045137448-
 6543211603 2129853947 1909319047 2395671246-8154811350-1630966851-3261871151-
 6543211701 1969463148-1493395147-3411453446-1285467947-2827162447 5698188646-3120495547
 6543211702 4007943046-9163276246 2436793247 6941374745-8224414946 3245245246 9429712446
 6543211703 2714058646-2395694346-1503246246 1970439550 3940909250 7881619650

TABLE XVII

BETA VECTORS AND CONTROL CARDS

3410001	3061057153	2395694346-1503246246	1970439550	3940909250	7881619650
	1947-3061057153	2395694346-1503246246	1970439550	3940909250	7881619650
3410001	6122109753	2395694346-1503246246	1970439550	3940909250	7881619650
	1947-6122109753	2395694346-1503246246	1970439550	3940909250	7881619650
3410001	1224419254	2395694346-1503246246	1970439550	3940909250	7881619650
	1947-1224419254	2395694346-1503246246	1970439550	3940909250	7881619650
3410002	8035382751-3730079351	1503246246	1970439550	3940909250	7881619650
	1947-8035382751-3730079351	1503246246	1970439550	3940909250	7881619650
3410002	1607079852-7460157751	1503246246	1970439550	3940909250	7881619650
	1947-1607079852-7460157751	1503246246	1970439550	3940909250	7881619650
3410002	3214142352-1492067152	1503246246	1970439550	3940909250	7881619650
	1947-3214142352-1492067152	1503246246	1970439550	3940909250	7881619650
3410002	9051181051	1074940252-1503246246	1970439550	3940909250	7881619650
	1947-9051181051	1074940252-1503246246	1970439550	3940909250	7881619650
3410002	1810233352	2149874852-1503246246	1970439550	3940909250	7881619650
	1947-1810233352	2149874852-1503246246	1970439550	3940909250	7881619650
3410002	3620479352	4299800452-1503246246	1970439550	3940909250	7881619650
	1947-3620479352	4299800452-1503246246	1970439550	3940909250	7881619650
3410001	1191864552-4299800452	1503246246	1970439550	3940909250	7881619650
	1947-1191864552-4299800452	1503246246	1970439550	3940909250	7881619650
3410001	2383730152-4299800452	1503246246	1970439550	3940909250	7881619650
	1947-2383730152-4299800452	1503246246	1970439550	3940909250	7881619650
3410001	4767425552-4299800452	1503246246	1970439550	3940909250	7881619650
	1947-4767425552-4299800452	1503246246	1970439550	3940909250	7881619650
3410003	1658513052	4096936051 2690856452-1970439550	3940909250	7881619650	
	1947-1658513052	4096936051 2690856452-1970439550	3940909250	7881619650	
3410003	3317031652	8193862951 5381710752-1970439550	3940909250	7881619650	
	1947-3317031652	8193862951 5381710752-1970439550	3940909250	7881619650	
3410003	6634020852	1638762552 1076343553-1970439550	3940909250	7881619650	

TABLE XVII (continued)

1947-6634020852	1638762552	1076343553-1970439550	3940909250	7881619650
3410002 6945896151	6117838350-1076343553-1970439550	3940909250	7881619650	
1947-6945896151	6117838350-1076343553-1970439550	3940909250	7881619650	
3410002 1389185552	1223586751-1076343553-1970439550	3940909250	7881619650	
1947-1389185552	1223586751-1076343553-1970439550	3940909250	7881619650	
3410002 2778335052	2447186251-1076343553-1970439550	3940909250	7881619650	
1947-2778335052	2447186251-1076343553-1970439550	3940909250	7881619650	
3410004 1100490952	-1313935551 2521450951 8066387251-3940909250	7881619650		
1947-1100490952	-1313935551 2521450951 8066387251-3940909250	7881619650		
3410004 2200979652	-2627874651 5042926151 1613278552-3940909250	7881619650		
1947-2200979652	-2627874651 5042926151 1613278552-3940909250	7881619650		
3410004 4401944552	-5255539651 1008553952 3226548052-3940909250	7881619650		
1947-4401944552	-5255539651 1008553952 3226548052-3940909250	7881619650		
3410001 8154811350	-5255539651 1008553952 3226548052-3940909250	7881619650		
1947-8154811350	-5255539651 1008553952 3226548052-3940909250	7881619650		
3410001 1630966851	-5255539651 1008553952 3226548052-3940909250	7881619650		
1947-1630966851	-5255539651 1008553952 3226548052-3940909250	7881619650		
3410001 3261871151	-5255539651 1008553952 3226548052-3940909250	7881619650		
1947-3261871151	-5255539651 1008553952 3226548052-3940909250	7881619650		
3410001 1970439550	5255539651 1008553952 3226548052-3940909250	7881619650		
1947-1970439550	5255539651 1008553952 3226548052-3940909250	7881619650		
3410001 3940909250	5255539651 1008553952 3226548052-3940909250	7881619650		
1947-3940909250	5255539651 1008553952 3226548052-3940909250	7881619650		
3410001 7881619650	5255539651 1008553952 3226548052-3940909250	7881619650		
1947-7881619650	5255539651 1008553952 3226548052-3940909250	7881619650		

TABLE XVIII
FORMAT FOR BETA VECTOR SEGMENTS

The beta vectors are read into the machine by the seven-per-card read-in routine which requires the following format:

Word 1	00xxxx000y
	xxxx is the location into which the first word of the corresponding card is to be read.
	y is the number of words in the card.
Words 2 to y	contain the elements of the associated beta vector segment.
Words y to 8	are irrelevant and may contain any number (i.e., residue of the punch band).

Note: Each beta vector segment is followed by a control card. The order of the beta vector segments and the control cards must not be disturbed.

TABLE XIX

FORMAT FOR CONTROL CARD FOR BETA VECTOR SEGMENTS

Word 1	0000001947 -
	Word 1 causes the seven-per-card load routine to transfer to lo- cation 1947.
Words 2 to 8	Irrelevant
	These words will contain the same numbers as the preceding card punched.

TABLE XX

SCALARS (OUTPUT)

7543210101	1892981955
7543210102	7571916555
7543210103	3028753056
7543210201	1418111554
7543210202	5672471054
7543210203	2268953555
7543210301	1352771554
7543210302	5411062154
7543210303	2164461455
7543210401	1777645554
7543210402	7110588754
7543210403	2844194155
7543210501	6247752754
7543210502	2499100355
7543210503	9996408155
7543210601	1246863154
7543210602	4987490454
7543210603	1994939755
7543210701	4651580454
7543210702	1860628055
7543210703	7442563555
7543210801	3482966854
7543210802	1393194555
7543210803	5572564355
7543210901	2582831654
7543210902	1033148555
7543210903	4132385555

TABLE XXI
FORMAT FOR SCALARS

Word 1

wxxxxxyyzz

wxxxxx is the identification in the
R | G matrix control card increased
by one in the position which is
specified by w.

yy is the sequential number of the
segments of the R^{-1} | B matrix.

zz is the sequential number of the
right hand member.

Word 2

The scalar value

Words 3 to 8

Irrelevant

APPENDIX B

PROGRAM FOR PHASE I

Phase I consists of the Beaton Correlation Routine. The write-up for Phase I as it appears in this thesis is a revision of the write-up which is on file at the Oklahoma State University Computing Center.

This program was designed to calculate the raw sums, raw sums of squares and crossproducts, covariances, corrected sums of squares and crossproducts, means, standard deviations and correlations for a maximum of forty-seven variables. The sum of squares for a variable cannot exceed ten digits.

Note: The drum must be cleared before executing Phase I. The program preceded by two drum clear cards is shown in Appendix A, Table 1.

The size of the variables can range from one digit to four digits and can be either one-per-word or packed; the one-per-word can be either positive or negative, the packed can only be positive.

The output of this program is in fixed decimal point for the raw sums and sums of squares but can be in either the fixed-point mode or the floating-point mode for all other statistics. The floating-point format is 50x.xxxxxxx. The mode is controlled by a trailer card which also specifies the quantities which are to be punched out by this program.

The input for this program consists of a header card,

the data, i.e., the X | Y matrix, and a trailer card. The unused columns of a word must be filled in with zeroes. It is unnecessary to punch the unused words of any input card.

Header:

The header card (load card) has the following format:

```
Word 1          xxy000000z
                xx is the number of variables
                y is 1 if the data is packed
                y is 0 if the data is not packed
                z is the number of words used in the
                header card starting with Word 2
```

Words 2 to z where z is defined in Word 1

Packed Case:

Each column indicates the number of digits in the associated variable, i.e., column 11 is associated with the first variable, column 12 with the second variable, etc. However, if for some reason all the variables are not on one card a minus (-) sign is used to indicate that there are variables on the following card. In the same manner the first column of the associated negative word indicates the number of digits in the first variable of the corresponding card; the second column, the second variable; etc.

Example:

```
Columns 11 -- 30 (Card 1 has 11 variables) 1223422121 +
                                                3000000000 +
31 -- 40 (Card 2 has 4 variables) 2223000000 -
41 -- 50 (Card 3 has 2 variables) 2100000000 -
```

Unpacked Case:

Each column indicates the number of variables in the associated card, i.e., column 11 is associated with the first card; column 12 with the second card; etc.

Example:

7570000000 - (Indicates 3 cards with 7 variables on the first card, 5 variables on the second card and 7 variables on the third card)

Data:

The data X | Y is in fixed decimal point mode. Word 1 is reserved for identification. Words 2 through 8 are for data. Word 1 can be key punched in from column 11 on, variable by variable, with no regard for end of word if all values are non-negative. If the data is unpacked, then no more than seven variables can be punched on a card with each variable in a separate word from 2 to 8.

Trailer:

The trailer card (load-card) has the following format:

Word 1 0000xx1355 -

xx is the number of variables

Word 2 is used for punch control

0 no punch; 1 punch in float point.

However if the quantity is in fixed-point (see columns 14, 16, 18 and 20 below) the non-zero digit indicates the number of desired decimal places.

The quantities associated with the columns in the trailer card are indicated below:

Column	Quantity
11	$\sum X_i$
12	$\sum X_i X_j$
13	Cov. - float
14	Cov. - fixed
15	S. S. Cr. Pr. - float
16	S. S. Cr. Pr. - fixed
17	\bar{X}, σ - float
18	\bar{X}, σ - fixed
19	Cor. - float
20	Cor. - fixed

Word 3 xxxx000000

xxxx is the identification desired in the output

Words 4 to 8 Blank

Output:|

The output has the following format (non load cards):

Word 1 xxxxwwyyzz

xxxx is problem identification (copied from the trailer card)

yy is the row number in the A matrix

zz is the card number in the row

ww is the code which identifies the associated quantities:

ww	Quantity
00	N
01	$\sum X_i$
02	$\sum X_i X_j$
03	Cov. - float
04	Cov. - fixed
05	S. S. Cr. Pr. - float
06	S. S. Cr. Pr. - fixed
07	\bar{X} - float
08	\bar{X} - fixed
09	σ - float
10	σ - fixed
11	Cor. - float
12	Cor. - fixed

Refer to page 4 of this thesis for a discussion of how Phase I was used in processing the sample problem.

VITA

Lee Vernon Brown

Candidate for the Degree of

Master of Science

Thesis: A PROGRAM FOR LEAST SQUARES ANALYSIS OF DATA WITH
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Evangel College, Springfield, Missouri.