

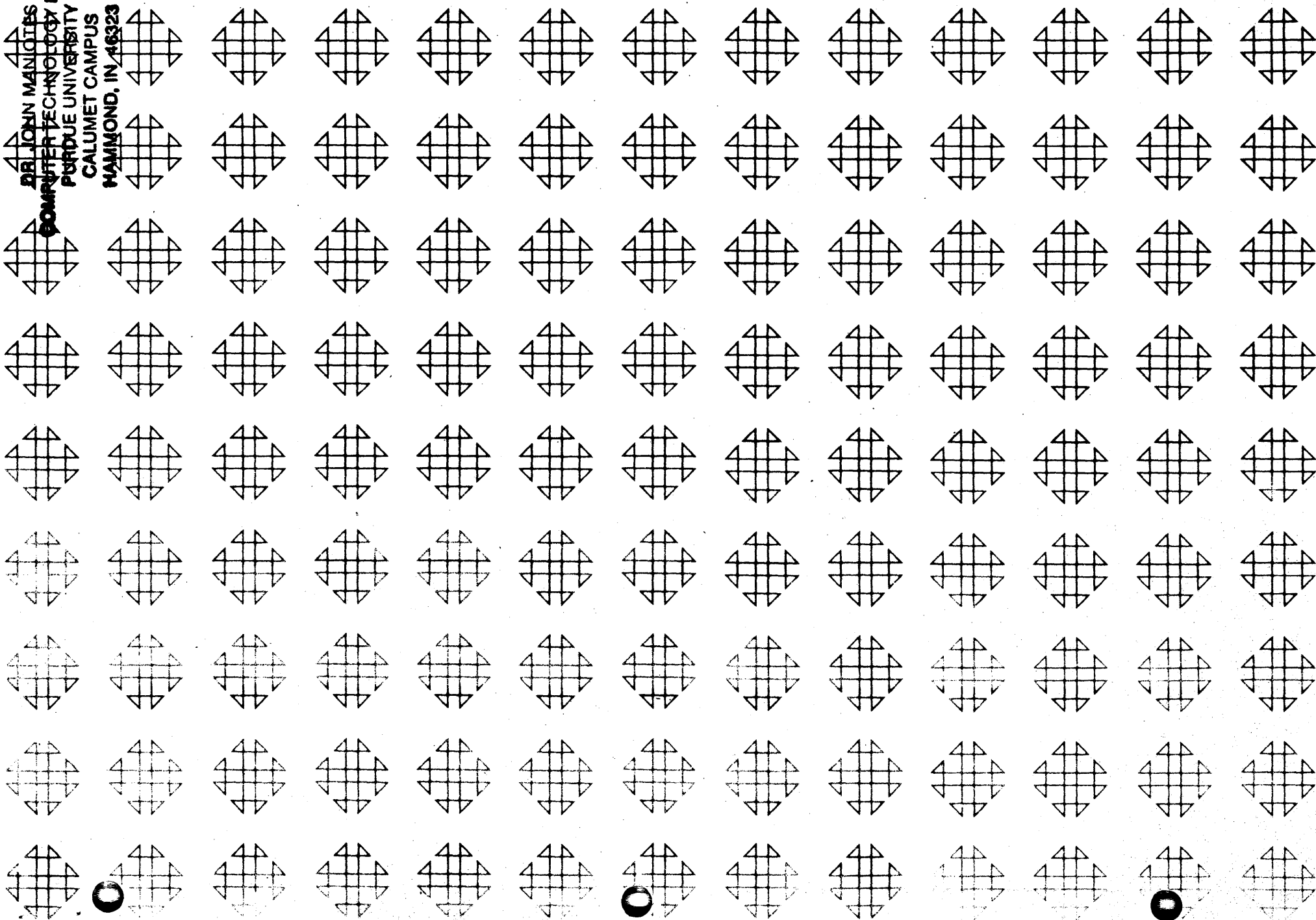


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1620 GENERAL PROGRAM LIBRARY

Eigenvalues of Real Symmetric Matrices on the 1620 Data Processing System 5.0.003

C-12



1620
Correction

5.0.003
Oct. 7, 1965

The authors new address is as follows:

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3

ERRATA

EIGENVALUES OF REAL SYMMETRIC MATRICES
ON THE
1620 DATA PROCESSING SYSTEM
(CARD)

Page 5 - bottom - add

This procedure yields the TRANSPOSE of the Eigenvectors. The matrix identification is then reversed on printing to yield proper subscripting.

Page 8 - OVERFLOW CHECK SWITCH

Should be set to PROGRAM.

Phase 3 basic and Phase 3 Auto Divide -- "TYPEV" block should read:

02758	25	0397102426	To Type + 6, Out J-2
02770	25	0397302427	To Type + 8, Out J
02782	25	0396502428	To Type + 12, Out I-1
02794	25	0396702429	To Type + 14, Out I

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6/14/61

FILE NO.

ABSTRACT

05.0.003

IBM 1620-EIGENVALUES OF REAL SYMMETRIC MATRICES ON THE 1620 DATA PROCESSING SYSTEM *CARD* AVAILABLE 1ST QUARTER 1962

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HONOLULU 13, HAWAII

DIRECT INQUIRIES TO AUTHOR

WILL SOLVE FOR THE EIGENVALUES AND ASSOCIATED EIGENVECTORS OF A REAL, SYMMETRIC MATRIX TO ORDER 50. FLOATING POINT ARITHMETIC IS USED FOR ALL CALCULATIONS IN PHASE 2 AND 3. NO OTHER SUBROUTINES ARE USED IN ANY OF THE THREE PHASES. 20,000 POSITIONS OF CORE STORAGE ARE UTILIZED BASIC 1620 CARD SYSTEM WITH DIRECT DIVISION AND INDIRECT ADDRESSING.

THIS PROGRAM AND ITS DOCUMENTATION WERE WRITTEN BY AN IBM EMPLOYEE. IT WAS DEVELOPED FOR A SPECIFIC PURPOSE AND SUBMITTED FOR GENERAL DISTRIBUTION TO INTERESTED PARTIES IN HOPE THAT IT MIGHT PROVE HELPFUL TO OTHER MEMBERS OF THE DATA PROCESSING COMMUNITY. THE PROGRAM AND ITS DOCUMENTATION ARE ESSENTIALLY IN THE AUTHORS ORIGINAL FORM. IBM SERVES AS THE DISTRIBUTION AGENCY IN SUPPLYING THIS PROGRAM. QUESTIONS CONCERNING THE USE OF THE PROGRAM SHOULD BE DIRECTED TO THE AUTHORS ATTENTION.

PROBLEM DEFINITION

The physical reasons for wishing to solve the eigenvalue problem come from a wide variety of fields, including vibration analysis, factor analysis and systems in dynamic equilibrium. Probably the most basic reason comes from the frequent need to solve a system of n linear differential equations in n unknowns:

$$\begin{aligned} \dot{x}_1 &= a_{11}x_1 + \dots + a_{1n}x_n \\ \dot{x}_2 &= a_{21}x_1 + \dots + a_{2n}x_n \\ &\dots \dots \dots \\ \dot{x}_n &= a_{n1}x_1 + \dots + a_{nn}x_n \end{aligned}$$

(1)
If the column vector $(x_1 \dots \dots x_n)^T$ is denoted by x, then this can be written as a single matrix equation

$$\dot{x} = Ax$$

where A is the n x n coefficient matrix.

A solution to this equation in the form $x = Ve^{\lambda t}$ is sought, where V is a column vector. This leads to the equation $Ve^{\lambda t} = AVe^{\lambda t}$ or $(A - \lambda I)Ve^{\lambda t} = 0$. Thus an eigenvalue, together with a corresponding eigenvector V, yields a solution $x = Ve^{\lambda t}$ of the matrix differential equation.

For an N x N square, symmetrical matrix, A, the problem to be solved is to find a number λ and a vector V such that $AV = \lambda V$. Each λ is referred to as an eigenvalue, characteristic root or latent root of the matrix A, and each related N-dimensional vector, V, is called an eigenvector or characteristic vector corresponding to the eigenvalue. The eigenvectors are mutually orthogonal, i.e., the inner or scalar product of any two resulting eigenvectors equals zero:

$$(V_i, V_j) = 0.$$

It can be shown that a solution exists if and only if

DEF $|A - \lambda I| = 0$, where I is an Nth order unit matrix. This relationship results in an Nth degree polynomial which has, in general, N real eigenvalues or roots.

MACHINE REQUIREMENTS

Program "A" Basic 1620 equipped with 1622 card read-punch.
Program "B" Basic card 1620 with direct division and indirect addressing features. Program B requires 6% less time than Program A for any given problem.

Other features, such as extra memory and additional instructions, have no effect on program operation.

A paper tape version of Program "A" is currently available from the 1620 program library.

PROGRAM OPERATION - GENERAL

I/O Check Switch----- STOP
OVERFLOW Check Switch---- STOP
PARITY Check Switch----- STOP

ON

Sense Switch 1
Sense Switch 2
Sense Switch 3
Sense Switch 4

Data on Cards
Punch rotation angles
Data will type out to verify
Error entered from typewriter

OFF

Data entered via typewriter
Do not punch rotation angles
Data will not type out
Normal

When a typing error occurs:

- 1) Place sense switch 4 ON
- 2) Depress RELEASE, START
- 3) Place sense switch 4 OFF
- 4) Re-enter record correctly from typewriter.

Clear memory. (31 00003 00002)
Prepare card punch and typewriter forms. All program halts not accompanied by error typeouts or error indicators are normal. They are included to allow program or data preparation.

All three phases are loaded by standard SPS methods:

Depress Load Key, then START

The transition between phases, however, is done automatically.

PHASE 1

- 1) Load program and data cards into 1622 read hopper:
 - A. Phase 1 program
 - B. Control Record card
 - C. Data cards
 - D. Trailer card (record mark in column 1)
 - E. Phase 2 program
 - F. Phase 3 program
- 2) Depress LOAD
- 3) When machine halts, depress START
- 4) Follow instructions typed out on the console typewriter.

PHASE 1 CONT.

- 5) Timeouts will occur with the following messages and their indications:

<u>LABEL TYPED</u>	<u>NORMAL</u>	<u>ERROR</u>	<u>CORRECTION POSSIBLE</u>
CONTROL RECORD ERROR N=XX	X	X	Re-enter correct control record via typewriter
DELTA=xxxxxxxxxx	X		
MATRIX TOO LARGE		X	Re-enter correct control record
MATRIX TOO SMALL		X	Re-enter correct control record
DATA ERR OR ADDITION record too long record too short I greater than J J greater than N record mark missing	X	X	Enter correct record: IJJAAAAAAAAA ¹ by typewriter, depress RELEASE and then START
IJ DUPLICATED	X	X	If in error, correct by 'ANY CHANGES', below
SINGULARITY POSSIBLE	X	X	None, (AI less than .000001)
MATRIX LOADED	X		OK if last record is in
ANY CHANGES	X	X	Type YES ¹ or NO ¹ . If YES, enter any additions or corrections as in 'DATA ERR', above
COUNT WRONG		X	One or more elements are missing, enter as in 'DATA ERR', above

- 6) The program will load into storage exactly $N(N+1)/2$ records. Should the data deck contain more than this number, the last record entered for any I and J will dominate, i. e., will destroy the earlier record.

- 7) The field address of any diagonal element is given by:

$$\text{Address} = 07248 + 10 I \text{ for any } (I, I).$$

The field address of any other element is given by:

$$\text{Address} = 07758 + J(J-3)*5 + 10 I \text{ for any } A(I, J). (I \neq J)$$

- 8) Program execution time is $.3(N^2/2)$ seconds or slightly less than full read speed.

It is important that no changes to 1620 storage addresses above 07000 take place between phases 1 and 2. Phase 2 assumes the existence of the data matrix and certain other information left in storage by phase 1.

PHASE 1 CONT.

- 9) Phase 2 will be automatically loaded when Phase 1 terminates.

PHASE 2

- 1) Sense switch 2 on if the eigenvectors are desired.
- 2) Depress START.
- 3) Program execution time is about $.0052 N^3$ minutes. If the vectors are desired, punch time (3.4 milliseconds per rotation) must be added. The number of rotations performed is generally bounded by $1.3 N^2$ and $2 N^2$, depending on the size and conditioning of the matrix.
- 4) If sense switch 2 is on, i. e., the eigenvectors are desired, phase 3 automatically loads into memory, if sense switch 2 is off, the program terminates and the card reader is unloaded by the program.

PHASE 3

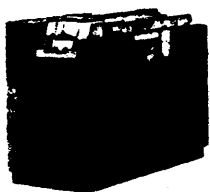
- 1) If the eigenvectors are desired, depress Reader START then START at the completion of phase 2. Follow instructions typed out on the console typewriter. Insure that all phase 2 output data cards (including the last one) follow phase 3.
- 2) A maximum of 32 eigenvectors will be typed out on the first pass. If N is greater than 32, reload the data cards now in the reader output hopper and hit START for the remaining N-32 vectors.
- 3) Average execution time = $.004N^3$ minutes.
- 4) Since phase 3 is independent of the other two phases, it may be run at any later time at the user's convenience. To operate phase 3 alone, perform the following operations:
 - (1) Clear memory (31 00003 00002)
 - (2) Load phase 3 program in Reader hopper.
 - (3) Depress LOAD key.
 - (4) When phase 3 loads, depress START.

PHASE 1 - MATRIX LOAD

Trailer Card

Matrix Data
Control Record

Matrix Loader
Phase 1



Messages
Errors
Data List

N = Matrix Size

PHASE 1

00402. Start
Clear Data
Area
Initialize

Tape
Read - N, D
RNCD or
RNTP

Verify Control Bad Error
Record Message

OK Last Record

Read 2

Read:
I, J, AIJ
RNCD or RNTP

Invalid Test
Error Message Validity
Valid

Store AIJ

Return
Count +1

No End Ask
Interrogate
operator-End?

End
Tstend

Count Short Error
Message No Count =
N(N+1)/2?

Yes
Exit
Instruc-
tions

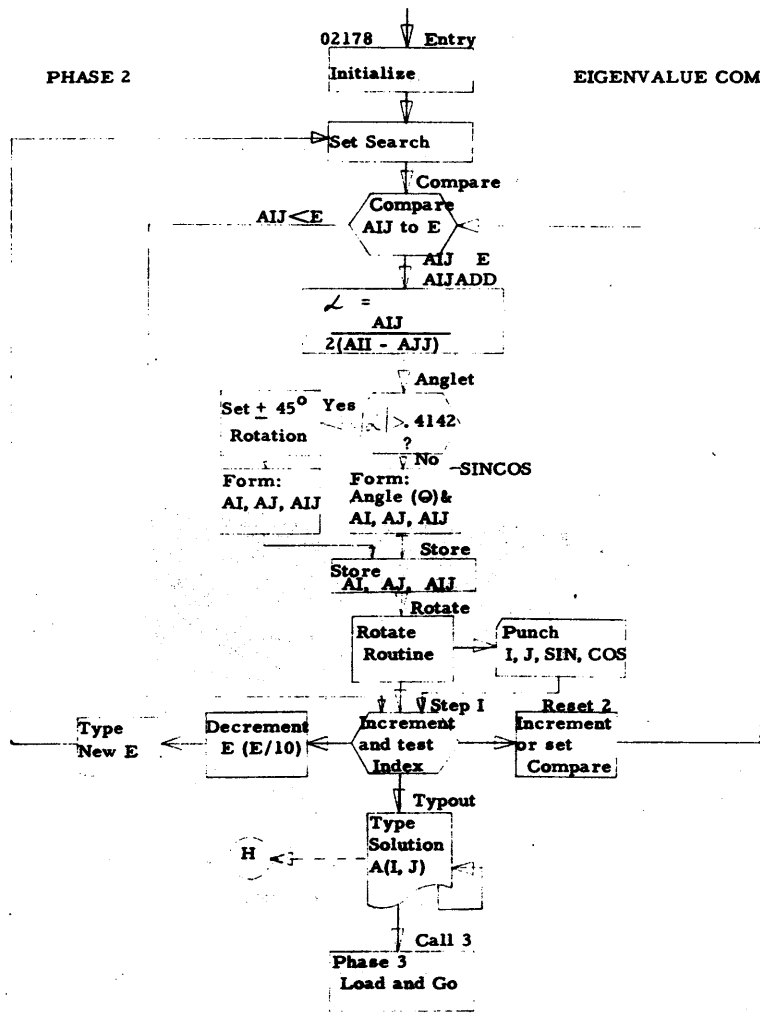
Halt

Phase 2 Load
and Go

MATRIX LOAD

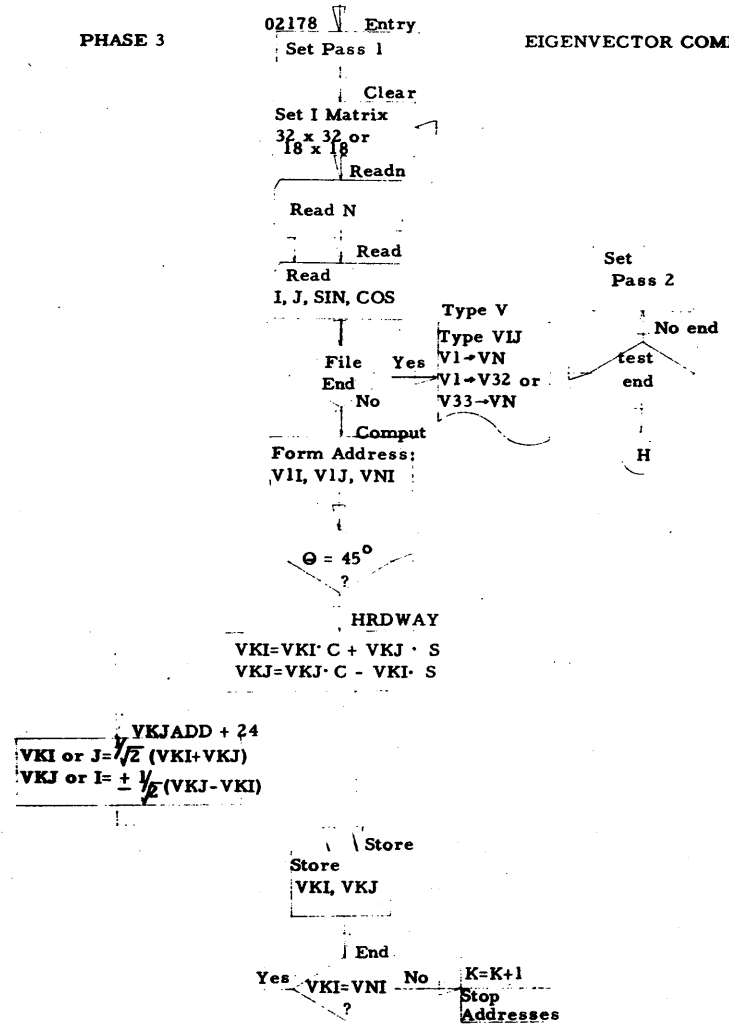
PHASE 2

EIGENVALUE COMPUTE



PHASE 3

EIGENVECTOR COMPUTE



PRECISION AND TIMING

For test purposes, two types of matrices are considered. A well behaved matrix C, and the notoriously ill-conditioned Hilbert matrix, H defined as:

$$C(I, J) = 2 D(I, J) - D(I, J + 1) - D(I, J - 1)$$

where D is the usual Kronecker delta function, i. e. $D(I, I) = 0$; $D(I, J) = 1$ for $I \neq J$ and $H(I, J) = 1 / (I + J - 1)$.

The eigenvalues of C are given by $\lambda_i = 4 \sin^2 (\pi * I / (2n + 2))$
 $i = 1, 2, \dots, n$.

A moderately conditioned matrix, X, was also tried.

Test results were:

Matrix Size	C, H or X	Time	Precision (No. of Correct Digits)
5	H	65 seconds	4
6	X	90 seconds	7
7	H	2 minutes	1
10	C	5-1/4 minutes	7
10	H	8 minutes	0
20	C	29 minutes	4
20	C	32 minutes	5
20	C	38 minutes	6

Since the floating point routines do not round after arithmetic operations, a general deterioration of precision is to be expected in the results of this program.

Program "B" requires 6% less time than program "A".

The reader will notice minor discrepancies between the results of program A and B. These are due to the computational differences of the direct divide and programmed divide methods. The results from program B have proved, in general, to be more accurate.

PROCEDURAL OPTIONS

The procedure of reducing all off-diagonal elements to a machine zero (delta) raises a problem in the selection of this input variable. If delta is chosen either too large or too small, precision will be lost. The effects of incorrectly choosing delta are:

- 1) Delta too large -
 - a) fast processing speeds
 - b) moderate to large error in Phase 2
 - c) moderate to large error in Phase 3
 - d) may necessitate a re-run to obtain the precision required.
- 2) Delta too small -
 - a) slow processing speeds, particularly in Phase 3
 - b) small to moderate truncation errors in Phase 2
 - c) moderate to large errors in Phase 3
 - d) very large errors and floating point overflows if less than about 10^{-20} .

The author has found empirically that the relation

$$\text{DELTA} = \text{MAXIMUM AIJ} (I \neq J) * 10^{-9}$$

is very close to an optimum value in terms of precision and speed, with precision very heavily weighted. Deviations from this value by a factor of 10 affect the results to a small degree. Increasing delta by a factor of 10 results in a small time reduction, whereas decreasing delta by a factor of 10 results in a very small increase in precision.

REFERENCES

- 1) P. White, Eigenvalue and Eigenvector Computations of a Matrix, Journal of the Society for Industrial and Applied Mathematics 4 (1958). Pages 393-437.
- 2) Howell, Hall, Eigenvalues of Real Symmetric Matrices by the Jacobi Method. IBM 650 program library file No. 5. 1. 006.
- 3) Corbato, IBM SHARE, 704 library program MI HD11 - May, 1958.

THIS IS A COMPLETE RECORD OF CONSOLE OPERATIONS FOR THE 1620 EIGENVALUE PROGRAM.
TEST MATRIX 3 X 3 - SWITCHES 1, 2 AND 3 ON. BASIC CARD 1620.

310000300002
SS1 ON-DATA ON CARDS, OFF-DATA ENTRY VIA TYP.
SS2 ON-PUNCH ROTATION ANGLES, OFF-NO PUNCH.
SS3 ON-DATA TYPED OUT TO VERIFY, OFF-NO TYPE.
SS4 ON-ERROR ENTERED FROM TYP., OFF-NORMAL.
CLEAR CARD PUNCH AND READY FORMS.
PLEASE LOAD DATA AND HIT START

N= 03 , DELTA = 4110000000
A(01,01) = 5120000000
A(01,02) = 5110000000
A(01,03) = 0000000000
A(02,02) = 5120000000
A(02,03) = 5110000000
A(03,03) = 5120000000
HAVE YOU ANY CHANGES, TYPE YES(RCJMK) OR NO(RCDMK)
NO:
E= 5110000000

MATRIX LOADED-WHEN PHASE 2 LOADS, HIT START
E = 5010000000
E = 4910000000
E = 4810000000
E = 4710000000
E = 4610000000
E = 4510000000
E = 4410000000
E = 4310000000
E = 4210000000
E = 4110000000

A(01) = 5134142151
A(02) = 5058578544
A(03) = 5119999993

00011 ROTATIONS.
MAXIMUM AIJ, (I NOT = J), = 3981672426

EIGENVALUES DONE, WHEN PHASE 3 LOADS, HIT START

LOAD PHASE 2 OUTPUT HIT START

V(01,01) = 5050000018
V(02,01) = 5070710712
V(03,01) = 5050000030
V(01,02) = 5050000005
V(02,02) = 5070710699
V(03,02) = 5050000030
V(01,03) = 5070710708
V(02,03) = 4362605540
V(03,03) = 5070710697
END

THIS IS A COMPLETE RECORD OF CONSOLE OPERATIONS FOR THE 1620 EIGENVALUE PROGRAM.
TEST MATRIX 3 X 3 - SWITCHES 1, 2 AND 3 ON. 1620 W/DIVIDE AND INDIRECT ADDRESSING.

310000300002
SS1 ON-DATA ON CARDS, OFF-DATA ENTRY VIA TYP.
SS2 ON-PUNCH ROTATION ANGLES, OFF-NO PUNCH.
SS3 ON-DATA TYPED OUT TO VERIFY, OFF-NO TYPE.
SS4 ON-ERROR ENTERED FROM TYP., OFF-NORMAL.
CLEAR CARD PUNCH AND READY FORMS.
PLEASE LOAD DATA AND HIT START

N= 03 , DELTA = 4110000000
A(01,01) = 5120000000
A(01,02) = 5110000000
A(01,03) = 0000000000
A(02,02) = 5120000000
A(02,03) = 5110000000
A(03,03) = 5120000000
HAVE YOU ANY CHANGES, TYPE YES(RCJMK) OR NO(RCDMK)
NO:
E= 5110000000

MATRIX LOADED-WHEN PHASE 2 LOADS, HIT START
E = 5010000000
E = 4910000000
E = 4810000000
E = 4710000000
E = 4610000000
E = 4510000000
E = 4410000000
E = 4310000000
E = 4210000000
E = 4110000000

A(01) = 5134142153
A(02) = 5058578477
A(03) = 5119999993

00011 ROTATIONS.
MAXIMUM AIJ, (I NOT = J), = 4011832334

EIGENVALUES DONE, WHEN PHASE 3 LOADS, HIT START

LOAD PHASE 2 OUTPUT HIT START

V(01,01) = 5050000020
V(02,01) = 5070710714
V(03,01) = 5050000035
V(01,02) = 5049999999
V(02,02) = 5070710708
V(03,02) = 5050000043
V(01,03) = 5070710722
V(02,03) = 4279476400
V(03,03) = 5070710697
END

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7. 22

16

21 2/

PHASE 1
ALL 1620 CARD SYSTEMS
SPS LISTING

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			*	THIS IS PHASE 1 - MATRIX LOADER	ANY 1620
			*	Z	
00402				DORG 402Z	
00414	16	00420	-7258	TFM START66,07258Z	
00414	26	-7258	03115	START TF 7258,ZERO,2Z	
00426	11	00419	000-1	AM *-7,1,10Z	
00438	14	00417	000K0	CM START63,20,10Z	
00450	47	00414	01200	BNZ STARTZ	
00462	15	01639	00009	TDM SW161,9,, SWITCH 1 OFFZ	
00474	34	00000	00102	RCTY Z	
00486	39	03223	00100	WATY MESS1Z	
00498	34	00000	00102	RCTY Z	
00510	39	03313	00100	WATY MESS2Z	
00522	34	00000	00102	RCTY Z	
00534	39	03399	00100	WATY MESS3Z	
00546	34	00000	00102	RCTY Z	
00558	39	03489	00100	WATY MESS4Z	
00570	34	00000	00102	RCTY Z	
00582	39	03575	00100	WATY MESS5Z	
00594	34	00000	00102	RCTY Z	
00606	39	02277	00100	WATY DATAZ	
00618	34	00000	00102	RCTY Z	
00630	48	00641	00641	TMPSTR H TEMP,TEMPZ	
00642	46	00698	00100	BC1 TAPE,,, ENTRY VIA TYPZ	
00654	34	00000	00102	RCTY Z	
00666	36	03116	00100	RNTY I-1Z	
00678	46	00654	00400	BC4 *-24Z	
00690	49	00710	00000	B TAPE612Z	
00698				DORG *-3Z	
00698	36	03116	00500	TAPE RNCD I-1,, READ N AND DELTAZ	
00710	45	00958	03128	BNR CNTRLR,1611Z	
00722	32	03116	00000	SF I-1,, SET N FLAGZ	
00734	33	03117	00000	CF I,,, N6Z	
00746	26	07247	03117	TF E,1Z	
00758	26	07227	03117	TF N,1Z	
00770	34	00000	00102	RCTY Z	
00782	39	02071	00100	WATY NEQUALZ	
00794	38	07246	00100	WNTY E-1Z	
00806	38	07246	00400	WNCD E-1,, PUNCH NZ	
00818	39	02639	00100	WATY DELTAKZ	
00830	38	03118	00100	WNTY J-1Z	
00842	32	03118	00000	SF J-1,, SET DELTA FLAGZ	
00854	26	07237	03127	TF DELTA,068Z	
00866	16	03104	-0000	TFM COUNT,, COUNT#0Z	

00878 14 07227 0000
00890 47 00990 01100
00902 34 00000 00102
00914 39 02341 00100
00926 34 00000 00102
00938 38 03116 00100
00950 49 00654 00000
00958
00958 34 00000 00102
00970 39 02541 00100
00982 49 00926 00000
00990
00990 14 07227 000-3
01002 46 01046 01300
01014 34 00000 00102
01026 39 02441 00100
01038 49 00926 00000
01046
01046 11 07247 000-1
01058 23 07247 07227
01070 26 07247 00099
01082 13 07247 000-5
01094 26 01733 00098
01106 26 07247 03115
01118 15 03130 00000
01130 46 01186 00100
01142 34 00000 00102
01154 36 03116 00100
01166 46 01142 00400
01178 49 01198 00000
01186
01186 36 03116 00500
01198 45 01254 03116
01210 15 03130 00000
01221 1
01222 15 03116 00000
01234 15 01639 00001
01246 49 01650 00000
01254
01254 45 02050 03130
01266 32 03120 00000
01278 32 03118 00000
01290 32 03116 00000
01302 24 07227 03119
01314 47 02050 01300

CM N,50,10Z
BNH LESS50Z
RCTY Z
WATY BIGZ
NERR RCTY Z
WNTY I-1Z
B TMPSTR624Z
DORG *-3Z
CNTRLR RCTY Z
WATY ERRORCZ
B NERRZ
DORG *-3Z
LESS50 CM N,3,10Z
BNL SIZEOKZ
RCTY Z
WATY SMALLZ
B NERRZ
DORG *-3Z
SIZEOK AM E,1,10,PLUS 1Z
M E,N,,N%N610/2Z
TF E,ACZ
MM E,5,10,%10/20%N%N610Z
TF TSTEND611,AC-1,, SET LND TESTZ
TF E,ZEROZ
LOOP TDM INPUT61,0,, RECORD MARK0Z
READ BC1 READ2Z
RCTY Z
RNTY INPUT-13Z
BC4 *-24Z
B *620Z
DORG *-3Z
READ2 RNCD INPUT-13,,READZ
BNR GUT,INPUT-13,, FILE TESTZ
TDM INPUT61Z
DC 1,0,*Z
TDM INPUT-13,0Z
TDM SW161,1,,SWITCH 1 NOW ONZ
B ASK,,,INGUIREZ
DORG *-3Z
GUT BNR INLARM,INPUT61,,CHECK RECORDZ
RCRDOK SF INPUT-9,,FLAG AIJZ
SF INPUT-11,,FLAG IJZ
SF INPUT-13,,FLAG 1Z
C N,JZ
BL INLARMZ

21

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01326 24 03118 03117
01338 47 02050 01300
01350 46 01638 01200
01362 24 03128 07246
01374 47 01398 01300
01386 26 07247 03129
01398 26 00641 03119
01410 12 00641 000-3
01422 23 00641 03119
01434 26 00641 00099
01446 13 00641 000-5
01458 11 00099 -7758
01470 21 00098 03117
01482 32 00095 00000
01494 26 01512 00099
01506 24 -00000 03115
01518 46 01578 01200
01530 34 00000 00102
01542 39 02721 00100
01554 38 03116 00100
01566 12 03104 000-1
01578 26 01596 00099
01590 26 00000 03129
01602 47 01626 00300
01614 17 02190 000-0
01626 11 03104 000-1
01638 49 01118 00000
01650 34 00000 00102
01662 39 02993 00100
01674 34 00000 00102
01686 37 03093 00100
01698 46 01674 00400
01710 45 02086 03097
01722 14 03104 -0000
01734 47 02142 01200
01746 34 00000 00102
01758 39 02663 00100
01770 28 07238 00100
01782 34 00000 00102
01794 34 00000 00102
01806 39 03643 00100
01818 36 00000 00500
01830 49 00000 00000
01838
01838 14 03121 00005

BL YALARMZ
BE STOR11,,DOES INJZ
C INPUT-1,E-1,, AIJ VS EZ
BL STOR1JZ
TF E,INPUT,,AIJ INTO E IF HIGHERZ
STOR1J TF TEMP,JZ
SM TEMP,3,10Z
M TEMP,J,,J%J-30 TO 4 DIGITZ
TF TEMP,AC,, ASAIJ0Z
MM TEMP,5,10, 5*TEMP-6 DIGITZ
PATCH1 AM AC,07758Z
A AC-1,1,,6 10*1Z
SF 95,,FIELD NOW 5 DIGITZ
TF STORE66,AC,, SET COMPARLZ
STORE C 0,ZERO,2, OCCUPIED TESTZ
BE DIJOB0Z
RCTY Z
WATY DUP,,TYPE DUP. ERRORZ
WNTY INPUT-13Z
SM COUNT,1,10, COUNT-1Z
DIJOB0 TF *618,ACZ
TF 0,INPUT,, STORE IF I NOT # JZ
BNCS RETURNZ
BTM OUTDUP,0,10Z
RETURN AM COUNT,1,10, COUNT61Z
SW1 B LOOP,,DUMMY - NOPZ
ASK RCTY Z
WATY INQUIRZ
RCTY Z
KATY ADD,, YES OR NO ENTERED,Z
BC4 *-24Z
BNR INLARM636,ADD64Z
TSTEND CM COUNT,, COUNT VS N%N610Z
BNE CTWRNGZ
EXIT RCTY Z
WATY EEQUALZ
WNTY E-9Z
RCTY Z
RCTY Z
WATY INQUIRZ
RNCD 00000,,LOAD PHASE 2 LOADERZ
B 00000,,EXECUTE LOADERZ
DORG *-3Z
STOR11 CM INPUT-8,45,10, 15 AI SMALLZ

22

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01850 46 01898 01100
 01862 34 00000 00102
 01874 39 02679 00100
 01886 38 03116 00100
 01898 16 01928 -7249
 01910 21 01927 03117
 01922 24 -0000 03115
 01934 46 -1994 01200
 01946 34 00000 00102
 01958 39 02721 00100
 01970 38 03116 00100
 01982 12 03104 000-1
 01994 26 02012 01928
 02006 26 -0000 03129
 02018 47 02042 00300
 02030 17 02190 000-0
 02042 49 01626 00000
 02050
 02050 34 00000 00102
 02062 15 03139 00000
 02073 1
 02074 38 03116 00100
 02086 39 02793 00100
 02098 34 00000 00102
 02110 36 03116 00100
 02122 46 02098 00400
 02134 49 01198 00000
 02142
 02142 34 00000 00102
 02154 39 02893 00100
 02166 38 03100 00100
 02178 49 01650 00000
 02190 25 03203 03116
 02202 25 03205 03117
 02214 25 03209 03118
 02226 25 03211 03119
 02238 34 00000 00102
 02250 39 03197 00100
 02262 38 03120 00100
 02274 42 00000 00000

IIOK IIOKZ
 RCTY Z
 WATY IILAKRZ
 WNTY INPUT-13Z
 IIOK TFM *630,DIAG-10,, A&AII#Z
 A *617,1,, L&AII#DIAC610*IZ
 C 0,ZERO,2, OCCUPIED TESTZ
 HE EDELSKAZ
 RCTY Z
 WATY DJPZ
 WNTY INPUT-13,,, BAD RECORDZ
 SM COUNT,1,10Z
 EDESKA TF *618,IIOK630Z
 TF 0,INPUT,2, STORE AIZ
 BNC3 *624Z
 BTM OUTDUP,0,10Z
 B RETURNZ
 DORG *-3Z
 INLAKM RCTY Z
 TDM INPUT610,,, INSURANCE RMZ
 DC 1,@,*Z
 WNTY INPUT-13Z
 WATY RCWRNG,,, BAD RECORDZ
 RCTY Z
 RNTY INPUT-13,,, CORRECT RECORDZ
 BC4 *-24Z
 B READ2612Z
 DORG *-3Z
 CTWRNG RCTY Z
 WATY NUMBERZ
 WNTY COUNT-4Z
 B ASK,,, ENTER MISSING RECORDZ
 OUTDUP TD OUTTYP66,1-1Z
 TD OUTTYP68,IZ
 TD OUTTYP612,J-1Z
 TD OUTTYP614,JZ
 RCTY Z
 WATY OUTTYPZ
 WNTY INPUT-9Z
 BB Z

02276

07758 1225 00010
 07258 50 00010
 02277 32
 02361 50
 02441 50
 02541 49
 02639 12
 02663 4
 02671 4
 02679 21
 02721 36
 02793 50
 02893 50
 02993 50
 03093 4
 03104 5
 03105 1
 00641 10
 03115 10
 03117 2
 03119 2
 03129 10
 07227 2
 07237 10
 07247 10
 07248 1
 03129
 03195 66
 03143 1
 00099
 03197 13
 03223 45
 03313 43
 03399 45
 03489 43
 03575 34
 03643 44
 00402

DORG *-9Z
 * PHASE 1 CONSTANTSZ
 ELEMNT DSB 1225,10,7758Z
 DIAG DSB 50,10,07258Z
 DATA DAC 32,PLEASE LOAD DATA AND HIT START @Z
 BIG DAC 50,MATRIX TOO LARGE,RE-ENTER CONTROL RECORD VIA TYP.@Z
 SMALL DAC 50,MATRIX TOO SMALL,RE-ENTER CONTROL RECORD VIA TYP.@Z
 ERRORC DAC 49,CONTROL RECORD ERROR,RE-ENTER VIA TYPEWRITER NOW@Z
 DELTAK DAC 12, , DELTA # @Z
 EEQUAL DAC 4,E# @Z
 NEQUAL DAC 4,N# @Z
 IILARM DAC 21,SINGULARITY POSSIBLE@Z
 DUP DAC 36,IJ DUPLICATED, RECORD USED WILL BE @Z
 RCWRNG DAC 50,DATA ERR OR ADDITION,INSERT VIA TYPEWRITER NOW @Z
 NUMBER DAC 50,COUNT WRONG,YOUR ANSWER MUST BE YES TO QUERY @Z
 INQUIR DAC 50,HAVE YOU ANY CHANGES,TYPE YES%RCMDK@ OR NO%RCMDK@Z
 ADD DAC 4,NOX@Z
 COUNT DS 5Z
 RM DS 1,@Z
 TEMP DS 10,TMPSTR611Z
 ZERO DC 10,-0Z
 I DS 2Z
 J DS 2Z
 AIJ DS 10Z
 N DS 2,7227Z
 DELTA DS 10,7237Z
 E DS 10,7247Z
 XYZ DC 1,@,7248Z
 INPUT DS ,AIJZ
 CARDIN DS 66Z
 INSURE DC 1,@,INPUT614Z
 AC DS ,99Z
 OUTTYP DAC 13, A%00,00# # @Z
 MESS1 DAC 45,SS1 ON-DATA ON CARDS,OFF-DATA ENTRY VIA TYP.@Z
 MESS2 DAC 43,SS2 ON-PUNCH ROTATION ANGLES,OFF-NO PUNCH.@Z
 MESS3 DAC 45,SS3 ON-DATA TYPED OUT TO VERIFY,OFF-NO TYPE.@Z
 MESS4 DAC 43,SS4 ON-ERROR ENTERED FROM TYP.,OFF-NORMAL.@Z
 MESS5 DAC 34,CLEAR CARD PUNCH AND READY FORMS.@Z
 INSTRC DAC 44,MATRIX LOADED-WHEN PHASE 2 LOADS, HIT START@Z
 DEND START-12Z

PHASE 2
BASIC 1620 CARD SYSTEMS
SPS LISTING

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* THIS IS PHASE 2 - EIGENVALUES COMPUTE BASIC 1620 Z
*
02178 15 00401 00-01
02190 16 06202 -0000
02202 16 05983 000-1
02214 16 05985 000-2
02226 16 02256 -7751
02238 15 04975 00001
02250 24 -7751 07240
02262 47 04914 01300
02274 15 04975 00009
02286 16 02321 -7248
02298 21 02320 05983
02310 26 06167 00000
02322 16 02357 -7248
02334 21 02356 05985
02346 26 06177 00000
02358 26 02393 02256
02370 11 02393 000-7
02382 26 06187 00000
02394 26 06197 06167
02406 16 00469 -2441
02418 16 00445 -6197
02430 49 00402 -6177
02442 47 02486 01200
02454 26 06233 06097
02466 25 06250 06187
02478 49 02654 00000
02486
02486 26 00099 06197
02498 16 00469 -2533
02510 16 00445 -0099
02522 49 00422 -0099
02534 16 00469 -2569
02546 26 01260 06187
02558 49 01422 -0099
02570 24 00096 06240
02582 47 03014 01300
02594 25 06250 00099
02606 16 00469 -2641
02618 26 01260 06197
02630 49 01262 -6087
02642 26 06233 00099
02654 26 06213 06177

ENTRY TDM 401,1,9Z
TFM 1KUDA-1,0Z
START TFM 1,1,10, 1#1Z
TFM J,2,10, J#2Z
TFM CMPARE66,7751,, SET SEARCHZ
11J1 TDM SW161,1,, 1 OFFZ
CMPARE C 7751,E-7,2,,LESS THAN EZ
BL STEP1,,, ****NO HITZ
HIT TDM SW161,9,, 1 ONZ
TFM IADD611,7248,, SET I ADDZ
A IADD610,1,, ALL ADDZ
IADD TF ALL,0Z
TFM JADD611,07246Z
A JADD610,J,, A&AJJ#Z
JADD TF AJJ,0Z
TF *635,CMPARE66Z
AM *623,7,10, AIJ ADDZ
AIJADD TF AIJ,0Z
TF AIMIAJ,AIJZ
FS AIMIAJ,AJJ,, AI-AJZ

BNZ SKIP2Z
TF NEWAIJ,ZEROZ
TD TEMP,AIJZ
B FORMAIZ
DORG *-3Z
SKIP2 TF AC,AIMIAJZ
FA AC,AC,, 2#AI-AJ#Z

FD AIJ,ACZ

ANGLET C 96,TAN225,, ALPHA TO TAN 22,5Z
BL SINCOZ,,, JUMP IF ALPHA SMALLZ
TD TEMP,AC,, ALPHA SIGNZ
FM AIMIAJ,HALFZ

TF NEWAIJ,AC,, AIJZ
FORMAI TF NEWAIJ,AJJZ

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02666 16 00469 -2701
 02678 16 00445 -6213
 02690 49 00422 -6167
 02702 16 00469 -2737
 02714 26 01260 06213
 02726 49 01262 -6087
 02738 26 06213 00099
 02750 26 06223 06213
 02762 16 00469 -2797
 02774 16 00445 -6213
 02786 49 00402 -6187
 02798 16 00469 -2833
 02810 16 00445 -6223
 02822 49 00422 -6187
 02834 15 04567 00009
 02846 15 05987 00000
 02857 1 1
 02858 44 02902 06250
 02870 15 05986 00000
 02882 15 05247 00001
 02894 49 04046 00000
 02902 1 1
 02902 15 05986 00008
 02914 15 05247 00009
 02926 26 06250 06213
 02938 26 06213 06223
 02950 26 06223 06250
 02962 44 02994 06233
 02974 33 06233 00000
 02986 49 04046 00000
 02994 1 1
 02994 32 06233 00000
 03006 49 04046 00000
 03014 1 1
 03014 26 06311 00099
 03026 16 00469 -3061
 03038 16 00445 -0099
 03050 49 00422 -0099
 03062 26 06301 00099
 03074 16 00469 -3109
 03086 26 01260 06311
 03098 49 01262 -6311
 03110 26 06005 00099
 03122 16 00469 -3157
 03134 16 00445 -0099

FA NEWAI1,AI1,, AI6AJZ
 FM NEWAI1,HALFZ
 TF NEWAI1,AC,, 1/2*AI6AJZ
 TF NEWAJJ,NEWAI1Z
 FS NEWAI1,AIJZ
 FA NEWAJJ,AIJZ
 TDM SW2&1,9,, SW2 ONZ
 TDM J62Z
 DC 1,@,*Z
 BNF PLUS,TEMP,, IS ALPHA-Z
 TDM J61,8,11Z
 TDM SW361,1,, SW3 OFFZ
 B STOREZ
 DORG *-3Z
 PLUS TDM J61,8Z
 TDM SW361,9,, SW3 ONZ
 TF TEMP,NEWAI1Z
 TF NEWAI1,NEWAJJZ
 TF NEWAJJ,TEMP,, SWITCH AI-AJZ
 BNF *632,NEWAI1Z
 CF NEWAIJ,, INVERT AIJ SIGNZ
 B STOREZ
 DORG *-3Z
 SF NEWAI1Z
 B STOREZ
 DORG *-3Z
 SINCOS TF SC,AC,, GAMMAZ
 FA AC,AC,, 2 GAMMAZ
 TF S2,ACZ
 FM SC,SCZ
 TF COS,AC,, GAMMA**2Z
 FA AC,ONE,, 16GAMMA**2Z

03146 49 00422 -6077
 03158 26 06250 00099
 03170 16 00469 -3205
 03182 26 01260 06301
 03194 49 01422 -6250
 03206 26 05995 00099
 03218 26 06260 06077
 03230 16 00469 -3265
 03242 16 00445 -6260
 03254 49 00402 -6005
 03266 16 00469 -3301
 03278 26 01260 06260
 03290 49 01422 -6250
 03302 26 06005 00099
 03314 16 00469 -3349
 03326 26 01260 06005
 03338 49 01262 -6005
 03350 26 06321 00099
 03362 26 06301 06077
 03374 16 00469 -3409
 03386 16 00445 -6301
 03398 49 00402 -6321
 03410 16 00469 -3445
 03422 26 01260 05995
 03434 49 01262 -6005
 03446 26 06311 00099
 03458 16 00469 -3493
 03470 26 01260 06311
 03482 49 01262 -6157
 03494 26 06250 00099
 03506 26 00099 06321
 03518 16 00469 -3553
 03530 16 00445 -0099
 03542 49 00402 -6301
 03554 16 00469 -3589
 03566 26 01260 00099
 03578 49 01262 -6157
 03590 1 0469 -3625
 03602 16 00445 -0099
 03614 49 00402 -6250
 03626 26 06233 00099
 03638 16 00469 -3673
 03650 26 01260 06311
 03662 49 01262 -6187
 03674 16 00469 -3700

TF TEMP,ACZ
 FD S2,TEMPZ
 TF SIN,AC,, SINEZ
 TF TEMP2,ONEZ
 FS TEMP2,COS,, 1-GAMMA**2Z
 FD TEMP2,TEMPZ
 TF -COS,ACZ
 FM COS,COSZ
 TF C2,AC,, C**2Z
 TF S2,ONE,, S2C2#1Z
 FS S2,C2,, #SIN**2Z
 FM SIN,COSZ
 AAA TF SC,ACZ
 FM SC,AI1IAJ,, SC%AI1-AJZ
 TF TEMP,ACZ
 TF AC,C2Z
 FS AC,S2Z
 FM AC,AIJZ
 FS AC,TEMPZ
 TF NEWAIJ,ACZ
 FM SC,AI1Z
 FA AC,ACZ

03686 16 00445 -0099
 03698 49 00422 -0099
 03710 26 06260 00099
 03722 16 00469 -3757
 03734 26 01260 06321
 03746 49 01262 -6167
 03758 26 06213 00099
 03770 16 00469 -3805
 03782 26 01260 06301
 03794 49 01262 -6177
 03806 16 00469 -3841
 03818 16 00445 -6213
 03830 49 00422 -0099
 03842 16 00469 -3877
 03854 16 00445 -6213
 03866 49 00422 -6260
 03878 16 00469 -3913
 03890 26 01260 06301
 03902 49 01262 -6167
 03914 26 06223 00099
 03926 16 00469 -3961
 03938 26 01260 06321
 03950 49 01262 -6177
 03962 16 00469 -3997
 03974 16 00445 -6223
 03986 49 00422 -0099
 03998 16 00469 -4033
 04010 16 00445 -6223
 04022 49 00402 -6260
 04034 15 04567 00001
 04046 26 04064 02357
 04058 26 00000 06223
 04070 26 04088 02393
 04082 26 00000 06233
 04094 26 04112 02321
 04106 26 00000 06213
 04118 26 02282 07227
 04130 11 06202 -0001
 04142 24 02282 05983
 04154 47 04210 01300
 04166 46 04866 01200
 04178 26 02284 02282
 04190 26 02246 05983
 04202 49 04234 00000
 04210

TF TEMP2,ACZ, *AIJ*SCZ
 FM C2,AIIZ

 TF NEWAI,ACZ
 FM S2,AJJZ

 FA NEWAI,ACZ

 FA NEWAI,TEMP2Z

 FM S2,AIIZ

 TF NEWAJJ,ACZ
 FM C2,AJJZ

 FA NEWAJJ,ACZ

 FS NEWAJJ,TEMP2Z

 TDM SW261,1,, SW2 OFFZ
 STORE TF *618,JADD611Z
 TF 00000,NEWAJJ,, STORE AJJZ
 TF *618,AIJADD611Z
 TF 00000,NEWAIJ,, STORE AIJZ
 TF *618,IADD611Z
 TF 00000,NEWAI,, STORE AIIZ
 ROTATE TF K,N,, KANZ
 AM IKUDA-1,1,, STEP COUNTZ
 C K,IZ
 BL SWCHIK,,, K LESS THAN IZ
 BE SKIP,,, K#IZ
 TF K1,K,, K GREATER THAN IZ
 TF I1,IZ
 B AAIKZ
 DORG *-3Z

21

04210 26 02284 05983
 04222 26 02246 02282
 04234 26 06250 02284
 04246 12 06250 000-3
 04258 23 06250 02284
 04270 26 06250 00099
 04282 13 06250 000-5
 04294 11 00099 -7758
 04306 21 00098 02246
 04318 32 00095 00000
 04330 26 04353 00099
 04342 26 06213 00000
 04354 24 02282 05985
 04366 47 04422 01300
 04378 46 04866 01200
 04390 26 02248 05985
 04402 26 02284 02282
 04414 49 04446 00000
 04422
 04422 26 02248 02282
 04434 26 02284 05985
 04446 26 06250 02284
 04458 12 06250 000-3
 04470 23 06250 02284
 04482 26 06250 00099
 04494 13 06250 000-5
 04506 11 00099 -7758
 04518 21 00098 02248
 04530 32 00095 00000
 04542 26 04565 00099
 04554 26 06223 00000
 04566 49 05078 00000
 04578 16 00469 -4613
 04590 26 01260 06005
 04602 49 01262 -6213
 04614 26 06260 00099
 04626 16 00469 -4661
 04638 26 01260 05995
 04650 49 01262 -6223
 04662 16 00469 -4697
 04674 16 00445 -6260
 04686 49 00422 -0099
 04698 16 00469 -4733
 04710 26 01260 05995
 04722 49 01262 -6213

SWCHIK TF K1,1,, K LESS THAN IZ
 TF I1,KZ
 AAIK TF TEMP,K1Z
 SM TEMP,3,10Z
 M TEMP,K1,, K#K-3#Z
 TF TEMP,ACZ
 MM TEMP,5,10, 6 DIGITZ
 AM AC,07758Z
 A AC-1,11,, ANAIK#Z
 SF AC-4Z
 TF AIKADD611,ACZ
 AIKADD TF AIK,0Z
 C K,JZ
 BL SWCHJKZ
 BE SKIPZ
 TF J1,J,, K GREATER THAN JZ
 TF K1,KZ
 B AAJKZ
 DORG *-3Z
 SWCHJK TF J1,K,, K LESS THAN JZ
 TF K1,JZ
 AAJK TF TEMP,K1,, AJK ADDZ
 SM TEMP,3,10Z
 M TEMP,K1Z
 TF TEMP,ACZ
 MM TEMP,5,10, 6 DIGITZ
 AM AC,07758Z
 A AC-1,J1Z
 SF AC-4Z
 TF AJKADD611,ACZ
 AJKADD TF AJK,0Z
 SW2 B DEG45Z
 FM COS,AIKZ

 TF TEMP2,ACZ
 FM SIN,AJKZ

 FA TEMP2,ACZ

 FM SIN,AIKZ

30

04734 26 06250 00099
 04746 16 00469 -4781
 04758 26 01260 06005
 04770 49 01262 -6223
 04782 16 00469 -4817
 04794 16 00445 -0099
 04806 49 00402 -6250
 04818 26 04836 04565
 04830 26 00000 00099
 04842 26 04860 04353
 04854 26 00000 06260
 04866 12 02282 000-1
 04878 47 04142 01200
 04890 47 04914 00200
 04902 38 05982 00400
 04914 11 05983 000-1
 04926 24 05983 05985
 04938 47 05370 01200
 04950 24 05985 07227
 04962 47 05346 01300
 04974 49 02202 00000
 04986 24 07246 07236
 04998 47 05390 01100
 05010 12 07239 000-1
 05022 34 00000 00102
 05034 39 06419 00100
 05046 38 07238 00100
 05058 46 05390 01200
 05070 49 02202 00000
 05078
 05078 16 00469 -5113
 05090 26 01260 06489
 05102 49 01262 -6213
 05114 26 06250 00099
 05126 16 00469 -5161
 05138 26 01260 06489
 05150 49 01262 -6223
 05162 26 06260 06250
 05174 16 00469 -5209
 05186 16 00445 -6260
 05198 49 00422 -0099
 05210 16 00469 -5245
 05222 16 00445 -0099
 05234 49 00402 -6250
 05246 49 04818 00000

TF TEMP,AC,, AIK*SINZ
 FM COS,AJKZ

 .FS AC,TEMPZ

 RTSTOR TF *618,AJKADD611Z
 TF O,AC,, AJK STOREDZ
 TF *618,AIKADD611Z
 TF O,TEMP2,, AIK STGRCDZ
 SKIP SM K+1,10, K-1Z
 BNZ ROTATE624,,, RETURNZ
 WANTU BNCZ STEPI,,, SKIP PUNCHZ
 WNCDO I-1,,, PUNCH I,J,SIN,COSZ
 STEPI AM I+1,10, I61Z
 C I,JZ
 BNE RESETZ
 C J,N,, J VS NZ
 BL RESET2-24Z
 SW1 B START,,, SOMETIMES NOPZ
 C E-1,DELTA-1,, E VS DELTAZ
 BNH TYP0UTZ
 SM E-8,1,10, EWE/10Z
 RCTY Z
 WATY EEQUALZ
 WNTY E-9Z
 BZ TYP0UTZ
 B STARTZ
 DORG *-3Z
 DEG45 FM SQRT2,AIKZ

 TF TEMP,ACZ
 FM SQRT2,AJKZ

 TF TEMP2,TEMPZ
 FA TEMP2,AC,, AIKZ

 FS AC,TEMP,, AJKZ

 SW3 B RTSTOR,,, NOPZ

31

05258 26 06250 06260
 05270 26 06260 00099
 05282 26 00099 06250
 05294 44 05326 06260
 05306 33 06260 00000
 05318 49 04818 00000
 05326
 05326 32 06260 00000
 05338 49 04818 00000
 05346
 05346 16 05983 000-1
 05358 11 05985 000-1
 05370 11 02255 000-1
 05382 49 02250 00000
 05390
 05390 34 00000 00102
 05402 34 00000 00102
 05414 16 05983 000-1
 05426 16 05497 -7258
 05438 25 06437 05982
 05450 25 06439 05983
 05462 34 00000 00102
 05474 39 06429 00100
 05486 26 06005 07258
 05498 33 05996 00000
 05510 38 05996 00100
 05522 11 05983 000-1
 05534 11 05496 000-1
 05546 24 05983 07227
 05558 47 05438 01100
 05570 34 00000 00102
 05582 34 00000 00102
 05594 38 06198 00100
 05606 39 06455 00100
 05618 26 06250 07227
 05630 12 06250 000-3
 05642 23 06250 07227
 05654 26 06250 00099
 05666 13 06250 000-5
 05678 11 00099 -7748
 05690 21 00098 07227
 05702 32 00095 00000
 05714 26 05821 00099
 05726 26 06005 06097
 05738 16 05761 -7758

TF TEMP,TEMP2,,SWITCH AIK-AJKZ
 TF TEMP2,ACZ
 TF AC,TEMPZ
 BNF SETF,TEMP2Z
 CF TEMP2Z
 B RTSTORZ
 DORG *-3Z
 SETF SF TEMP2,,,INVERT AIK SIGNZ
 B RTSTORZ
 DORG *-3Z
 TFM I+1,10, I#1Z
 AM J+1,10, J61Z
 RESET2 AM CMPARE65,1,10, AIJ&1Z
 B CMPARE,,, LOOP BACKZ
 DORG *-3Z
 TYP0UT RCTY Z
 RCTY Z
 TFM I+1,10, I#1Z
 TFM VARG11,DIAGZ
 AGAIN TD OUTPUT68,I-1,, SET INDEXZ
 TD OUTPUT610,IZ
 RCTY Z
 WATY OUTPUTZ
 VAR TF COS,DIAGZ
 CF COS-9Z
 WNTY COS-9Z
 AM I+1,10, I61Z
 AM VARG10,1,10, STEP FETCHZ
 C I,N,, I VS NZ
 BNH AGAINZ
 RCTY Z
 RCTY Z
 WNTY IKUDA-5,,, TYPE ROTATIONSZ
 WATY CNTZ
 TF TEMP,NZ
 SM TEMP,3,10Z
 M TEMP,N,, N&N-3#Z
 TF TEMP,ACZ
 MM TEMP,5,10Z
 AM AC,07748Z
 A AC-1,NZ
 SF AC-4Z
 TF ENDSQR611,ACZ
 TF COS,ZEROZ
 TFM CHANGE611,07758Z

32

05750 26 06250 00000
 05762 24 06004 06249
 05774 46 05798 01100
 05786 26 06005 06250
 05798 11 05760 000-1
 05810 14 05761 -0000
 05822 47 05750 01100
 05834 34 00000 00102
 05846 39 06099 00100
 05858 36 05996 00100
 05870 15 05982 00000
 05881 1
 05882 38 05982 00400
 05894 34 00000 00102
 05906 34 00000 00102
 05918 46 05950 00200
 05930 39 06263 00100
 05942 49 05962 00000
 05950
 05950 39 06323 00100
 05962 36 00000 00500
 05974 49 00000 00000
 05982

07758 1225 00010
 07258 50 00010
 07247 10
 07248 1
 07237 10
 07227 2
 05983 2
 05985 2
 05995 10
 06005 10
 06006 1
 06009 30
 02246 2
 02248 2
 02284 2
 02282 2
 06077 10
 06087 10
 06097 10
 06099 30
 06167 10

CHANGE TF TEMP,0000Z
 C COS-1,TEMP-1Z
 BH *624Z
 TF COS,TEMPZ
 AM CHANGE010,1,10Z
 ENDSQR CH CHANGE011,0Z
 BRH CHANGEZ
 RCTY Z
 WATY MESS2Z
 WNTY COS-9Z
 TDM 1-1Z
 DC 1,*,*Z
 WNCU 1-1Z
 PHASE2 RCTY Z
 RCTY Z
 BC2 CALL3Z
 WATY ENDZ
 B CALL3612Z
 DORG *-3Z
 CALL3 WATY PHASE3,,, INSTRUCTIONSZ
 RNCD 0,,, LOAD PHASE 3 LOADERZ
 B 00,,, EXECUTE LOADERZ
 DORG *-3Z
 * PHASE 2 CONSTANTSZ
 ELEMNT DSS 1225,10,7758Z
 DIAG DSS 50,10,7258Z
 L DS 10,7247Z
 RM2 DC 1,*,7248Z
 DELTA DS 10,7237Z
 N DS 2,7227Z
 I DS 2Z
 J DS 2Z
 SIN DS 10Z
 COS DS 10Z
 RM DC 1,*,*Z
 CMPATE DAC 30,LOAD PHASE 2 OUTPUT-HIT STARTZ
 I1 DS 2,11J168Z
 J1 DS 2,11J1610Z
 K1 DS 2,HIT610Z
 K DS 2,HIT68Z
 ONE DC 10,5110000000Z
 HALF DC 10,5050000000Z
 ZERO DC 10,0Z
 MESS2 DAC 30,MAXIMUM AIJ,*,*I NOT # JB, # @Z
 AII DS 10Z

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06177 10
 06187 10
 06197 10
 06203 6
 06213 10
 06223 10
 06233 10
 06240 7
 06250 10
 06260 10
 00099
 06263 15
 06301 10
 06311 10
 06321 10
 06213 10
 06223 10
 06323 48
 06419 5
 06429 13
 06455 13
 06489 10
 02178

AJJ DS 10Z
 AIJ DS 10Z
 AIMIAJ DS 10Z
 IKUDA DC 6,0@Z
 NEWAII DC 10,0Z
 NEWAJJ DC 10,0Z
 NEWA1J DC 10,0Z
 TAN225 DC 7,5041421Z
 TEMP DS 10Z
 TEMP2 DS 10Z
 AC DS *,*9Z
 END DAC 15,END OF PROGRAM@Z
 S2 DS 10Z
 SC DS 10Z
 C2 DS 10Z
 AIK DS 10,NEWAIIZ
 AJK DS 10,NEWAJJZ
 PHASE3 DAC 40,EIGENVALUES DONE, WHEN PHASE 3 LOADS, HIT START@Z
 EEQUAL DAC 5,*E # @Z
 OUTPUT DAC 13, A*000 # @Z
 CNT DAC 13, ROTATIONS,@Z
 SQRT2 DC 10,5070710678Z
 DEND ENTRYZ

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PHASE 3
 BASIC 1620 CARD SYSTEMS
 SPS LISTING

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* TH IS I S PHASE 3 - EIGENVECTOR COMPUTE BASIC CARD 1620 Z
*
02178 15 02419 00-01
02190 16 02427 000-1
02202 34 00000 00102
02214 34 00000 00102
02226 39 03859 00100
02238 34 00000 00102
02250 34 00000 00102
02262 48 02273 02273
02274 16 02429 000-1
02286 16 02304 -4008
02298 26 04008 03957
02310 11 02303 000-1
02322 14 02301 000K0
02334 47 02298 01200
02346 16 02364 -4008
02358 26 04008 03947
02370 11 02363 000L3
02382 14 02364 04238
02394 47 02358 01100
02406 36 03828 00500
02418 49 02626 00000
02430 16 02993 000-1
02442 14 03829 000L2
02454 46 02546 01100
02466 26 03165 03829
02478 16 02865 -3678
02490 13 03829 000L3
02502 21 02864 00099
02514 15 03003 00001
02526 26 02889 03829
02538 49 02722 00000
02546
02546 16 03165 000L2
02558 16 02865 -3998
02570 13 03829 000L2
02582 21 02864 00099
02594 16 02889 000L2
02606 15 03003 00099
02618 49 02722 00000
02626
02626 26 03165 03829
02638 12 03165 000L2
ENTRY TDM SW161,1,9, 1 OFFZ
      TFM OUT1,1,10, 1#12
      RCTY Z
      RCTY Z
      WATY MESSGEZ
      RCTY Z
      RCTY Z
HALT H TEMP,TEMPZ
      TFM OUTJ,1,10Z
CLEAR TFM SET166,MATRIXZ
SETI TF -MATRIX,ZEROZ
      AM *-7,1,10, DATA AREA#02
      CM SET163,20,10Z
      BNE SET1Z
AL1SET TFM ALL166,MATRIX,, 18-32Z
ALLI TF MATRIX,ONE,, 18-32Z
      AM *-7,33,10, 18-32Z
ALLI2 CM ALL166,14238,, 18-32Z
      BNH ALLI2
READN RNCD N-1Z
SW1 B PASS2FZ
      TFM ISET611,1,10, SET 1Z
      CM N,32,10Z
      BH OVER32Z
UNDR33 TF FUNCTN,NZ
      TFM LSTRCD,MATRIX-330Z
      MM N,33,10Z
      A LSTRCD-1,ACZ
      TDM SW261,1,, 2 OFFZ
      TF ICMPAR611,NZ
      B READZ
      DORG *-3Z
OVER32 TFM FUNCTN,32,10Z
      TFM LSTRCD,MATRIX-10Z
      MM N,32,10Z
      A LSTRCD-1,ACZ
      TFM ICMPAR611,32,10Z
      TDM SW261,9,, 2 ONZ
      B READZ
      DORG *-3Z
PASS2F TF FUNCTN,NZ
      SM FUNCTN,32,10Z
  
```

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02650 16 02865 -3358
 02662 13 03829 000L3
 02674 21 02864 00099
 02686 15 03003 00001
 02698 26 02889 03829
 02710 16 02993 000L3
 02722 36 03832 00500
 02734 45 03106 03832
 02746 16 02841 -4008
 02758 25 03965 02426
 02770 25 03967 02427
 02782 25 03971 02428
 02794 25 03973 02429
 02806 34 00000 00102
 02818 39 03959 00100
 02830 26 03855 04008
 02842 38 03846 00100
 02854 14 02841 -0000
 02866 46 03002 01200
 02878 14 02427 -0000
 02890 46 02934 01300
 02902 11 02427 000-1
 02914 11 02840 000-1
 02926 49 02758 00000
 02934
 02934 11 02429 000-1
 02946 16 02841 -3688
 02958 13 02429 000L2
 02970 21 02840 00099
 02982 16 02427 -0000
 02994 49 02758 00000
 03002
 03002 49 03050 00000
 03014 34 00000 00102
 03026 39 03989 00100
 03038 48 03049 03049
 03050 15 02419 00009
 03062 16 02427 000L3
 03074 16 02357 04248
 03086 16 02393 09858
 03098 49 02202 00000
 03106
 03106 16 03213 -3688
 03118 13 03833 000L2
 03130 21 03212 00099

TFM LSTRCD,MATRIX-050Z
 MM N,33,10Z
 A LSTRCD-1,ACZ
 TDM SW1&1,1,, 2 OFFZ
 TF ICMPAK611,NZ
 TFM ISET611,33,10, SET 33Z
 READ KNCD 1-1,,, READ 1,J,S,CZ
 BNR COMPUT,1-1Z
 TYPEV TFM OUT611,MATRIXZ
 TD TYPE66,OUTI-1Z
 TD TYPE68,OUTIZ
 TD TYPE612,OUTJ-1Z
 TJ TYPE614,OUTJZ
 RCTY Z
 WATY TYPEZ
 OUT TF COS,MATRIX,, TYPE VIJZ
 WNTY COS-9Z
 TEST CM OUT611,,, LAST RECORDZ
 BE SWZZ
 ICMPAR CM OUTI,,, N OR 32Z
 BNL JSETZ
 AN OUTI,1,10, 161Z
 AM OUT610,1,10Z
 B TYPEV612Z
 DORG *-3Z
 JSET AM OUTJ,1,10, J61Z
 TFM OUT611,MATRIX-320Z
 MM OUTJ,32,10Z
 A OUT610,ACZ
 ISET TFM OUTI,,, 1 OR 33Z
 B TYPEV612Z
 DORG *-3Z
 SW2 B PASSZZ
 RCTY Z
 WATY PAUMSGZ
 TRICK H TRICK2,TRICK2,, ENDZ
 PASSZ TDM SW1&1,9,, 1 ONZ
 TFM OUTI,33,10, I#33Z
 TFM ALISET611,MATRIX610240Z
 TFM ALLI2611,19858Z
 B ENTRY624Z
 DORG *-3Z
 COMPUT TFM VKIADD611,MATRIX-320Z
 MM I,32,10,A%AIJ#320%I-1#6MATRIXZ
 A VKIADD610,ACZ

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03142 26 03797 03213
 03154 11 03796 -3165
 03166 16 03225 -3688
 03178 13 03835 000L2
 03190 21 03224 00099
 03202 26 03927 00000
 03214 26 03937 00000
 03226 45 03474 03837
 03238 25 03049 03836
 03250 26 02273 03927
 03262 16 00469 -3297
 03274 16 00445 -2273
 03286 49 00422 -3937
 03298 16 00469 -3333
 03310 26 01260 02273
 03322 49 01262 -3827
 03334 26 02273 00099
 03346 16 00469 -3381
 03358 16 00445 -3937
 03370 49 00402 -3927
 03382 16 00469 -3417
 03394 26 01260 03937
 03406 49 01262 -3049
 03418 44 03714 03836
 03430 26 03927 00099
 03442 26 00099 02273
 03454 26 02273 03927
 03466 49 03714 00000
 03474
 03474 16 00469 -3509
 03486 26 01260 03927
 03498 49 01262 -3855
 03510 26 02273 00099
 03522 16 00469 -3557
 03534 26 01260 03937
 03546 49 01262 -3845
 03558 16 00469 -3593
 03570 16 00445 -2273
 03582 49 00422 -0099
 03594 16 00469 -3629
 03606 26 01260 03927
 03618 49 01262 -3845
 03630 26 03927 00099
 03642 16 00469 -3677
 03654 26 01260 03937

ADDF TF END611,VKIADD611Z
 AM END610,FUNCTNZ
 TFM VKJADD611,MATRIX-320Z
 MM J,32,10,A%AIJ#320%J-1#6MATRIXZ
 A VKJADD610,ACZ
 VKIADD TF VKI,,, STORE VKIZ
 VKJADD TF VKJ,,, STORE VKJZ
 BNR HRDWAY,J62,, THETA NOT 45 DEGZ
 TD TRICK2,J61,, 8 OR FLAG 8Z
 TF TEMP,VKIZ
 FA TEMP,VKJ,, VKI&VKJZ
 FM TEMP,SQRTZZ
 TF TEMP,ACZ
 FS VKJ,VKIZ
 FM VKJ,TRICK2,, DIFFERENCEZ
 NEGTV BNF STORE,J61Z
 TF VKI,ACZ
 TF AC,TEMPZ
 TF TEMP,VKIZ
 B STOREZ
 DORG *-3Z
 HRDWAY FM VKI,COS,, VKI*COSZ
 TF TEMP,ACZ
 FM VKJ,SINZ
 FA TEMP,AC,,VKI+C6VKJ*S#VKJZ
 FM VKI,SINZ
 TF VKI,ACZ
 FM VKJ,COSZ

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03666 49 01262 -3855
 03678 16 00469 -3713
 03690 16 00445 -0099
 03702 49 00402 -3927
 03714 26 03732 03213
 03726 26 00000 02273
 03738 26 03756 03225
 03750 26 00000 00099
 03762 11 03212 000-1
 03774 11 03224 000-1
 03786 14 03213 -0000
 03798 47 03202 01200
 03810 49 02722 00000
 03818

00099
 03049 10
 03827 10
 02273
 03829 2
 03830 1
 03831 1
 03833 2
 03835 2
 03845 10
 03855 10
 03856 1
 03859 30
 03927 10
 03937 10
 02427 2
 02429 2
 03165 5
 02865 5
 03947 10
 03957 10
 03959 13
 03989 4
 04008 1600 00010
 02178

FS AC,VKI,,VKJ*C-VKI*S#VKJZ
 STORE TF *618,VKIADD611Z
 TF ,TEMP,, STORE VKI2
 TF *618,VKJADD611Z
 TF ,AC,, STORE VKJZ
 AM VKIADD610,1,10, 161Z
 AM VKJADD610,1,10, J61Z
 END CM VKIADD611,, TEST ENDZ
 BNE VKIADDZ
 B READZ
 DORG *-3Z

* PHASE 3 CONSTANTSZ
 * 2
 AC DS ,99Z
 TRICK2 DC 10,-5070710678,TRICK611Z
 SQRT2 DC 10,5070710678Z
 TEMP DS ,HALT611Z
 N DS 2Z
 RM DC 1,@Z
 DUMMY DS 1Z
 I DS 2Z
 J DS 2Z
 SIN DS 10Z
 COS DS 10Z
 RMZ DC 1,@Z
 MESSGE DAC 30,LOAD PHASE 2 OUTPUT HIT START@Z
 VKI DS 10Z
 VKJ DS 10Z
 OUTI DS 2,SW169Z
 OUTJ DS 2,SW1611Z
 FUNCTN DS 5,ADDF611Z
 LSTRCD DS 5,TEST611Z
 ONE DC 10,5110000000Z
 ZERO DC 10,-0Z
 TYPE DAC 15, V#00,00# # 0Z
 PAUMSG DAC 4,END@Z
 MATRIX DSB 1600,10,04008Z
 DEND ENTRYZ

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PHASE 2
 1620 CARD SYSTEMS WITH DIVIDE AND INDIRECT ADDRESSING
 SPS LISTING

* PHA SE 2 - EIGENVALUES COMPUTE 1620 W/DIV 6 IDA Z
 * Z

02178 15 00401 00-01
 02190 16 06142 -0000
 02202 16 05923 000-1
 02214 16 05925 000-2
 02226 16 02256 -7751
 02238 15 04915 00001
 02250 24 -7751 07240
 02262 47 04854 01300
 02274 15 04915 00009
 02286 16 02321 -7248
 02298 21 02320 05923
 02310 26 06107 00000
 02322 16 02357 -7248
 02334 21 02356 05925
 02346 26 06117 00000
 02358 26 02393 02256
 02370 11 02393 000-7
 02382 26 06127 00000
 02394 26 06137 06107
 02406 16 00469 -2441
 02418 16 00445 -6137
 02430 49 00402 -6117
 02442 47 02486 01200
 02454 26 06173 06037
 02466 25 06190 06127
 02478 49 02654 00000
 02486
 02486 26 00099 06137
 02498 16 00469 -2533
 02510 16 00445 -0099
 02522 49 00422 -0099
 02534 16 00469 -2569
 02546 26 01260 06127
 02558 49 01422 -0099
 02570 24 00096 06180
 02582 47 03014 01300
 02594 25 06190 00099
 02606 16 00469 -2641
 02618 26 01260 06137

ENTRY TDM 401.1,9Z
 TFM IKUDA-1,0Z
 START TFM 1.1,10, 1#1Z
 TFM J.2,10, J#2Z
 TFM CMPARE66,7751,, SET SEARCHZ
 ILJ1 TDM SW161.1,, 1 OFFZ
 CMPARE C 7751,E-7,2,,LESS THAN EZ
 BL STEPI,,, ****NO HITZ
 HIT TDM SW161.9,, 1 ONZ
 TFM IADD611,7248,, SET I ADDZ
 A IADD610,1,, AII ADDZ
 IADD TF AII,0Z
 TFM JADD611,07248Z
 A JADD610,J,, A%AJJBJZ
 JADD TF AJJ,0Z
 TF *635,CMPARE66Z
 AM *623,7,10, AIJ ADDZ
 AIJADD TF AIJ,0Z
 TF AIMIAJ,AIIZ
 FS AIMIAJ,AJJ,, AI-AJZ
 BNZ SKIP2Z
 TF NEWAIJ,ZEROZ
 TD TEMP,AIJZ
 B FORMAIZ
 DORG *-3Z
 SKIP2 TF AC,AIMIAJZ
 FA AC,AC,, 2%AI-AJBJZ
 FD AIJ,ACZ
 ANGLET C 96,TAN225,, ALPHA TO TAN 22.8Z
 BL SINCOS,, JUMP IF ALPHA SMALLZ
 TD TEMP,AC,, ALPHA SIGNZ
 FM AIMIAJ,HALFZ

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02630 49 01262 -6027
 02642 26 06173 00099
 02654 26 06153 06117
 02666 16 00469 -2701
 02678 16 00445 -6153
 02690 49 00422 -6107
 02702 16 00469 -2737
 02714 26 01260 06153
 02726 49 01262 -6027
 02738 26 06153 00099
 02750 26 06163 06153
 02762 16 00469 -2797
 02774 16 00445 -6153
 02786 49 00402 -6127
 02798 16 00469 -2833
 02810 16 00445 -6163
 02822 49 00422 -6127
 02834 15 04531 00009
 02846 15 05927 00000
 02857 1
 02858 44 02902 06190
 02870 15 05926 00000
 02882 15 05187 00001
 02894 49 04046 00000
 02902
 02902 15 05926 00008
 02914 15 05187 00009
 02926 26 06190 06153
 02938 26 06153 06163
 02950 26 06163 06190
 02962 44 02994 06173
 02974 33 06173 00000
 02986 49 04046 00000
 02994
 02994 32 06173 00000
 03006 49 04046 00000
 03014
 03014 26 06251 00099
 03026 16 00469 -3061
 03038 16 00445 -0099
 03050 49 00422 -0099
 03062 26 06241 00099
 03074 16 00469 -3109
 03086 26 01260 06251
 03098 49 01262 -6251

FORMAI TF NEWAIJ,AC,, AIJZ
 TF NEWAIJ,AJJZ
 FA NEWAIJ,AII,, AI6AJZ
 FM NEWAIJ,HALFZ
 TF NEWAIJ,AC,, 1/2%AI6AJBJZ
 TF NEWAIJ,NEWAIJZ
 FS NEWAIJ,AIJZ
 FA NEWAIJ,AIJZ
 TDM SW261.9,, SW2 ONZ
 TDM J62Z
 DC 1.0,*Z
 BNF PLUS,TEMP,, IS ALPHA-Z
 MINUS TDM J61.8,11Z
 TDM SW361.1,, SW3 OFFZ
 B STOREZ
 DORG *-3Z
 PLUS TDM J61.8Z
 TDM SW361.9,, SW3 ONZ
 TF TEMP,NEWAIJZ
 TF NEWAIJ,NEWAIJZ
 TF NEWAIJ,TEMP,, SWITCH AI-AJZ
 BNF *632,NEWAIJZ
 CF NEWAIJ,, INVERT AIJ SIGNZ
 B STOREZ
 DORG *-3Z
 SF NEWAIJZ
 B STOREZ
 DORG *-3Z
 SINCOS TF SC,AC,, GAMMAZ
 FA AC,AC,, 2 GAMMAZ
 TF S2,ACZ
 FM SC,SCZ

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03110 26 05945 00099
 03122 16 00469 -3157
 03134 16 00445 -0099
 03146 49 00422 -6017
 03158 26 06190 00099
 03170 16 00469 -3205
 03182 26 01260 06241
 03194 49 01422 -6190
 03206 26 05935 00099
 03218 26 06200 06017
 03230 16 00469 -3265
 03242 16 00445 -6200
 03254 49 00402 -5945
 03266 16 00469 -3301
 03278 26 01260 06200
 03290 49 01422 -6190
 03302 26 05945 00099
 03314 16 00469 -3349
 03326 26 01260 05945
 03338 49 01262 -5945
 03350 26 06261 00099
 03362 26 06241 06017
 03374 16 00469 -3409
 03386 16 00445 -6241
 03398 49 00402 -6261
 03410 16 00469 -3445
 03422 26 01260 05935
 03434 49 01262 -5945
 03446 26 06251 00099
 03458 16 00469 -3493
 03470 26 01260 06251
 03482 49 01262 -6137
 03494 26 06190 00099
 03506 26 00099 06261
 03518 16 00469 -3553
 03530 16 00445 -0099
 03542 49 00402 -6241
 03554 16 00469 -3589
 03566 26 01260 00099
 03578 49 01262 -6127
 03590 16 00469 -3625
 03602 16 00445 -0099
 03614 49 00402 -6190
 03626 26 06173 00099
 03638 16 00469 -3673

TF CGS,AC,, GAMMA**2Z
 FA AC,ONE,, 16GAMMA**2Z
 TF TEMP,ACZ
 FD S2,TEMPZ
 TF SIN,AC,, SINEZ
 TF TEMP2,ONEZ
 FS TEMP2,COS,, 1-GAMMA**2Z
 FD TEMP2,TEMPZ
 TF COS,ACZ
 FM COS,COSZ
 TF C2,AC,, C**2Z
 TF S2,ONE,, S2C2#1Z
 FS S2,C2,, #SIN**2Z
 FM SIN,COSZ
 TF SC,ACZ
 FM SC,AI,IAJ,, SC,AII-AJJ#Z
 TF TEMP,ACZ
 TF AC,C2Z
 FS AC,S2Z
 FM AC,AIJZ
 FS AC,TEMPZ
 TF NEWAIJ,ACZ
 FM SC,AIJZ

AAA

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03650 26 01260 06251
 03662 49 01262 -6127
 03674 16 00469 -3709
 03686 16 00445 -0099
 03698 49 00422 -0099
 03710 26 06200 00099
 03722 16 00469 -3757
 03734 26 01260 06261
 03746 49 01262 -6107
 03758 26 06153 00099
 03770 16 00469 -3805
 03782 26 01260 06241
 03794 49 01262 -6117
 03806 16 00469 -3841
 03818 16 00445 -6153
 03830 49 00422 -0099
 03842 16 00469 -3877
 03854 16 00445 -6153
 03866 49 00422 -6200
 03878 16 00469 -3913
 03890 26 01260 06241
 03902 49 01262 -6107
 03914 26 06163 00099
 03926 16 00469 -3961
 03938 26 01260 06261
 03950 49 01262 -6117
 03962 16 00469 -3997
 03974 16 00445 -6163
 03986 49 00422 -0099
 03998 16 00469 -4033
 04010 16 00445 -6163
 04022 49 00402 -6200
 04034 15 04531 00001
 04046 26 0235P 06163
 04058 26 0239L 06173
 04070 26 0232J 06153
 04082 26 02282 07227
 04094 11 06142 -0001
 04106 24 02282 05923
 04118 47 04174 01300
 04130 46 04806 01200
 04142 26 02284 02282
 04154 26 02246 05923
 04166 49 04198 00000
 04174

FA AC,ACZ
 TF TEMP2,AC,, 2*AIJ*SCZ
 FM C2,AIJZ
 TF NEWAIJ,ACZ
 FM S2,AJJZ
 FA NEWAIJ,ACZ
 FA NEWAIJ,TEMP2Z
 FM S2,AIJZ
 TF NEWAJJ,ACZ
 FM C2,AJJZ
 FA NEWAJJ,ACZ
 FS NEWAJJ,TEMP2Z
 TD# SW261,1,, SW2 OFFZ
 STORE TF JADDG11,NEWAJJ,6, IDA* STORE AJJZ
 TF AJJADD011,NEWAIJ,6, IDA* STORE AI
 TF IADDG11,NEWAIJ,6, IDA* STORE AIJZ
 ROTATE TF K,N,, K#NZ
 AI IKUDA-1,1,, STEP COUNTZ
 C K,IZ
 BL SWCHIK,,, K LESS THAN IZ
 BE SKIP,,, K#IZ
 TF K1,A,, K GREATER THAN IZ
 TF I1,IZ
 E AAIKZ
 DORG *-32

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04174 26 02284 05923
 04186 26 02246 02282
 04198 26 06190 02284
 04210 12 06190 000-3
 04222 23 06190 02284
 04234 26 06190 00099
 04246 13 06190 000-5
 04258 11 00099 -7758
 04270 21 00098 02246
 04282 32 00095 00000
 04294 26 04317 00099
 04306 26 06153 00000
 04318 24 02282 05925
 04330 47 04386 01300
 04342 46 04806 01200
 04354 26 02248 05925
 04366 26 02284 02282
 04378 49 04410 00000
 04386
 04386 26 02248 02282
 04398 26 02284 05925
 04410 26 06190 02284
 04422 12 06190 000-3
 04434 23 06190 02284
 04446 26 06190 00099
 04458 13 06190 000-5
 04470 11 00099 -7758
 04482 21 00098 02248
 04494 32 00095 00000
 04506 26 04529 00099
 04518 26 06163 00000
 04530 49 05016 00000
 04542 16 00469 -4577
 04554 26 01260 05945
 04566 49 01262 -0153
 04578 26 06200 00099
 04590 16 00469 -4625
 04602 26 01260 05935
 04614 49 01262 -6163
 04626 16 00469 -4661
 04638 16 00445 -6200
 04650 49 00422 -0099
 04662 16 00469 -4697
 04674 26 01260 05935
 04686 49 01262 -6153

SWCHK TF K1,K,, K LESS THAN IZ
 TF I1,KZ
 AAIK TF TEMP,K1Z
 SM TEMP,3,10Z
 M TEMP,K1,, K&K=30Z
 TF TEMP,ACZ
 MM TEMP,5,10, 6 DIGIT5Z
 AM AC,07758Z
 A AC-1,I1,, A&AIK0Z
 SF AC-4Z
 TF AIKADD011,ACZ
 AIKAUD TF AIK,0Z
 C K,JZ
 BL SWCHJKZ
 BE SKIPZ
 TF J1,J,, K GREATER THAN JZ
 TF K1,KZ
 B AAJKZ
 DORG *-3Z
 SWCHJK TF J1,K,, K LESS THAN JZ
 TF K1,JZ
 AAJK TF TEMP,K1,, AJK ADDZ
 SM TEMP,3,10Z
 M TEMP,K1Z
 TF TEMP,ACZ
 MM TEMP,5,10, 6 DIGIT5Z
 AM AC,07758Z
 A AC-1,J1Z
 SF AC-4Z
 TF AJKADD011,ACZ
 AJKAUD TF AJK,0Z
 B DEG45Z
 FM COS,AIKZ
 TF TEMP2,ACZ
 FM SIN,AJKZ
 FA TEMP2,ACZ
 FM SIN,AIKZ

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04698 26 06190 00099
 04710 16 00469 -4745
 04722 26 01260 05945
 04734 49 01262 -6163
 04746 16 00469 -4781
 04758 16 00445 -0099
 04770 49 00402 -6190
 04782 26 0452R 00099
 04794 26 0431P 06200
 04806 12 02282 000-1
 04818 47 04106 01200
 04830 47 04854 00200
 04842 38 05922 00400
 04854 11 05923 000-1
 04866 24 05923 05925
 04878 47 05310 01200
 04890 24 05925 07227
 04902 47 05286 01300
 04914 49 02202 00000
 04936 47 03330 07230
 04950 12 07239 000-1
 04962 34 00000 00102
 04974 39 06359 00100
 04986 38 07238 00100
 04998 46 05330 01200
 05010 49 02202 00000
 05018
 05018 16 00469 -5053
 05030 26 01260 06429
 05042 49 01262 -6153
 05054 26 06190 00099
 05066 16 00469 -5101
 05078 26 01260 06429
 05090 49 01262 -6163
 05102 26 06200 06190
 05114 16 00469 -5149
 05126 16 00445 -6200
 05138 49 00422 -0099
 05150 16 00469 -5185
 05162 16 00445 -0099
 05174 49 00402 -6190
 05186 49 04782 00000
 05198 26 06190 06200
 05210 26 06200 00099

TF TEMP,AC,, AIK*SINZ
 FM COS,AJKZ
 FS AC,TEMPZ
 RTSTOR TF AJKADD011,AC,6, IDA* AJK STOREDZ
 TF AIKADD011,TEMP2,6, IDA* AIK STOREDZ
 SKIP SM K,1,10, K-1Z
 BNZ ROTATE24,,, RETURNZ
 WANTU BNC2 STEPI,,, SKIP PUNCHZ
 WNC2 I-1,,, PUNCH 1,J,SIN,COSZ
 STEPI AM I,1,10, I61Z
 C I,JZ
 BNE RESET2Z
 C J,N,, J VS NZ
 OL RESET2-24Z
 SW1 B START,,, SOMETIMES NOPZ
 C BNH E-1,DELTA-1,, E VS DELTAZ
 TYP0UTZ
 SM E-8,1,10, E#E/10Z
 RCTY Z
 WATY EEQUALZ
 WNTY E-9Z
 BZ TYP0UTZ
 B STARTZ
 DORG *-3Z
 DEG45 FM SQRT2,AIKZ
 TF TEMP,ACZ
 FM SQRT2,AJKZ
 TF TEMP2,TEMPZ
 FA TEMP2,AC,, AIKZ
 FS AC,TEMP,, AJKZ
 SW3 B RTSTOR,,, NOPZ
 TF TEMP,TEMP2,,SWITCH AIK-AJKZ
 TF TEMP2,ACZ

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05222 26 00099 06190
 05234 44 05266 06200
 05246 33 06200 00000
 05258 49 04782 00000
 05266
 05266 32 06200 00000
 05278 49 04782 00000
 05286
 05286 16 05923 000-1
 05298 11 05925 000-1
 05310 11 02255 000-1
 05322 49 02250 00000
 05330
 05330 34 00000 00102
 05342 34 00000 00102
 05354 16 05923 000-1
 05366 16 05437 -7258
 05378 25 06377 05922
 05390 25 06379 05923
 05402 34 00000 00102
 05414 39 06369 00100
 05426 26 05945 07258
 05438 33 05936 00000
 05450 38 05936 00100
 05462 11 05923 000-1
 05474 11 05436 000-1
 05486 24 05923 07227
 05498 47 05378 01100
 05510 34 00000 00102
 05522 34 00000 00102
 05534 38 06138 00100
 05546 39 06395 00100
 05558 26 06190 07227
 05570 12 06190 000-3
 05582 23 06190 07227
 05594 26 06190 00099
 05606 13 06190 000-5
 05618 11 00099 -7748
 05630 21 00098 07227
 05642 32 00095 00000
 05654 26 05761 00099
 05666 26 05945 06037
 05678 16 05701 -7758
 05690 26 06190 00000
 05702 24 05944 06189

TF AC,TEMPZ
 BNF SETF,TEMPZ
 CF TEMPZ
 B RTSTORZ
 DORG *-3Z
 SETF SF TEMPZ,,,INVERT AIR SIGNZ
 B RTSTORZ
 DORG *-3Z
 TFM I,1,10, I#1Z
 AM J,1,10, J#1Z
 RESETZ AM COMPARE&5,1,10, AIJ&1Z
 b COMPARE,,, LOOP BACKZ
 DORG *-3Z
 TYP0UT RCTY Z
 RCTY Z
 TFM I,1,10, I#1Z
 TFM VAR&11,DIAGZ
 AGAIN TD OUTPUT&8,1-1,, SET INDEXZ
 TD OUTPUT&10,1Z
 RCTY Z
 WATY OUTPUTZ
 VAR TF COS,DIAGZ
 CF COS-9Z
 WNTY COS-9Z
 AM I,1,10, I#1Z
 AM VAR&10,1,10, STEP FETCHZ
 C I,N,, I VS NZ
 BNH AGAINZ
 RCTY Z
 RCTY Z
 WNTY IKUDA-5,,, TYPE ROTATIONSZ
 WATY CNTZ
 TF TEMP,NZ
 SM TEMP,3,10Z
 M TEMP,N,, N%N-3#Z
 TF TEMP,ACZ
 MM TEMP,5,10Z
 AM AC,07748Z
 A AC-1,NZ
 SF AC-4Z
 TF ENDSQR&11,ACZ
 TF COS,ZEROZ
 TFM CHANGE&11,07758Z
 CHANGE TF TEMP,00000Z
 C COS-1,TEMP-1Z

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05714 46 05738 01100
 05726 26 05945 06190
 05738 11 05700 000-1
 05750 14 05701 -0000
 05762 47 05690 01100
 05774 34 00000 00102
 05786 39 06039 00100
 05798 38 05936 00100
 05810 15 05922 00000
 05821 1
 05822 38 05922 00400
 05834 34 00000 00102
 05846 34 00000 00102
 05858 46 05890 00200
 05870 39 06203 00100
 05882 49 05902 00000
 05890
 05890 39 06263 00100
 05902 36 00000 00500
 05914 49 00000 00000
 05922
 07758 1225 00010
 07258 50 00010
 07247 10
 07248 1
 07237 10
 07227 2
 05923 2
 05925 2
 05935 10
 05945 10
 05946 1
 05949 30
 02246 2
 02248 2
 02284 2
 02282 2
 06017 10
 06027 10
 06037 10
 06039 30
 06117 10
 06117 10
 06127 10

BH #624Z
 TF COS,TEMPZ
 AM CHANGE&10,1,10Z
 ENDSQR CM CHANGE&11,0Z
 BNH CHANGEZ
 RCTY Z
 WATY MESS2Z
 WNTY COS-9Z
 TDM I-1Z
 DC 1,@,*Z
 WNCDC I-1Z
 PHASE2 RCTY Z
 RCTY Z
 BC2 CALL3Z
 WATY ENDZ
 B CALL3&12Z
 DORG *-3Z
 CALL3 WATY PHASE3,,, INSTRUCTIONSZ
 RNCD 0,,, LOAD PHASE 3 LOADERZ
 B 00,,, EXECUTE LOADERZ
 DORG *-3Z
 * PHASE 2 CONSTANTSZ
 ELEMNT DSB 1225,10,7758Z
 DIAG DSB 50,10,7258Z
 E DS 10,7247Z
 RM2 DC 1,@,7248Z
 DELTA DS 10,7237Z
 N DS 2,7227Z
 I DS 2Z
 J DS 2Z
 SIN DS 10Z
 COS DS 10Z
 RM DC 1,@Z
 CMPATB DAC 30,LOAD PHASE 2 OUTPUT-HIT START#Z
 I1 DS 2,11J168Z
 J1 DS 2,11J1610Z
 K1 DS 2,HIT&10Z
 K DS 2,HIT&8Z
 ONE DC 10,5110000000Z
 HALF DC 10,5050000000Z
 ZERO DC 10,0Z
 MESS2 DAC 30,MAXIMUM AIJ,%I NCT # JB, # @Z
 AIJ DS 10Z
 AJJ DS 10Z
 AIJ DS 10Z

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06137	10	AIMIAJ	DS	10Z
06143	6	IKUDA	DC	6.0@Z
06153	10	NEWAI1	DC	10.0Z
06163	10	NEWAJJ	DC	10.0Z
06173	10	NEWAIJ	DC	10.0Z
06180	7	TAN225	DC	7.5041421Z
06190	10	TEMP	DS	10Z
06200	10	TEMP2	DS	10Z
00099		AC	DS	.99Z
06203	15	END	DAC	15. END OF PROGRAM@Z
06241	10	S2	DS	10Z
06251	10	SC	DS	10Z
06261	10	C2	DS	10Z
06153	10	AIK	DS	10. NEWAI1Z
06163	10	AJK	DS	10. NEWAJJZ
06263	48	PHASE3	DAC	48. EIGENVALUES DONE, WHEN PHASE 3 LOADS, HIT START@Z
06359	5	EEQUAL	DAC	5. E # @Z
06369	13	OUTPUT	DAC	13. A*00# # @Z
06395	13	CNT	DAC	13. ROTATIONS.@Z
06429	10	SQRT2	DC	10.5070710678Z
02178		DEND	ENTRYZ	

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PHASE 3

1620 CARD SYSTEMS WITH DIVIDE AND INDIRECT ADDRESSING

SPS LISTING

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02178 15 02419 00-01
 02190 16 02427 000-1
 02202 34 00000 00102
 02214 34 00000 00102
 02226 39 03835 00100
 02238 34 00000 00102
 02250 34 00000 00102
 02262 48 02273 02273
 02274 16 02429 000-1
 02286 16 02304 -4008
 02298 26 04008 03933
 02310 11 02303 000-1
 02322 14 02301 000K0
 02334 47 02298 01200
 02346 16 02364 -4008
 02358 26 04008 03923
 02370 11 02363 000L3
 02382 14 02364 04238
 02394 47 02358 01100
 02406 36 03804 00500
 02418 49 02626 00000
 02430 16 02993 000-1
 02442 14 03805 000L2
 02454 46 02546 01100
 02466 26 03165 03805
 02478 16 02865 -3678
 02490 13 03805 000L3
 02502 21 02864 00099
 02514 15 03003 00001
 02526 26 02889 03805
 02538 49 02722 00000
 02546
 02546 16 03165 000L2
 02558 16 02865 -3998
 02570 13 03805 000L2
 02582 21 02864 00099
 02594 16 02889 000L2
 02606 15 03003 00009
 02618 49 02722 00000
 02626
 02626 26 03165 03805
 02638 12 03165 000L2

* P HASE 3 - EIGENVECTOR COMPUTE 1620 W/DIVIDE & IND. ADD. Z
 *
 ENTRY TDM SW161,1,9, 1 OFFZ
 TFM OUT1,1,10, 1#1Z
 RCTY Z
 RCTY Z
 WATY MESSGEZ
 RCTY Z
 RCTY Z
 HALT H TEMP,TEMPZ
 TFM OUTJ,1,10Z
 CLEAR TFM SLTI66,MATRIXZ
 SETI TF MATRIX,ZEROZ
 AM *-7,1,10, DATA AREA#0Z
 CM SETI63,20,10Z
 BNE SETIZ
 ALISET TFM ALLI66,MATRIX,, 18-32Z
 ALLI TF MATRIX,ONT,, 18-32Z
 AM *-7,33,10,, 18-32Z
 ALLI2 CM ALLI66,14238,, 18-32Z
 BNH ALLIZ
 READN RNCD N-1Z
 SW1 B PASS2FZ
 TFM ISET611,1,10, SET 1Z
 CM N,32,10Z
 BH OVER32Z
 UNDR33 TF FUNCTN,NZ
 TFM LSTRCD,MATRIX-330Z
 MM N,33,10Z
 A LSTRCD-1,ACZ
 TDM SW261,1,, 2 OFFZ
 TF ICMPAR611,NZ
 B READZ
 DORG *-3Z
 OVER32 TFM FUNCTN,32,10Z
 TFM LSTRCD,MATRIX-10Z
 MM N,32,10Z
 A LSTRCD-1,ACZ
 TFM ICMPAR611,32,10Z
 TDM SW261,9,, 2 ONZ
 B READZ
 DORG *-3Z
 PASS2F TF FUNCTN,NZ
 SM FUNCTN,32,10Z

02650 16 02665 -3358
 02662 13 03805 000L3
 02674 21 02864 00099
 02686 15 03003 00001
 02698 26 02889 03805
 02710 16 02993 000L3
 02722 36 03808 00500
 02734 45 03106 03808
 02746 16 02841 -4008
 02758 25 03941 02426
 02770 25 03943 02427
 02782 25 03947 02428
 02794 25 03949 02429
 02806 34 00000 00102
 02818 39 03935 00100
 02830 26 03831 04008
 02842 38 03822 00100
 02854 14 02841 -0000
 02866 46 03002 01200
 02878 14 02427 -0000
 02890 46 02934 01300
 02902 11 02427 000-1
 02914 11 02840 000-1
 02926 49 02758 00000
 02934
 02934 11 02429 000-1
 02946 16 02841 -3688
 02958 13 02429 000L2
 02970 21 02840 00099
 02982 16 02427 -0000
 02994 49 02758 00000
 03002
 03002 49 00000 00000
 03014 34 00000 00102
 03026 39 03965 00100
 03038 48 03049 03049
 03050 15 02419 00009
 03062 16 02427 000L3
 03074 16 02357 04248
 03086 16 02393 03858
 03098 49 02202 00000
 03106
 03106 16 03213 -3608
 03118 13 03809 000L2
 03130 21 03212 00099

TFM LSTRCD,MATRIX-650Z
 MM N,33,10Z
 A LSTRCD-1,ACZ
 TDM SW261,1,, 2 OFFZ
 TF ICMPAR611,NZ
 TFM ISET611,33,10, SET 33Z
 READ RNCD I-1,, READ I,J,S, CZ
 BNR COMPUT,1-1Z
 TYPEV TFM OUT611,MATRIXZ
 TD TYPE66,OUT1-1Z
 TD TYPE66,OUT1Z
 TD TYPE612,OUTJ-1Z
 TD TYPE614,OUTJZ
 RCTY Z
 WATY TYPEZ
 OUT TF COS,MATRIX,, TYPE VIJZ
 WNTY COS-9Z
 TEST CM OUT611,,, LAST RECORDZ
 BE SW2Z
 ICMPAR CM OUT1,, N OR 32Z
 BNL JSETZ
 AM OUT1,1,10, 161Z
 AM OUT610,1,10Z
 B TYPEV612Z
 DORG *-3Z
 JSET AM OUTJ,1,10, 061Z
 TFM OUT611,MATRIX-320Z
 MM OUTJ,32,10Z
 A OUT610,ACZ
 ISET TFM OUT1,, 1 OR 33Z
 B TYPEV612Z
 DORG *-3Z
 SW2 B PASS2Z
 RCTY Z
 WATY PAUMSGZ
 TRICK H TRICK2,TRICK2,, ENDZ
 PASS2 TDM SW161,9,, 1 ONZ
 TFM OUT1,33,10, 1#33Z
 TFM ALISET611,MATRIX610240Z
 TFM ALLI2611,19858Z
 B ENTRY624Z
 DORG *-3Z
 COMPUT TFM VKIADD611,MATRIX-320Z
 MM 1,32,10,A%AIJ#320%I-106,MATRIXZ
 A VKIADD610,ACZ

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03142 26 03173 03213
 03154 11 03172 -3165
 03166 16 03225 -3688
 03178 13 03811 000L2
 03190 21 03224 00099
 03202 26 03903 00000
 03214 26 03913 00000
 03226 45 03474 03813
 03238 25 03049 03812
 03250 26 02273 03903
 03262 16 00469 -3297
 03274 16 00445 -2273
 03286 49 00422 -3913
 03298 16 00469 -3333
 03310 26 01260 02273
 03322 49 01262 -3803
 03334 26 02273 00099
 03346 16 00469 -3381
 03358 16 00445 -3913
 03370 49 00402 -3903
 03382 16 00469 -3417
 03394 26 01260 03913
 03406 49 01262 -3049
 03418 44 03714 03812
 03430 26 03903 00099
 03442 26 00099 02273
 03454 26 02273 03903
 03466 49 03714 00000
 03474
 03474 16 00469 -3509
 03486 26 01260 03903
 03498 49 01262 -3831
 03510 26 02273 00099
 03522 16 00469 -3557
 03534 26 01260 03913
 03546 49 01262 -3821
 03558 16 00469 -3593
 03570 16 00445 -2273
 03582 49 00422 -0099
 03594 16 00469 -3629
 03606 26 01260 03903
 03618 49 01262 -3821
 03630 26 03903 00099
 03642 16 00469 -3677
 03654 26 01260 03913

ADDF TF ENDG11,VK1AD0611Z
 AM ENDG10,FUNCTIONZ
 TFM VKJADD611,MATRIX-320Z
 MM J,32,10,A#A1J0#320%J-106MATRIXZ
 A VKJADD610,ACZ
 VKIADD TF VKI,,, STORE VKIZ
 VKJADD TF VKJ,,, STORE VKJZ
 BNR HRDWAY,J62,, THETA NOT 45 DEGZ
 TD TRICK2,J61,, 8 OK FLAG 8Z
 TF TEMP,VKIZ
 FA TEMP,VKJ,, VKI6VKJZ
 FM TEMP,SGRT2Z
 TF TEMP,ACZ
 FS VKJ,VKIZ
 FM VKJ,TRICK2,, DIFFERENCEZ
 BNF STORE,J61Z
 NEGTF TF VKI,ACZ
 TF AC,TEMPZ
 TF TEMP,VKIZ
 B STOREZ
 DORG *-3Z
 HRDWAY FM VKI,COS,, VKI*COSZ
 TF TEMP,ACZ
 FM VKJ,SINZ
 FA -TEMP,AC,,VKI*C6VKJ*S#VKJZ
 FM VKI,SINZ
 TF VKI,ACZ
 FM VKJ,COSZ

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